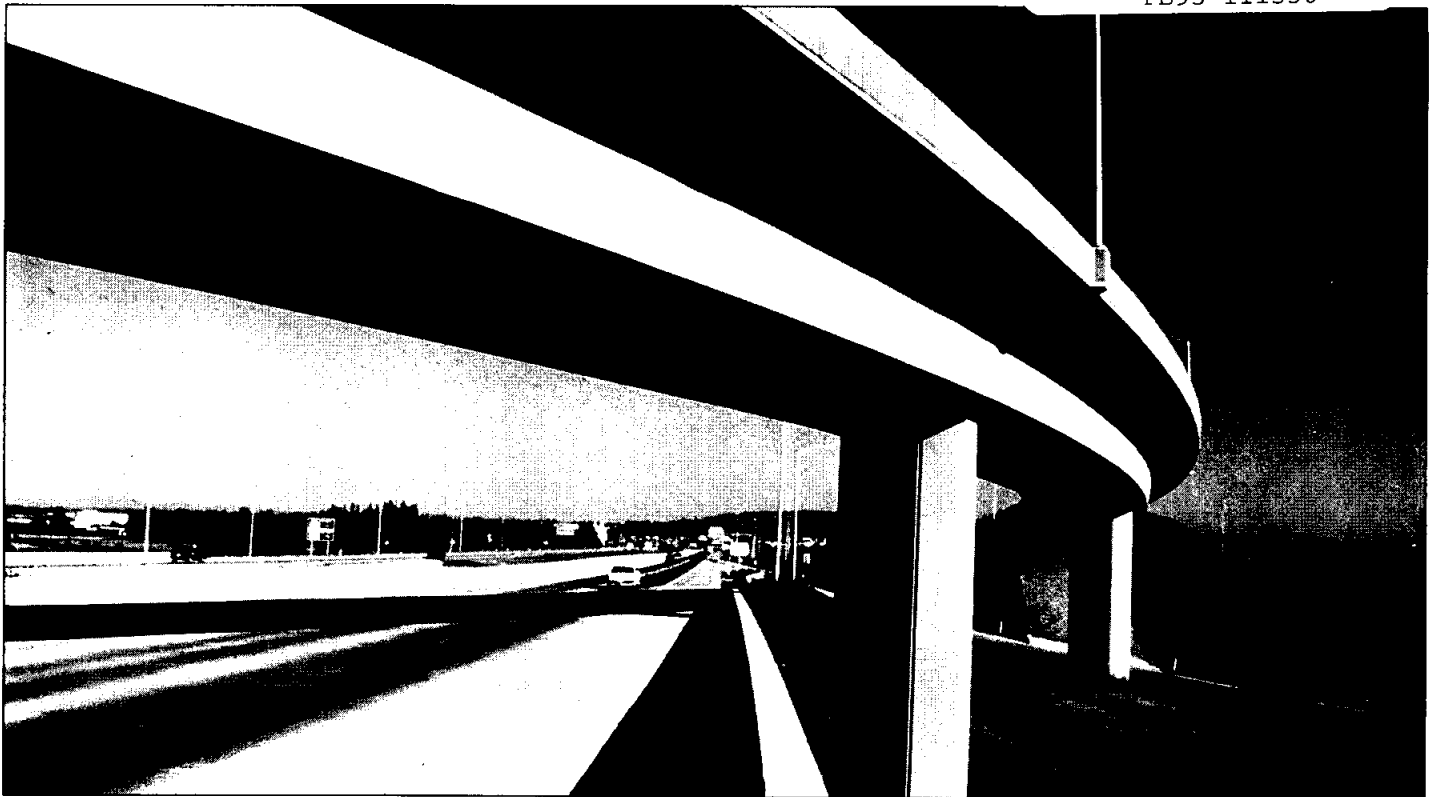




# CONSTRUCTION SAND AND GRAVEL

By Valentin V. Tepordei

1993

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

REPRODUCED BY:  
U.S. Department of Commerce  
National Technical Information Service  
Springfield, Virginia 22161







# CONSTRUCTION SAND AND GRAVEL



U.S.  
DEPARTMENT  
OF THE  
INTERIOR

Bruce Babbitt  
Secretary



BUREAU  
OF  
MINES

September 1994

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**COVER PHOTO:**  
*Highway and bridge construction continue to represent one of the major uses of construction sand and gravel as the basic raw material. The cover picture shows some examples of such uses of sand and gravel in combination with cement and asphalt. (Photo courtesy of Portland Cement Association.)*

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# CONSTRUCTION SAND AND GRAVEL

By Valentin V. Tepordei

Mr. Tepordei, a geological engineer with more than 20 years of industry experience, has been the construction sand and gravel commodity specialist with the U.S. Bureau of Mines since 1979. Domestic survey data were prepared by the construction sand and gravel survey staff of the Branch of Data Collection and Coordination.

Construction sand and gravel is one of the most accessible natural resources and a major basic raw material used mostly by the construction industry. Despite the relative low value of its basic products, the construction sand and gravel industry is a major contributor to and an indicator of the economic well-being of the Nation.

Beginning with this issue, the statistical information included in the Annual Report for Construction Sand and Gravel is published in metric units in compliance with the provisions of the Metric Conversion Act of 1975 and the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418). The information that was published in prior years in short tons was converted to metric tons in this issue of the Annual Report. During 1994, only the totals in each table are published in dual units: metric tons and short tons.

A total of 869 million metric tons [958 million short tons (Mst)] of construction sand and gravel was estimated to have been produced in the United States in 1993, a 4.2% increase compared with the total production of 1992. This tonnage represents the highest production level since the record production of 1978, indicating a significant increase in the demand for construction aggregates in the United States in 1993. (See table 1.)

Foreign trade of construction sand and gravel remained relatively small. Exports of construction sand and gravel decreased 20.4% to 1.1 million metric tons (1.2 Mst), while value decreased 13.2% to \$15.6 million. Imports of construction sand and gravel remained unchanged at 1.3 million metric tons (1.5 Mst), while the value decreased slightly to \$15.4

million. Domestic apparent consumption of construction sand and gravel was 869 million metric tons (958 Mst).

The major issues of concern to the construction sand and gravel industry continue to be the implementation of the Clean Air Act Amendments of 1990 and their complex legal and technical provisions; the amended Federal Water Pollution Control Act of 1977, the Clean Water Act, section 404, dealing with "wetlands" and the associated "no net loss of wetlands" policy; the Storm Water Pollution Prevention Program; the Occupational Safety and Health Administration's (OSHA) Hazard Communication Standards regulating the use of products containing more than 0.1% crystalline silica; and the provisions of the Federal Endangered Species Act.

## DOMESTIC DATA COVERAGE

Domestic production data for construction sand and gravel are developed by the U.S. Bureau of Mines (USBM) from voluntary surveys of U.S. producers. Full surveys of construction sand and gravel producers are conducted for even-numbered years only. For odd-numbered years, only annual estimates for each State are generated based on information provided by the quarterly sample survey of construction sand and gravel and crushed stone producers. This survey provides production estimates by quarters for each State and the nine geographic regions. The sample surveys canvass most of the large companies in each State, accounting for up to 80% of most States' total tonnage. The results of this survey are published each quarter in a separate publication, the Quarterly

Mineral Industry Survey.

## BACKGROUND

Sand and gravel is a granular, unconsolidated, and usually rounded agglomeration of particles of rocks and minerals, resulting primarily from the natural disintegration and abrasion of rocks through weathering or erosion. Sand and gravel, as one of the most accessible natural resources, has been used since the earliest days of civilization, mostly as a construction material. At the beginning of the 20th century, U.S. production of construction sand and gravel, used mostly for construction purposes, was relatively small and its uses limited. Today, annual sand and gravel production tonnage ranks second in the nonfuel minerals industry after crushed stone and is the only mineral commodity produced in all 50 States. The United States is, in general, self-sufficient in sand and gravel, producing enough to meet all domestic needs and to be a small net exporter, mainly to consumption points along the U.S.-Canadian and U.S.-Mexican borders.

Most sand and gravel is used for construction purposes, mainly as aggregate in concrete; as road base material in the construction and repair of highways, railways, and runways; and as aggregate in asphaltic concrete for paving highways, streets, etc. Construction sand and gravel has one of the lowest average per ton values of all mineral commodities. The constant dollar price has changed relatively little over the past 20 years. Increased operating costs have been partially offset by automation and

other means of increasing operating efficiency.

Although construction sand and gravel resources are widespread and in adequate supply nationally, local shortages exist. Land use conflicts and environmental problems associated with rapid urban expansion are major factors contributing to these shortages. In addition, in some geographic areas with sufficient resources, some shortages occur because the proportions of various size fractions of sand or gravel may not meet size specifications of the construction industry. Demand pressures, land use regulations, and the cost of meeting environmental and reclamation requirements are factors that will cause a rising price trend. Larger operations with more efficient equipment, more automation, and better planning and design will be the trend of the industry in the future. This will permit increased use of less accessible and lower quality deposits and will keep prices at competitive levels.

### Definitions, Grades, and Specifications

Sand is defined throughout the industry and by the American Society for Testing and Materials (ASTM) as naturally occurring unconsolidated or poorly consolidated rock particles that pass through a No. 4-mesh (4.75-millimeter) U.S. standard sieve and are retained on a No. 200-mesh (75-micrometer) U.S. standard sieve. Gravel consists of naturally occurring unconsolidated or poorly consolidated rock particles that pass through a sieve with 3-inch (76.2-millimeter)-square openings and are retained on a No. 4-mesh U.S. standard sieve.

