CODE OF PRACTICE FOR RAILWAY PROTECTION

2024 EDITION

Land Transport Authority

We Keep Your World Moving

Infrastructure Protection Division

Development & Building Control Subgroup

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PREFACE

The **Code of Practice for Railway Protection** (referred to as the Code) plays a pivotal role in providing guidance for the continuous and safe operation of train services by safeguarding the Rapid Transit System from the effects of development and building works in its vicinity. Issued under the Rapid Transit Systems (Development and Building Works in Railway Corridor and Railway Protection Zone) Regulations, the Code establishes a robust framework for regulating such development and building works and outlines the processes for obtaining approvals and permits before commencing works.

In line with our commitment to maintaining high safety standards and facilitating efficient processes, the Land Transport Authority embarked on the review of the Code in July 2023. This review, culminating in the December 2024 version, aimed to update, clarify, and align the Code with prevailing standards, industry best practices, and regulatory requirements. The collaborative effort involved contributions from both LTA staff and industry practitioners, ensuring that the Code reflects the latest advancements and addresses pertinent considerations.

We extend our sincere appreciation to all individuals and organizations who provided valuable feedback and support during the review process. Their insights and expertise have been instrumental in enhancing the clarity, relevance, and effectiveness of the Code. As we release this latest version, we welcome continued engagement and feedback from all users. Your suggestions and contributions will be invaluable in shaping future editions of the Code, further strengthening its utility and relevance.

Infrastructure Protection Division
Development & Building Control Subgroup
Land Transport Authority
Singapore

DISCLAIMER

The information and materials contained in this document are provided “as is” and “as available”.

Whilst every effort is made to ensure that the information and materials provided are correct, the Land Transport Authority does not warrant their accuracy, adequacy or completeness and expressly disclaims liability for any errors or omission in such information and materials.

The information contained herein is to be used only as a reference and is not intended to exempt any person from otherwise complying with the Rapid Transit System (Development and Building Works in Railway Protection Zone) Regulations and the Rapid Transit System (Railway Protection, Restricted Activities) (Amendment) Regulations.

The Land Transport Authority shall in no event be liable for any damages, losses or expenses including without limitation direct, indirect, special or consequential damage or economic loss arising from any reliance on the contents of this Code. This exclusion clause shall take effect to the fullest extent permitted by law.

PART I – GENERAL

This part covers the general information related to railway matters which are essential in preparing proposals for Authority's approval.

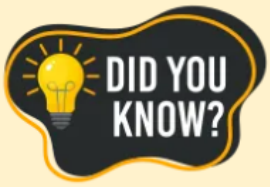
1. USEFUL REFERENCES

1.1 HANDBOOK ON DEVELOPMENT & BUILDING WORKS IN RAILWAY PROTECTION ZONE

The *handbook* is written in an easy-to-read manner, and it contains supplementary materials such as photographs, diagrams, explanatory notes, case examples, etc. to illustrate the interpretation of the technical requirements in this Code.

1.2 GUIDES ON RESTRICTED ACTIVITIES

1.2.1 Under the Rapid Transit Systems (Railway Protection, Restricted Activities) Regulations (the RPRA Regulations), any person intending to carry out restricted activities in the railway protection zone shall obtain prior written permission from the Authority before commencement of works on site.



Restricted Activity

Restricted activities are activities which when carried out in the vicinity of the railway could expose the railway to danger. They could cause injuries and fatalities to passengers or results in damage to the railway thus disrupting passenger service if no proper design and method of construction or safety measures are provided. The types of restricted activities stipulated in the schedule of the RPRA Regulations can be found here.

1.2.2 To offer guidance to any person proposing to carry out restricted activities in the railway protection and safety zones, the Authority has published a document entitled *"Guide to Carrying out Restricted Activities within Railway Protection and Safety Zones"*. The submission requirements for obtaining the Authority's permission to carry out any restricted activities and the suggested safety considerations are given in this publication.

1.3 GUIDEBOOK FOR CARRYING OUT MODIFICATION WORK TO RTS STATIONS OR RAILWAY BY PRIVATE DEVELOPER

1.3.1 The *guidebook* provides additional guidance to private developers, qualified persons, builders and parties who intend to carry out development and building works above and/or adjacent to the rapid transit systems which involve modification to existing rapid transit system structures, facilities and systems, but are not familiar with the regulatory requirements, processes and procedures with some basic information on how to approach, plan, design, construct and implement the requirements.

1.3.2 The submission processes stipulated in this guidebook are applicable to any development works by private developers where the proposed development is integrated with existing rapid transit system. It also contains the submission requirements and technical design requirements to be complied with by private developers and his appointed qualified person and/or builders.

1.4 QUICK GUIDES

Quick Guides are published to facilitate a deeper understanding of specific issues on LTA's requirements for railway protection. This series is meant to complement LTA's existing resource publications and presents bite-sized information in an engaging manner.

1.5 INFRASTRUCUTRE DESIGN CRITERIA (IDC)

The *IDC* defines the criteria and parameters for design and construction of Land Transport Facilities for the Authority. Some chapters and annexes of the IDC are not available for download. The full IDC will only be issued to parties contracted with LTA.

1.6 CIVIL DESIGN CRITERIA (CDC)

The *CDC* contains requirements for the design and detailing of all Civil Engineering Works to meet the following objectives: they shall be safe, robust, economical, durable, with operation and maintenance costs reduced to a practicable minimum, and shall be fit for purpose.

1.7 ARCHITECTURAL MATERIALS & WORKMANSHIP SPECIFICATIONS AND MATERIALS & WORKMANSHIP SPECIFICATIONS FOR CIVIL & STRUCTURAL WORKS

The *Materials & Workmanship Specifications* define the basic standards for the quality of materials and workmanship required by the Authority for architectural, civil and structural works.

2. DEFINITIONS

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

"**above ground structure**" shall include viaduct, bridge, abutment and any rapid transit systems station which adjoins the railway viaduct;

"**alternative solution**" means a solution which complies with the performance requirements other than by reason of complying with the deemed-to-satisfy provisions;

"**amendment plan**" has the same meaning as in the Rapid Transit Systems (Development and Building Works in Railway Corridor and Railway Protection Zone) Regulations;

"**assessment method**" means a method used for determining or establishing that a development solution complies with the performance requirements;

"**at grade structure**" shall include any rapid transit systems station where the platform level is at ground level, on embankment or in cutting and any section of the railway with tracks at ground level, on embankment or in cutting;

"**Authority**" means the Land Transport Authority of Singapore established under the Land Transport Authority of Singapore Act 1995;

"**building works**" has the same meaning as in the Building Control Act 1989;

"**deemed-to-satisfy provisions**" means the provisions contained in *Part III Section 3* of this Code which are deemed to comply with the performance requirements;

"**solution**" means a solution which complies with the performance requirements and is:

(a) an alternative solution; or

(b) a solution which complies with the deemed-to-satisfy provisions; or

(c) a combination of (a) and (b)

"**development**" has the same meaning as in the Planning Act 1998.

"**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;

"**registered surveyor**" means a person registered under the Land Surveyors Act 1991 and has a valid practising certificate issued by Land Surveyors Board;

"**objectives**" mean a statement contained in this Code that forms the aim of the Authority in safeguarding the railway;

"**performance requirement**" means a requirement which states the level of performance which a development solution must meet;

"**professional engineer**" means a person registered under the Professional Engineers Act;

"**plan**", in relation to any development or building works, means a document containing any drawing, details, diagram, calculation, structural details or structural calculation showing or relating to the development or building works;

"**qualified person**" means a person as defined in the Building Control Act 1989;

"**railway area**" has the same meaning as in the Rapid Transit Systems Act 1995;

"**railway corridor**" means the part of the land or area that is within 40 metres from the outermost edge of any part of a railway area;

"**railway protection zone**" means that part of the land or area which is within 40 metres from the outermost edge of any part of the railway that is on, above or below the ground;

DEFINITIONS

"**railway safety zone**" means the land delineated as such in plans and maps prepared by the Authority pursuant to Regulation 4 of the Rapid Transit Systems (Railway Protection, Restricted Activities) Regulations;

"**rapid transit systems**" has the same meaning as in the Rapid Transit Systems Act 1995;

"**restricted activities**" has the same meaning as in the Rapid Transit Systems (Railway Protection, Restricted Activities) Regulations;

"**sub-aqueous structure**" shall include any rapid transit systems structure beneath river or sea;

"**the Regulations**" means the Rapid Transit Systems (Development and Building Works in Railway Corridor and Railway Protection Zone) Regulations as amended from time to time;

"**transition structure**" shall include any rapid transit systems structure that occurs between underground structure and above ground or at grade structure;

"**underground structure**" shall include inter-alia any rapid transit systems underground station, bored tunnel, cut and cover tunnel, interchange shaft, pedestrian passage, cross passageway between tunnels and emergency escape shafts;

"**verification method**" means a test, inspection, calculation or other method that determines whether a development solution complies with the relevant performance.

3. CONSULTATION

3.1 The appointed qualified person may consult the Authority on any requirements relating to railway protection before making any formal application for approval.

3.2 Any preliminary consultation with the Authority or submission of plans shall not be taken as approval or disapproval of the proposed development or to be construed as having the agreement of the Authority.

3.3 Registered Architects or Professional Engineers is required to fill up the Consultation Request Form and email to the DBC Officer-In-Charge (OIC) assigned to the project with supporting documents. The assigned OIC's name and email address can be obtained from the DBC Officer Search page available on the Authority's website.

4. RAPID TRANSIT SYSTEMS AS-BUILT DRAWINGS

The appointed qualified person may submit the application to the DBC officer for the viewing of rapid transit systems as-built drawings at the Authority's Office. The application shall be accompanied by the following items:

(a) Qualified person's appointment letter from the owner/developer;

(b) Qualified person's e-CORENET registration record as a member of the project; and

(c) Plan showing location of the proposed works with brief description.

5. RAILWAY PROTECTION PLAN

5.1 The railway protection plan shows graphically whether "selected" approved cadastral lots fall within or within the vicinity of the Railway Safety Zone and Railway Protection Zone and Railway Corridor. Plans delineating the Railway Corridor and Railway Protection and Safety Zones are available for viewing by the public free of charge at the following address:

Development & Building Control Department
Land Transport Authority
251, North Bridge Road
Singapore 179102

Please note that the viewing is by appointment only. Alternatively, the public can view and purchase the railway protection plan via *INLIS*.

5.2 The information on the plans is indicative only. Details and exact location of the rapid transit system structures must be verified on site.

5.3 The information on the plans is provided "as is" and "as available". Whilst every effort is made to ensure that the information is correct, the Authority does not warrant their adequacy and completeness and expressly disclaims liability for any error or omission.

5.4 The plans may be modified, deleted or replaced from time to time and at any time in the absolute discretion of the Authority.

5.5 The Authority shall in no event be liable for any damages, losses or expenses including without limitation direct, indirect, special or consequential damage or economic loss arising from any reliance on the information on the drawings.

5.6 Sample of a railway protection plan showing the "selected" approved cadastral lots fall within or within the vicinity of the Railway Safety Zone and Railway Protection Zone can be found in *Figure 1*. Sample of a railway protection plan showing the "selected" approved cadastral lots fall within or within the vicinity of the Railway Safety Zone and Railway Corridor can be found in *Figure 2*.

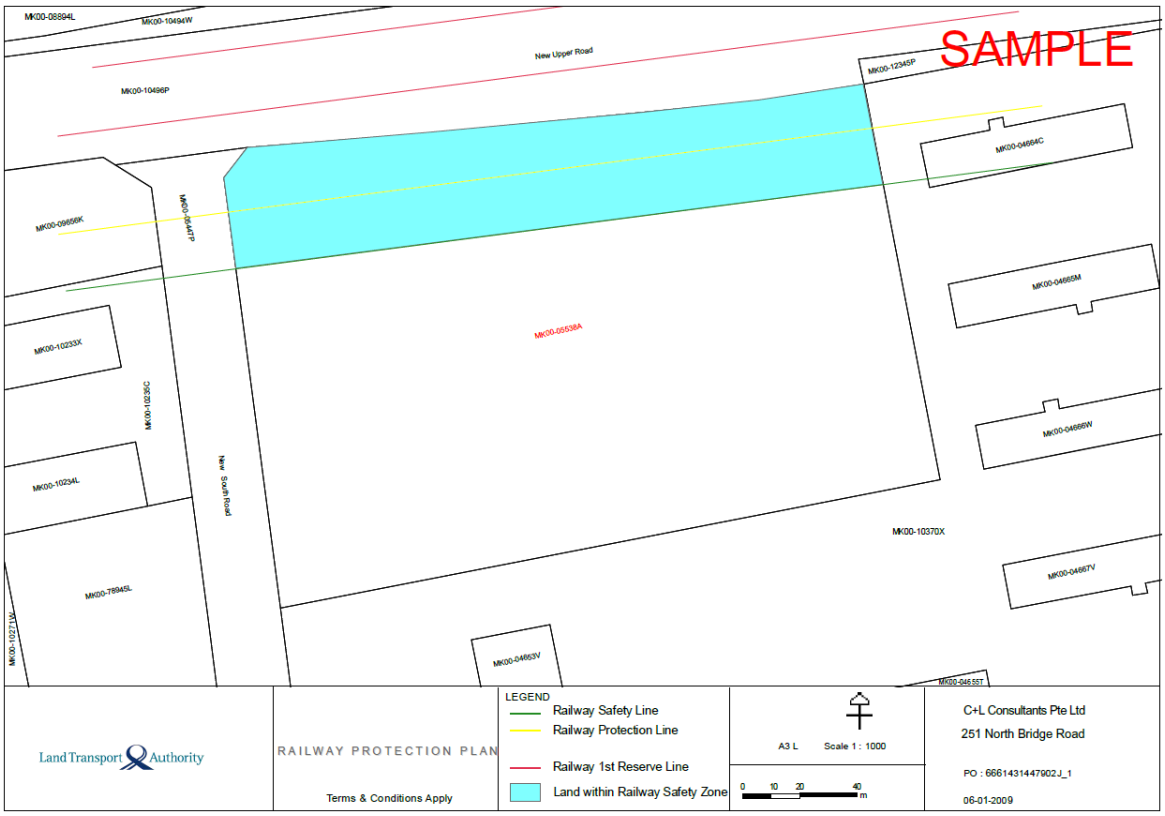


Figure 1 - Sample of a railway protection plan

Explanatory note

1. The "selected" lot's text is reflected in red.
2. Portions of land falling within the railway protection and safety zone is shaded in light blue.

Figure 2 - Sample of a railway protection plan showing the railway corridor

Explanatory note

1. The "selected" lot's text is reflected in red.
2. Portions of land falling within the railway corridor and safety zone is shaded in light blue.
3. Land not included in the plan is shaded in grey.

6. RAILWAY RESERVE LINES

The railway reserve lines are defined and illustrated in Figure 3 – 6.

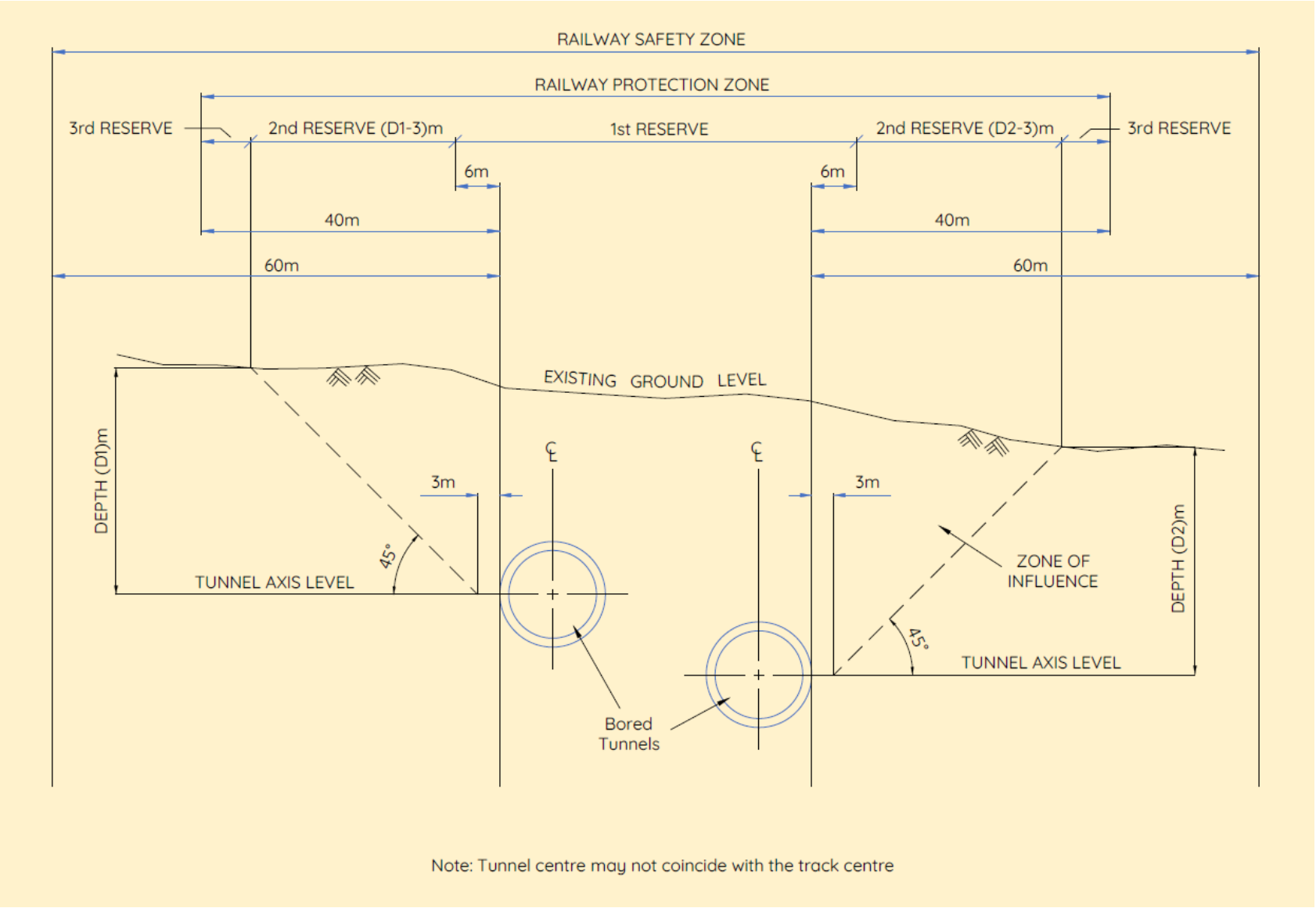


Figure 3 - Definition of reserve lines and zone of influence for bored tunnels

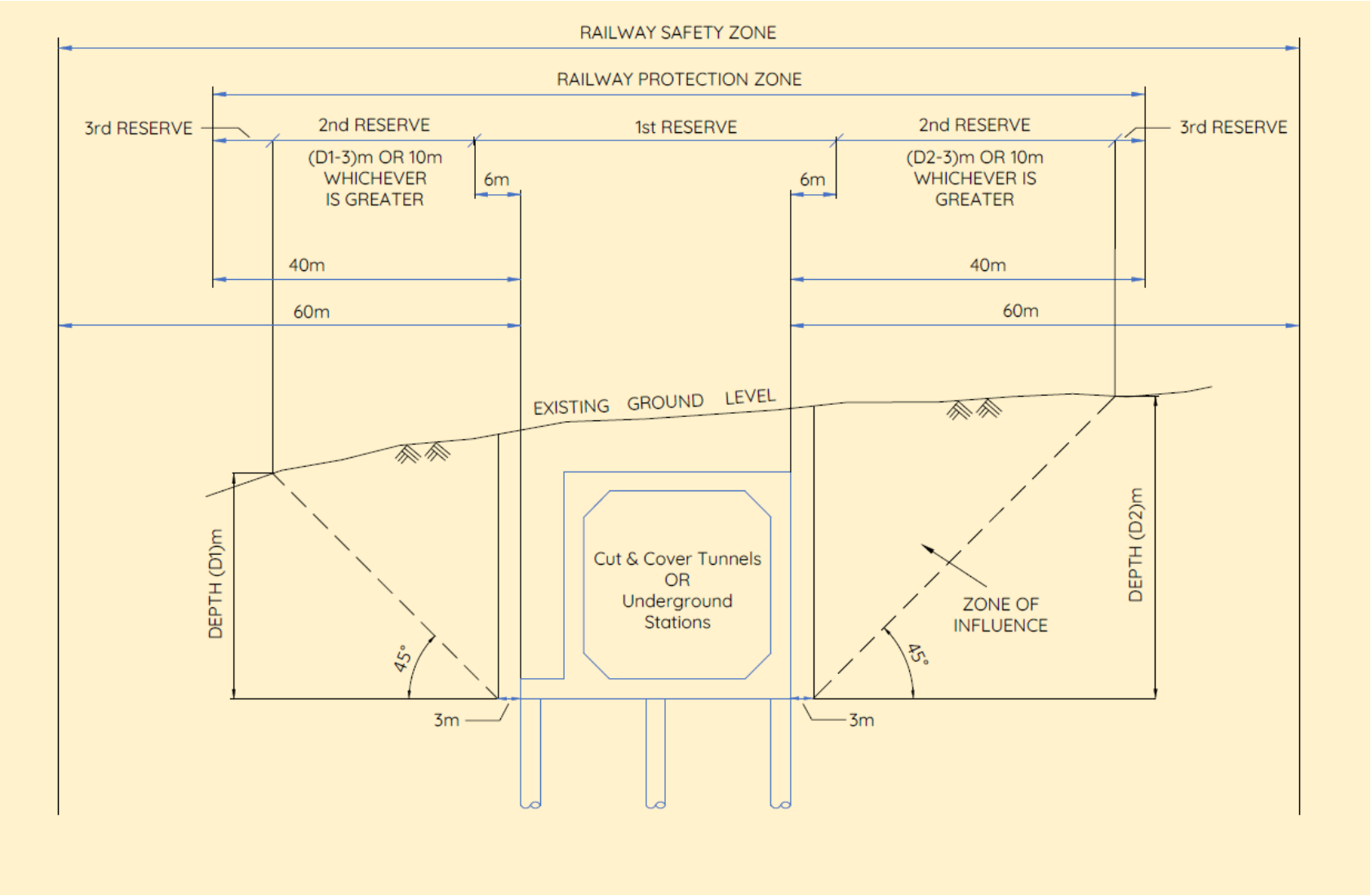


Figure 4 - Definition of reserve lines and zone of influence for underground and transition structures

