# Advances and Prospects in Seismic Research on Pile Foundations in Soft Soil (Postprint)

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## Abstract

Pile foundations represent a commonly adopted foundation type on soft soil ground. During earthquakes, seismic settlement of soft soil foundations can result in foundation damage and failure, causing substantial casualties and property losses, a problem that has long garnered extensive attention within the earthquake engineering community. Presently, due to the extreme scarcity of actual field observation data on soft soil seismic settlement, significant scientific challenges persist, including unclear estimation of settlement magnitudes, poorly understood mechanisms of pile-soil interaction accounting for both soft soil seismic settlement and negative skin friction, and inadequate understanding of seismic damage to pile foundations. By compiling engineering seismic damage data and field investigation experiences from major domestic and international earthquakes in recent years, this study provides a comprehensive review of the principal methods and approaches for pile foundation seismic performance from the perspectives of model testing, numerical analysis, simplified theoretical analysis, and empirical methods. It synthesizes the latest research findings on the seismic resistance of pile foundations in soft soil deposits, elucidates the phenomena and mechanisms of seismic damage to such foundations, and systematically organizes and summarizes recent research outcomes. The majority of studies demonstrate that dynamic damage and failure of pile foundations constitute the combined result of pile-soil dynamic interaction under seismic loading, wherein foundation failures such as soft soil seismic settlement represent external factors, while inherent strength deficiencies in the pile foundation itself constitute internal factors. Finally, addressing the existing problems and limitations in current research efforts, this paper proposes prospects and recommendations for future research directions and methodologies, particularly emphasizing that against the backdrop of lacking seismic damage experience and observational records, the application of efficient and scientific model testing represents a crucial technical approach and research tool for resolving current pile-soil interaction issues.

## Full Text

## Preamble

The following section contains foundational mathematical formulations and preliminary definitions that establish the theoretical framework for subsequent analysis. Key expressions include the core mathematical relationships describing the computational framework, which establish the basis for analyzing system behavior under various conditions. The parameters and variables are defined through subsequent derivations, with further mathematical development extending the computational framework to its final form. The complete set of preliminary equations establishes the necessary boundary conditions and constraints.

These mathematical foundations provide the necessary theoretical underpinning for the methodological developments and empirical analyses presented in subsequent sections of this work.

*Note: Figure translations are in progress. See original paper for figures.*