Analysis of Back Injuries in Construction

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Abstract: It has been found that back injuries represent one of the largest segments of worker injuries in the U.S. Only the common cold accounts for more lost work days. It impacts not only the health of individuals, it is also a huge economic burden to the industry due to medical cost, benefits, lost productivity, and absenteeism. However, the complexity and its cumulative nature make this injury difficult to understand, much less to propose preventive steps based on scientific analyses. This paper provides an overview of regulations and prevention methods used today. The major part of the paper presents a detailed discussion of possible causes of back injuries in construction. Statistical data from insurance companies, the Construction Safety Association of Ontario, and a national survey is used to pinpoint critical tasks and motions, as well as common catalysts of this type of injury. In addition, sectors of the industry that indicate a higher occurrence of injuries involving the back are being identified. Based on these findings, a technological approach to the problem of back injuries seems to be the only viable process to improve the situation. It is felt that, due to the special characteristics of this industry, a concentrated and industry-specific effort is needed to reduce the hazards and risks of injuring the human spine.

INTRODUCTION

After an investigation of back injuries caused by manual handling in construction, Stubbs and Nicholson (1979) concluded that "73% of back injuries were specifically linked to these same (lifting/loading and lifting/carrying) activities." Tasks that require these handling motions are most needed in everyday work on the traditional stick built–oriented construction sites of today. Such tasks include the lifting of cement bags, manual hoisting of mortar and bricks onto scaffolds, manual transportation of lumber for carpentry work, manual assembly of scaffolds and concrete formwork as well as common digging, which requires the lifting of a full shovel.

Despite the fact that the International Labour Organization proposed to limit the loads to be lifted and carried by humans to 53 lb (235.7 N) (for men between the ages of 20 and 35) and to 32 lb (142.3 N) for women, the weight of a common bag of cement is 94 lb (418 N), and a roll of roofing paper weighs 60–80 lb (267–356 N)(Oglesby et al. 1989).

There are two basic approaches to improving safety: (1) Prevention through regulations, education, work redesign, and so forth; and (2) technology-based modifications of unsafe operations. Although safety may be the final goal of work improvements using new technologies, such achievements have many times been accompanied by increases in productivity and quality (e.g., tunneling). Recently, automation and robotics has been identified as an emerging technology capable of providing opportunities for improving the safety of construction workers. Although economic incentives for applying high-technology are primarily considered in the literature, many authors have also mentioned safety-related issues, such as main drivers for auto-

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mating and robotizing dangerous tasks in the future (Bernold 1987; Kangari and Halpin 1989; Warszawski 1984). Safety problems in construction are generally related to the exposure to unhealthy and dangerous conditions presented by the presence of dust, gases, or fumes. However, the magnitude of the issue of back injuries in construction demands that this safety problem receives special attention. Unfortunately, too little is known about these work-related injuries.

This paper presents the results of an investigation related to the identification and analysis of construction processes with a high risk for causing back injuries. This investigation was motivated by the alarming number of these kinds of injuries in the construction industry, and the opportunities offered by high technology to abolish this unfortunate situation. The paper will discuss existing rules and regulations, as well as causes and effects pertaining to back injuries in construction.

BACKGROUND

According to Lahey (1988), the percentage of back and trunk injuries in construction amounted to 24% of all recorded construction injuries in 1986, an increase of 4% since 1979 (Klein et al. 1984). Pizatella et al. (1988), in a report by the National Institute of Occupational Safety and Health (NIOSH), showed that musculoskeletal injuries to the trunk account for approximately 32% of all compensable injuries and 42% of worker compensation costs in the U.S. The same report also states that mining and construction have the highest rates of compensation claims for back injuries, averaging more than 1.5 claims per 100 workers annually. Webster et al. (1990) informed that, based on 98,999 claims within 45 states of the U.S., the mean cost for indemnity, medical, and expense payments for back injuries in 1986 was $6,807. The same study also showed that differences in benefit levels, coverage, and waiting periods resulted in large cost variations among individual states. "For example, the mean cost per case in Louisiana was more than 10 times greater than the mean cost per case in Indiana" (Webster et al. 1990). In addition, the study also pointed out that the cost trend for these types of accidents was rising at a faster rate than other types of compensable injuries. The analysis was based on cases handled by Liberty Mutual Worker's Compensation.