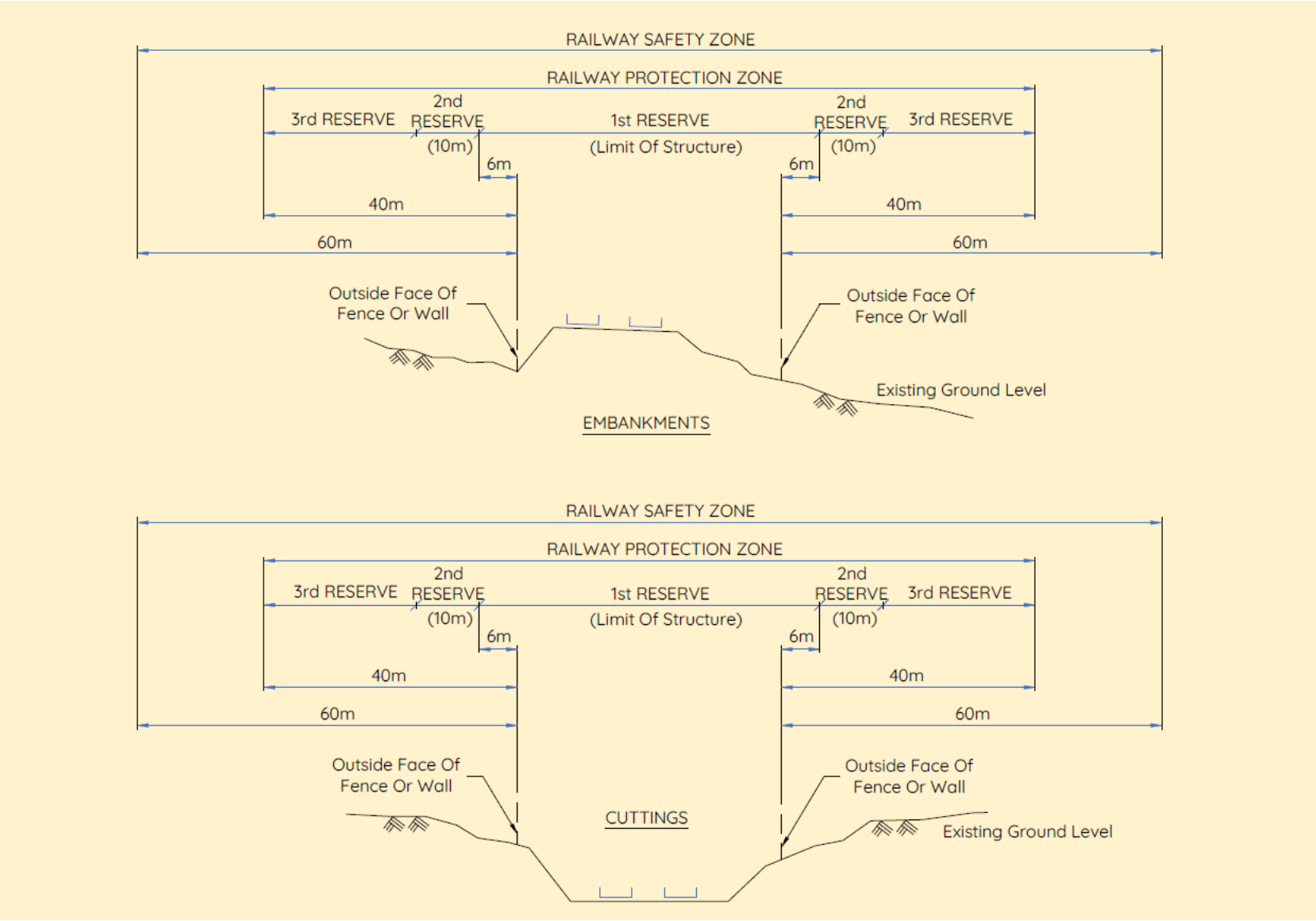


Figure 5 - Definition of reserve lines for at grade structures

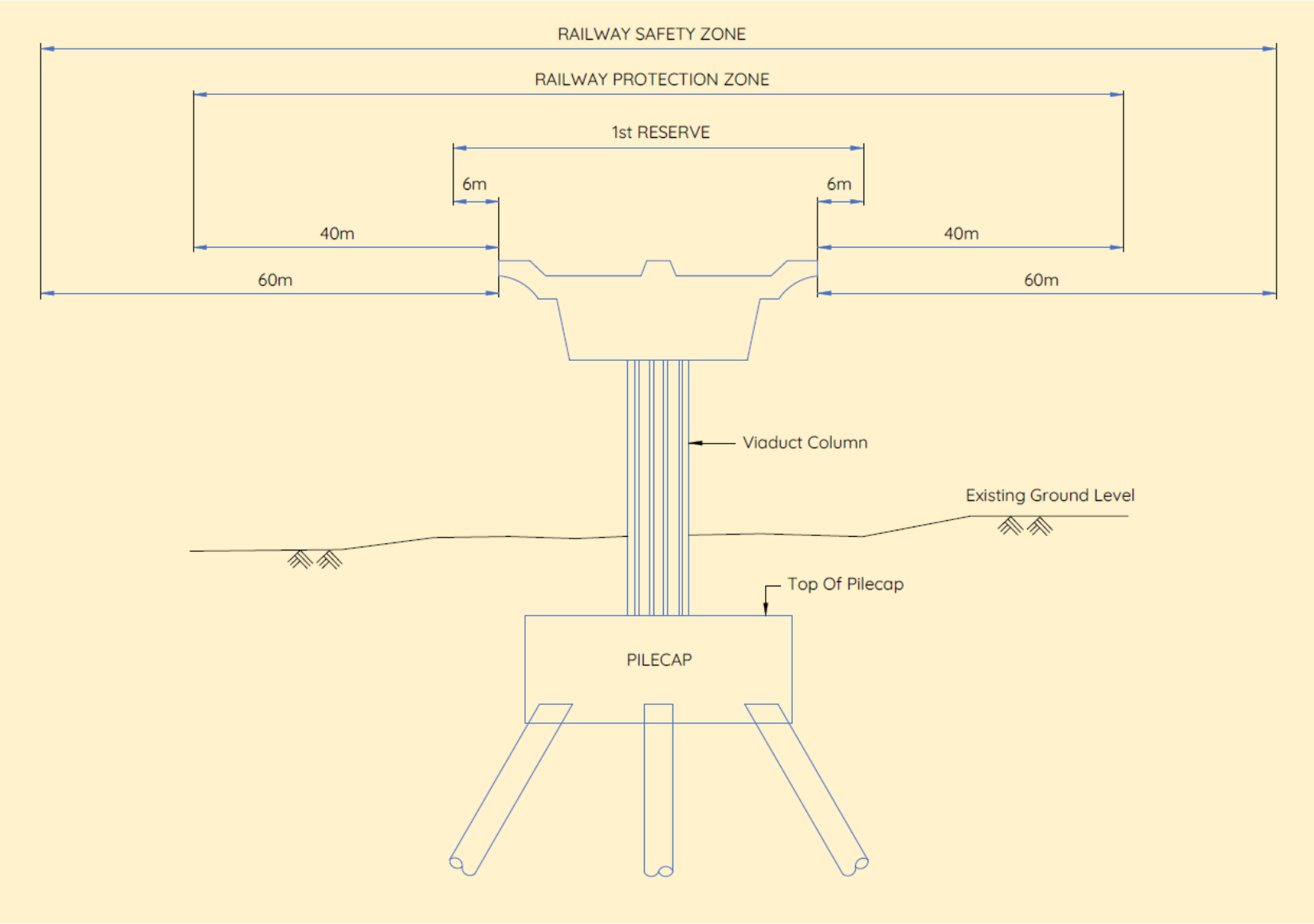


Figure 6 - Definition of reserve lines for above ground structures

PART II - SUBMISSION REQUIREMENTS

This part covers the submission procedures and requirements for obtaining the approval for development and building proposals, the permit to commence engineering works and the clearance for the release of certificate of statutory completion for works in the railway corridor and the railway protection zone.

The general submission process for any development work in the railway protection zone and railway corridor is as shown in Appendix A.

All submissions pertaining to railway matters shall be submitted via e-CORENET platform, unless otherwise advised by the Authority.

1. DEVELOPMENT PROPOSAL

This section stipulates the procedures and requirements for obtaining approval for a development proposal in the railway protection zone and railway corridor.

1.1 APPLICATION FOR APPROVAL OF DEVELOPMENT PROPOSAL

1.1.1 Application for approval of development proposal in the railway protection zone and railway corridor shall be submitted to the Authority for approval in accordance with *Regulation 4*.

1.1.2 An application for the approval of development proposal shall be accompanied by the following items:

(a) Plan for development works;

(b) Preliminary Engineering Assessment;

(c) Certified survey plans (applicable for critical development involving tunnelling, piled foundation, basement construction, etc. within the first reserve of underground rapid transit system structures); and

(d) Relevant documents indicating planning approval from the competent Authority.

Lodgment Scheme

Instant grant of Notice of Approval (NOA) for Development/Building Proposal relies on QP's self-declaration for compliance. NOA will be revoked if false declaration is found at engineering work stage. QP will be required to make a fresh application for development/Building Proposal and application for permit to carry out engineering works will be rejected. Please click here for the list of development type application for lodgment scheme.

1.2 INFORMATION TO BE INDICATED ON PLAN

1.2.1 The qualified person shall sign on every sheet of the plans. This requirement shall also apply to plans submitted electronically.

1.2.2 Site and layout plans shall show the following items:

(a) Scale of plans;

(b) Location and clearances of the proposed development works in relation to the rapid transit system structures (or railway area if applicable);

(c) First, second and third reserve lines of the rapid transit system structures (where applicable); and

(d) Basement outline (if any).

1.2.3 Sections and elevations shall show the following items:

(a) Scale of the plans;

(b) Platform levels of the proposed development works;

(c) Minimum horizontal and vertical clearances between proposed development works and the nearest rapid transit system structures (or railway area if applicable); and

(d) First, second and third reserve lines of the rapid transit system structures (where applicable).

1.3 PRELIMINARY ENGINEERING ASSESSMENT

1.3.1 A Professional Engineer (Civil) should be engaged at this stage to carry out a preliminary engineering assessment of the effects of the development proposal on the rapid transit systems. The appointed Professional Engineer (Civil) is encouraged to initiate a consultation meeting with the Authority (please refer to Part 1, section 3 on consulting LTA) to discuss his proposal before submitting a formal application.

1.3.2 In the event when the rapid transit system structure is yet to be constructed within the railway corridor, the evaluation report shall include an assessment of the likely effects of the construction and operation of the proposed rapid transit systems on the proposed development. The report must clearly demonstrate that the design of the proposal has taken into consideration the effects due to the construction and operation of the proposed rapid transit systems.

1.3.3 A copy of the engineering evaluation report, accompanied by plans for engineering works, endorsed by the appointed Professional Engineer (Civil) shall be submitted together with the application for the approval of development proposal.

1.4 CERTIFIED GEOMETRIC SURVEY PLANS

1.4.1 Certified survey plans are applicable for critical developments involving tunnelling, piled foundation, basement construction, etc. within the first reserve of underground rapid transit system structures.

1.4.2 Certified survey plans shall be prepared and endorsed by a registered surveyor after conducting a physical geometric survey of the relevant sections of the rapid transit system structures. The procedure for applying access to track and station premises is stipulated under *Appendix B*.

1.4.3 Certified survey plans related to rapid transit system reserve lines, tunnel geometry and piling/drilling works within first reserve shall be prepared and submitted using Form *LTA DBC RAIL-S4A*.

1.4.4 Certified survey plans related to structure gauge clearance of equipment installed in rapid transit system tunnel and noise barrier installation at elevated viaduct shall be prepared and submitted using Form *LTA DBC RAIL-S4B.*

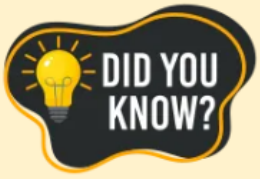
1.4.5 Survey practices pertaining to preparation of certified survey plans are stipulated under *Appendix C*.

1.5 APPROVAL OF DEVELOPMENT PROPOSAL

The Authority will approve the development proposal in writing if the following requirements are complied with:

(a) Qualified Person has complied with the requirements of Clause 1.1 to Clause 1.4 of this section and that all items submitted are found to be in order; and

(b) Qualified person has demonstrated and confirmed that it is feasible for the development proposal to fully meet the technical requirements stipulated in PART III of this Code.



Mapping of CORENET X Submission Gateway

CORENET X submission gateway has been mapped to the current submission processes. There is no major change to the submission processes or requirement. Details of the mapping can be found in Appendix D.

2. BUILDING PROPOSAL

This section stipulates the procedures and requirements for obtaining approval for a building proposal in the railway protection zone and railway corridor.

2.1 APPLICATION FOR APPROVAL OF BUILDING PROPOSAL

2.1.1 Application for approval of building proposal in the railway protection zone and railway corridor shall be submitted to the Authority for approval in accordance with *Regulation 5*.

2.1.2 An application for the approval of building proposal shall be accompanied by the following items:

(a) Plan for building works;

(b) Engineering evaluation report accompanied by plan for engineering works; and

(c) Construction schedule for the proposed development within Railway Corridor (if applicable).

2.2 INFORMATION TO BE INDICATED ON PLAN

2.2.1 The qualified person shall sign on every sheet of the plans. This requirement shall also apply to plans submitted electronically.

2.2.2 Site and layout plans shall show the following items:

(a) Scale of plans;

(b) Building and boundary lines of building;

(c) Location and clearances of the proposed building works in relation to the rapid transit system structures (or railway area if applicable);

(d) First, second and third reserve lines of the rapid transit system structures (where applicable), the reserve lines shall be based on the approved certified survey plan (if any);

(e) Existing ground level and proposed platform levels;

(f) Basement outline (if any);

(g) Discharge outlet from pump sump in basement (if any); and

(h) Main roads and special landmarks.

2.2.3 Sections and elevations shall show the following items:

(a) Scale of the plans;

(b) Building and boundary lines of building;

(c) Horizontal and vertical clearances between rapid transit system structures (or railway area if applicable) and the proposed development;

(d) First, second and third reserve lines of rapid transit system structures (where applicable);

(e) Depth of basement (if any);

(f) Details of proposed drainage system including discharge outlet (if any);

(g) Proposed platform level if the development is connected or integrated with the rapid transit systems; and

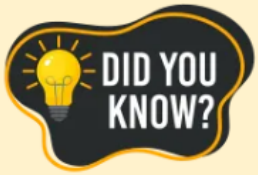
(h) Affected drain lines and lightning protection system of the rapid transit systems.

2.3 APPROVAL OF BUILDING PROPOSAL

The Authority will approve the building proposal in writing if the following requirements are complied with:

(a) Qualified person has complied with the requirements of Clause 2.1 to Clause 2.2 of this section and that all items submitted are found to be in order; and

(b) Qualified person has demonstrated and confirmed that it is feasible for the building works to fully meet the technical requirements stipulated in PART III of this Code.



Obligation relating to development and building works

A persion shall be guilty of an offence under the Regulations if the person carries out, or permits, or otherwise authorises the carrying out of a development without **supervision by appointed qualified person, an approved proposal and a valid engineering work permit.**

3. DEPARTURE OR DEVIATION FROM APPROVED PROPOSAL

3.1 In accordance with *Regulation 6*, the qualified person shall apply to the Authority for approval to amend the approved proposal for any departure or deviation from approved proposal.

3.2 An application for approval of amendment proposal shall be accompanied by one set of the following documents prepared, signed and submitted by the qualified person:

(a) A copy of the amendment plans showing the amended proposal; and

(b) Engineering evaluation report accompanied by plans for engineering works (if applicable).

3.3 No person shall carry out any building works in departure or deviation from the approved plan unless the amendment plan has been approved.

4. ENGINEERING WORKS

This section stipulates the procedures and requirements for obtaining a permit to commence engineering works in the railway protection zone and railway corridor.

4.1 GENERAL

4.1.1 Engineering works means any kind of construction work or activity relating to any development or building works that may affect the structural integrity of any structure associated with a rapid transit system or its safe and efficient operation and functioning, such as but not limited to —

(a) building works;

(b) any act of excavating earth, rock or other material (by whatever means) in connection with —

(i) any work for or relating to the construction, reconstruction, extension, renovation, alteration, demolition or repair of any building, structure, road, railway, bridge, viaduct, flyover, drain or sewer;

(ii) any work for or relating to the laying, inspecting, repairing or renewing of any main, pipe, cable, fittings or other apparatus; or

(iii) any soil investigation works;

(c) any act of boring, dredging, jacking, levelling, piling or tunnelling on or under any land or street by any mechanical means;

(d) the driving or sinking of any earth rod, casing or tube into the ground;

(e) the carrying out of earthworks and backfilling, or the shifting or pushing of earth or soil from one area to another, whether or not for the formation of a slope or an embankment; and

(f) any storage or placement of large construction equipment, construction materials and stockpiling of earth or heavy objects;

4.1.2 In accordance with *Regulation 10*, an application for a permit to commence any works for which the plans have been approved under Regulation 4, 5 or 6 shall be made.

4.1.3 No engineering work shall commence on site without the permission of the Authority in writing.

4.2 APPLICATION FOR PERMIT

4.2.1 An application for permit to commence a specific phase of engineering works shall be submitted by the qualified person appointed under *Regulation 11* for supervision and accompanied by the following items:

(a) Plan for engineering works;

(b) Engineering evaluation report;

(c) Instrumentation proposal;

(d) Method statement of work;

(e) Contingency plan / Emergency procedure;

(f) Pre-condition survey report;

(g) Certified survey plan (if not submitted at Development Proposal stage, or if there is any piling/drilling work within the first reserve);

(h) Endorsed Form *LTA DBC RAIL-PERMIT*[1];

(i) Construction schedule for the proposed development if the development falls within the railway corridor.

4.2.2 The requirements for the above items are given in Clause 4.3 to Clause 4.9 of this section for compliance.

1 Form LTA DBC RAIL-PERMIT is to be submitted for each of the engineering works and it is required to be resubmitted if there is any change in the developer/owner, qualified person appointed for supervision or builder).

4.3 PLAN FOR ENGINEERING WORKS

4.3.1 Plans for engineering works shall be prepared in accordance with the requirements of the Regulations and endorsed by a qualified person.

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

(a) Scale of the plans;

(b) Building and boundary lines of building;

(c) Vertical and horizontal distances of the engineering works (site preparation, substructures and building construction works, etc.) in relation to the existing rapid transit system structures (or railway area if applicable); and

(d) First, second and third reserve lines of the rapid transit system structures and the line of influence (where applicable), reserve lines shall be based on the approved certified survey plans.

4.4 ENGINEERING EVALUATION REPORT

4.4.1 Engineering evaluation report shall be prepared and endorsed by a qualified person.

4.4.2 The report shall address the following items:

4.4.2.1 Predicted movements of the existing rapid transit system structures due to the proposed engineering works at various stages of construction and at completion of the development works. The evaluation shall include the following items:

(a) Layout plan with topographic information;

(b) Detailed examination of the ground conditions at site (i.e. latest soil investigation report);

(c) Calculations for the derivations of the predicted movements; and

(d) 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.

4.4.2.2 Assessment of the likely effects of movement on the existing rapid transit systems. The effects on structural integrity, track beds, structural gauge clearances, drainage of the existing rapid transit systems, etc. shall be considered.

4.4.2.3 Proposal for any special measures or advance works needed to minimise the susceptibility of the existing rapid transit systems to damage and to ensure the continuation of safe train-operating conditions.

4.4.2.4 Proposal for rectification works to the existing rapid transit system structures. These may include specifications for remedial grouting or structural repair, requirements to adjust the track during or after construction, the need to realign the affected drains, etc.

4.4.2.5 Proposal for any strengthening work to the existing rapid system structures.

4.4.2.6 The report shall clearly demonstrate that the performance provisions in *Part III Section 2* are fully met after all works have been completed.

4.4.3 Notwithstanding the above, the Authority reserves the right to specify any other requirements on the engineering evaluation report which are deemed necessary for the safeguarding of the rapid transit systems.

4.5 INSTRUMENTATION PROPOSAL

4.5.1 Instrumentation proposal shall be prepared and endorsed by a qualified person and submitted to the Authority for approval.

4.5.2 The proposal shall include the following items:

(a) Comprehensive monitoring system to monitor the behaviour of the existing rapid transit systems and the ground adjacent to it;

(b) Layout plans and relevant cross-sections indicating the locations of proposed instruments relative to the rapid transit system structures;

(c) Details of the instruments or equipment, including the types, function of instruments, depth of installation, etc.;

(d) Frequency of monitoring;

(e) Review levels (Alert Level and Work Suspension Level) based on the predicted movements from the engineering evaluation report at various stages of construction;

(f) Valid calibration certificates for the instruments proposed (where applicable); and

(g) Schedule for instrument installation works within the premises of rapid transit system structures indicating the number and frequency of access required.

4.5.3 In preparing the above proposal, the qualified person shall comply with the requirements stipulated in *PART II Section 6* of this Code.

4.5.4 For any installation of instruments in the trainway, the requirements in *PART II Section 7* shall also be complied with.

4.5.5 A copy of the initial readings endorsed by the qualified person shall be submitted to the Authority prior to the commencement of the proposed engineering work. The initial reading must be determined based on readings taken over a period of time, and shall be accurate, reliable,

precise, repeatable and stable that can confidently be taken as datum or reference to which subsequent readings will be compared with.

4.6 METHOD STATEMENT OF WORK

4.6.1 Method statement for carrying out any engineering works shall be prepared and endorsed by a qualified person.

4.6.2 The proposal shall be accompanied by the following items:

(a) Layout plan showing the location of the engineering works relative to the rapid transit system structures;

(b) Write-up and/or plans indicating step-by-step sequence of carrying out each phase of works or activities;

(c) Type of machinery used, design calculation to check the stability of the working platform, ground bearing capacity and toppling analysis showing the arc of collapse with respect to the elevated rapid transit system structures, if any; and

(d) Hazard analysis identifying all possible risks that may be posed to the rapid transit system and a description of the safety and precautionary measures to mitigate these risks.

4.7 CONTIGENCY PLAN/EMERGENCY PROCEDURE

4.7.1 GENERAL

4.7.1.1 This section serves as a guide to the preparation of a contingency plan and emergency procedure. It aims to ensure that a set of the contingency plan and emergency procedure is in place for immediate implementation should the needs arise at site.

4.7.1.2 A contingency plan and emergency procedure prepared using the guidelines given below shall be endorsed and submitted by a qualified person.

4.7.2 IDENTIFICATION OF EMERGENCY SITUATIONS

4.7.2.1 An emergency situation may arise due to various incidents at site. Such as:

(a) Monitoring results exceed the alert level and/or work suspension level specified by the qualified person;

(b) Incidents such as construction material falls onto the viaduct, crane topples onto the viaduct, drilling into the tunnels, etc.; and

(c) Water ingress into the station premises, etc.

4.7.2.2 The qualified person shall prepare an emergency plan stating the immediate actions to be taken in the event of an emergency to safeguard the integrity of the rapid transit systems. In addition, the follow-up actions to be taken after the implementation of control measures at site should also be provided.

4.7.2.3 The qualified person shall also identify all possible hazardous situations that may arise due to the proposed works and prepare a contingency plan.

4.7.3 EMERGENCY/INCIDENT PROCEDURE REPORT

4.7.3.1 An emergency/incident procedure report shall include the following items:

(a) Descriptions of the project and proposed works or activities to be carried out in the railway protection zone;

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

(c) Governing criteria for initiating an emergency procedure;

(d) Step-by-step procedure or flow chart showing the actions to be taken by the qualified person and the project team should an emergency/incident happens. Where applicable, the procedure shall incorporate 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, etc.; and

(e) Call-up list stating the names and contact numbers of all key personnel including the qualified person, the project manager, the site supervisors, the instrumentation specialist and LTA officer. A flow chart for the emergency/incident reporting shall also be included.

4.7.3.2 For critical developments (e.g. development falls within the first reserve), the call-up list shall include Operation Control Centre (OCC) and Land Transport Operation Centre (LTOC). In the event in which an incident takes place, the initial verbal report must reach LTOC within 10 minutes, from the time the incident was being made known, by telephone call to LTOC Duty Shift Manager Hotline at 6396 2222 or 6396 2882 should there be any incident pertaining to the safe operation of rapid transit system, safety of passengers traveling on the trains or structural integrity of rapid transit system. After the initial verbal report, there shall be progress updates made to LTOC every 30 minutes by telephone call or when there is any significant development, until the situation is back to normalcy or resolution of the incident. The incident report must be submitted within 24 hours of the incident occurrence to LTOC via email: *ltoc@lta.gov.sg*. Please refer to *Appendix F* for the report template to be submitted to LTOC.

4.8 PRE-CONDITION SURVEY REPORT

4.8.1 A condition survey report (including photographic record of the rapid transit system structures) shall be prepared and endorsed by an independent person who has the appropriate qualifications, for example, professional engineer or building surveyor.

4.8.2 Condition surveys to be undertaken shall include physical surveys of rapid transit system structures to be carried out by a registered land surveyor. The procedure to apply for access to the rapid transit systems tracks and station premises is given in *Appendix B*.

4.9 CERTIFIED SURVEY PLAN

4.9.1 The submission of certified survey plan shall meet the requirements stated in *PART II Clause 1.4*.

4.9.2 Survey plans[2] endorsed by registered surveyor shall be submitted for any drilling works within railway protection zone of underground rapid transit system structures.

4.10 COMMENCEMENT OF WORK

4.10.1 The Authority will issue the permission in writing to commence works upon approving the relevant engineering work plans if the following requirements are complied with:

(a) Qualified person has complied with the requirements of Clause 4.2 to Clause 4.9 of this section and that all items submitted are found to be in order.; and

(b) Qualified person has fully demonstrated that the proposal satisfies the technical requirements in PART III of the Code.

4.10.2 Written clearance from the Development & Building Control Department of the Authority shall be obtained before the commencement of construction works including soil investigation and foundation works on site.

2 Survey plans shall be based on the information approved in certified survey plan (if any) such as the railway reserve lines.

5. CERTIFICATE OF STATUTORY COMPLETION

5.1 The qualified person shall make an application to the Authority to issue clearance for the release of the certificate of statutory completion.

5.2 An application for clearance of certificate of statutory completion shall be accompanied by the following items:

(a) As-built foundation, structural and building plans/ details endorsed by the relevant qualified person;

(b) As-built mechanical and electrical plans/ details endorsed by a qualified person (applicable for development with integration/ interface with the rapid transit systems);

(c) Final condition survey report; and

(d) *FORM LTA DBC RAIL-INSTR* for removal of instruments, if any.

5.3 The Authority will issue clearance for the release of the certificate of statutory completion in writing if the following requirements are complied with:

(a) Qualified person has complied with Clause 5.2 of this section and that all items submitted are found to be in order; and

(b) The development and building works are completed in accordance with the approved plans and any damage to the rapid transit systems or defects of new rapid transit system structures are rectified to the satisfaction of the Authority.

6. INSTRUMENTATION PROPOSAL

This section stipulates the minimum monitoring requirements for development and building works in railway protection zone and railway corridor.

