Journal of Construction in Developing Countries, Vol. 12, No. 1, 2007

The Unsafe Acts and the Decision-to-Err Factors of Thai Construction Workers

*Thanet Aksorn and B.H.W. Hadikusumo

Abstract: The unsafe acts of workers are considered as major contributors of work-related accidents and injuries on construction sites. However, not much work has been done to address the reasons why unsafe acts of workers occur particularly in construction industry. The aim of this paper therefore, is to investigate the major unsafe acts (i.e., at-risk behavior), and the decision-to-err factors causing unsafe acts. A questionnaire survey was conducted to collect data from a total of 214 workers from 20 building construction projects in Thailand. The findings revealed that the failure of workers to wear personal protective equipment (PPE), improper lifting or handling of materials, and keeping sharp objects in dangerous locations, are the major unsafe acts which frequently occur on construction sites in Thailand. In addition, the paper reported that the top three most frequent unsafe acts are statistically associated with several decision-to-err factors, including lack of management support, management pressure, group norms, overconfidence, being uncomfortable, past experience and laziness.

Keywords: Accident, Construction, Decision-to-err, Human factor, Safety, Unsafe behavior.

INTRODUCTION

In Thailand, many construction activities have been carried out to meet the high demands of the expansive market. However, the construction industry has faced a wide range of challenges, one of which is the high accident and injury rate at the project level. According to the accident rate in all industries recorded by Ministry of Labour (International Labour Organization, 2005), the rate of accidents and fatalities in Thai construction is reported as the highest. In 2003, the construction industry accounts for 14% of the total number of 787 deaths at work and 24% of the total 17 cases of permanent disability. Construction is a labor-intensive industry, in which workers play a very important role in the success of the various projects undertaken. Thus, the need to protect workers from accidents becomes a major consideration in any construction organization. For many years, safety practitioners have addressed physical preventive measures such as machine guarding, housekeeping and inspection, since poor physical conditions are believed to cause accidents. However, not

Construction Engineering and Infrastructure Management, School of Civil Engineering, Asian Institute of Technology, Pathumthani, THAILAND. *Corresponding author: artty_th@yahoo.com

much preventive work has been done on the human aspects. The fact that many researchers are of the opinion that unsafe acts of workers are the major contributors of accidents and injuries, rather than poor working conditions (e.g., Sawacha et al., 1999; Abdelhamid and Everett, 2000; Stranks, 2000; Haupt, 2001; Holt, 2001; Goetsch, 2005), suggests that there is the need for a change of direction in construction safety research to identify the possible influential factors of workers' decisions.

Theoretically, there are two types of unsafe acts, which can be classified as either errors or violations (Reason, 1990). In the most accident databases, the errors are major contributor to accidents. Violations, on the other hand, are less common. Unsafe acts of workers may occur in two conditions. First, a worker does not know while he/she is acting unsafely and second, he/she knows while he/she is acting unsafely. The first case can be easily tackled by providing safety education to the worker, close supervision, good work system design, etc. However, the second case is more complex because the reasons for acting unsafely could be due to different factors, such as the worker's personality, the nature of the job being undertaken, the extent of managerial support and workgroup influence. The second case is known as "the worker's decision-to-err", in which, though a worker is fully aware that he/she is working unsafely, he/she still decides to carry on with such unsafe acts. Therefore, knowing the causes behind the decisions to act unsafely can enable construction projects to develop the appropriate strategies to improve working practices of workers. This is the purpose for which this research was conducted.

OBJECTIVE OF THE STUDY

This research is designed to investigate the relationship between the decision-to-err factors and the unsafe acts. This relationship is important for management to study what unsafe acts could occur on the site, to find out what decision-to-err factors might contribute to these unsafe acts and to develop solutions which could reduce such unsafe acts.

UNSAFE ACTS

Generally, accidents at work occur either due to unsafe working conditions and unsafe worker acts. In construction, it is suggested that unsafe act is the most significant factor in the cause of site accident (Sawacha et al., 1999; Abdelhamid and Everett, 2000). There is no general agreement on definition of an unsafe act. However, it has been defined in similar focus on unaccepted practices which have the potential for producing future accidents and injuries. For example, Stranks (2000) gave the definition

of unsafe act as "…any act that deviates from generally recognized safe way of doing a job and increases the likelihood of an accident…". Several unsafe acts have been identified by many researchers such as Petersen (1984), Anton (1989), Stranks (1994), Simachokdee (1994), Michuad (1995), Abdelhamid and Everett (2000), and Holt (2001).

