

The term *monitoring* refers to the set of activities aimed at observing, collecting, and analysing data related to systems, processes, or phenomena. In the engineering field, and particularly in structural engineering, monitoring plays a central role in understanding the behaviour of structures over time and in detecting potential signs of degradation or damage at an early stage. Now more than ever, it is evident that buildings, infrastructure, and civil engineering works are increasingly fragile and vulnerable. This is due, on the one hand, to the natural aging of many structures built in the post-war period, which have now exceeded the useful life for which they were originally designed, and on the other, to rapid urbanization which has increased the risk of extreme events that threaten their integrity. Earthquakes, floods, landslides, and other natural phenomena, sometimes exacerbated by climate change, together with anthropogenic risks, but above all the demand for ever-increasing safety standards, have highlighted the critical issues of the built environment, stressing the urgency of equipping it with effective tools to ensure its safety and durability.

In this context, Structural Health Monitoring (SHM) has emerged, using sensor networks to continuously track the health of structures and emphasising the importance of constant monitoring to prevent irreparable damage. However, although the advantages of SHM are widely recognised in structural engineering, its large-scale adoption remains limited due to several critical issues. In fact, equipping a structure with a complete monitoring system entails high costs and requires highly specialised personnel. The monitoring system must be designed and customised in deep detail for each structure. Furthermore, once sensors are installed at strategic points on the structure, the data collected not only need to be transmitted and stored, but also interpreted to extract useful information that allows effective communication with the structure, which can reveal its conditions. In this regard, the field of structural monitoring is undergoing continuous research to develop new technologies and techniques that will allow such processes to be implemented across a wider range of structures.

This thesis explores the use of data obtained from satellite remote sensing for structural monitoring. Satellite data are chosen primarily because, being acquired remotely, they allow for the monitoring of multiple structures or entire urban areas without the need to install sensors, often at no cost, thus avoiding the expenses associated with designing monitoring systems, purchasing sensors, and employing specialised personnel. Moreover, since satellite data have been available since the launch of satellite platforms into orbit, they provide long historical datasets, which are crucial for SHM in observing the evolution of the structural condition over time. An additional advantage of remote sensing is that the data collected can provide information about the surrounding environment and the soil on which the structure rests. In fact, when structures are monitored, they are often treated as isolated

entities, without considering the system in which the structure is embedded. This leads to the installation of sensors exclusively on the structure itself, without addressing the surrounding environment. However, to fully understand the conditions of a structure, it is crucial to consider it as part of a more complex system, which includes both the environment and the soil. Environmental variables, the so-called Environmental Operational Variations (EOVs), can directly influence the structure or indirectly affect it through the soil that interacts with the structure. Furthermore, the variability of environmental and operational conditions presents a significant challenge for structural monitoring, requiring the development of sophisticated methods to manage the data collected. Statistical analysis of measurements, combined with advanced algorithms, allows for distinguishing between changes caused by damage and those due to external factors such as weather conditions. From this perspective, identifying environmental variables that could influence the structural system response and understanding their interactions is essential to distinguishing between normal and abnormal behaviour. This differentiation enables the distinction between what is physiological (normal) and what is pathological (abnormal), thus optimising resources and potential corrective actions to mitigate damage. Therefore, satellite data represent a valid tool for collecting information on both the environment and the soil without the need for in-situ data.

The aim of this thesis is to integrate satellite data into well-established SHM protocols, applicable to full-scale structures. However, satellite data are originally designed for purposes other than structural monitoring and are thus fundamentally different from data collected from in-situ sensors. For this reason, this thesis involves a careful processing of satellite data, with the aim of making them as compatible as possible, in terms of format and visualisation, with traditional monitoring data through signal processing techniques. Furthermore, the integration of satellite data with in-situ data, both structural and environmental, has been studied not only to compare their correlation but also to reconstruct historical datasets where sensors have been installed recently, thereby filling the historical gap and enabling the collection of as much concurrent data as possible. This thesis focuses on the types of SHM that seeks to understand the interactions between the structure, the environment, and the soil, which is crucial for the development of dynamic predictive models. As both structural and environmental conditions evolve over time, continuous or periodic monitoring becomes key to distinguishing between physiological changes and pathological anomalies. By integrating diverse data sources and updating models accordingly, it becomes possible not only to improve predictive accuracy, but also to anticipate structural vulnerabilities and enable timely, informed interventions, ultimately fostering a more resilient and sustainable built environment.