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EVALUATING THE LIFE CYCLE COST OF STEEL BRIDGES

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Carnegie Mellon University College of Engineering

ATLSS

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Evaluating the Life Cycle Cost of Steel Bridges

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Steel bridges represent more than 30 percent of the total number of highway bridges in the United States and represent a critical component of our transportation infrastructure system. These bridges, if placed in highly corrosive environments, due to de-icing salts or marine exposure, may require frequent maintenance and repair actions during their service life. To address this issue, several steel types offering better corrosion resistance have been introduced by steel manufacturers to reduce the need for maintenance in corrosive environments.

With PITA funding, Lehigh University Professor Dan Frangopol partnered with ArcelorMittal, the world's leading steel and mining company, with operations in Coatesville, Pa., to evaluate the life-cycle cost of a representative Pennsylvania steel bridge.

They did this by comparing whether the bridge is constructed using painted conventional carbon steel or ArcelorMittal's corrosion-resistant steel, coded as ASTM A1010.

For bridges under heavy chloride exposure, coated carbon steel is typically used and multiple repainting maintenance actions are performed throughout the service life of the bridge to ensure its acceptable performance. The corrosion-resistant A1010 steel, as a maintenance-free alternative, has been found to be superior in such applications. However, it has a considerably higher initial cost when compared to the painted carbon steel. Frangopol and ArcelorMittal quantified the life-cycle cost of both alternatives, so that bridge managers can rationally select the appropriate material that best suits their needs.

"Life cycle performance and cost analysis of steel bridges represents an important part of ArcelorMittal's development of ASTM A1010 that is manufactured exclusively in Pennsylvania," stated Fred Fletcher, principal research engineer at ArcelorMittal.

The research team used a model of the bridge that carries State Route (SR) 987 over the SR 22 to illustrate the life-cycle cost computational procedure. The life-cycle cost consists of the initial cost, which includes the cost of materials, fabrication, initial painting, shop inspection and transportation, along with the cost of repainting maintenance performed during the bridge's service life. The cost of maintenance includes the repainting and traffic control costs, in addition to the indirect costs arising from the traffic delays and their related social and environmental impacts. In order to determine the total life-cycle cost of the bridge, the team used a Monte Carlo simulation.

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From their research, the team concluded that the A1010 steel represents a more sustainable alternative to the conventional carbon steel for bridge construction in corrosive environments. The life-cycle cost of the bridge constructed using the A1010 is constant throughout the service life of the bridge. In addition, they found that although the A1010 provides a higher initial cost than the carbon steel, the life-cycle cost of the bridge constructed using carbon steel is significantly higher and can reach a value of up to two times that of the same bridge constructed using the A1010 steel after 100 years of service life.

The outcomes from this collaboration contribute to the management of the steel bridge infrastructure, especially in Pennsylvania where the vast population of bridges are made of steel. Pennsylvania companies, such as ArcelorMittal, will also benefit from this project because it provides a life-cycle cost model that clearly indicates the economic advantages of new solutions for steel bridges in terms of material and configuration, which provide maintenance-free service during the lifetime of a bridge.