The most recent data provided by Consolidated Administrators, Inc., which insures the North Carolina Home Builders and the Associated General Contractors (AGC) of North and South Carolina, are presented in Table 1. In 1986, the average claims cost in South Carolina was approximately 55% higher than in North Carolina. Both states, however, were well below average in per case cost in 1986, which was $6,807 (Webster et al. 1990). This situation is basically the same for the construction companies

TABLE 1. Cost Trends of Back Injuries

State (1)	AGC 7/1/90 to 5/31/91 Total claims (%) (2)	AGC 7/1/90 to 5/31/91 Cost per case (3)	Home Builders 1990 Total claims (%) (4)	Home Builders 1990 Cost per case (5)	Liberty Mutual 1986 Cost per case (6)
North Carolina	15	$8,647	32	$13,769	$2,896
South Carolina	22	$15,659	—	—	$4,948

included in the AGC study during the 1990–1991 time frame. The data also indicates that residential construction, represented by the North Carolina Homebuilders Association, might have a larger share of this type of accident than other parts of the construction industry. As will be shown in the latter part of this paper, other statistics support this observation.

Niskanen et al. (1989) presented the results of a more detailed investigation on the causes of back injuries in construction. He found that of 442 accident reports involving materials handling in one large construction company in Finland, 28% involved injuries to the back. Of the materials-handling accidents, 64% occurred during manual lifting and carrying. These findings correspond with Stubbs and Nicholson (1979), mentioned earlier, who also reported a strong correlation between lifting/carrying and back-related accidents.

Lifting is one of the most common motions performed in all areas of construction, on all levels of a project. The material, tools, and equipment handled are generally getting heavier (not necessarily bigger), and new types of heavy support material (e.g., formwork elements) are being rapidly introduced to the industry. However, the methods and technology used for lifting and transporting were not modified at the same time. The development of remedies has been left to the initiative of companies or individuals. It was hoped that economic pressure caused by the escalating costs of accidents would encourage such developments. As stated by Oglesby et al. (1989), "it should be obvious that to date, contractors and those who design structures or equipment or supply materials for construction are oblivious to or have not taken seriously back-injury problems. Given its cost and possible liability implications for suppliers as well as contractors, this situation may well change." Unfortunately, such an approach does not consider personal sufferings as well as the cost to the economy in lost manpower. Especially for the construction industry, which faces an increasing gap between the number of skilled workers available and the number of skilled workers needed for the building needs of tomorrow, the prospect of losing more and more workers due to back injuries is unsettling.

PRESENT STANDARDS AND REGULATIONS

The International Labour Organization (ILO) (*Maximum* 1967) proposed that the highest permissible weight to be carried manually by one adult male worker should be 55 lb (245 N). Previously ("Manual" 1962), ILO published recommendations regarding acceptable weight levels based on gender and age. These two publications represent some of the earliest general guidelines on the subject of back injuries worldwide.

In the U.S., to date, no federal regulations exist related to the prevention of back injuries. Yet, an abundance of written material is available on the subject of safe lifting, which has been strongly related to back injuries. As an example, NIOSH published the technical report *Work Practices Guide for Manual Lifting* (*Work* 1981). The guideline includes a quantitative representation of maximum permissible and acceptable lifting conditions that are based on the combined effect of the weight and moment arm created by the horizontal distance between the spine and the load. A graphical representation of the guideline shows two hyperbolic lines relating the horizontal moment arm of a load (x axis) with its weight (y axis). Using this graph, sectors for three levels of lifting are defined: unacceptable, acceptable only with special guidance or training, and acceptable. By using this guide-

line, provisions for lifting conditions, such as the height of the pickup location, can be made in a quantitative assessment of the safety.

Although back injuries have been identified as a very costly and painful problem of the construction industry, regulations in the U.S. are not addressing this health hazard sufficiently. Although many experts, such as Ayoub (1982) or Helander (1981), have tried to analyze the basic problem, much is still unknown about this subject. Thus, recommendations for prevention are generally based on the basic principles of safe lifting.

PRESENT PREVENTION SCHEMES

In 1988, NIOSH proposed a series of steps for reducing back injuries (Pizatella et al. 1988). They consisted of: (1) Improving health and hazard surveillance systems; (2) use of a multilevel data base; (3) study of cause and effects by many scientific disciplines; (4) redesign of jobs and tools; (5) training of workers to use techniques that do not stress the musculoskeletal system; and (6) preemployment screening. This report again stresses the magnitude of this health problem using quantitative measures. It also emphasizes the value of training, job redesign, and screening as important means to reduce back injuries in the work place.

