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Dear Sir/Madam

REQUIREMENTS ON BORED TUNNELLING WORKS FOR LARGE DIAMETER TBM

Objective

This Circular is applicable for bored tunnelling works using large diameter Tunnel Boring Machine (TBM) with the Outer Diameter (OD) of the tunnel greater than 9m. This circular shall be read in conjunction with the Circular “Requirements on Bored Tunnelling Works” dated 15 Sep 2017.

Background

2 Large diameter TBMs are expected to be adopted in Singapore following their successful adoption in overseas infrastructure projects. Over the past months, BCA had met up with IES, ACES, BCA-Industry Joint Tunnelling Working Committee (JTWC), GeoSS, TUCSS, CAG and LTA to gather feedback on the requirements for large diameter TBMs. The requirements in this circular are for compliance by Qualified Persons (“QP”), Accredited Checkers (“AC”), site supervisors, builders and developers who are adopting large diameter TBMs for tunnelling works.

Requirements / Control Measures with large diameter TBM


3 As large diameter TBMs involve bigger excavation volumes, they pose higher risk and greater impact to the surrounding building and structures. The control measures in Annex A of this Circular shall be additional/updated requirements to supplement the Circular “Requirements on Bored Tunnelling Works” dated 15 Sep 2017 (“2017 Circular”). These measures aim to mitigate the risk to surrounding buildings and structures posed by the use of large diameter TBMs. Annex B, which provides advisories and good practices to further help mitigate the risk caused by tunnelling works, are for the project party’s consideration.

4 The QP and builder shall carry out detailed engineering studies and risk assessment to develop technically feasible solutions and implement necessary mitigation measures to prevent surrounding buildings and structures from being damaged and mitigate the risk of tunnel incidents such as sinkholes or blowouts.

5 Nothing contained in this circular is meant to replace or negate the need to comply with the provisions of the Building Control Act and the Building Control Regulations in all aspects. QPs are to note that they have duties under the Building Control Act, amongst others, to take all reasonable steps and exercise due diligence to ensure that building works are designed in accordance with the provisions of the Building Control Act and the Building Control Regulations.

6 I would appreciate it if you could disseminate the contents of this circular to your members. Please submit your enquiry through BCA's Online Feedback Form at <https://www.bca.gov.sg/feedbackform/> or call us at 1800 342 5222. Thank you.

Yours faithfully



ER DR POH TEOH YAW
DIRECTOR, GEOTECHNICAL ENGINEERING DEPARTMENT
For and on behalf of COMMISSIONER OF BUILDING CONTROL

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Annex A

Annex A comprises the additional/updated requirements when using **large diameter Tunnel Boring Machine (TBM)** with the Outer Diameter (OD) of the tunnel greater than 9m. These requirements are supplementary to the Circular “Requirements on Bored Tunnelling Works” dated 15 Sep 2017 (“**2017 Circular**”) and are for compliance by Qualified Persons (“QP”), Accredited Checkers (“AC”), site supervisors, builders and developers.

Item	Subject	Additional/updated requirements for large diameter TBM
1	Definition of close proximity	<p><u>Updated requirement:</u> -</p> <p>Zone of close proximity is defined as 0.5D for ground category 1* or 1.0D for ground categories 2* and 3*.</p> <p>Note: Refer to Annex 2 of “2017 Circular” for ground category. D refers to the outer diameter of the permanent Tunnel.</p> <p>The project QP may propose an alternative zone of close proximity using sound engineering methodology e.g. via 3D FEM or equivalent method(s) to determine the zone of close proximity for each site. In determining the zone of close proximity, QP shall consider the risk of damage to buildings and the risk of tunnel incident such as excessive volume loss or a sinkhole.</p>
2	Risk category of large diameter TBM	<p><u>Updated requirement:</u> -</p> <p>Update of Risk category for tunnelling in close proximity to buildings and under mixed face conditions from “High” to “Very High”.</p> <p>Note: Refer to Annex 2 of “2017 Circular” for Risk Category and definition of Mixed face.</p>
3	Over-excavation limit when tunnelling in “Close Proximity”	<p><u>Updated requirement:</u> -</p> <p>% over-excavation detected at the end of each ring excavated for Actions to be taken are revised to: -</p> <p>a) ± 10% (from 15%) b) ± 20% (from 25%)</p> <p><i>When under-excavation exceeding the stipulated limit has been observed, QPs shall check the face support pressure applied to the previous operation to assess if the under-excavation is a result of preceding occurrence of over-excavation and to implement necessary measures to mitigate risk of ground movements.</i></p> <p>Note: Refer to table in Annex 4 of “2017 Circular”. % over-excavation limit is not actual over-excavation. It is the tolerance of the Excavation Management System given the limitation of its accuracy.</p>
4	Measurement of over-excavation volume	<p><u>Updated requirement:</u> -</p> <p>The Builder and QPs shall subsequently verify the magnitude of over-excavation volume by adopting a holistic assessment, comprising but not limited to:</p> <p>a) muck reconciliation for slurry TBMs using continuous volume calculations of STP separated muck including gravel, sand and fines for each tunnel ring</p>

