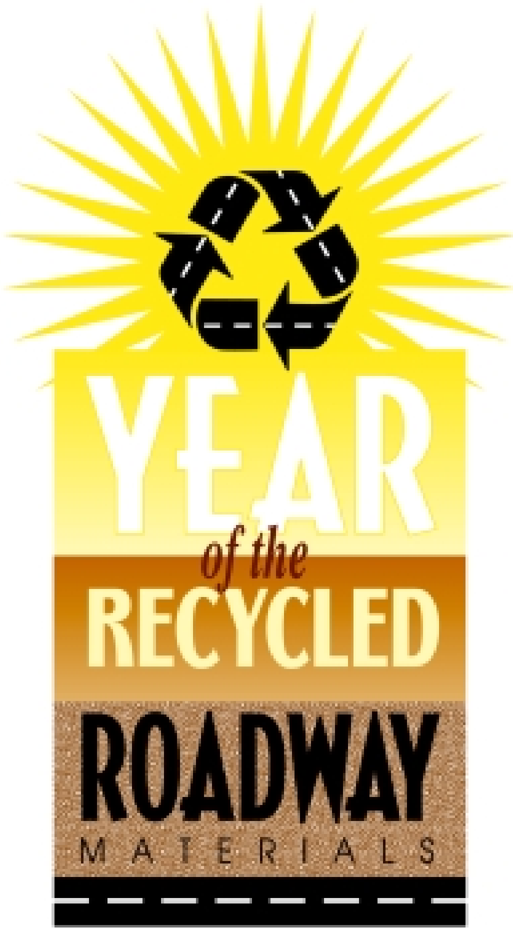
July Reclaimed Metals



This packet provides information about how and why to use reclaimed metals in various applications.

Material Summary #1	Performance of Weathering Steel in Highway Bridges
Material Summary #2	High-Performance Steel
TxDOT Experience	Summary of TxDOT experience using reclaimed metals in various applications

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Material Brief

One of the keys to controlling the amount of material thrown into landfills is to reuse products as many times as possible. Reuse conserves natural resources because fewer new products have to be manufactured. In fact, reusing a material is often more resource-ful than recycling it.

Reuse eliminates exorbitant waste disposal fees and allows consumers to obtain raw materials at a fraction of their original cost. Furthermore, reuse reduces the quantity of materials dumped in landfills while lessening damage to the environment.

Almost all metals include some recycled content. Steel and aluminum are used routinely in the road construction industry, and they are both infinitely reusable and recyclable.

For example, aluminum sign blanks can be used over and over again at less cost than buying new blanks. Hydrostripping is a process that allows the reuse of

Americans throw away enough aluminum every three months to rebuild our entire commercial air fleet.

aluminum signs that is much more effective than sanding.

The process involves a high-pressure cleaning system that uses 36,000 psi to strip the most stubborn laminates but does not harm expensive corrosion resistant coatings. Even the excess water is filtered and recycled for additional use while allowing for safe, nonhazardous disposal.

Overview

Steel

The steel industry recycles millions of tons of steel scrap from recycled cans, automobiles, appliances, construction materials and other steel products. All of this scrap is remelted to produce new steel. In fact, the industry's overall recycling rate is nearly 68 percent.

There are two processes for making steel. The Basic Oxygen Furnace process, which is used to produce the steel needed for packaging, car bodies, appliances and steel framing, uses about 28 percent recycled steel.

The Electric Arc Furnace process uses virtually 100 percent recycled steel to produce plate, rebar, structural beams, railroad ties and bridge spans. In fact, recycling one ton of steel saves 2,500 pounds of iron ore, 1,400 pounds of coal and 120 pounds of limestone.

Under the Transportation Equity Act for the 21st Century (TEA-21), public funding for bridge repair and construction jumped by 27 percent. The Federal Highway Administration (FHWA) estimates nearly one-third of America's 578,000 bridges need to be repaired or replaced.

The more than 12 million cars recycled in 1995 would cause a traffic jam stretching from New York City to Los Angeles 15 times.

There are structural and economic advantages to using steel in bridges. As steel is recycled, it maintains its strength and integrity, so it can be made into one quality product after another. Its strength makes it highly resistant to extreme natural disasters, such as earthquakes. Other engineering benefits include its lighter weight, which means lighter foundations and lower erection costs.

Various types of steel can be made to satisfy different end-use requirements. For example, weathering steel, which does not require painting, is low maintenance. High performance steel has enhanced durability, weldability and strength.

Aluminum

Like steel, aluminum is a recycled metal used routinely in road construction. It is the most abundant metal on earth, but it still makes sense to recycle it. Doing so saves 95 percent of the energy necessary to produce aluminum from virgin ore.

The 1.7 million tons of steel recycled in 1997 would yield enough steel to build 200 Eiffel Towers.

