



HIGHWAYS DEPARTMENT

GUIDANCE NOTES

ON

**DESIGN OF ROAD TUNNEL STRUCTURES
AND TUNNEL BUILDINGS
TO BE MAINTAINED
BY HIGHWAYS DEPARTMENT**

Bridges & Structures Division

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1. **INTRODUCTION**

These Guidance Notes provide general guidance and requirements on structural design considerations and maintenance provisions for road tunnel structures and tunnel buildings to be maintained by HyD.

A road tunnel is a subsurface structure for vehicular traffic constructed through or under an obstacle. This obstacle may be in the form of other infrastructure development, natural terrain, a mountain, a body of water or the combination of the above. For the purpose of these Guidance Notes, road tunnel structures should include all major structures of a road tunnel, including permanent structural lining, structural compartments, portals, adits, ventilation buildings/shafts etc. which are structurally integrated with the road tunnel structures.

Road tunnels can be designed and constructed by different methods, depending on a number of factors, including functional requirements, geological and environmental considerations, construction methodologies and technologies, plant and equipment etc.

For demarcation purpose, an underpass is a highway structure that goes beneath another road(s), railway(s) or other highway structures and is usually forming part of a local grade separated highway system. Reference should be made to Structures Design Manual for Highways and Railways 2013 Edition (SDMHR) ^[1] for the design of the underpass.

Tunnel buildings to be maintained by HyD are engineering structures such as ventilation buildings, pumping station, kiosks, toll booths, satellite control buildings/points, control kioks etc. Tunnel buildings to be maintained by ArchSD include administration buildings which is basically for office accommodation with human activities in support of tunnel operation, building elements such as internal finishes and architectural features, workshops and garages. A maintenance matrix should be devised and agreed at the design stage.

The recommendations in these Guidance Notes will take immediate effect, and are applicable to projects which are new or under planning involving road tunnels or tunnel buildings to be maintained by HyD. In addition, designers and project offices should consult maintenance authorities to specify Tunnel Protection Zone for road tunnels to prevent adverse impact due to future developments.

These Guidance Notes should not be considered as exhaustive. Designers and project offices should also observe and comply with relevant up-to-date standards and statutory requirements relating to safety, structural integrity, durability, maintenance and operational need, and ensure that provisions and recommendations given in these Guidance Notes are applicable to their designs.

Designs of road tunnel structures and tunnel buildings to be maintained by HyD should be circulated to B&S Division for comments on structural design aspects and respective Regional Offices on maintenance aspects. Designs on geotechnical aspects, geometry, traffic control and surveillance, E&M provisions, fire safety provisions, etc. are outside the scope of these Guidance Notes. Designers and project office should seek advice from relevant authorities and departments accordingly.

2. ROAD TUNNEL STRUCTURES

Road tunnels in Hong Kong are commonly constructed by the following methods/ combination of methods: (i) Boring by Tunnel Boring Machine (TBM), (ii) Drill-and-blast, (iii) Cut-and-cover and (iv) Prefabricated tubes immersion. Designers and the project office should decide on the options to be adopted in the design with due regard to functional need, constructability, safety, geological and environmental consideration, economy as well as long-term durability and maintenance requirement, etc.

2.1 GENERAL DESIGN REQUIREMENTS

The structural design of road tunnels should take into consideration the requirements for tunnel operation, inspection and maintenance. The needs for the provision of maintenance access, lighting, communication, utility troughs, electrical and mechanical installations, drainage, provision of fire service installations, ventilation and traffic surveillance equipment etc. should be well addressed in advance of the structural design stage so as to assess their loading effects on road tunnels. Adequate maintenance access and opening should be provided for the delivery of plant and materials for maintenance. Designers should seek comments and advice from relevant authorities and parties.

According to Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and

Equipment ^[3] by Fire Services Department (FSD), systems for fire service installations and ventilation shall be provided when tunnel exceeds 230 m in length.

In practice, length of road tunnels in Hong Kong is usually longer than 230m. There are however exceptional cases that shorter road tunnels of length less than 230m exist in Hong Kong.

2.2 DESIGN WORKING LIFE

Unless otherwise agreed, the design working life of road tunnels and associated structures structurally integrated with tunnels should be taken as 120 years. For the avoidance of doubt, any tunnel buildings which are structurally integrated with a tunnel or essential for tunnel operations, such as ventilation buildings, ventilation shafts, etc., should be designed as tunnel structures with 120 years of design working life.