6.1 GENERAL

6.1.1 The type of instrument and spacing should be appropriate to capture the critical situation. It is also important to establish monitoring criteria as a basis for monitoring and frequency of monitoring that tie-in with the proposed engineering works.

6.1.2 The Authority reserves the right to impose any additional requirements deemed necessary to safeguard the rapid transit systems.

6.2 GROUND MONITORING

6.2.1 The ground surrounding the rapid transit system structures needs to be monitored as its compressibility has impact on the stability of rapid transit system structures and its deformation and hence could affect the safe operation of railway. The ground shall be monitored for changes in ground conditions and movements which may result from the proposed works.

6.2.2 Typical ground instruments such as water standpipes, inclinometers, piezometers, borehole extensometers and settlement markers shall be provided where applicable. The type of ground instrument to be provided shall be appropriate for the ground conditions.

6.2.4 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 tie in with the criticality of the stage of works. Typical instrumentation and frequency for

construction activities within the railway protection zone is illustrated in *Table 1*.

Type of Instruments			Underground, Transition, Sub-aqueous & At Grade Structures	Above ground Structures
Ground	Inclinometer		Daily	Twice weekly
	Water standpipe		Daily	Twice weekly
	Piezometer		Daily	Thrice weekly for critical cases only
	Extensometer		Daily	Thrice weekly for critical cases only
	Surface settlement marker		Daily	Thrice weekly for critical cases only
Rapid Transit System Structure	ATMS		Continuous	Continuous for critical cases only
	Manual Survey	Without ATMS	Weekly	Twice weekly
		With ATMS	Monthly	Monthly for critical cases only
	Track survey		Monthly	Monthly for critical cases only
	Tilt meter		Continuous	Twice weekly
	Vibration sensor		Continuous	Continuous (Where applicable)
	Crack meter		Weekly (Where applicable)	Weekly (Where applicable)

Table 1 - Typical instrumentation & frequency for construction activities within the railway protection zone

Note: Ground instruments may be monitored twice weekly for works within MRT 3rd reserve

6.3 RAPID TRANSIT SYSTEM STRUCTURES & TRACKS MONITORING

6.3.1 Rapid transit system structures and tracks shall be closely monitored during the construction stage of the development and building works if the development and building works have implications on the integrity of the rapid transit system and its operation.

6.3.2 Typical monitoring instruments such as precision surveying theodolite, tiltmeter, vibration sensor, crack meter, electrolevel, tape extensometer can be used.

6.3.3 Where the cumulative movement of the underground or at-grade rapid transit system structure is expected to exceed 5 mm, an automatic remote-control monitoring of the structures (referred as Automatic Tunnel Monitoring System, ATMS) shall be provided. At least four monitoring cycles of results shall be provided for the entire monitoring zone within a period of 24 hours.

6.3.4 The ATMS shall also have the facility to be switched to continuous mode for reading points within any localised areas of interest along the rapid transit system tunnels.

6.3.5 The software used in processing of data shall be in accordance with the procedure recommended by the manufacturer. The software must be proven to be reliable, and the Authority reserves the right to reject any proposed software that is deemed not acceptable.

6.3.6 All remote-control systems shall be equipped with automatic data acquisition and processing units, viewing screen and printer for hard copy printout of the monitoring results.

6.3.7 Where automatic monitoring is provided, manual survey shall be provided to countercheck all the monitoring points and control points. This shall be carried out at least once a month.

6.3.8 The rapid transit system tunnels shall be monitored for movements along its length spaced not more than 3m intervals within the predicted zone of influence. At least four points around each tunnel ring at these intervals shall be monitored. Monitoring shall extend at least 20m beyond the zone of influence. This monitoring and that for more massive part of rapid transit system stations and related structures shall not be more than 5m apart as illustrated in ***Figure 7***.

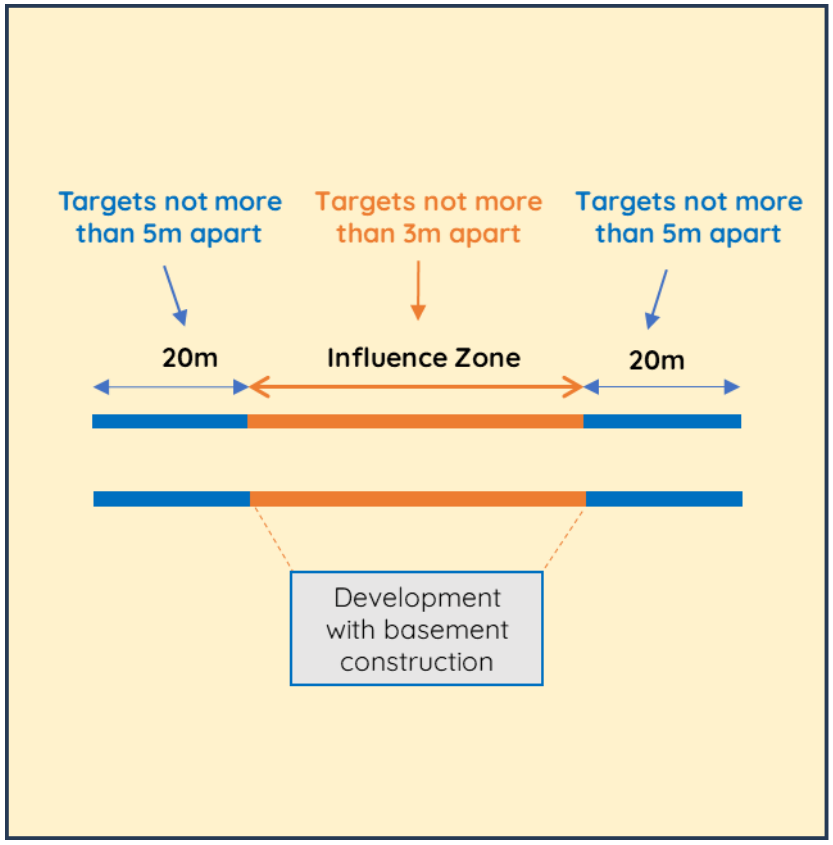


Figure 7 - Influence zone and extent of monitoring

6.3.9 The at-grade rapid transit system structures are supported on ballast and sub-ballast. Where the proposed works have implications on these structures, there shall be additional monitoring to check that there is no differential settlement between the sub-ballast and the sub-soil below it as this may cause derailment of train.

6.3.10 Manual survey shall be carried out using 1sec theodolite and distance accuracy of 1mm+/- 2ppm or better. The results shall be certified by registered surveyor for submission to the Authority. The monitoring instrument and set up must take into consideration the effects of train operation and changes in ambient conditions such as vibration, changes in air pressure and temperature.

6.3.11 The rapid transit system tracks shall be monitored against the allowable track distortions given in *Table 2(c)* if the track is expected to be affected by the development and building works.

6.3.12 All monitoring results shall be analysed and compared with the approved alert and work suspension levels specified by a qualified person.

6.4 CALIBRATION

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

6.5 INSTALLATION

6.5.1 The type of anchor and bolt used shall be HKD-SKR or equivalent. The material shall be made of stainless steel. The anchor shall be 30 mm long and 10 mm in diameter. The bolt shall be 8 mm in diameter. Before drilling into the rapid transit system structures, checks shall be made to identify the depth and location of the embedded reinforcements. The proposed drilling locations shall be away from the existing reinforcements.

6.5.2 The above-ground rapid transit system structure comprises pre-stressed post tensioned viaduct beams. Drilling of the viaduct beam is not allowed for the installation of instruments and its fixtures. Prisms shall be installed using heavy-duty double-sided tape or equivalent.

6.5.3 Upon completion of monitoring, all fixtures installed must be removed and the rapid transit system structures shall be made good to the acceptance of the Authority. Approval shall be obtained from the Authority for any other left-in fixtures.

6.6 ACCURACY OF READINGS

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

6.6.2 The readings taken by automatic tunnel monitoring system must be consistent and stable. High precision 3D equipment designed for tunnel and subway monitoring with an accuracy of 1 second (angle) and 1mm + 1ppm (distance) shall be used.

6.6.3 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 three numbers of reference points on opposite

ends of site shall be provided. In addition, reference points must be located on very stable structures which would not be affected by the adjacent development.

6.7 INITIAL READINGS AND TERMINATION OF MONITORING

6.7.1 Readings must be stabilised before commencement of work.

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

6.7.3 For automatic monitoring of the rapid transit system structures for movements, the initial set of readings must include test results to demonstrate the monitoring system meets the required accuracy as stated in Clause 6.6.2.

6.7.4 Before termination of monitoring, the sub-structural works must be completed, the ground conditions and the monitoring readings shall both shown to have stabilised and thereafter no further change is expected in the long term. If the construction of superstructure is expected to affect adversely on the ground conditions and the rapid transit system structures, monitoring shall be continued until their completion and stable readings obtained.

6.7.5 The qualified person is required to tabulate and submit the final monitoring cycle readings in excel format, respectively for both tunnel bounds. This should include the chainages for every monitoring ring and all prisms shall be measured. The qualified person should ensure that the final readings follow the left-hand rule convention as shown in *Figure 8.*

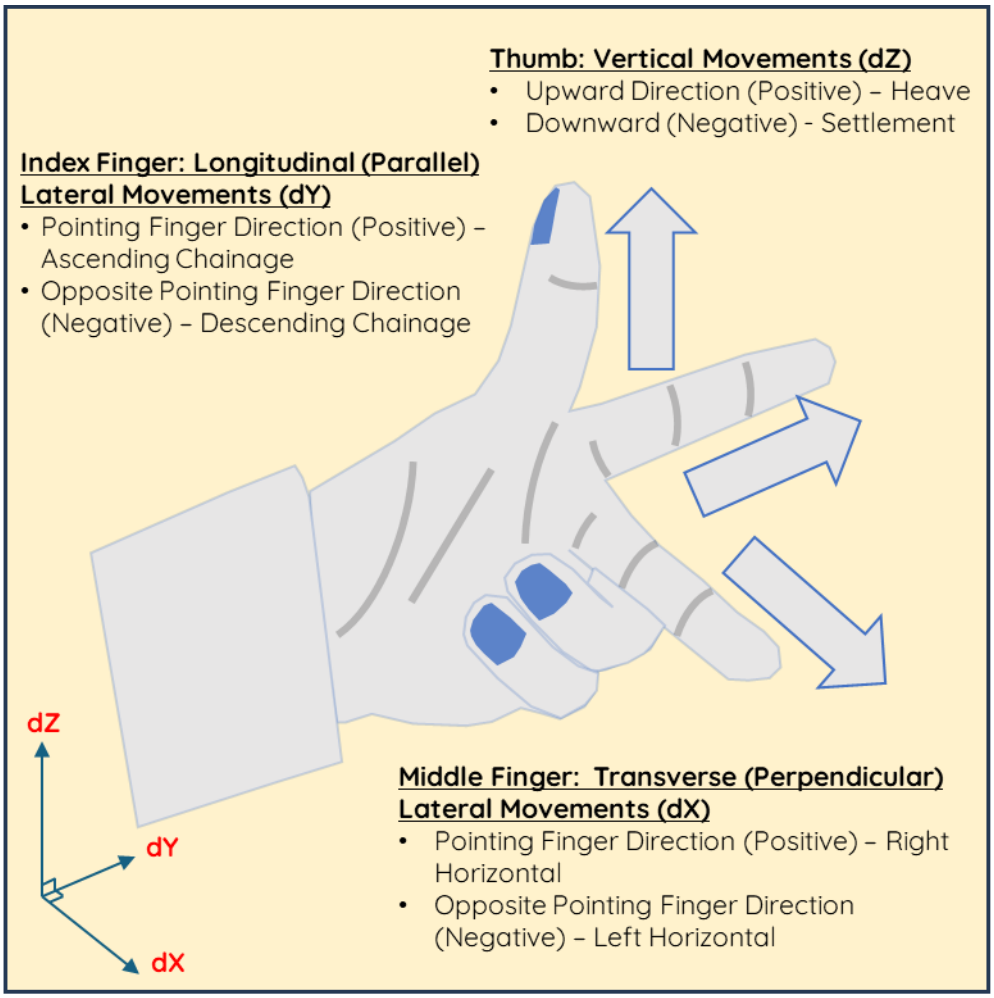


Figure 8 - Left-hand rule (with index finger point towards ascending chainages direction)

6.7.6 The following information shall be included in the final monitoring report:

(a) Chainages for all monitoring sections;

(b) All prisms shall be measured;

(c) The sign convention uses (if left hand rule is adopted); and

(d) Approved ATMS plan.

7. INSTALLATION OF INSTRUMENTS IN TRAINWAY

This section stipulates the requirements for obtaining approval for the installation of instruments that may infringe into the structure gauge of the operating rapid transit system tunnel or trainway. All instruments to be installed in the trainway shall be submitted to the Authority for approval before track access can be granted for the installation works.

7.1 APPLICATION FOR INSTRUMENT INSTALLATION

7.1.1 An application for the approval of instrument installation in trainway shall be submitted by the qualified person appointed under *Regulation 11* and the application shall be accompanied by the following items:

(a) Form *LTA DBC RAIL-S4B*;

(b) Instrumentation layout plan;

(c) Tunnel or trainway cross-sectional plan;

(d) Fixing details and calculations endorsed by professional engineer (Civil);

(e) Document stating the name and particulars of the appointed registered surveyor and his assignee, if any, responsible for checking structure gauge clearance of instruments installed on site; and

(f) Document stating the name and particulars of the appointed professional engineer (civil) and his assignee, if any, responsible for checking fixing details of instruments installed on site.

7.2 INFORMATION TO BE INDICATED ON PLANS AND CALCULATIONS

7.2.1 Instrumentation layout plan shall show the following items:

(a) Registered surveyor's endorsement on every plan;

(b) Scale of drawing;

(c) Rapid transit system tunnel or trainway alignment with respect to the development site; and

(d) Chainages of all instrument locations.

7.2.2 Tunnel or trainway cross-sectional plans (refer to Figure 9 – 11) shall show the following items:

(a) Registered surveyor's endorsement on every plan for structure gauge clearance;

(b) Professional engineer (civil)'s endorsement on every plan for fixing details;

(c) Scale of drawing;

(d) Chainage of tunnel or trainway cross-sections;

(e) Direction of tunnel or trainway cross-section, i.e., orientation facing towards a particular station or towards increasing chainage;

(f) Horizontal & vertical offsets of outmost object protrusion towards the track, with reference from the inner side of the lower rail;

(g) Cant of track in the direction of cross-section;

(h) Horizontal throw;

(i) Structure gauge profile without throw or with throw (if applicable);

(j) All instruments including brackets are indicated to be outside the structure gauge; and

(k) Clearance from the outermost object protrusion towards the structure gauge.

7.2.3 Fixing details and calculations shall show the following items:

(a) Professional engineer (civil)'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, cables (conforming to the railway operator's requirements), etc.; and

(d) Design calculations on all fixing including hold down bolts, anchorage, etc.

7.2.4 The following shall be adopted in the application for easy management of the tunnel monitoring data:

(a) The naming of left/ right wall of the tunnels:

- Left wall = Left Hand Side (when facing ascending chainage direction)
- Right wall = Right Hand Side (when facing ascending chainage direction)

(b) The sign convention of the tunnel absolute movements. (See Left Hand Rule)

(c) Ascending Chainage of the RTS lines:

- NSL = Marina South Pier towards Bishan
- EWL = Redhill towards Kallang
- NEL = Harbourfront towards Punggol
- CCL = Marina Bay towards Harbourfront
- DTL = Expo towards Bukit Panjang
- TEL = Woodlands North to Bayshore

7.3 APPROVAL FOR INSTRUMENT INSTALLATION

7.3.1 The Authority will stamp "Approved for Installation" on every sheet of the proposal plans for the installation of instrument in the trainway if all the requirements listed in Clause 7.1 and Clause 7.2 are complied with.

7.3.2 The Authority will not allow any installation in the trainway that do not meet the details shown on the approved drawings. Modification or alteration of any details which may be required due to site constraints shall be submitted to the Authority for approval first before actual installation.

7.4 SUPERVISION OF INSTALLATION

7.4.1 The registered surveyor and professional engineer (civil) whose names appear on the approved plans shall be fully responsible for the supervision of instrument installation as shown on the approved plans.

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

7.4.3 Upon completion of the installation works, the registered surveyor and the professional engineer (civil) or their assignee(s) shall sign on the certificate of supervision *Form LTA DBC RAIL-INSTR* and submit it to the Authority's officer prior to leaving the tunnel or train.

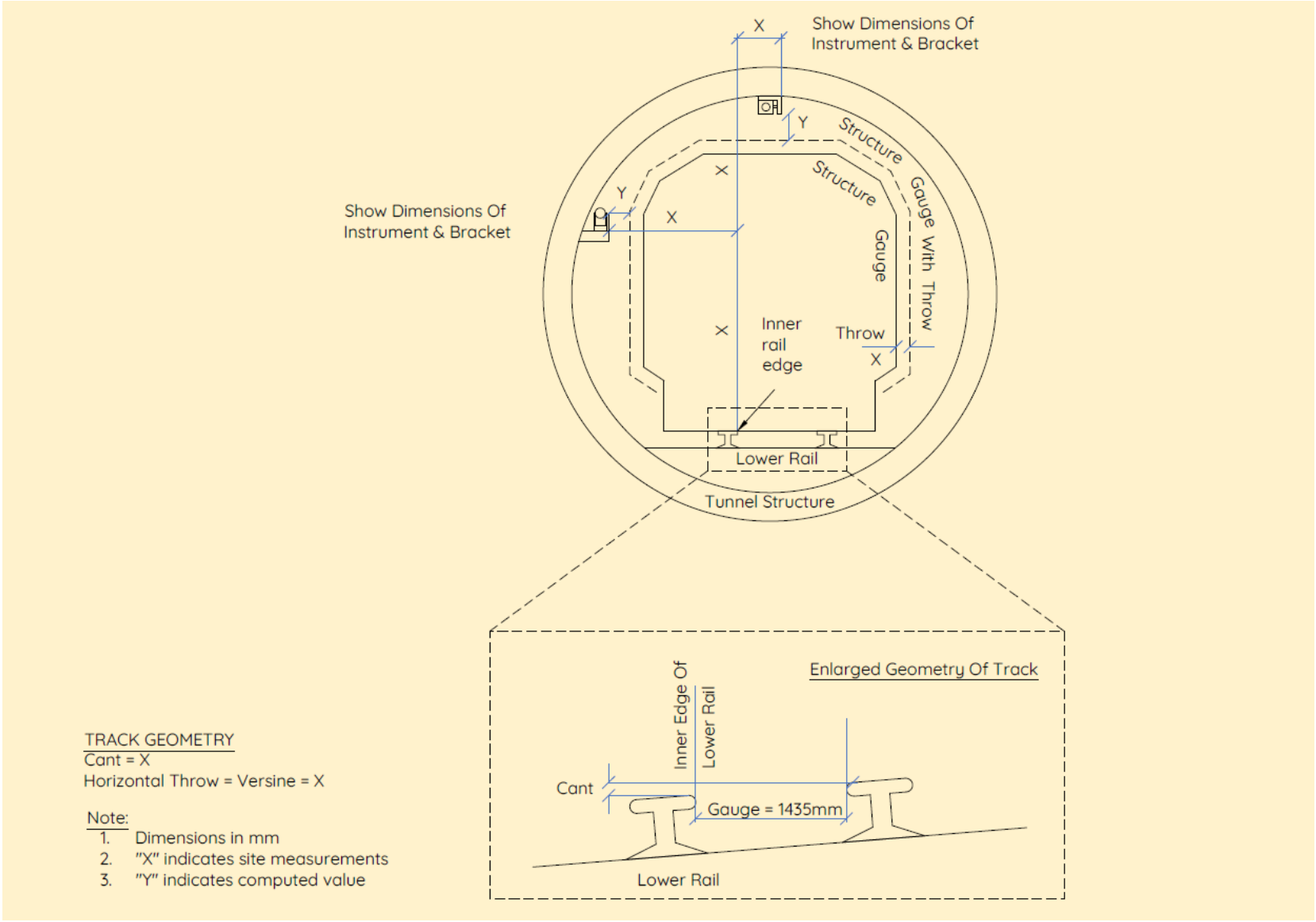


Figure 9 - Typical trainway cross section for bored tunnels

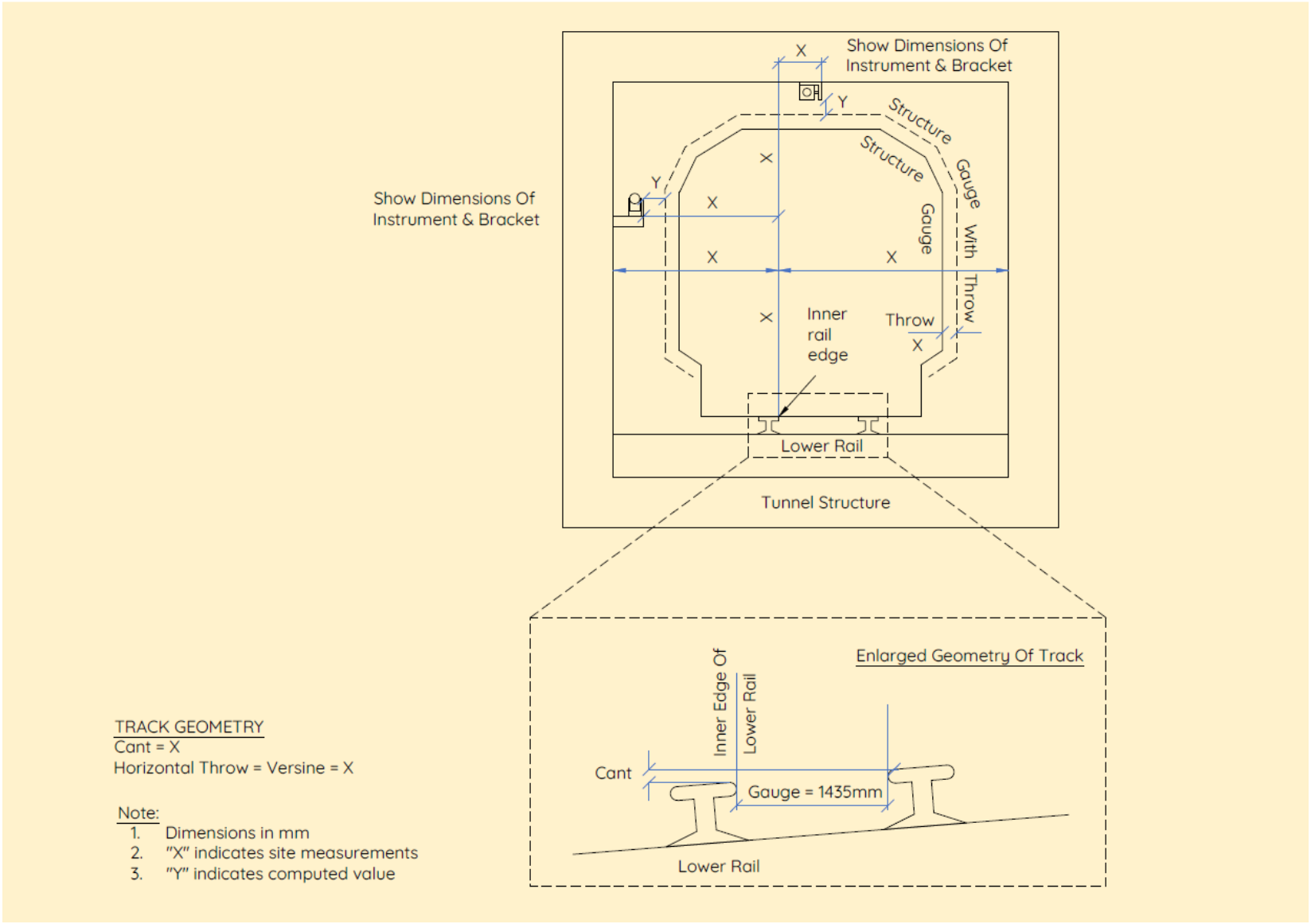


Figure 10 - Typical trainway cross section for boxed tunnels

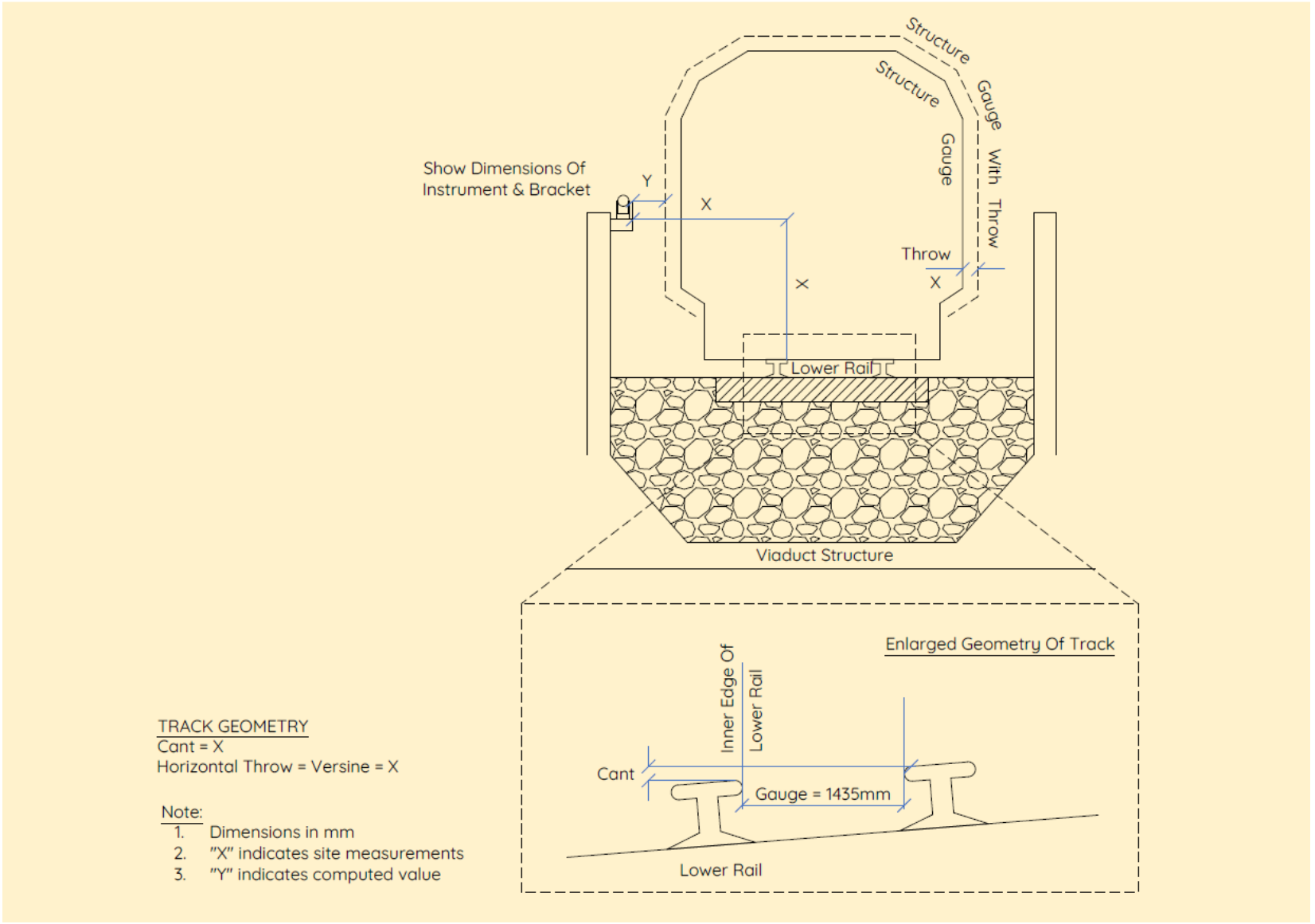


Figure 11 - Typical trainway cross section for viaduct

PART III – TECHNICAL REQUIREMENTS

This section stipulates the technical requirements for various types of building works and engineering works in the railway protection zone and railway corridor.