Traditionally, prevention schemes rely on: (1) Guidelines and manuals related to safe lifting (*Work* 1981); (2) education and training; and (3) screening of workers. Although ergonomics has been found to be potentially very fruitful, it is only recently getting strong support (Stubbs 1986; Lawrence 1990). The goal of ergonomics is to redesign existing workplaces, jobs, and equipment to fit the worker; thus, it is also called the science of fitting the job to the worker, rather than the worker to the job. Most recently, OSHA suggested the implementation of engineering, as well as administrative controls. According to Lawrence (1991), "Engineering controls can directly involve redesigning the work station, adapting equipment, and minimizing awkward movement. Through the use of engineering controls, one attempts to ergonomically redesign a job to fit the worker so tasks such as lifting or bending become less hazardous." One of the key items of the engineering control scheme is the "installation of mechanical aids such as pneumatic lifts, conveyors, and/or automated handling equipment" ("Back" 1989). The administrative controls, on the other hand, focus on training, education about the mechanics of the body, and promotion of fitness on the job. Thus, it represents the more traditional approach to prevention.

The literature is full of concepts on how to prevent back injuries in general, and in construction specifically. An example of an illustrated and construction-oriented manual on safe procedures for lifting has been published by the Construction Safety Association of Ontario (*Stand* 1986). Using graphical presentations, it promotes exercise programs and work techniques for different tasks with do and do nots in a concise format.

Despite the surge of schemes and concepts surfacing in the recent literature, deep knowledge and understanding of the problem is only very limited, especially in construction (Stubbs 1986). As a result, more data collection and studies are proposed to better analyze the phenomenon (Pizzatella et al. 1988). Until such efforts are underway, guidelines will continue to be based on proposing qualitative and general rules on safe lifting, such as the one published by the United Food and Commercial Workers International Union (*Lifting* 1989).

The remainder of this paper will be devoted to the presentation of a more detailed discussion of back injuries in construction. The main sources for

the analysis are: (1) The literature; (2) a detailed data base established by the Construction Safety Association of Ontario, Canada; (3) personal interviews with safety experts familiar with construction; and (4) a national survey conducted by the writers in the fall of 1990.

MANUAL HANDLING: THE MAIN CULPRIT

As discussed earlier, several authors have stressed manual handling as a main cause of back injuries in construction. For example, Nicholson (1985) compared the telecommunications, electrical, and construction industries in the U.K. based on data about accidents that resulted in an absence from work for more than three days, which can be considered a serious accident. The available data covered the period between 1977 and 1981. The statistical data showed that the construction industry had the highest rate of handling accidents, with 14.0 per 1,000 persons at risk to have a severe accident during the period of a year. The critical importance of material handling within the industry was emphasized based on a comparison with other causes. In fact, manual handling of goods and items was the major cause (35.3%) of all back injuries. The second and third places were taken by falls (23%) and use of machinery (10.5%), respectively. The author (Nicholson 1985) also states that: "Analyses of back injures by age supports the suggestion that back injuries commonly arise as the result of an accumulation of minor damage over several years but that acute trauma can occur in early years in tasks demanding heavy manual input." Although Nicholson (1985) was able to identify manual handling as the main cause of back injuries in construction, other authors question the level of detail used by Nicholson "to provide the information to show the incidence and causation of given injuries so that appropriate steps can be taken" (Stubbs 1986). In the same article, Stubbs (1986) emphasized: "Whilst much scientific literature has been devoted to lifting, it is emphasized that manual handling should have a much broader definition to include all force applications of the body to external objects whether transmitted via the hand or other parts of the body e.g. the shoulder. Pushing, pulling, carrying, supporting loads and lowering loads should all be included." Again, it is acknowledged that equally as important as the weight of the static load are other attributes of the lifting operation. They include factors such as duration, frequency, and dynamics of the motion.

Niskanen and Lauttalamni (1989) have since presented the results of a more detailed investigation of back injuries related to materials handling, based on its decomposition into more defined tasks. They include: (1) Transporting; (2) lifting and carrying at the construction site; (3) assembly of formwork; and (4) stripping of formwork. They reported that, in the observed five-year period, the lifting/transporting of building boards, doors, windows, timber, and of bags/sacks were the most hazardous activities. In addition, they concluded that manual lifting and manual carrying were equally important, while other motions (such as pulling and pushing) were less hazardous.

Although researchers in the area of back injuries in construction emphasize the importance of a more detailed and systematic approach to the problem, they also generally recognize that it is very difficult to identify causes because of the possible cumulative effects of contributing motions preceding the actual injury. Furthermore, the complex relationships between the physiological and the psychological elements of the work and the human spine make it very difficult to establish clear cause and effect rela-

tionships. Despite these difficulties, it is imperative, at least at present, to pursue efforts that will help evaluate back injuries based on an even more detailed list of criteria. This would enable us to pinpoint critical construction tasks, trades, and even industry segments.