Sand and gravel is made up of varying amounts of different rock types and is, therefore, of varying chemical composition. Silica is the major constituent of most commercial sands, and lesser amounts of feldspar, mica, iron oxides, and heavy minerals are common. Most applications of sand and gravel have specifications for size, physical characteristics, and chemical composition. A compilation of 42 ASTM Specifications and Test Methods,

including the latest revisions and updates pertaining to aggregates, concrete, and admixtures, was reprinted by the National Aggregates Association.<sup>1</sup>

Specifications for sand and gravel used in roadbuilding and concrete construction are often rigid regarding particle size gradation and shape and include physical as well as some chemical properties. However, these specifications can differ in detail from State to State or even from city to city within the State. Soil conditions, climate, and peculiarities in different deposits may necessitate adjustments of requirements of sand and gravel mixtures and chemical composition.

Specifications are written by commercial users; Government agencies, including Federal; State, county, and city construction and highway departments; and the ASTM. Problems arise for the producers of construction aggregates when their product is sold or used in several different cities, counties, or States, many of which may have different specifications. Some progress is being made toward the standardization of aggregate sizes for similar requirements. A need exists for a more active interchange of data and experience among aggregate consumers and producers.

### Uses and Products for Trade and Industry

Concrete is made by mixing properly sized aggregate, portland cement, and water into a slurry. Chemical action between the cement and the water results in the crystallization of hydrous calcium aluminum silicates, which causes the mass to bind and harden. Round particles in the aggregate are desirable because they improve the workability of the concrete as it is poured. If broken material is used and angular or flattish fragments exceed about 15% of the total volume, workability can be maintained only by increasing the amount of sand and water, thus reducing strength, or by adding more cement, thus increasing the cost of the concrete.

Sized and broken sand and gravel is used to make asphaltic concrete aggregate and road bases. Broken surfaces adhere

to the hot asphaltic mixture better than do rounded surfaces and provide interlocking surfaces that tend to strengthen the asphaltic concrete. Broken particles pack better and tend to move less under load than do rounded particles and, therefore, make better road bases for highway and road construction. This is essential because bases and asphaltic concrete tend to flow when placed under great or long-duration stresses.

### Industry Structure

Because of the low unit value, construction sand and gravel is produced near the point of use; therefore, the industry is concentrated in or nearby large, expanding urban areas and, on a transitory basis, in areas where highways, dams, and other large-scale public and private works are under construction. In the United States, sand and gravel is produced in every State. The largest operations tend to be concentrated in the States with the largest populations and largest production of sand and gravel.

Construction sand and gravel is produced in virtually all countries, but relatively few of them publish official statistics on sand and gravel and even fewer regularly survey their industries.

On the basis of tonnage, the construction sand and gravel industry is the second largest nonfuel mineral industry in the United States. In 1992, the last year when a full survey was conducted, there were 4,213 companies producing construction sand and gravel from 5,999 operations with 8,424 pits. The individual operations range in size from those producing millions of tons annually to those reporting less than 25,000 tons per year. Most operations are small, turning out one product or a limited number of products, but most of the tonnage comes from large operations. For example, the 18 operations reporting more than 2 million tons each in 1992 represented only 0.2% of the total number of operations but produced 6.7% of the total tonnage, while 81 operations reporting between 1 and 2 million tons each, representing only 1.4% of the total number of operations, produced 12.2% of the total tonnage. In 1992, most of the

construction sand and gravel was produced by operations reporting between 200,000 and 1,000,000 tons each—1,191 operations, or 20% of the total, produced 52.1% of the total tonnage.

The leading companies producing construction sand and gravel, in descending order of tonnage, based on the 1992 survey, were CalMat Co. of Los Angeles, CA; Beazer U.S.A. Inc./Hanson PLC of Walnut Creek, CA; CSR America, Inc., of Atlanta, GA; APAC Inc., of Atlanta, GA, a subsidiary of Ashland Oil of Russell, KY; and Western Mobile, Inc., of Ft. Collins, CO, a subsidiary of Redland PLC of Groby, Leicester, United Kingdom. The top 5 companies operated 203 pits and produced 10.1% of the U.S. total. Three of these five companies are subsidiaries of foreign companies.

Many producers are in the sand and gravel business exclusively, but others are diversified in various degrees in the production of other mineral raw materials, intermediate construction products such as ready-mixed concrete and concrete blocks, final manufactured products, or construction of buildings, roads, and other structures. At the same time, construction companies are entering more into the sand and gravel business to integrate their operations.

### Geology-Resources

The processes of formation and deposition impart to sands and gravels the physical characteristics that largely determine the commercial value for a particular use and influence the manner of development. The principal types, based on origin, are stream, glacial, residual, marine, and lake. Windblown deposits are of minor importance. Much of the commercial production is from stream deposits, many of which are deficient in the fines required by present-day grading specifications for concrete aggregates. Stream deposits usually exhibit stratification and often large-size gradation. The beds vary in thickness and sometimes have interspersed lenses of clay or fine sand. The degree of roundness and the particle size varies with the hardness and distance

transported. Glacial deposits have the least sorting of all transported deposits, while marine and lake deposits exhibit the best sorting with coarse and fine particles, often well segregated. Residual deposits are found overlying the parent rock and are unstratified mixtures of pebbles, boulders, sand, and clay. They often contain much soft material that prohibits commercial production. Marine or offshore deposits could become more important as inland deposits become depleted or environmentally less desirable to extract. A comprehensive report showing geologic occurrences of potential sources of sand and gravel and crushed stone of the conterminous United States for use as natural aggregates was published by the U.S. Geological Survey.<sup>2</sup>

On the basis of geologic evidence, world reserves are sufficient to meet demands, although not necessarily at precisely the locations where needed. Reserves, which are measurable amounts of sand and gravel that can be produced profitably with current technology under existing economic and political conditions, are controlled mostly by land use and/or environmental constraints. The total sand and gravel resources of the United States are very large. However, the geographic distribution and/or quality of the reserve base often does not match market patterns or requirements.

### Technology

Major technological developments that have been instrumental in maintaining adequate production at relatively stable real costs include use of larger operating units, more efficient portable and semiportable plants, unitized plants for versatility of plant capacity, new prospecting methods utilizing aerial and geophysical surveying methods, and greatly increased rehabilitation and resale of mined areas. Use of mined-out pits as lake beds and as sanitary landfill areas has been successful at numerous localities. Automatic controls, along with monitoring by closed-circuit television coordinated with automated counting and recording and radio communications systems, have been installed in many of

the larger and newer operations. Along with the use of improved equipment, these have permitted recovery of salable fractions from deposits previously considered too low in quality for profitable exploitation. These practices will increase as pressures build to improve productivity and minimize environmental conflicts.

**Exploration.**—Sand and gravel deposits, like any mineral deposit, must be explored and evaluated before development. Preliminary examination can establish the extent and nature of the deposits. This is followed by a detailed exploration program aimed at obtaining reasonably accurate information on the quantity of material available, the degree of uniformity throughout the deposit, and, especially, variations in particle size, both vertically and horizontally. Also, the nature and amount of waste materials and the economic feasibility of their removal must be studied.

Geophysical methods are of value in preliminary surveys. Detailed exploration may be achieved by a systematic arrangement of test pits, trenches, boreholes, or other procedures designed to obtain a cross-section of the deposit in conjunction with sampling and testing. Advances in interpretation of aerial photographs and increased application of geophysical techniques have made evaluation of sand and gravel deposits more quantitative. For underwater exploration, mining devices such as dredges and draglines are used. Pilot runs are necessary to determine if required specifications can be met consistently and economically.

Much of the sand and gravel that is being mined in stream, floodplain, alluvial fan, riverbeds and terrain, and glacial deposits is good quality material with nearly equal amounts of gravel and sand and small amounts of unusable material. As these deposits become depleted in future years, less desirable and more expensive sources will have to be developed where mining, reserves, ratio of sand to gravel, quality of material, waste factors, and environmental factors such as waste disposal will present more problems.

Exploration and planning will become more important in assessing deposits, particularly hillslope deposits of older sand and gravel. Grading to meet required slope and setback requirements at hillslope sites may necessitate leaving large tonnages of material unmined. Many millions of tons of material is available, but it may not be of proper quality or ratio of sand to gravel. More deposits of marginal quality will have to be developed to provide for future demand.

**Mining.**—Sand and gravel generally occur in the same deposit, but the relative proportions of each vary greatly within most deposits. Consequently, the control problem of producing aggregate to rigid specifications involves combinations of many types of equipment like screens, washers, classifiers, crushers, and grinding mills. The two basic sand and gravel mining methods are open pit excavation and dredging. Open pit excavation and processing has four major steps: (1) site clearing—removing trees and vegetation, stripping overburden and topsoil, and transporting, redepositing, or stockpiling it at or off the site; (2) mining—removing the sand and gravel from the deposit; (3) processing—screening, washing, crushing, blending, and stockpiling the mined material to conform to standards and specifications; and (4) reclamation of the extraction area. Processing may or may not take place at the mining site. Mining equipment ranges from small, simple units such as tractor-mounted high-loaders and dump trucks to more sophisticated systems involving large power shovels, draglines, bucket wheel excavators, and belt conveyors. Increasingly, mining systems are being designed to provide for more efficient and economical land reclamation.

Mining with a dredge usually involves mounting the equipment on boats or barges. Suction or bucket-type dredges are used most commonly to harvest sand and gravel from the bottom of a body of water. The sand and gravel is processed either on board or transported to land for processing.