1. FRAMEWORK FOR DEVELOPING SOLUTIONS FOR DEVELOPMENT AND BUILDING WORKS

The framework for developing solutions for development and building works within the railway protection zone comprises of the following components that are structured as shown in ***Figure 12***:

(a) The objectives;

(b) The performance requirements;

(c) The solutions; and

(d) The assessment methods.

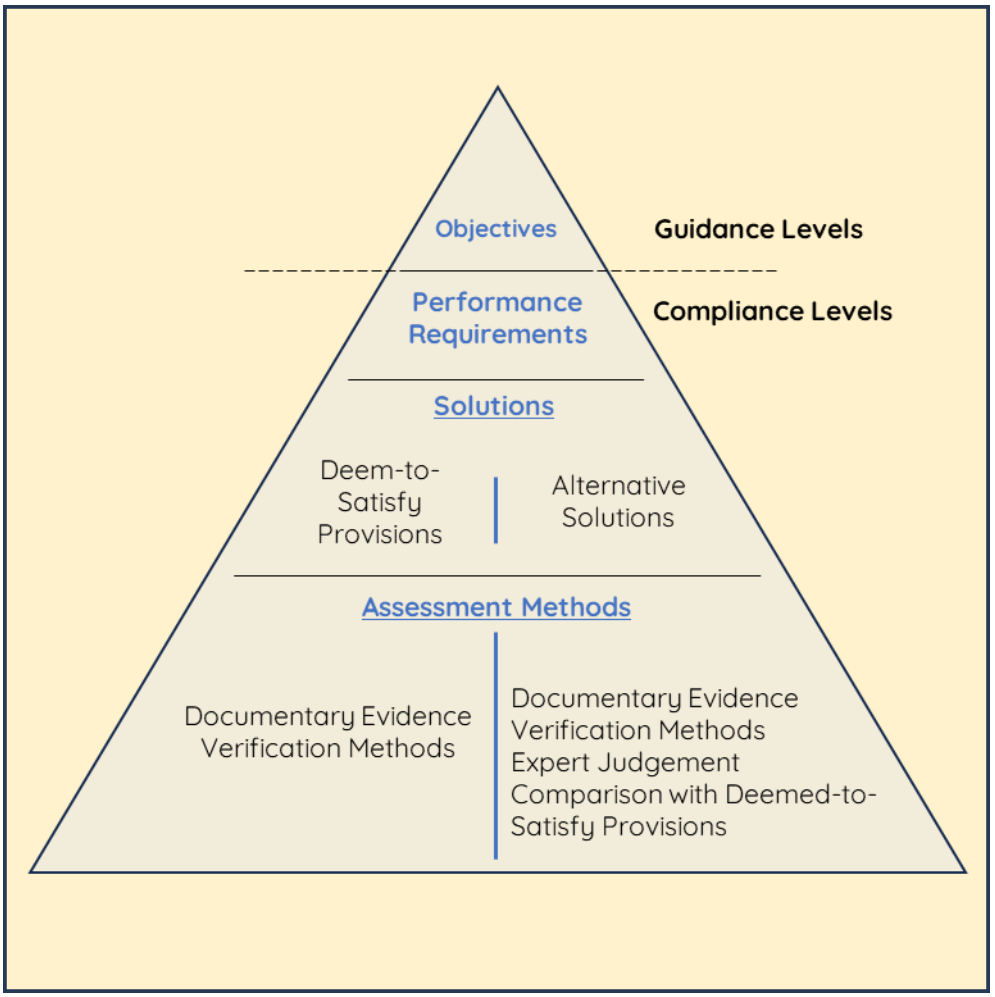


Figure 12 - Framework for Developing Solutions for Development and Building Works

1.1 MEETING THE PERFORMANCE REQUIREMENTS

Compliance with the performance requirements can be achieved by:

(a) complying with the deemed-to-satisfy provisions contained in *Section 3*; or

(b) formulating an alternative solution which:

(i) complies with the performance requirements contained in *Section 2*; or

(ii) is shown to be at least equivalent to the deemed-to-satisfy provisions; or

(c) a combination of (a) and (b).

1.2 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 requirement or the deemed-to-satisfy provisions.

This assessment method shall be supported with documentary evidence that clearly shows that a similar solution had been proven to be suitable and successful in meeting the objectives in similar circumstances.

(b) Verification methods

The verification methods shall include any method deemed relevant or appropriate by the appointed qualified person. 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 rapid transit systems will be subjected to, and the effective measures to mitigate these risks.

In developing solutions to meet the performance requirements, the qualified person is required to either show that the solutions meet the deemed-to-satisfy provisions or propose alternative solutions. It is crucial that the methods used to model or simulate the actual conditions are suitable for use in similar situations. Sensitivity studies will be required where necessary to check the parameters used are reasonable.

In addition, a system to monitor and check the results of the evaluation during construction shall be proposed. Necessary mechanisms must be in place to determine whether any re-evaluation or review needs to be considered during the implementation of the alternative solutions. Actions can be taken and decisions can be made if the situation develops differently from forecast and before a dangerous condition arises. This would therefore include a hazard analysis and measures to mitigate those risks identified.

(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.

(d) Comparison with the deemed-to-satisfy provisions

Alternative solution is deemed to satisfy performance requirement if it is demonstrated to be equivalent to the deemed-to-satisfy provisions by comparison.

2. PERFORMANCE PROVISIONS

This section stipulates the objectives and performance requirements for safeguarding the rapid transit systems in the following aspects:

- *Structural safety*
- *Operational safety*
- *Fire safety*
- *Flood protection*
- *Inspection and maintenance*

2.1 STRUCTURAL SAFETY

2.1.1 OBJECTIVE

The objective is to safeguard the structural integrity of the rapid transit systems against damage arising from any development or building works.

2.1.2 Performance Requirements

The design and construction of any development or building works must make adequate provisions to check and ensure that the rapid transit system structures are capable of sustaining at an acceptable level of safety and serviceability under:

(a) the most adverse combination of loads;

(b) the most adverse movements; and

(c) other actions

to which the rapid transit system structures may reasonably be subjected to.

2.2 OPERATIONAL SAFETY

2.2.1 Objective

The objective is to ensure the safe operation of the rapid transit systems is not being affected by any development or building works.

2.2.2 Performance Requirements

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

(a) the rapid transit system structures and tracks are not subjected to deformation and changes that will not allow trains to operate at the maximum design speed;

(b) the impact on the rapid transit system structures and tracks will not compromise the safety and comfort of passengers;

(c) there is no obstruction to the free flow of public moving in and out of the rapid transit system station; and

(d) the performance of the mechanical and electrical services is maintained.

2.3 FIRE SAFETY

2.3.1 Objective

The objective is to ensure that the fire safety measures and fire protection works for the rapid transit systems are adequately provided for and are acceptable arising from integration of any development or building works.

2.3.2 Performance Requirements

The design and construction of any development or building works must be carried out in such a manner that:

(a) there is provision of adequate protection for the rapid transit systems against the spread of fire from any development or building work;

(b) there is provision of adequate egress capacity for the rapid transit systems in compliance with the Code of Practice for Fire Precautions in Rapid Transit Systems;

(c) there is no re-circulation of smoke into the station in the event of station fire or fire from any development or building works; and

(d) provision of firefighting measures in the rapid transit systems is not compromised.

2.4 FLOOD PROTECTION

2.4.1 Objective

The objective is to protect the safety of people in the rapid transit systems against the ingress of water due to flooding or other means.

2.4.2 Performance Requirements

The design and construction of any development or building works with underground connections to the rapid transit systems must make adequate provisions to:

(a) prevent the ingress of water into rapid transit systems due to flooding or other means including run off from the surface; and

(b) avoid the likelihood of water discharged or redirected into the rapid transit systems.

2.5 INSPECTION AND MAINTENANCE

2.5.1 Objective

The objective is to ensure that there are adequate provisions of access and facilities for inspection and maintenance of the rapid transit system structures including the viaduct columns, beams and bearings in the development.

2.5.2 Performance Requirements

The design and construction of any development or building works must be carried out in such a manner as to ensure that:

(a) there is provision of adequate facilities for the inspection and maintenance of the rapid transit system structures including the viaduct columns, beams and bearings; and

(b) the existing lightning protection and drainage systems of the rapid transit systems are not adversely affected or compromised.

3. DEEMED-TO-SATISFY PROVISIONS

Development and building works in the railway protection zone shall meet the technical requirements contained in this section. Proposals that comply with the deemed-to-satisfy provisions of this section will be deemed to have satisfied the objectives and performance requirements stipulated in this Code.

3.1 ALLOWABLE LIMITS

3.1.1 ALLOWABLE IMPOSED LOADS

3.1.1.1 The design and construction of development and building works in the railway protection zone shall satisfy the allowable limits for imposed loads on the rapid transit system structures as given in *Table 2(a)*.

3.1.1.2 The allowable imposed load is defined as the load applied at the finished ground level directly above, straddling or to the side of the rapid transit system structure, that gives the most onerous effect to the rapid transit system structure as illustrated in *Figure 13*.

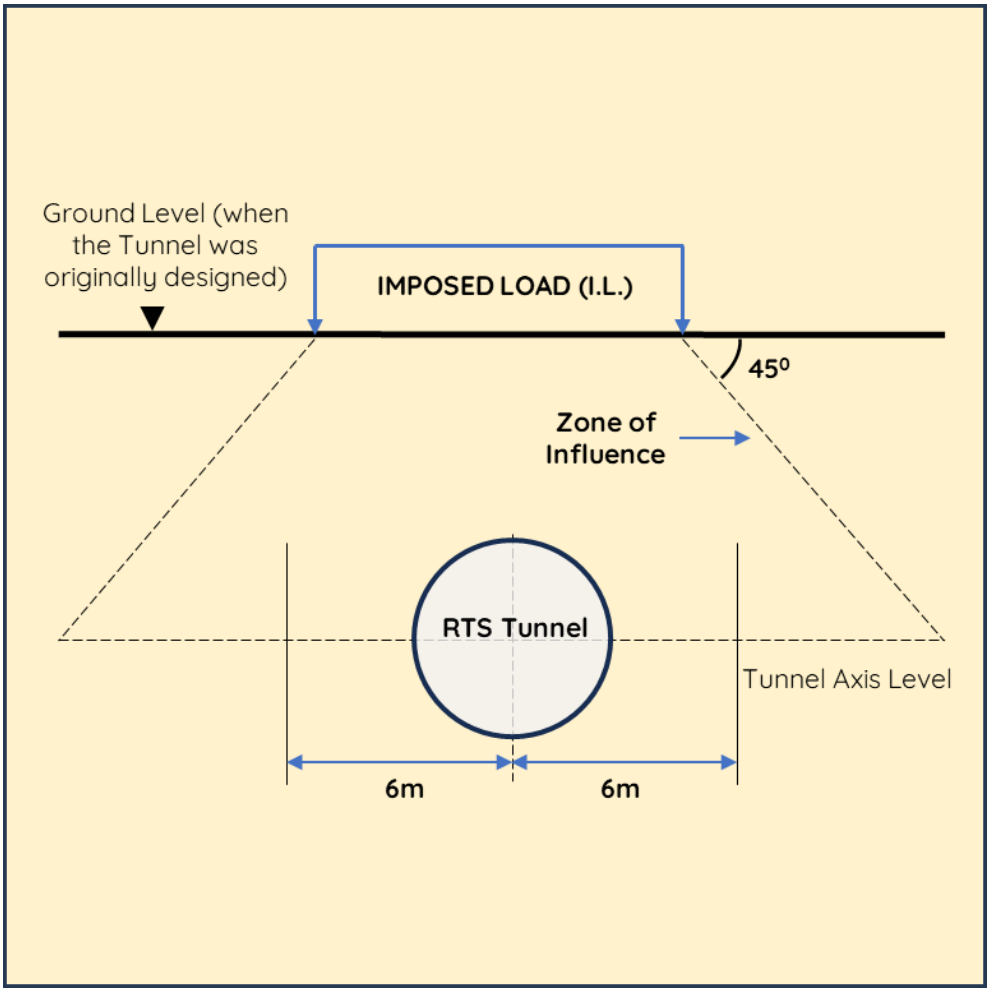


Figure 13 - Allowable imposed load for rapid transit system structures not under the roadway

RAPID TRANSIT SYSTEM LINES	TYPES OF RAPID TRANSIT SYSTEM STRUCTURES		IMPOSED LOAD (kN/m²) #		
			COVER UNDER ROADWAY (m)		NOT UNDER ROADWAY##
			≤ 1.5	> 1.5	
East West Line (except Expo Station to Changi Airport Station) and North South Line	Underground, Transition & Sub-aqueous	Bored Tunnel	-	15	15
		Cut & Cover Tunnel & Station	(a) HA loading or 45 units of HB loading dispersed in accordance with BS5400 Part 2 and HB vehicle placed within the central 5m of the carriageway and no HA loading in combination with the HB vehicle.		
	At Grade	Embankment	-	-	40 (outside 1st reserve)
		Cutting	-	-	15 (outside 1st reserve)
Expo Station to Changi Airport Station	Underground & Transition	Bored Tunnel	-	22.5	22.5
		Cut & Cover Tunnel & Station	[(a) + 7.5] or 22.5, whichever is greater		
North East Line	Underground & Sub-aqueous	Bored Tunnel	-	22.5	22.5
		Cut & Cover Tunnel & Station	[(a) + 7.5] or 22.5, whichever is greater		
Circle Line	Underground & Sub-aqueous	Bored Tunnel	-	25	75
		Cut & Cover Tunnel & Station	[(a) + 7.5] or SS EN 1991-2 relevant traffic action or 25, whichever is greater		25
Downtown Line	Underground & Sub-aqueous	Bored Tunnel	-	75	
		Cut & Cover Tunnel & Station	[(a) + 7.5] or SS EN 1991-2 relevant traffic action or 25, whichever is greater	25	
Thomson-East Coast Line	Underground & Sub-aqueous	Bored Tunnel	-	75	
		Cut & Cover Tunnel & Station	[(a) + 7.5] or SS EN 1991-2 relevant traffic action or 25, whichever is greater	25	

Table 2(a) - Allowable Imposed Loads on Rapid Transit System Structures

Notes:

Load that the rapid transit system structures, except for sub-aqueous structures, are designed for. Note that the imposed load values serve as a general guide only. The actual imposed load shall be checked against the as-built drawings for detailed checks and assessment.

For structures influenced by load imposed from an existing building, the magnitude of load applied at the foundation level of the building shall be the building permanent actions with appropriate allowance for variable actions in accordance with the relevant codes, BS 6399 or SS EN 1991. Where the effect of this load is less than the surcharge given in "Not Under Roadway", the values for imposed load in table 1(a) shall be adopted.

3.1.2 ALLOWABLE MOVEMENT LIMITS ON RAPID TRANSIT SYSTEM STRUCTURES

3.1.2.1 The design and construction of development and building works in the railway protection zone shall satisfy the movement limits on the rapid transit system structures as given in *Table 2(b)* unless otherwise advised by the Authority at development proposal stage.

3.1.2.2 Alternative solution shall be adopted if the allowable limits given in *Table 2(b)* have already been exceeded during the construction of a past development.

3.1.2.3 Allowable movement limits for the above ground rapid transit system structures, such as the viaduct, are dependent on the allowable capacity of the bearings and the structural system of the rapid transit system structures.

3.1.2.4 The developer shall appoint a qualified person to carry out an inspection of all bearings that are within the influence zone of the proposed development and assess the capacity of these bearings to tolerate further movements. The inspection report prepared and endorsed by the qualified person shall be submitted to the Authority. Other constraints such as tie beams, cross beams, bearings, etc. that form an integral part of the rapid transit system structures must also be checked before adopting the allowable values in *Table 2(b)*, where applicable.

3.1.2.5 Total movement refers to the bodily displacement of the rapid transit system structure or track. An example is illustrated in *Figure 14* for point A. The resultant displacement, m_1 comprising components x_1 and y_1 must be less than the allowable value.

3.1.2.6 An example for the differential movement between two points in the transverse plane is illustrated in *Figure 15* for a circular tunnel section. The maximum elongation or shortening shall be limited to 15mm or less, or the angular rotation of the rapid transit system structural element that would occur must also at the same time be less than 1:1000 as a result of any differential movement, whichever is lesser.

3.1.2.7 The squatting of the tunnel caused by activities carried out in its vicinity as illustrated in *Figure 15*. If point A moves to A_1 and point B moves from B to B_1, the maximum elongation or change in diameter of AB shall not be more than the allowable, i.e. A_1B_1-AB < allowable. The predicted angular rotation of the rapid transit system structural element that would occur must also at the same time be less than 1:1000. Combining the two criteria for total and differentiate movements, point A can move to a point anywhere within an acceptable zone of movement as illustrated in *Figure 15*. Similarly, in the case of ovalisation, the shortening of tunnel diameter in the horizontal axis shall also be less than the allowable movement.

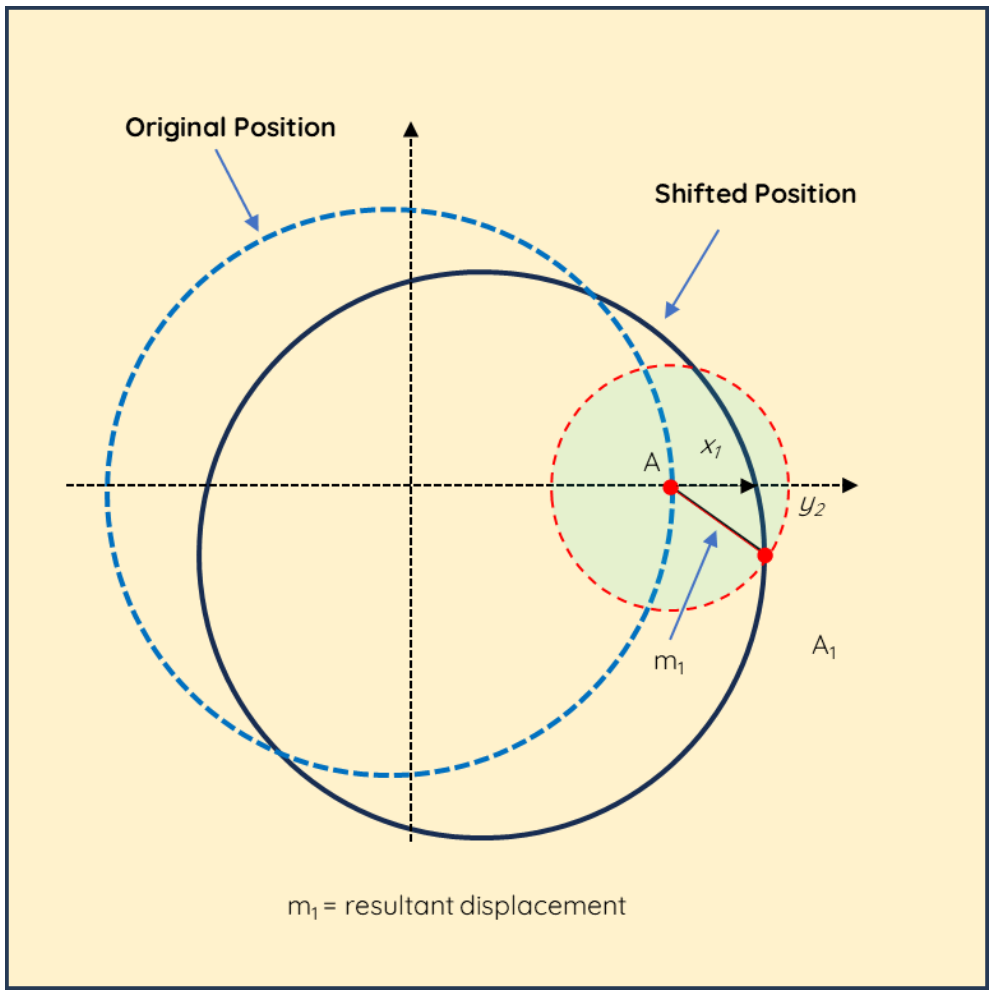


Figure 14 - Interpretation of total movement in any direction

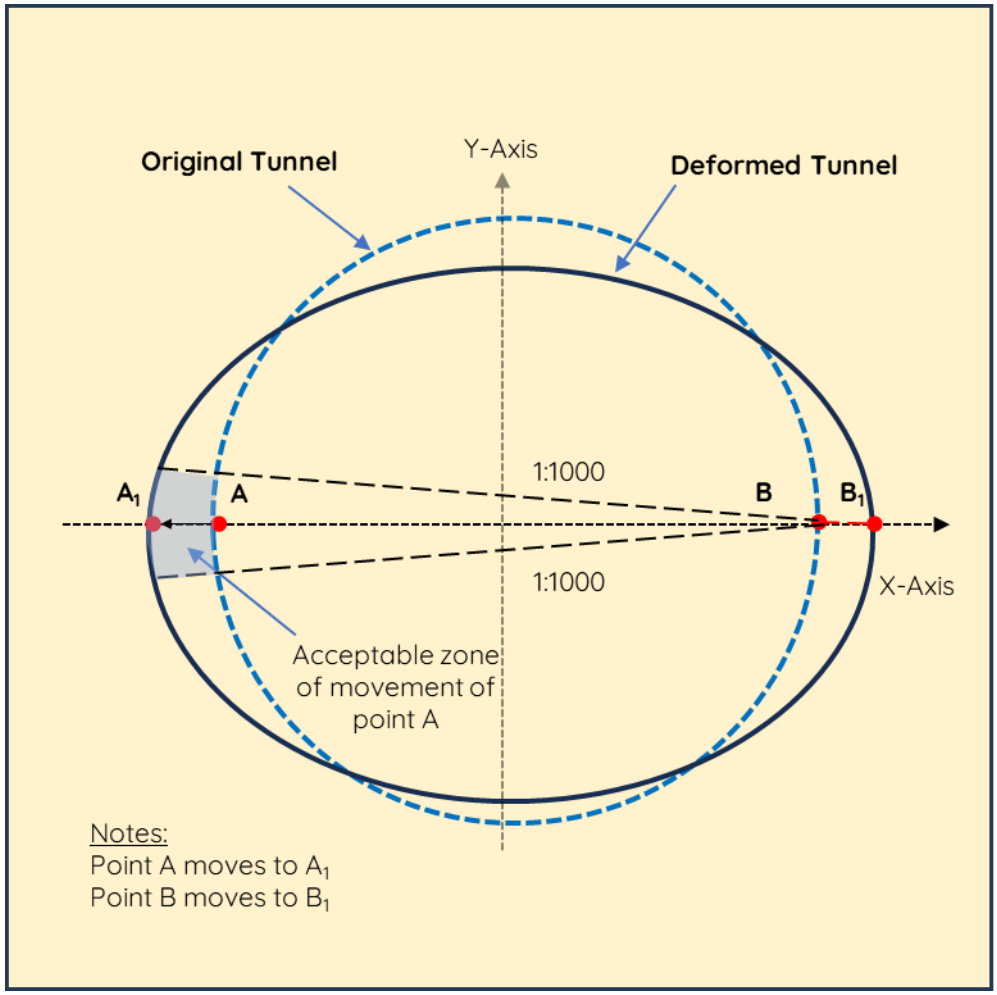


Figure 15 - Differential movements in transverse plane

RAPID TRANSIT SYSTEM LINES	TYPES OF RAPID TRANSIT SYSTEM STRUCTURES	MOVEMENT (mm)	
		TOTAL MOVEMENT IN ANY DIRECTION	DIFFERENTIAL MOVEMENT IN ANY PLANE
East West Line (except Bored Tunnel Expo station to Changi Airport station) and North South Line	Bored Tunnel	15	15 or 1:1000 (whichever is lesser)
	Cut & Cover Tunnel and Station		
	Embankment		
	Cutting		
	Viaduct	15**	15 or 1:1000** (whichever is lesser)
	Above Ground Station		5**
Expo station to Changi Airport station	Bored Tunnel	15	15 or 1:1000 (whichever is lesser)
	Cut & Cover Tunnel and Station		
	Viaduct	15**	15 or 1:1000** (whichever is lesser)
	Above Ground Station		5**
North East Line	Bored Tunnel	15*	15 or 1:1000* (whichever is lesser)
	Cut & Cover Tunnel and Station		
Bukit Panjang LRT	Cutting	10	10
	Viaduct	10**	10 or 1:500** (whichever is lesser)
	Station		
Sengkang & Punggol LRT	Viaduct	15**	15 or 1:500** (whichever is lesser)
	Station		
Circle Line Downtown Line Thomson-East Coast Line	Bored Tunnel	15	15 or 1:1000 (whichever is lesser)
	Cut & Cover Tunnel and Station		

Table 2(b) - Allowable Limits for Movement for Rapid Transit System Structures

Notes:

* Value is not applicable to 36 tunnel rings located along Race Course Road, between North Bound Chainage 32733 to 32823 and South Bound Chainage 32711 to 32803 and as identified in drawing no. LTA/DBC/RP/NEL/016. These 36 rings have limited capacity to tolerate distortion and that an alternative evaluation shall be adopted to determine the tolerable distortion.

