tion, these results underscore the need for better traffic control management in construction work areas to reduce pedestrian fatalities. As the second leading cause of traumatic death in construction, with an annual average share of 15% of the total deaths, exceeded only by falls, prevention of work- related motor vehicle research should become a greater priority in the construction industry.

Category: Engineering and Protective Technology

Near Fatal Events—Momentary Lapses in Reason?—Stobbe TJ, Cormier W, Monteressi C

Every day people die in the workplace. Many of the deaths occur when highly experienced people who knew better, select actions that put them at high risk of serious injury or death. The question is WHY? Are they careless? Ignorant? Risk takers? Indifferent? This paper discusses the why by summarizing the results of 134 structured interviews of workers who had been involved in incidents that could have been fatal for them.

The purpose of the project was to understand why these incidents occurred so that intervention strategies could be developed. The interviewees were experienced coal miners at underground and surface coal mines. One or more of the authors conducted the interviews, and they lasted one to one and one-half hours. The interviews were conducted at the worksite. The focus of the interviews was to understand both what happened during the incidents, and the interviewee's role in the incident. Once these were understood, the interviews focus shifted to trying to understand WHY what happened happened—both in the global incident, and in the actual actions of the interviewee. We were particularly interested in the interviewee's actions and the judgements that led to the actions and outcomes.

The results show that the data fell into six categories. The categorie were: following orders, conscious choice, making assumptions about the state of the world, did not know the risk, were "unconscious" at the time of the incident, and deliberate risk taking. Each of these categories suggests a different combination of intervention strategies. For example, when a worker is following a supervisor's orders when they make unsafe behavior choices, it is primarily a management problem which may be addressable through supervisor training—or it may take a complete change in corporate philosophy about the comparative importance of safety and production. In comparison, a worker who does not know about a risk may need to be educated about the hazards and risks that exist in his/her workplace with classic cognitive training methods.

The paper discusses each of the six behavior categories, gives examples of each, and discusses ways in which the "safety" problems associated with each category may be addressed. It also discusses an intervention project that is being developed to address some of the categories.

An Ergonomic Audit of a Mississippi River Revetment Process—Chervak SG

An ergonomics team from the U.S. Army Center for Health Promotion and Preventive Medicine performed an assessment of a Mississippi River revetment operation.

Revetment is the process used to reinforce riverbanks with concrete plates to combat erosion. The task is unique, but the ergonomic risk factors involved are fairly typical.

The ergonomics team identified specific ergonomic hazards that can contribute to cumulative trauma disorders, resulting in decreased productivity, increased errors, lost work time, and increased costs. Tasks at the revetment operation included facilitating the removal of concrete slabs from a storage barge, aligning the slabs onto the roller barge, straightening the slabs as needed, and tying together the concrete slabs using a pneumatic tying tool. The risk factors identified included awkward postures, forceful exertions, mechanical stresses, and repetitive motions. Recommendations to reduce the risk of suffering a cumulative trauma disorder injury included modifying the tying tool to minimize poor back postures and to eliminate the amount of repetition, reducing force required to operate the tool, and eliminating mechanical stresses. The ergonomics team also recommended that the operation be examined to determine if certain jobs in the process can be eliminated and that employees be educated in the proper use of the tying tool.

Development of a Data Collection System for a Pen-based Computer—Ching CR

To facilitate the recording of survey information, an ergonomics team from the U.S. Army Center for Health Promotion and Preventive Medicine developed a data collection system for use with a pen-based computer.

The team had to evaluate video display terminal workstations at U.S. Army installations in Belgium and determine compliance with Belgian Royal Decree. In addition to the Decree, the team used International Standards Organization and European Community standards to research evaluation criteria. The survey involved three pen-based computers, each running the same software program. The team wrote a data collection program with the interface designed to take advantage of pen-based computer features. Five evaluators received training in the use of the pen-based computers. Evaluators entered information, such as features of the individual workstation and environment, and recorded potentially damaging postures. The multilingual system gave immediate feedback and "quick-fix" recommendations for each workstation. The team evaluated 340 workstations within a 15-day period with each survey lasting approximately 10 minutes. The team downloaded survey results from each pen-based computer to create one large data base for analysis. The data collection system was efficient and easy to use. The team will modify or customize the program for other applications.

Hazards Associated with Roof Drilling and Bolt Installation in Underground Coal Mines—Unger RL, Cornelius KM, Turin FC

Roof drilling and bolt installation in underground coal mines is labor intensive, repetitive, and exposes operators to many hazards which can result in accidents, both acute and cumulative in nature. One concern of mine safety officials is the number accidents occurring where the roof bolter operator is crushed by the powerful hydraulic drill boom. Another concern is the rising number of injuries due to cumulative trauma. A NIOSH team of researchers examined these problems with several goals in mind. The first was to identify the root causes of the acute trauma accidents and develop effective solutions that could be implemented promptly. The second goal was to examine the cumulative trauma exposure of roof bolter operators and develop recommendations aimed at reducing the risk of developing injuries. Finally, the team developed materials to educate the mining industry on human factors engineering principles with the intention of improving the design of roof bolting machines.

