



Guide to Carrying Out Engineering Works within Road Structure Safety Zone and Engineering Activity on Land adjoining Public Streets



January 2011 Edition



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PREFACE

This publication provides guidance to the Qualified Person, contractor or any person who intends to carry out engineering works within road structure safety zone and engineering activity on land adjoining public streets. It highlights the submission procedures and technical requirements in relation to obtaining the Authority's approval of engineering works within road structure safety zone and notification to the Authority of the intention to commence engineering activity on land adjoining public streets. The Authority may impose terms and conditions as it thinks fit.

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PART I – INTRODUCTION

SECTION 1 GENERAL

1.1 SCOPE

- 1.1.1 This guide covers the submission procedures and requirements for obtaining approval to commence engineering works within the road structure safety zone and notification to commence engineering activity on land adjoining public streets.
- 1.1.2 Nothing in this guide shall derogate or prejudice the Authority's powers, rights and remedies under the Street Works Act, as amended from time to time.

1.2 USEFUL REFERENCES

- 1.2.1 Street Works Act

1.3 CONSULTATION

- 1.3.1 The applicant may consult the Authority on any requirement relating to the protection of road structures and public street before making any formal submission.
- 1.3.2 Any preliminary consultation with the Authority or submission of plans shall not be taken as approval or disapproval of the proposed engineering works, or to be construed as having the agreement of the Authority.
- 1.3.3 Unless otherwise stated, all conditions and comments stipulated during the consultation process shall be addressed in the submission for approval of engineering works or notification to commence engineering activity.
- 1.3.4 The submission for approval of engineering works and notification of commencement of engineering activity (except those relating to utility works), including related requests for consultation meetings, information and other correspondences shall be addressed to:

Deputy Director
Development & Building Control Division
Land Transport Authority
251, North Bridge Road
Singapore 179102

The submission for approval of engineering works and notification of commencement of engineering activity relating to utility works, including related requests for consultation meetings, information and other correspondences shall be addressed to:

Deputy Director
Road Infrastructure Management Division
Land Transport Authority
No 1 Hampshire Road
Block 3 #03-00
Singapore 219428

1.4 DEFINITIONS

For the purpose of this guide, the following definitions shall apply :

“above-ground structure” includes bridge, abutment, approach structure, embedded retaining wall and ancillary structure that are above ground level;

“accredited checker” means a person who is registered under Section 16 of the Building Control Act (Cap 29);

“approved” means approved by the Authority;

“assessment method” means a method used for determining or establishing that a solution complies with the performance requirements;

“at-grade structure” shall include any at-grade road carriageway, structure with platform level at the ground level, on embankment or in cutting;

“applicant” means the person appointed by the developer/owner to make application and obtain approval to carry out engineering works from the Authority;

“Authority” means the Land Transport Authority of Singapore established under the Land Transport Authority of Singapore Act 1995;

“bridge” has the same meaning as in the Street Works Act;

“engineering activity” means any of the following activities:

- (i) excavation that extend to a depth of more than 1.5 metres and located within a distance of 2 times the maximum excavation depth measured from the edge of the public street;
- (ii) any of the following activities that is carried out within 20 metres from the edge of a public street:
 - (a) construction of tunnels and related underground structures;
 - (b) installation of bore-holes or wells;
 - (c) installation or extraction of sheet piles, deep foundations, ground anchors, soil nails, horizontal tie-back or diaphragm wall;
 - (d) jet-grouting works or other ground treatment works to enhance the

engineering properties of the ground;

- (e) filling, storage or placing of concrete, aggregates, steel sand, soil, slurry and other similar construction materials that extend to a height of more than 1.5 metres; or
- (f) the use of explosive substances for the purpose of blasting, demolition or removal of rocks

“engineering works” has the same meaning as in the Street Works Act;

“expert judgement” means the judgement of an expert (or group of experts) who has the relevant qualifications, substantial knowledge and experience in a particular subject/ field to determine whether a development solution complies with the performance requirements. The appointed expert shall be approved by the Authority;

"geotechnical aspects" has the same meaning as defined in the Building Control Act (Cap 29);

“geotechnical report” has the same meaning as defined in the Building Control Regulations;

"geotechnical engineer" has the same meaning as defined in the Building Control Act;

“land surveyor” means a person who is registered under the Land Surveyors Act;

“objective” means a statement contained in this guide that forms the aim of the Authority in safeguarding the road structures and/or public road;

“performance requirement” means a requirement which states the level of performance which an engineering solution must meet;

“professional engineer” means a person who is registered as a civil or structural engineer under the Professional Engineers’ Act and who possesses a valid practising certificate;

“public street” has the same meaning as in the Street Works Act;

"road carriageway" is a portion of the public street devoted particularly to the use of vehicles, inclusive of the shoulders and auxillary lanes;

“road structure” has the same meaning as in the Street Works Act;

“road structure safety zone” has the same meaning as in the Street Works Act;

"specialist accredited checker" has the same meaning as defined in the Building Control Act;

“underground structure” includes road tunnel, underpass, depressed road structure, cross passage between tunnels and the part of any road structure that is located below ground level such as emergency escape shaft of road tunnel, etc ;

"utility works" has the same meaning as in the Street Works Act;

“verification method” means a test, inspection, calculation or other method that determines whether a engineering solution complies with the relevant performance requirements.

PART I – INTRODUCTION

SECTION 2 STRUCTURE OF GUIDE

2.1 STRUCTURE

2.1.1 This guide is divided into four main parts as follows :

- (a) Part I - Introduction
- (b) Part II - Engineering Works
- (c) Part III - Engineering Activity
- (d) Part IV - Appendices

2.2 REQUIREMENTS

2.2.1 The submission procedures and requirements for obtaining approval to commence engineering works within the road structure safety zone are stipulated in Part II of this guide.

2.2.2 The submission procedures and requirements to notify the Authority of the intention to carry out any engineering activity on any land adjoining a public street are stipulated in Part III of this guide.

2.2.3 The Authority reserves the right to impose any additional requirement deemed necessary to safeguard the road structures and public streets.

