

# ENGINEERING SURVEYING FOR THE CONSTRUCTION OF RAILWAY TUNNELS IN HONG KONG

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*This paper provides an overview of the accuracy standards, specifications, and recent advances of engineering survey operations for the design and construction of railway tunnels in Hong Kong. It covers geodetic control, deformation monitoring surveys, detail mapping, geometric modelling, setting-out, as-built surveys and total quality management (TQM). Recent advances include an integrative approach to: (1) combine measurements collected by geodetic and geotechnical systems including interferometric synthetic aperture radar (InSAR) in monitoring ground displacements and structural deformation at local and regional scales; (2) map geospatial data into computer aided design (CAD) formats and geographic information systems (GIS) by both conventional and mobile surveying systems; (3) collect as-built data of railway tracks and tunnels by positioning instruments, track sensors and laser scanners together; (4) incorporate Outsource Plan into the TQM system under ISO 9001:2008.*



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*Cet article présente un aperçu des normes de précision, des spécifications et des récents progrès des opérations de levés d'ingénierie pour la conception et la construction de tunnels de chemin de fer à Hong Kong. Il couvre le contrôle géodésique, les levés de surveillance des déformations, la cartographie détaillée, la modélisation géométrique, le piquetage, les levés d'ouvrages finis et la gestion de la qualité totale (GQT). Les progrès récents comprennent une approche intégrative à : (1) la combinaison des mesures recueillies par les systèmes géodésiques et géotechniques, y compris le radar interférométrique à synthèse d'ouverture (InSAR) pour la surveillance des déplacements de terrain et la déformation structurale aux échelles locale et régionale; (2) la représentation graphique des données géospatiales dans des formats de conception assistée par ordinateur (CAO) et des systèmes d'information géographique (SIG) par des systèmes d'arpentage autant traditionnels que mobiles; (3) la collecte de données sur les ouvrages finis pour les rails et tunnels de chemin de fer en regroupant l'information provenant d'instruments d'arpentage, de capteurs de rails et de numériseurs au laser; (4) l'incorporation du plan d'impartition dans le système de la GQT sous ISO 9001:2008.*



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## Introduction

Railway tunnels are increasingly built for transportation systems of Hong Kong in order to preserve open above ground space for enhancing visual environment and people's recreation activities. These tunnels also provide easy passages to residential, office and retail buildings for residents, workers and tourists, which further encourage and support the economic, social, and cultural activities of the city. Construction methods include cut-and-cover method for shallow tunnels, shield method, or tunnel boring machine (TBM) for driving through sub-aqueous soils and rocks, drill-and-blast method for driving through hard rocks, and joining immersed tubes on seabed to form cross-harbour tunnels. The design and construction of engineering survey operations (Figure 1) are explained in the following sections.

## Geodetic Control and Deformation Monitoring Surveys

The establishment of horizontal and vertical geodetic networks for tunnel construction in Hong Kong has been explained in [Lam and Tang 2001a] according to [Chrzanowski 1981, Grafarend and Sanso 1985; Chen et al. 1990] and associated standards. During the life cycle of the tunnel project, geodetic markers and geotechnical sensors are georeferenced from these control points to detect ground displacements and structural deformation for ascertaining safety of construction workers and the public. At site level, an integrated approach of combining geodetic and geotechnical measurements [e.g., Chrzanowski et al. 1986] have been