**Processing.**—Although small amounts of unprocessed bank-run sand and gravel are used for fill, most of the U.S. production is processed in some way. Present methods include washing with water during the screening process, in some cases followed by crushing of the larger particles in cone or gyratory crushers. Secondary crushing may be done by roll crushers. Sizing is done in most plants by horizontal or sloped single or multideck vibratory screens. If necessary, heavy-media separation or jigging is used to remove heavy, unusable materials. Sand for use in construction is freed from clay by log washers or rotary scrubbers. The scrubbing is followed by classification, use of separatory cones or hydroseparators to remove water, and fine screening for grading. Rodmilling is often required for production of small-sized fractions of sand. Transfer of processed sand and gravel from the processing plant to stockpiles or bins is accomplished by flexible combinations of conveyor belts, bucket elevators, and screw conveyors.

Permanent installations are built when large deposits are to be operated for many years. Portable and semiportable units are used in many pits that have an intermediate working life. Several such units can be tied together to obtain large initial production capacity or to add capacity as needed. Mobile screening plants can be quickly moved from one deposit to another without undue interruption or loss of production.

**Recycling.**—As the Nation moves into an age of increased environmental consciousness, recycling of old concrete and asphalt, used mostly in pavements, is increasing. Local scarcity or high cost of construction aggregates in some areas as well as waste disposal problems are making recycling more attractive economically. In some States, limited recycling, especially in road construction, is either encouraged or required by law. The best utilization for recycled cement concrete is as road base material, because the matrix of concrete cannot be converted back to cement and also because of the lower strength of concrete compared with that of natural aggregates.

Sound crushed concrete can make good coarse aggregate, but the fines produced in crushing the concrete have a higher absorption, are more friable, and will require a higher amount of asphalt in asphaltic concrete and a higher amount of mixing water in portland cement.<sup>3</sup> The amount of asphalt roads recycled is significantly larger than that of concrete roads, mainly because asphalt can be rejuvenated with oil additives and used in pavements, significantly reducing the cost of the finished road. Experience has shown that about 35% of crushed asphalt pavement can be recycled into new asphalt mixtures. Proper testing under engineering supervision in all construction projects using recycled materials as aggregates should be performed to ensure that the technical specifications are met.

### Byproducts and Coproducts

Small amounts of gold and silver are recovered as a byproduct or coproduct of sand and gravel extraction, particularly in highly sorted deposits.

### Economic Factors

Construction sand and gravel is a high-volume, low-value commodity. The industry is highly competitive and is characterized by thousands of operations serving local or regional markets. Production costs vary widely depending on geographic location, the nature of the deposit, and the number and type of products produced. Constant dollar unit values have been quite steady during the past 20 years. As a result of rising costs of labor, energy, and mining and processing equipment, the average unit price of construction sand and gravel increased from \$1.1 per ton, f.o.b. plant, in 1970 to \$3.63 in 1992. However, the unit price in constant 1982 dollars fluctuated between \$2.64 and \$2.71 per ton for the same period. Increased productivity achieved through increased use of automation and more efficient equipment was mainly responsible for maintaining the prices at this level. Constant dollar prices are expected to rise in the future because of decreased deposit quality and more stringent environmental

and land use regulations.

Accessibility is a problem for the construction sand and gravel industry. The high-volume and low-unit value of sand and gravel requires that operations be close to the market location. Markets for sand and gravel are construction sites that are mostly in areas of high population density. New operations, close to population centers, are difficult to develop because the land is often attractive for other uses such as housing, shopping centers, agriculture, or parks and recreational areas and because of public dislike for mining operations close to populated areas. Existing operations in expanding communities face increasing costs because of increasing land values and increasing restrictions on operations as suburban development comes closer. Deposits are often small, and once exhausted, the operation must be moved to a new site that invariably is farther from the market because closer sites are being used for other purposes.

The industry also faces increasing competition from crushed stone that can substitute for sand and gravel in most of its applications. Stone operations are generally longerlived, can afford greater capital investment for higher efficiency, and often are where competing land use pressures are less severe. The topographically rugged stone-bearing areas are usually less desirable for construction purposes than sand-and-gravel-bearing areas, which are generally flatter.

A 5% depletion allowance based on gross income is allowed for construction sand and gravel. There are no import tariffs.

### Operating Factors

Many States, counties, and cities in the United States have zoning laws, and land within each governmental unit is usually zoned to indicate acceptable land uses. If mining is permitted in a zone and a sand and gravel company owns or leases land within that zone, the company may apply for a use permit or its equivalent to begin an operation. If the parcels to be quarried are on lands under both city and county jurisdiction, permits usually must

be obtained from each. An acceptable reclamation plan that meets the guidelines or regulations of the appropriate governmental agency must also be approved. Environmental concerns such as noise, dust, beautification, and storage of wastes must be accounted for in a manner satisfactory to the governmental entity involved. Wastewater discharge requirements must be planned for and met. If the deposit to be worked is on a river or land controlled by a river or water or flood control agency, whether municipal, State, or Federal, that agency's requirement must also be satisfied.

In most States, permits for sand and gravel operations require an Environmental Impact Report or Environmental Impact Statement (EIS). A reclamation plan and a use permit application may also be required, with considerable overlap of subject matter with the EIS. A complete EIS may cover all the problem areas at once and facilitate acceptance.

**Environmental Issues.**—Two main points are involved in environmental land use and reclamation factors. First, the industry must be concerned about any practices that can affect the community environment. An effective effort must be made to reduce noise, air, and water pollution; to reclaim pits after the operation is complete; and to improve the overall appearance of the operating mine, processing plant, and transportation facilities. Second, the industry and community must recognize the time and costs required to protect the environment and the importance of agreeing on fair and realistic environmental standards.

Because sand and gravel is a local commodity, supply deficiencies and cost of material will affect the local community first. Undue delay and unreasonably high cost can strongly affect the movement of sand and gravel into the marketplace. Also, stringent controls by the local government that prevent permits being issued to operators can have adverse economic effects on the communities around them. These conditions can make it difficult to assess the timing and even the possibility of

plants going on-stream and can therefore affect the supply of sand and gravel into the marketplace.

Although much progress is being made through premining planning, the sand and gravel industry continues to have problems with environmental controls, land use conflicts, and reclamation practices. Many of these problems are acute because extraction areas and plants must be reasonably near to consumers who are largely in metropolitan areas. Major environmental considerations that must be dealt with in mining and processing sand and gravel are emission of particulate matter into the air, processing water discharge, noise abatement, and employee and public health and safety.

**Transportation.**—Transportation is a major factor in the delivered price of construction sand and gravel. The cost of moving construction sand and gravel from the plant to the market often exceeds the sales price of the product at the plant. Because of the high cost of transportation, construction sand and gravel continues to be marketed locally. Economies of scale, which might be realized if fewer larger operations served larger marketing areas, would probably not offset the increased transportation costs.

Truck haulage is the main form of transportation used in the construction sand and gravel industry. Many producers have their own truck fleet and deliver their own raw materials and products. A significant and increasing amount of sand and gravel, however, is being hauled by independent truckers because of the cost of maintaining a truck fleet, particularly when the market is highly variable. Rail and water transportation combined account for about 10% to 20% of total construction sand and gravel shipments.

### ANNUAL REVIEW

A total of 869 million metric tons (958 million short tons) of construction sand and gravel was estimated to have been produced in the United States in 1993, a 4.2% increase compared with the total

production of 1992. This tonnage represents the highest production level since the record production of 1978, indicating a significant increase in the demand for construction aggregates in the United States in 1993. (See table 3.)

During the year, production of construction sand and gravel increased every quarter, compared with the same period of 1992, with the largest increases occurring in the third and fourth quarters of 1993.

### Legislation

The Department of Transportation and Related Agencies Appropriation Act of 1994 (Public Law 103-122) was signed by the President on October 27, 1993. The act appropriates \$20.6 billion for new highway spending, a \$2 billion increase from the fiscal year 1993 total. The act also includes a \$2.2 billion appropriation in grants for airport construction and provision for a 1-year delay in the imposition of the "crumb rubber" use in highway construction as required by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991.

### Issues

The implementation of the provisions of the amended Federal Water Pollution Control Act of 1977, the Clean Water Act, section 404, dealing with "wetlands" and the establishment of a "no net loss of wetlands" policy constitutes one of the major areas of concern to the crushed stone industry. There is a significant amount of uncertainty regarding the process of designating some lands as wetlands and whether the current exemptions to the Clean Water Act, section 404, permit program will be maintained in the future. On August 24, 1993, the administration's wetlands policy was announced. The new policy endorses an interim goal of "no overall net loss" of wetlands and a long-term goal of increasing wetlands quantity and quality; provides for administrative appeals of permitting process decisions; establishes deadlines for the Army Corps of Engineers' decisions on permit

applications, generally within 90 days; mandates the use of the 1987 Wetlands Delineation Manual by the Army Corps of Engineers, Environmental Protection Agency (EPA), Soil Conservation Service, and Fish and Wildlife Service to identify wetlands; encourages the development of wetland mitigation banks; and promotes the long-term restoration of wetlands through voluntary, nonregulatory programs.

Several bills were reintroduced in the 103d U.S. Congress to replace the current section 404 of the Federal Water Pollution Control Act. These proposed bills plan to provide a concise and structured program for the delineation of wetlands based on their functions and values and will balance the need for effective protection of the Nation's important wetlands with the need for essential community growth and the constitutional rights of landowners.

