

IDENTIFICATION OF COST DRIVERS FOR TUNNEL CONSTRUCTION PROJECTS

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1. Introduction

Throughout the world, tunnels interconnect cities, cut through mountains, transport water and dive deep into mines. These passages have become a necessary part of everyday life and because of their usefulness will only continue to see increased usage and expansion in upcoming years. Tunnels are unlike any other civil engineering structures. In buildings or bridges the building materials have defined and testable properties, whereas this is not the case in tunneling. In addition, the costs and regulations associated with tunnel construction can vary greatly from place to place and are very difficult to predict since construction occurs underground in unknown territory. This paper explores tunnels construction costs through studying the tunnels types, required materials, construction methods and the surrounding conditions which affect the construction costs in order to identify the cost drivers of tunnels projects. In this study we will discuss the tunnel project cost issue, then provide an overview about tunnels to explain its types, required materials and method of construction, after that we will clarify the methodology used in this study and will lead some conclusions.

2. Costs of Tunnel Project

Tunneling is unique when compared to other types of civil construction. It differs from the construction of other infrastructure in a plethora of ways. The main issues that distinguish tunnels from other infrastructure arise from the risk involved with excavation through unknown ground conditions and the numerous individual cost factors that contribute to the overall cost. These construction projects are very expensive ventures, costing from millions to billions of dollars. In addition, it is mostly funded through the country budget or loans coming from donor countries and international agencies. This gives considerable importance to the project cost beside the significant role which it plays in selecting the tunnel alignment and other related technical matters. This illustrates the importance of studying project's costs for tunnels especially construction costs (civil works), where it represents the largest proportion of the total project cost as we can see in Fig.1.

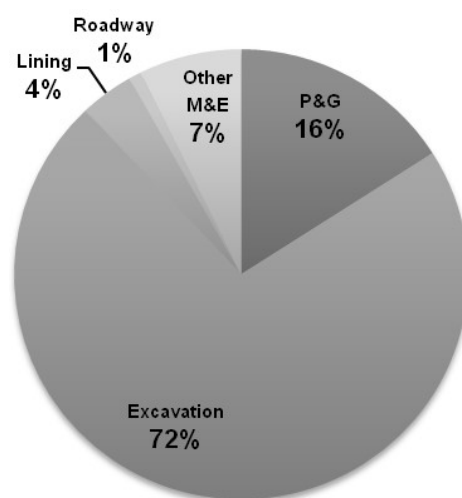


Fig.1 Road tunnel cost composition breakdown¹⁾

3. An Overview of Tunnels

There are many types of tunnels and can be classified in many ways. Table 1 explains three ways to classify tunnels which are purpose or end-use of the tunnel, shape of tunnel lining (cross section) and geological conditions. Every type has different specification and requirements which makes tunnel type is the first element in determination of the project cost.

Table 1 Tunnels types classification

Classified by	Example of tunnels
Purpose	Mining, water, transportation, cable, and scientific
Shapes of Tunnel Lining	Rectangular, circular, elliptical, egg, horse, shoe, and segmental shape.
Geological conditions	Rock tunnels and soft ground tunnels

- The principal materials for permanent lining of bored tunnels are:
- 1- In-situ concrete, it used frequently in rock tunneling.
 - 2- Preformed segments made of cast iron, steel or precast concrete, it usually comes with TBM or shield tunneling methods.
 - 3- Sprayed Concrete, it used usually in rock tunneling and associated with the New Austrian Tunneling Method.

Tunnels can be constructed by using a number of different techniques. In order to choose the most appropriate construction technique, aspects such as the ground characteristics, tunnel depth and size, the impact of the tunnel construction on the surroundings, as well as the economic and health and safety issues need to be considered. The main techniques used in tunnel construction are Cut and Cover Method, Pipe Jacking, Tunnel Boring Machine (TBM), Drill and Blast Method, New Austrian Tunneling Method and Submerged Tunnel.

4. Methodology

The approach used to achieve the study objectives can be summarized in four steps. Firstly, identify the tunnels types, components and general specifications. Secondly, finding out the different materials, equipment and method of constructions can be used in tunnels projects. Thirdly, determine the stakeholders and the external factors which affect the project cost. Finally, based on the previous steps we can conclude the cost drivers of tunnels projects. To verify the results that have been concluded, we will conduct interviews with experts in the field of tunnels to discuss these results in addition to identify the impact of these factors separately on the total construction cost.

5. Conclusions

There are numerous cost drivers associated with tunnel projects. These can be grouped into physical, economic and political.

The physical costs are tunnel depth and size, geological conditions and the purpose of tunnel. Most of these elements are out of control, however it is considering as the main driver of the project cost. So in planning of tunnel projects, we need to study carefully these elements. Because once we start the construction process, it will be so difficult to change any of these factors. Even if we can change, it will sharply increase the project cost.

The economic costs are labors, materials, equipment, insurances, bonds, indirect elements and market structure. Some of these elements depend on the country where the tunnel is constructed, in addition to the tunnel industry level in this country. These elements can be modified or improved. Therefore, when we want to improve the tunnel industry in any country (or in a company), these will be the main elements which can be used to achieve this purpose.

The political costs are location (urban or rural area), safety and environmental regulations, government / public support and client knowledge. It considers as inert elements in tunnels projects. It represents a small proportion of the total project cost, however it can extremely increase the cost and sometimes it causes abandoned of the project.

6. Future Plan

Based on this study in addition to data collection of previous tunnels projects, (Parametric Cost Estimation Model for Tunnel Projects) will be created. This model will utilize an artificial intelligence techniques (AI) known as case-based reasoning (CBR) in cost estimation of tunnel construction projects at the early stages.

References:

- 1) Analysing International Tunnel Costs, Nathaniel Efron & Megan Read, Worcester Polytechnic Institute, 2012.
- 2) Technical Manual for Design and Construction of Road Tunnels – Civil Elements, U.S. Department of Transportation-Federal Highway Administration, Publication No. FHWA-NHI-10-034, 2009.
- 3) Introduction to Tunnel Construction, David Chapman, Nicole Metje and Alfred Stärk , 2010.