Using Recycled Industrial Materials in Roadways

Greening the Nation's Infrastructure. This fact sheet discusses the use of industrial materials in roadways and other infrastructure projects as an alternative to virgin materials and construction products. Industrial materials are the byproducts of industrial processes. Each year in the United States, industries produce over half a billion tons of potentially usable materials, such as coal combustion products (CCPs), construction and demolition (C&D) materials, spent foundry sands, used tires, and slags. Many have chemical and physical properties that make them valuable resources when recycled or beneficially reused, but they are often disposed of as waste. The U.S. Environmental Protection Agency (EPA) is committed to increasing the recycling of industrial materials as part of its ***Resource Conservation Challenge***, a national effort to save energy and reduce greenhouse gas emissions by managing materials more efficiently. Industrial materials recycling is helping to green the nation's infrastructure by making roadways more durable, conserving natural resources, decreasing energy use, and reducing greenhouse gas emissions.

www.epa.gov/industrialmaterials

An Overview:

Why Use Industrial Materials in Roadways?

Environmental Benefits

Since many industrial materials are used to replace non-renewable virgin materials that must be mined and processed, using industrial materials conserves natural resources and reduces the energy use and pollution associated with these activities. For example, substituting fly ash (a CCP) for portland cement in concrete saves the energy and greenhouse gas emissions associated with producing cement. Roads and other structures made with industrial materials can be more durable. Maintaining and replacing roads less frequently is good for the environment because it conserves natural resources and energy.

Economic Benefits

Using industrial materials makes good economic sense for project owners and contractors. If industrial material use is planned from the beginning, the total project bid cost can be lower, allowing the project owner to accomplish more work with the same budget. Industrial materials are often less expensive than the virgin materials they replace, and recycling or reusing materials onsite can reduce material hauling and disposal costs. Putting industrial materials such as fly ash to use in infrastructure projects also reduces the need for new or expanded landfills, saving valuable landfill capacity.

Performance Benefits

Industrial materials offer significant performance enhancement benefits. For example, steel slag, when used as an aggregate for asphalt roadway riding surfaces, has a high-friction surface that makes driving safer. Using fly ash as a partial replacement for portland cement in concrete enhances the durability and smoothness of the concrete. Rubber tires used as lightweight fill material offer outstanding long-term performance benefits and are less expensive than many alternatives. Asphalt pavement made with used tires is also more flexible, quieter, and less prone to cracking than standard asphalt pavement.

Green Design

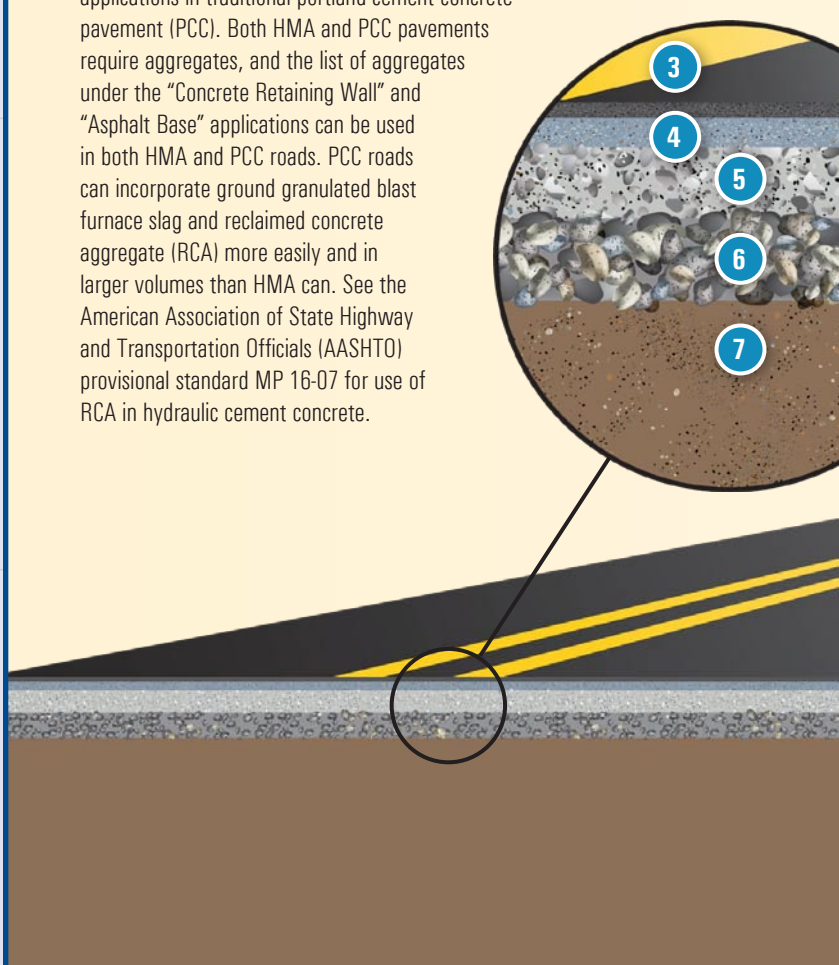
Organizations are encouraging highway construction and renovation activities that have a reduced impact on the environment. The U.S. EPA, the Federal Highway Administration, and the Maryland State Highway Administration sponsor the Mid-Atlantic Green Highways Partnership (GHP). The GHP seeks to incorporate environmental streamlining and stewardship into all aspects of the highway development lifecycle, including using industrial materials. Visit www.greenhighways.org