The complex legal and technical provisions of the comprehensive amendments to the Clean Air Act of 1990 and implementation of regulations for these provisions continues to constitute another major area of concern to the crushed stone industry. One major emphasis of the amendments is the expanded authority given to EPA and the States to enforce the new law and to assess increased penalties. EPA is now authorized to issue administrative orders with penalties of up to \$200,000 for noncompliance, and its field inspectors can issue citations for minor violations with penalties of up to \$5,000 per day for each violation. The law also includes provisions for new Federal permits to be issued by the State agencies that include source-specific emission limitations and related monitoring, recordkeeping, and reporting requirements. Complying with the new provisions of the Clean Air Act, amendments will constitute a major challenge to all crushed stone producers.

Another issue of concern to the construction aggregates industries is the classification of crystalline silica as a probable human carcinogen by the International Agency for Research on Cancer, an agency of the World Health Organization. OSHA-regulated sites that receive and/or use products containing

more than 0.1% crystalline silica must comply with OSHA's Hazard Communication Standards. Both the classification of crystalline silica as a probable human carcinogen and the requirement to quantitatively analyze for crystalline silica at the 0.1% level are controversial.

### Production

The production estimates indicate that in 1993 the U.S. production of construction sand and gravel was 869 million metric tons (958 million short tons), a 4.2% increase compared with the total production of 1992. Of the four major geographic regions, the West again led the Nation in the production of construction sand and gravel with 314 million tons, or 36.1% of the U.S. total, followed by the Midwest with 274 million tons, or 31.5% of the total, and the South with 188 million tons, or 21.6%. Compared with 1992, production by major geographic regions increased in the South, 9.4%; in the West, 4.5%; and in the Midwest, 2.4%; while decreasing in the Northeast by 1.9%. (See table 2 and figure 1.) Of the nine geographic regions, the East North Central led the Nation with 181 million tons, or 20.9% of the U.S. total. Next was the Pacific with 164 million tons, or 18.9% of the total, and the Mountain with 150 million tons, or 17.2% of the total. Compared with 1992, production increased in all regions except New England, West North Central, and Pacific. The largest increases were recorded in the Mountain region, 13.3%; the East South Central region, 10.7%; and the West South Central region, 9.5%. (See table 2.)

The estimated production by quarters for 1993 indicated that most of the construction sand and gravel in the United States was produced in the third quarter, followed by the second quarter and the fourth quarter. Estimated production by each quarter of 1993 was also available for most of the States. (See table 5.)

Construction sand and gravel was produced in every State, and the 1993 production estimates indicate that the 10 leading States, in descending order of

tonnage, were California, Texas, Ohio, Michigan, Washington, Arizona, New York, Illinois, Minnesota, and Colorado. Their combined production represented 50.5% of the national total. (See table 4.)

Compared with 1992, production increased in 34 States, including 8 of the top 10 States. The major increases, in percentage, occurred in Mississippi, 39.8%; New York, 22.3%; and Arizona, 14%. Production decreased in 15 States, with the major decreases, in percentage, occurring in Maine, 27.6%; Minnesota, 10.6%; and California, 6%.

Limited information about the production of construction sand and gravel in foreign countries may be found in the USBM "Minerals Yearbook, Area Reports: International." For nonreporting countries, estimates of sand and gravel and crushed stone outputs can be based on indirect sources of information such as the level of cement consumption.

In the second half of 1993, Beazer USA, Inc./Hanson Industries of Walnut Creek, CA, a subsidiary of Hanson PLC of London, United Kingdom, reorganized its U.S. operations to provide more local operational and financial control and to capitalize on the company's more recognizable names in regional markets. Beazer Northeast became General Materials & Construction Co. of Easton, PA; Beazer Southeast became Benchmark Materials Co. of Research Triangle Park, NC; Beazer Northwest became Kaiser Materials Corp. of Pleasanton, CA; and Beazer Southwest became Southwest Construction Materials and Services Co. of Long Beach, CA. Gifford-Hill & Co. of Dallas, TX, and Spectrum Construction Co. of Virginia Beach, VA, also part of the Beazer Group, will retain their original names.

On November 12, 1993, Martin Marietta Corp. announced that its construction materials division, Martin Marietta Aggregates, will become a separate company, Martin Marietta Materials Inc., in Raleigh, NC. The new company that was incorporated in North Carolina will be a wholly owned subsidiary of Martin Marietta Corp. On December 8, 1993, a registration

statement was filed with the Security and Exchange Commission for an underwritten public offering of about 19% of the company's common stocks.

In December 1993, Lafarge Corp. of Reston, VA, announced the restructuring of its North American operations by consolidating 11 cement and construction materials regional operating units into six units. Effective January 1, 1994, Lafarge's new North American organization will include three regional centers for construction materials: Western, based in Calgary, Alberta, Canada; Eastern, based in Toronto, Ontario, Canada; and the United States, based in Canfield, Ohio; and three regional offices for cement's group in Calgary, Alberta, Canada; Montreal, Quebec, Canada; and the United States in Southfield, MI.

### Consumption and Uses

Sand and gravel reported by producers to the USBM is actually material that is "sold or used" by the companies and is defined as such. Stockpiled production is not reported until it is sold to a user or consumed by the producer outside its own operation. Because no consumption surveys are conducted by the USBM, the "sold or used" tonnage is assumed to represent the amount produced for domestic consumption and export.

The largest use of construction sand and gravel is as aggregate for the production of concrete, used in nearly all residential, commercial, and industrial buildings, and in most public works projects such as highways and roads, bridges, dams, airport runways, sewer systems, tunnels, etc.

Of the 834 million metric tons (919 Mst) of construction sand and gravel produced in 1992, the last year when a complete survey of producers was conducted by the USBM, 213 Mmt (235 Mst) or 25.6% of the total was for unspecified uses. Of the remaining 588 Mmt (648 Mst) 41% was used as concrete aggregates; 29.9% for road base and coverings and road stabilization; 14.9% as asphaltic concrete aggregates and other bituminous mixtures; 13.7% as construction fill; 1.9% for concrete

products such as blocks, bricks, pipes, etc.; 1.5% for plaster and gunite sands; and the remainder for snow and ice control, railroad blast, roofing granules, filtration, and other miscellaneous uses.

To provide a more accurate estimation of the consumption patterns for construction sand and gravel, "Unspecified uses—actual and estimated" are not included in the above percentages. The "Unspecified uses" represent quantities reported by some producers only as their total production without a breakdown by uses and estimated quantities for nonreporting companies. It is recommended that in any marketing or use pattern analysis the quantities included in "Unspecified uses" be distributed among the reported uses by applying the above percentages.

Sand and gravel are usually used mixed, but some uses require only sand or only gravel. Sand is used in mortar, plaster, and gunite and for snow and ice control. Gravel is used to improve or control drainage and as covering and stabilizer on load-bearing surfaces such as unpaved roads, driveways, and parking areas. For 1993, only production estimates were generated for construction sand and gravel, and therefore no information by end uses is available for this year.

### Prices

Prices in this chapter are f.o.b. plant, usually at the first point of sale or captive use. This value does not include transportation from the plant or yard to the consumer. It does, however, include all costs of mining, processing, in-plant transportation, overhead costs, and profit. Compared with that of 1992, when the last full annual survey was conducted, the estimated 1993 average unit prices increased only 1.2% to \$4.06 per metric ton (\$3.63 per short ton).

As a result of rising costs of labor, energy, and mining and processing equipment, the average unit value of construction sand and gravel increased from \$1.22 per metric ton, f.o.b. plant, in 1970, to \$4.06 in 1993. However, the unit price in constant 1987 dollars declined from \$5.48 in 1970 to \$2.89 in

1993.

## Foreign Trade

The widespread distribution of domestic sand and gravel deposits and the high cost of transportation limits foreign trade mostly to local transactions across international boundaries. U.S. imports and exports are small, representing less than 1% of the domestic consumption.

**Exports.**—Exports of construction sand decreased 31.4% to 597,000 metric tons, compared with 1992 totals, while value decreased 15.9% to \$10.6 million. Canada was the major destination, receiving 61.3% of the total, followed by Mexico with 28.8%. Exports of construction gravel declined 2.9% to 534,000 metric tons, compared with 1992, while value declined 6.9% to \$5 million. Canada was the major destination with 88.6% of the total, followed by Mexico with 3.6%. (See table 6.)

**Imports.**—Imports of construction sand and gravel remained at the 1992 level in terms of quantity, 1.3 Mmt, as well as value, \$15.4 million. Canada continued to be the major source of imported construction sand and gravel with 73.1% of the total, followed by the Bahamas with 15%. (See table 7.)

## Current Research

The Center for Aggregates Research (CAR), established by the National Aggregates Association and the National Stone Association and managed through the Aggregates Foundation for Technology, Research, and Education, is the first organization dedicated wholly to aggregates research. A technical advisory committee overseeing the center's activity identified six priority areas of research that include fine aggregates properties and their influence on end products; uses for fines resulting from the processing of aggregates; performance-related tests for aggregates; proper use of aggregates in asphaltic concrete to minimize rutting; prevention of alkali-silica and alkali-carbonate

reactivity of aggregates in portland cement concrete; and nature and effects of coatings on aggregates. CAR will concentrate its efforts into these areas.