2.3 APPENDICES

2.3.1 The following items are presented in the appendices of this guide :

- (a) Appendix A - Drawings indicating the definitions of road structure safety zone
- (b) Appendix B - Typical cross-sectional details showing clear envelope for road tunnel and underpass

PART II - ENGINEERING WORKS

SECTION 1 PROCEDURES AND REQUIREMENTS

1.1 GENERAL

- 1.1.1 This section stipulates the procedures and requirements for obtaining approval to commence engineering works in the road structure safety zone.
- 1.1.2 Engineering works refers to any kind of construction work that is likely to affect the structural integrity of any road structure and the safety of its operations and includes:-
- (a) excavations for basements and other building structures under land;
 - (b) installation of foundation piles, sheet piles, bore holes, wells, ground anchors and tie backs; and
 - (c) operation of any crane, hoist or heavy equipment.
- 1.1.3 The Authority reserves the right to impose any additional requirement deemed necessary to safeguard the road structures.
- 1.1.4 An application for approval to commence engineering works within the road structure safety zone shall be made. The application shall be made:
- (a) where the engineering works are required by a statutory authority, by an officer of the statutory authority who has been duly authorised for that purpose;
 - (b) where the engineering works are required by a utility service provider duly licensed by the relevant authority, by an officer of the utility service provider who has been duly authorised and accepted by the Authority for that purpose; or
 - (c) where the engineering works comprise only the operation of any crane, hoist or heavy equipment, by a contractor engaged by the person for whom the engineering works are to be carried out; or
 - (d) in any other case, by a professional engineer engaged by the person for whom the engineering works are to be carried out.

1.2 APPLICATION FOR APPROVAL TO COMMENCE ENGINEERING WORKS

1.2.1 An application for approval to commence engineering works shall be submitted by the applicant. The application shall be accompanied by the following items where applicable:

- (a) Plans for engineering works;
- (b) Engineering evaluation report;
- (c) Instrumentation proposal;
- (d) Method statement of work;
- (e) Contingency plans / Emergency procedure;
- (f) Pre-condition survey report;
- (g) Certified survey plan (for underground structures only); and
- (h) Soil investigation report.

1.2.2 The requirements for the above items are given in clause 1.3 to clause 1.10 for compliance.

1.3 PLANS FOR ENGINEERING WORKS

1.3.1 Plans for engineering works shall be prepared and endorsed by a professional engineer. Where applicable, the plan shall also be endorsed by an accredited checker, a qualified person who is a geotechnical engineer and a specialist accredited checker in accordance with the Building Control Act (Chapter 29, Section 49) and its Regulations.

1.3.2 Layout plans and cross sectional details shall indicate the following items :

- (a) Scale of plans;
- (b) Location of engineering works in relation to the road structures; and
- (c) Vertical and horizontal distances of the engineering works (site preparation, substructures, building construction works, and etc.) in relation to the road structures, where applicable.

1.4 ENGINEERING EVALUATION REPORT

1.4.1 Engineering evaluation report shall be prepared and endorsed by a professional engineer. Where applicable, the report shall also be endorsed by an accredited checker, a qualified person who is a geotechnical engineer and a specialist accredited checker in accordance with the Building Control Act (Chapter 29, Section 49) and its Regulations;

1.4.2 The above report shall address the following items:

- (a) Design of the engineering works;
- (b) Predicted movements of the existing road structures due to the proposed engineering works at various stages of construction till completion of the works. The evaluation shall include the following items :
 - (i) Detailed examination and assessment of the ground conditions at site;
 - (ii) Analysis and design calculations for the derivations of the predicted movements of the road structures; and
 - (iii) Appropriate sensitivity analysis to check that the assessment would not be affected by any variation in input parameters and conditions that may occur during all stages of the construction work.
- (c) Assessment of the likely effects of the movement on existing road structure. The following shall be complied with:
 - (i) The assessment shall include analysis and design calculations to show that the foundation, substructure and superstructure of the road structures (including main beams, deck slabs, half joints, movement joints, retaining walls, wing walls, piers, tie beams, crossbeams, crossheads, diaphragm beam, bearings, shear pins and approach structure of the bridges) are capable of accommodating the additional movements and forces resulting from the engineering works; and
 - (ii) The design loading adopted for the assessment of existing road structures shall be in accordance with the Land Transport Authority's Civil Design Criteria.
- (d) When required by the Authority, the person for whom the engineering works are carried out shall appoint a professional engineer to carry out an inspection and assessment of the existing road structures within the influence zone of the proposed engineering works. The inspection and assessment report shall be prepared and endorsed by the appointed professional engineer and shall include the following:

- (i) Visual survey of the condition of the bridge and approach structures including the bearings, movement joints, etc;
 - (ii) Assessment on the pre-existing movements of the bridge structure and approach structure that may have occurred prior to the commencement of the proposed engineering works. The assessment shall be derived from the site survey and measurement of the existing movements of bearings, movement joints, etc.
- (e) Proposal for any special/protective measures or advance works, either temporary or permanent, that are required to minimise the susceptibility of the existing road structures and/or road carriageway to damage and to ensure the continuation of safe operating conditions for the public street. These may include temporary props, strengthening or underpinning works, modification or replacement of bridge bearings and shear pins, etc.
- 1.4.3 The report shall clearly demonstrate that the requirements in Part II Section 5 and Section 6 are fully met during construction and after all works have been completed.

1.5 INSTRUMENTATION PROPOSAL

- 1.5.1 The response of the existing road structures and the ground adjacent to it shall be monitored with a comprehensive instrumentation monitoring system. The instrumentation proposal shall be prepared and endorsed by a professional engineer and submitted to the Authority for approval.
- 1.5.2 The instrumentation proposal shall include the following items:
- (a) Layout plans and relevant cross-sections indicating the locations of proposed instruments relative to the road structures;
 - (b) Details of the instruments or equipment, including the types, function of instruments, depth of installation, fixing details, etc.;
 - (c) Frequency of monitoring;
 - (d) Review levels, i.e work alert and work suspension level for all instruments at the various critical stages of work in accordance with the design estimates; and
 - (e) Valid calibration certificates for the instruments proposed, where applicable.
- 1.5.3 In preparing the above proposal, the requirements stipulated in Part II Section 2 shall be complied with.
- 1.5.4 For any installation of instruments in road tunnel, the requirements in Part II Section 3 shall also be complied with.

1.6 METHOD STATEMENT OF WORK

- 1.6.1 Method statement for carrying out any engineering works shall be prepared and endorsed by a professional engineer.
- 1.6.2 The proposal shall be accompanied by the following items :
- (a) Layout plan and sections showing the vertical and horizontal distances of the boundary line and engineering works relative to the road structures;
 - (b) Layout plan showing the site utilisation and movement of machineries and lifting equipment;
 - (c) Write-up and/or plans indicating step-by-step sequence of carrying out each phase of works or activities;
 - (d) Hazard analysis identifying all possible risks from the engineering works that may be posed to the road structures and a description of the safety and precautionary measures to mitigate the risks.
- 1.6.3 For proposal involving crane, hoist or heavy equipment, the application shall also be accompanied by the following items:-
- (a) Layout plan and sections showing collapse radius of equipment relative to the road structures;
 - (b) Complete list of machinery, equipment, etc. to be used;
 - (c) Names of qualified site supervisors, safety officers, lifting supervisors;
 - (d) Copy of test certificates of lifting appliances that will be used;
 - (e) Calculations by a professional engineer to check on the stability of the working platform or foundation and the access for the crane or mechanical equipment, etc;
 - (f) Calculations by a professional engineer on design of tie-back for tower crane (where applicable).

