

# Inspection of Highway and Rail Transit Tunnels

An Online Continuing Education Course for Engineers

**Course Number: T-6004**

**Credit: 6 Hours / 6 PDH / 6 CPD**

# Inspection of Highway and Rail Transit Tunnels

## INTRODUCTION

### Scope

The purpose of this course is to provide highway and rail transit engineers guidance for establishing procedures and practices for the inspection, documentation, and priority classification of deficiencies for various elements that comprise an existing tunnel.

This course addresses inspection procedures for the functional aspect of the tunnel, focusing on the civil/structural, mechanical, and electrical components. The course does, however, provide brief guidance on other systems/appurtenances, such as track, traction power, signals, and communications, which comprise the operational aspects of a rail transit tunnel. This brief guidance is only meant to provide general knowledge and not in-depth inspection criteria for such systems/appurtenances.

### Contents

To ensure consistency of definition of particular elements, this course contains several chapters that explain the various types of elements that exist within the tunnel. For example, the description of tunnel components such as tunnel configuration, liner types, invert types, ventilation systems, lighting systems, tunnel finishes and other systems/appurtenances (track, traction power, signals, and communications) are each provided in separate sections to assist engineers in educating their inspectors as to the particular system used for the tunnel to be inspected. Furthermore, the course provides suggested guidelines for inspection personnel qualifications and equipment to be used for performing the inspection. Since most tunnels are constructed of concrete, steel, masonry, and timber (to a very limited degree), this course provides extensive definitions of the types of common defects that occur within these major structural elements so that the inspection documentation is consistent according to the guidelines provided.

The course contains procedures for documenting the inspection findings. These range from identifying a particular defect (cracking, scaling, spalling, corrosion, etc.) and its severity (minor, moderate, or severe) to assessing the overall condition of an element within a particular region of the tunnel. The course is based upon a condition assessment scale that varies from “0” to “9,” with 0 being the worst condition and 9 being the best condition. This is similar to the scale used for the National Bridge Inventory that is familiar to most highway/transit engineers. The length of a tunnel segment for which these ratings will be applied will vary with each tunnel and tunnel owner. Some tunnels have panels that are numbered between particular joints, which make it easy for determining the segment length over which condition assessments are to be evaluated. Other engineers may choose to have the evaluation performed for a segment of a tunnel, say 30 m (100

ft) or 60 m (200 ft). Regardless, the entire tunnel is to be inspected and condition assessments applied for all tunnel segments.

The course will also provide guidance for the inspector to prioritize defects for repair and rehabilitation. Although this course proposes the use of three prioritizations for conducting repairs, namely critical, priority, and routine, engineers can adopt other prioritizations as appropriate.

This course is developed for a hands-on, up-close inspection of the tunnel structure. The procedures developed herein are for visual and non-destructive methods of evaluating the tunnel elements. This does not preclude the lead inspector from requesting that certain destructive means (e.g., extracting cores for determination of freeze/thaw resistance or concrete strength) be requested to aid in determining soundness/adequacy of the tunnel elements.

Although this course is produced for a hands-on, non-destructive evaluation of the inside face of the tunnel structure, other state-of-the-art, non-destructive testing methods may be used in areas that require a more in-depth structural evaluation. These methods may include mechanical oscillation techniques such as sonic or ultrasonic measurements (more commonly referred to as Impact-Echo), electronic techniques such as geo-radar, and optical techniques such as infrared thermography and multispectral analysis. Each of the above methods has been used successfully in tunnels; however, a full understanding of the applications and limitations of each method is necessary to maximize their benefits.

It is felt, however, that these state-of-the-art methods are probably only cost effective in long, rail transit tunnels in metropolitan areas. It is assumed that these methods will mostly supplement and not replace the hands-on, non-destructive testing methods described in this course for many engineers in the United States.

