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Ground shaking scenarios at the town of Vicoforte, Italy

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ABSTRACT

Vicoforte is a small town in Northern Italy, which hosts a Cathedral with the world's largest elliptical dome. The name of the Basilica is "Regina Montis Regalis" and it is of extraordinary architectural and structural importance. The main objective of this study is the definition of the seismic hazard at the site of Vicoforte following a deterministic approach. Although Vicoforte is located in an area of moderate seismicity, the calculation of the most unfavourable seismic ground shaking scenarios is of great interest due to the importance of the Basilica and its vulnerability to even a moderate seismic excitation.

The closest active faults to Vicoforte were identified in order to simulate the potentially most severe ground shaking scenarios compatibly with the tectonic and seismic setting of the region. Subsequently, numerical simulations were conducted through finite faults numerical models using two different approaches: the extended kinematic source model of Hisada and Bielak [24] and the stochastic method of Motazedian and Atkinson [38]. They, respectively, simulate the low and high frequency ranges of predicted ground motion. The numerical models used for the simulations were calibrated by a comparison between synthetic results and recorded data. A parametric study was finally carried out to identify the most critical fault rupture mechanisms.

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1. Introduction

This paper illustrates the steps that were undertaken to estimate the worst rock shaking scenarios at the site of Vicoforte, a municipality of the city of Cuneo in Northern Italy, where the "Regina Montis Regalis" Basilica sits. Although Vicoforte is located in an area of moderate seismicity, it was selected as case study due to the presence of the Cathedral with the world's largest elliptical dome (Fig. 1).

The internal axes of the dome of the Sanctuary are 37.15 m × 24.8 m, making it the fifth largest dome in the world (after the Pantheon and Saint Peter in Rome, S. Maria del Fiore in Florence, Italy and Gol Gumbaz Mausoleum in India) and by far the largest elliptical structure.

The Basilica was first conceived by Duke Charles Emanuel I of Savoy as the mausoleum of the family. The original architectural composition was an idea of engineer Ercole Negro di Centallo, Cont of Sanfrount, but architect Ascanio Vitozzi implemented the project. The construction started in 1596 and since the early beginning the building was affected by differential settlements due to inhomogeneity of foundation soil. Due to the large settlements (of the order of 25–30 cm) in 1615 the project was abandoned for more than a century, till 1692 when the construction works were entrusted to the architect Francesco Gallo. The dome was completed in 1731.

Crack patterns due to the foundation settlements and to the structural configurations of the Cathedral are currently present on the dome-drum system, but they seem stabilized. From the historical records at the Sanctuary, it is known that cracking phenomena began to occur in the early stages of the construction, in particular in the zone between the drum windows and at the base of the buttresses. In 1985 such severe cracking prompted the decision to undertake monitoring and strengthening works. A system of 56 active tie-bars, slightly stressed by jacks, was installed in 1987 within the masonry at the top of the drum along 14 tangents around the perimeter, and a complex monitoring system was set up to measure movements of the structure and propagation of cracks, as well as stresses in the reinforcing tie-bars. In recent years a new project was started for a thorough renovation of the monitoring system [15] and the updating of the structural models adopted to explore the static configuration and integrity of the Basilica and to define the characteristics of the strengthening system [13].

The present study was developed in the framework of a more wide-ranging research aimed to define the seismic input for dynamic analyses of the Basilica. The study was carried out in two phases: the first part concerned with site-specific Probabilistic Seismic Hazard Analysis (PSHA, [28]), while the second part focused on a Deterministic Seismic Hazard Analysis (DSHA) at the site, both under the assumption of stiff ground and level topographic condition.

The choice of whether using PSHA or DSHA for an adequate analysis constitutes a vivid debate in the scientific community. Fiercely discussions whether PSHA or DSHA or a possible combination of the two should be used show how debated this topic is [9,26,27]. Nevertheless, both methods present advantages and limitations,

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