** Subject to tolerance of viaduct bearings against further movements including settlement.

3.1.3 ALLOWABLE TRACK DISTORTIONS

3.1.3.1 The design and construction of development and building works in the railway protection zone shall satisfy the track limits as given in *Table 2(c)*, unless otherwise advised by the Authority at development proposal stage.

3.1.3.2 The allowable track distortions are applicable for the rapid transit systems that run on rail and not for light rail transit systems which have rubber wheels. These are not absolute values, but relative values obtained before development works and values measured during the works. Track distortion criteria are dependent on the bogie spacing of the rapid transit system cabin as shown in ***Figure 16***.

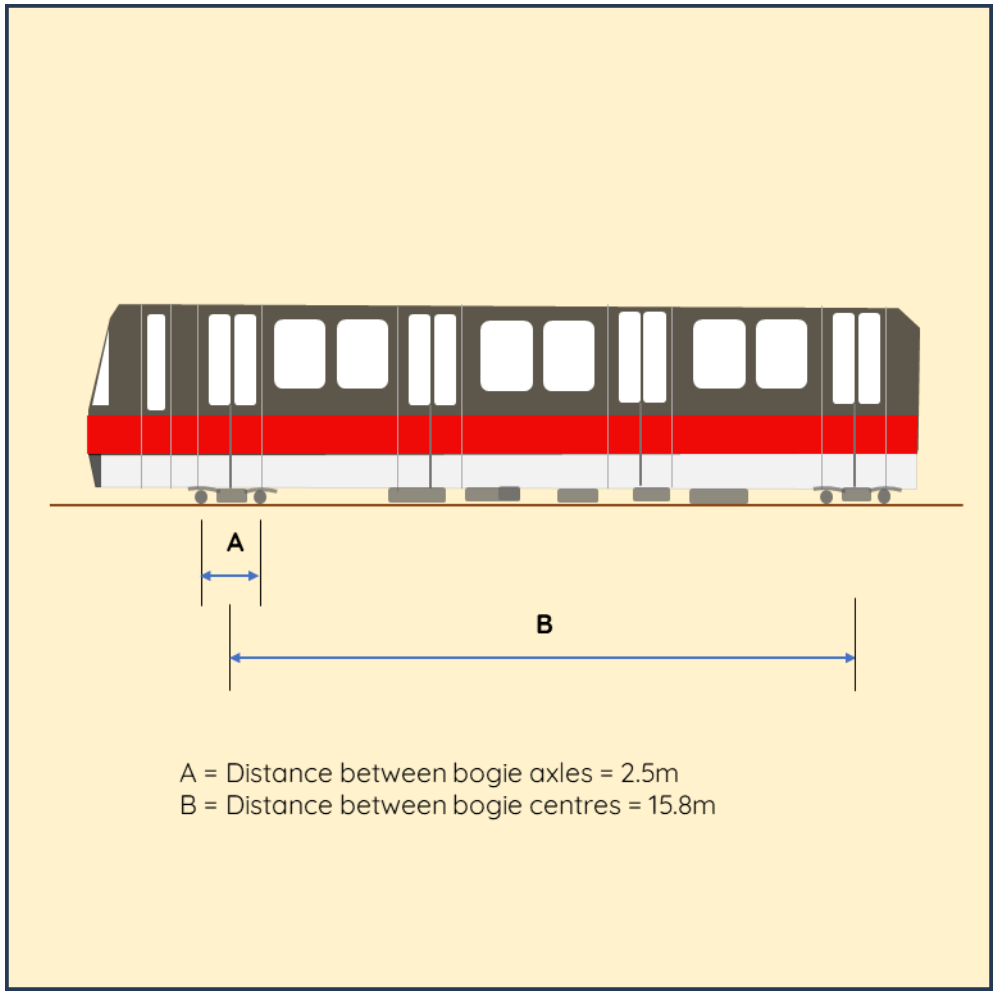


Figure 16 - Typical bogie axle spacing of trains used for North South Line, East West Line, North East Line, Downtown Line, Circle Line and Thomson-East Coast Line

3.1.3.3 Measurements of track distortions can be made by manual survey. In situations where the track conditions are expected to be affected by the development work, the survey prisms monitored automatically could be correlated to provide real time measurements. Track twist could also be monitored automatically using electrolevels spaced at 2.5m interval.

3.1.3.4 The interpretation of track twist, vertical dip or peak and change in horizontal versine is given in *Figure 17.* The limits given in *Table 2(c)* refer to the allowable deformations to the track in comparison with present conditions.

(a) Twist

Track twist measures the relative rotation of the bogie axles which are spaced 2.5m apart. The allowable value is 1.5mm for the standard measurement distance of 2.5m. This is proportioned accordingly for measurements made at different intervals.

(b) Vertical dip or peak

This is a measurement of the vertical distortion of the rail over a chord length of 5m. The average value for both rails is used to check against the allowable value.

(c) Horizontal versine

Similar to vertical peak or dip, horizontal versine is a measurement of the change in horizontal curvature over a 16m chord, the distance between two sets of bogies in a carriage. The average value for the two rails is used again. It should be noted that the existing rail may have a design curvature and monitoring is checked based on the change in condition before development work commences.

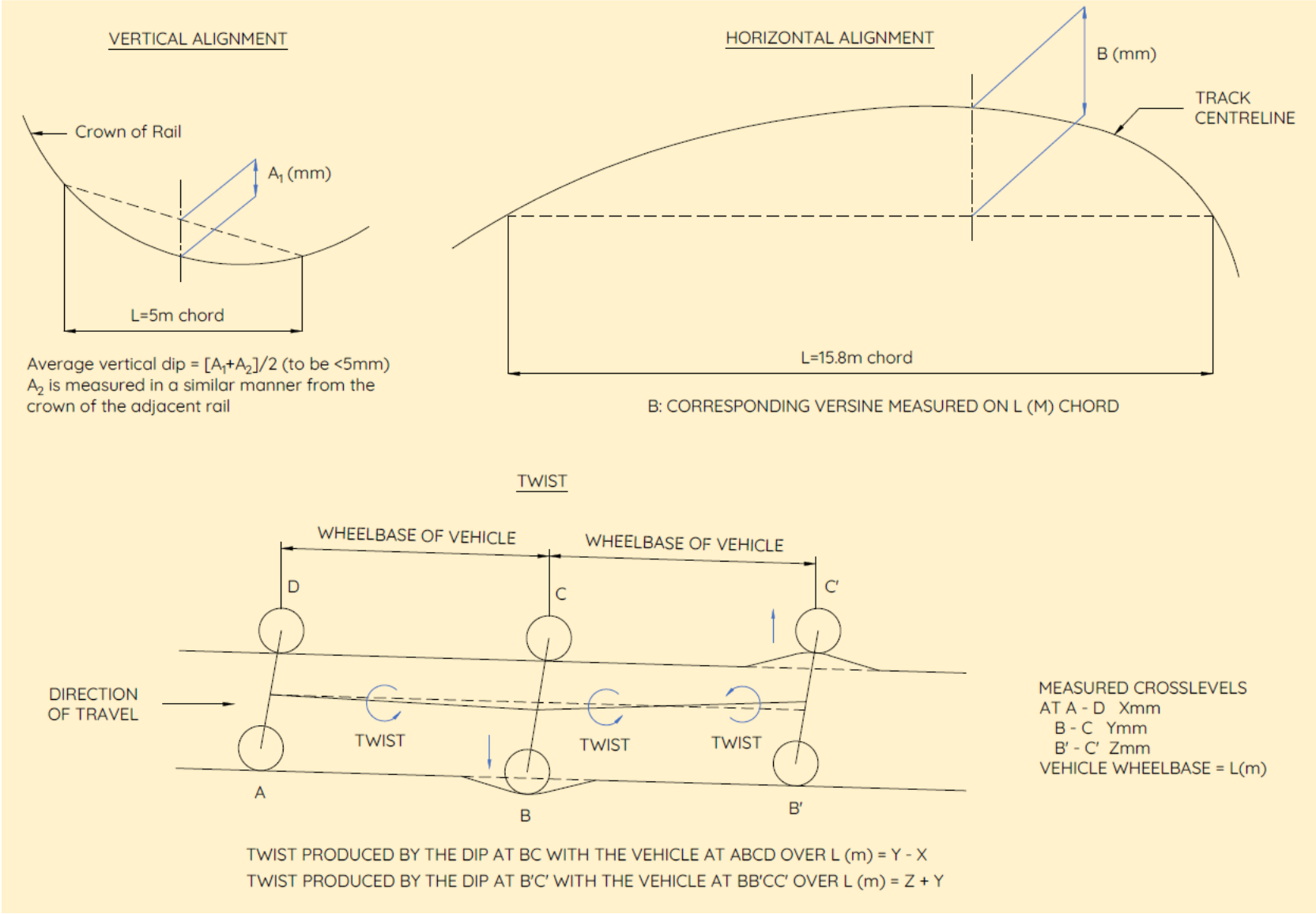


Figure 17 - Interpretation of track criteria

3.1.3.5 The allowable differential movements between any 2 points along the track bed in the longitudinal direction shall be less than 1:1000 as illustrated in ***Figure 18***.

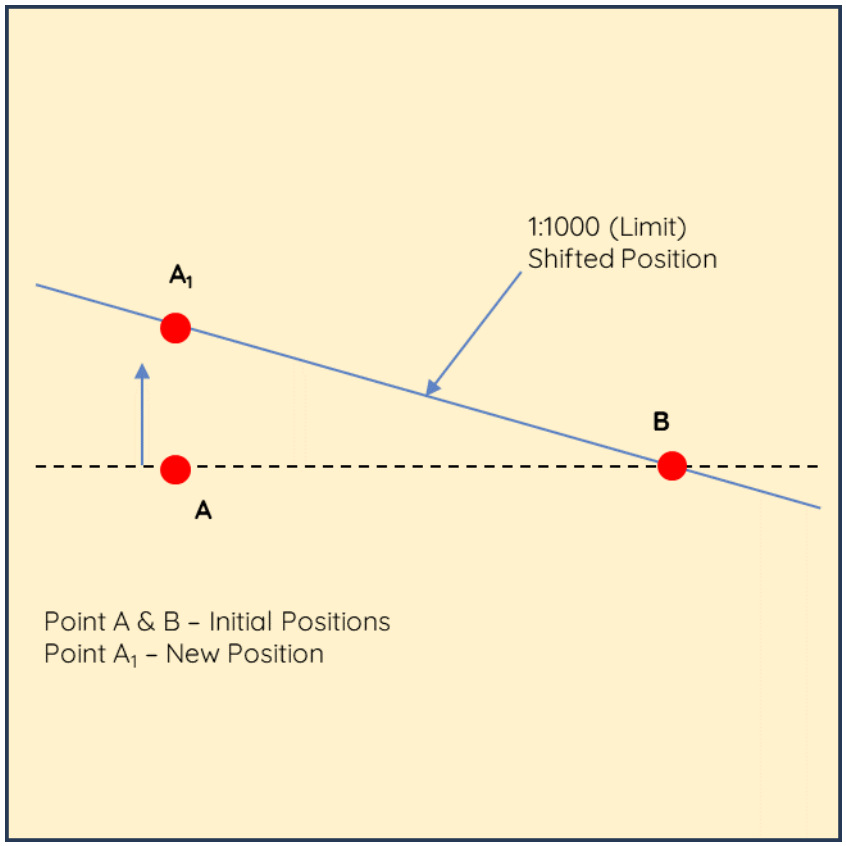


Figure 18 - Differential Movement in Longitudinal Plane

RAPID TRANSIT SYSTEM LINES	TRACK		
	TWIST/ CHANGE IN CANT	VERTICAL DIP OR PEAK	CHANGE IN HORIZONTAL VERSINE
East West Line North South Line North East Line Circle Line Downtown Line Thomson-East Coast Line	1.5 mm (measured over 2.5m) or 1:1666	5 mm (measured over 5m chord)	6 mm (measured over 16m chord)
Bukit Panjang LRT Sengkang & Punggol LRT	Not Applicable	Not Applicable	Not Applicable

Table 2(c) - Allowable Limits for Track Distortions

3.1.4 VIBRATION LIMITS

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

3.2 SITE PREPARATION

Site preparation works within the railway protection zone and railway corridor shall satisfy the conditions of Clause 3.2.1 to Clause 3.2.3.

3.2.1 MOBILIZATION WORKS

Mobilization works in the railway protection zone and railway corridor shall satisfy the following conditions:

(a) The first, second and third reserve lines of the rapid transit system structures, where applicable, must be pegged and demarcated clearly on site by a registered surveyor based on the approved certified survey plan. Details of first reserve line should follow the typical cross section given in the Handbook on Development and Building Works in Railway Protection Zone.

(b) Temporary buildings such as site office, worker's quarter or similar shall be located outside the first reserve.

(c) Access under the railway must have height restriction gantries on both sides of the viaduct beam erected.

3.2.2 DEMOLITION WORKS

3.2.2.1 Demolition of buildings is generally acceptable in all reserves. However, special care shall be taken during demolition works to prevent any physical damage to the rapid transit system structures. No blasting shall be carried out during any demolition work in the railway protection zone.

3.2.2.2 Stockpiling of debris is not allowed within the influence zone of rapid transit system. The debris must be cleared as soon as possible such that the allowable surcharge load on the rapid transit system structures will not be exceeded.

3.2.2.3 Special precaution and method of demolition shall be considered for development and building works interface with the rapid transit system structures.

3.2.3 TEMPORARY PROVISIONS BY CONSTRUCTION WORKS AFFECTING STATIONS

3.2.3.1 Where additional and alterations works are to be carried out within a rapid transit system station, the existing fire safety measures (e.g., means of escape, fire compartments, etc.) and the existing fire protection systems (e.g., sprinklers, smoke detectors, etc.) shall not be affected. In addition, hoarding having at least 2-hour fire resistance in compliance with Fire Code shall be provided to separate the works area from station area. A copy of the Declaration of Compliance (DOC) form shall be submitted for the fire rated materials used. If the Authority is satisfied that the construction activities will not pose any fire risk to the station, the hoarding may be constructed using non-combustible materials.

3.2.3.2 All means of escape must be maintained at all times during the construction and shall comply with the Code of Practice for Fire Precautions in Rapid Transit Systems.

3.2.3.3 Safe and protected passageway for commuters' access to the station entrance must be maintained at all times during the construction.

3.2.3.4 Construction activities in the vicinity of the vent shafts must not generate dust pollution, smoke & exhaust fumes that could affect the environmental control equipment, activation of fire protection system and the fire & smoke detection system of the station. Any exhaust from any building must not be directed towards areas where fresh air intake of the station is located or draught relief shaft of a station.

3.2.3.5 Where firefighting equipment such as fire hydrant, breeching inlets, firefighter intercom, etc. are affected and need to be temporarily relocated, proposal shall be submitted to the Authority for approval. The proposed installation shall be designed and supervised by a qualified person. Upon completion, the installation must be fully tested and commissioned. The qualified person shall submit a certificate of supervision to the Authority. The changeover operation must be done in accordance with the railway operator's requirements and must not have any adverse implication of the safe operation of railway. The qualified person shall also submit a certificate of supervision to the Authority upon reinstatement of the firefighting equipment.

3.2.3.6 Where the directional signage, passenger information display, station name sign, etc are affected by the development, proposal for relocation or replacement shall be submitted to the Authority for approval. The design of the signage shall be compatible with the standard adopted by the Authority.

3.2.3.7 Lighting and ventilation in accordance with Building Control Regulation shall be provided. The developer shall engage a relevant qualified person to design, and the proposal shall be submitted to the Authority for clearance.

3.3 SUBSTRUCTURE WORKS

3.3.1 FOOTINGS AND RAFTS WORKS

Footings and rafts are allowed in the railway protection zone. The design and layout of the footing and rafts shall allow for the maintenance of the viaduct structure including bearing replacement.

3.3.2 PILING AND DRILLING WORKS

Piling works including the construction of foundation piles, temporary or permanent earth retaining walls and any other drilling works in the railway protection zone shall satisfy the conditions of *Table 3* of this section.

		First Reserve	Outside First Reserve	
			Second Reserve	Third Reserve
Underground, Transition or Sub-aqueous	Clearance	Not allowed*	Allowed if piles are kept at least 6m clear on plan from the exterior edge of rapid transit system structures.	Allowed
	Debonding	Not applicable	Load bearing piles within the zone of influence of rapid transit system structures shall be debonded according to the requirements of Clause 3.3.3.	Not Required
	Method of Installation	Not applicable	Piles shall generally be constructed by augering or reverse circulation drilling techniques. Stability of the ground shall be ensured by using casings and/or drilling mud as appropriate. Use of percussively driven concrete piles, steel H-piles, sheet piles or tanalised timber piles is not acceptable. Use of rock chopping chisels is prohibited. Use of vibratory method of installing and extracting sheet piles, H-piles or casings is prohibited.	Rock chiselling and percussive piling techniques are acceptable.
At Grade	Clearance	Not allowed	Allowed	Allowed
	Method of Installation	Not applicable	Use of percussively driven concrete piles, steel H-piles, sheet piles or tanalised timber piles is not acceptable. Use of drilling fluid in the drilling of piles shall be carefully controlled to prevent an increase in the piezometric head in the railway protection zone.	
Above ground	Clearance	Not allowed	Allowed if piles are kept at least 3m clear on plan of the toe of the existing raker pile supporting the rapid transit system structures.	

Table 3 - Piling Works

Note:

* The following may be considered on case-by-case basis.

(a) Piling, retaining walls and boreholes which are located less than 6m but more than 3m horizontally from the extreme edge of rapid transit system structures; and

(b) Limited bakau piling terminating at least 3m above the crown of the rapid transit system tunnels or underground structures.

(c) For diaphragm wall excavation within or near to first reserve, the panel size shall not exceed 3m in width.

3.3.3 DEBONDING OF LOAD BEARING PILES

3.3.3.1 Load bearing piles shall be designed so that they are debonded within the zone of influence of the underground, transition or sub-aqueous structures. They shall develop their load capacities either in shear or end bearing from soil located below the zone of influence of the underground, transition (see *Figure 3* and *Figure 4*) or sub-aqueous structures.

3.3.3.2 Details of the proposal including the thickness of all casings, gap between inner and outer permanent casings, type and thickness of debonding membrane, etc. shall be clearly shown.

3.3.3.3 The installation sequence and procedure including the measures to prevent concrete flowing into the gap between the inner and outer permanent casings during concreting shall also be included.

3.3.3.4 For piles with single permanent casing, temporary casing shall be provided to prevent the debonding membrane on the permanent casing from being damaged during installation.

3.3.3.5 All temporary casing shall be installed to the debonding level to prevent the ground from moving into the borehole.

3.3.3.6 Where piles within the first reserve of the rapid transit system structures are permitted, permanent left-in outer casing shall be provided to ensure ground stability. The depth of outer casing must be equal to the length of the debonding depth.

3.3.3.7 Details for a single and double casing debonding system as illustrated in *Figure 19* and *Figure 20* shall be adopted.

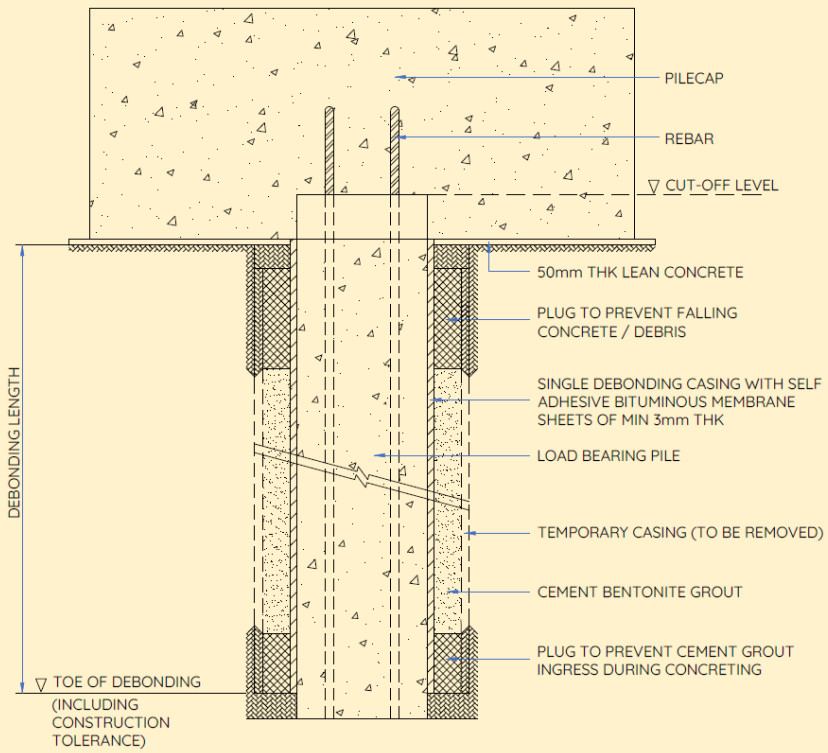


Figure 19 - Typical single casing debonding details

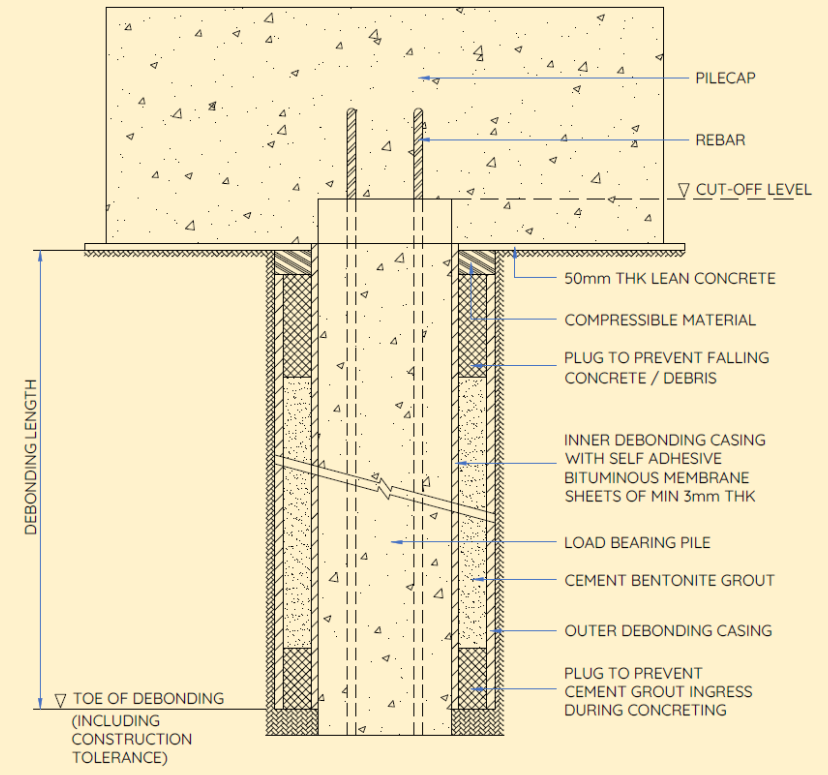


Figure 20 - Typical double casing debonding details

3.3.4 GROUND ANCHOR OR TIE BACKS

The use of ground anchors or tie backs in the railway protection zone shall satisfy the conditions of *Table 4* below.

