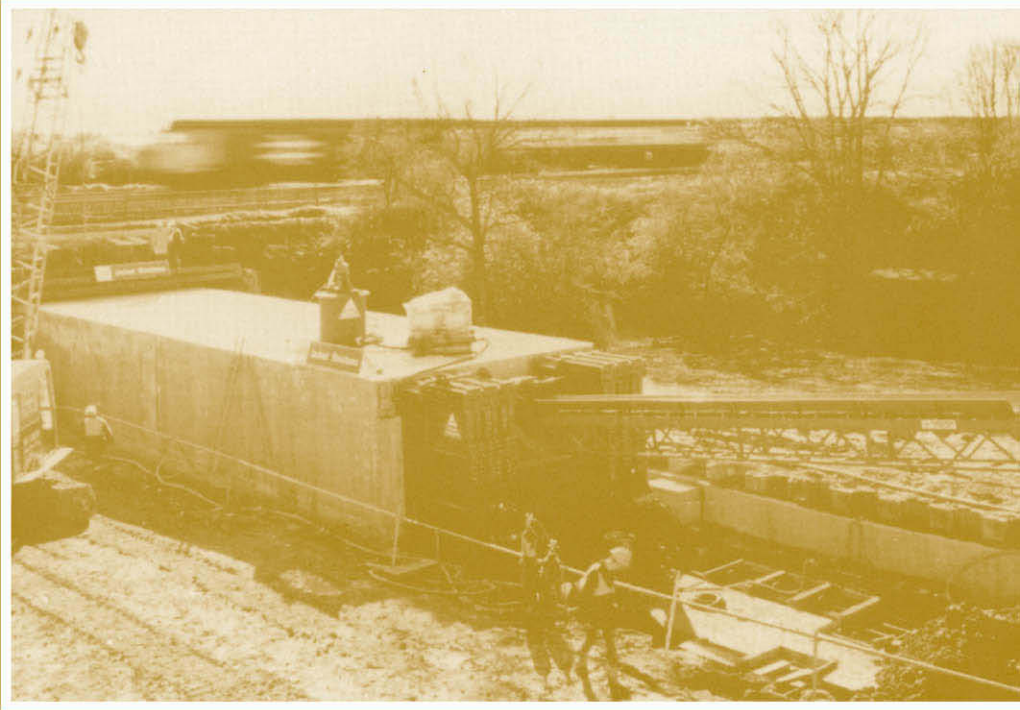
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JACKED TUNNEL DESIGN AND CONSTRUCTION

EDITED BY MARCO D. BOSCARDIN



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JACKED TUNNEL DESIGN AND CONSTRUCTION

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Marco D. Boscardin

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Abstract: Tunnel jacking is used to construct large shallow underground openings in areas where disruption to surface use and activities cannot be tolerated. The technique of tunnel jacking is not new, but in recent years it has been used to construct openings primarily in Europe and Asia, often under railroad lines and highways. The method has had limited use in the United States; however, a state-of-the-tunnel jacking project currently is underway as part of the Central Artery/Tunnel Project in Boston, Massachusetts. These papers have been prepared by experienced designers of tunnel jacking projects to provide the reader with an introduction to large jacked tunnel design, construction, and instrumentation.

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Preface

The jacked tunnel method of constructing shallow underground structures with a minimum of disruption to surface activities or disturbance to surface and near surface structures developed in the 1960's as an outgrowth of pipe jacking. During the past thirty years, this method has been used to install increasingly larger underground openings in confined urban environments, particularly in Europe and Asia. Typical projects include pedestrian walkways beneath busy roads, drainage structures beneath roads and railroads, and short vehicular tunnels beneath highways and railroads. The typical competing method of construction for these projects is the cut-and-cover method.

Use of the method in the United States, to date, has been limited. However, the I-90/I-93 Interchange of the Central Artery Project, which is currently under construction, will be one of the largest, 12 m high by 25 m wide by up to 110 m long, and most complex jacked tunnel projects in the world. The interchange tunnels will be constructed under eight rail lines serving South Station in Boston, comprising one of the busiest commuter rail areas in the Northeast.

The objective of this publication is to provide information on the design, construction, and monitoring of jacked tunnels to assist owners and engineers in and initial evaluation of the applicability of this method to their particular site and conditions.

