DESIGN REQUIREMENTS AND APPROVAL SYSTEM OF SINGAPORE MRT PROJECT

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This paper introduces the outline for Underground Permanent Structures/ Temporary Earth Retaining Structures (TERS) design of Singapore MRT. The design concepts and submission process are summarized.

1. Introduction

The economic growth of Singapore is outstanding among Asian countries. The government has long term vision to develop the infrastructures for supporting the increase of population and reducing the congestion in the city area. Land Transport Authority (LTA) recently announced several MRT extension projects; such as Downtown Line, Boon Lay Extension. Not only Singapore contractors, but also contractors from oversea invited for the international biddings. Due to stringent design verification and complicated approval system, it is essential to understand clearly the design concepts and submission system before starting the Singapore MRT project.

2. Submission/Approval Systems of Singapore MRT projects

Before commencement of construction, it is necessary to get approvals from the authorities as indicated in Fig. 1. For underground permanent structures, structural plan submission to Building Control Authority (BCA) is necessary while for temporary structures TERS submission is needed. In case of aboveground structures, it requires clearances from related authorities, such as URA and CBPU before BCA building plan submission. In the case that proposed structures are proximity to existing railway or road structures, approval from Development and Building Control (DBC) is necessary. All submission documents must be endorsed and signed by QP(D)/PE(TERS). Persons shown in Fig. 1 have to be qualified as Professional Engineer (PE) of PEB Singapore[1] and if it is deep excavation design, PE in Geotechnical Engineer is needed. In addition, qualifications mentioned below are required by LTA.

QP(D) : min.10 yrs geotechnical/ structural engineering experience after tertiary education and at least 8 yrs experience in the Building structure design.

PE(TERS): min.10 yrs experience on similar projects in design/construction supervision of temp works.

QP(S) : PE assigned by the Authority to supervise the construction of permanent works.

AC : Independent PE accredited by BCA. LTA will appoint AC to carry out independent checking and review of temporary and permanent works design.

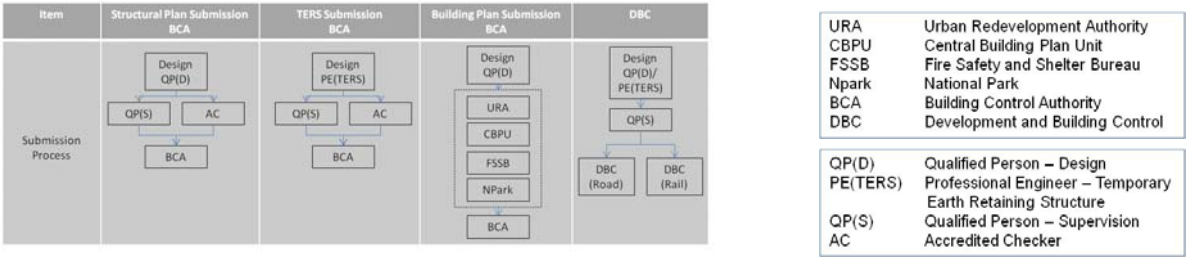

Fig. 1 Approval System of TERS and Permanent Structures

3. Design Characteristics

Civil Design Criteria (CDC) for Road and Rail Transit System[2] is the design code for Singapore MRT project. The design concepts of TERS and underground permanent structures are stated clearly inside.

Keyword Singapore MRT, TERS, One-strut failure, Professional Engineer, Singapore Standard

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3.1 Design of Temporary Earth Retaining Structures (TERS)

FEM softwares called "PLAXIS" and "SAGE CRISP" are commonly used for TERS design in Singapore. Soil is modeled by nonlinear, time dependent, anisotropic element. Retaining wall is modeled by plate element and the strut by spring element. It is different from general design method in Japan that elasto-plastic spring is used for representing soil and classical theory is used for calculating applied soil pressure.

For TERS support system it is stated in Chapter 16 of CDC that the design should allow for 1) Accidental load ≥ 50kN applied normal to strut at any point in any direction, 2) One-strut failure (OSF), 3) Temperature loads of minimum different of ±10°c. Comparing with Japanese design guideline, it recommends to consider 150kN as additional load due to temperature change[3] but it does not mention about OSF and accidental load. The OSF design is introduced after Nicoll Highway Collapse in 2004. It is assumed that when any strut at any location is failed, TERS is still stable. The capacity of steel strut/waler needs to be examined when the loading span is double increased due to the removal of one support point (Fig 2, 3). It is also necessary to reexamine the capacity of retaining wall due to the strut stiffness reduction at the level in which a member is removed. Since OSF is occasional load case, load factor can be used as low as 1.0 instead of 1.4 in normal case. It is noted that OSF concept is not applied to concrete strut so there is an advantage to introduce concrete strut system.

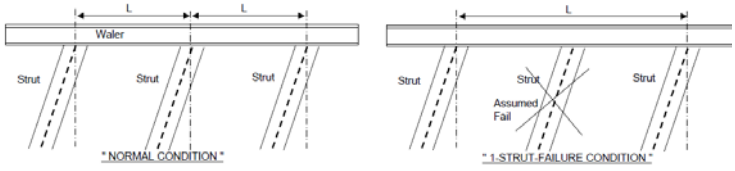

Fig. 2 Normal/one-strut failure condition

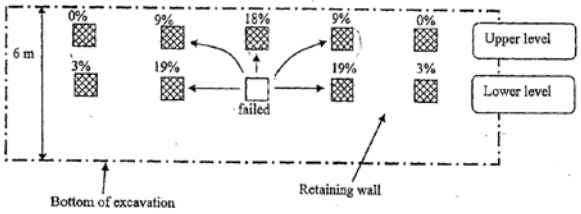

Fig. 3 Example of load distribution in OSF case

After Nicoll Highway Collapse, BCA set allowable deflection of retaining wall as strict as 0.5% of excavation depth to prevent the damage to adjacent structures. However, from 2nd April 2009, the value is relieved to be between 0.5 to 1.0% depending on the distance of adjacent structures/ utilities.

3.2 Design of Underground Permanent Structure

Design requirements for underground structures are stated in Chapter 8 of CDC. The load combinations are indicated in Fig. 4. It is noted that unbalance load and the future development need to be considered.

Load Combination	Description
1	Maximum vertical, maximum horizontal including end of construction stage
2	Maximum vertical, minimum horizontal
3	Minimum vertical, maximum horizontal
4	Unbalance load (Fig. 5)
Any other load combination that shall be determined to be more onerous.	

Fig. 4 Load combinations for underground str. design

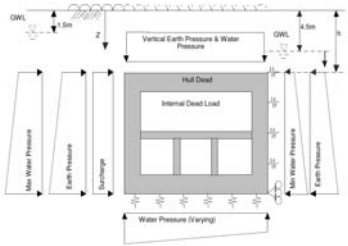

Fig. 5 Unbalance load case

4. Conclusion

For Singapore MRT projects, it is shown that several clearances from related authorities must be obtained before work commencement; therefore, submission should be done at very early stage. The understanding of design requirements and regulations is essential to accelerate the approval process.

References

1. PE Board Homepage: http://www.peb.gov.sg/peb/html/index.html.
2. Rail & Engineering Groups, LTA "Civil Design Criteria for Road and Rail Transit System" Rev A6, Feb 2008.
3. 日本道路協会"道路土工 仮設構造物工指針" 平成11年3月。