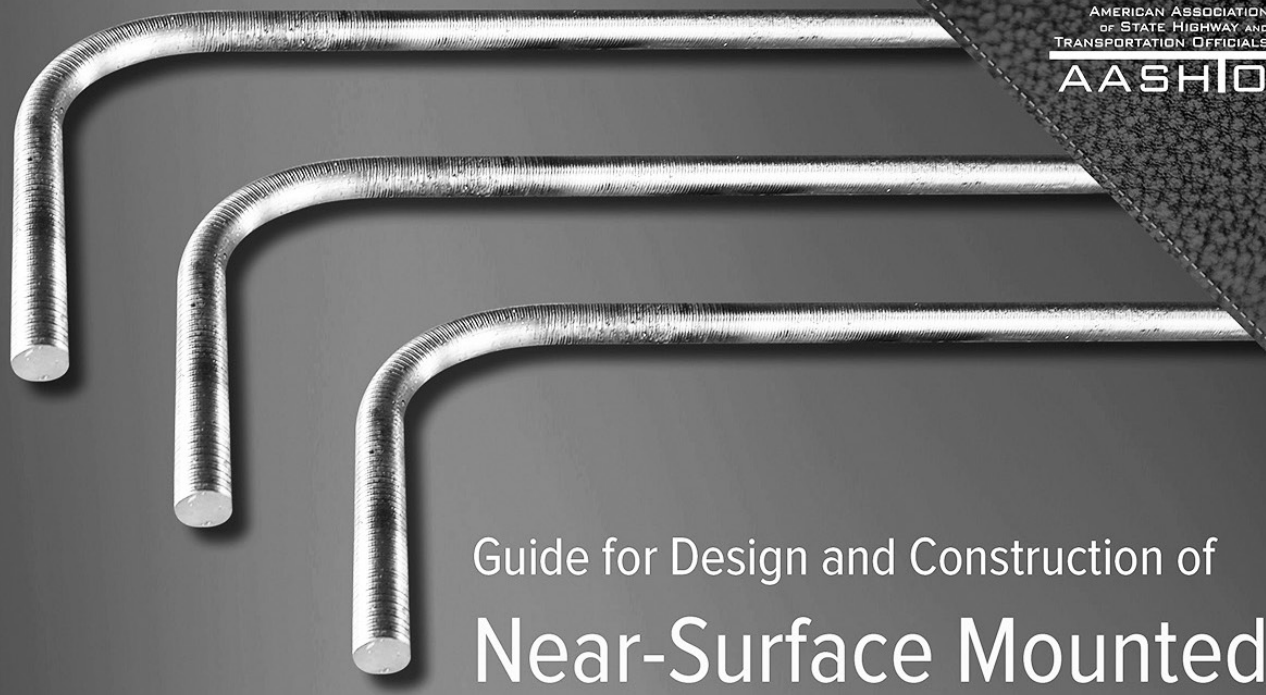

American Association of State Highway and Transportation Officials

AASHTO

Guide for Design and Construction of

Near-Surface Mounted Titanium Alloy Bars

for Strengthening Concrete Structures

2020 EDITION

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PART 1: GENERAL

CHAPTER 1—INTRODUCTION AND SCOPE

1.1 SCOPE

This guide provides design and construction recommendations for strengthening existing reinforced concrete (RC) structures with titanium alloy bars with 6 percent aluminum and 4 percent vanadium alloying elements (TiABs) using the near-surface mounted (NSM) construction method. The overall approach and organization of this guide are based on those presented in ACI 440.2R (ACI, 2017). Recommendations are provided for shear and flexural strengthening. The design approach is based on and adapted from the *AASHTO LRFD Bridge Design Specifications* (2017), hereafter referred to as "AASHTO LRFD Design." The recommendations are supported by experimental and analytical research as well as field experiences that have demonstrated the application of TiABs for strengthening full-scale specimens typical of bridge girders. The available experimental evidence includes the influences of combined high-cycle fatigue and environmental durability on the structural performance of NSM-TiAB-strengthened girders.

TiABs are not sensitive to environmental deterioration such as corrosion. Their use near the concrete surface will not be adversely affected by environmental degradation. Long-term durability of applications with TiABs will be controlled by the concrete substrate and bonding materials.

This guide does not address seismic strengthening applications.

1.2 APPLICATION AND LIMITATIONS

Many existing RC structures need strengthening due to inadequacies from the original design or construction, changes in usage, deterioration, damage, or other causes. Designers have many methods and materials available to strengthen RC structures. The most common modern approach is the application of fiber-reinforced polymers (FRPs). Design and construction approaches using FRPs have advanced significantly over the past two decades as documented in ACI 440.2R (ACI, 2017), and these approaches lay a foundation for application of TiABs that serve the same functionality as FRPs. TiABs offer the added benefit of ductility and inherent mechanical anchorage at terminations.

This guide applies only to the application of NSM-TiABs for strengthening existing RC structures for flexure and shear. The methods require the use of standard 90-degree hooks at both ends of the bars to provide anchorage. The methods are not applicable to straight-bar applications without hooks at the ends. The methods include interactions of flexure on shear strength. The methods are applicable to concrete substrates that are able to effectively transmit bond stresses along the length of the bars and that can anchor the hooks. The minimum required concrete compressive strength is 3 ksi.

The bond of TiABs along the NSM length provides crack control and limits deflections. At ultimate strength, significant cracking of the concrete, distress around the bonded regions, and debonding of the TiABs are anticipated.

These methods are applicable to design with TiABs when the load effects are established using conventional elastic structural analysis with the load distribution factors prescribed in *AASHTO LRFD Design* (2017). Use of this guide combined with advanced methods of structural analyses requires additional care.

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