MOST EXPOSED SECTIONS AND TRADES

During the past four years, the Construction Safety Association of Ontario, Canada, has collected data throughout Ontario on lost time due to back injuries for a set of different criteria: injuries by construction sectors and construction trades. Fig. 1 presents a four-year comparison of the nine most important construction sectors.

As shown, low-rise residential building construction has constantly shown the largest share of back injuries during the last four years, averaging about 22%. Commercial building construction, which averaged about 5–6%, showed a major increase in 1990 when it reached 10.6%. However, according to the provided statistics, residential construction is by far the most critical sector of the industry.

Other statistics provided by the Construction Safety Association of Ontario show that in 1990 24.1% of the injured persons were general laborers, 12.4% were carpenters and wood workers, followed by electricians with 4.7%. Thus, it can be surmised that most of the accidents affecting the back happened in traditionally small construction companies working as general contractors in the residential low-rise building sector of the industry.

Although the data were collected in Ontario, the similarities in work practice and organization of the industry suggest that the presented distributions should be comparable to the U.S.

CRITICAL MOTIONS AND TASKS

To gain a better understanding of relationships between work motions, work conditions, and their hazard level as it pertains to back injuries, a

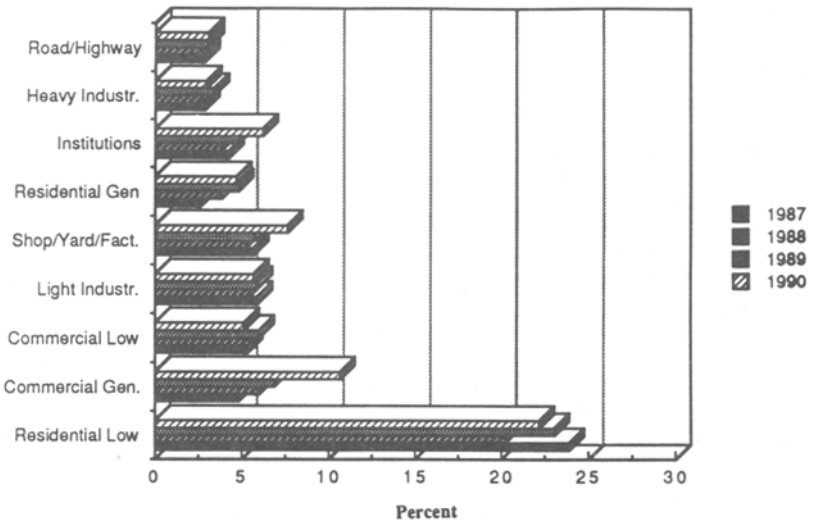

FIG. 1. Distribution of Back Injuries by Construction Sectors in Ontario, Canada

national survey of safety engineers was conducted by the writers of this paper. For this purpose, a questionnaire was developed with the help of several construction-safety experts working in the Washington, D.C. area (see Acknowledgments section). The core of the questionnaire was a matrix, presented in Fig. 2, that integrated motions with materials or equipment to be handled. Seven hundred safety engineers in the U.S. construction industry were asked to prioritize the criticality of each identified task-motion combination. Further sections of the questionnaire were related to other issues, such as the catalysts of such accidents. In the following section, the results of this survey will be presented. The data are based on the 35 questionnaires (5%) that were returned.

As indicated earlier, one of the objective of the U.S. survey conducted by the writers was to identify the most critical motions leading to back injuries. Fig. 3 presents the first set of data. It is important to realize that the data generated by the U.S. survey is based on the perceptions of safety experts and is not based on actual facts. However, it will be demonstrated later that they correlate closely with data collected in Ontario.

The black bars shown in Fig. 3 represent the number of responses for each of the listed motions measured in percent of the total amount of responses. The dashed bars indicate the weighted responses. The weights were calculated based on each respondents' account of the criticality of that particular motion or task for the type of work the represented company specialized in.