2.3 TYPICAL COMPONENTS OF A ROAD TUNNEL

A road tunnel should be able to accommodate the designed envelope for traffic movement as well as other functional and maintenance requirements, including ventilation, drainage, lighting, utilities and power, traffic surveillance equipment, maintenance walkway and emergency cross passage etc. A typical road tunnel should contain the following structural elements:

- (i) Tunnel lining
- (ii) Internal wall
- (iii) Suspended ceiling slab for overhead ventilation ducts (OHVD) or other utility installation
- (iv) Suspension systems (e.g. hangers) for ceiling slab
- (v) Road slab and pavement
- (vi) Road plinth and safety walkway
- (vii) Cross passage
- (viii) Ventilation shaft / adits
- (ix) Portal structure
- (x) Approach ramp and retaining side walls

Provision of other non-structural components including road drainage, utility trough, non-structural cladding/ finishing, ventilation ducts, lighting, fire-fighting and traffic surveillance equipment etc. should also be considered in the design.

2.4 TYPICAL LOADINGS TO BE CONSIDERED IN ROAD TUNNEL STRUCTURES

Various loadings typical to road tunnel structures are listed below. The list of loadings shown below is not exhaustive. Designers should carefully assess types, magnitudes and directions of loadings that would occur in road tunnel and combine them in such a way with due consideration to produce critical structural effect:

- (i) Self-weight of all tunnel elements, supported carriageway, footpath, supported tunnel buildings, supported bridges and landscaped decks;
- (ii) Soil loads on tunnel structures;
- (iii) Groundwater, seepage forces and earth pressure loads as well as floatation under various water tables;
- (iv) Loads arising from differential settlement of structures and structural elements;
- (v) Traffic loads;
- (vi) Accidental loads due to vehicle collision, vehicle explosion, fire load, impact of vessel anchors etc.;
- (vii) Dead loads and maintenance loads of E&M installations and vibration loadings due to E&M equipment's operations;
- (viii) Wind loads such as wind loads on tunnel portals and shafts;
- (ix) Loads due to temperature effects, creep and shrinkage;
- (x) Earthquake loads;
- (xi) Loads during construction;
- (xii) All other existing loads on the top of the tunnel;
- (xiii) Loads due to extreme weather, tidal impact and climate change effects;
and
- (xiv) Loads due to other planned development on top or in the vicinity of road tunnels, including future roads, buildings and infrastructure development

2.4.1 EARTHQUAKE LOADS

For earthquake loads, road tunnels should be designed to withstand seismic forces and distortions imposed on them by lateral ground movements resulted from the earthquake ground motion as well as dynamic loads arisen from the inertia response of structural elements under seismic actions. The following three types of deformations imposed by the surrounding ground, namely, (a) compression and extension in the longitudinal direction, (b) bending in the longitudinal direction, and (c) ovaling/ racking in the

transverse direction should be considered. Dynamic approaches as stated in Eurocodes should be adopted in the structural analysis. For the purpose of the design of road tunnels, the Importance Factor as stated in SDMHR ^[1] for earthquake resistance should be 2.3 which corresponds to a return period of 2500 years.

2.4.2 LOADINGS DUE TO EXTREME EVENTS

For other effects arising from extreme weather, including the rise in sea level, abnormal rainfall intensities, temperature changes etc., precautionary measures such as raised road profile at entrances, tunnel sumps, entrance barriers and floodgates etc. should be considered in the design. Comments from relevant authorities including HKO, DSD and CEDD should be sought where appropriate.

2.4.3 COMBINATION OF LOADINGS

As regards the various combination of loadings acting on road tunnels arising from surrounding interfaces, including soil, rock, aqueous bodies and other imposed loads due to other structures and geotechnical features etc., designers should consult and agree with the relevant authorities on geotechnical aspects with regard to the geotechnical design parameters, assumptions and designed loads to be adopted for assessing and designing road tunnels.

2.4.4 EFFECT OF SHRINKAGE

Effect of shrinkage due to different humidity across the depth of the pavement/lining should be duly considered in particular when the back of pavement/lining is close to the source of subsurface run-off or seepage.

