A Unified Approach to Seismic Analysis, Design, and Detailing of Prestressed Concrete Piles

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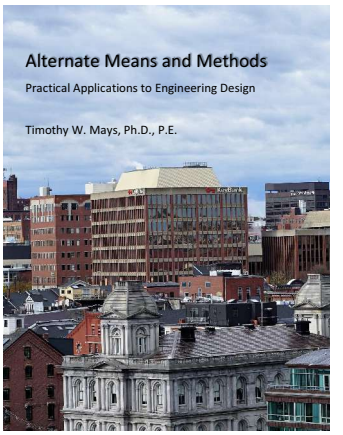

Seismic analysis, design, and detailing provisions for piles used to support building structures are very different than those for piles supporting bridge and pier superstructures. The main difference involves the expected performance of piles during the design earthquake, as reflected by the overall pile behavior philosophy mandated in the codes governing the design of these two types of structures.

For building structures, standard practice considers the pile foundation system to be the fixed-base portion of a structural model, and the foundation design is governed by reactions at the base of the above-ground structure at or near the pile head. Pile foundation forces for buildings are based on lateral forces obtained using code-prescribed response modification coefficients (*R* values) for the building's specific lateral force-resisting system. (For buildings, it is assumed that all damage takes place above grade). Additional prescriptive deflection limits and other criteria are intended to ensure an elastic response of the building piles. Contrary to the anticipated elastic pile behavior described above, and as an additional measure of conservatism, prescriptive detailing provisions for building piles result in ductile capacities that approach those for columns in special reinforced concrete moment frames.

In bridge and pier structures, the piles are often considered to be the structure's lateral-force-resisting system. In fact, response modification coefficients are provided in the bridge and pier codes for these applications, but *R* values are not provided for piles in building applications because building piles are not permitted to be elements of a lateral-force-resisting system. In addition, bridge and pier codes encourage performance-based seismic design of piles that includes or allows for pile hinging and controlled pile damage. Performance-based seismic design of piles involves detailing the needed (not prescriptive) amounts of spiral reinforcement and providing this reinforcement only where needed as based on soil-structure interaction modeling, appropriate consideration of head fixity, and other design considerations.

Education courses based on the new book *Alternate Means and Methods: Practical Applications to Engineering Design* are currently being presented by Structural Engineers Association chapters in various cities in the southeastern United States. This book, which goes into great detail about a variety of practical solutions to complicated problems in the building industry, includes a special section on prestressed concrete pile design with an example building that uses piles with stick-up as part of a building's lateral-force-resisting system. Most recently, on the campus of The Citadel in Charleston, S.C., a related presentation was given to the local chapter of the Pile Driving Contractors Association on how a unified approach to prestressed concrete pile design leads to significant economic benefits (10% to 30%, or more, in overall material cost savings) while also offering the design engineer a more reliable load path and a better understanding of how the pile system will respond to the design earthquake.

The Precast/Prestressed Concrete Institute is leading an effort to unify prestressed concrete pile provisions for all structures. The approach will allow for both traditional prescriptive design and performance-based design of piles. Special analysis, design, and detailing provisions will also be provided, depending on whether the piles are being considered as part of the structure's lateral-force-resisting system (that is, whether controlled pile damage is being permitted as part of the overall structural seismic response).

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EDITOR'S NOTE

For more information regarding these training sessions, please contact Dr. Mays at mayst1@citadel.edu