## **TUNNEL CONSTRUCTION AND SYSTEMS**

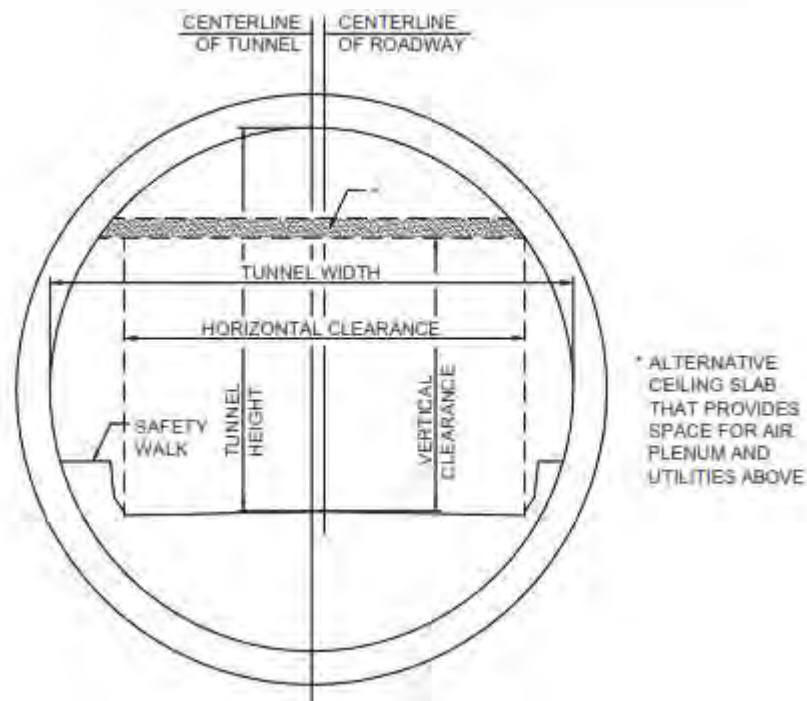
### **TUNNEL TYPES**

This section describes the various types of highway and rail transit tunnels. These tunnel types are described by their shape, liner type, invert type, construction method, and tunnel finishes. It should be noted that other types may exist currently or be constructed in the future as new technologies become available. The purpose of this section is to look at the types that are most commonly used in tunnel construction to help the inspector properly classify any given tunnel. As a general guideline a minimum length of 100 meters (~300 feet) was used in defining a tunnel for inventory purposes. This length is primarily to exclude long underpasses, however other reasons for using the tunnel classification may exist such as the presence of lighting or a ventilation system, which could override the length limitation.

