

Materials in Use in U.S. Interstate Highways

Materials Usage

Natural aggregates (construction sand and gravel and crushed stone) make up the largest component of nonfuel mineral materials consumed in the United States (fig. 1). Most of these materials are used in construction activities, such as in buildings and roads. In highways, natural aggregates are incorporated into asphalt and concrete and are used as road base.

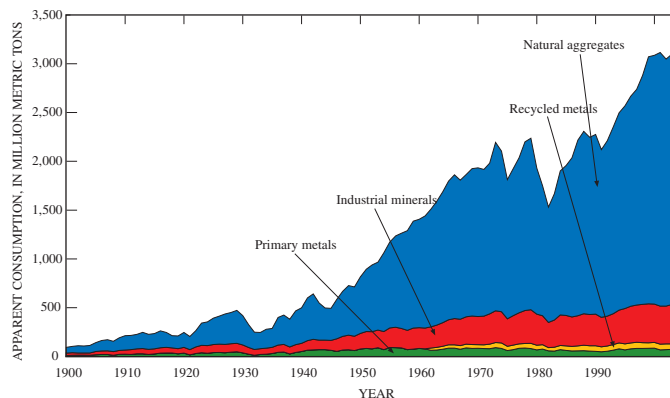


Figure 1. Graph showing U.S. apparent consumption of raw materials.

Roads and Highways

Comprising 9.6 million square kilometers (3.7 million square miles), the United States is the third largest country in the world. With a large, complex economy, the United States requires a vast system of roads and highways in order to move goods and supply services and for other travel purposes. Almost 3 trillion vehicle-miles (4.8 trillion vehicle-kilometers) were traveled in the United States in 2004 (Bureau of Transportation Statistics, 2005). There is almost 4 million miles (6.5 million kilometers) of roads in the United States, with just over 45,000 miles [73,000 kilometers (km)] composing the Interstate Highway System (fig. 2) (Federal Highway Administration, 2004). The total distance of U.S. roads combined could circle the Earth at the equator 160 times; the interstate highways, almost two times.

The Interstate Highway System, formally known as the Dwight D. Eisenhower National System of Interstate and Defense Highways, began to be constructed in the 1950s. Interstate highways were required to meet specific standards to ensure a long service life and provide safe travel. Standards included limited access, a design to accommodate vehicle speeds of 50 to 70 miles per hour (80 to 113 km per hour), a minimum of two travel lanes in each direction, 12-foot [3.7-meter (m)] lane widths, 10-foot (3-m) paved right shoulder, and a 4-foot (1.2-m) paved left shoulder (Federal Highway Administration, 2006). A generalized cross section of an interstate highway is shown in figure 3.

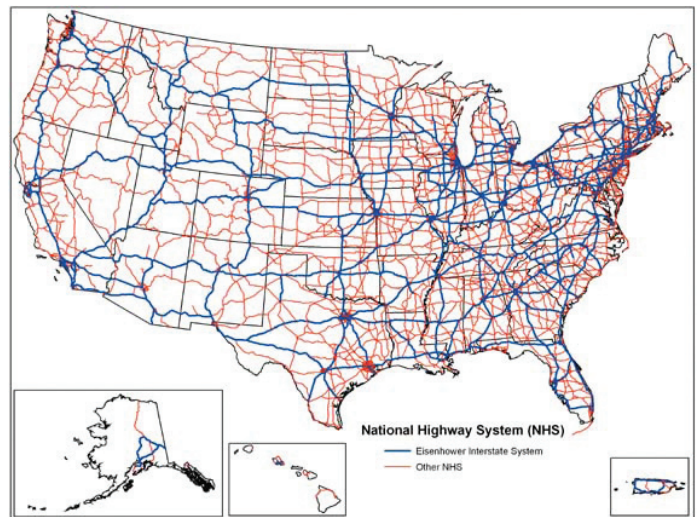


Figure 2. Map showing the National Highway System. Interstate highways are drawn in blue. Map from Federal Highway Administration (2006b).

Materials in Use

The materials used to construct interstate highways are in continuous use except for those replaced during maintenance and lost through wear and tear. Even during maintenance much of the concrete and asphalt that is removed is eventually placed back in the highway. A U.S. Geological Survey study showed that, in the Denver, Colo., area in 1996, 80 percent of asphalt pavement debris and 50 percent of cement concrete debris were reused in some capacity, thereby reducing the need for new material from mining operations (Wilburn and Goonan, 1998).

Figure 4 shows the total quantity as of 2006 of selected mineral materials estimated to be in use in the roadways composing the Interstate Highway System. The data that were used to

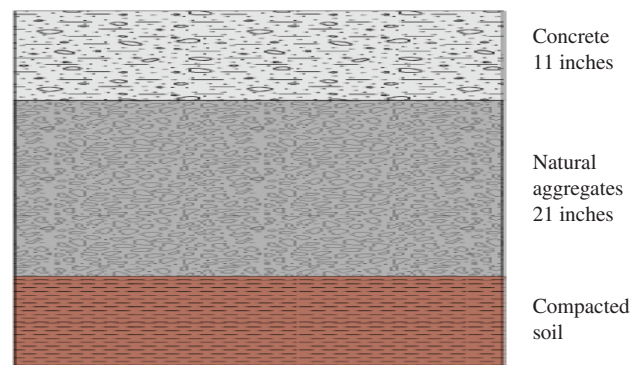


Figure 3. Cross section showing of a typical interstate highway with concrete pavement. Data from Bob Bisgard, Asphalt Paving Company, Golden, Colo., oral commun., 2005.