2.5 CONDITION OF EXPOSURES

The design condition of exposures, nominal cover to reinforcement and design crack width to be adopted for reinforced concrete elements would have significant influence on the durability of road tunnels. Exposure class XC4 in Table 5.2 of SDMHR ^[1] with limiting crack width of 0.25mm shall be adopted for assuming the durability of road tunnel elements under the aggressive environment of road tunnel.

Notwithstanding the above, designers should carry out reviews and

assessments in order to specify exposure class which commensurate with the tunnel's specific situations and other controlling factors such as humidity, carbon dioxide concentration, design assumptions and concrete protective measures, etc. Designers should provide full substantiations if lower exposure class is adopted to ensure the adequacy of concrete cover in protection against carbonation.

2.6 FIRE RESISTANCE

- (1) Road tunnels should be designed to prevent catastrophic collapse and spalling of concrete in the case of a fire incident so as not to endanger tunnel users during evacuation and firefighters in fire-fighting or rescue. Designers should adopt the latest fire design codes and comply with the latest requirements of FSD in the design of tunnel structures.
- (2) Designers should assess fire risks of road tunnels and their consequences and adopt risk mitigation measures for various elements of road tunnels according to relevant fire design codes. The fire curves to be used, elements to be protected, forms and extents of protection required should be assessed with due considerations of fire exposure by the designers. Time for repairing and re-opening the tunnel to traffic due to various fire conditions and the associated long-term performance, inspection and maintenance requirements after respective fire conditions should also be addressed in the design.
- (3) To reduce the risk of concrete spalling under fire for all structural concrete, monofilament propylene fibres not less than 1.5kg/m^3 shall be included in the concrete mix regardless of any thermal barrier to be installed. The fibres shall be 6 – 12mm long and 18 – 32 μm in diameter, and shall have a melting point less than 180°C . Wire mesh should not be adopted in the prevention of concrete spalling under fire.

2.6.1 FIRE RESISTANCE PERIOD

As a general rule, the Fire Resistance Period should be taken as 4 hours unless agreed otherwise. Designers should document all considerations for deriving the adopted Fire Resistance Period in the design of road tunnel structures. Designers should also check with relevant authorities including FSD and TD with regard to any specific fire resistance requirements, prohibition of dangerous goods vehicles from using road tunnels, etc. in determining the Fire Resistance Period.

2.6.2 VENTILATION PROVISION IN FIRE RESISTANCE DESIGN

Reference should be made to the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment ^[3] by FSD when carrying out fire resistance design and risk assessment for road tunnels. According to Clause 4.41 of the subject Code of Practice, systems for fire service installations and ventilation shall be provided according to the Code when tunnel exceeds 230 m in length. Comments from FSD and EMSD and appropriate maintenance authorities should be sought.

2.6.3 THERMAL BARRIER

Thermal barriers should be installed to protect the tunnel lining in case of fire when the road tunnel is submerged in the sea or located in “unstable ground”(“unstable ground” is defined as “ground that will collapse if unsupported” with reference to Guidelines for Structural Fire Resistance for Road Tunnel ^[15] published by the International Tunneling Association (ITA)) where the consequence of tunnel lining collapse could be considered as catastrophic. The system of thermal barriers should be capable to withstand the Rijkswaterstaat (RWS) time/temperature fire curve for 120 minutes ^[4].

The system of thermal barriers should be a board type and pass the jet fire test in accordance with ISO 22899-1:2007 ^[5]. It should not be made of Magnesium Oxide (MgO) or materials affecting the durability of any tunnel elements/facilities.

The anchor used for fixing the thermal barrier on the tunnel lining should be made of High Corrosion Resistance (HCR) steel capable to withstand the Rijkswaterstaat (RWS) time/temperature fire curve for 120 minutes. The anchor should also be designed to hold the thermal barrier in case of earthquake. Non-destructive test should be carried out on at least 5% of total number of anchors to verify the anchor strength after installation. At least 2% of the thermal barriers should be fixed by anchors which allow removal and reinstatement of barrier panels without replacement of anchors.

2.7 DRAINAGE DESIGN

- (1) Road tunnels should be provided with drainage systems designed to cope with water from all sources such as underground seepage, surface runoff,

water leakage from broken pipes, tunnel cleansing water, etc. Entrances of approach ramps, all openings into road tunnels and associated elements such as adits, ventilation shafts etc. should be located above the 1 in 200-year return period flood level of the adjacent area with adequate provision for storm surge and freeboard wherever possible. Prior approval from authorities, including Drainage Services Department and the tunnel maintenance authorities, should be sought on any non-compliance with the aforementioned requirements with full justification provided and documented. The impact of burst water mains and blocked surface water drains causing the change of the design flood level should be assessed. The design of waterproofing system for road tunnels should follow BS 8102: 2009 – Code of Practice for Protection of Below Ground Structures against water from the ground ^[6].

