

TECHNICAL REFERENCE

Bi-directional static axial load test



Published by

Enterprise
Singapore

TR 63 : 2018
(ICS 93.020)

TECHNICAL REFERENCE

Bi-directional static axial load test

All rights reserved. Unless otherwise specified, no part of this Technical Reference may be reproduced or utilised in any form or by any means, electronic or mechanical, including photocopying and microfilming, without permission in writing from Enterprise Singapore. Request for permission can be sent to: standards@enterprisesg.gov.sg.

ISBN 978- 981-47-8496-2

This Technical Reference was endorsed by the Building and Construction Standards Committee on behalf of the Singapore Standards Council on 30 April 2018.

First published, 2018

The Building and Construction Standards Committee, appointed by the Standards Council, consists of the following members:

	Name	Capacity
Chairman	: Ar. Chan Kok Way	<i>Individual Capacity</i>
Deputy Chairman	: Er. Clement Tseng	<i>Building and Construction Authority</i>
Secretary	: Ms Amy Sim	<i>Standards Development Organisation – The Institution of Engineers, Singapore</i>
Members	: Mr Bin Chee Kwan	<i>National Environment Agency</i>
	Er. Chan Ewe Jin	<i>The Institution of Engineers, Singapore</i>
	Mr Shawn Chan	<i>Singapore Manufacturing Federation</i>
	Er. Chee Kheng Chye	<i>Housing & Development Board</i>
	Mr Chng Chee Beow	<i>Real Estate Developers' Association of Singapore</i>
	Mr Dominic Choy	<i>Singapore Contractors Association Limited</i>
	Er. Paul Fok	<i>Land Transport Authority</i>
	Mr Goh Ngan Hong	<i>Singapore Institute of Surveyors and Valuers</i>
	Mr Desmond Hill	<i>Individual Capacity</i>
	Prof Ho Puay Peng	<i>National University of Singapore</i>
	Ar. William Lau	<i>Individual Capacity</i>
	Ar. Benedict Lee	<i>Singapore Institute of Architects</i>
	Er. Lee Chuan Seng	<i>Individual Capacity</i>
	A/Prof Leong Eng Choon	<i>Nanyang Technological University</i>
	Mr Darren Lim	<i>Building and Construction Authority</i>
	Dr Lim Lan Yuan	<i>Association of Property and Facility Managers</i>
	Er. Lim Peng Hong	<i>Association of Consulting Engineers Singapore</i>
	Er. Mohd Ismadi	<i>Ministry of Manpower</i>
	Ms Kay Pungkothai	<i>National Parks Board</i>
	Er. Yvonne Soh	<i>Singapore Green Building Council</i>
	Mr Christopher Tan	<i>Singapore Civil Defence Force</i>
	Er. Tang Pei Luen	<i>JTC Corporation</i>
	Mr Young Joo Chye	<i>PUB, Singapore's National Water Agency</i>

The Technical Committee on Civil and Geotechnical Works appointed by the Building and Construction Standards Committee and responsible for the preparation of this standard, consists of representatives from the following organisations:

	Name	Capacity
Chairman	: A/Prof Leong Eng Choon	<i>Individual Capacity</i>
Secretary	: Ms Jasmine Bai	<i>Standards Development Organisation – The Institution of Engineers, Singapore</i>
Members	: Dr Chan Chin Loong	<i>Singapore Polytechnic</i>
	Assistant Prof Darren Chian	<i>National University of Singapore</i>
	Mr Chong Chen Chuan	<i>JTC Corporation</i>
	Ms Choo Chai Foong	<i>Land Transport Authority</i>
	Er. Chua Tong Seng	<i>Individual Capacity</i>
	Er. Chuck Kho	<i>Association of Consulting Engineers Singapore</i>
	Er. Jerry Lim Kee Chay	<i>Housing and Development Board</i>
	Mr Loo Pak Chai	<i>Urban Redevelopment Authority</i>
	Dr Ng Tiong Guan	<i>Geotechnical Society of Singapore</i>
	Dr Ong Chee Wee, Victor	<i>Singapore Institute of Building Limited</i>
	Dr Poh Teoh Yaw	<i>Building and Construction Authority</i>
	Ms Lily Yeo	<i>The Institution of Engineers, Singapore</i>
	Mr Jeffrey Yu	<i>Singapore Contractors Association Limited</i>

The Working Group on Bi-directional Static Axial Load Test, appointed by the Technical Committee to assist in the preparation of this standard, comprises the following experts who contribute in their *individual capacity*:

	Name
Co-Convenors	: Dr Ng Tiong Guan Er. David Ng Chew Chiat
Members	: Mr Foo Hee Kang Dr Jeyatharan Kumarasamy Mr Khoo Han Sen Mr Koh Chiep Ping Er. Jerry Lim Kee Chay Dr Ong Chee Wee, Victor Dr Ooi Poh Hai Ms Sia Ai Ling Mr Tan Yong Beng Er. Wong Keam Tong Dr Yet Nai Song Mr Jeffrey Yu

The organisations in which the experts of the Working Group are involved are:

Building and Construction Authority
Fugro Singapore Land Pte Ltd
Geokon (S) Pte Ltd
Golder Associates (Singapore) Pte Ltd
Housing & Development Board
HSL Ground Engineering Pte Ltd
KH Foges Pte Ltd
KTP Consultants Pte Ltd
Land Transport Authority
Ministry of Manpower
ONE SMART Engineering Pte Ltd
Soil Investigation Pte Ltd
Woh Hup (Private) Ltd