As depicted in Fig. 3, simple lifting was rated as the most hazardous

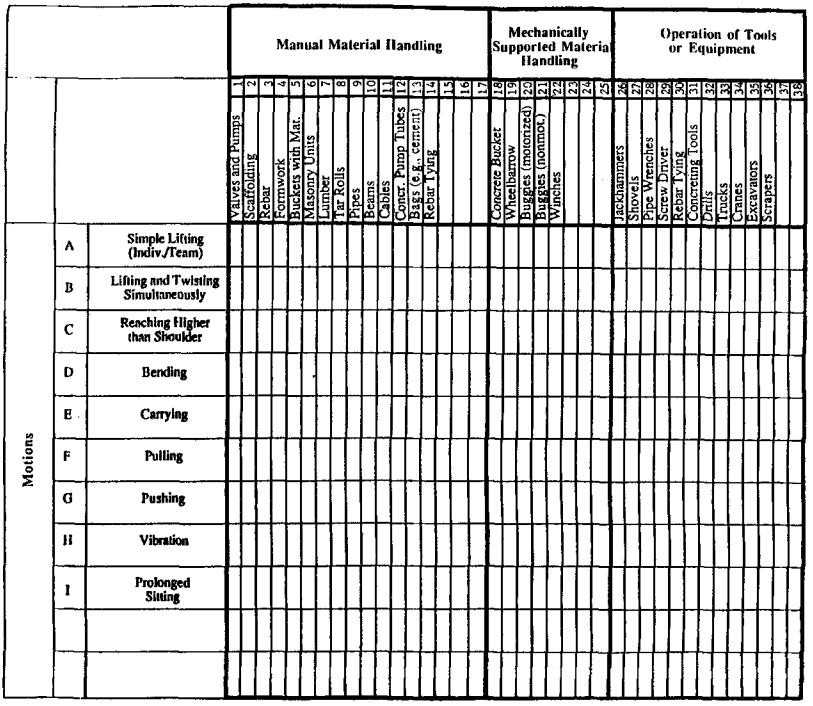

FIG. 2. Task-Motion Matrix for Back Injury Identification

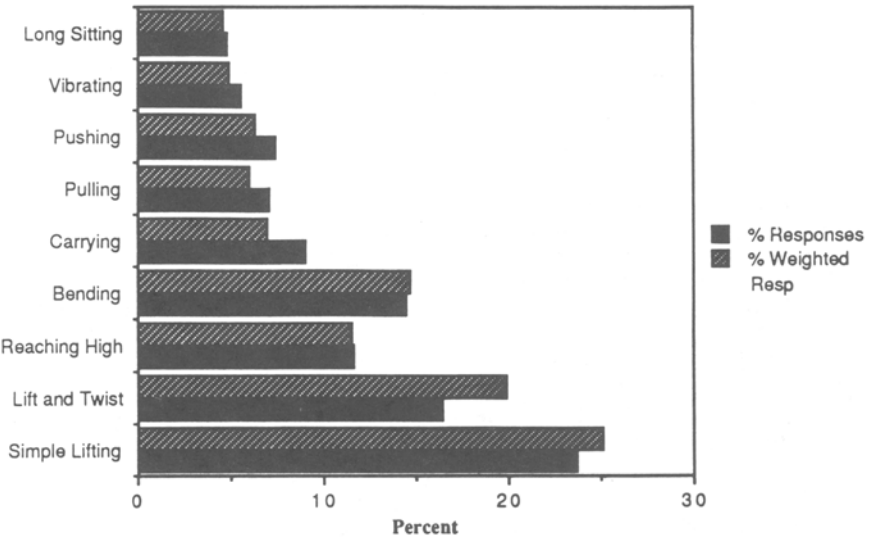

FIG. 3. Distribution of Back Injuries with Respect to Motions Based on U.S. Survey

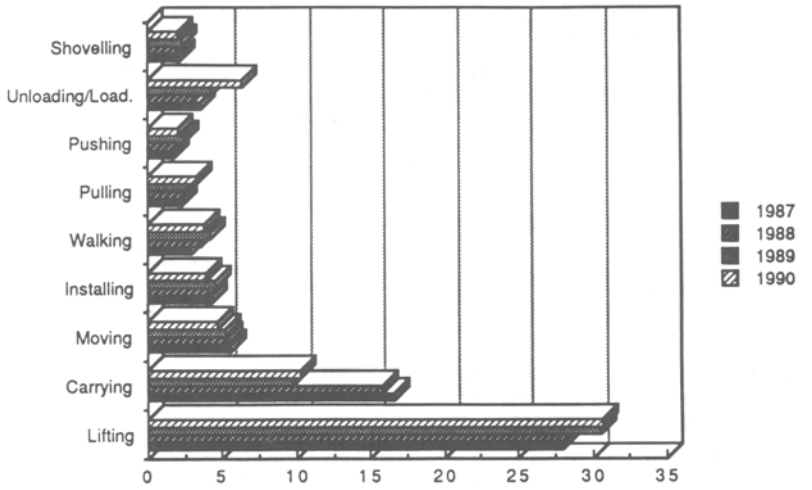

FIG. 4. Distribution of Back Injuries in Respect to Motions in Ontario, Canada

motion by 23.7% of the respondents, followed by lifting and twisting (16.4%), bending (14.5%), and reaching higher than the shoulder (11.6%). The importance of the first three motions was reemphasized by the fact that the respondents also gave them high criticality marks. This means that these particular motions are performed most often by the workers of the represented companies. Interestingly, the data representing the situation in Ontario shows a similar distribution. Fig. 4 shows the nine statistically most

important motions and tasks listed in the Ontario yearly summaries for the last four years.