- (2) Drains located underneath the carriageway would be blocked after years of accumulation of debris and mineral precipitation from tunnel seepage in view of high mineral content of groundwater in rock tunnel. Cleansing of these blocked drains is extremely difficult and their in-situ replacement is in general not feasible due to the operation of the road tunnel. As such, the sub-soil drain should be specifically designed with due consideration on the adequacy of drainage capacity especially due to blockage. Specific drainage product of sufficient strength, adequate size and durability should be adopted to minimize the chance of blockage. Adequate space should be allowed for personnel to carry out inspection and cleansing of the drainage components subject to the requirements of the maintenance parties. Covered U-channel instead of drains located underneath the carriageway should be adopted along the carriageway to facilitate inspection and maintenance work whenever possible. U-channels should be properly designed and they should be robust, durable and free from rocking.
- (3) Cross-fall and longitudinal fall should be provided on carriageway throughout the tunnel. Pump stations, sumps and separators should be provided at suitable locations in the tunnel where possible impacts on tunnel operation would be minimized. Flameproof drainage system with reference to requirements stipulated in BD78/99 ^[7] should be adopted considering accidental spillage of fuel from vehicles.

To avoid stormwater and other surface runoff flowing into the tunnel, road levels at tunnel entrances, both longitudinal and transverse, should be properly designed and associated drainage system including cut off drain etc. with adequate discharge capacity should be provided.

2.8 VENTILATION AND OTHER E&M SYSTEM

- (1) The structural design of road tunnels, including the lining, OHVD slab, suspended ceiling and hanging system for E&M equipment etc., should take into account the loading and vibration effects arising from the operations of the ventilation systems.
- (2) The internal dimension and layout of the road tunnel should be designed to accommodate ventilation ducts and other E&M equipment. Either natural ventilation, longitudinal ventilation, transverse ventilation or any variations or combinations of them are commonly adopted to suit the actual operational circumstances. The primary objectives of a tunnel ventilation system are (a) to monitor the air quality inside the tunnel continuously and take necessary action to limit the concentration of air pollutants from vehicles emissions to allowable levels and (b) to control the spread of smoke in case of a tunnel fire.

2.9 MAINTENANCE CONSIDERATIONS

- (1) A comprehensive maintenance strategy should be developed for the maintenance of road tunnels in good conditions. Different types of tunnels, locations, ground and surroundings would require different maintenance strategies. In this regard, individual tunnel should have its own maintenance strategy which should be reflected in an inspection and maintenance manual for future inspection and maintenance. The inspection and maintenance manual should include, but not limited to the following:
 - (i) Maintenance scope, objectives and strategy
 - (ii) Maintenance parties, roles and responsibilities
 - (iii) Service life of various elements of road tunnels.
 - (iv) Types of defects that may occur
 - (v) Types and frequency of inspection for various elements of road tunnels as well as their monitoring requirements, if any
 - (vi) Inspection equipment and monitoring device
 - (vii) Criteria of maintenance actions
 - (viii) Maintenance schedule and programme for various types of structural and non-structural elements
 - (ix) Recommended maintenance works and procedures
 - (x) Inspection procedure and sequence for special features, such as tunnel lining, hanging system for E&M equipment, drainage system, fire service installation etc.

- (xi) Design information relevant to maintenance planning and implementation, e.g. loadings, drawings, schedule of movement joints along the tunnel with information regarding their locations and movement ranges, etc.
 - (xii) Maintenance records or reports, certification or service reports
 - (xiii) Details and requirements of cyclic lane closure for inspection and maintenance
 - (xiv) Any other items as required by the designers and the maintenance parties.
- (2) During the design stage, comments from relevant maintenance parties should be sought and reference should be made to HyD Guidelines No. HQ/GN/26 Guidelines on Maintenance of Road Tunnels ^[9].

