

Errata for
Guide for Design and Construction of Near-Surface Mounted
Titanium Alloy Bars for Strengthening Concrete Structures,
First Edition (NSMT-1)

March 2024

Dear Customer:

Recently, we were made aware of some technical revisions that need to be applied to *Guide for Design and Construction of Near-Surface Mounted Titanium Alloy Bars for Strengthening Concrete Structures*, First Edition. Please scroll down to see the full erratum.

In the event that you need to download this file again, please download from AASHTO's online bookstore at: <https://downloads.transportation.org/NSMT-1-Errata.pdf>.

The new changes in this erratum are detailed in the table under the "March 2024" heading. Pages with the new changes have a gray box in the page header reading as follows:

March 2024 Errata

AASHTO staff sincerely apologizes for any inconvenience to our readers. Please feel free to contact us if you have questions or need any additional information.

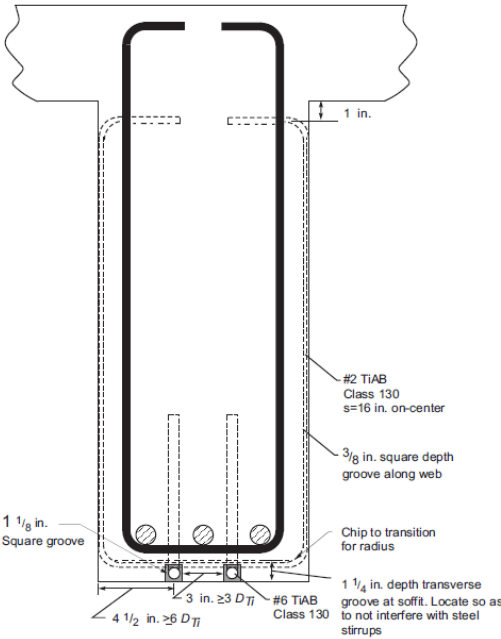
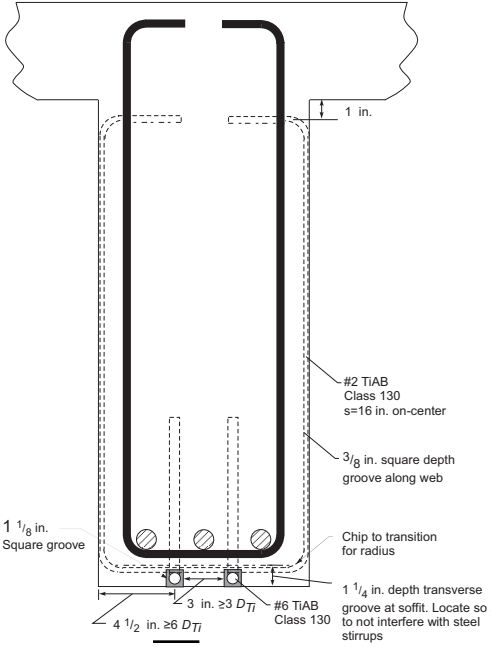
Sincerely,
AASHTO Publications

Summary of Errata Changes for NSMT-1, March 2024

Page	Existing Text/Notes	Corrected Text
<i>Chapter 7</i>		
8	Yield strains for TiABs are approximately 8,400 $\mu\epsilon$ for Class 130 material with insensitive bonding materials and 6,580 $\mu\epsilon$ for Class 120 material with sensitive bonding materials.	Yield strains for TiABs are approximately 8,400 $\mu\epsilon$ for Class 130 material with insensitive bonding materials and 7,700 $\mu\epsilon$ for Class 120 material with sensitive bonding materials.
<i>Chapter 9</i>		
13	$\epsilon_s = \frac{\frac{ M_u }{d_v} + V_u - V_p - A_{ps}f_{po}}{E_s A_s + E_p A_{ps} + \alpha_E E_{Ti} A_{Ti}} \quad (9.4-5)$	$\epsilon_s = \frac{\frac{ M_u }{d_v} + V_u - V_p - A_{ps}f_{po}}{E_s A_s + E_p A_{ps} + E_{Ti} A_{Ti}} \quad (9.4-5)$
14	if $V_u < 0.125\sqrt{f'_c}b_v d_v$, then $s_{\max} \leq 0.4d_v \leq 12.0$ in. (9.6-2)	if $V_u \geq 0.125\sqrt{f'_c}b_v d_v$, then $s_{\max} \leq 0.4d_v \leq 12.0$ in (9.6-2)

