

Special Specification 4155

Near Surface Mounted Titanium Strengthening



1. DESCRIPTION

Retrofit existing concrete member with titanium alloy bars installed marginally below the surface to provide strengthening.

2. MATERIALS

Provide material mill sheets showing compliance with requirements.

- 2.1. **Reinforcement.** Furnish titanium alloy bars with chemical composition meeting ASTM B348 Grade 5 (Ti-6Al-4V) and ASTM B1009 (2018). Provide either ASTM B1009 (2018) Class 120 or Class 130 as specified on the plans meeting Table 1 tensile requirements.

Table 1
Tensile Requirements

| Property | Class 120 | Class 130 |
|-------------------------------|------------|------------|
| Min. Yield Strength | 120 ksi | 130 ksi |
| Min. Ultimate Strength | 130 ksi | 140 ksi |
| Min. Elongation | 10% | 10% |
| Nominal Modulus of Elasticity | 15,500 ksi | 15,500 ksi |

Provide bars with deformed surfaces to enhance bond and with 90 degree hooks on each end. Make deformations uniform and equally spaced along the titanium alloy bars with a minimum deformation height of 0.01 in. and a maximum spacing of 0.06 in. The deformations should not have sharp stress risers. The final cross-sectional area of the bars including the deformations must not be less than 96% of the nominal area of undeformed bars.

- 2.2. **Bonding Materials.** Provide a Type III, Class E Epoxy adhesive in accordance with DMS-6100 to anchor and bond titanium bar to concrete.

3. CONSTRUCTION

Retrofit existing concrete member with near surface mounted titanium bars. Perform work in accordance with the following and as shown on the plans.

- 3.1. **Submittals.** Provide method and sequence of work, including but not limited to:
- The sequence of anchor hole and groove preparation as it relates to the overall construction Plan.
 - Methods for locating and protecting existing steel reinforcement. Details regarding the Equipment and structural attachments required for installation of the titanium alloy reinforcement.
 - Details of the proposed method, if different than specified, for ensuring the titanium alloy reinforcement will be installed as shown.
- 3.2. **Groove.** Locate reinforcing steel in cap, depth and location. Create groove in concrete surface to contain titanium reinforcement by an approved method. Do not cut existing reinforcing steel.

- 3.3. **Anchor.** Create holes in concrete member at correct locations to allow embedment of 90 degree hooks at each end of the reinforcement. Drill holes for hook embedment depth and size as shown using a rotary hammer drill with a carbide tipped drill bit. If existing reinforcement is encountered, stop drilling and adjust the hole location. Adjust the location of the holes for the end anchorage up to three inches longitudinally and laterally to avoid conflicts. Maintain the titanium bar lengths.
- 3.4. **Groove.** Cut grooves as shown to the designed width and depth $\pm 1/8$ in. Make grooves deep enough to allow the titanium bar to be installed at least $1/8$ in. below the surface in all locations along the length of bars. Do not cut into existing rebar during construction of sawcut grooves. Visually inspect all existing rebar locations after saw-cutting grooves. When existing reinforcement is cut, inform the Engineer before installation of titanium reinforcement.
- Groove spacing may be adjusted in the field as necessary to avoid existing reinforcement or other unforeseen conflicts; however, the average spacing of all grooves over any two foot long section may not be more than the spacing as shown.
- 3.5. **Anchor Hole and Groove Preparation.** Prepare saw-cut grooves and anchor holes for titanium reinforcement installation as follows:
- 3.5.1. **Surface Cleaning:** Clean the groove and anchor holes thoroughly by water blasting and a nonmetallic brush. Before the groove and anchor holes dry out, blow it free of water and debris with compressed air. Ensure that all dust, sand, laitance, grease, curing compounds, and any other bond-inhibiting matter is removed from the groove and anchor holes. The concrete surface of groove and anchor holes must be clean and structurally sound before installing titanium bars.
- 3.5.2. **Moisture on Groove and Hole Surfaces.** Before installation of titanium bars, dry groove and anchor hole surfaces according to the epoxy resin manufacturer's recommendations. Dry groove and anchor hole surfaces using a drying method approved by the Engineer and according to the epoxy manufacturer's recommendations. Do not directly apply a flame to the groove and anchor holes surfaces.
- 3.5.3. **Titanium Bar Installation.** Begin installation only after groove and anchor hole preparation Work is complete.
- Install the titanium bars to the embedment depths and in the anchor holes as shown.
- Do not install the titanium bars and epoxy resin when the concrete temperature is below 50 °F, unless otherwise advised by the resin manufacturer's recommendations.
- Mask the concrete adjacent to the groove to prevent excess epoxy from adhering to the concrete outside the groove.
- Place nylon or polyethylene spacer material between the titanium bars and exposed, existing steel reinforcement.
- Fill two-thirds of the anchor hole and one-half of the groove with epoxy resin. Press the titanium bar in the anchor holes and in the center of groove using approved centering devices at one-third points along the titanium bar. Centering devices must not have less than $1/8$ in. resin cover when installed.
- Ensure epoxy resin is well consolidated around the bars without air pockets. Level epoxy resin flush with the surface of the adjacent concrete.

4. MEASUREMENT

This Item will be measured by the foot of titanium bar installed including the hooks on the bars.

5. **PAYMENT**

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement," will be paid for at the unit bid price for "NSM Titanium Strengthening" of the grade and size specified. These prices are full compensation for routing groove in concrete, surface preparation, materials, placement, equipment, labor, tools, and incidentals.