Statistics-based Safety

Part 1: An analysis of the crushed stone injuries occurring during a 10-year span provides insight into improving safety.

by Vijia K. Karra, Ph.D.

Making sure workers within the aggregates industry go home safely each day is the goal of aggregate companies throughout the United States. At the National Institute for Occupational Safety and Health (NIOSH) researchers are contributing to NIOSH's vision of safety and health through a fact-finding approach to reducing injuries/illnesses in various mineral sectors. Surveillance data from the 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 crushed stone category referred to in this article is represented as crushed and broken stone in the MSHA database.

Crushed Stone Fatalities
1994-2003

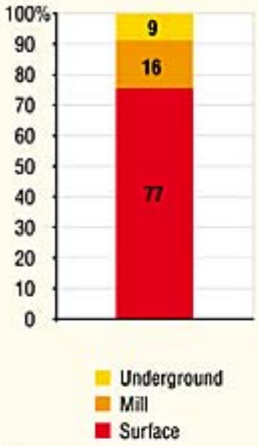
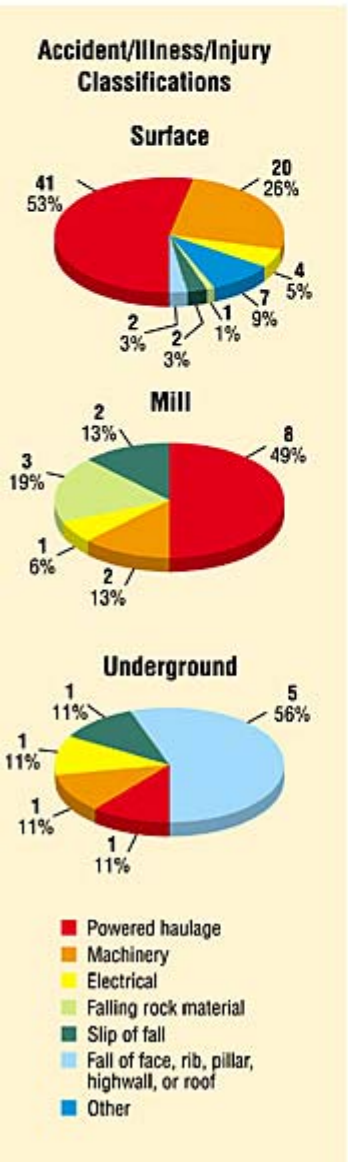
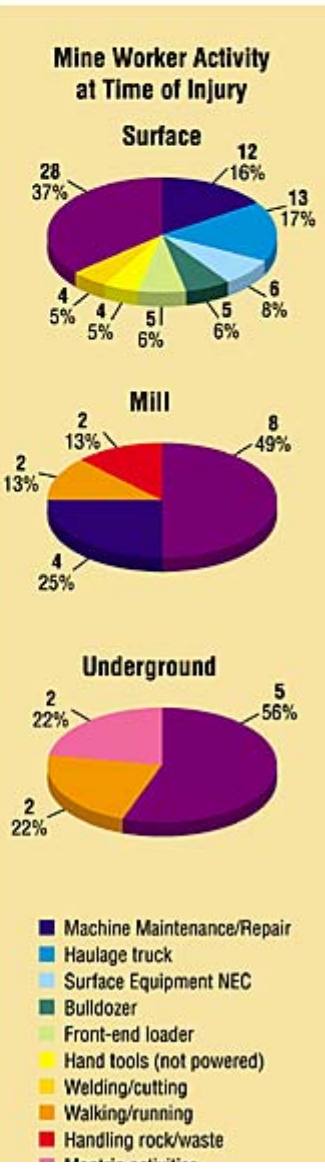


Figure 1:
Distribution of crushed stone fatalities in the three work locations.

Figure 4:
Distribution of equipment-related MRC fatalities.





Data analysis protocol

In 2003, MSHA reports that 3,412 mines produced crushed stone, representing 23.7 percent of all mining operations. Crushed stone included limestone, granite, traprock, sandstone, slate, marble, and stone NEC (not elsewhere classified). There were 46,991 employees, comprising 22.2 percent of all mine operator employee hours. There were seven work-related fatalities and 1,443 non-fatal lost-time injuries resulting in 65,441 days lost from work. For further analysis of data, a 10-year period from 1994 to 2003 was selected.

Average annual production during this 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, data for mean employee hours was used for determining the rate. Production-based rates were adjusted for 100 million tons production of crushed stone. Employee-hour based rates were adjusted for 10 million employee hours.

Surface, mill, and underground 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 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 (not elsewhere classified), 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 crushed stone was 1.443 billion metric tons, representing 93.2 percent of all stone production, and the corresponding mean employee hours for all the three work locations were 104.446 million.

Fatalities

There were 104 fatalities in the crushed stone segment during the 10-year period. The fatality rate based on average production was 0.72, while the fatality rate based on mean employee hours was 1.00. The employee-hour based rate better reflects the exposure to risk for workers involved in the operations. Out of the 104 fatalities, 102 accounted for the three work locations: surface (77), mill (16), and underground (9), as shown in Figure 1. Clearly, surface operations need the most emphasis for fatality prevention.