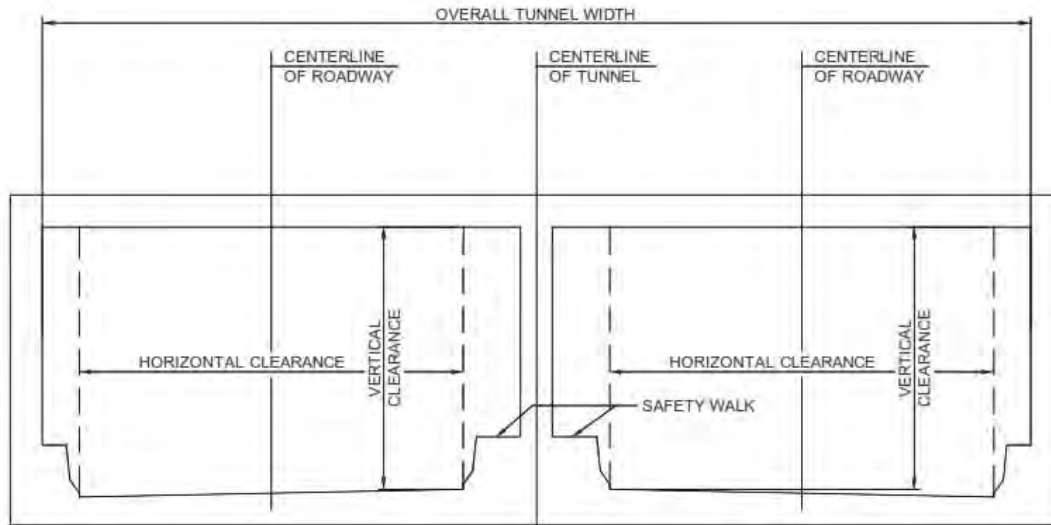
## Shapes

### a) Highway Tunnels

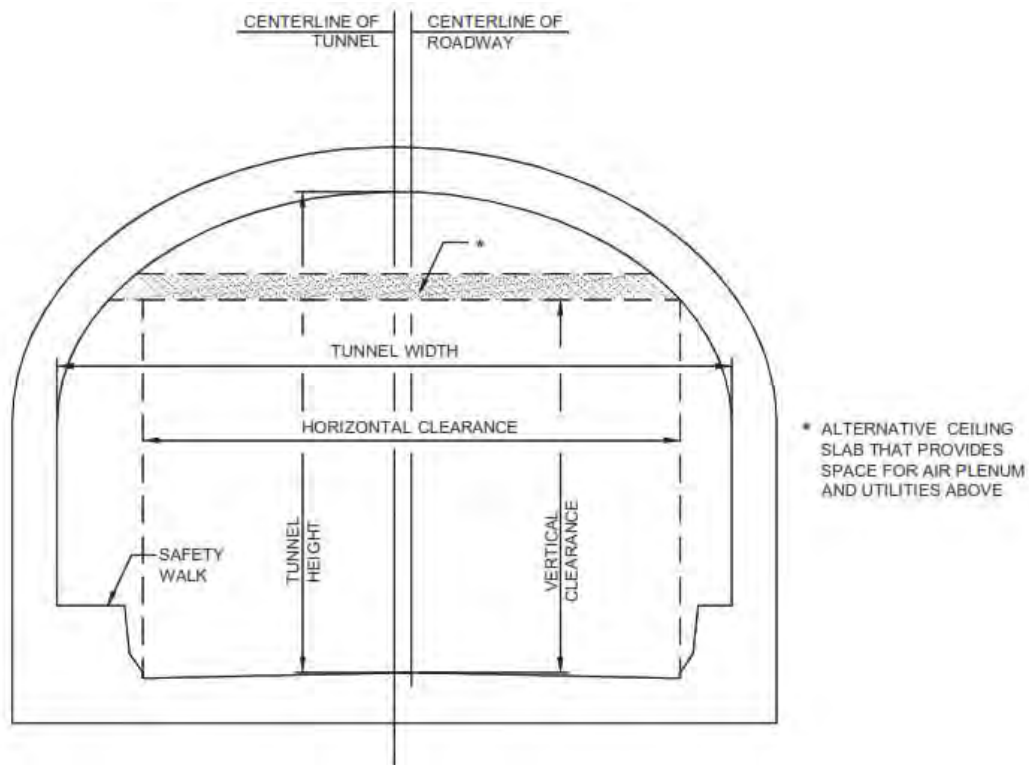
As shown in Figures 2.1 to 2.4, there are four main shapes of highway tunnels – circular, rectangular, horseshoe, and oval/egg. The different shapes typically relate to the method of construction and the ground conditions in which they were constructed. Although many tunnels will appear rectangular from inside, due to horizontal roadways and ceiling slabs, the outside shape of the tunnel defines its type. Some tunnels may be constructed using combinations of these types due to different soil conditions along the length of the tunnel. Another possible highway tunnel shape that is not shown is a single box with bi-directional traffic.



**Figure 2.1** – Circular tunnel with two traffic lanes and one safety walk. Also shown is an alternative ceiling slab. Invert may be solid concrete over liner or a structural slab.



**Figure 2.2** – Double box tunnel with two traffic lanes and one safety walk in each box. Depending on location and loading conditions, center wall may be solid or composed of consecutive columns.



**Figure 2.3** – Horseshoe tunnel with two traffic lanes and one safety walk. Also shown is an alternative ceiling slab. Invert may be a slab on grade or a structural slab.

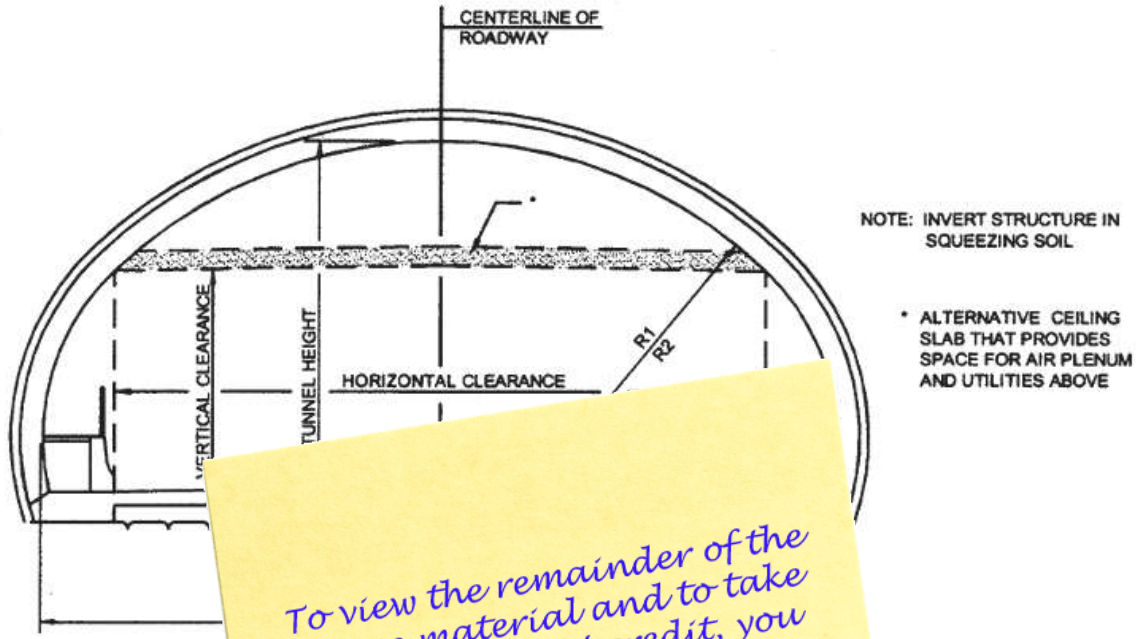


Figure 2.4 –

b) Rail Transit Tunnels

Figures 2.5 to 2.9 show the shape typically relates to the ground conditions. The shape of rail transit tunnels typically change at the transition between ground conditions. However, the change in ground conditions.

to safety walks.

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highway tunnels, the shape typically varies in cross-section. However, variations in