ABSTRACT

The stability of a structure relies heavily on the performance of connections such as beam-to-column, beam-to-slab, column-to-foundation, and wall-to-foundation connections, which are commonly realized using anchors. These connections are frequently subjected to bending moments. If anchors are not properly designed for such loading, brittle concrete-related failures may occur, potentially leading to partial or total structural collapse. Consequently, a clear understanding of anchor behavior under bending moment is essential for achieving safe and ductile design of connections.

When anchors are subjected to bending moment, a tension–compression couple develops. Tension is resisted by the anchors, whereas compression is transferred into the concrete through baseplate or column bearing. This compression suppresses tensile cracking of concrete and enhances anchor capacity compared to pure tension loading. However, current design provisions do not adequately account for this effect. As a result, they can lead to overly conservative designs especially for certain anchor geometries and configurations. The objective of this dissertation is to improve the understanding and design of anchors subjected to bending moment, with particular emphasis on concrete-related failure modes.

To address these limitations, this dissertation presents a systematic experimental and numerical investigation of anchors subjected to predominant bending moment. Extensive experimental studies were conducted to evaluate the influence of key parameters, including internal lever arm, anchor diameter, embedment depth, edge proximity, foundation geometry, and loading type. Both monotonic and cyclic loading conditions were considered. In addition, three-dimensional nonlinear finite element models were developed and validated against experimental results. These models were subsequently used to perform parametric studies beyond the experimental scope and to gain insight into load transfer mechanisms and overall anchor performance.

The results demonstrate that bending-induced compression significantly enhances anchor capacity for both concrete cone failure and combined pullout and concrete failure. This enhancement is strongly influenced by internal lever arm, anchor geometry, and edge conditions. Based on the

combined experimental and numerical evidence, improved and new design expressions were developed for the modification factor $\psi_{M,N}$. Statistical evaluation indicates that the proposed expressions provide improved predictive accuracy and reduced scatter over a wider range of parameters compared to current design provisions.

In conclusion, this dissertation advances the understanding of anchor behavior under bending moment and provides improved design models for anchors governed by concrete-related failure modes. The proposed formulations offer a more reliable and mechanics-based approach for design, contributing to improved safety and reliability of anchorage systems.