Each of the papers included in this publication has received two positive peer reviews. All of the papers are eligible for discussion in the Journal of Geotechnical and Geoenvironmental Engineering of ASCE, and all are eliglble for ASCE awards. Reviewers of the papers were Michael P. Walker, Michael Paster, R. Lee Wooten and myself.

Marco D. Boscardin
Editor

"Developments in Tunnel Jacking"

Stephen Taylor[1] Derek Winsor[2]

Abstract

This paper describes the development of tunnel jacking from its early days of small section tunnels (100 sq.ft. face or less), through to the current day when tunnels with a face area in excess of 3000 sq.ft. are being installed. The development will be illustrated using a selection of design details, diagrams, and construction photographs.

Tunnel jacking is a term which refers to the installation of tunnels by pushing them into the ground while excavating from an open face. The tunnels, which are usually of rectangular cross section, are installed beneath a facility which cannot be removed or which the facility owner does not wish to be removed. This technique can be used for relatively small sections (6ft x 6ft) up to large, full size highway sections (80ft x 40ft) in lengths up to several hundred feet.

The technique developed from pipe jacking when the circular sections available were either too small or inefficient for the final use of the tunnel. The technique is most often used in soft ground and at shallow depth. It has been used successfully in a variety of ground conditions, including soft clays, granular material, filled ground and mixed ground. It is a specialist technique which requires a clear and precise understanding of the inter-relationship between design and construction, and perhaps for this reason it has been carried out by a relatively small number of contractors around the world. The contractors often have their own preferred methods of installing the tunnels. Some of the methods and/or the equipment used are patented by individual organizations, although there are usually several alternative methods and details which can be used.

Although it is not the solution in all situations where a tunnel or underbridge is required beneath a facility, it is certainly an approach which should be considered in many applications and often provides the most beneficial and cost-effective solution in situations when all factors and costs are taken into account.

Introduction

Tunnel Jacking is a technique for installing an access way beneath a facility which is not easily relocated or which the owner/user does not wish to be relocated. The process is generally used in soft ground for relatively short lengths of tunnel where a tunnel boring machine is not appropriate and for tunnels which would usually be

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constructed by cut-and-cover methods. It is a technique which evolved from pipe jacking and retains many of the same features as pipe jacking. Pipe jacking was introduced on the Northern Pacific Railroad in the late 1890's as a method for installing culverts without severe disruption to the overlying rail service.[1]

The development from pipe jacking to tunnel jacking was made in the 1960's when the circular pipe jacked sections were found to be either too small or were inefficient for their intended purpose. At that time, contractors started to jack rectangular sections. These were typically reinforced concrete, pre-cast off site. In the 30 or so years since those early days, the technique has developed significantly and now includes a wide variety of possible end products, ranging from 3m square (10ft square) rectangular pedestrian subways installed beneath busy roadways, to 25m wide x 12m high (80ft x 40ft) monolithic rectangular tunnel sections to accommodate full width and height clearance highway traffic beneath operating rail tracks, roads, rivers, or airport runways.

The technique has also been used to install relatively small tunnel sections within which concrete foundations can be constructed in readiness to receive a bridge superstructure. This can either be jacked into position with no disruption to the overlying facility operations, or slid into position during a limited possession of the overlying facility. Superstructures installed by this method have included simply supported spans, multi-span bridges and portal frame bridges. Large skews have been accommodated.

Tunnel jacking has been used in many parts of the world, including Europe (particularly in the UK and Germany), Australia, India, South Africa, and Canada. It has been used extensively in the Far East, particularly in Japan. It is not a technique which has been used to any significant extent in the USA to date, although a few tunnels have been jacked in California over the past 10 years or so. The I-90/I-93 Interchange (Section 9A4) on the Boston Central Artery/Tunnel Project, which is currently under construction, will be the largest and one of the most complex tunnel jacking projects to date in the world. It will, therefore, bring United States engineering to the forefront of this specialist technology.[2]

The following sections give brief descriptions of a selection of tunnel jacking projects. They are intended to provide an overview of situations which could benefit from the use of the tunnel jacking technique and also provide an indication of some of the major developments in the technique over the past 30 years.

When is Tunnel Jacking a Suitable Construction Technique?

The preferred method of construction for shallow tunnels in soft ground will often be the cut-and-cover method. This will generally represent the lowest structural cost and