The all-aluminum can was introduced in 1964. Today aluminum cans are the most common material recycled by consumers. More than 51 percent of a new aluminum can is made from recycled aluminum. In fact, aluminum beverage cans return to the grocery store shelf after recycling, remelting, rolling, manufacturing and distribution in only 90 days.

Every minute of everyday, an average of 113,204 aluminum cans is recycled. Approximately 32 cans make one pound of aluminum.

Material Summary #1

Performance of Weathering Steel in Highway Bridges

Since 1964, bridge engineers have utilized uncoated weathering steel because of performance, economical and environmental benefits. As a result, more than 2,300 bridges in the U.S. have been built with this material over the last 30 years.

Approximately 90 percent of TxDOT steel bridge projects use weathering steel. Studies show that using weathering steel reduces both initial and life cycle costs. Current U.S. highway legislation mandates life cycle cost analysis in the highway materials selection process.

The enhanced atmospheric corrosion resistance of steel is indicated by the letter "W" that follows the grade.

The Weathering Process

During the weathering process, steel develops a durable, tightly adherent protective oxide coating. Alloy content and environmental conditions influence the formation of this film on steel. The appearance, texture and maturity of this oxide coating all depend on three natural factors: time, degree of exposure and atmospheric environment.

Over time the oxide coating changes from a "rusty" red-orange to a dark, rich, purple-brown patina. The moderately rough texture becomes more distinct as the coating thickens. This weathering process extends up to 20 or 30 years depending on these natural factors.

Benefits

Weathering steel's cost-effectiveness as a construction material has been demonstrated in both short- and long-term savings. The additional cost of this grade of steel is offset because the need for initial and maintenance painting of the structure is eliminated.

Environmental benefits also result from the use of this material. The absence of initial painting reduces volatile organic compounds (VOC) emissions when oil-based coatings are used. In addition, the need for coating removal and for contaminated blast cleaning debris disposal over the life-span of the structure is eliminated. There are documented cases where the estimated cost of collection and disposal of materials from a structure repainting project were so great that the structure was either abandoned or replaced with a new bridge.

Inappropriate Applications

While weathering steel is performing well overall, there are some circumstances where weathering steel is not recommended in a bare, uncoated condition, because the protective, tight oxide film will not form properly.

Weathering steel is not recommended in

- Atmospheres containing concentrated corrosive industrial or chemical fumes.
- Locations subject to saltwater spray or salt-laden fog.
- Applications where the steel may be continuously submerged in water, buried in soil, or on bridges where water runoff contaminated with deicing salts drains through leaky seals, open joints or expansion dams.
- Applications where the steel is in direct contact with timber decking. Timber retains moisture and may be treated with salt-bearing preservatives.

- Bridges over tunnel-like highways that permit salt-laden road sprays caused by traffic passing under the bridge to accumulate on the superstructure.

Problems associated with these circumstances can be avoided by eliminating joints and by using good details.

Conclusions

There is a long history of uncoated weathering steel bridges performing well throughout the U.S.

References

1. Steelworks. *Performance of Weathering Steel in Highway Bridges: A Third Phase Report*,http://www.steel.org/markets/infrastructure/bridges/phaseIII.htm

2. Bethlehem Steel. *Weathering Steel: The Weathering Process*, http://www.bethsteel.com/divisions/burns/bhwsweath.htm

3. Federal Highway Administration. Uncoated Weathering Steel in Structures. FHWA Technical Advisory T 5140.22, October 3, 1984.

4. Federal Highway Administration. *Forum on Weathering Steel for Highway Structures: Summary Report*, FHWA Report TS-89-016, June 1989.

For help in evaluating areas suitable for use of weathering steel, contact:

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Material Summary #2

High Performance Steel

High Performance Steel (HPS) is defined as steel that has enhanced durability, weldability, strength and toughness characteristics due to a refined metallurgical formulation.

In the past, steels with enhanced strength have experienced a higher percentage of weld problems compared to lower strength steels. Controlling the weld temperature to minimize problems significantly adds to the cost and time required for welding. Consequently, only a few bridges have been built with higher strength steels.

The goal of a cooperative research program between the Federal Highway Administration (FHWA), the U.S. Navy and the American Iron and Steel Institute was to develop a High Performance Steel that can be welded without excessive weld-process controls that increase costs. As a result of this research, a new grade of high performance structural steel, HPS-485-W, is now commercially available for highway bridge construction.

Superior Performance

The new steel alloys possess superior weldability and toughness compared to conventional steels of this strength range. The lower welding preheat requirements are due to lower carbon and carbon equivalents. Lower sulfur content allows significantly increased toughness. This extra toughness provides a high resistance to brittle fracture that allows structures to tolerate high fatigue levels without risk of sudden failure. This provides added confidence to enable designers to use the full strength of this steel.