	First Reserve	Outside First Reserve	
		Second Reserve	Third Reserve
Underground, Transition or Sub-aqueous	Not allowed	Not allowed	Allowed
At grade	Not allowed	Not allowed	Allowed
Above ground	Not allowed	Allowed if ground anchors or tie-backs are kept at least 3m clear on plan of the toe of the existing raker pile supporting the rapid transit system structure.	

Table 4 - Ground Anchors or Tie Backs

3.3.5 DREDGING WORKS

Dredging of seabed or riverbed in the railway protection zone shall satisfy the conditions of *Table 5* below.

Location	Allowable Dredging Level Singapore Height Datum (m)
Between Raffles Place station to City Hall station (Singapore River)	-3.8
Between Clarke Quay station to Dhoby Ghaut station (Singapore River)	-4
Between Nicoll Highway station to Boulevard station (Kallang Basin River)	-6

Table 5 - Allowable dredging level

Note:
Vertical control datum shall be based on Singapore Height Datum (SHD).

3.3.6 Basement Construction

3.3.6.1 Where basements are more than 1m below the existing ground water table, they shall be made watertight. The base slab shall be designed for full hydrostatic pressures and pressure relief in the form of weepholes or drainage blankets is not allowed.

3.3.6.2 The base of an excavation shall be provided with blinding concrete immediately after reaching the formation to minimise lowering of ground water.

3.3.7 Tunnel Construction

3.3.7.1 Tunnelling could result in ground loss which is highly dependent on the tunnelling or construction technique employed and the ground conditions. The construction method adopted shall minimise risks related to the following:

(a) Movement to rapid transit system structures.

(b) Safety of the rapid transit systems associated with ground collapse.

(c) Danger to the operation of the railway and the integrity of the existing rapid transit system structures.

(d) Vibration levels which may influence the integrity of the rapid transit system structures and operation of the railway.

3.3.7.2 To mitigate the risk to the rapid transit systems, the following measures shall be considered and provided where relevant:

(a) The tunnel shall be continuously and fully supported with a permanent lining designed to support the full overburden including water load with minimal deformation during the work as illustrated in *Figure 21*. Technique such as NATM method where the ground is not immediately supported after excavation is not acceptable unless the inherent risks are reduced to acceptable levels.

(b) Ground loss from the face and tail void or over-break, etc. shall be minimised by providing adequate support to the face and continuous tail void grouting as illustrated in *Figure 21*.

(c) Ground improvement measures such as grouting, pipe arch roof techniques shall be adopted to prevent ground collapse or ravelling of soil, etc.

(d) Use of blasting technique to remove hard strata or obstruction is not acceptable unless the inherent risks are reduced to acceptable levels.

(e) Measures to prevent ingress of water with fines/ soil must be implemented.

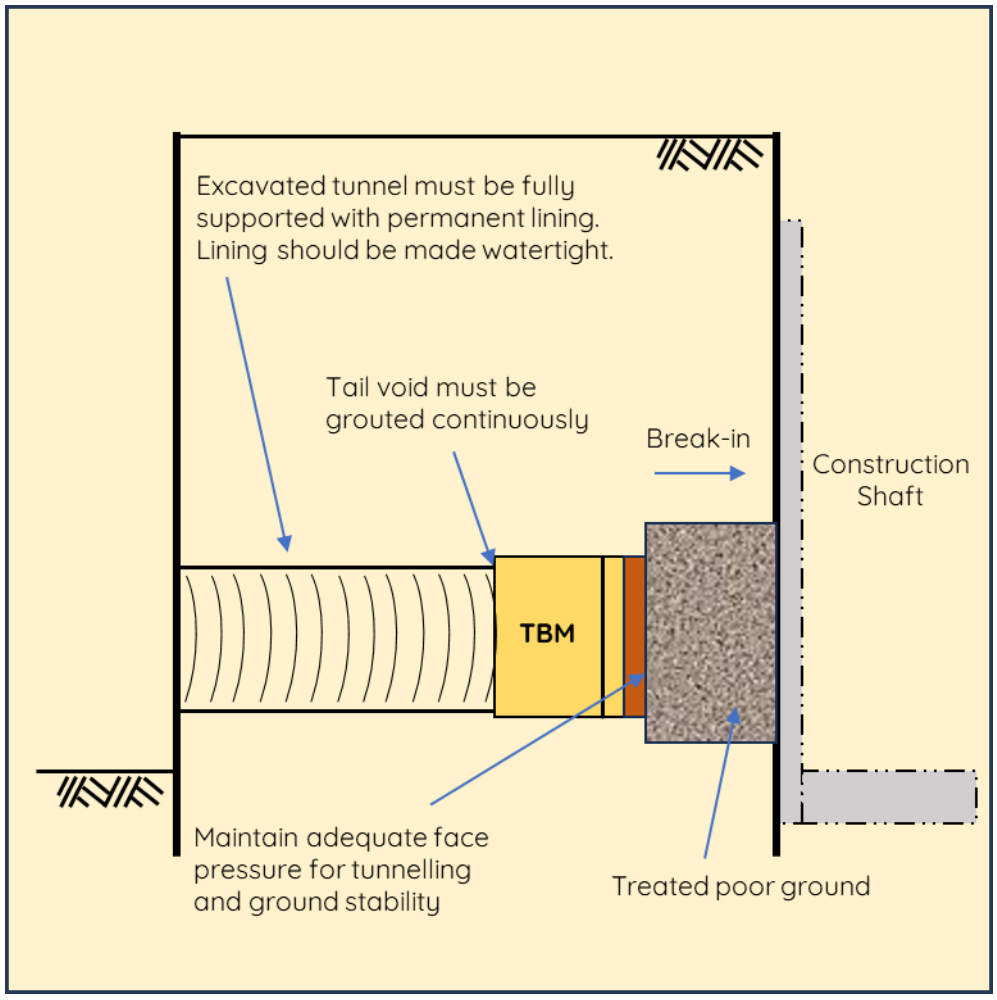


Figure 21 - Precautions to be taken during tunnelling works.

3.3.7.3 Where a proposed tunnel is required to "break-in" or "breakout" at a construction shaft located near the existing rapid transit system structures, the following shall be considered:

(a) Stability of temporary wall erected for the shaft construction during "break-in" or "breakout."

(b) Adequacy of the permanent shaft wall for the creation of the opening for the tunnel.

(c) Vibration induced at the nearby rapid transit system structures during the breaking of permanent shaft wall shall not exceed the limit in the Code.

(d) Water draw-down through any gap between the shaft and temporary wall shall be avoided.

3.3.7.4 Where tunnel construction works are permitted, the temporary or permanent linings shall be made watertight to prevent any seepage of water into the proposed tunnels under both temporary and permanent conditions.

3.3.8 Excavation Works

3.3.8.1 Excavation works in the railway protection zone shall satisfy the following conditions, where applicable:

(a) Piezometric Pressure in Compressible Soil

The piezometric pressure in compressible soils within the first and second reserves shall not be reduced by more than 10kPa. Where the rapid transit system structures are supported on piles or other foundations extending below the compressible layer, this clause may be waived. The definition of compressible soils shall be referred from the LTA Civil Design Criteria for Road and Rail Transit Systems.

(b) Cut-off Wall

No trench, excavation, caisson, pile or well deeper than 1m below the existing ground water level shall be allowed unless suitable measures such as installation of cut-off wall, excavation under stabilising fluid or mud, etc. are taken to control the reduction of piezometric pressure.

(c) The stability of the rapid transit system structures adjacent to/ below the excavation shall be checked against the effect of buoyancy, uplifting, etc.

(d) The design of temporary works for the excavation shall ensure adequate factor of safety against basal heave, hydraulic uplift of the base, toe-stability of retaining walls, material failure, strut failure, etc.

3.3.8.2 The design of temporary works for the excavation shall be in accordance with acceptable codes of practice. Besides other safety considerations, the design shall consider the following aspects:

(a) Effects due to hydrostatic pressure from the soil

(b) Effects due to both drained and undrained conditions of the soil

(c) Effects of surcharge loads, including incidental loads, adjacent slope

(d) Wall embedment and overall wall stability

(e) Provisions of restraints in structural members' connections, ties and bracings

(f) Adequate embedment for piles and temporary retaining walls

(g) Provision of preloading on struts

(h) Varying load conditions on the wall during stages of the construction

3.3.8.3 The design of temporary works for excavation shall also include the following specific control:

(a) Cater for a surcharge load of at least 10kN per square metre and other incidental loadings

(b) Adopt full water table height when considering water pressure acting on the wall

(c) Not to use Terzaghi's and Peck Pressure Envelope to compute bending moment on the wall

(d) Not to use net pressure method in stability analysis for the wall

(e) Cater for a minimum depth of 0.5m for unplanned excavation

(f) Check for one-strut failure

(g) Comply with prevailing requirements and regulations from respective technical agencies and latest Singapore's adoption of Eurocode (SS EN) and their National Annexes.

3.3.8.4 For works within first reserve, it must not affect the integrity of waterproofing system of the underground rapid transit system structures.

3.3.8.5 Excavation shall be carried out in a compartmentalised manner to minimise the ground movement where appropriate. Lateral supports to earth retaining walls shall be installed immediately after each stage of excavation.

3.3.8.6 Earth retaining walls shall be sufficiently watertight to prevent ground water draw-down and gaps between individual pile of earth retaining walls shall be sealed.

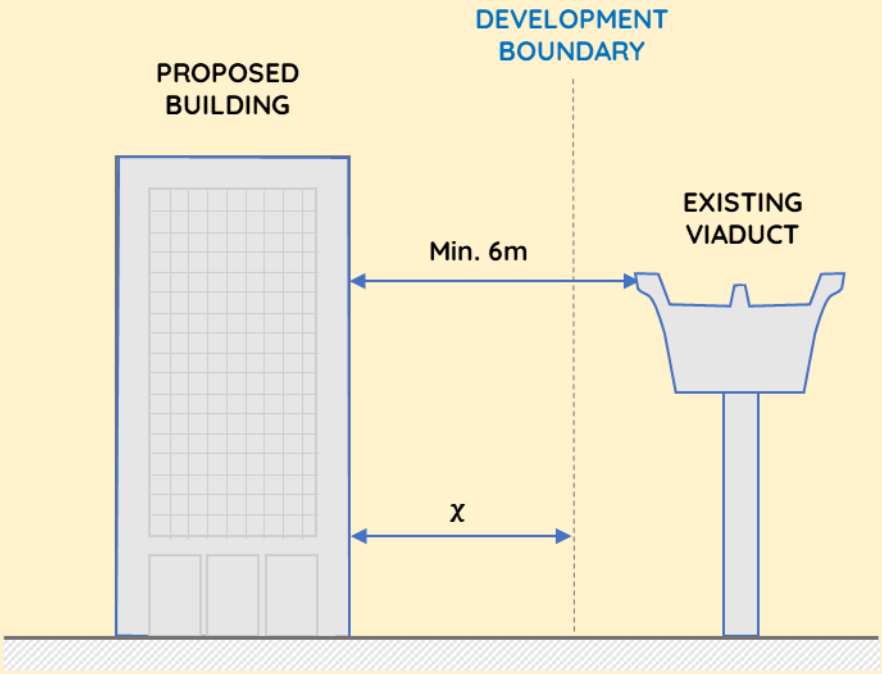
3.4 BUILDING WORKS IN ALL RESERVES

3.4.1 Building Adjacent to Above Ground Structure

3.4.1.1 The layout and design of any building adjacent to the aboveground structures shall comply with the conditions below:

(a) The external walls of adjacent building shall be at least 6m clear or the separation setback distance calculated for unprotected opening in accordance with the Code of Practice for Fire Precautions in Buildings (Fire Code), whichever is greater, from the outermost edge of the rapid transit system structures as shown in *Figure 22(a)* to *Figure 22(e).*

(b) The building shall be orientated preferably with the end walls facing the rapid transit system structures. The building facade facing the rapid transit system structures shall be designed such that incidence of "Killer Litter" that will affect the safety of railway will not occur. Adequate screening of windows or openings shall be provided where necessary.



Distance between the proposed building and outermost edge of rapid transit system viaduct shall be at least 6m.

Distance between the proposed building and development boundary, χ, must also comply with the distance stipulated in the Fire Code.

Figure 22(a) - Separation Distance – Viaduct outside development boundary

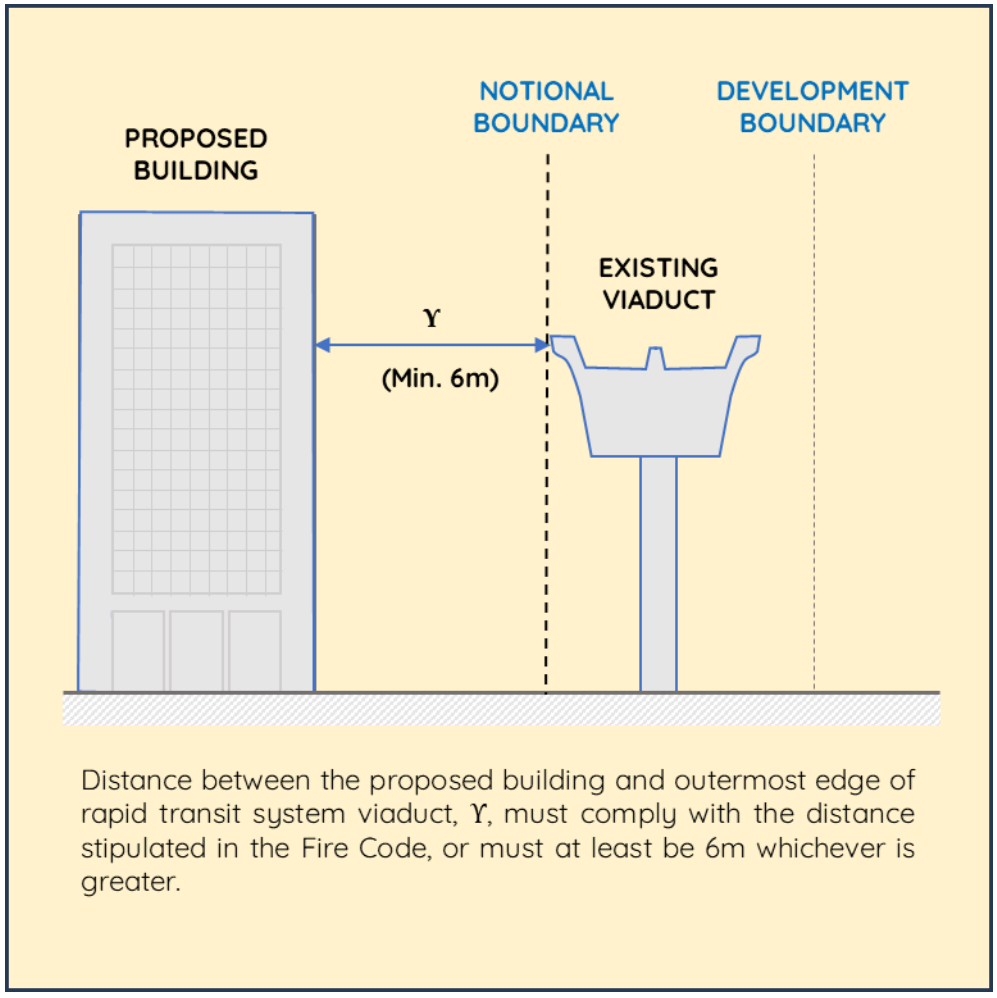


Figure 22(b) - Separation Distance – Viaduct within development boundary

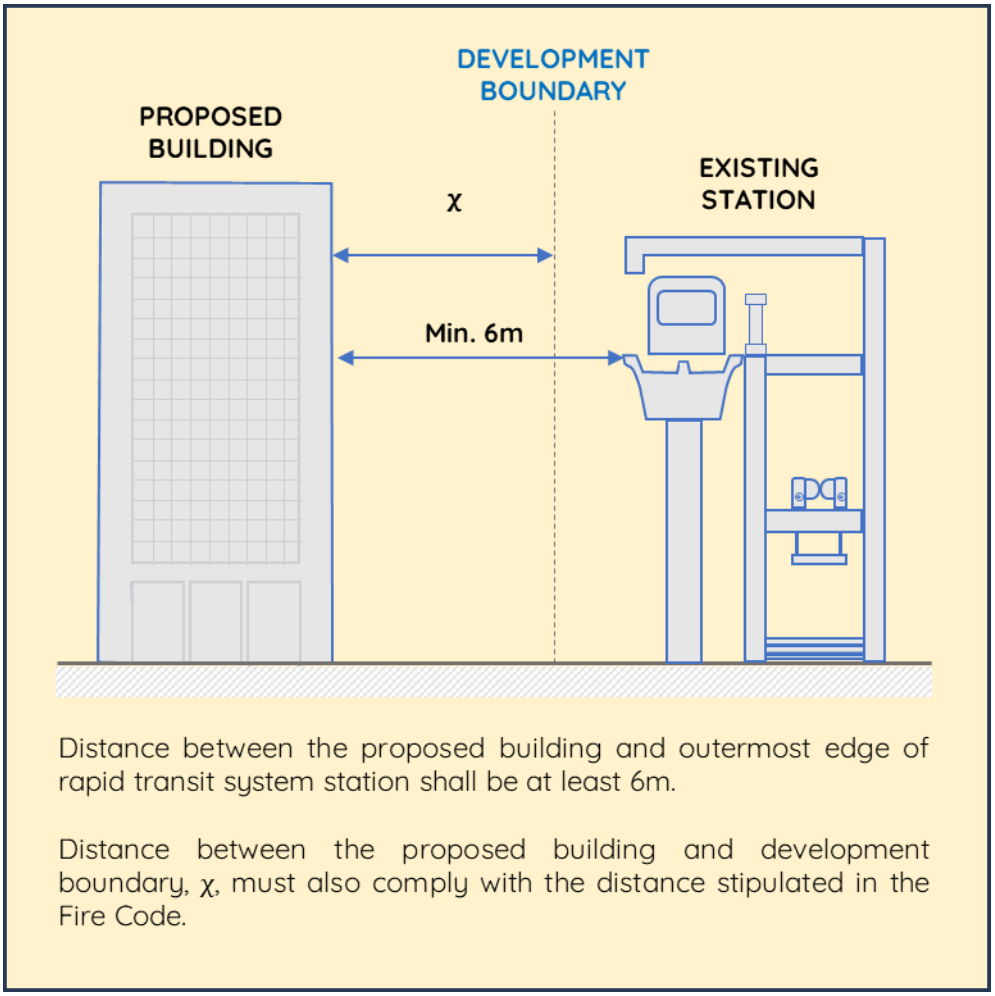


Figure 22(c) - Separation Distance – Station outside development boundary

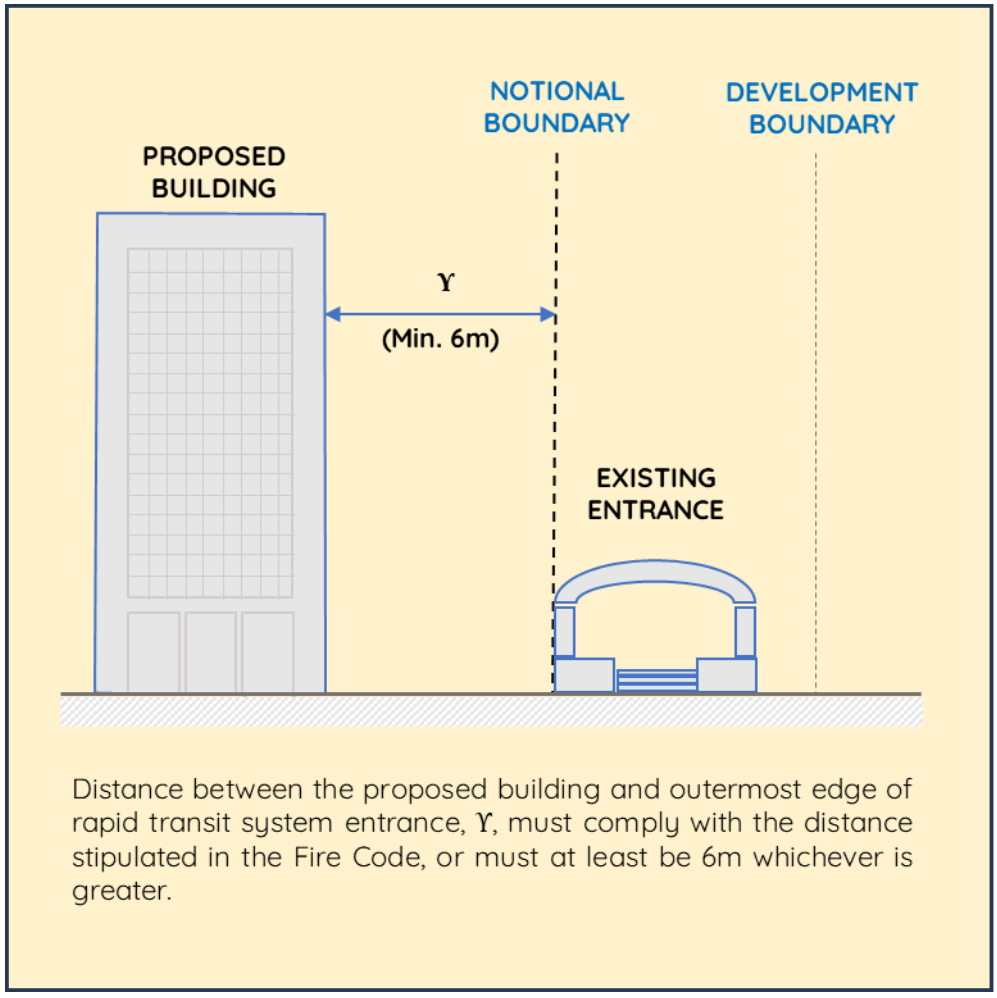
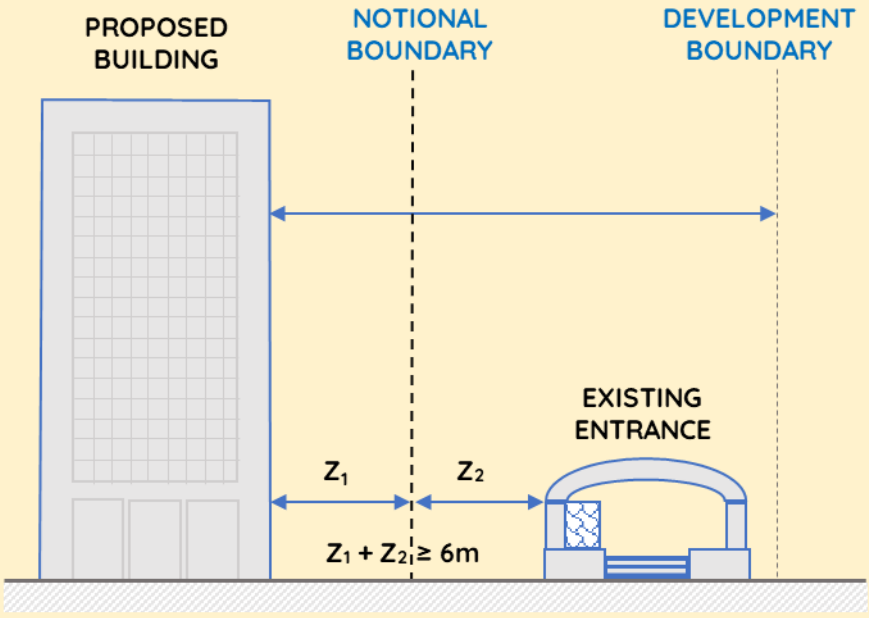


Figure 22(d) - Separation Distance – Station entrance (without habitable room) within development boundary



Distance between the proposed building and outermost edge of rapid transit system station entrance shall be at least 6m.

