



# Statistics-based Safety

## Part 2: An analysis of the sand and gravel operator injuries occurring during a 10-year span provides insight into improving worker safety.

**T**he goal of aggregates producing companies across the United States is to ensure their workers go home safely each day. At the National Institute for Occupational Safety and Health (NIOSH), researchers are pursuing this vision of safety and health through a fact-finding approach for reducing injury/illness in various mineral sectors. Surveillance data from Mine Safety and Health Administration (MSHA) has been the primary source for such analyses. It helps to focus research efforts on key machinery, workers, and their tasks. The second installment of this two-part series follows last month's focus on crushed stone.

### Data analysis protocol

In 2003, MSHA reports that 7,070 mines produced sand and gravel, representing 49.1 percent of all mining operations. There were 35,966 employees, contributing 12.6 percent of all mine operator employee hours. During that year, there were 10 work-related fatalities and 846 non-fatal, lost-time injuries resulting in 39,843 days lost from work. To analyze the data further, the 10-year period from 1994 to 2003 was selected. Average annual production during the 10-year period was used where feasible for determining the rate for the category under consideration. When production data was not available for a specific category, mean employee-hours data was used for determining the rate. Production-based rates were adjusted for 100 million tons production of sand and gravel. Employee-hours based rates were adjusted for 10 million employee hours.

Surface and dredge work locations were considered. Fatal injuries were assessed by the number of fatalities during the 10-year period. In the case of non-fatal injuries, non-fatal days lost (NFDL) data was used for the assessment. Each of these injury categories was further analyzed in terms of the accident/illness/injury classification and worker activity at the time of injury. The later was analyzed further for identification of top subcategories.

In a recent report to the National Stone, Sand & Gravel Association, MSHA created a broader category — maintenance,

repair, and construction (MRC) — comprising: machine maintenance and repair, non-powered hand tools, surface construction NEC, welding and cutting elect/acetyl, powered hand tools, moving equipment (fans/pumps etc.), grinding bits/steel/welds, electrical maintenance/repair, operate hoist, working with chemicals, and working with noxious materials. This composite category was also assessed for fatal and non-fatal injuries and equipment responsible for those injuries.

During the 10-year period, average annual production of sand and gravel was 1.036 billion metric tons, and the corresponding mean employee hours for the two work locations was 63.974 million.

### Fatalities

There were 96 fatalities in the sand and gravel sector during the 10-year period. The fatality rates based on production and employee hours were 0.93 and 1.5, respectively. Employee-hours based rate better reflects the exposure to risk for workers involved in the operations. Out of the 96 fatalities, 73 were in surface and 23 in dredge locations, as shown in Figure 1. Clearly, surface operations need most emphasis in fatalities prevention.

Further analysis showed surface fatalities were attributed to powered haulage, machinery, and slip/fall of person from an elevation. Dredge location fatalities were classified as: slip/fall of person from an elevation, powered haulage, electrical, and machinery. The distribution of these classifications for each location is shown in Figure 2.

### Economic Impact

The aggregates industry comprising of the sand and gravel and crushed stone sectors is a significant contributor to the Gross Domestic Product of the United States and is a major source of employment and income to the nation. In 2003, the industry generated \$14.63 billion in sales, of which \$5.81 billion was the contribution from the sand and gravel sector.

# Sand & Gravel Fatalities

1994-2003

Overall, for all the 96 cases, major accident classifications were: powered haulage, machinery, slip/fall of person from an elevation, and electrical. Interventions developed for tasks in one location may be adapted for similar tasks in the other location.

Worker activities associated with the surface fatalities, as shown in Figure 3, were: machine maintenance/repair, operating front-end loader, operating haulage truck, welding/cutting, and the rest spread widely in 23 other categories. Major activities in the dredge location fatalities were the following: operating barge/boat/dredge, machine maintenance/repair, and handling materials/supplies. Sixteen of the 23 dredge fatalities were drowning accidents.

There were 29 fatalities in the maintenance, repair, and construction category, and all were equipment related. As shown in Figure 4, front-end loader, hand tools (not powered), ore haulage trucks, welding machine, conveyor (all types), and crane/derrick were involved in 16 cases.

Employee-hours based fatality rates for the surface and dredge locations were 1.34 and 2.41 respectively. The rate for dredge location was about 80 percent higher than the rate for the surface location. If one were to compare surface location fatality rates for sand and gravel and crushed stone, the rates were similar and the sand and gravel rate was slightly higher by 12.6 percent.