According to the data generated in Ontario, lifting (which is not further qualified) is the leading cause of back injuries in Ontario. Carrying diminished in importance over the last four years (with 10%, compared to second place in 1990), while lifting increased from 28% in 1987 to almost 31% in 1990. Although some of the terms used in Fig. 3 and Fig. 4 to describe motions are different, the Ontario data supports the analysis of the responses given by the safety engineers in the U.S.

Consistent with other research reports mentioned earlier in this paper (Niskanen and Lauttalamni 1989), the data in Fig. 4 suggests that manual lifting in combination with other motions, such as twisting the body, can be singled out as a main cause for back injuries in construction. Still, the key issues of the cumulative effect of several critical factors related to the occurrence of a back injury and the role of working conditions have not been addressed. One condition that is particularly important is the type or shape of the handled material. The next section will provide a more detailed discussion of this condition.

CRITICAL MATERIAL-HANDLING OBJECTS

The injury of the skeleton is hardly ever caused by a motion alone, but rather by a combination of factors such as the weight of the object to be handled and the horizontal distance between the trunk and the center of gravity of the object, which results in a normal force and moment to be supported by the human body. In other words, the type, shape, size, and, most importantly, the weight of the handled objects have to be considered in the analysis of causes.

The questionnaire matrix used for the U.S. survey conducted by the writers (see Fig. 1) allowed the respondents to identify the materials and tools, or equipment, that they believe to be most responsible for the occurrence of back injuries. Fig. 5 presents a distribution of the eight most mentioned items.

Overall, concrete formwork was considered to be the most critical material causing back injuries, with an 11.7% weighted response rate. Rebar placement and the movement of concrete tubes, all related to concrete, were all rated high in this survey. These results represent a major difference in priorities between the data collected by the Construction Safety Association of Ontario and the U.S. survey. Because low-rise residential construction showed the highest incident rate in Ontario, materials such as lumber, masonry, and boards are identified more often than concrete or scaffolds as dangerous materials. In contrast, 45% of the contract value generated by the construction companies represented in the U.S. survey was in commercial construction, followed by highway construction with 24%, and industrial construction with 16%. It is, therefore, probable that the priority list of materials, tools, and equipment related to back-injury incidents differ based on sectors or specialties within the construction industry. One material might receive high priority in one sector, but might not be mentioned in another.

Although the attributes of the handled objects are closely related to the mechanics controlled by the laws of physics, other conditions can also serve as catalysts of an accident. One particular objective of the U.S. survey was to establish a better understanding of the importance of such conditions.