Distance between the proposed building and the notional boundary, Z_1, must comply with the distance stipulated in the Fire Code.

Distance between the proposed building and the notional boundary, Z_2, must comply with the distance stipulated in the Fire Code.

Figure 22(e) - Separation Distance - Station entrance (with habitable rooms) within development boundary

3.4.1.2 For proposed development within 20m of any MRT station's exterior entrance or aboveground rapid transit system structures with CCTV installed, the qualified person must ensure that the CCTV's field of view is not affected by the proposed development. This must be clearly indicated in the submission.

3.4.1.3 For above ground rapid transit system structures, there must be a minimum 3000mm spherical clearance from the edge of the RTS façade such as MRT viaduct, station soffit etc. to the proposed works/development. Minimum 3000mm clearance must be indicated on both the layouts and cross-sectional drawings.

3.4.2 Building Under Rapid Transit System Viaduct

3.4.2.1 The space beneath the viaduct can be used for commercial, institutional and other purposes as given in the examples below:

(a) Commercial – Kiosk, convenience/ retail store, shopping complex, office, bank, restaurant, pub, beer garden, café, entertainment, cinema, karaoke lounge, video arcade, commercial school, etc.

(b) Institutional – Police station, community club, home for the aged, library, museum, childcare centre, family activities centre, tuition centre, etc.

(c) Others – Parks, children playground, etc.

3.4.2.2 The layout and design of any building under and within 6m from outermost edge of the rapid transit system viaduct shall comply with the conditions below:

3.4.2.2.1 Fire safety requirements

(a) The development shall not affect the accessibility to firefighting facilities for the rapid transit system viaduct at all times.

(b) The rapid transit system columns enclosed within the building shall be provided with a 25mm thick plaster all-round the development as shown in *Figure 23(a).*

(c) Fire-rated wall/roof with minimum 2-hour fire rating shall be provided within 6m of the rapid transit system viaduct to protect the viaduct against fire from the development. The fire-rated wall/roof provided shall be constructed to the same specification as that of a specimen exposed to test by fire in accordance with the method and procedure under BS 476: Part 20 to 23 and satisfied the requirements of that test for the three performance criteria of stability, integrity and insulation for not less than 2 hours. There shall be no opening on the fire-rated roof. For windows and other openings on the fire-rated walls, 2-hour fire-rated dampers/doors/shutters shall be provided. If sprinkler protection is provided, the fire resistance rating can be reduced to at least 1 hour. (See Figure 23(a))

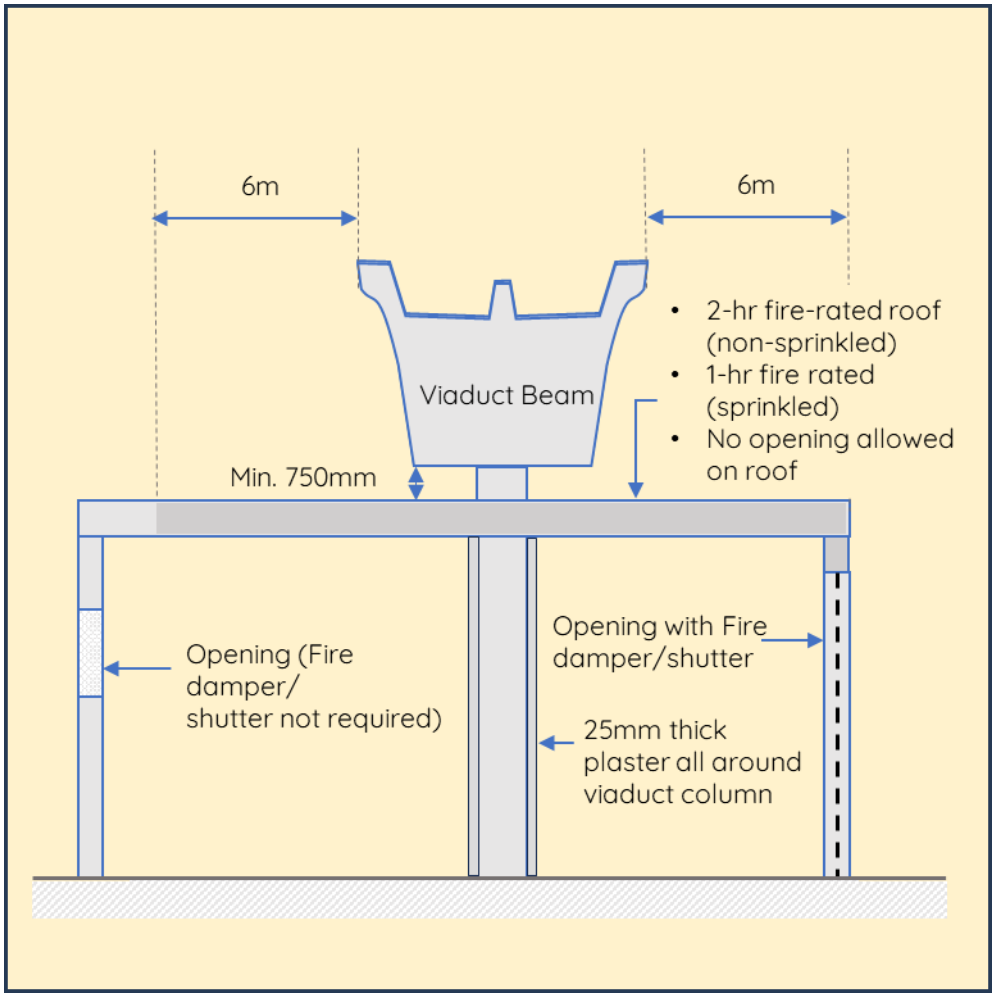


Figure 23(a) - Proposed building below viaduct

(d) Sprinkler Protection

(i) For building with fire-rated compartment(s) smaller or equal to 150m^2, automatic fire sprinkler system need not be provided.

(ii) For building with compartment larger than 150m^2 and below 4000m^2, automatic fire sprinkler system shall be provided as shown in *Figure 23 (b).* The automatic fire sprinkler system shall be designed in compliance with SS CP 52 Code of Practice for Automatic Sprinkler System with the following exceptions:

- The system to be designed by hydraulic calculation.
- Pump sized according to the flow and pressure required from hydraulic calculation.
- The minimum stored water supply requirement is the maximum calculated demand for a period of 30 minutes.
- Fire Service breeching inlet is not required.

(e) An automatic fire alarm system shall be provided in compliance with SS 645:2019 Code of Practice for the Installation and Servicing of Electrical Fire Alarm Systems. For buildings protected by automatic fire sprinkler system, sprinkler flow switch can be allowed to activate the fire alarm system. The automatic fire alarm system shall be connected to a fire station through an approved alarm monitoring station.

(f) There shall not be any use of liquefied petroleum gas or any storage of flammable liquids or highly combustible substances.

(g) Where low-pressure PUB manufactured gas supply is provided, the gas supply systems shall comply with the requirements of SS 608 Code of Practice for Gas Installation. The safety cut-off valve of the gas monitoring system shall also be interlocked with the fire alarm system to cut off the gas supply in the event of fire emergency. Approved extinguishing systems shall be fitted for all the cooking facilities.

(h) The building owner shall engage a Qualified person to carry out annual testing of the automatic fire protection and detection systems, fire safety measures, gas monitoring system, etc. provided and to

certify them to be in good working condition and shall submit a copy of the certification to the Authority.

(i) Equip cooking facilities and kitchen hood (if any) with automatic fire extinguishing system as illustrated in *Figure 23(c)*.

3.4.2.2.2 Maintenance requirements

(a) Building roof shall be at least 0.75m clear below the viaduct beam soffit level as shown in *Figure 23(a).*

(b) There shall be no placement of equipment such as air-con condenser above the level of the building roof.

(c) There shall be proper access provided to allow for the inspection and maintenance of the rapid transit system structures.

(d) Building roof below the viaduct shall be designed for bearing replacement such that the jacking load could be transferred to the ground. The ground floor slab must likewise be designed for the imposed loading.

(e) Building shall not transfer any loading onto the rapid transit system viaduct structures.

3.4.2.2.3 Other requirements

(a) Viaduct drainage system, if affected, shall be suitably diverted. Building drainage system shall not be discharged into the viaduct drainage system.

(b) Viaduct lightning protection system, if affected, shall be suitably diverted, reinstated and tested.

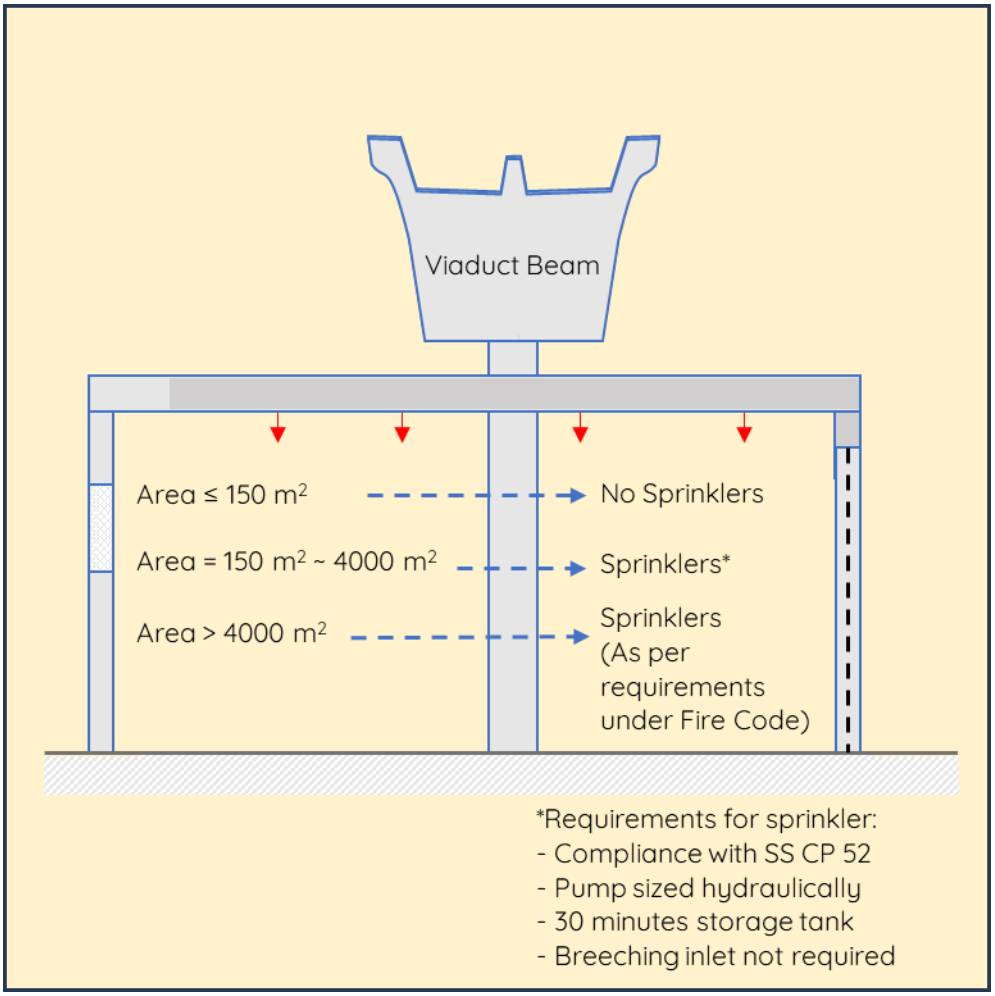


Figure 23(b) - Provision of sprinkler for building under viaduct

Note: When sprinkler is provided in a building, the sprinkler system's flow switch can be allowed to activate the fire alarm system. In such case, detector(s) may be omitted in sprinkler protected areas.

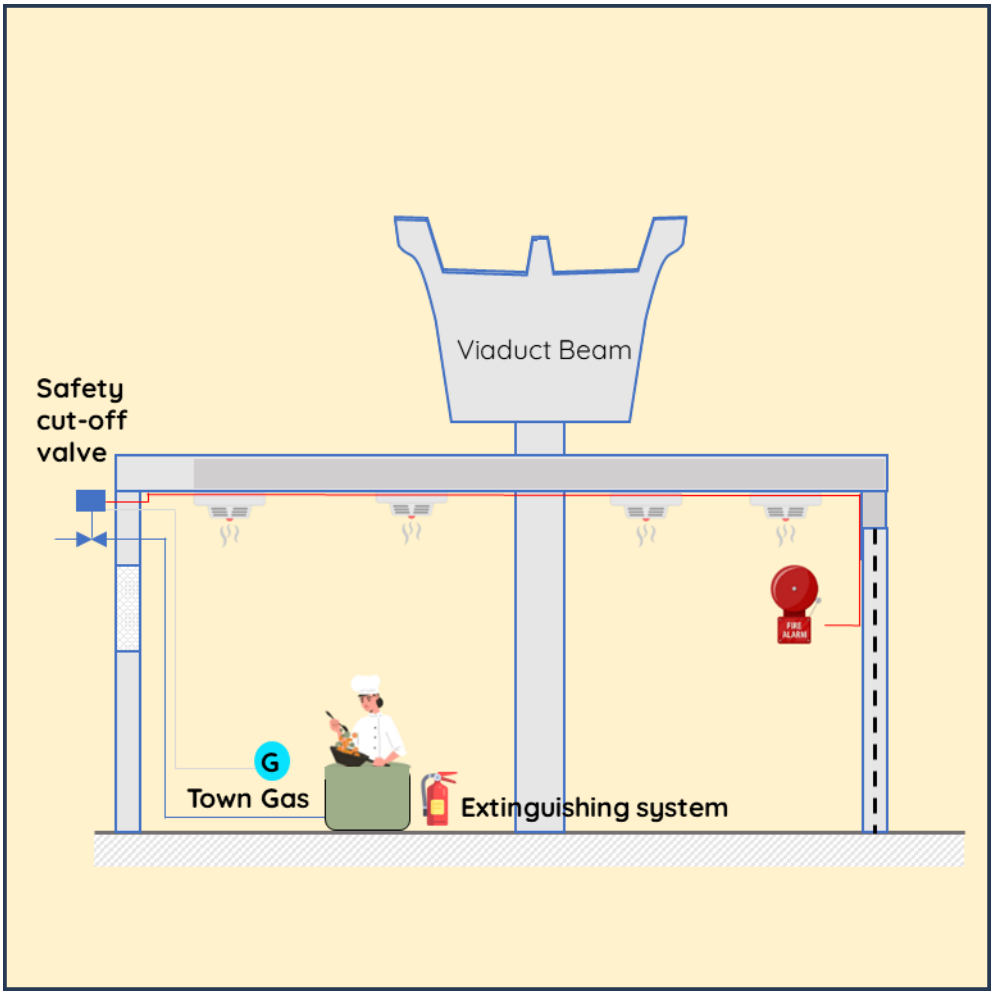


Figure 23(c) - Cooking facilities and cooker hood (if any) provided with fire protection system for building under viaduct

3.4.3 Building Over Rapid Transit System Viaduct

3.4.3.1 Where there is building with habitable floor(s) directly above and around a trainway, as shown in *Figure 24*,

(a) The fire resistance of the elements of structure around the trainway shall be not less than 4 hours. The trainway shall be considered as an enclosed trainway. The fire safety provisions for the enclosed trainway shall comply with the Code of Practice for Fire Precautions in Rapid Transit Systems. These may include but not limited to the following:

(i) Exit signs and emergency lighting

(ii) Dry rising main system

(iii) Emergency ventilation system, etc.

(b) The proposed building shall also take into consideration the space required for structure gauge clearance, viaduct beam replacement, etc. The qualified person must assess and demonstrate that the above conditions are met for enclosing the trainway.

(c) The building facade facing the rapid transit system structures shall be designed such that incidence of “Killer Litter” or unauthorised access that will affect the safety of railway will not occur. Adequate screening of windows or openings shall be provided where necessary.

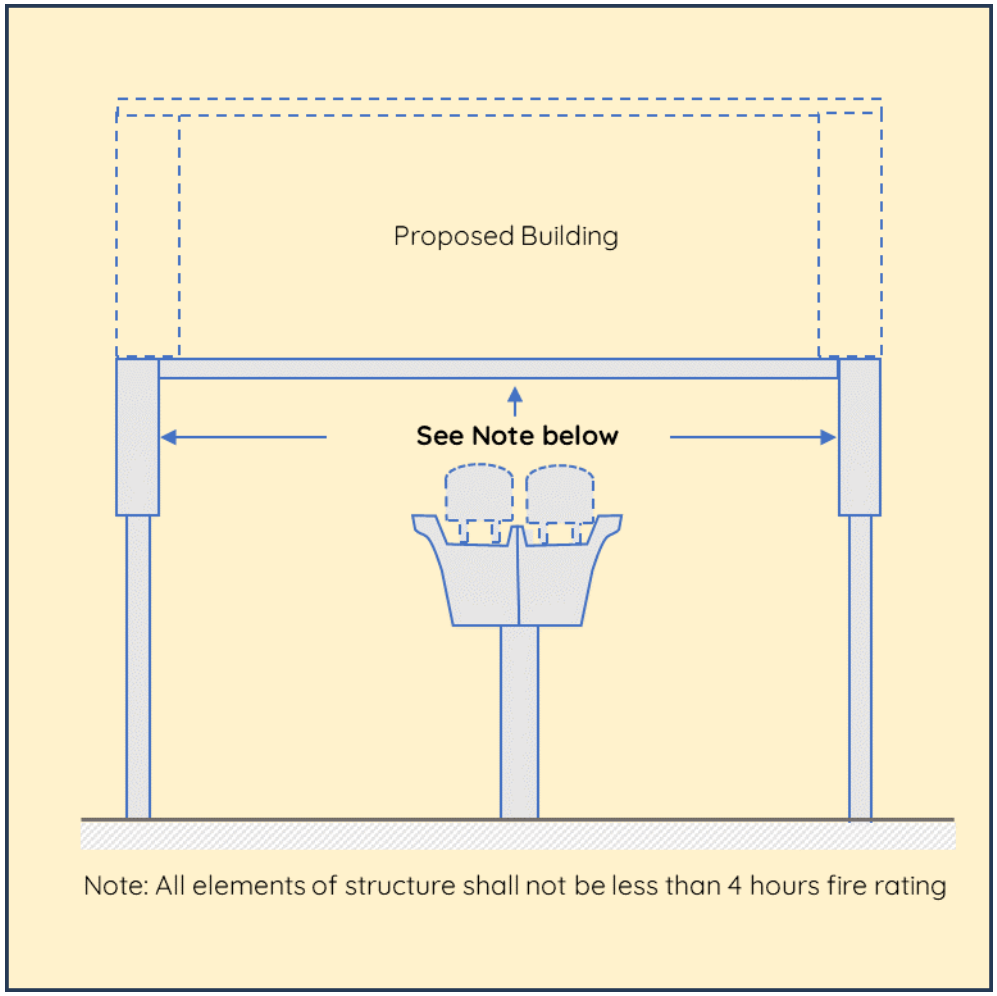


Figure 24 - Fire resistance of elements of structure around trainway

3.4.4 Building With Integration or Interface With Rapid Transit System Station

3.4.4.1 General

3.4.4.1.1 Building with integration or interface with rapid transit system station shall satisfy the requirements of this section, and PART III of the Guidebook for Carrying Out Modification Work to Rapid Transit System (RTS) Stations or Railway by Private Developer where applicable.

3.4.4.1.2 Any structures and facilities to be handed over to the Authority for railway operation upon completion shall comply with Authority's prevailing requirements, which include:

(a) LTA Civil Design Criteria for Road and Rails Transit Systems

(b) LTA Materials & Workmanship Specification for Architectural works

(c) LTA Materials & Workmanship Specification for Civil & Structural works

(d) LTA Infrastructure Design Criteria

(e) Engineering Standards (Environmental control systems, fire protection and electrical systems) and specification (lifts, escalators, etc).

3.4.4.2 Fire safety requirements

All building works including any fire safety works to be carried out within the boundary of the rapid transit systems shall comply with prevailing requirements of the Code of Practice for Fire Precautions in Rapid Transit Systems.

3.4.4.2.1 Where a proposed building (including any linkage in the form of underground pedestrian network) integrates or interfaces with the entrance of an underground rapid transit system station, the conditions below shall be satisfied:

(a) Unobstructed egress from the entrance to the external shall be provided. The egress width shall not be less than the total width of the entrance stairs and escalators.

(b) The proposed building shall be separated from the station entrance, other than the egress opening to the external, with fire barriers having

at least 2 hours fire resistance. The link shall not be used as a means of escape.

(c) There shall be no unprotected openings of occupancy area within 3m of the ventilation openings located in the external wall of the entrance. A smoke barrier/screen shall be provided at the interface to prevent smoke at the ceiling level of the proposed building from entering the station entrance as illustrated in *Figure 25(a).* The lower edge of the smoke barrier/screen shall be at least 500mm lower than the ceiling level or the facial beam at the external facade of the proposed building, whichever is lower, as illustrated in *Figure 25(b)*.

(d) Fire shutter(s) with minimum 2 hours fire resistance shall be provided within the boundary of the proposed building for the purpose of fire separation. The design of the fire shutter(s) and its mode of activation shall comply with the requirements stipulated in the Code of Practice for Fire Precautions in Rapid Transit Systems and PART III of the Guidebook for Carrying Out Modification Work to Rapid Transit System (RTS) Stations or Railway by Private Developer.

(e) The developer shall carry out regular maintenance of the fire shutter(s) and engage a qualified person (mechanical discipline) to carry out annual testing of the fire shutter(s) to be witnessed by the Authority. The qualified person shall submit a letter certifying that the fire shutter(s) and monitoring system are in good working condition.

(f) Where an entrance to the underground station is enclosed and without fresh air supply, there shall be adequate openings to allow replacement air to be supplied to the station. Automatic louvered vents and automatic doors designed to open upon activation of the station smoke purging system or the emergency ventilation for the trainway shall be proposed.