Further analysis showed surface location fatalities were attributed to powered haulage, machinery, and electrical tasks. Mill location fatalities were attributed to: powered haulage, falling/rolling/sliding rock/material, machinery, slip/fall of person from an elevation, and electrical tasks. Five of the underground fatalities were attributed to in-place fall of face/rib/pillar/side/highwall and fall of roof/back/brow. These classifications are shown in Figure 2.

Within the surface location, powered haulage and machinery tasks demand more prevention emphasis. Interventions developed for powered haulage fatalities prevention in the surface location may be

adapted for similar tasks in the mill location.

In surface location, worker activities associated with the fatalities were: haulage truck, machine maintenance/repair, surface equipment NEC, bulldozer, front-end loader, hand tools, and welding/cutting. For mill location, the activities were the following: machinery maintenance/repair, walking/running, and handling rock/waste. For underground location, the activities in four of the nine fatalities were walking/running and mantrip. Distribution of fatalities for the three work locations in terms of worker activities is shown in Figure 3.

These details are interesting, but for focused prevention efforts, it is valuable to know the accident classification of majority of the 104 cases. Fatalities were classified as powered haulage (50), machinery (25), and electrical (6).

Activities that led to 50 percent of these 104 cases included the following: machinery maintenance/repair (17), haulage truck (13), front-end loader (6), surface equipment NEC (6), bulldozer (5), and walking/running (5).

There were 31 fatalities in the maintenance repair and construction category, and 26 of those were related to equipment. Their distribution is shown in Figure 4. Crane/derrick, crusher/breaker/mills, and conveyor were involved in 13 of the equipment-related fatalities.

Analysis of the employee-hour based fatality rates for the worker locations showed that the rate for the underground (2.85) was 89 percent higher than the rate for the surface (1.51). The fatality rate for the surface location was 4.6 times the rate for the mill location (0.33).

Crushed Stone Non-Fatal Days Lost Injuries
1994-2003

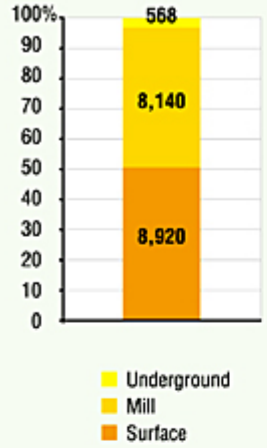


Figure 5:
Contribution of the surface, mill, and underground work locations to non-fatalities.

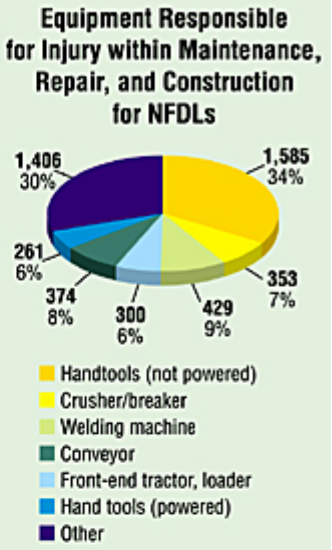
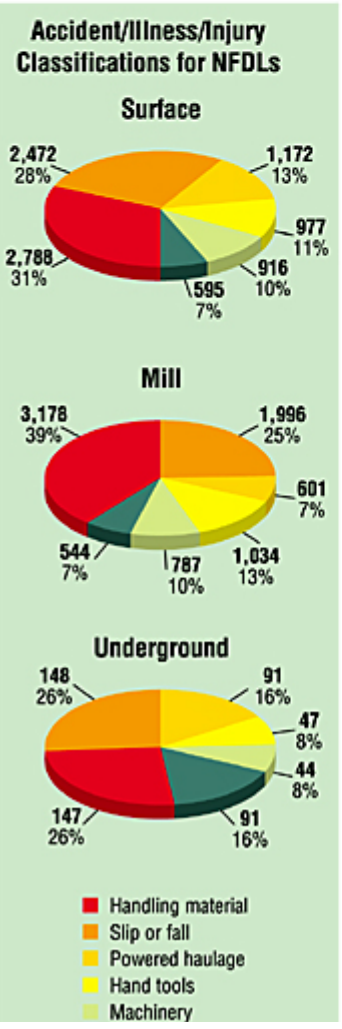
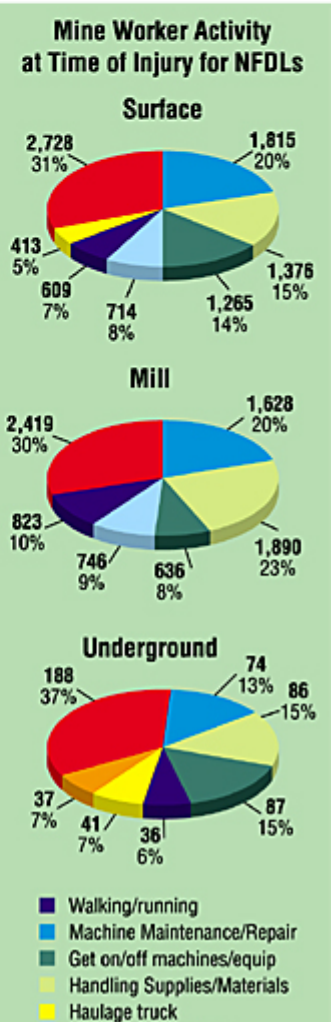


Figure 8:
Distribution of the equipment-related injuries according to the type of equipment involved.