1.7 CONTINGENCY PLANS/ EMERGENCY PROCEDURE

- 1.7.1 A contingency plan and emergency procedure shall be prepared and endorsed by a professional engineer for emergency situations due to various incidents at site, such as:
- (a) Monitoring results exceeding the alert levels / work suspension levels specified by the professional engineer;
 - (b) Excessive movement of the road structure that affect the functionality and safe operation of the public street;
 - (c) Accidents such as lifting equipment or machineries toppling onto the road structures, etc; and

(d) Failure/collapse of earth retaining systems that affect the structural integrity of the road structures.

1.7.2 The contingency plan/emergency procedure report shall include the following items:

(a) Descriptions of the project and proposed works to be carried out in the road structure safety zone;

(b) List of all possible hazard/ emergency situations that may arise due to the proposed works;

(c) Governing criteria for initiating an emergency procedure;

(d) Contingency plan and emergency procedure (step-by-step or flow chart) showing the immediate actions to be taken by the professional engineer and the contractor in the event of an emergency to safeguard the integrity of the road structures. Where applicable, the contingency plan and emergency procedure shall include the steps to review the monitoring results obtained, the re-examination of the method of work, the revision to the predictions, the review of instrumentation provisions, the contingency measures to be implemented, plans for road diversion, etc;

(e) The follow-up actions to be taken after the implementation of control measures at site; and

(f) Call-up list stating the names and contact numbers of all key personnel including the professional engineer, the geotechnical engineer, the project manager, the site supervisors and the instrumentation specialist, etc. The organisation chart and a flow chart for the emergency reporting shall also be included.

1.8 PRE-CONDITION SURVEY REPORT

1.8.1 A condition survey report shall be prepared and endorsed by an independent person who has the appropriate qualifications, for example, a professional engineer or building surveyor.

1.8.2 The condition survey report shall include the following:

(a) Physical survey of the road structures;

(b) Photographic record of the road structures;

(c) Topographical survey of the road reduced levels, at 3m grid spacing along each traffic lane. The survey shall be conducted and certified by a registered land surveyor.

1.9 CERTIFIED SURVEY PLAN (FOR UNDERGROUND STRUCTURES ONLY)

1.9.1 Certified survey plan shall be endorsed by a registered land surveyor after conducting a physical geometric survey of the relevant sections of the underground structures.

1.9.2 The certified survey plan shall indicate the following:

- (a) Scale of plan and existing contours;
- (b) Alignments, chainages, co-ordinates and levels of the underground structures;
- (c) Boundary lines of the development and lot numbers, where applicable; and
- (d) Cadastral coordinates of drilling positions and offset from the road structures (for proposal involving any drilling or boring works in the road structure safety zone of underground road structures)

1.10 APPLICATION FOR APPROVAL OF ENGINEERING WORKS INVOLVING OPERATION OF CRANE, HOIST OR HEAVY EQUIPMENT ONLY

The applicant shall make an application to the Authority for approval to carry out operation of crane, hoist or heavy equipment. The application shall be accompanied by the following items:

- (a) Layout plan and section showing location of the operation and collapse radius of equipment relative to the road structures ;
- (b) Method statement of work describing the activities to be carried out and a step by step sequence of carrying out each phase of these activities;
- (c) Risk assessment report identifying all possible risks due to the operation of equipment that may be posed to the road structures and a description of the safety and precautionary measures to mitigate these risks;
- (d) Write-up on contingency plan and emergency procedure describing the actions that would be taken in the event of emergency situations which pose safety hazards to the road structures;
- (e) Call-up list stating the name and contact number of all the key personnel including the applicant, the professional engineer, the project manager, the site supervisors, etc. The list shall be updated whenever there are changes and shall be resubmitted to the Authority for record;

- (f) Complete list of machinery, equipment, etc. to be used;
- (g) Names of qualified site supervisors, safety officers, lifting supervisors;
- (h) Copy of test certificates of lifting appliances that will be used;
- (i) Calculations by a professional engineer to check on the stability of the working platform or foundation and the access for the crane or mechanical equipment, etc;
- (j) Calculations by a professional engineer on design of tie-back for tower crane (where applicable); and

1.11 COMMENCEMENT OF WORK

The Authority will issue clearance to commence works upon approving the relevant engineering works plans if all the relevant requirements in Part II of this guide are complied with.

1.12 DEPARTURE OR DEVIATION FROM APPROVED PLAN

- 1.12.1 Engineering works that depart or deviate from the approved proposal shall be submitted to the Authority for approval.
- 1.12.2 An application for approval of the revised engineering works proposal shall be submitted in accordance with clause 1.2 or clause 1.10 of this section whichever applicable.
- 1.12.3 No person shall carry out any engineering works that depart or deviate from the approved proposal without the Authority's written approval.

PART II – ENGINEERING WORKS

SECTION 2 INSTRUMENTATION PROPOSAL

2.1 GENERAL

- 2.1.1 This section stipulates the minimum monitoring requirements for engineering works in road structure safety zone.
- 2.1.2 The Authority reserves the right to impose any additional condition deemed necessary to safeguard the road structures.

2.2 GROUND MONITORING

- 2.2.1 The ground shall be monitored for changes in ground conditions and movements which may result from the proposed works.
- 2.2.2 Typical ground instruments such as water standpipes, inclinometers, piezometers, borehole extensometers and deep settlement markers shall be provided, where applicable.
- 2.2.3 The monitoring shall cover the full length of the work and extend 20 metres beyond the zone of influence or up to the next pier (if applicable) outside the zone of influence, whichever greater.
- 2.2.4 Adequate monitoring instruments shall be provided. The spacing of instruments shall be such that adverse changes in the ground conditions can be captured. The frequency of monitoring must be able to capture any drastic changes in the monitoring readings timely for appropriate follow-up action.

2.3 MONITORING OF ROAD STRUCTURES

- 2.3.1 Road structures shall be monitored if the engineering works have implications on the integrity of the road structures and its safe operation.
- 2.3.2 Typical monitoring instruments such as precision surveying theodolite, tiltmeter, vibration sensor, crack meter, electrolevel, tape extensometer, can be used.

2.4 INSTALLATION

- 2.4.1 There shall be no drilling on prestressed concrete elements. The proposed drilling locations shall be away from the existing reinforcements. Before drilling into the road structures, checks shall be made to identify the depth and location of the embedded reinforcements

2.4.2 Upon completion of monitoring, all fixtures installed (except the stainless steel anchors) must be removed and the road structures shall be made good to the acceptance of the Authority. Approval shall be obtained from the Authority for any other left-in fixtures.