Page	30
<i>Chapter 11</i>	
Existing Text/Notes	$\epsilon_s = \frac{\frac{ M_u }{d_v} + V_u }{E_s A_s + \alpha_E E_{Ti} A_{Ti}} = \frac{\frac{507.2 \text{ kip ft} (12 \text{ in./ft})}{33.3 \text{ in.}} + 112.5 \text{ kips} }{29,000 \text{ ksi} (4.68 \text{ in.}^2) + 0} = 0.002175 \text{ in./in} \quad (11.3.1-2a)$
Corrected Text	$\epsilon_s = \frac{\frac{ M_u }{d_v} + V_u }{E_s A_s + E_{Ti} A_{Ti}} = \frac{\frac{507.2 \text{ kip-ft} (12 \text{ in./ft})}{33.3 \text{ in.}} + 112.5 \text{ kips} }{29,000 \text{ ksi} (4.68 \text{ in.}^2) + 0} = 0.002175 \text{ in./in} \quad (11.3.1-2a)$
Existing Text/Notes	$117.4 \text{ kips} \geq 0.125\sqrt{3.3 \text{ ksi}} (13 \text{ in.}) 33.3 \text{ in.} = 9.83 \text{ kips} \quad (11.3.1-5)$
Corrected Text	$117.4 \text{ kips} \geq 0.125\sqrt{3.3 \text{ ksi}} (13 \text{ in.}) 33.3 \text{ in.} = 98.3 \text{ kips} \quad (11.3.1-5)$
Page	34
Existing Text/Notes	$T_{\text{demand}} = \frac{ M_u }{\phi_s d_v} + \left[\frac{V_u}{\phi_s} - \frac{V_s}{2} - \frac{V_{Ti}}{2} - \left(\frac{\gamma_{DC} w_{DC}}{2} + \frac{\gamma_{DW} w_{DW}}{2} + \frac{\gamma_{LL} w_{lane} DF_M}{2} \right) d_v \cot \theta \right] \cot \theta$ $= \frac{359.1 \text{ kip-ft} (12 \text{ in./ft})}{(0.9) 33.31 \text{ in.}} + \left[\frac{98.3 \text{ kips}}{0.9} - \frac{63.7 \text{ kips}}{2} - \frac{27.9 \text{ kips}}{2} - \left(\frac{1.25 (1.18 \text{ kip/ft})}{2} + \frac{1.5 (0.33 \text{ kip/ft})}{2} + \frac{1.75 (0.64 \text{ kip/ft}) (0.78)}{2} \right) \frac{33.31 \text{ in.}}{12 \text{ in./ft}} \cot 34.87^\circ \right] \cot 34.87^\circ$ $= 226.6 \text{ kips} \quad (11.3.3-3)$