Non-fatalities

During the 10-year period, there were 17,978 non-fatalities (NFDL) in the crushed stone segment. The corresponding production based rate was 124.59. The rate based on mean employee-hours was 172.13. The employee-hour based rate better reflects the exposure to risk for workers involved in the operations.

In crushed stone, the three work locations — surface, mill, and underground — accounted respectively for 8,920, 8,140, and 568 of the non-fatal injuries representing 17,628 of the total 17,978 injuries. The share of non-fatalities among the three locations is shown in Figure 5.

Surface location non-fatal injuries were attributed to the following: handling material (2,788), slip/fall of person from an elevation (2,472), powered haulage (1,172), hand tools (977), and machinery (916), with the remaining injuries dispersed among 14 other causes.

Mill non-fatal injuries were attributed to: handling material (3,178), slip/fall of person from an elevation (1,996), hand tools (1,034), machinery (787), and powered haulage (601), with the remaining injuries attributed to 13 other causes.

Underground non-fatal injuries were attributed to: slip/fall of person from an elevation (148), handling material (147), powered haulage (91), hand tools (47), and machinery (44), with the remaining injuries distributed among 10 other causes. These distributions are shown in Figure 6.

Key worker activities leading to surface non-fatal injuries were: machine maintenance/repair (1,815), handling supplies/material (1,376), get on/off equipment/machines (1,265), non-powered hand tools (714), walking/running (609), and haulage truck (413), with the remaining injuries stemming from 74 other activities.

For the mill location, key activities leading to non-fatal injuries included the following: handling supplies/material (1,890), machine maintenance/repair (1,628), walking/running (821), non-powered hand tools (746), get on/off equipment/machines (636), and hand load/hand shoveling/mucking (293), with the remaining injuries fragmented among 68 other activities.

For the underground location, key activities involved were as follows: get on/off equipment/machines (87), handling supplies/material (86), machine maintenance/repair (74), bar down face/rib/side (43), haulage truck (41), handling explosives (37), and walking/running (36), with the remaining injuries divided into 37 other activities.

Key work activities contributing to non-fatal injuries for the three work locations are shown in Figure 7.

Of the 17,978 non-fatal injuries, 6,445 fell into the maintenance/repair/construction category. Of these 6,445 injuries, 4,708 injuries involved equipment. Key equipment such as non-powered hand tools, welding machines, conveyors, crusher/breaker/mills, front-end loader/tractor-shovels, and powered hand tools accounted for 3,302 injuries, while the remainder involved 46 other types of equipment. Figure 8 shows distribution of the 4,708 injuries according to the equipment responsible for the injuries.

Conclusions

For prevention of fatalities in crushed stone operations, primary focus should be on the surface and mill locations and on the analysis of powered haulage and machinery-related tasks. Worker activities associated with machinery maintenance, haulage trucks, front-end loaders, dozers, and other surface

equipment should be a top priority in effective safety programs. In the MRC category, focus should be on tasks involving crane/derrick, crusher/breaker/mills, conveyors, and front-end loader/tractor-shovel.

For non-fatalities prevention, the main focus should again be on the surface and mill locations and on the analysis of handling of material, slip/fall of person from an elevation, and tasks involving hand tools, powered haulage, and machinery. Key activities for improving safety should include machine maintenance/repair, handling supplies/material, getting on/off equipment/machines, non-powered hand tools, walking/running, and hand load/shoveling/mucking. In the MRC category, focus should be on tasks involving hand tools of all types, welding machine, all types of conveyors, crusher/breaker/mills, and front-end loader/tractor-shovel.

Through emphasis on the above areas, proper training, and application of best work practices, the aggregates industry can continue to improve its safety record and to protect its employees.

Since 2003, Vijia K. Karra, Ph.D., is the chief of the Mining Injury Prevention Branch at the National Institute for Occupational Safety and Health's Pittsburgh Research Laboratory. Previously, he was vice president for technology and business development at Metso Minerals.

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.

Economic Impact

The aggregates industry is important to the economic health of the United States and constitutes a major source of employment and income nationally and in the producing states. It produces major and essential inputs to many other industries across the breadth of the economy. It makes a significant contribution to gross domestic product. In 2005, the U.S. Geological Survey estimates that output of the aggregates industry totaled $17.4 billion. The crushed stone sector generated $10.2 billion in total sales.