## Non-fatalities

During the 10-year period, there were 9,902 non-fatal injuries in the sand and gravel segment. Of these, 8,247 were in the surface work location, and the remaining 1,655 were in the dredge location as shown in Figure 5.

Surface location non-fatal injuries were classified as: handling material (2,698), slip/fall of person from an elevation (2,149), hand tools (1,028), powered haulage (1,017), machinery (817), and rest were dispersed among 13 other categories. Dredge non-fatal injuries were classified as: handling material (602), slip/fall of person from an elevation (447), hand tools (190), machinery (174), powered haulage (132), and the rest were attributed to nine other categories. These distributions are shown in Figure 6.

In terms of worker activity at the time injury (Figure 7), surface non-fatalities showed the following key activities: machine maintenance/repair (1,893), handling supplies/material (1,360), get on/off equipment/machines (985), non-powered hand tools (714), walking/running (595), hand load/hand shoveling/mucking (328), operating front-end loader (295), and the rest stemmed from 65 other activities. In the case of dredge non-fatalities, key activities were as follows: handling supplies/material (388), machine maintenance/repair (323), get on/off equipment/machines (164), walking/running

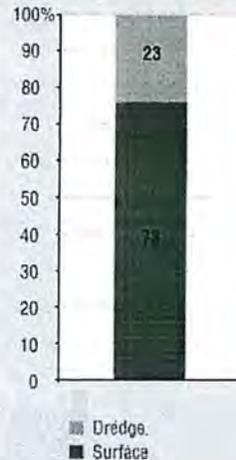


Figure 1: Distribution of sand and gravel fatalities in two work locations.

## Equipment Responsible for Injury within Maintenance, Repair, and Construction

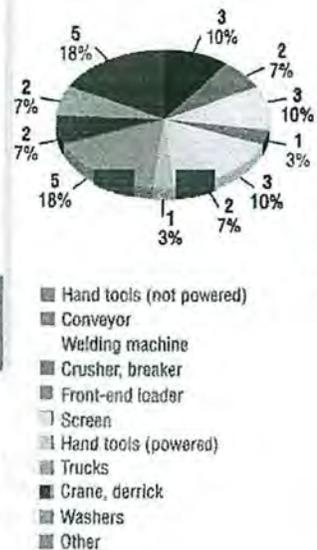


Figure 4: Distribution of equipment-related MRC fatalities.

## Accident/Illness/Injury Classifications

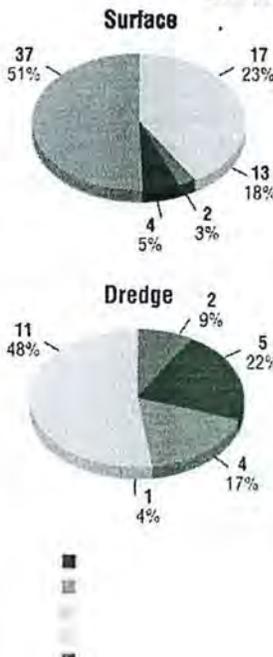


Figure 2: Distribution of sand and gravel fatalities within each work location.

## Mine Worker Activity at Time of Injury

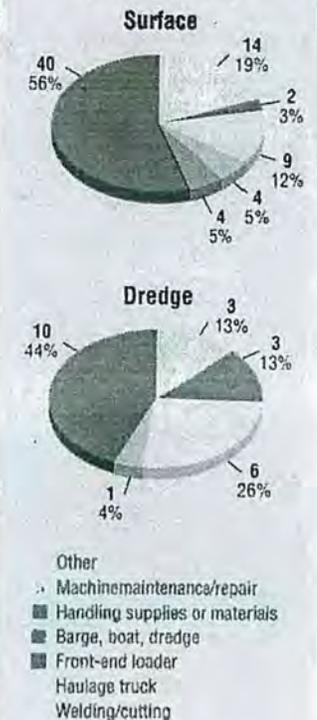


Figure 3: Distribution of fatalities according to worker activities for each work location.

## The primary safety focus should be on surface operations.

(147), non-powered hand tools (131), welding/cutting (66), moving equipment (49), and the rest were fragmented among 46 other activities.

In the maintenance, repair, and construction category (Figure 8), during the 10-year period, there were 3,838 non-fatal injuries. The breakdown for the two work locations was 3,219 at surface locations and 619 at dredge

sites. Equipment-related injuries totaled 2,935. Key equipment involved were non-powered hand tools, all types of conveyors, welding machine, crusher/breaker/mills, front-end loader/tractor-shovel, screen, and powered hand tools accounting for 78 percent of the injuries, with the remaining divided among 38 other types of equipment.

