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# The Effect of Non-Simultaneous Excavation of Closely-Spaced Twin Tunnels on Ground Surface Settlement

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## ABSTRACT

Tunnel excavation on soil lands may lead to horizontal and vertical displacements around the tunnel. The displacements can reach the ground surface and cause damages to existing structures on the ground. Hence it is so important to estimate the ground settlement induced by excavation, particularly in urban environments. In this study, the effect of longitudinal distance between two tunnel faces on the ground surface settlement is examined during the excavation of twin tunnels. Accordingly, the ground settlement is measured for the states where the distance between tunnel faces is 0D, 0.5D, 1D, 1.5D and 2D. The most important results suggest that creating a longitudinal distance (lagging) between the faces of twin tunnels during excavation operations causes changes in surface ground settlement. The maximum surface ground settlement along the width and length of tunnels decreases as the distance between two tunnel faces increases.

**Keywords:** twin tunnels, ground settlement, tunnel face, excavation, lagging distance

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## 1. INTRODUCTION

The increasing population growth and density in cities, on the one hand, and technological progress, on the other hand, has enhanced the demand for development of public spaces, e.g. underground metros. The density of urban spaces and rapid rise in the number of cars pose problems with appropriate communications throughout cities. Hence the construction of traffic tunnels and urban rail transit systems has become an overriding priority for the efficiency of urban transport. One of the most challenging aspects of tunnel engineering is to evaluate the impacts of deformation on the ground surface and potential holes which may emerge in buildings placed above the tunnel and its surrounding area [1]. Tunnel excavation on a soil land may result in horizontal and vertical displacements around the

tunnel. The displacements can reach the ground surface and cause damages to existing structures on the ground. Therefore, it is of great importance to estimate the ground settlement induced by excavation, particularly in urban environments. There are a variety of factors in the tunneling-induced ground settlement, e.g. the excavation method, type of excavating machines and natural and artificial factors during excavation. Thus, it is necessary to investigate the settlement induced by each of these factors for more precise analyses [2]. A variety of factors play a key role in this displacement, e.g. soil conditions, underground water, specifications of structures, tunnel depth, tunnel diameter, excavation length and pressure on tunnel face. It is of great importance to estimate the settlement and predict its distribution before