2.9.1 MAINTENANCE CONSIDERATIONS IN PAVEMENT DESIGN AND HEADROOM REQUIREMENTS

- (1) Both flexible and rigid pavements are commonly adopted in road tunnels. If rigid road pavement is to be adopted, the design should be such that it could facilitate efficient reconstruction of the pavement using precast rigid pavement panel. In that connection, the sizes of the pavement panel should be standardized as far as practicable and precise as-built construction record should be provided.
- (2) Structural slabs inside the road tunnels should not be used as the running surface. Concrete wearing slab or bituminous surfacing should be provided on top of the structural slabs of the tunnel.
- (3) When designing the approach carriageway to road tunnel including the toll plaza, the heavy traffic load due to frequent acceleration and deceleration of vehicles should be properly addressed in the pavement design of the carriageway.
- (4) Where concrete pavement is to be adopted in a road tunnel, an additional clearance of 0.1m should be provided on top of the designed minimum vehicular vertical clearance of 5.1m as specified in Transport Planning & Design Manual (TPDM) ^[14] to cater for future overlaying of bituminous surfacing.
- (5) The ceiling of carriageways should be painted in black with inorganic paint.

2.9.2 MAINTENANCE CONSIDERATIONS IN WATERPROOFING DESIGN

- (1) Tunnel can be designed to be either undrained or drained, according to the groundwater/seepage control methodology. The lining of undrained tunnels should be designed to withstand full hydrostatic pressures as well as the pressures generated by the ground. In the drained tunnel design, seepage forces should be taken into account in the design of lining.
- (2) Undrained tunnel design with complete waterproofing layer is the preferable tunnel design option for drill-and-blast rock tunnels. If drained tunnel design is to be adopted for drill-and-blast rock tunnels, waterproofing layer should be provided at tunnel crown and behind tunnel walls of tunnel lining.
- (3) Waterproofing details of the joints between tunnel units and segments should be duly designed in ensuring the water tightness. Provision should be allowed for any monitoring and collection of seepage in the joints in the future.

2.9.3 ACCESS FOR MAINTENANCE AND INSPECTION WORKS

- (1) Adequate and safe maintenance access to all locations and components of the tunnel for inspection and maintenance should be provided. Side access (designated shaft or incorporated in cross-passage) to overhead ventilation duct should be provided wherever possible, instead of opening at ceiling slab. Similar side access should also be provided to the tunnel chamber and ventilation duct below carriageway wherever possible, instead of a manhole at road slab. The access should be provided at intervals of not exceeding 200m. Provision of safe and effective inspection and maintenance access should be considered in the design stage with reference to Guidelines on Inspection of Road Tunnels, HyD Guidelines No. HQ/GN/04 ^[8]. Provisions should be made for future installation of access facilities inside ventilation shafts without affecting their operation so as to allow close inspection of shaft faces.
- (2) Heat resistant lighting luminance with minimum 6500 lumen output shall be installed along the centre of the ceiling of OHVD at 25m interval, such that no additional lighting would be required during inspection and maintenance works. Lighting switches and electricity sockets shall be provided near the access openings and power supply socket-outlets should be provided at ventilation ducts and underground chambers. Sufficient clearance between

tunnel elements and E&M equipment should be provided for maintenance works subject to manufacturer's recommendations and requirements of tunnel maintenance authorities.

- (3) Where access is provided for carrying out inspection and maintenance to any tunnel components including but not limited to ventilation ducts, ventilation buildings, ventilation shafts and E&M equipment, minimum headroom of not less than 1.9m and clear width of not less than 1m should be provided for the passage of personnel and equipment. If any maintenance access (whole or part) cannot achieve the required dimensions, the designer should consider using very durable materials, such as stainless steel reinforcement, for those components of the tunnel in lack of proper maintenance access. In case of doubt, advice on adequacy of accessibility from maintenance authorities should be sought.
- (4) Inspection and maintenance of tunnel elements will normally be carried out under restricted working hours. Due considerations and sufficient clearance, including the provision of adequate openings and cross passages, should be given during the design stage to facilitate maintenance and repair in the tight schedule. Wall panels should be designed with built-in inspection doors at 30m intervals to facilitate future inspection of the tunnel lining covered by wall panels. Comments from maintenance authorities should be sought.
- (5) Apart from the provision of chainage markers at carriageway level, the chainage markers should be provided along ventilation ducts and underground chambers for reference of inspection and record of defects.