2.5 ACCURACY OF READINGS

2.5.1 Instruments used shall have calibration done once every 6 months. Certificates for calibration shall be submitted to the Authority for record.

2.5.2 The readings shall attain the level of accuracy as specified by the manufacturer. The instruments shall be maintained in good working condition. Damaged instruments shall be immediately replaced to the acceptance of the Authority and readings correlated with the previous.

2.5.3 Control and reference points shall be located outside the zone of influence of the proposed works and such that they do not impact on the accuracy of monitoring results. At least two numbers of control points on opposite ends of site shall be provided. In addition, control points must be located on very stable structures which would not be affected by the adjacent development.

2.6 INITIAL INSTRUMENTATION READINGS

2.6.1 Readings must be stabilised before commencement of work.

2.6.2 Readings which are the most representative of the initial condition shall be taken as the initial readings.

2.6.3 A copy of the initial readings endorsed by the professional engineer and registered land surveyor where applicable shall be submitted to the Authority for approval to commence work.

PART II - ENGINEERING WORKS

SECTION 3 INSTALLATION OF INSTRUMENTS IN ROAD TUNNEL

3.1 GENERAL

- 3.1.1 This section stipulates the requirements for obtaining approval for installation of instruments in road tunnel.
- 3.1.2 All instruments to be installed in the road tunnel shall be submitted to the Authority for approval before permission can be granted for the installation works.

3.2 APPLICATION FOR INSTRUMENT INSTALLATION

- 3.2.1 An application for the approval of instrument installation in road tunnel shall be accompanied by the following items:
- (a) Instrumentation layout plan;
 - (b) Cross sectional details of the road tunnel;
 - (c) Plans and calculations on fixing details;
 - (d) Document stating the name and particulars of the appointed registered surveyor and his assignee, if any, responsible for checking structure clearance of instruments installed on site; and
 - (e) Document stating the name and particulars of the appointed professional engineer and his assignee, if any, responsible for checking fixing details of instruments installed on site.
- 3.2.2 Two set of virus free soft copy of item (a) and item (b) shall also be submitted.

3.3 INFORMATION TO BE INDICATED ON PLANS & CALCULATIONS

- 3.3.1 Instrumentation layout plan shall show the following items :
- (a) Registered surveyor's endorsement on every plan;
 - (b) Scale of drawing;
 - (c) Road tunnel alignment with respect to the engineering works; and
 - (d) Chainages of all instrument locations.

- 3.3.2 Cross-sectional details of the road tunnel shall show the following items:
- (a) Registered surveyor's endorsement on every plan ;
 - (b) Professional engineer's endorsement on every plan for fixing details;
 - (c) Scale of drawing;
 - (d) Chainage of tunnel and cross-sections;
 - (e) Direction of tunnel cross section i.e orientation based on direction of travel or tunnel chainage;
 - (f) Horizontal & vertical offsets of the outermost part of the fixture protruding into the tunnel;
 - (g) Clear envelope profile of tunnel/underpass (Part IV- Appendix B);
 - (h) Clearance between the outermost part of the fixture and the clear envelope - as stipulated in Part IV - Appendix B; and
 - (i) All instruments including brackets are indicated to be outside the clear envelope as stipulated in Part IV – Appendix B.

3.3.3 Fixing details and calculations shall show the following items :

- (a) Professional engineer's endorsement on the first and last sheets of calculations;
- (b) 3-dimensional details of instruments, brackets (including mounting holes & any extendable parts), hold down bolts, fixing details of cables, etc.;
- (c) Specifications of all instruments and cables; and
- (d) Design calculations on all fixing including hold down bolts, anchorage, etc.

3.4 APPROVAL FOR INSTRUMENT INSTALLATION

The Authority will approve the proposal plans for the installation of instrument in the road tunnel if all the requirements listed in clause 3.2 and clause 3.3 are complied with.

3.5 SUPERVISION OF INSTALLATION

- 3.5.1 The registered surveyor and professional engineer who prepared and endorsed the plans shall be fully responsible for the supervision of instrument installation as shown on the approved plans.

3.5.2 In the event the registered surveyor or the professional engineer cannot be in attendance on site, subject to the approval of the Authority, they shall appoint an experienced assignee(s) to act and suitably discharge their responsibilities as required. Notwithstanding such assignment, the registered surveyor and professional engineer shall be deemed fully responsible for all action taken by the assignee with or without their consents or sanctions.

PART II - ENGINEERING WORKS

SECTION 4 SUPERVISION OF WORKS

4.1 APPOINTMENT OF SUPERVISOR

- 4.1.1 The person for whom any engineering works are to be carried out within the road structure safety zone, shall appoint a suitably qualified person to supervise the carrying out of such works. The suitable qualified person is referred to as the supervisor in this guide.
- 4.1.2 The person carrying out any engineering works within the road structure safety zone, shall ensure that whenever such works are being carried out, there is at least one supervisor present at the site of the works to supervise the carrying out of such works.
- 4.1.3 The supervisor for engineering works other than lifting works shall be a professional engineer.
- 4.1.4 The supervisor for lifting works in the road structure safety zone with toppling zone of equipment more than 6m clear from the outermost edge of the road structure shall be a qualified lifting supervisor.
- 4.1.5 Subject to the approval of the authority for lifting works where the equipment collapse radius is less than 6 metres from the outermost edge of the road structures, the supervisor for the lifting works shall be a professional engineer.

The professional engineer appointed to be the supervisor may appoint an assignee to act on his behalf to discharge his responsibilities as required in his absence. The assignee shall be a person accredited as a resident engineer under the Building Control Act or Joint Accreditation Committee of the Institution of Engineers Singapore and the Association of Consulting Engineers Singapore. The professional engineer shall submit the form “Undertaking To Supervise Crane Operation”.

Notwithstanding the assignment, the professional engineer shall be fully responsible for all actions taken by his assignee with or without his prior consent or sanction.

4.2 GENERAL DUTIES

- 4.2.1 The appointed supervisor shall take all reasonable steps and exercise due diligence in supervising the carrying out of the engineering works within the road structure safety zone.