Roadway Applications for Industrial Materials

Roadways are a central component of the nation's infrastructure and present a wide array of opportunities for using industrial materials. This diagram illustrates the most common roadway applications for industrial materials. Note that the availability of specific industrial materials can vary regionally, so visit the Web sites in the "Resources for More Information" section of this document for information on identifying suppliers of industrial materials in your region as well as local C&D materials recyclers.

Recycling Industrial Materials in Concrete Pavements.

This image portrays the use of industrial materials in hot-mix asphalt pavement (HMA); however, industrial materials have very similar applications in traditional portland cement concrete pavement (PCC). Both HMA and PCC pavements require aggregates, and the list of aggregates under the "Concrete Retaining Wall" and "Asphalt Base" applications can be used in both HMA and PCC roads. PCC roads can incorporate ground granulated blast furnace slag and reclaimed concrete aggregate (RCA) more easily and in larger volumes than HMA can. See the American Association of State Highway and Transportation Officials (AASHTO) provisional standard MP 16-07 for use of RCA in hydraulic cement concrete.



1 Embankment

Topsoil on roadside embankments can be amended with compost, pulp and paper byproducts, FGD material, or steel slag, if soil conditions merit. These industrial materials can improve the condition of the soil, increase plant growth, and reduce runoff. Foundry sand, steel slag, and coal ash are suitable for embankment fill.

2 Mechanically Stablizied Earth (MSE) Wall

Retaining walls hold back soil and rock and prevent the erosion of roadside slopes; they are often made of concrete or modular blocks.

- Fly ash and ground granulated blast furnace slag can be used as partial replacements for portland cement in concrete, making the concrete stronger and more durable.
- Concrete aggregates can include bottom ash, foundry sands, reclaimed concrete, and blast furnace slag.
- Portland cement can contain fly ash, FGD gypsum, foundry sands, drywall, blast furnace slag, and steel slag.

3 Asphalt Surface

Blast furnace slag, steel slag, and boiler slag can replace virgin aggregate in the asphalt surface layer.

4 Asphalt Base

Fly ash, bottom ash, foundry sands, and reclaimed concrete and asphalt can be used as aggregate in the asphalt base layer.

Ground rubber tires and ground roofing shingles can be added to the hot asphalt surface and base mix, increasing the flexibility and durability of the pavement and reducing the need for costly virgin asphalt.

5 6 Granular Base and Sub-Base

A variety of industrial materials can be used as granular base and sub-base, including:

- Bottom ash
- Foundry sand
- Reclaimed concrete and asphalt
- Glass
- Roofing shingles
- Blast furnace slag
- Steel slag
- Scrap tires

Fly ash can also be used as mineral filler in asphalt base, granular base, and sub-base.

7 Subgrade (Original Soil)

Fly ash can be used to improve the structure and stability of the subgrade upon which the road will be built.