2.9.4 SPARE PARTS

Spare parts and storage accommodation should be provided for those components which are susceptible to damage or wear during the service life of a road tunnel. Reference should be made to Section 16.1.3 of SDMHR ^[1]. The maintenance authorities should be consulted at an early stage in the design of the structures, including tunnel buildings, for advice on the requirements for spare parts for maintenance. The designers should prepare and agree with the maintenance authorities on the list of inventory and items which would require routine maintenance, such as wall panels, E&M equipment, drainage cover etc. The list should include details of their location, number, materials and available suppliers.

2.9.5 HANGING SYSTEM, HOLDING DOWN, ANCHORAGE AND OTHER FIXING ARRANGEMENT

In the circumstance that hanging system or hangers, including holding down bolts, dowel bars and anchorage are provided to support E&M equipment, including jet fans, lighting etc., the design of the hanging system should take into account the following requirements:

- (1) The hanging system, including holding down bolts, anchorage, connecting dowel bars etc. should be designed to be permanently fixed or cast in the structural elements of the tunnel without inducing crack or opening in the structural element concerned. Subsequent drilling into the permanent concrete lining to create holes for inserting and fixing the anchorage bolts (by expansion bolts or chemical grouting etc.) should be avoided as far as possible.

The proposed hanging, and anchorage system, with all material testing certificates, design calculations, check certificates, maintenance/inspection and repairing manual should be submitted to the responsible maintenance parties for comment.

- (2) If subsequent drilling into any reinforced concrete elements is necessary for the installation of anchor bolts, proprietary hollow drill bit with vacuum cleaning function should be used. Anchor bolts should be made of A4 grade stainless steel or equivalent. All gaps inside a bolt hole should be sealed with proprietary grout or alternatively treated to maintain the original durability of the concrete elements. Designers should substantiate that the anchor bolts are suitable for structural fixing taking into consideration the stress conditions of the concrete elements.

The potential risk of post-drilled anchor bolt fallen off of overhead slabs, especially due to fatigue, vibration and in the case of fire, should also be duly considered and mitigated. In this regards, undercut bolts should be considered.

- (3) For tunnels in oval or horseshoes shape, ceiling slabs for overhead ventilation ducts should be in arch form or other form without using hangers. For tunnels in rectangular shape, the use of hanging system or hangers for tunnel suspended ceiling should be avoided.
- (4) The hanging system should be designed to be anchored and cast permanently into the structural element with sufficient anchorage length and strength so

that no part of the system will become loosened by mechanical vibration/movement due to the operation of the E&M equipment or cracks that might appear in the concrete element supporting the hanging system during the service life.

- (5) Designers should adopt very durable materials to construct metal frames for supporting heavy elements. Tunnel claddings should be supported by Grade 316 stainless steel frames. Other heavy parts including lighting fittings should be supported by galvanized mild steel frames with painting suitable for long-term protection of structural steel works in aggressive environment. Reference should be made to Section 16.4 of SDMHR ^[1].

All connecting dowel bars, connectors, holding down, anchorages and fixing arrangements, and all other fixtures should be fabricated from austenitic stainless steel. Reference should be made to Section 16.6 of SDMHR ^[1].

The cable hangers should be galvanized and coated with epoxy powder to improve resistance against abrasion and corrosion.

2.9.6 INCORPORATION OF UTILITY INSTALLATIONS IN TUNNELS

- (1) Prior approval should be sought on any proposal to accommodate utility installations in the tunnel. The need for accommodating utility installations should be confirmed at an early stage in the design to allow designers to make adequate and appropriate provision having due regard to the functions of the tunnel.
- (2) Regarding utility services installations road tunnels, reference should be made to Section 1.7 of District Administration Handbook ^[10] and all utilities should be clearly labeled at 200m interval.
- (3) As the utility trough covers are vulnerable to damage, the bottom longitudinal edges of the covers and recess receiving the covers shall be protected by GMS angle wherever appropriate.
- (4) Proper design should be conducted for the use of the space behind wall panels for utility installation, including the hangers installed behind the wall panels for supporting cables. To facilitate the laying of new cables onto hangers behind tunnel wall panels, “leading wire” should be provided for all unused hooks of the hangers, such that removal of wall panels at close intervals could be avoided.