4.3 MONITORING OF ROAD STRUCTURES

- 4.3.1 The supervisor shall exercise due diligence and reasonable care in ensuring that the response of the road structures and the adjacent ground are closely monitored during the construction stage.
- 4.3.2 Once the monitoring readings are taken, the supervisor shall analyse the monitoring results and compare with the alert and work suspension levels, predict the likely trends and notify the Authority of any deviation from the predicted results and trends. He shall also make proposal to change the method of working or to implement an emergency plan as a result of monitoring.
- 4.3.3 A report of the review and the monitoring results endorsed by the supervisor shall be submitted to the Authority fortnightly or as directed by the Authority. The report shall also include description on progress of works.
- 4.3.4 During the progress of the works, if it becomes apparent from the monitoring results that the ground movement and/or the structural movement are likely to exceed the limits, works shall be suspended and immediate actions taken to ensure that additional measures are implemented to control movements to within the acceptable limits and safe road operations. These measures implemented shall be at the cost and expense of the person for whom the works are carried out. The findings, assessment and recommendations in a report duly prepared and endorsed by a professional engineer shall be submitted to the Authority for approval. The work shall only be allowed to resume if it can be demonstrated that the continuation of works will not adversely affect the road structures.
- 4.3.5 The monitoring shall continue until all works that may affect the movement of the road structures have been completed and the monitoring results show that the road structures and the surrounding ground have stabilised and no further movement or change would be anticipated. Approval shall be obtained from the Authority prior to the termination of monitoring.
- 4.3.6 Upon termination of monitoring works, all monitoring instruments installed shall be removed and made good to the acceptance of the Authority. The supervisor shall submit to the Authority a soft copy of the final instrumentation readings, verified and endorsed by the supervisor or licensed land surveyor whichever applicable for record. The final instrumentation readings shall be presented in spreadsheet format.

4.4 REMEDIAL WORKS

- 4.4.1 Any damage or defect on the road structures due to the engineering works shall be carried out on a timely basis to the satisfaction of the Authority. The supervisor shall submit to the Authority for approval a proposal on making good of all damages or defects in the road structures prepared and endorsed by a professional engineer.
- 4.4.2 Proposal for remedial works to the road structures may include specifications for remedial grouting or structural repair, requirements on the adjustment of road level, alignment of affected drains, replacement of movement joints, bearings, shear pins, etc. during or subsequent to the construction.
- 4.4.3 The supervisor shall inform the authority and ensure that any damage or defect that affects the structural safety and or operational safety of the road structures are immediately rectified.
- 4.4.4 The person for whom the works are carried out shall bear all direct or indirect costs arising from the remedial works.

4.5 COMPLETION OF WORK

Post-condition survey of the road structures shall be carried out upon completion of the engineering works or at intermediate stages as directed by the Authority. Defects found shall be highlighted and compared with findings of the pre-condition survey. Any defect on the road structures due to the engineering works shall be rectified in compliance with clause 4.4 of this section. The supervisor shall submit a copy of the post-condition survey report prepared and endorsed by an independent person who has the appropriate qualifications, for example a professional engineer or building surveyor to the Authority for record.

PART II – ENGINEERING WORKS

SECTION 5 PERFORMANCE REQUIREMENTS

5.1 GENERAL

The design and construction of the engineering works in the road structure safety zone shall meet the performance requirements contained in this section in the following aspects:

- (a) structural safety; and
- (b) operational safety.

5.2 STRUCTURAL SAFETY

5.2.1 OBJECTIVE

The objective is to safeguard the structural integrity of the road structures against damage arising from any engineering works.

5.2.2 PERFORMANCE REQUIREMENTS

The design and construction of any engineering works must make adequate provisions to check and ensure that the road structures are capable of sustaining at an acceptable level of safety and serviceability under:

- (a) the most adverse combination of loads on the road structures;
- (b) the maximum movements derived from the most adverse load combinations of the engineering works; and
- (c) any other action.

5.3 OPERATIONAL SAFETY

5.3.1 OBJECTIVE

The objective is to ensure the safe operating condition for the road structure is not being affected by the engineering works.

5.3.2 PERFORMANCE REQUIREMENTS

The design and construction of any engineering works must make adequate provisions to check and ensure that:

- (a) the road structures are not subjected to movement and deformation that will adversely affect the safe operation of the road, riding quality and the comfort of the road user;

- (b) there is no obstruction to the free flow of vehicular traffic; and
- (c) the durability and serviceability of the road structures including drainage are not adversely affected.

5.4 ASSESSMENT METHODS

The following assessment methods, or any combination of them, shall be used to determine a solution which complies with the performance requirements:

- (a) Documentary evidence

Evidence to support that the form of construction or design meets the performance requirements.

- (b) Verification methods

The verification methods shall include any method deemed relevant or appropriate by a professional engineer. For an alternative solution, such verification shall be carried out by an expert(s). The verification methods shall also include a detailed assessment of the risks or hazards which the road structures will be subjected to, and the effective measures to mitigate these risks.

- (c) Expert judgement

The expert (group or individual) shall make his judgement based on independent factual information and experience. He shall be responsible for all evaluation and necessary information used to arrive at this judgement.

The basis of his judgement shall be clearly stated and must be demonstrated to be applicable and relevant to the local environmental and ground conditions.

PART II – ENGINEERING WORKS

SECTION 6 TECHNICAL AND SAFETY REQUIREMENTS

6.1 GENERAL

- 6.1.1 Engineering works in the road structure safety zone shall meet the technical and safety requirements contained in this section.
- 6.1.2 The Authority reserves the right to impose any additional conditions deemed necessary to safeguard the road structures.

6.2 ALLOWABLE SURCHARGE LOADS

The additional surcharge loads imposed by the engineering works onto the road tunnels shall not exceed the allowable surcharge as given in Table 6.1.

Table 6.1

Road Tunnel	Allowable surcharge loads (applied at ground level)
Central Expressway	15 kN/m ²
Kallang / Paya Lebar Expressway	25 kN/m ²

6.3 VIBRATION LIMIT

The peak particle velocities at any road structures resulting from demolition works, driving or withdrawal of piles or any other construction activities which can induce vibration shall not exceed peak particle velocity of 15 mm/sec.

6.4 SUBSTRUCTURE WORKS

6.4.1 FOOTINGS AND RAFTS

The design and layout of the footing and rafts shall allow for the maintenance of the bridge including bearing replacement.

6.4.2 PILING AND DRILLING WORKS

Piling works including the construction of foundation piles, earth retaining structures and any other drilling works shall satisfy the following requirements:

- 6.4.2.1 All piles and drilling works shall be at least 3m clear on plan of the exterior edge of road structures and at least 3m clear on plan of the toe of the existing raker piles, if any supporting the bridges.
- 6.4.2.2 The professional engineer shall carry out an engineering assessment to demonstrate that the loads imposed by the piles within the zone of influence

of the underground road structures will not exceed the allowable surcharge the underground road structures were designed for.

- 6.4.2.3 In the event that the requirement in Clause 6.4.2.2 cannot be met, load bearing piles within the zone of influence of underground road structures such as road tunnels, underpass and depressed road including earth retaining structures, etc. shall be debonded. The piles shall develop their load capacities from soil located below the zone of influence of the road structures. The zone of influence of the tunnel is derived by drawing a 45 degrees line originating from a point at 3m offset from the outermost edge of the tunnel side wall at tunnel formation level to ground level.
- 6.4.2.4 The method of installing and extracting piles or casings within road structure safety zone of road tunnel and underpass shall not cause vibration induced to exceed the limit specified in Part II, Section 6.3.
- 6.4.2.5 All boreholes, drillings including excavation for installation of foundation piles and earth retaining walls within road structure safety zone shall be fully supported with casings and/or stabilising mud.
- 6.4.2.6 Diaphragm wall excavation located less than 6m but more than 3m horizontally from the extreme edge of road structures shall be constructed in panel length not exceeding 3m.
- 6.4.2.7 Extraction of casings and piles located within 6m from the outermost edge of the road structures are not allowed.