High performance steel, by definition, also has a high corrosion resistance. This gives designers the option to eliminate painting in many bridge locations and requires only limited painting in others. Experience has shown that eliminating painting can reduce the life cycle cost of many steel structures.

All steels possess properties that determine how well they perform their intended function. Strength, weldability, toughness, ductility, corrosion resistance and formability are all important factors. High-performance steel can be defined as having an optimized balance of these properties to give maximum performance in bridge structures while remaining cost-effective.

Testing and Evaluation

An extensive effort is underway to evaluate the weldability and structural performance of bridge members fabricated from HPS-485W. Standard tension and CVN tests are performed on each plate made available through this program. This process will be continued as future plates are produced to develop a comprehensive database on material properties and variability. These basic tests are supplemented by more advanced fracture mechanics tests conducted at FHWA and Navy laboratories.

Weldability is being studied through a series of tests. Fundamental performance is evaluated using the gapped bead-on-plate (G-BOP) test, Y-groove test and Implant tests. These tests study the performance of all parts of the weld, including the base metal, weld metal and heat-affected zone between the two. These tests are still in progress.

Additionally, a series of standard procedure qualification plates have been welded according to requirements in the

American Association of State Highway Transportation Officials American Welding Society's (AASHTO/AWS) Bridge Welding Code. These tests are used to qualify welding procedures prior to welding in the fabrication shop. Preliminary results indicate that HPS-485W may be capable of being welded without preheat and interpass control, using both the submerged arc welding (SAW) and shielded metal arc welding (SMAW) processes. More work is being done to verify performance and develop updated code provisions for the new steel.

Structural performance of welded steel bridge members is also evaluated through a series of full-scale tests. The FHWA Structures Laboratory in McLean, Va., is performing a series of full-scale fatigue and fracture tests to determine what effect the high toughness has on performance. It should be possible to show that the new steels make members more resistant to fatigue and fracture due to the high toughness. The University of Nebraska at Lincoln is performing static bending tests to determine the strength and ductility of bridge I-girders. This research will be the basis for optimizing the AASHTO specifications to take full advantage of the properties of HPS.

Cost Comparisons

Cost estimates for the initial HPS-485W bridge built in 1997 in Tennessee indicate that the steel weight was reduced by almost 25 percent compared to the original grade 345W design. Because HPS-485W currently costs slightly more than grade 345W steel, this resulted in a 16 percent reduction in the total cost to fabricate and erect steel for this bridge. This results in a cost savings of about $78,000, according to estimates prepared by the Tennessee Department of Transportation.

The demonstration project in Tennessee is showing that HPS can reduce the first cost of steel bridges by reducing the weight of steel in the structure. These savings are being realized even though many of the projected cost savings associated with fabrication efficiency are not yet available for this job. Therefore, even greater savings are projected for the future when welding and fabrication procedures are totally optimized.

The HPS alloy should have a significant impact on the bridge industry. Since the initial bridge constructed in 1997, approximately 32 HPS bridges are in various stages of development across the U.S. Research to further improve the strength and performance of HPS is continuing. Additional savings in transportation, erection and substructure costs can be realized due to the reduction in steel weight.

References

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2. S.J. Manganello and E.M. Focht. "Development of a High Performance 485W Bridge Steel," Proceedings, ASCE Materials Engineering Conference, Washington, D.C., Nov. 1996.

3. American Iron and Steel Institute News, American Iron and Steel Institute, Washington, D.C., Sept. 1996.

4. "High Performance Steel: Research to Practice." Turner Fairbanks Highway Research Center. Wright, William.

TxDOT Experience

This table provides information about TxDOT's experience using reclaimed metals in signs and traffic signals.

District Name	Construction Application	Material	Results	Installed	Specification	Location	Additional Comments
Beaumont	Roadside Safety Devices	Metal Signs (reused)	Good	1988	N/A	Liberty	
Lubbock	Roadside Safety Devices	Metal Signs (reused)	Unknown	1996		Garza	
Lufkin	Roadside Safety Devices	Metal Signs (reused)	Good	1990		District-wide	
Pharr	Roadside Safety Devices	Metal Signs (reused)	Excellent				Turned in to be re-furbished. Long-time district practice.
Yoakum	Roadside Safety Devices	Metal Signs (reused)	Excellent	1982	None	District-wide	Send used signs to TDC, resheeted and returned.
Pharr	Roadside Safety Devices	Traffic Signals (reused)	Good				For signals installed by District signal section and as spare parts to maintain existing systems. Long time District practice.
Yoakum	Roadside Safety Devices	Traffic Signals (reused)		1977	None	District-wide	Disassemble old signals and salvage reusable parts.