The University of Texas at Austin and Texas A&M University, the two institutions operated jointly by CAR, already have considerable research in progress related to aggregates. Some of the projects under way are:

- Evaluation of the performance of pavements made with different coarse aggregates including those with different thermal coefficients and the development of design procedures;

- Evaluation of the effectiveness of large stone mixtures in resisting plastic deformation—rutting—in asphalt pavements and recommended design procedures and quality assurance testing and constructability;

- Study of the alkali-silica reaction in concrete containing fly ash. The objectives of the study are to identify the most relevant components of fly ash, portland cement, and aggregates affecting the alkali-silica reaction and to determine the type and amount of a given component to be used in producing high-quality concrete.

- Study of surface friction of seal coat pavements to identify the best methods for determining aggregates properties and characteristics that will accurately predict surface friction performance of seal coats.

- Potential engineering and environmental uses of quarry fines.<sup>4</sup>

The ISTEA of 1991 authorized about \$108 million for Strategic Highway Research Program (SHRP) implementation and Long Term Pavement Performance (LTPP) projects. With the completion of SHRP's 5-year research program, the Federal Highway Administration (FHWA) was assigned the responsibility of implementing the research results, products, and techniques through FHWA's Technology Applications program. A series of implementation actions is also being undertaken by the American Association of State Highway and Transportation Officials (AASHTO) and the Transportation Research Board (TRB). AASHTO's Subcommittee on Materials amended its procedures to accept new

product standards on a provisional basis for a maximum of 4 years, during which time hands-on testing will be conducted. At the end of 2 years, the product standards can be balloted for acceptance as regular standards, or the provisional status can be extended for an additional 2 years. The Subcommittee on Materials is also developing information about the specific resources needed to implement SHRP products. TRB has created the TRB/SHRP committee, which will provide industry, highway agencies, and research specialists with a continuing forum to coordinate activities related to implementation of SHRP products and continuation of the LTPP program.

## Technology

A new mobile conveyor system designed to load or unload bulk commodity railcars was introduced by Granite Rock Co. of Watsonville, CA, at the Rock by Rail Third Conference held in April 1993 in League City, TX. TransloadXpress conveyor system was engineered by Granite Rock Co. to provide a cost-effective, efficient, and fast method of loading and unloading railcars. TransloadXpress can convey bulk materials at rates of up to 800 tons/hour and can unload rail-to-truck systems at rates averaging 300 tons/hour. TransloadXpress can unload materials into waiting trucks for short hauls to the job site or can convey materials directly into portable ready-mix concrete and asphalt plants. TransloadXpress helps the aggregates producer take advantage of the economies of scale offered by rail shipments and also provides significant environmental advantages. According to a study conducted by the Department of Energy, rail delivers more than eight times the energy efficiency of trucking when measured by the required BTU's per ton-mile of transportation.<sup>5</sup>

A comprehensive review of the available microcomputer software for use in the aggregate-producing industry was published by Rock Products magazine. The review includes software for mine planning, geographic information systems, plant design, mining cost analysis, blasting design, scale

management, financial modeling, and accounting. Available information on environmental and occupational health and safety standards, State and Federal regulatory requirements, and legal and engineering codes and standards affecting the aggregates industry is also included in the review.<sup>6</sup>

Quarry blasting usually requires considerably greater control than most mining or public works rock blasting. Maximizing the breakage of rock during primary blasting reduces significantly the need for secondary breakage of oversize rock and therefore reduces the energy consumption required to produce the final product. Efficient and cost-effective blasting requires proper selection of blasthole pattern, explosive selection, delay timing, and initiation sequence, as well as a thorough understanding of the impact the blasting will have on nearby structures. A comprehensive review of the technology, including blasting fragmentation, drilling accuracy, explosive performance, ground vibration, blast size and delay timing, and how the technology can be used to reduce blasting costs, was published by Quarry Management magazine and was reprinted by Rock Products magazine.<sup>7</sup>

## OUTLOOK

The demand for construction sand and gravel in 1994 is expected to be about 900 million metric tons (992 Mst), a 3.6% increase from that of 1993. Gradual increases in demand for construction aggregates are anticipated, based on increased volume of work on the infrastructure occurring as a result of the funding provided by ISTEA of 1991. The law authorized \$151 billion to be spent in the next 6 years on transportation projects, of which \$119.5 billion is for highway work and \$32.5 billion for mass transit. It is estimated that the demand for construction sand and gravel will reach 930 Mmt (1,025 Mst) in 1995. The projected increases will be influenced by construction activity in the public as well as the private construction sector.

The value of public construction work as part of the gross domestic product has declined constantly from about 3% in the

1950's and 1960's to less than 2% in the 1980's. If this trend begins to reverse in the 1990's, a significant increase in spending for public construction work could be expected that will significantly alter the above forecasts.

Construction sand and gravel f.o.b. prices are not expected to increase significantly, even if the demand for construction aggregates will rise over the above forecasts. However, the delivered prices of construction sand and gravel are expected to increase, especially in and near metropolitan areas, mainly because more aggregates are transported from distant sources.

<sup>1</sup>Natural Aggregates Association Compilation of ASTM Standards Relating to Aggregates and Concrete. Nat. Aggregates Assoc. Circ. 113, Feb. 1990.

<sup>2</sup>Langer, W. E. Natural Aggregates of the Conterminous United States. U.S. Geol. Surv. Bull. 1594, 1988, 33 pp.

<sup>3</sup>Meininger, R. C. National Aggregates Association Technical Information Letter. No. 395, 1988, p. 7.

<sup>4</sup>Flowler, D. W. Center for Aggregates Research: Dedicated to Helping the Industry. Stone Review, v. 9, No. 3, June 1993, pp. 20-22.

<sup>5</sup>Obershaw, D. A. New Innovation for Loading and Unloading Rail Cars. Stone Review, v. 10, No. 3, June 1994, pp. 12-13.

<sup>6</sup>Carter, R. A. What's New in Software for Aggregates Producers. Rock Products, v. 97, No. 5, May 1994, pp. 44-65.

<sup>7</sup>McKenzie, C. Diagnosis Makes for Better Blasting. Rock Products, v. 97, No. 4, Apr. 1994, pp. 34-43.

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TABLE 1  
SALIENT U.S. CONSTRUCTION SAND AND GRAVEL STATISTICS

|                            |                                  | 1989         | 1990        | 1991         | 1992        | 1993         |
|----------------------------|----------------------------------|--------------|-------------|--------------|-------------|--------------|
| Sold or used by producers: |                                  |              |             |              |             |              |
| Quantity <sup>1</sup>      | thousand metric tons             | 814,017      | 828,713     | 707,876      | *834,000    | *868,700     |
| Quantity                   | thousand short tons <sup>2</sup> | *897,300     | 913,500     | *780,300     | 919,300     | 957,600      |
| Value <sup>1</sup>         | thousand dollars                 | *\$3,249,100 | \$3,267,500 | *\$2,805,500 | \$3,341,300 | *\$3,530,100 |
| Exports                    | value, thousand dollars          | \$13,591     | \$11,880    | \$19,044     | \$17,963    | \$15,594     |
| Imports                    | do.                              | \$6,618      | \$22,912    | \$16,638     | \$15,463    | \$15,445     |

\*Estimated. †Revised.

<sup>1</sup>Hawaii and Puerto Rico excluded from all sand and gravel statistics.

<sup>2</sup>One short ton is equal to 907 kilograms or 2,000 pounds. To convert metric tons to short tons, divide metric tons by 0.907185.

TABLE 2  
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY  
PRODUCERS IN THE UNITED STATES, BY GEOGRAPHIC REGION

| Geographic region    | 1992                                  |                     |                      |                     | 1993*                                 |                     |                      |                     |
|----------------------|---------------------------------------|---------------------|----------------------|---------------------|---------------------------------------|---------------------|----------------------|---------------------|
|                      | Quantity<br>(thousand<br>metric tons) | Percent<br>of total | Value<br>(thousands) | Percent<br>of total | Quantity<br>(thousand<br>metric tons) | Percent<br>of total | Value<br>(thousands) | Percent<br>of total |
| <b>Northeast:</b>    |                                       |                     |                      |                     |                                       |                     |                      |                     |
| New England          | 33,681                                | 4.0                 | \$154,535            | 4.6                 | 31,400                                | 3.6                 | \$150,100            | 4.2                 |
| Middle Atlantic      | 60,971                                | 7.3                 | 305,015              | 9.1                 | 61,500                                | 7.0                 | 325,500              | 9.2                 |
| <b>Midwest:</b>      |                                       |                     |                      |                     |                                       |                     |                      |                     |
| East North Central   | 171,394                               | 20.5                | 617,290              | 18.4                | 181,300                               | 20.8                | 683,100              | 19.4                |
| West North Central   | 95,851                                | 11.4                | 291,705              | 8.7                 | 92,400                                | 10.6                | 287,900              | 8.2                 |
| <b>South:</b>        |                                       |                     |                      |                     |                                       |                     |                      |                     |
| South Atlantic       | 64,103                                | 7.6                 | 265,299              | 7.9                 | 69,600                                | 8.0                 | 295,000              | 8.4                 |
| East South Central   | 35,956                                | 4.3                 | 145,651              | 4.3                 | 39,800                                | 4.5                 | 160,300              | 4.5                 |
| West South Central   | 71,755                                | 8.6                 | 278,891              | 8.3                 | 78,600                                | 9.0                 | 314,700              | 8.9                 |
| <b>West:</b>         |                                       |                     |                      |                     |                                       |                     |                      |                     |
| Mountain             | 132,104                               | 15.8                | *506,919             | 15.1                | 149,700                               | 17.2                | 562,400              | 15.9                |
| Pacific              | 168,115                               | 20.1                | *732,638             | 21.9                | 163,900                               | 18.9                | 751,100              | 21.3                |
| Total <sup>1</sup>   | *834,000                              | 100                 | 3,341,300            | 100                 | 868,700                               | 100                 | 3,530,100            | 100                 |
| Total <sup>2 3</sup> | 919,300                               | XX                  | 3,341,300            | XX                  | 957,600                               | XX                  | 3,530,100            | XX                  |

\*Estimated. †Revised. XX Not applicable.

