Ti-6Al-4V Bars for Strengthening and Cathodic Protection of Reinforced Concrete Structures

Amanda Slawinski, Christopher Higgins, Ph.D, P.E., Burkan Isgor, Ph.D, P.E.

PROJECT OVERVIEW

• Impressed Current Cathodic Protection (ICCP) systems require electrically conductive path between anode (steel rebar) and cathode (TiABs).

• To capitalize on both strength and corrosion resistance properties of TiABs, a structural grout that is also electrically conductive is needed with resistivity of around 0.1 kΩ-cm, compressive strength of 3000 psi, and bond strength with TiABs of 1000 psi.

• Large scale tests of steel reinforced concrete beams utilizing epoxy with TiABs achieved structural performance. Can cementitious grouts perform similarly?

METHODOLOGY

• Carbon fibers and carbon black added in different volume percentages to cementitious grout creating electrically conductive and structural bonding material.

• Pullout tests conducted to assess bond between concrete, grout mix, and TiABs.

• Steel reinforced concrete beams exposed to corrosive chloride environment typical of coastal and cold weather climates.

• Beams retrofitted with TiABs and conductive grout to form ICCP system.

• Data used to model the lifespan of system.

WHAT’S NEXT?

• Test bond strength using the final grout design with TiABs through pullout tests in steel reinforced concrete blocks and cylinders.

• Construct full-scale steel reinforced concrete beams 8 ft in length, and retrofit with TiABs and conductive grout.

• Connect TiABs to steel rebar to form ICCP system. Establish current density to prevent corrosion of steel rebar.

REFERENCES

1. NIST (2017)
2. NACE International
4. V&C Cathodic Corrosion Protection Austria
5. SW Concrete Repairs

ACKNOWLEDGEMENTS

• Using commercially available grout, 0.4% by volume carbon fiber with 6mm length fibers, 0.2% by weight methyl cellulose, resulted in a resistivity of 0.16 kΩ-cm with compressive strength of 8700 psi.

• A conductive carbon black will be added to this mix design to achieve resistivity 0.1 kΩ-cm.

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WHY IS THIS IMPORTANT FOR THE TITANIUM INDUSTRY?

• 15% of US bridge inventory is structurally deficient due to corroded steel and steel reinforcement2.

• Direct costs of corrosion range between $6 to $9 billion annually3.

• Corrosion reduces reinforcing steel area and causes spalling and cracking of concrete. These compromise structural integrity, resulting in the need for restoration.

• Titanium alloy bars (Ti-6Al-4V) (TiABs), with a surface pattern that allows for the material to bond with structural epoxy, have been developed to strengthen existing structures for both gravity and seismic loads.

• Titanium is commonly used in cathodic protection systems to prevent corrosion.

• Combining structural strengthening and corrosion prevention produces immediate and long-term benefits not possible with alternatives.

• TiABs can act as a multi-functional material that provides a new approach for retrofitting and restoring the nation’s infrastructure.

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