Corrected Text	$T_{\text{demand}} = \frac{ M_{ui} }{\phi_b d_v} + \left[\frac{V_{ui}}{\phi_v} - \frac{V_s}{2} - \frac{V_{Ti}}{2} - \left(\frac{\gamma_{DC} W_{DC}}{2} + \frac{\gamma_{DW} W_{DW}}{2} + \frac{\gamma_{LL} W_{lane} DF_M}{2} \right) d_v \cot \theta \right] \cot \theta$ $= \frac{359.1 \text{ kip-ft (12 in./ft)}}{(0.9)33.31 \text{ in.}} +$ $\left[\frac{98.3 \text{ kips}}{0.9} - \frac{63.7 \text{ kips}}{2} - \frac{27.9 \text{ kips}}{2} - \left(\frac{1.25(1.18 \text{ kip/ft})}{2} + \frac{1.5(0.33 \text{ kip/ft})}{2} + \frac{1.75(0.64 \text{ kip/ft})0.78}{2} \right) \frac{33.31 \text{ in.}}{12 \text{ in./ft}} \cot 34.87 \right] \cot 34.87$ $= 226.6 \text{ kips}$ <p style="text-align: right;">(11.3.3-3)</p>
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Page	Existing Text/Notes	Corrected Text
36	 <p>1 in.</p> <p>#2 TIAB Class 130 s=16 in. on-center</p> <p>3/8 in. square depth groove along web</p> <p>1 1/8 in. Square groove</p> <p>Chip to transition for radius</p> <p>1 1/4 in. depth transverse groove at soffit. Locate so as to not interfere with steel stirrups</p> <p>3 in. ≥ 3 D_{TI}</p> <p>#6 TIAB Class 130</p> <p>4 1/2 in. ≥ 6 D_{TI}</p>	 <p>1 in.</p> <p>#2 TIAB Class 130 s=16 in. on-center</p> <p>3/8 in. square depth groove along web</p> <p>Chip to transition for radius</p> <p>1 1/4 in. depth transverse groove at soffit. Locate so as to not interfere with steel stirrups</p> <p>3 in. ≥ 3 D_{TI}</p> <p>#6 TIAB Class 130</p> <p>4 1/2 in. ≥ 6 D_{TI}</p> <p>1 1/8 in. Square groove</p>

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the fatigue truck including 15 percent impact. The existing structure should be able to meet the following condition:

$$\phi R_n \geq 1.05DC + 1.1DW + 0.75LL \quad (7.2-1)$$

where ϕR_n is the design strength of the existing structure without TiABs and DC , DW , and LL are the load effects from weight of components, weight of wearing surface, and live load (with 15 percent impact), respectively.

If future loads are not to be increased and when calculations show the existing structure does not satisfy Equation 7.2-1, demonstrated in-service performance can be used as evidence of sufficient underlying operational strength.

TiABs have been shown in the laboratory not only to fully restore the strength of a failed structural girder, but to increase the strength above the expected unstrengthened capacity (Higgins, Amneus, and Barker, 2015a). Thus, it is possible to design TiABs to strengthen structures that do not meet the conditions of Equation 7.2-1. For such conditions, additional care shall be exercised by the designer, and inspection procedures and intervals shall be established to ensure long-term performance.

7.3 FIRE ENDURANCE

No specific fire endurance limits are proposed at present. The use of hooked ends that are anchored in the core concrete provide some additional robustness for TiAB-strengthened systems compared to other surface-only bonded materials.

If TiABs are used in cases that do not satisfy Equation 7.2-1, fire endurance should be considered by the designer.

7.4 PREFERRED FAILURE MODES

Application of supplemental strengthening materials can shift or alter failure modes. It can also result in failures at unstrengthened locations in the member. Ductile failure modes are preferred. When possible, failures should be controlled by ductile flexural modes rather than diagonal tension (shear).

7.5 ENVIRONMENTAL DURABILITY

TiABs are not sensitive to degradation from environmental exposure. However, the materials used to bond TiABs to the concrete substrate can be sensitive to such exposure. Some bonding materials are less sensitive than others to different environmental conditions. No bonding materials should be used that exhibit marked degradation in bond performance after exposure testing.

To account for reduced bond strength along the NSM length due to environmental exposure, exposure factors, α_E , are applied that depend on the environmental sensitivity of the bonding material. The factors are shown in Table 7.5-1. The slightly larger exposure factors compared to FRP systems are due to the beneficial hooked ends that are anchored in the concrete core and are better protected from surface environmental conditions.

Table 7.5-1 Environmental Exposure Factors

Exposure Sensitivity	Environmental Exposure Factor, α_E
Routine	0.85
Insensitive	1.00