Contents

	Page
Foreword _____	6
1 Scope _____	7
2 Normative references _____	7
3 Terms and definitions _____	7
4 Roles and responsibilities for bi-directional axial static load tests _____	8
5 Apparatus _____	9
6 Test procedure _____	18
7 Safety _____	22
8 Design and reporting _____	24

Annexes

A Typical loading schedule _____	29
B Non-standard bi-directional load tests _____	31

Tables

A.1 Single cycle loading schedule for ultimate pile test _____	29
A.2 Two cycle loading schedule for working pile test _____	30

Figures

1 Typical jack loading assembly _____	11
2 Typical bi-directional jack connection through common manifold _____	13
3 Bi-directional jack connection using the daisy chain method _____	14
4 Schematic instrumentation layout for a bi-directional test pile _____	15
5 Example of tremie funnel on the jack loading assembly for a ϕ 1200 mm test pile _____	19
6 Ideal position of hydraulic jack _____	24
B.1 Schematic of dual level bi-directional load test _____	31
B.2 Multi-level test sequence _____	32

Bibliography _____	33
--------------------	----

Foreword

This Technical Reference was prepared by the Working Group on Bi-directional Static Axial Load Test appointed by the Technical Committee on Civil and Geotechnical Works under the direction of the Building and Construction Standards Committee.

Bored cast in-place concrete piles are commonly used in Singapore as deep foundations. Full scale maintained load testing is an important aspect in the design of such deep foundation. The load test may be classified into preliminary load test, which is often used to verify design parameters and optimise the foundation design, and working load test, which is carried out to confirm the as-constructed piles satisfy both the designed load carrying capacity and serviceability settlement criteria.

Traditionally, full scale maintained load testing in Singapore is carried out using the Kentledge method (GeoSS, 2011). Bi-directional load testing, using a purpose built system such as those pioneered by Osterberg (1989), was introduced in Singapore since 1990's and has gained some popularity in recent years. The bi-directional load test method uses much less resource and manpower than conventional pile load test using Kentledge method resulting in time, space and transport savings for the whole project. The technologically more advanced bi-directional load testing method also enables higher capacity static load testing of bored and barrette piles. The bi-directional load test is particularly useful at sites with space constraints.

The procedure of bi-directional load test is currently not described in any local or international published standard. The bi-directional load tests are carried out by specialist testers using equipment and test method developed by the respective specialists. Due to the lack of standardisation, the local industry users encounter difficulties in the design and interpretation of such a test method.

This Technical Reference aims to provide good practices to the key aspects related to the apparatus, test procedures, safety, design and reporting of the bi-directional load test. The objective of this Technical Reference is to promote the better and proper use of such pile load testing method.

This Technical Reference is a provisional standard made available for application over a period of three years. The aim is to use the experience gained to update the Technical Reference so that it can be adopted as a Singapore Standard. Users of the Technical Reference are invited to provide feedback on its technical content, clarity and ease of use. Feedback can be submitted using the form provided in the Technical Reference. At the end of the three years, the Technical Reference will be reviewed, taking into account any feedback or other considerations, to further its development into a Singapore Standard if found suitable.

At the time of publication, this Technical Reference is expected to be used by parties involved in design, construction and testing of deep foundation, including developers, consultants, contractors and specialist testers.

Attention is drawn to the possibility that some of the elements of this Technical Reference may be the subject of patent rights. Enterprise Singapore shall not be held responsible for identifying any or all of such patent rights.

NOTE

1. *Singapore Standards (SS) and Technical References (TR) are subject to periodic review to keep abreast of technological changes and new technical developments. The changes are documented through the issue of either amendments or revisions.*
2. *An SS or TR is voluntary in nature except when it is made mandatory by a regulatory. It can also be cited in contracts making its application a business necessity. Users are advised to assess and determine whether the SS or TR is suitable for their intended use or purpose. If required, they should refer to the relevant professionals or experts for advice on the use of the document. Enterprise Singapore shall not be liable for any damages whether directly or indirectly suffered by anyone as a result of the use of any SS or TR.*
3. *Compliance with a SS or TR does not exempt users from any legal obligations.*

Technical Reference for bi-directional static axial load test

1 Scope

This Technical Reference establishes good practices for the execution of bi-directional static axial load tests.

The provisions of this TR apply to cast-in-situ bored piles and barrette piles.

This TR outlines the apparatus for applying and measuring loads and displacements, test procedures, safety, design and reporting of the test method.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

prEN ISO 22477-1	Geotechnical investigation and testing – Testing of geotechnical structures – Part 1 : Pile load test by static axially loaded compression
SS EN 1990	Eurocode : Basis of structural design
NA to SS EN 1990	Singapore National Annex to Eurocode : Basis of structural design
SS EN 1997-1	Eurocode 7 : Geotechnical design – Part 1 : General rules
NA to SS EN 1997-1	Singapore National Annex to Eurocode 7 : Geotechnical design – Part 1 : General rules
SS EN 1997-2	Eurocode 7 : Geotechnical design – Part 2 : Ground investigation and testing
NA to SS EN 1997-2	Singapore National Annex to Eurocode 7 : Geotechnical design – Part 2 : Ground investigation and testing