6.4.3 EXCAVATION WORKS

- 6.4.3.1 All earth retaining structures, excavations, ground improvement, tunnelling and pipe jacking works shall be designed and executed such that the ground movements are minimised and there is no risk of damage to the road structures.
- 6.4.3.2 The lowering of ground water table, if any shall not cause any damage to the road structures. The professional engineer's engineering assessment to show that this requirement is complied with shall be submitted.

6.5 DRAINAGE/ LIGHTNING PROTECTION REQUIREMENTS

- 6.5.1 Viaduct drainage system shall be maintained at all times. The runoff from existing viaduct drainage system, if affected, shall be suitably diverted to the approval of the relevant authority particularly PUB Drainage Department.
- 6.5.2 Road structure lightning protection system, if affected, shall be suitably relocated, reinstated and tested. It shall be designed to CP SS33.

6.6 SITE MOBILISATION & UTILISATION WORKS

- 6.6.1 The underground structures and road structure safety zone must be pegged and demarcated clearly on site by a registered land surveyor based on the approved certified survey plan.
- 6.6.2 Storage and placing of combustible material, flammable fluid, generator and petrol/diesel powered equipment shall be at least 6m clear from the outermost edge of the road structures.
- 6.6.3 Equipment access under the road structures must have height restriction gantries erected on both sides of the bridge with at least 1m clearance from the bridge soffit.
- 6.6.4 Load imposed by the site utilisation, machineries and equipment shall not impose additional surcharge load that would exceed the allowable surcharge load stipulated in Part II, Section 6.2

6.7 OPERATION OF CRANE, HOIST AND HEAVY EQUIPMENT

- 6.7.1 The operation of equipment shall not pose risk to the road structures or affect safety of the road operations and road users.
- 6.7.2 The toppling zone of equipment shall be at least 6 metres clear from the outermost edge of the road structures.
- 6.7.3 The total maximum equipment load including material being lifted bearing on the ground and transmitted to the underground structures must not exceed the allowable surcharge load as given in Part II, Section 6.2.
- 6.7.4 The Authority may on a case-by-case basis allow operation of equipment where the equipment collapse radius is less than 6m clear of the outermost edge of the road structures subject to conditions including standing supervision by a professional engineer or the professional engineer's assignee approved by the Authority as stipulated in Part II, Section 4.

PART III – ENGINEERING ACTIVITY

SECTION 1 PROCEDURES AND REQUIREMENTS

1.1 GENERAL

- 1.1.1 A person carrying out any engineering activity on any land adjoining a public street shall at no later than 10 working days prior to commencing such engineering activity, give the Authority notice in writing of the intention to carry out such engineering activity.
- 1.1.2 This section stipulates the requirements of the notification to the Authority to carry out engineering activity.

1.2 NOTIFICATION TO THE AUTHORITY

- 1.2.1 A person carrying out any engineering activity shall notify the Authority in writing of the intention to carry out such engineering activity. The notification shall be accompanied by the following items where applicable:
- (a) Plans for engineering activity;
 - (b) Engineering evaluation report;
 - (c) Instrumentation proposal;
 - (d) Method statement of work;
 - (e) Contingency plans / Emergency procedure;
 - (f) Pre-condition survey report;
 - (g) Soil investigation report; and
 - (h) Particulars of the person who carries out the work and the person for whom the works are being carry out.
- 1.2.2 The requirements for the above items are given in Clause 1.3 to Clause 1.8 of this section for compliance.

1.3 PLANS FOR ENGINEERING ACTIVITY

- 1.3.1 Plans for engineering activity shall be prepared and endorsed by a professional engineer. Where applicable, the plans shall also be endorsed by an accredited checker, a qualified person who is a geotechnical engineer and a specialist accredited checker in accordance with the Building Control Act (Chapter 29, Section 49) and its Regulations.
- 1.3.2 Layout plans and cross sectional details of the engineering activity such design of earth retaining structures shall indicate the horizontal distances of the engineering activity in relation to the road reserve line and road carriageway.

1.4 ENGINEERING EVALUATION REPORT

- 1.4.1 Engineering evaluation report shall be prepared and endorsed by a professional engineer. Where applicable, the report shall also be endorsed by an accredited checker, a qualified person who is a geotechnical engineer and a specialist accredited checker in accordance with the Building Control Act (Chapter 29, Section 49) and its Regulations;
- 1.4.2 The above report shall address the following items:
- (a) Design of the elements required for the engineering activity;
 - (b) Predicted road settlement contour due to the proposed engineering activity at each stage of work until the completion of works. The evaluation shall be based on the most credible or most like condition to be encountered at site and include the following items:
 - (i) Detailed examination and assessment of the ground conditions at site;
 - (ii) Analysis and design calculations for derivations of the predicted movements of the public street; and
 - (iii) Appropriate sensitivity analysis to check that the assessment how the results would be affected by any variation in input parameters and conditions that may occur during all stages of the construction work.
- 1.4.3 The report shall clearly demonstrate that the technical requirements in Part III Section 4 are fully met during construction and after all works have been completed.

1.5 INSTRUMENTATION PROPOSAL

- 1.5.1 Instrumentation proposal shall be prepared and endorsed by a professional engineer and submitted to the Authority for approval.

- 1.5.2 The proposal shall include the following items:
- Comprehensive monitoring system to monitor the response of the existing public street and the ground adjacent to it.
- (a) Layout plans and relevant cross-sections indicating the locations of proposed instruments relative to the public street;
 - (b) Details of the instruments or equipment, including the types, function of instruments, depth of installation, etc.;
 - (c) Frequency of monitoring;
 - (d) Review levels, i.e. work alert and work suspension level for all instruments at the various critical stages of work in accordance with the design estimates; and
 - (e) Valid calibration certificates for the instruments proposed, where applicable.
- 1.5.3 In preparing the above proposal, the requirements stipulated in Part III Section 2 shall be complied with.

1.6 METHOD STATEMENT OF WORK

- 1.6.1 Method statement for carrying out engineering activity shall be prepared and endorsed by a professional engineer.
- 1.6.2 The proposal shall be accompanied by the following items:
- (a) Layout plan and sections showing the vertical and horizontal distances of the boundary line and engineering activity relative to the road reserve line and road carriageway;
 - (b) Write-up and/or plans indicating step-by-step sequence of works.
 - (c) Hazard analysis identifying all possible risks from the engineering activity that may be posed to the public street and a description of the safety and precautionary measures to mitigate the risks.