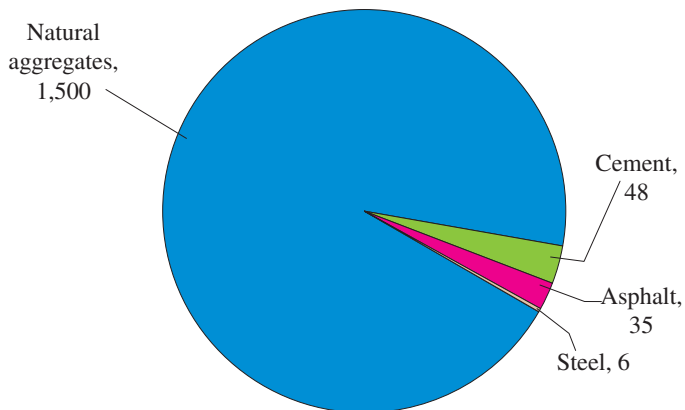


Figure 4. Pie chart showing selected materials estimated to be in use in the National Highway System. Data are in million metric tons.

develop figure 4 were extrapolated from published information giving the average quantities of material inputs per million dollars of construction for major highway construction (Federal Highway Administration, 2003). Estimates are based on a generalized model of the Interstate Highway System in which all roadways of the system have uniform characteristics. The materials used in this analysis were natural aggregates (used in asphalt, concrete, and as road base), asphalt (used as a binder with aggregates to produce asphalt pavement, or “blacktop”), cement (used as a binder with aggregates and water to produce concrete; excludes cement in concrete pipe), and steel (used as culvert pipe, reinforcements, and structural support). Bridge railing, clay pipe and tile, concrete pipe, corrugated aluminum culvert, guardrail, and lumber were not included in the analysis.

This analysis is based on a 42,500-mile (73,000-km) Interstate Highway System with four 12-foot (3.7-m) wide lanes. **Sixty percent of the system is paved with concrete that is 11 inches (28 centimeters) thick.** By volume, concrete is typically 60 to 75 percent aggregate, 15 to 20 percent water, 10 to 15 percent cement, and 5 to 8 percent entrained air (Portland Cement Association, 2006). The weight-percent of cement in concrete is similar. For this analysis concrete was assumed to be 12.5 weight-percent cement.

The analysis shows that a total of approximately 1.5 billion metric tons (Gt) of aggregates, 35 million metric tons (Mt) of asphalt, 48 Mt of cement, and 6 Mt of steel is in place in interstate highways. These estimates illustrate the large quantities of these materials used in the Interstate Highway System.

The 1.5 Gt of aggregates estimated to be in interstate highways is more than 50 percent of the combined estimated sand and gravel and crushed stone used in construction in the United States in 2005. The 35 Mt of asphalt used in 2005 is slightly more than the total estimated asphalt and road oil used in the United States in 2000 (Kelly, 2005). The 48 Mt of cement is equivalent to almost 40 percent of the cement used in the United States during 2005 (van Oss, 2006).

Summary

The vast system of roads and highways in United States provides a critical service to the country’s economy and people. The construction of these roads and highways has required and continues to require large quantities of materials, such as aggregates, asphalt, cement, and steel. The materials are providing services every time the road or highway is used.

References Cited

- Bureau of Transportation Statistics, 2005, National transportation statistics 2005, Table 1-32—U.S. vehicle-miles: Bureau of Transportation Statistics Web site at http://www.bts.gov/publications/national_transportation_statistics/html/table_01_32.html. (Accessed May 26, 2006.)
- Federal Highway Administration, 2003, Highway statistics, 2003, Usage factors for major highway construction materials and labor: Federal Highway Administration Web site at <http://www.fhwa.dot.gov/policy/ohim/hs03/hm/pt4.htm>. (Accessed January 21, 2006.)
- Federal Highway Administration, 2004, Highway statistics, 2004, Section V—Roadway extent, characteristics and performance, Table HM-15: Federal Highway Administration Web site at <http://www.fhwa.dot.gov/policy/ohim/hs04/hm/hm15.htm>. (Accessed January 21, 2006.)
- Federal Highway Administration, 2006a, Dwight D. Eisenhower National System of Interstate and Defense Highways: Federal Highway Administration Web site at <http://www.fhwa.dot.gov/programadmin/interstate.html>. (Accessed January 13, 2006.)
- Federal Highway Administration, 2006b, National highway system (NHS): Federal Highway Administration Web site at <http://www.fhwa.dot.gov/hep10/images/nhsjpg.jpg>. (Accessed April 19, 2006.)
- Kelly, T.D., 2005, Organics (nonrenewable), *in* Kelly, T.D., and Matos, G.R., comps., Historical statistics for mineral and material commodities in the United States (ver. 1.0): U.S. Geological Survey Data Series 140, available only online at <http://minerals.usgs.gov/minerals/ds/2005/140/organics.pdf>. (Accessed January 31, 2006.)
- Portland Cement Association, 2006, Concrete basics, Portland Cement Association Web site at http://www.cement.org/basics/concretebasics_concretebasics.asp. (Accessed February 9, 2006.)
- van Oss, H.G., 2006, Cement: U.S. Geological Survey Mineral Commodity Summaries 2006, p. 44-45. (Also available online at <http://minerals.er.usgs.gov/minerals/pubs/commodity/cement/cemenmcs06.pdf>.)
- Wilburn, D.R., and Goonan, T.G., 1998, Aggregates from natural and recycled sources—Economic assessments for construction applications—A materials flow analysis: U.S. Geological Survey Circular 1176, available only online at <http://pubs.usgs.gov/circ/1998/c1176/c1176.pdf>. (Accessed April 24, 2006.)

For more information, contact:

Daniel E. Sullivan
 U.S. Geological Survey
 Box 25046
 Denver Federal Center, Mail Stop 750
 Denver, CO 80225-0046
 Telephone: (303) 236-8747 x267
 E-mail: desulliv@usgs.gov