		<p>with at least one other methods of either i) dry mass computation or ii) total volume measurements; or</p> <p>b) muck reconciliation for EPB TBMs using 3 independent devices such as i) gantry crane weigher, ii) belt weigher and iii) belt volume scanner.</p> <p>Alternative method of measurement has to be independent and to be reviewed by Mud Engineer or Materials Balance Engineer.</p> <p>Note: Refer to item 2a) and 2b) in Annex 4 explanatory notes of “2017 Circular”</p>
5	Upstream control of face pressure variation when tunnelling in “ Close Proximity ”	<p><u>Additional requirement: -</u></p> <p>When tunnelling in “Close Proximity”, the control margin for target face pressure variation shall not exceed: -</p> <p>a) ± 0.3 bar (for EPB TBM) b) ± 0.2 bar (for Slurry TBM)</p> <p>Note: QP(D) to include this item into approved plans</p>
6	Sudden changes of excavation volume	<p><u>Additional requirement: -</u></p> <p>During excavation, project parties shall pay attention and investigate to find the cause of sudden changes of excavation volume exceeding 5%.</p> <p>Note: QP(D) to include this item into approved plans</p>
7	Use of better quality slurry when tunnelling in “ Close Proximity ”	<p><u>Additional requirement: -</u></p> <p>When tunnelling in “Close Proximity”, better quality slurry is to be adopted.</p> <p>Note: QP(D) to include this item into approved plans</p>
8	Clarification to item 32 in Annex 3 of “ 2017 Circular ”	<p><u>Clarification:-</u></p> <p>(For High risk and Very High Risk categories under Case 3) The impact assessment report* shall also need to include QP(D) assessment on the need of the following if necessary^:</p> <p>a) change the alignment; or b) temporarily decant the occupants; or c) provide ground improvement or strengthening/underpinning building foundation to ensure tunnelling works pass through safely.</p> <p>^to mitigate the risk of damage to adjacent buildings and the risk of a tunnel incident such as excessive ground movement or a sinkhole.</p> <p>*The impact assessment report shall contain recommendations on the measures to be taken in connection with the tunneling works so as to prevent any settlement or other movement which may impair the stability of or cause damage to the whole or part of any premises or building adjacent or in otherwise close proximity to the tunneling works.</p>

Annex B

Annex B comprises advisories/good practices that are recommended for developer's, builder's and Qualified Person's ("QP") consideration.

Item	Subject	Advisory/Good practice for large diameter TBM
1	Pre-qualification for large diameter TBM	Developers are recommended to set and enforce strict conditions for pre-qualification of Contractors, TBM suppliers and key personnel with relevant experience when large diameter TBM is adopted.
2	Maintenance	Project parties are recommended to incorporate frequent engineering hours (e.g daily) to maintain the TBM and minimise the need for major CHI.
3	Compartmented chamber to assess cutter disc.	Large diameter TBMs are recommended to comprise compartmented chambers to assess cutter disc so that the change of cutter disc can be carried out within the safety of the compartmented chamber under free air.
4	TBM capabilities	Project parties are recommended to consider the employment of advancement in TBM capabilities to assist the tunnelling works. (e.g drilling / grouting capabilities, cutter disc wear monitoring, double (jaw and roller) crusher, geophysical survey capability within TBM, monitoring of mud flow, etc.)