The following steps were taken to investigate traumatic crushing injuries: interviewed roof bolter operators, analyzed video tapes of roof bolting operations, discussed issues with roof bolter manufacturers, analyzed mine accident data, and reviewed past research on roof bolter safety. The team determined that the goal of any intervention should focus on reducing the probability of a control being accidentally activated and reducing the chances of roof bolter operators placing themselves in hazardous positions around the machine. To achieve that goal, the team developed a list of solutions based on their analysis of the information collected. Some of the recommended solutions include the use of an operator-in-position interlock device, fixed barriers at pinch points, improved control guarding, and reduction in speed of the fast feed. Many of these ideas have already been implemented.

In response to cumulative trauma exposure concerns, members of the project team conducted a study at an underground coal mine to examine roof bolter tasks that performed over time could put the operator at risk. For this study, three primary forms of data were collected and analyzed. Researchers analyzed 43 lost time incident descriptions, conducted a series of interviews with roof bolter operators, and observed operators performing roof bolting tasks. Common roof bolting activities were examined and issues identified as putting operators at risk of injury were discussed. Recommendations were developed which address the three elements which define a system: human, equipment, and environment. The recommendations can be used to increase worker awareness of risk factors, modify job procedures, improve existing equipment, and provide guidelines for future equipment design.

Efforts to educate the mining industry have included the development of seminars on human factors design geared toward design engineers and mine safety personnel, the construction of mockups that demonstrate human factors principles, and the publication of a world-wide-web page devoted to human factors design issues associated with mobile underground mining equipment.

Safety Considerations for Transport of Ore and Waste in Underground Ore Passes—Stewart BM, Beus MJ, Iverson SR, Moreland MW

Researchers at the Spokane Research Center of the National Institute for Occupational Safety and Health are investigating methods to improve safety during transport of ore in underground mines and to prevent injuries and fatalities to miners around ore passes. Five fatalities in the last three years were directly related to ore hang-ups resulting in ore pass structural failure and ore chute blowout. Mine Safety and Health Administration (MSHA) accident statistics have identified ore pass hazards. Mine accident data has shown that injuries and fatalities have resulted during ore pass chute and gate operations. Nearly 75% of the accidents related to pulling or freeing ore pass chutes are caused by the use of hand tools and falls of broken rock. Recent ore pass failures have underlined the need for improved designs, standards, structural monitoring methods, and improved hang up prevention/removal techniques. A fault tree analysis identified five leading causes of ore pass failure. Ore pass transport practices and problems at past and present operating mines are discussed.

Design criteria and hang up prevention and remediation strategies include effects of static and dynamic ore and waste rock loads on chutes, walls, gates, and support structures. Particle flow analysis methods were used to simulate the response of various ore pass designs to a wide range of ore loading conditions. A full-scale and 1/3 scale mock-up of ore pass and chute assemblies currently installed were duplicated and tested for load response. Data from the particle flow code, and the mock-ups are compared. Instrumentation and load measurements of an active ore pass will be conducted after the mock-up tests are completed. Development of safer ore pass design and ore handling proceedures are the goals of the project.

Graphical Analysis of Energy Expenditure—Belard J-L, Dotson B, Wassell JT, Long D, Wojciechowski W

Waste abatement workers, due to the nature of their job, require a high level of protection and must therefore commonly wear personal protective equipment such as a self-contained breathing apparatus (SCBA) and encapsulating suits. Wearing this type of personal protective equipment while working adds a weight burden, impedes heat exchange and can lead to physiological strain and increased energy expenditure. This strain and increased energy expenditure can in turn lead to exhaustion in a period of time much shorter than would be experienced without this equipment. The goal of this study was to analyze the energy expenditure of hazardous waste abatement workers while performing tasks common to their jobs.
Nine asbestos workers aged 27 to 40 performed six typical hazardous waste abatement tasks in a laboratory setting. Subjects carried an SCBA and wore a Mine Safety Appliances Company (MSA) BlueMaxTM totally encapsulating suit. This level of protection is designated "Level A" and is utilized by workers who require the ultimate possible protection during waste site cleaning operations. Although all subjects were in a safe laboratory environment, they were required to wear this complete protection in order to approximate work site energy expenditures. However, since no activity in a toxic environment was involved, subjects were allowed to keep the garment open and the SCBA disconnected. All tests were conducted in a neutral environment (20°Centigrade, 60% relative humidity). Heart rate, respiratory frequency, and oxygen consumption were measured every 30 seconds during the performance of the various activities.

Six different tasks were selected for simulation through an agreement with hazardous waste abatement union experts. The activities simulated typical tasks performed daily on hazardous waste sites. These typical tasks included: walking from one place to another, carrying equipment, decontamination of soiled surfaces, shoveling toxic dirt into drums, digging to uncover barrels, and crawling in confined spaces. These tasks were simulated with the following activities: walking on a treadmill at 1.5 miles an hour, carrying a 20-pound bucket at the same speed, mopping the floor at 60 strokes per minute, shoveling sand from ground level into a drum, digging at ten shovels per minute, and crawling on the treadmill at 0.3 miles an hour. In all, each tested activity lasted ten minutes, including a