



# Effects of Subsidence Induced by Tunnelling on Buildings: The Sagrada Familia Temple Case

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## Abstract

The paper deals with the controversy that arose over the effects of the construction of a tunnel in Barcelona, for the High-Speed train, on the Temple of the Sagrada Familia. The construction of the tunnel was considered by many as a great structural risk for the temple, as well as for the Casa Milà, both by the famous architect Gaudí. The preventive measures taken, the monitoring implemented, the structural modelling, the control carried out and the results obtained will be explained. It is an example of how to address the risks of a construction which could affect UNESCO World Heritage.

**Keywords:** tunnelling; world heritage; buildings; subsidence.

## 1 Introduction

The High-Speed Rail Tunnel Madrid-Barcelona-French Border Line crosses the city of Barcelona connecting Sants and Sagrera Stations. It is a 5.664 Km long tunnel, mostly built by a single EPB shield machine. At both ends of the tunnel, cut and cover stretches were designed for the connection with the stations.

The tunnel crosses a residential area of the city developed at the beginning of the 20<sup>th</sup> Century called "Els Quatre Gats" which is known for its modernist architecture. Most of the buildings are about 100 years old, with brick bearing walls and from 5 to 8 storeys high, being quite sensible to ground displacements. Most of the have very shallow foundations.

The tunnel follows to of the main streets of the district, Mallorca and Provenza. At Mallorca street two of the main buildings designed by world

famous architect Antonio Gaudí, are located, Sagrada Familia Temple and Casa Milà. Both of them are included in the World Heritage Catalogue by UNESCO. Figure 1 shows a plan view of the tunnel and Figure 2a longitudinal profile, with the location of the Sagrada Familia Temple.

Sagrada Familia Temple occupies a large block of Mallorca street. The parts built by Gaudí are the crypt, apse and the "Nativity" façade before his death, dated in 1926. The temple is still under construction. The façade facing Mallorca street is the "Gloria" façade, which was started in 2002 and not completed yet.

The tunnel at the Sagrada Familia Temple location is a 11.475 m external diameter reinforced concrete precast lining. Seven segments 0.38 m thick form the lining. The overburden is about 25 m over the crown. The tunnel cross-section is shown in Figure 3.