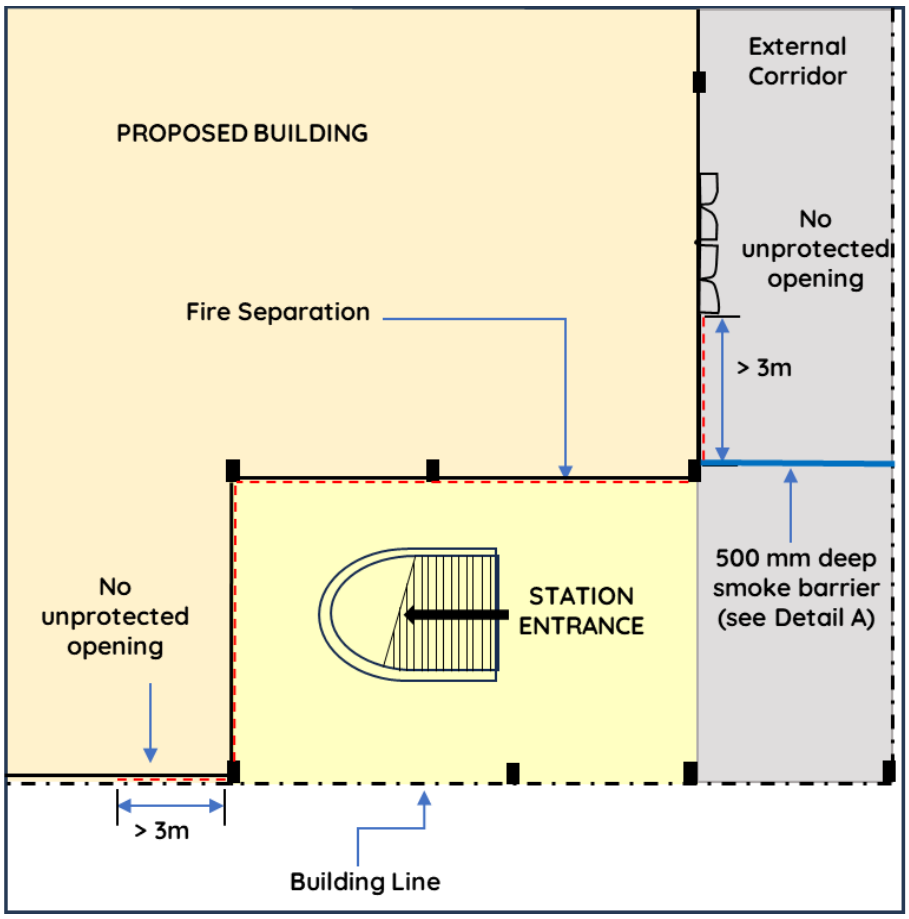


Figure 25(a) - Locations of "fire separation", "no unprotected opening" and smoke barrier at interface

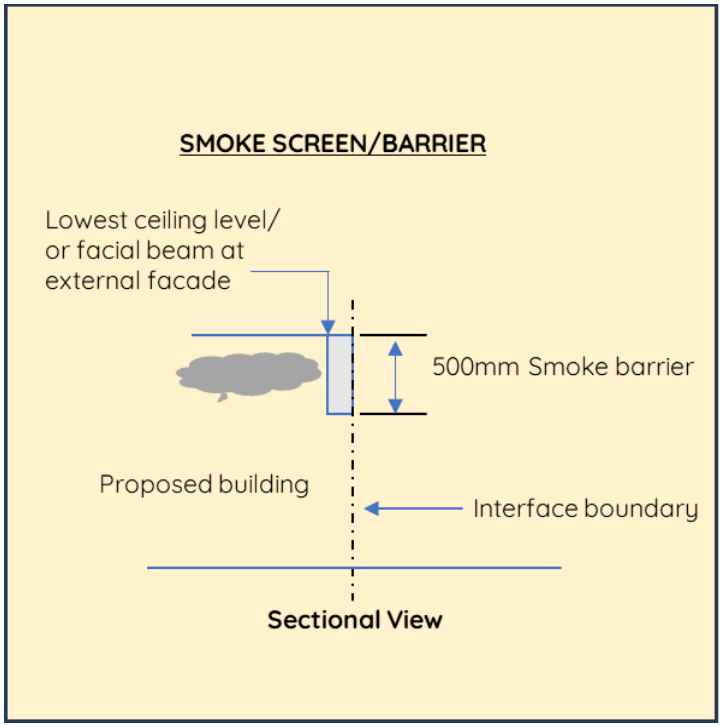


Figure 25(b) - Detail A – Provision of smoke barrier at interface

3.4.4.3 Flood protection requirements

(a) The minimum crest level for all entrances or openings of the proposed underground structures shall comply with the requirements of the Code of Practice on Surface Water Drainage. A copy of clearance letter from the competent Authority shall be submitted.

(b) The construction and design of the integrated development and affected rapid transit systems discharge pipes and sewer pipes shall comply with the requirements of LTA Civil Design Criteria for Road and Rail Transit Systems and the Guidebook for Carrying Out Modification Work to Rapid Transit System (RTS) Stations or Railway by Private Developer.

(c) Openings and services penetrations below the minimum crest levels shall be permanently sealed and made watertight.

(d) Any part of the existing rapid transit system structures below the minimum crest level shall not be punctured unless the construction of the integrated structure and adjoining development has reached a level at or above the station threshold level.

(e) A temporary shelter structure with built-up wall to minimum crest level or 1.3m above the existing ground level (whichever is greater) shall be erected around the openings to prevent water inflow as illustrated in *Figure 26*.

(f) Discharge pipes and sewer pipes shall be provided with a swan neck connection to prevent any back flow of water into the proposed underground structures integrating with the existing station. The invert level of the pipe at the swan neck location shall not be lower than the minimum crest levels as stipulated in the Code of Practice on Surface Water Drainage.

(g) The developer shall carry out regular maintenance and annual testing of the flood protection systems to be witnessed by the Authority to ensure that they are in good working condition. During commissioning and annual testing, the flood protection systems must be certified by a competent person such as a Professional Engineer in Mechanical or Civil disciplines or a Marine Surveyor with Lloyd Registry of Shipping, ABS who have relevant experience. A letter certifying that the flood

protection system(s) is in good working condition shall be submitted to the Authority.

(h) The link structure of the development shall be screeded to fall and drain away from the rapid transit system structure.

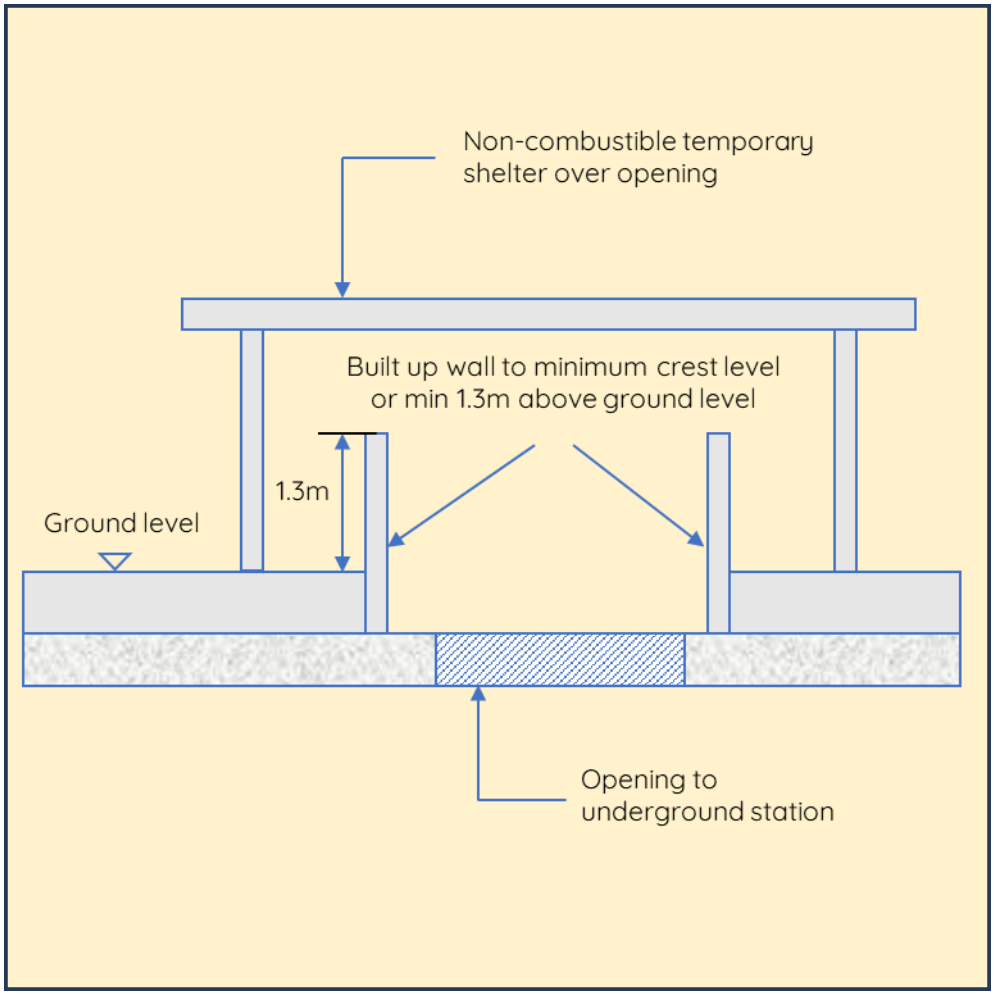


Figure 26 - Temporary flood protection measures provided for opening created in the rapid transit system structure

3.4.4.4 Waterproofing requirements

(a) The interface between the proposed building and the existing underground station shall be provided with a waterproofing system, which is robust and able to withstand the calculated hydrostatic pressure and differential movements between the connecting structures.

(b) The design of the waterproofing system shall comply with the requirements of the LTA Materials & Workmanship Specification for Civil & Structural works.

(c) The waterproofing system shall have at least a ten-year warranty period. The developer shall be responsible for the maintenance and replacement of the waterproofing system at the interface. The extent of areas for the waterproofing warranty shall be extended 3m beyond and all-round the affected waterproofing area. A warranty certificate covering the interest of the Authority shall be submitted.

4. TECHNICAL REQUIREMENTS WITHIN RAILWAY CORRIDOR

This section stipulates the general technical requirements for any development and building works in railway corridor.

4.1 Notwithstanding the provisions in this section, the Authority reserves the right to impose any other requirements that are deemed necessary for safeguarding of the proposed rapid transit systems.

4.2 Development and building works in the railway corridor shall comply with the requirements below:

(a) The design and construction of the proposed development shall comply with the Code of Practice for Railway Protection and other conditions under which the plans and amendments are cleared.

(b) The proposed development may be affected by changes in ground conditions, vibration and noise as a result of the construction and the operation of the proposed rapid transit systems. The design of the proposal shall take into consideration these effects and the engineering evaluation report submitted shall include an assessment of the likely effects of the construction and operation of the proposed rapid transit systems on the proposed development.

(c) The proposed development shall not cause the proposed rapid transit system structures to be stressed beyond design loading catered for. The surcharge value at ground level for this assessment shall be obtained from the Authority.

(d) Deep foundation, secant pile wall, contiguous bored pile wall, sheet pile wall, diaphragm wall or similar are not permitted within the railway area and 3m from it.

(e) The platform level of the proposed development shall meet requirements for flood protection of rapid transit systems if there is connection to future underground station. The minimum crest levels for all entrances or openings of the proposed development shall comply with the requirements of the Code of Practice on Surface Water Drainage.

4.3 In addition, when the rapid transit system structures are in place while the development and building works are in progress, the developer shall comply with the requirements stipulated for railway protection zone.

PART IV – SUPERVISION OF WORKS

The developer shall appoint and notify the Authority of the qualified person supervising the development and engineering works in accordance with Regulation 11.

This part specifies the duties to be carried out by the qualified person in addition to those stipulated in *Regulation 11* and *Regulation 13*.

1. UNDERTAKING FOR SUPERVISION

1.1 Qualified person appointed under Regulation 11 for supervision shall provide an undertaking to supervise development and engineering work in the railway protection zone and railway corridor using *Form LTA DBC RAIL-PERMIT*.

1.2 The above form shall be resubmitted whenever there is a change in the owner/ developer or qualified person appointed for supervision or the builder.

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2. MONITORING OF RAPID TRANSIT SYSTEMS

2.1 The qualified person shall continuously monitor the effects of construction works on the rapid transit system structures, tracks and the ground. He shall analyse the monitoring results, 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.

2.2 Once the monitoring readings are taken, they shall be submitted to the Authority weekly. A report of the review and the monitoring results endorsed by a qualified person shall be submitted to the Authority within a week from the date of monitoring.

2.3 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, the Authority may revoke the permit. The developer shall take additional measures to control movements to within the acceptable limits, all at the cost and expense of the developer before the work is allowed to resume.

2.4 The monitoring shall continue until all works that may affect the movement of the rapid transit system structures have been completed and the monitoring results show that the rapid transit system structures and the surrounding ground have stabilised and no further movement or change would be anticipated.

3. PROTECTION OF RAPID TRANSIT SYSTEMS

Preventive measures shall be taken during construction stage to prevent any damage to the existing rapid transit systems such as their structures, mechanical and electrical works (including signalling), architectural finishes, external works and lightning protection and drainage systems of above ground structures.

4. COMPLETION OF WORK

4.1 Condition surveys of the rapid transit systems shall be carried out upon completion of the proposed works or at intermediate stages as directed by the Authority. Defects found shall be highlighted and compared with the findings of precondition survey.

4.2 A proposal on making good of all defects arising from the development found in the rapid transit systems (including that of its facilities and tracks) prepared and endorsed by the qualified person shall be submitted to the Authority for prior approval.

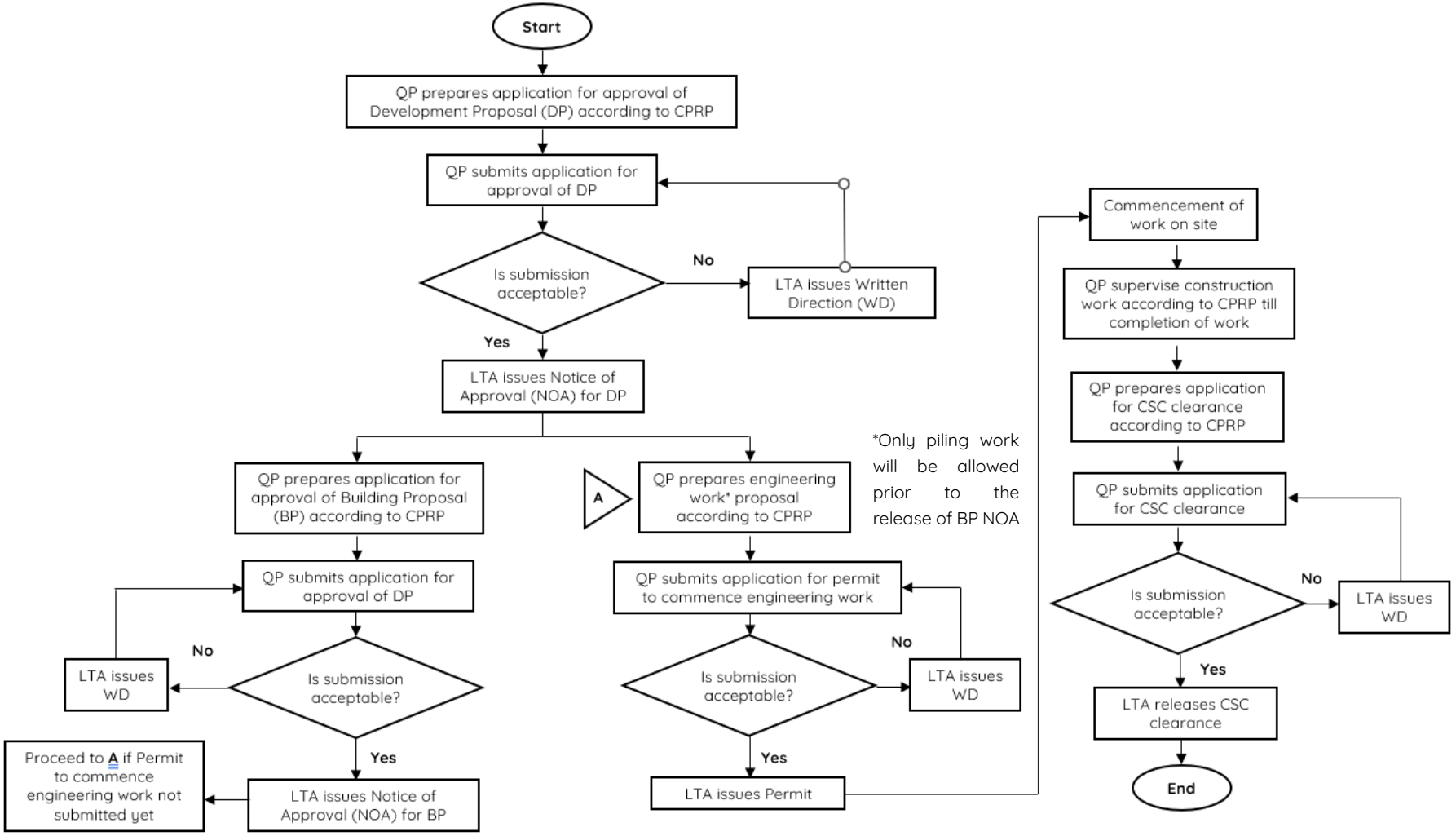
4.3 Making good of defects arising from the development and building works shall be completed to the satisfaction of the Authority. The developer shall bear all direct or indirect costs arising from the rectification works. A report on the remedial work done shall be submitted upon completion of all remedial work.

4.4 Defects and damages rectified shall be highlighted with photograph and compared with those found after the completion of work indicated in the final condition survey report.

PART V – APPENDICES

This section provides supplementary materials to enhance the understanding of the Code.

Appendix A – General submission process for development work within the railway protection zone and railway corridor



Appendix B – Application For Access

1. GENERAL

1.1 This section stipulates the procedure for applying to gain access to the rapid transit system track or station premises.

1.2 Access to track can only be obtained during non-operational hours of trains.

1.3 All personnel working in rapid transit system premises shall abide by the rules and conditions of the Authority and its licensed transit operator.

2. APPLICATION FOR ACCESS

2.1 Application for access to track or into the station premises shall be submitted to Authority's officer-in-charge at least two weeks in advance of the access required.

2.2 The applicant shall clearly state the following items:

(a) The reason(s) for requesting an access to the track or into the station premises;

(b) The names and identification card numbers of all personnel gaining access to the track or into the station premises;

(c) List and details of equipment, tools to be brought to the track or into the station premises; and

(d) Drawing clearly showing the stretch (or chainages, if applicable) of tunnels, viaduct or the station premises to be accessed.

3. GRANTING OF ACCESS

3.1 The Authority will issue a no-objection for the applicant to apply and obtain access from the railway operator if the application is found to be in order and the reason(s) for requesting the access is acceptable.

3.2 The actual date and time of track access are determined and will be notified by the railway operator.

3.3 All persons working on track are required to wear proper clothing, high visibility vests and safety shoes. Those who fail to comply with this rule will not be permitted to access the track.

3.4 All persons working on track or within the station premises shall comply with the rules and regulations of the railway operator and instructions from the Authority's officer-in-charge.

Appendix C – Survey Practices

1. RESPONSIBILITY OF REGISTERED SURVEYOR

The responsibilities of registered surveyor shall include but not limited to the following:

(a) Management of all aspects of surveying and setting out for the duration of the works must adhere to the prevailing directives in respect of the Land Surveyors Board Singapore "LSB Directives on Land Survey & Geomatics Practices."

(b) Ensure all surveys are conducted to the requisite accuracy with sufficient checks. Survey transparency, good record system and clear presentation of reliable information are expected at all times. Survey data shall be produced and made available to the Authority upon request.

(c) Submission of certified survey plans to the Authority for all the reserve lines based on the tunnel geometric survey, rapid transit system structure and road structure.

(d) Upon approval of the reserve lines stated in Clause 1 (c), a copy of the certified survey pre-computation plans for the critical development shall be submitted to the Authority.

2. INSTRUMENT SERVICING AND CALIBRATION

2.1 All survey instruments employed shall be in good condition and properly calibrated. Test measurements and instrument calibration shall be carried out under local field conditions. The date of the calibration certificates and/or statements of service endorsed by local authorised instruments agent must be within 6 months.

2.2 Test measurements and instrument calibration certificates and/or statements shall be maintained by the Registered Surveyor and submitted to the Authority upon request.

3. SURVEY INSTRUMENTS, CONTROL OBSERVATION AND ADJUSTMENT

3.1 Horizontal and vertical control networks shall be carried out with precise survey instruments consisting of but not limited to the following:

a) 1" arc electronic total station with accuracy not inferior to (2mm +2ppm)

b) Precise digital level with a standard deviation of 1mm per km of double run levelling with an invar staff

3.2 Survey control network shall tie through from one survey station to another and include existing Permanent Survey Markers (PSM). Where practical, all survey points within a horizontal survey control network shall be occupied and observed from. Forced centring techniques shall be used throughout.

3.3 Survey control shall include redundant observations. Observations networks shall be processed using the method of least squares adjustments.

3.4 Precise levelling shall be using equal back and fore sights at each instrument set up. Levelling sights shall not exceed 30m.

3.5 Control observation data and processing data shall be maintained by the registered surveyor. Observations data and/or least square adjustments shall be submitted to the Authority upon request.

4. GEOMETRIC SURVEY

4.1 For bored tunnel, a minimum of 6 well-spaced points around the circumference of the tunnel lining shall be surveyed.

4.2 For cut and cover tunnels and station boxes, every section shall be surveyed with 2 points taken at the base, 2 at each wall and 2 at the soffit.

4.3 Cross-passage shall be surveyed.

4.4 Left and right rail (at same profile) of the track shall be surveyed.

5. TOPOGRAPHIC SURVEY

5.1 Topographic survey of the contract area shall be conducted under the direct supervision of the registered surveyor.

5.2 The survey datums shall be SVY21 and Singapore Height Datum (SHD).

5.3 Control traverse stations shall be correct to 10 millimetres on the ground. Control stations shall be correct in height to within 5 millimetres on the ground.

5.4 Spot levels shall be taken on all roads, at intersections, outline of buildings, edges of carriageways and invert of drains, footpaths, other ground features, etc. and at all changes in grade. Spot level information shall be at intervals of 10 metres across the full width of the survey corridor.

6. SETTING-OUT

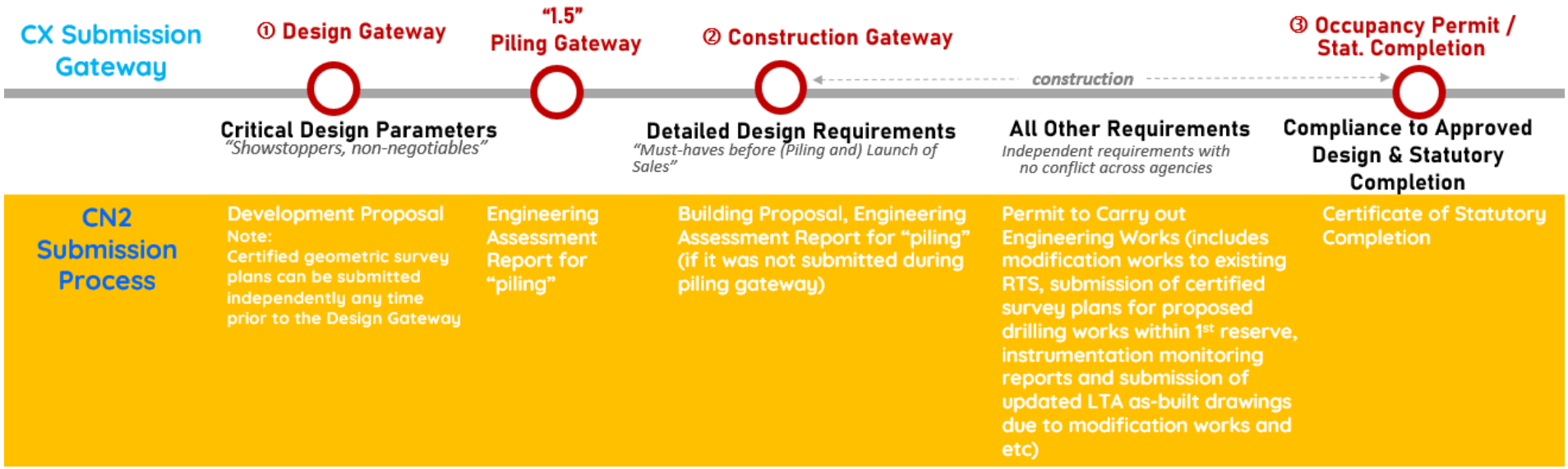
6.1 The method of setting out for each element of the work shall comply with the required accuracy and the survey markers shall be appropriate for site conditions.

6.2 In the setting out process, all elevation transfer conducted by levelling shall start on an established benchmark and finish on a different benchmark. If a significant misclosure is detected, the reason shall be determined, and the necessary corrective action shall be taken.

6.3 A spreadsheet shall be used to tabulate the difference (or offset) in mm between the actual set out (or as-built) co-ordinates from the design co-ordinates.

6.4 All setting out surveys within first reserve shall be pegged by Registered Surveyor and an endorsed setting out report, in plan and table format (supported with photograph image of set-out points) shall be submitted to the Authority. A joint site inspection shall be arranged with the Authority prior to the commencement of any drilling or piling works. Subsequently, the qualified person shall ensure the pegs on site are not disturbed or shifted.

Appendix D – Gateways in CORENET X (CX)



Appendix E – Template for Incident Report To LTOC

A. Level of Incident (L1 / L2 / L3S / L3)

B. Nature of Incident (Service / Safety / Security / Reputational Impact / Media Effect)

C. Date & Time of Incident

D. Location of Incident (To insert pictorial presentation for illustration with annotation of a prominent landmark and to align the map to "North" direction)

E. Details of Incident

F. Effects of Incident

G. Impact to members of public / commuters / passengers

H. Possible Cause / Preliminary Findings

I. Actions Plan / Recovery Plan (To spell out the measures that could be done to savage the situation as at that time)

J. Support Required

K. Photos of Incident

L. Public Communication

M. Remarks

Appendix F – Lodgment Criteria

The following developments are eligible for lodgment submissions:

Non-LTA Projects	LTA Projects
Developments with **NO BASEMENT** and with site boundary located **> 20m away** from the outermost edge of Rapid Transit System (RTS) structure: 1. Landed residential 2. Standalone fire station 3. Standalone petrol station 4. Standalone sub-station 5. Standalone commuter facilities (i.e. covered linkway, taxi stand or bus stop) 6. A&A work without any structural modification (i.e. piling, excavation, demolition) to existing building.	1. Covered linkway (without any encroachment into station boundary or interface with RTS structures) 2. Cycling/foot path 3. Minor A&A work within station premises: • toilet upgrading • handicap ramp • bicycle rack installation / removal • weather protection • pick-up/drop-off/taxi bay • landscaping/tiling works