2.9.7 TUNNEL MOVEMENTS MONITORING

Monitoring and instrumentation plan for tunnel movements should be formulated for comments by maintenance parties. Strategic long-term monitoring points should be devised and installed before hand-over of the road tunnel to the maintenance parties. Designers should seek comment from maintenance parties for the instrumentation plan and adoption of maintenance instruments, such as survey makers etc.

2.9.8 MAINTENANCE REQUIREMENTS FOR SPECIFIC STRUCTURAL FEATURES

Since there are many post-drilling works to be carried out at the OHVD slab, prestressed OHVD slab should not be used unless there are very strong justifications on the durability of tendons being affected by the post-drilling works. In case of using prestressed OHVD slab, the tendon should be protected by High Density Polyethylene (HDPE) sheathing ducts with full grouting. Specific structural features or installations such as rock bolts, ground anchors, etc. may require special maintenance measures. Advice from maintenance authorities should be sought to the adoption of any of these specific structural features in the design stage. All specific maintenance and inspection procedures for these specific structural features should be detailed in the maintenance and inspection manual.

2.9.9 TUNNEL CLADDINGS

Cladding panels should be designed to facilitate removal and subsequent reinstatement of covering for the concerned tunnel lining for inspection and repair. Regular or ad-hoc inspections should be implemented. In case Vitreous Enamel (VE) claddings are adopted in the tunnel design, the fixing and arrangement of VE panels should be designed to allow removal and installation of individual panels without moving any adjacent panels. Such design arrangement would enhance the efficiency during inspection and maintenance works, in particular in the event of emergency repair so as to minimise the impact to the public nuisance due to temporary road closure.

3. TUNNEL BUILDINGS

3.1 GENERAL STRUCTURAL DESIGN REQUIREMENTS

- (1) Designers should ensure the compliance of the structural design of the tunnel buildings with the statutory requirements relevant to building construction and associated works in Hong Kong and fulfillment of the corresponding functional purposes and requirements in terms of structural layout, loadings, access, emergency escape requirements, durability, fire resistance, etc.
- (2) Designers should ensure that the buildings are designed in accordance with the relevant Codes of Practice for Buildings in Hong Kong. Reference should be made to the Code of Practice for Structural Use of Concrete ^[11], Code of Practice for Foundations ^[12], Code of Practice for Structural Use of Steel ^[13] and Code of Practice for Fire Safety in Buildings 2011 ^[2] issued by Buildings Department. Reinforced concrete should be designed to meet the minimum concrete cover requirement as stated in the Code of Practice for Fire Safety in Buildings 2011 ^[2] issued by Buildings Department and the relevant requirements by the FSD.

3.2 DESIGN WORKING LIFE

A design approach based on a design working life of 50 years should be adopted in the design of tunnel buildings.

3.3 OTHER DESIGN REQUIREMENTS

For building services, fire services installations and other building facilities, designers should seek comments from ArchSD, EMSD, FSD, etc. accordingly to ascertain the required information for the structural design. For geotechnical information necessary for structural design of tunnel buildings, comments from GEO should be sought.

3.4 DESIGN REQUIREMENTS FOR TUNNEL BUILDINGS DESIGNED FOR SPECIAL USE

Tunnel buildings designed for special use, such as fuel filling station, dangerous goods store, garage etc., comments from relevant authorities including FSD, EMSD, etc. should be sought with regard to the building design requirements and regulations concerned.

3.5 MAINTENANCE CONSIDERATIONS

An inspection and maintenance manual should be prepared during the design stage to cater for the particular design and functions of the tunnel buildings. The items that should be included in the manual should cover but not limited to those items for the inspection and maintenance manual of road tunnel structures listed in Section 2.9 above. Comments from relevant maintenance parties, including HyD/Region, should be sought on aspects which require regular maintenance, such as soft landscaping, during the design stage.

4. INDEPENDENT CHECKING

The designers should ensure the compliance of the relevant design requirements as well as the safety and integrity of the road tunnel structures and tunnel buildings.

4.1 ROAD TUNNEL STRUCTURES

Independent checking of the design of the road tunnel structures should be carried out under Structure Category III as shown in Table 2.2 of SDMHR ^[1].

4.2 TUNNEL BUILDINGS

Tunnel buildings should be designed and checked in accordance with the statutory requirements relevant to building construction and associated works in Hong Kong. Reference should be made to Buildings Department's Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers.

5. ENQUIRIES

For any enquiries on this document, please contact Chief Highway Engineer/Bridges and Structures.

6. REFERENCES

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