8 Structural Fill

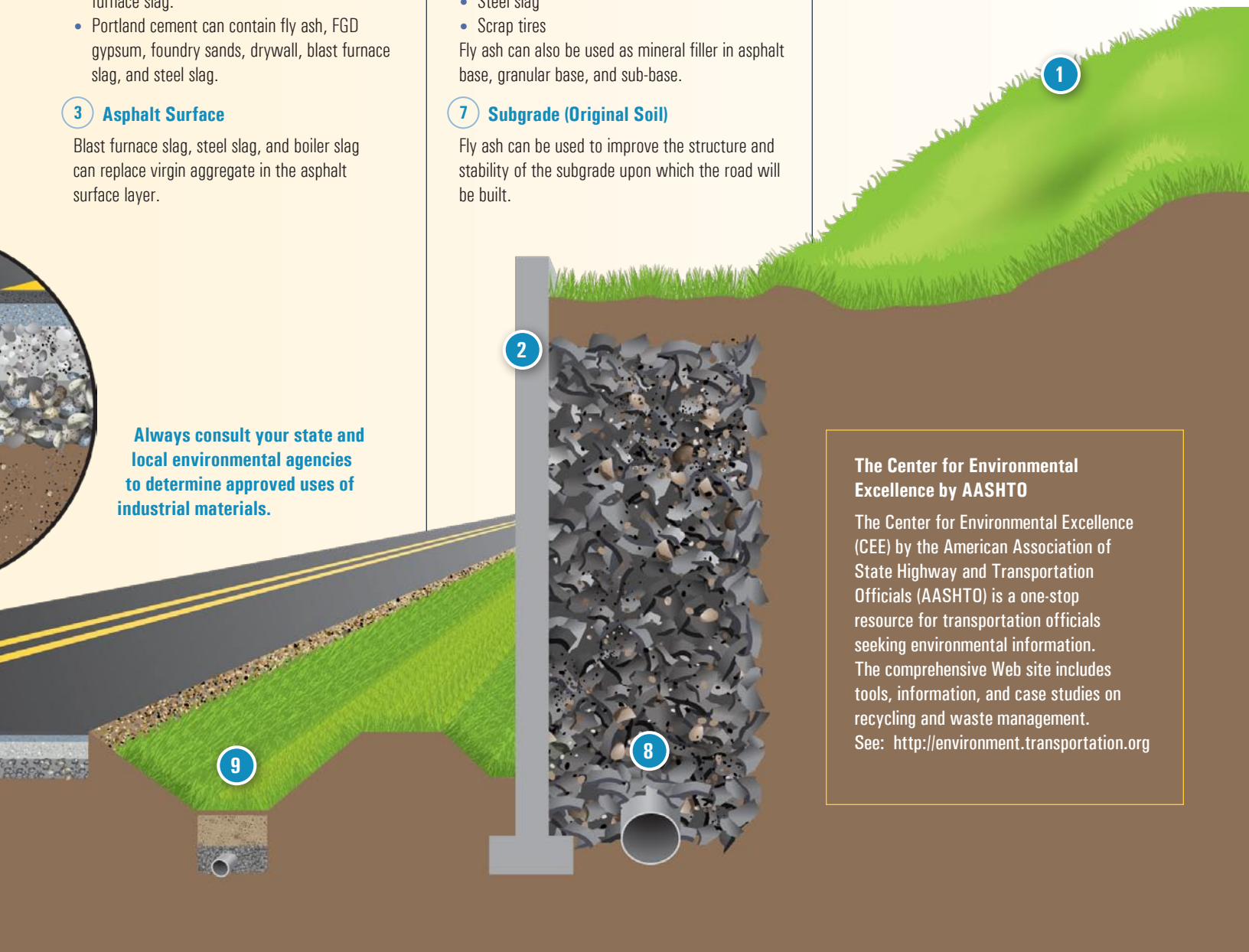
Structural fill supports and relieves pressure from retaining walls.

- Shredded scrap tires are particularly well suited for fill applications; they are lightweight, drain well, and resist frost penetration.
- Fly ash, reclaimed asphalt pavement, concrete, crushed glass, and foundry sand can also be used as backfill for retaining walls.

9 Vegetated Swale

One environmentally-friendly way to provide adequate drainage for roadways is through vegetated swales, which can help improve water quality.

- Scrap tires, reclaimed concrete or asphalt, glass cullet, and blast furnace slag can be used in place of traditional drainage materials, such as virgin sand or gravel.



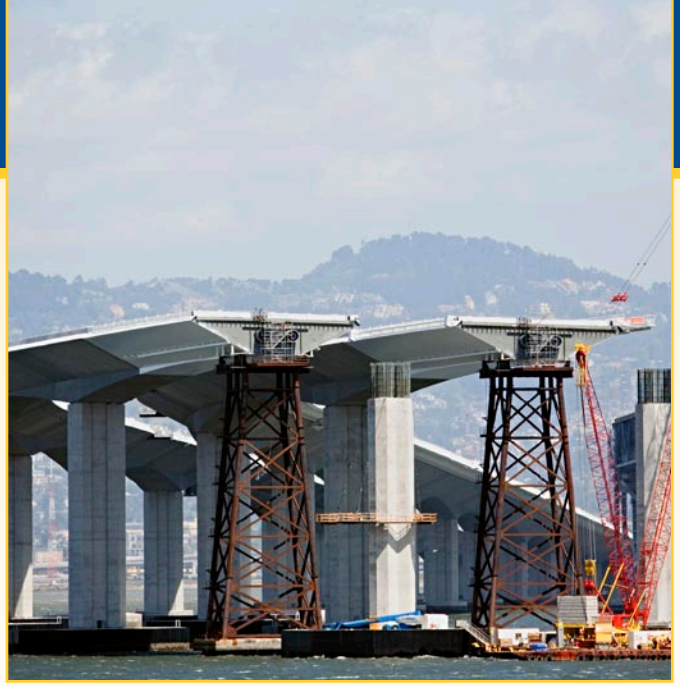
Always consult your state and local environmental agencies to determine approved uses of industrial materials.

