Florida Department of Transportation Research

Bearing Capacity Factors for Shallow Foundations Subject to Combined Lateral and Axial Loading

December 2020

Project Number
BDV31-977-66

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Current Situation

In Florida, many types of structures are built on shallow foundations, which are usually concrete pads that provide footings for a structure and distribute a load over a wide area. For large structures, such as bridges, the footings are primarily designed to handle the vertical, or axial, load applied by the structure, with the usual assumption that this load will be carried at the center of the footing, where it is evenly distributed. However, for real structures, the footing may be subjected to loads that are off-center (referred to as eccentric) and/or effectively applied at an angle, or inclined, instead of axially. Also, the location of the footing may result in forces against the sides of the footing (referred to as lateral) that further complicate a precise understanding of forces on the footing that can affect its bearing capacity. Currently, there is no consensus about how to analyze footings in these situations and accurately predict their bearing capacity.

Workers assist as a precast bridge footing is prepared for placement.

Research Objectives

University of Florida researchers tested lab-scale structures using inclined and eccentric loads on footings and used their findings to select the most appropriate methods for determining bearing capacity.

Project Activities

A series of footing types – strip, rectangular, and square – were tested under a variety of inclined and eccentric loads and on support media that represented very dense to medium dense sand of types commonly found in Florida. Support-footing-structure mockups were tested in a centrifuge, allowing the researchers to vary the applied loads over a wide range, up to failure of the support. Sensors made it possible for the researchers to accurately document the forces on the footing and the failure mode of the support.

In addition to sand types, parameters tested in the experiments included how deep the footing was embedded in the support material, footing width, lateral-to-axial load ratios, and load eccentricity. Load, displacement, and pressure in the support material were measured. Bearing pressure versus displacement curves were monitored until the support medium failed. Measurements of the soil pressure beneath the footings confirmed the pressure distribution of a rigid footing on sand, the eccentricity of resultant load, and the observed effect of inclined load to enhance or diminish the eccentricity.

Methods for estimating the bearing capacity drawn from standard specifications and the scientific literature were compared to experimental results. These methods may focus on different aspects of the problem and were often used in combination. The researchers recommended specific combinations of methods for specific situations. For example, Hansen's self-weight and inclination factors used with Loukidis's factor gave good agreement with most cases involving combined eccentric-inclined loads.

Project Benefits

This project provides and important new resource for more accurate modeling of shallow foundations on Florida soils.

For more information, please see www.fdot.gov/research/.