1.7 CONTINGENCY PLANS/ EMERGENCY PROCEDURE

- 1.7.1 A contingency plan and emergency procedure shall be prepared and endorsed by a professional engineer for emergency situations due to various incidents at site, such as:
- (a) Monitoring results exceeding the alert levels /work suspension levels specified by the professional engineer;

- (b) Excessive settlement and defects of the public street that affect the functionality and safe operation of public street;
- (c) Failure/collapse of temporary earth retaining systems that affect publicstreet, and etc.

1.7.2 The contingency plan / emergency procedure report shall include the following items:

- (a) Descriptions of the project and proposed activities to be carried out on land adjoining a public street;
- (b) List of all possible hazard/ emergency situations that may arise due to the proposed activities;
- (c) Governing criteria for initiating an emergency procedure;
- (d) Contingency plan and emergency procedure (step-by-step or flow chart) showing the immediate actions to be taken by the professional engineer and contractor in the event of an emergency in order to safeguard the public street. Where applicable, the contingency plan and emergency procedure shall include the steps to review the monitoring results obtained, the re-examination of the method of work, the revision to the predictions, the review of instrumentation provisions, the contingency measures to be implemented, plans for road diversion, etc.;
- (e) The follow-up actions to be taken after the implementation of control measures at site;
- (f) Call-up list stating the names and contact numbers of all key personnel including the professional engineer, the geotechnical engineer, the project manager, the site supervisors and the instrumentation specialist, etc. The organisation chart and a flow chart for the emergency reporting shall also be included.

1.8 PRE-CONDITION SURVEY REPORT

1.8.1 A condition survey report shall be prepared and endorsed by an independent person who has the appropriate qualifications, for example, a professional engineer or building surveyor.

1.8.2 The condition survey report shall include the following:

- (a) Photographic record of the public street;
- (b) Topographical survey of the road reduced levels, at 3m grid spacing along each traffic lane. The survey shall be conducted and certified by a registered land surveyor.

1.9 STOPPAGE OF ENGINEERING ACTIVITY CAUSING DAMAGE TO PUBLIC STREET

1.9.1 If the Authority is of the opinion that the carrying out of any activity on any land adjoining a public street has caused or is likely to cause the public street or any part thereof to be in a dangerous or defective condition, the Authority may order the stoppage of the activity or other appropriate actions under the provision of the Street Works Act.

PART III – ENGINEERING ACTIVITY

SECTION 2 INSTRUMENTATION PROPOSAL

2.1 GENERAL

2.1.1 This section stipulates the minimum monitoring requirements for engineering activity on land adjoining public streets.

2.1.2 The Authority reserves the right to impose any additional conditions deemed necessary to safeguard the public street.

2.2 GROUND MONITORING

2.2.1 The ground shall be monitored for changes in ground conditions and movements which may result from the proposed works.

2.2.2 Typical ground instruments such as water standpipes, inclinometers, piezometers, borehole extensometers and deep settlement markers shall be provided where applicable.

2.2.3 The monitoring shall cover the full length of the work and extend 20 metres beyond the zone of influence.

2.2.4 Adequate monitoring instruments shall be provided. The spacing of instruments shall be such that adverse changes in the ground conditions can be captured. The frequency of monitoring must be able to capture any drastic changes in the monitoring readings timely for appropriate follow-up action.

2.3 ACCURACY OF READINGS

2.3.1 Instruments used shall have calibration done once every 6 months. Certificates for calibration shall be submitted to the Authority for record.

2.3.2 The readings shall attain the level of accuracy as specified by the manufacturer. The instruments shall be maintained in good working condition. Damaged instruments shall be immediately replaced to the acceptance of the Authority and readings correlated with the previous.

2.3.3 Control and reference points shall be located outside the zone of influence of the proposed works and such that they do not impact on the accuracy of monitoring results. At least two numbers of control points on opposite ends of site shall be provided. In addition, control points must be located on very stable structures which would not be affected by the adjacent development.

2.4 INITIAL INSTRUMENTATION READINGS

- 2.4.1 Readings must be stabilised before commencement of work.
- 2.4.2 Readings most representative of the initial condition shall be taken as the initial readings.
- 2.4.3 A copy of the initial readings endorsed by the professional engineer and registered land surveyor where applicable shall be submitted to the Authority for the approval to commence work.

PART III – ENGINEERING ACTIVITY

SECTION 3 SUPERVISION OF WORKS

3.1 GENERAL DUTIES

3.1.1 Every person carrying out any engineering activity on any land adjoining a public street and every person for whom such activity are carried out, shall:

- (a) ensure that such activity are carried out:
 - (i) in accordance with this guide and any conditions imposed by the Authority;
 - (ii) in such a manner as not to endanger the safety of any person using the public street ;
 - (iii) in such a manner as not to cause any damage to the public street where such damage has not been approved by the Authority; and
 - (iv) minimize any inconvenience which may be caused to persons using the public street;
- (b) ensure that the structure of the public street, or any road related facility is not damaged or altered as a result of the activity;
- (d) ensure that any utility or apparatus situated on or along, or beneath the surface of the public street (not being the utility or apparatus in respect of which the works are being carried out) is adequately protected from damage when the activity is being carried out;
- (e) submit to the Authority such reports, certificates and other documents relating to the progress of engineering activity as the Authority may require and as may be specified in the guide;
- (f) render such assistance and co-operation to the Authority and its employees or officers as may be necessary to ensure compliance with and to prevent the contravention of the Street Works Act;
- (g) comply with such directions as the Authority may give to ensure compliance with and to prevent the contravention of the Street Works Act; and
- (h) keep and maintain such documents, books and records as may be required by the Authority and as may be specified in the guide.

3.2 MONITORING OF PUBLIC STREETS

3.2.1 The person carrying out the engineering activity shall exercise due diligence and reasonable care in ensuring that the response of the public street and

adjacent ground are closely monitored during the construction stage.

