Design Guide for Pile Caps

A Detailed Guide Providing a Comprehensive Overview of Pile Cap Design, Detailing, and Analysis Methodologies Meeting Current Codes and Standards.

First Edition

Concrete Reinforcing Steel Institute
2015
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Foreword

The CRSI Design Handbook, 10th Edition, 2008, was the last comprehensive undertaking completed by CRSI. The Pile Cap Design Guide follows the long-established tradition of providing complete, tabulated designs of common reinforced concrete structural members. The tabulated designs are for normally encountered conditions, and are based on the latest applicable code provisions and materials specifications. All of the tabulated designs in this design guide are prepared in accordance with “Building Code Requirements for Structural Concrete (ACI 318-14).” The majority of the notations used in this design guide follows ACI 318-14. In those instances where other notation had to be introduced, symbols are defined or shown on figures.

Since the first CRSI Design Handbook in 1952, users of CRSI publications have been cooperative in suggesting to the Design Aids Committee and CRSI Staff, many improvements, clarifications and additional design short-cuts. This professional assistance is very helpful, and is appreciated. Comments regarding the Pile Cap Design Guide are welcome so that future Design Guides can be further improved. Please direct all comments to Mike Mota, Ph.D., PE., SECBI, FSEI, FASCE, FACI, CRSI Vice President of Engineering.

Author

Timothy Mays, Ph.D., PE., The Citadel

Review Panel Committee

Farid Alfawakhiri, Ph.D., PE., Steel Market Development Institute
Dave Borger, PE. Skyline Steel
Mary Ellen C. Bruce, PE. Deep Foundations Institute
Michael Engestrom, Nucor-Yamato Steel
Michael Garlich, PE., S.E., Collins Engineers
John Hema, Ph.D., PE., CMC Americas
Terence Holman, Ph.D., PE., Geosyntec
Samuel J. Kosa, Monotube Pile Corporation
Jay Larson, PE., F. ASCE American Iron and Steel Institute
Gerald Verbeek, Allnamics-USA, LLC
Andrew Verity, Terracon
Michael Wysockey, Ph.D., PE., Thatcher Foundations
CRSI Staff
Mike Mota, Ph.D., PE., SECBI, FSEI, FASCE, FACI, (Project Manager)
Anthony Felder, PE.
John Turner, PE.

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DFI Headquarters
326 Lafayette Avenue
Hawthorne, NJ 07506, USA
Tel: 973-423-4030  •  Fax: 973-423-4031
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CHAPTER 1
Introduction

1.1 General

The CRSI Pile Cap Design Guide has been developed as a standalone publication intended to provide the practicing engineer with a detailed overview of pile cap design, detailing, and analysis methodologies that represent the current state of practice in the industry and meet the latest codes and standards including the 2012 International Building Code (IBC) and ACI 318-14. The CRSI Pile Cap Design Guide is much more than an updated version of Chapter 13 of the CRSI Design Handbook (2008). When the CRSI Design Handbook (2008) was developed, pile allowable loads exceeding 200 tons were not common. Since that time, 16 inch and 18 inch HP sections with higher allowable loads have been developed and this guide has an expanded scope that includes pile allowable loads up to 400 tons. The use of larger and stronger piling (tagged “high load piling” in this guide) necessitates deeper pile caps with larger edge distances. In order to better understand the behavior of deep pile caps, a finite element study was performed and recommendations obtained from that study are presented here and incorporated into new details used for all pile caps utilizing pile allowable loads greater than 200 tons.

On a separate note, lateral loads on pile caps are considered for the first time in a CRSI publication in this design guide. A complete design example for detailing a pile cap under combined vertical loading, lateral loading, and overturning is included in this guide. Tabulated designs are also provided for all CRSI considered pile cap configurations and a wide range of vertical loading, lateral loading, and overturning effects.

Although pile caps are an important structure, they are somewhat neglected in handbooks on structural steel design because they are constructed of reinforced concrete or in handbooks on reinforced concrete design in the range where steel piles are commonly used. The complex and often misunderstood load path fundamentals associated with pile caps and the fact that most pile caps are not open to visual inspection under service warrants a conservative design approach. Complete nonlinear finite element modeling of pile caps is not practical in routine design practice and applying geometry specific strut and tie design models for all pile caps can be unconservative when certain modes of failure control the pile cap’s response. On the contrary, research performed during the development of this guide suggests that deeper pile caps associated with larger and stronger piling than was considered in the CRSI Design Handbook (2008) warrant some new steel details as presented in this guide.

Chapter 2 of this design guide provides an overview of load types considered and how these loads are appropriately combined to design pile caps. Chapter 3 provides an overview of assumptions used to determine the load distribution to piles when caps are subjected to different load cases. Chapter 4 presents pile cap configurations that are considered in the design guide, dimensioning requirements, and the overall recommended layout of steel reinforcement in the pile cap. Chapter 5 and Chapter 6 present pile cap design procedures for vertical and lateral/overturning loads, respectively. Chapter 7 is a special chapter devoted to seismic design of pile caps and Chapter 8 includes practical pile cap design examples including complete manual solutions for vertical and lateral load situations. Chapter 9 presents a description of the tabulated pile cap designs for both vertical loads (based on Chapter 5 methodologies) and combined, vertical, lateral, and overturning actions (based on Chapter 6 methodologies). The design tables are in Section T. The appendices are also replete with practical information. Appendix A presents detailed derivations for several simplified design equations presented in the design guide. Column-to-pile cap and pile-to-pile cap connection details are discussed in Appendix B and C, respectively.

In common with the CRSI Design Handbook (2008), this design guide includes simple, easy to use design tables for vertically loaded pile caps. New to this design guide are expanded tables to include piles with larger allowable loads and the inclusion of tabulated designs that also include the effects of lateral loads and overturning. Also new to this publication are downloadable Excel spreadsheets that can be used to design pile caps under different assumptions than those used to generate the tabulated designs presented in Appendix A in this publication.