The Center for Environmental Excellence by AASHTO

The Center for Environmental Excellence (CEE) by the American Association of State Highway and Transportation Officials (AASHTO) is a one-stop resource for transportation officials seeking environmental information. The comprehensive Web site includes tools, information, and case studies on recycling and waste management.
See: http://environment.transportation.org

Case Study

San Francisco Bay Bridge Reconstruction Maximizes the Use of Fly Ash in Concrete Mix



Ongoing construction of the new east span of the San Francisco Oakland Bay Bridge is taking advantage of the unique properties of fly ash and ground granulated blast furnace slag to enhance the durability and strength of the concrete used. The California Department of Transportation (Caltrans) started the new span in 2002 to replace the old, seismically vulnerable span that was damaged in a 1989 earthquake and subsequently repaired. The chemical and physical properties of fly ash concrete help mitigate the corrosive effects of seawater and salt fog and the structural requirements of an earthquake zone.

The high-salt zones of the bridge will use a concrete mix containing 50% fly ash, which prevents cracking as the cement hardens, a common problem in a salt-water environment. The round fly ash particles also improve flow and workability in the mix. The fly ash concrete used is also denser and stronger than traditional concrete and can better carry heavy loads. Caltrans will use over 30 concrete mix designs in the new bridge, some containing more than 50% fly ash. In addition, ground granulated blast furnace slag was used in pier columns to improve durability and workability and reduce bleeding. In 2006, Caltrans received an award for Innovation from EPA's Coal Combustion Products Partnership (C^2P^2), in part based on its work on the new Bay Bridge.

Did You Know?

The American Association of State Highway Transportation Officials (AASHTO) has developed standards for using recycled industrial materials in cement and concrete. AASHTO M 295 and AASHTO M 302 are standard specifications for using fly ash and ground granulated blast furnace slag in cement and concrete in roadways. Contact your state or local environmental agency for more information about approved uses of industrial materials in your region. You can also contact your state Department of Transportation to determine whether they have developed specifications for using industrial materials in roadways. See the AASHTO Web site at: bookstore.transportation.org. See also the American Society for Testing Materials at: www.astm.org.

Resources for More Information

EPA's Industrial Materials Recycling Homepage: Provides an overview of industrial materials, their benefits, and opportunities for reuse and recycling: www.epa.gov/industrialmaterials

EPA's Comprehensive Procurement Guidelines: Includes information about construction and transportation products containing recycled content: www.epa.gov/cpg

Construction Industry Compliance Assistance (CICA) Center: Contains a C&D materials State Resource Locator, where you can find state environmental agency Web sites: www.cicacenter.org

The Federal Highway Administration (FHWA) Office of Pavement Technology's Recycling Web page: Provides information about current projects and activities, research and references, publications, and policies pertaining to the use of recycled materials: www.fhwa.dot.gov/pavement/recycling

The Recycled Materials Resource Center (RMRC): The RMRC's mission includes systematically testing, evaluating, developing appropriate guidelines for and demonstrating environmentally acceptable increased use of recycled materials in transportation infrastructure construction and maintenance. This Web site provides information on recycling and reusing industrial materials in roadways: www.recycledmaterials.org

User Guidelines for Byproducts and Secondary Materials Use in Pavement Construction: Provides information and general guidance on engineering evaluation requirements, environmental issues, and economic considerations for determining the suitability of using recycled materials in highway applications: www.recycledmaterials.org/tools/uguidelines/index.asp

Industrial Resources Council (IRC): Contains information about industrial materials and their applications. The IRC is composed of industry trade associations representing coal combustion products, foundry sands, iron and steel slag, wood and pulp materials, rubber materials, and construction and demolition materials: www.industrialresourcescouncil.org

Mid-Atlantic Green Highway Partnership: Seeks to incorporate environmental sustainability into all surface-transportation infrastructure, including using industrial materials: www.greenhighways.org

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Environmental Protection Agency
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