### Fatality prevention

For prevention of fatalities in sand and gravel operations, primary emphasis should be on surface locations with emphasis on analysis of tasks associated with powered haulage, machinery, and slips/fall of a person from an elevation. In dredge locations, taking steps to prevent drowning accidents with emphasis on slips/falls, powered haulage, and electrical-related tasks should lead to a major reduction in fatalities. Worker activities associated with machine maintenance/repair, operating front-end loaders, operating haulage trucks, and welding/cutting for surface locations, as well as operating barge/boat/dredge, machine maintenance/repair, and materials/supplies handling for dredge locations, should be top priority in effective safety programs. In the MRC category, prevention focus should be on tasks involving haulage trucks, front-end loaders, welding machines, and non-powered hand tools to be extended later to others such as conveyors, washers, and crane/derrick.

For non-fatalities prevention, the main focus should be on surface locations. Task analysis of handling of materials, slips/falls, hand tools, powered haulage, and machinery should be performed at both work locations. Efforts for significant injury prevention should target worker activities involving machine maintenance/repair, handling supplies/materials, getting on/off machinery/equipment, non-powered hand tools, and walking/running. In the MRC category, focus should be on tasks involving hand tools of all types, conveyors, welding machines, crusher/breakers, front-end loaders, and screens.

Ensuring emphasis on the above areas, and with proper training and application of best practices, the aggregates industry can continue to improve its safety record for protecting its employees. **AW**

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**Author note:** The findings and conclusions in this paper are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

# Sand & Gravel Non-Fatal Days Lost Injuries

1994-2003

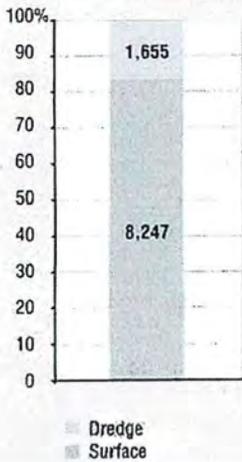


Figure 5: Contribution of the surface and dredge locations to non-fatal injuries.

## Equipment Responsible for Injury within Maintenance, Repair, and Construction for NFDLs

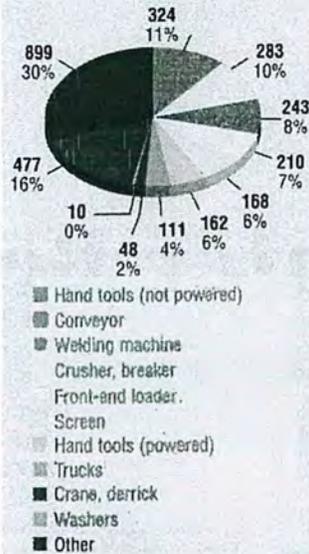


Figure 8: Distribution of equipment-related non-fatal injuries according to the type of equipment involved.

## Accident/Illness/Injury Classifications for NFDLs

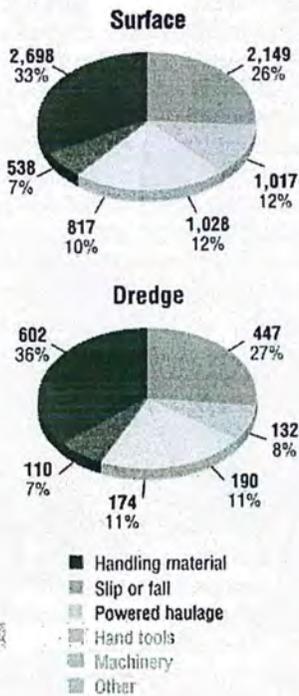


Figure 6: Distribution of non-fatal injury classifications for the two work locations.

## Mine Worker Activity at Time of Injury for NFDLs

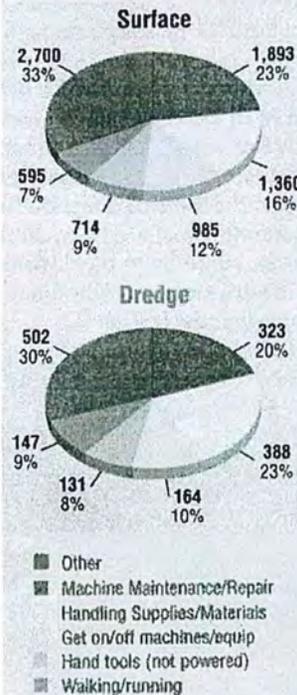


Figure 7: Distribution of non-fatal injuries for the two work locations according to worker activity at the time of injury.