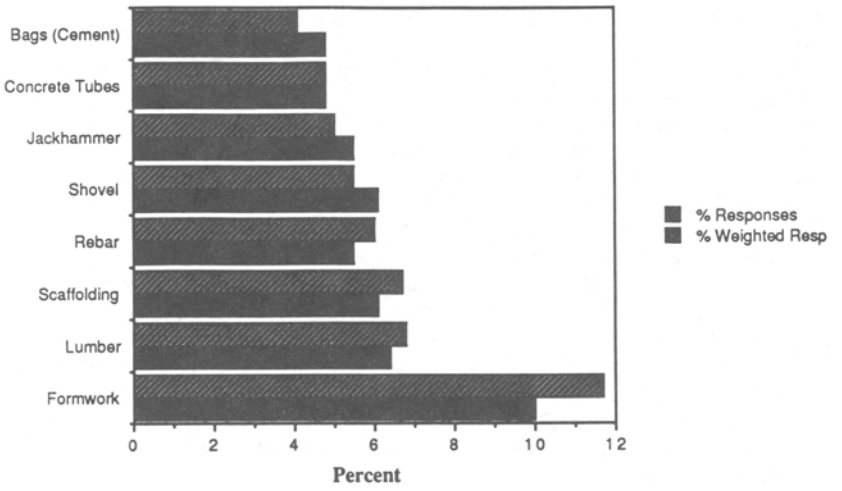

FIG. 5. Distribution of Most Dangerous Handled Objects Based on U.S. Survey

CATALYSTS OF BACK ACCIDENTS

The conditions and circumstances existing during, or prior to, an accident leading to a back injury could be called indirect causes or catalysts. For instance, although a direct cause might be lifting formwork, factors that contribute to the incident could include an unexpected higher weight, macho behavior of the laborer at the moment of the incident, and/or lack of body fitness. As an example, contractors in Ontario once used standard concrete forms 2 ft (0.61 m) wide and 4 ft (1.22 m) long. To improve productivity of setting the formwork, the width of the forms was extended by 1 ft (0.3 m). Thus, while the traditional forms weighed between 60 lb (267 N) and 80 lb (356 N), depending on the amount of concrete sticking to the form, the weight of the newer forms was now between 100 lb (445 N) and 130 lb (578 N). It seems only natural that if transportation of the heavier forms will be done traditionally, more back injuries, which can be related to the sharp increase in the weight of the forms, will occur.

The questionnaire sent to safety engineers in the U.S. included a list of major catalysts presented in Table 2. The list had originally been developed together with mainly Washington, D.C.–based construction-safety engineers (experts are listed in the Acknowledgments section). The respondents were asked to identify catalysts that increase the risk and severity of back injuries due to adverse conditions. Fig. 6 presents the overall distribution of the responses followed by a comparison with responses that were directly related to simple lifting, and lifting with twisting.

Overall, the respondents felt that the three most frequent adverse conditions were: (1) Lack of body fitness (identified by 12% of the respondents); (2) weight of material (identified by 11% of the respondents); and (3) bulkiness of material (identified by another 11% of the respondents). In a second tier, four more factors were highlighted: (4) Lack of lifting techniques (8%); (5) poor housekeeping (7%); (6) low safety awareness (7%); and (7) muscle tiredness (6%). It is important to recognize that lack of lifting aids or professional training were not considered very important. One would expect that the second-ranked condition (labeled weight of material) should

TABLE 2. Catalysts of Back Injuries

Code (1)	Catalyst (2)
	(*a*) Situational Catalysts
10	Temperature of the material
11	Weight of the material
12	Bulkiness of the material
13	Lack of handles
20	Confined work space
21	Poor housekeeping
22	Walking obstructions (stubs, cords)
23	Noise
24	Gases, fumes
25	Lack of lifting aids
26	Improper lighting
27	Improper use of ladders (e.g., too short)
30	Wind
31	Heat >85°F (30°C)
32	Cold <40°F (4.5°C)
33	Heat with high humidity
34	Rain
35	Frozen ground
40	Lack of company safety training policy
41	Low safety consciousness
42	Poor supervision
43	Hiring practices which don't consider health factors
44	Improper use of lifting techniques
	(*b*) Physical and Psychological Catalysts (of Worker)
50	Lack of body fitness
51	Poor health
52	Old age
53	Muscle tiredness
54	Influence of alcohol or drugs
60	Fear of losing the job
61	Macho behavior
62	Negative peer pressure
63	Anger
64	Personal distress
70	Lack of professional training
71	Inexperience in judgment of the weight of the material
72	Lack of communication capabilities
	(*c*) Frequency
80	Constant involvement in task-motion (more than 60% of time)

be accompanied by a high-ranked lack of lifting aids, another option on the list of potential catalysts shown in Table 2. Such a relationship, however, was not confirmed by the data.

To analyze the sensitivity of the catalysts for different motion, the responses for the two most mentioned hazardous motions were studied separately. The most drastic change was the higher response rate for lifting