<sup>1</sup>Data may not add to totals shown because of independent rounding, and differences between projected totals by States and by regions.

<sup>2</sup>One short ton is equal to 907 kilograms or 2,000 pounds. To convert metric tons to short tons, divide metric tons by 0.907185.

<sup>3</sup>Total shown in thousand short tons and thousand dollars.

**TABLE 3**  
**CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN**  
**THE UNITED STATES IN 1993, BY GEOGRAPHIC REGION AND QUARTER<sup>1</sup>**

(Thousand short tons and thousand dollars)

| Geographic region                     | Quantity<br>(thousand metric tons) |                |                |                | Total            | Value<br>(thousands) | Number of<br>companies <sup>2</sup> |
|---------------------------------------|------------------------------------|----------------|----------------|----------------|------------------|----------------------|-------------------------------------|
|                                       | 1st quarter                        | 2d quarter     | 3d quarter     | 4th quarter    |                  |                      |                                     |
| <b>Northeast:</b>                     |                                    |                |                |                |                  |                      |                                     |
| New England                           | 4,000                              | 9,600          | 11,700         | 9,300          | 34,600           | \$150,100            | 25                                  |
| Middle Atlantic                       | 7,300                              | 19,800         | 23,500         | 17,100         | 67,800           | 325,500              | 31                                  |
| <b>Midwest:</b>                       |                                    |                |                |                |                  |                      |                                     |
| East North Central                    | 20,000                             | 55,400         | 68,800         | 55,700         | 199,900          | 683,100              | 51                                  |
| West North Central                    | 10,300                             | 27,900         | 34,200         | 29,400         | 101,800          | 287,900              | 42                                  |
| <b>South:</b>                         |                                    |                |                |                |                  |                      |                                     |
| South Atlantic                        | 15,200                             | 21,400         | 21,200         | 18,900         | 76,700           | 295,000              | 49                                  |
| East South Central                    | 7,500                              | 12,500         | 12,700         | 11,300         | 43,900           | 160,300              | 22                                  |
| West South Central                    | 17,400                             | 23,000         | 25,100         | 21,200         | 86,600           | 314,700              | 19                                  |
| <b>West:</b>                          |                                    |                |                |                |                  |                      |                                     |
| Mountain                              | 28,300                             | 43,800         | 48,900         | 44,100         | 165,000          | 562,400              | 32                                  |
| Pacific <sup>3</sup>                  | 31,800                             | 44,800         | 47,600         | 42,000         | 166,200          | 751,100              | 26                                  |
| <b>Total<sup>4</sup></b>              | <b>141,700</b>                     | <b>258,000</b> | <b>293,700</b> | <b>249,100</b> | <b>957,600</b>   | <b>\$3,530,100</b>   | <b>XX</b>                           |
| <b>Total<sup>5</sup> <sup>7</sup></b> | <b>128,600</b>                     | <b>234,100</b> | <b>266,400</b> | <b>226,000</b> | <b>\$868,700</b> | <b>\$3,530,100</b>   | <b>XX</b>                           |

<sup>1</sup>Revised. XX Not applicable.

<sup>2</sup>As revised from data published in the "Crushed Stone and Sand and Gravel in the Fourth Quarter of 1993 Mineral Industry Survey."

<sup>3</sup>Number of companies reporting for the quarterly survey.

<sup>4</sup>Does not include Alaska and Hawaii.

<sup>5</sup>Data may not add to totals shown because of independent rounding and differences between projected totals by States and by regions.

<sup>6</sup>Includes Alaska.

<sup>7</sup>One metric ton is equal to 1,000 kilograms or 2,204.62 pounds. To convert short tons to metric tons, multiply short tons by 0.907185.

<sup>8</sup>Total shown in thousand metric tons and thousand dollars.

**TABLE 4**  
**CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY**  
**PRODUCERS IN THE UNITED STATES, BY STATE**

| State       | 1992                                  |                                |               | 1993 <sup>*</sup>                     |                                |               |
|-------------|---------------------------------------|--------------------------------|---------------|---------------------------------------|--------------------------------|---------------|
|             | Quantity<br>(thousand<br>metric tons) | Value<br>(thousand<br>dollars) | Unit<br>value | Quantity<br>(thousand<br>metric tons) | Value<br>(thousand<br>dollars) | Unit<br>value |
| Alabama     | 11,153                                | 42,038                         | \$3.77        | 10,300                                | 39,100                         | \$3.80        |
| Alaska      | 13,613                                | 43,335                         | 3.18          | 13,100                                | 42,600                         | 3.25          |
| Arizona     | 30,701                                | 123,517                        | 4.02          | 35,000                                | 138,300                        | 3.95          |
| Arkansas    | 9,896                                 | 39,627                         | 4.00          | 10,100                                | 40,900                         | 4.05          |
| California  | 102,410                               | 522,108                        | 5.10          | 96,300                                | 475,700                        | 4.94          |
| Colorado    | 26,721                                | 105,281                        | 3.94          | 29,000                                | 117,500                        | 4.05          |
| Connecticut | 5,466                                 | 30,107                         | 5.51          | 6,400                                 | 34,900                         | 5.45          |
| Delaware    | 2,257                                 | 8,574                          | 3.80          | 2,500                                 | 10,300                         | 4.12          |
| Florida     | 21,107                                | 66,141                         | 3.13          | 22,800                                | 73,100                         | 3.21          |
| Georgia     | 4,409                                 | 15,581                         | 3.53          | 4,600                                 | 16,600                         | 3.61          |
| Idaho       | 13,522                                | 40,728                         | 3.01          | 13,600                                | 44,900                         | 3.30          |
| Illinois    | 32,382                                | 123,720                        | 3.82          | 34,500                                | 137,300                        | 3.98          |
| Indiana     | 26,183                                | 95,889                         | 3.66          | 27,000                                | 102,600                        | 3.80          |
| Iowa        | 15,263                                | 58,382                         | 3.82          | 16,600                                | 64,700                         | 3.90          |
| Kansas      | 10,867                                | 27,289                         | 2.51          | 11,900                                | 30,700                         | 2.58          |
| Kentucky    | 6,710                                 | 24,412                         | 3.64          | 7,700                                 | 29,900                         | 3.88          |

See footnote at end of table.

TABLE 4—Continued  
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY  
PRODUCERS IN THE UNITED STATES, BY STATE

| State                | 1992                                  |                                |               | 1993*                                 |                                |               |
|----------------------|---------------------------------------|--------------------------------|---------------|---------------------------------------|--------------------------------|---------------|
|                      | Quantity<br>(thousand<br>metric tons) | Value<br>(thousand<br>dollars) | Unit<br>value | Quantity<br>(thousand<br>metric tons) | Value<br>(thousand<br>dollars) | Unit<br>value |
| Louisiana            | 11,470                                | 48,698                         | \$4.25        | 11,900                                | 51,500                         | \$4.33        |
| Maine                | 6,081                                 | 26,932                         | 4.43          | 4,400                                 | 18,900                         | 4.30          |
| Maryland             | 10,875                                | 69,297                         | 6.37          | 11,200                                | 72,200                         | 6.45          |
| Massachusetts        | 10,916                                | 48,671                         | 4.46          | 10,800                                | 51,300                         | 4.75          |
| Michigan             | 43,539                                | 143,107                        | 3.29          | 45,000                                | 157,500                        | 3.50          |
| Minnesota            | 34,114                                | 98,673                         | 2.89          | 30,500                                | 85,400                         | 2.80          |
| Mississippi          | 10,403                                | 44,124                         | 4.24          | 14,500                                | 57,300                         | 3.95          |
| Missouri             | 8,186                                 | 26,457                         | 3.23          | 6,400                                 | 19,800                         | 3.09          |
| Montana              | 10,078                                | 31,375                         | 3.11          | 10,000                                | 32,000                         | 3.20          |
| Nebraska             | 11,980                                | 38,108                         | 3.18          | 12,900                                | 41,900                         | 3.25          |
| Nevada               | 22,020                                | 93,585                         | 4.25          | 24,900                                | 107,600                        | 4.32          |
| New Hampshire        | 5,839                                 | 25,570                         | 4.38          | 4,800                                 | 20,700                         | 4.31          |
| New Jersey           | 14,892                                | 79,993                         | 5.37          | 14,700                                | 80,100                         | 5.45          |
| New Mexico           | 10,170                                | 46,176                         | 4.54          | 11,100                                | 51,100                         | 4.60          |
| New York             | 28,538                                | 130,379                        | 4.57          | 34,900                                | 161,500                        | 4.63          |
| North Carolina       | 9,283                                 | 42,717                         | 4.60          | 11,100                                | 53,800                         | 4.85          |
| North Dakota         | 7,929                                 | 20,609                         | 2.60          | 7,700                                 | 20,400                         | 2.65          |
| Ohio                 | 42,874                                | 177,508                        | 4.14          | 46,400                                | 202,900                        | 4.37          |
| Oklahoma             | 8,985                                 | 24,204                         | 2.69          | 9,700                                 | 27,300                         | 2.81          |
| Oregon               | 14,958                                | 69,536                         | 4.65          | 15,800                                | 74,800                         | 4.73          |
| Pennsylvania         | 17,540                                | 94,643                         | 5.40          | 16,100                                | 83,900                         | 5.21          |
| Rhode Island         | 2,227                                 | 11,964                         | 5.37          | 2,500                                 | 13,900                         | 5.56          |
| South Carolina       | 6,256                                 | 19,923                         | 3.18          | 6,800                                 | 21,800                         | 3.21          |
| South Dakota         | 7,511                                 | 22,187                         | 2.95          | 8,300                                 | 25,000                         | 3.01          |
| Tennessee            | 7,691                                 | 35,077                         | 4.56          | 7,200                                 | 34,000                         | 4.72          |
| Texas                | 41,404                                | 166,362                        | 4.02          | 47,100                                | 195,000                        | 4.14          |
| Utah                 | 16,037                                | 54,819                         | 3.42          | 16,000                                | 56,000                         | 3.50          |
| Vermont              | 3,152                                 | 11,291                         | 3.58          | 3,000                                 | 10,400                         | 3.47          |
| Virginia             | 8,659                                 | 37,336                         | 4.31          | 9,000                                 | 40,500                         | 4.50          |
| Washington           | 37,134                                | 140,994                        | 3.80          | 40,200                                | 158,000                        | 3.93          |
| West Virginia        | 1,256                                 | 5,730                          | 4.56          | 1,400                                 | 6,700                          | 4.79          |
| Wisconsin            | 26,415                                | 77,066                         | 2.92          | 27,600                                | 82,800                         | 3.00          |
| Wyoming              | 2,855                                 | 11,438                         | 4.01          | 3,400                                 | 15,000                         | 4.41          |
| Total <sup>1</sup>   | 834,000                               | 3,341,300                      | 4.01          | 868,700                               | 3,530,100                      | 4.06          |
| Total <sup>2 3</sup> | 919,300                               | 3,341,300                      | 3.63          | 957,600                               | 3,530,100                      | 3.69          |

