



**POLITECNICO
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Master's Degree in Civil Engineering

Master's Degree Thesis Abstract

**Digital Twin of Metro Infrastructure through BIM and IoT Sensor Integration:
The Case of Certosa Metro Station, Turin**

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Abstract

This thesis explores the integration of Building Information Modeling (BIM) technologies with Structural Health Monitoring (SHM) strategies for the development of a digital twin of the Certosa Metro Station project in Turin, carried out in collaboration with Infra.To. The work addresses the current gap between traditional structural monitoring practices and next generation digital platforms, with the goal of enabling real time visualization, analysis, and decision making within urban infrastructure.

The BIM model of the metro station was originally provided by Infra.To, and it was complemented in this study with the surrounding area and the integration of virtual monitoring sensors. The research begins with the creation of a georeferenced 3D environment derived from QGIS and CAD data, refined in Revit and InfraWorks to obtain a realistic representation of the project site and its built environment. The extended BIM model was enriched with IoT based virtual sensors, including accelerometers, tiltmeters, and inclinometer chains, strategically positioned on both the station and the surrounding soil.

In particular, two nearby buildings were modeled with accelerometers and tiltmeters to evaluate vibration and inclination responses, while an inclinometer chain was placed beneath the railway alignment to capture ground settlements and shear deformations. Sensor parameters and metadata were defined in Revit through shared and project parameters, ensuring consistency with Tandem requirements.

Subsequently, data integration workflows were implemented. Synthetic datasets were generated in Excel, based on examples from other monitoring projects, technical sheets of the sensor manufacturers, and reference values typical for this ground and excavation type. These datasets were then processed in Python within Jupyter Notebook to automate their conversion into JSON streams. The resulting files were uploaded and connected to Autodesk Tandem, where each sensor was mapped to its respective digital counterpart. The workflows were tested to ensure that sensor connections could be visualized in real time, laying the groundwork for vibration and settlement simulations.

The preliminary results demonstrate the feasibility of combining BIM environments with SHM data streams to build a functioning digital twin for metro infrastructure. The study highlights both the technical potential and the practical challenges of such integration, particularly in terms of data formatting, parameter mapping, and interoperability across software platforms.

Overall, the thesis provides a structured methodology for bridging BIM and SHM through digital twins, offering a replicable framework that can be applied to similar infrastructure projects beyond Turin.