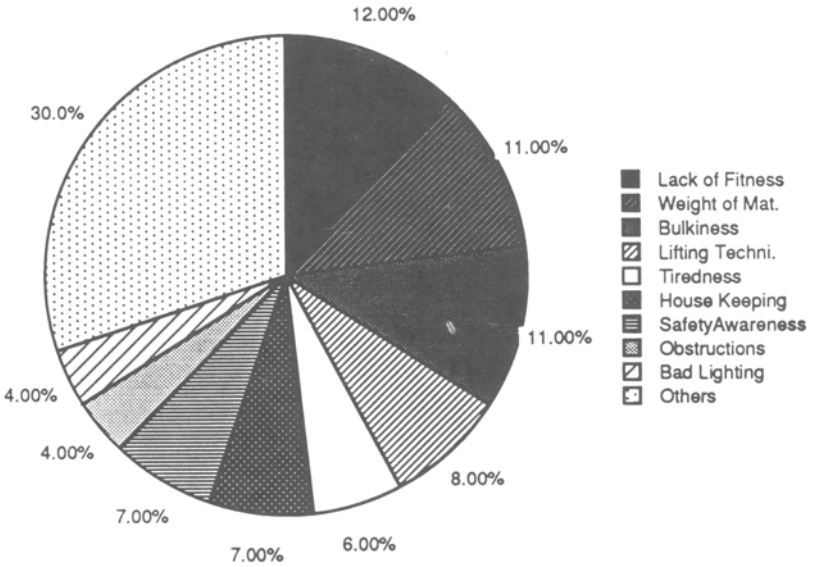

FIG. 6. Catalysts of Back Injuries Based on U.S. Survey

techniques, which jumped from an average of 5% to 13.2% for the motion simple lifting, and to 8.4% for lifting and twisting. The aspect of the frequency of task execution was downgraded for simple lifting, but was considered very important for lifting motions, which included twisting (e.g., shoveling). As expected, the weight of the material was found to have a higher than average adverse effect (15%) on the simple lifting motion. Higher than average responses were also assigned to the effect of macho behavior (5% for simple lifting) as a catalyst.

In summary, the respondent experts in the field of construction safety felt that the physiological conditions of the workers (i.e., lack of fitness) and the properties of the construction material (e.g., weight and bulkiness) are the critical catalysts causing back injuries in construction. Also rated high is the improper use of lifting techniques. Again, it must be stressed that the data from the U.S. survey is based on the combined experiences of 35 safety engineers, and is not the result of measured observations.

The impetus for the U.S. survey was the need for identifying critical areas for further research. In the final section of this paper, a concentrated and systematic effort to address this urgent issue scientifically and to develop methods to reduce or eliminate the risks of back injuries will be proposed.

AFFORDABLE LIFTING TECHNOLOGY AS POTENTIAL REMEDY

The data about the seriousness of the back-injury problem in construction and the apparent need of the industry to increase productivity sets the stage for conflicting goals. The increased scrutiny of construction practices by OSHA in the recent past has highlighted such conflicts. And, always in the background, lingers the problem of a shrinking work force exposed to the negative promotion of construction as a risky business.

Based on many interviews with safety engineers in construction (see Acknowledgments section), the industry has reacted to OSHA's new emphasis

on safety in construction by adding new positions in safety engineering. Thus, the already available knowledge about how to design work areas ergonomically and how to train the work force will eventually find its way into the industry. However, because of its special character, construction cannot rely on experiences gained in the manufacturing industry to solve its problems. For example, NIOSH's new recommendation to install mechanical material-handling devices to reduce manual lifting ("Back" 1989) is easily accomplished in a plant environment. On construction sites, however, the same undertaking provides a major challenge because of the constantly moving place of work and the complexity of assembly. Additionally, although the size and the weight of materials has generally increased over time, economical materials-handling devices capable of supporting the construction laborers are scarce. Moreover, although residential construction seems to be one of the key sectors where back-related accidents occur, it is the sector that can afford expensive hardware the least.

Despite the mentioned difficulties in developing new and affordable lifting technologies for construction, these technologies present the only real alternative to education and training. The elimination of the need to lift heavy material units or components (e.g., wall frames) would remove the motion identified by many research studies worldwide as being the most critical cause leading to back injuries, namely, simple lifting.

CONCLUSION

There is ample evidence that back injuries will continue to be a major problem in the workplace of tomorrow. Experts point out that too little is known about causes and effects, and too little is being done to reduce the risks for these types of accidents. Construction, due to its unique characteristics, requires a specialized effort if one intends to address the problem in a comprehensive manner.

Residential construction has the highest occurrence of back injuries in Ontario, Canada. Although residential construction in Canada includes more concrete work, the residential sector in the U.S. may have a similarly higher number of back injuries than other sectors of the construction industry. Several studies have identified simple lifting of common construction materials, such as lumber, bricks, formwork, and scaffolding, as a task that shows the highest risk of leading to a back injury. Experts in construction safety strongly believe that the major catalysts to back-related accidents are the poor fitness of workers as well as the weight and the bulkiness of the construction material of today. It is without question that the past and future trend of heavier construction elements must be accompanied by affordable aids for handling them as individual units (e.g., single beam) or as preassembled micromodules (e.g., windows). The writers believe that a concentrated effort in studying and developing innovative new technologies to reduce the need for lifting heavy material in construction would lead to a significant reduction of this workplace hazard. The resulting savings in the escalating treatment cost as well as the direct and indirect cost accrued by an accident is expected to far outweigh the cost of utilizing affordable lifting technologies.

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APPENDIX. REFERENCES

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