\*Estimated. †Revised.

<sup>1</sup>Data may not add to totals shown because of independent rounding and differences between projected totals by States.

<sup>2</sup>One short ton is equal to 907 kilograms or 2,000 pounds. To convert metric tons to short tons, divide metric tons by 0.907185.

<sup>3</sup>Total shown in thousand short tons and thousand dollars.

TABLE 5  
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS  
IN THE UNITED STATES IN 1993, BY STATE AND QUARTER<sup>1</sup>

| State                     | Quantity<br>(thousand short tons) |            |            |             |                    | Value<br>(thousands) | Number<br>of<br>companies <sup>2</sup> |
|---------------------------|-----------------------------------|------------|------------|-------------|--------------------|----------------------|----------------------------------------|
|                           | 1st quarter                       | 2d quarter | 3d quarter | 4th quarter | Total <sup>2</sup> |                      |                                        |
| Alabama                   | 2,400                             | 3,300      | 2,900      | 2,700       | 11,300             | \$39,100             | 9                                      |
| Alaska <sup>4</sup>       | —                                 | —          | —          | —           | 14,500             | 42,600               | —                                      |
| Arizona                   | 7,000                             | 9,900      | 11,400     | 10,800      | 38,600             | 138,300              | 9                                      |
| Arkansas                  | 2,100                             | 2,800      | 3,300      | 2,900       | 11,100             | 40,900               | 4                                      |
| California                | 20,600                            | 28,800     | 30,500     | 26,200      | 106,100            | 475,700              | 12                                     |
| Colorado                  | 4,800                             | 9,800      | 10,400     | 7,800       | 32,000             | 117,500              | 8                                      |
| Connecticut               | 700                               | 1,800      | 2,300      | 2,300       | 7,100              | 34,900               | 6                                      |
| Delaware                  | 400                               | 1,000      | 800        | 600         | 2,800              | 10,300               | 5                                      |
| Florida                   | 5,900                             | 6,700      | 6,600      | 6,500       | 25,200             | 73,100               | 9                                      |
| Georgia                   | 1,100                             | 1,400      | 1,400      | 1,200       | 5,100              | 16,600               | 8                                      |
| Idaho                     | 1,000                             | 3,800      | 6,800      | 3,400       | 15,000             | 44,900               | 4                                      |
| Illinois                  | 3,100                             | 10,700     | 13,000     | 11,200      | 38,000             | 137,300              | 8                                      |
| Indiana                   | 3,600                             | 8,400      | 10,200     | 7,600       | 29,800             | 102,600              | 12                                     |
| Iowa                      | 1,400                             | 5,000      | 6,500      | 5,400       | 18,300             | 64,700               | 7                                      |
| Kansas                    | 1,700                             | 3,800      | 4,100      | 3,500       | 13,100             | 30,700               | 8                                      |
| Kentucky                  | 1,200                             | 2,500      | 2,600      | 2,200       | 8,500              | 29,900               | 5                                      |
| Louisiana                 | 2,700                             | 3,800      | 3,700      | 3,500       | 13,200             | 51,500               | 5                                      |
| Maine                     | 300                               | 1,300      | 1,600      | 1,600       | 4,800              | 18,900               | 4                                      |
| Maryland                  | 2,100                             | 3,200      | 3,500      | 3,500       | 12,300             | 72,200               | 8                                      |
| Massachusetts             | 1,900                             | 3,100      | 4,000      | 2,900       | 11,900             | 51,300               | 6                                      |
| Michigan                  | 4,500                             | 13,900     | 18,200     | 14,100      | 49,700             | 157,500              | 10                                     |
| Minnesota                 | 4,100                             | 8,000      | 12,300     | 9,200       | 33,600             | 85,400               | 13                                     |
| Mississippi               | 2,900                             | 4,100      | 4,600      | 4,400       | 16,000             | 57,300               | 6                                      |
| Missouri                  | 800                               | 2,100      | 1,700      | 2,500       | 7,100              | 19,800               | 6                                      |
| Montana <sup>4</sup>      | —                                 | —          | —          | —           | 11,000             | 32,000               | —                                      |
| Nebraska                  | 900                               | 4,800      | 5,100      | 3,900       | 14,200             | 41,900               | 6                                      |
| Nevada                    | 6,100                             | 6,900      | 7,000      | 7,500       | 27,500             | 107,600              | 5                                      |
| New Hampshire             | 600                               | 1,700      | 1,800      | 1,200       | 5,300              | 20,700               | 5                                      |
| New Jersey                | 2,500                             | 4,500      | 4,900      | 4,300       | 16,200             | 80,100               | 5                                      |
| New Mexico                | 2,100                             | 3,300      | 3,500      | 3,300       | 12,200             | 51,100               | 3                                      |
| New York                  | 3,900                             | 10,900     | 14,200     | 10,100      | 38,500             | 161,500              | 11                                     |
| North Carolina            | 2,800                             | 3,600      | 3,100      | 2,700       | 12,200             | 53,800               | 4                                      |
| North Dakota <sup>4</sup> | —                                 | —          | —          | —           | 8,500              | 20,400               | —                                      |
| Ohio                      | 5,700                             | 14,200     | 17,400     | 13,800      | 51,100             | 202,900              | 16                                     |
| Oklahoma                  | 1,900                             | 2,900      | 3,300      | 2,600       | 10,700             | 27,300               | 7                                      |
| Oregon                    | 2,300                             | 3,500      | 5,500      | 6,100       | 17,400             | 74,800               | 4                                      |
| Pennsylvania              | 1,600                             | 5,400      | 6,400      | 4,300       | 17,700             | 83,900               | 15                                     |
| Rhode Island <sup>4</sup> | —                                 | —          | —          | —           | 2,800              | 13,900               | —                                      |
| South Carolina            | 1,500                             | 1,900      | 2,000      | 2,100       | 7,500              | 21,800               | 7                                      |
| South Dakota              | 400                               | 2,400      | 3,700      | 2,600       | 9,100              | 25,000               | 5                                      |
| Tennessee                 | 1,200                             | 2,400      | 2,400      | 1,900       | 7,900              | 34,000               | 6                                      |
| Texas                     | 11,000                            | 13,700     | 15,200     | 12,200      | 51,900             | 195,000              | 10                                     |
| Utah <sup>4</sup>         | —                                 | —          | —          | —           | 17,600             | 56,000               | 2                                      |
| Vermont                   | 300                               | 900        | 1,300      | 800         | 3,300              | 10,400               | 4                                      |

See footnotes at end of table.

TABLE 5—Continued  
**CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS  
 IN THE UNITED STATES IN 1993, BY STATE AND QUARTER<sup>1</sup>**

| State              | Quantity<br>(thousand short tons) |            |            |             |                    | Value<br>(thousands) | Number<br>of<br>companies <sup>3</sup> |
|--------------------|-----------------------------------|------------|------------|-------------|--------------------|----------------------|----------------------------------------|
|                    | 1st quarter                       | 2d quarter | 3d quarter | 4th quarter | Total <sup>2</sup> |                      |                                        |
| Virginia           | 1,900                             | 2,900      | 2,900      | 2,200       | 9,900              | \$40,500             | 7                                      |
| Washington         | 8,900                             | 12,600     | 12,100     | 10,700      | 44,300             | 158,000              | 10                                     |
| West Virginia      | 200                               | 500        | 500        | 300         | 1,500              | 6,700                | 4                                      |
| Wisconsin          | 3,000                             | 8,100      | 10,000     | 9,300       | 30,400             | 82,800               | 13                                     |
| Wyoming            | 600                               | 1,200      | 1,200      | 800         | 3,800              | 15,000               | 3                                      |
| Total              | XX                                | XX         | XX         | XX          | 957,600            | 3,530,100            | XX                                     |
| Total <sup>4</sup> | XX                                | XX         | XX         | XX          | 868,700            | 3,530,100            | XX                                     |

XX Not applicable.