- 3.2.2** Once the monitoring readings are taken, a professional engineer shall analyse the monitoring results and compare with the alert and work suspension levels, predict the likely trends and notify the Authority of any deviation from the predicted results and trends. The professional engineer shall also make proposal to change the method of working or to implement an emergency plan where necessary.
- 3.2.3** A report of the review and the monitoring results endorsed by a professional engineer shall be submitted to the Authority fortnightly or as directed by the Authority. The report shall also include description on progress of works.
- 3.2.4** During the progress of the works, if it becomes apparent from the monitoring results that the ground movement are likely to exceed the limits, the person carrying out the engineering activity shall suspend works and take immediate actions to ensure that additional measures are implemented to control movements to within the acceptable limits and safe road operations. These measures implemented shall be at the cost and expense of the person for whom the works are carried out. The findings, assessment and recommendations in a report duly prepared and endorsed by a professional engineer shall be submitted to the Authority for approval. The work shall only be allowed to resume if it can be demonstrated that the continuation of the activity will not adversely affect the public street.
- 3.2.5** The monitoring shall continue until all activities that may affect the movement of the public street have been completed and the monitoring results show that the public street and the surrounding ground have stabilised and no further movement or change would be anticipated. The person carrying out the activities must notify the Authority in writing with the stabilised monitoring results and status of work at least 10 working days before terminating the monitoring.
- 3.2.6** Upon termination of monitoring works, all monitoring instruments installed shall be removed and made good to the acceptance of the Authority. The person who carried out the activity shall submit to the Authority a soft copy of the final instrumentation readings, verified and endorsed by a professional engineer or licensed land surveyor whichever applicable for record. The final instrumentation readings shall be presented in spreadsheet format.

3.3 REMEDIAL WORKS

- 3.3.1** Any damage or defect on public street due to the engineering activity shall be repaired and made good on a timely basis to the satisfaction of the Authority. A proposal on making good of all damages or defects on public street shall be prepared, endorsed by a professional engineer and submitted by the person carrying out the activity to the Authority for acceptance.
- 3.3.2** The person carrying out the activity shall inform the Authority and rectify immediately any damage or defect that affects the riding quality or safety of the public street.

3.3.3 The person for whom the engineering activity is carried out shall bear all direct or indirect costs arising from the remedial works.

3.4 COMPLETION OF WORK

Post-condition of the public street shall be carried out upon completion of the engineering activity or at intermediate stages as directed by the Authority. Defects found shall be highlighted and compared with findings of the pre-condition survey. Any defect on the public street due to the engineering activity shall be rectified in compliance with clause 3.3. The person who carried out the activity shall submit a copy of the post-condition survey report prepared and endorsed by an independent person who has the appropriate qualifications, for example a professional engineer or building surveyor to the Authority for record.

PART III – ENGINEERING ACTIVITY

SECTION 4 TECHNICAL REQUIREMENTS

4.1 GENERAL

4.1.1 Any engineering activity on land adjoining public streets shall meet the technical requirements contained in this section.

4.1.2 The Authority reserves the right to impose any additional conditions deemed necessary to safeguard the public streets.

4.2 REQUIREMENTS

An engineering assessment endorsed by a professional engineer shall be submitted to show that the following requirements are complied with:

4.2.1 The intervention values for movement of road carriageway must not be exceeded. The intervention value defines the maximum severity of a defect at or before which remedial action must be taken. The intervention values for movement of road carriageway are as follows:

Intervention values for movement of road carriageway	
Settlement	Differential settlement
> ±30mm beneath a 3m straight edge	Slope > 1:100

4.2.2 All earth retaining structures, excavations, ground improvement, tunnelling and pipe jacking works shall be designed and executed such that the ground movements are minimised and there is no risk of damage to the public streets.

4.2.3 All boreholes, drillings including excavation for installation of foundation piles and earth retaining walls shall be fully supported with casings and/or stabilising mud.

4.2.4 The lowering of ground water table, if any shall not cause settlement to the public street that will adversely affect the safe operation and riding quality of the public streets.

4.2.5 Surcharge loads from filling, storing or placing of materials shall not damage the public streets.

PART IV APPENDICES

APPENDIX A

DEFINITION OF ROAD STRUCTURE SAFETY ZONE

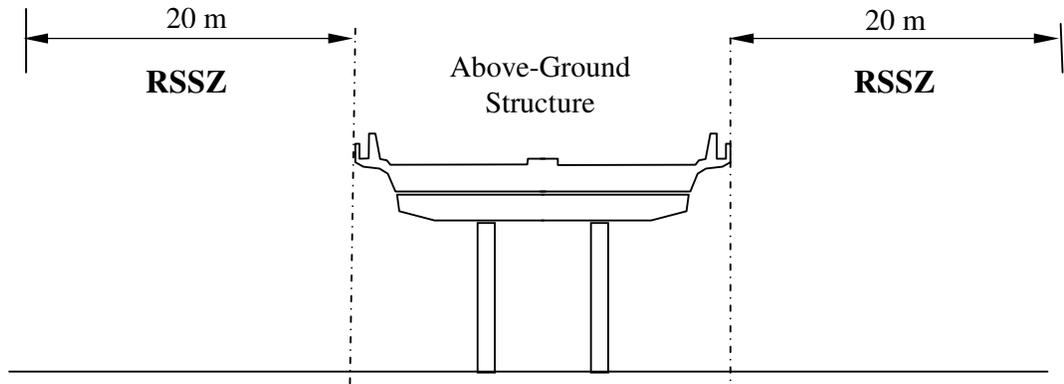


Figure A1 : Definition of Road Structure Safety Zone for Above-Ground Structure

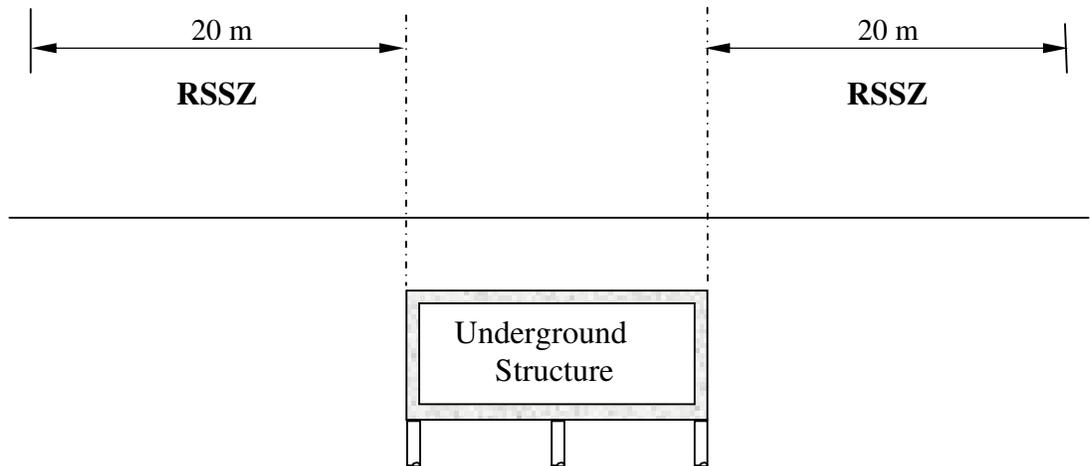


Figure A2 : Definition of Road Structure Safety Zone for Below Ground Structure

APPENDIX B

TYPICAL CROSS-SECTIONS FOR ROAD TUNNEL AND UNDERPASS