<sup>1</sup>As revised from data published in the "Crushed Stone and Sand and Gravel in the Fourth Quarter of 1993 Mineral Industry Survey."

<sup>2</sup>Data may not add to totals shown because of independent rounding and differences between projected totals by States.

<sup>3</sup>Number of companies reporting for the quarterly survey.

<sup>4</sup>Due to a low number of reporting companies, no production estimates by quarters were generated.

<sup>5</sup>One metric ton is equal to 1,000 kilograms or 2,204.62 pounds. To convert short tons to metric tons, multiply short tons by 0.907185.

<sup>6</sup>Total shown in thousand metric tons and thousand dollars.

TABLE 6  
**U.S. EXPORTS OF CONSTRUCTION SAND  
 AND GRAVEL IN 1993, BY COUNTRY**

(Thousand metric tons and thousand dollars)

| Country or territory   | Sand             |                              | Gravel           |                              |
|------------------------|------------------|------------------------------|------------------|------------------------------|
|                        | Quantity         | F.a.s.<br>value <sup>1</sup> | Quantity         | F.a.s.<br>value <sup>1</sup> |
| <b>North America:</b>  |                  |                              |                  |                              |
| Bahamas, The           | 3                | 46                           | 1                | 9                            |
| British Virgin Islands | ( <sup>2</sup> ) | 12                           | 3                | 39                           |
| Canada                 | 366              | 2,955                        | 473              | 2,181                        |
| Guadeloupe             | —                | —                            | 4                | 54                           |
| Mexico                 | 172              | 1,979                        | 19               | 1,749                        |
| Netherlands Antilles   | ( <sup>2</sup> ) | 12                           | 1                | 12                           |
| Other <sup>3</sup>     | 5                | 213                          | 15               | 279                          |
| Total <sup>4</sup>     | 545              | 5,218                        | 516              | 4,325                        |
| <b>South America:</b>  |                  |                              |                  |                              |
| Argentina              | 8                | 953                          | ( <sup>2</sup> ) | 3                            |
| Chile                  | 1                | 93                           | —                | —                            |
| Peru                   | 1                | 71                           | —                | —                            |
| Venezuela              | 7                | 1,412                        | ( <sup>2</sup> ) | 10                           |
| Other                  | ( <sup>2</sup> ) | 71                           | ( <sup>2</sup> ) | 12                           |
| Total <sup>4</sup>     | 16               | 2,601                        | ( <sup>2</sup> ) | 24                           |
| <b>Europe:</b>         |                  |                              |                  |                              |
| Belgium                | 5                | 467                          | ( <sup>2</sup> ) | 6                            |
| Germany                | 3                | 231                          | ( <sup>2</sup> ) | 32                           |
| United Kingdom         | ( <sup>2</sup> ) | 64                           | 1                | 59                           |
| Other <sup>3</sup>     | 3                | 500                          | 1                | 27                           |
| Total <sup>4</sup>     | 12               | 1,261                        | 2                | 124                          |

See footnotes at end of table.

TABLE 6—Continued  
**U.S. EXPORTS OF CONSTRUCTION SAND  
AND GRAVEL IN 1993, BY COUNTRY**

(Thousand metric tons and thousand dollars)

| Country or territory             | Sand             |                              | Gravel                |                              |
|----------------------------------|------------------|------------------------------|-----------------------|------------------------------|
|                                  | Quantity         | F.a.s.<br>value <sup>1</sup> | Quantity              | F.a.s.<br>value <sup>1</sup> |
| <b>Asia:</b>                     |                  |                              |                       |                              |
| Japan                            | 1                | 432                          | 5                     | 270                          |
| Hong Kong                        | 1                | 31                           | ( <sup>2</sup> )      | 8                            |
| Singapore                        | 1                | 208                          | —                     | —                            |
| Taiwan                           | 2                | 87                           | 10                    | 119                          |
| Other <sup>3</sup>               | 1                | 272                          | ( <sup>2</sup> )      | 17                           |
| <b>Total<sup>4</sup></b>         | <b>7</b>         | <b>1,030</b>                 | <b>15</b>             | <b>413</b>                   |
| <b>Oceania:</b>                  |                  |                              |                       |                              |
| Australia                        | 1                | 38                           | ( <sup>2</sup> )      | 34                           |
| Other                            | ( <sup>2</sup> ) | 7                            | ( <sup>2</sup> )      | 22                           |
| <b>Total<sup>4</sup></b>         | <b>1</b>         | <b>41</b>                    | <b>(<sup>2</sup>)</b> | <b>56</b>                    |
| <b>Middle East:</b>              |                  |                              |                       |                              |
| United Arab Emirates             | 5                | 137                          | ( <sup>2</sup> )      | 23                           |
| Other                            | —                | —                            | ( <sup>2</sup> )      | 29                           |
| <b>Total<sup>4</sup></b>         | <b>5</b>         | <b>137</b>                   | <b>1</b>              | <b>53</b>                    |
| <b>Africa:</b>                   |                  |                              |                       |                              |
| British Indian Ocean             | 7                | 95                           | —                     | —                            |
| St. Helena                       | 2                | 132                          | —                     | —                            |
| Other                            | ( <sup>2</sup> ) | 81                           | —                     | —                            |
| <b>Total<sup>4</sup></b>         | <b>10</b>        | <b>307</b>                   | <b>—</b>              | <b>—</b>                     |
| <b>Grand total<sup>4</sup></b>   | <b>597</b>       | <b>10,599</b>                | <b>534</b>            | <b>4,995</b>                 |
| <b>Grand total<sup>7</sup> *</b> | <b>658</b>       | <b>10,599</b>                | <b>589</b>            | <b>4,995</b>                 |

<sup>1</sup>Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.

<sup>2</sup>Less than 1/2 unit.

<sup>3</sup>Includes Antigua and Barbuda, Martinique, Montserrat, Panama, Trinidad and Tobago, Turks and Caicos Islands, and others.

<sup>4</sup>Data may not add to totals shown because of independent rounding.

<sup>5</sup>Includes Ireland, Italy, Sweden, and others.

<sup>6</sup>Includes China, Indonesia, Thailand, and others.

<sup>7</sup>One short ton is equal to 907 kilograms or 2,000 pounds. To convert metric tons to short tons, divide metric tons by 0.907185.

\*Total shown in thousand short tons and thousand dollars.

Source: Bureau of the Census.

**TABLE 7**  
**U.S. IMPORTS FOR CONSUMPTION OF**  
**CONSTRUCTION SAND AND GRAVEL, BY COUNTRY**

(Thousand metric tons and thousand dollars)

| Country or territory   | 1992             |                           | 1993     |                           |
|------------------------|------------------|---------------------------|----------|---------------------------|
|                        | Quantity         | C.i.f. value <sup>1</sup> | Quantity | C.i.f. value <sup>1</sup> |
| Antigua and Barbuda    | 43               | 912                       | 39       | 455                       |
| Australia              | 13               | 909                       | 12       | 852                       |
| Bahamas, The           | 196              | 411                       | 197      | 549                       |
| Barbados               | 26               | 223                       | 8        | 72                        |
| British Virgin Islands | 3                | 93                        | 2        | 55                        |
| Canada                 | 940              | 7,018                     | 962      | 7,608                     |
| Dominica               | 6                | 59                        | 9        | 71                        |
| Germany                | 3                | 2,174                     | 3        | 2,144                     |
| Japan                  | 17               | 818                       | 38       | 888                       |
| Mexico                 | 41               | 1,038                     | 8        | 592                       |
| Netherlands Antilles   | 4                | 35                        | 5        | 58                        |
| Norway                 | 5                | 299                       | 4        | 201                       |
| Sweden                 | ( <sup>2</sup> ) | 52                        | 1        | 147                       |
| United Kingdom         | 2                | 485                       | 1        | 546                       |
| Other <sup>3</sup>     | 13               | 939                       | 28       | 1,206                     |
| Total <sup>4</sup>     | 1,311            | 15,463                    | 1,316    | 15,445                    |
| Total <sup>5 6</sup>   | 1,445            | 15,463                    | 1,451    | 15,445                    |

<sup>1</sup>Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.

<sup>2</sup>Less than 1/2 unit.

<sup>3</sup>Includes Austria, Bangladesh, Belgium, Brazil, China, Denmark, France, Hong Kong, India, Indonesia, Israel, Italy, Luxembourg, Malaysia, Mali, Papua New Guinea, the Philippines, Singapore, Tanzania, the former U.S.S.R., and the United Arab Emirates.

<sup>4</sup>Data may not add to totals shown because of independent rounding.

<sup>5</sup>One short ton is equal to 907 kilograms or 2,000 pounds. To convert metric tons to short tons, divide metric tons by 0.907185.

<sup>6</sup>Total shown in thousand short tons and thousand dollars.

Source: Bureau of the Census.

**FIGURE 1**  
**PRODUCTION OF CONSTRUCTION SAND AND GRAVEL IN THE**  
**UNITED STATES IN 1993, BY GEOGRAPHIC REGION**

(Million metric tons)