These unsafe acts are:

- Working without authority on the job can cause accidents since unauthorized workers may lack the necessary skills, or unfamiliar with the job process.
- Failure to warn or to secure members out of danger is considered as an unsafe act since many accidents occur because workers pay less attention to warning or securing co-workers who are working under conditions with high probability of accident occurrence.
- Working at improper speeds, exceeding the prescribed speed limits, or unsafe speed actions could cause accidents, e.g. workers who handle objects quickly could slip and be injured.
- Improper lifting, handling, or moving of objects may cause serious back pains, e.g. workers who manually lift heavy objects without proper force-saving equipment.
- Improper placing and stacking of objects and materials in dangerous locations can result in unpredicted accidents e.g. a worker could collide with such objects.
- Incorrect use of tools and equipment, hand tools, power tools, and machinery can also cause accidents. For instance, workers who frequently climb or stand on rebars instead of using a ladder could fall down.
- Using defective equipment and tools to work, e.g. a worker who uses a substandard ladder could fall and be injured.
- Annoyance and horseplay in the workplace such as young workers who play roughly around the workplace could encounter unexpected accidents.
- Ignoring to wear personal protective equipment (PPE) may increase chances of getting injured, e.g. workers without hardhats are more prone to getting head injuries from falling objects.

- Removing safety guards from the workplace or equipment could raise the chances of getting accidents, e.g. workers who remove guardrails could fall down.

- Smoking, creating naked flame or sparks in areas where flammable materials are stored could cause explosions.

- Leaving nails or other sharp objects protruding from timber may cause accidents as workers who do not wear safety shoes could step on these objects and be injured.

- Throwing or accidentally dropping objects from high levels could expose other workers to sustaining possible head injury.

- Working under the effects of alcohol and other drugs could increase workers' unawareness and cause serious accidents.

- Improper positioning of tasks can also result in accidents, e.g., workers on high levels could fall and be seriously injured.

- Improper posture for tasks such as workers taking shortcuts by climbing or jumping from high levels instead of using ladders could result in serious injury.

- Servicing equipment which is in operation, e.g. refueling a machine without first turning off the engine could cause a severe accident.

- Working with lack of concentration, such as workers talking while undertaking a job could cause distraction and result in an accident.

- Working in poor physical conditions such fatigue, stress, or drowsiness could also increase the likelihood of accidents.

Table 1. Identification of Unsafe Acts and Coding

Coding	List of Unsafe Acts
US-01	Working without authority on the job
US-02	Failure to warn or to secure members out of danger
US-03	Working at improper speeds, exceeding the prescribed speed limits, or unsafe speed actions
US-04	Improper lifting, handling, or moving of objects
US-05	Improper placing and stacking of objects and materials in dangerous locations
US-06	Incorrect use of tools and equipment, hand tools, power tools, and machinery
US-07	Using defective equipment and tools to work
US-08	Annoyance and horseplay in the workplace
US-09	Ignoring to wear personal protective equipment (PPE)
US-10	Removing safety guards from the workplace or equipment
US-11	Smoking creating naked flame or sparks in areas where flammable materials are stored
US-12	Leaving nails or other sharp objects protruding from timber
US-13	Throwing or accidentally dropping objects from high levels
US-14	Working under the effects of alcohol and other drugs
US-15	Improper positioning of tasks
US-16	Improper posture for tasks
US-17	Servicing equipment which is in operation
US-18	Working with lack of concentration
US-19	Working in poor physical conditions

DECISIONS-TO-ERR IN OCCUPATIONAL SAFETY

The decision-to-err can contribute to human errors which could subsequently lead to the occurrence of accidents (Wiegmann et al., 2005). On the other hand, human errors could stem from the decisions made by workers (LaDou, 1994). For instance, if a supervisor pressures a worker to increase the rate of production, the worker might choose an unsafe approach rather than a safe one in order to save time and get the job done as quickly as possible. Petersen (1984) proposed a causation model which explains that the decisions of workers to err are due to three main causes:

1. Logical decisions in different situations such as peer pressure, close supervision, management priorities, and personal value system.
2. Unconscious decisions-to-err, which includes proneness and mental problems.
3. Perceived low probability in which the workers believe that they will not have an accident. Decision-to-err factors were gathered from literature review and interview with 20 Thai construction workers. Twenty factors were identified and grouped under four categories: personal, job, management and workgroup (see Fig. 1). Table 2 shows the identification of decision-to-err factors and their codes.

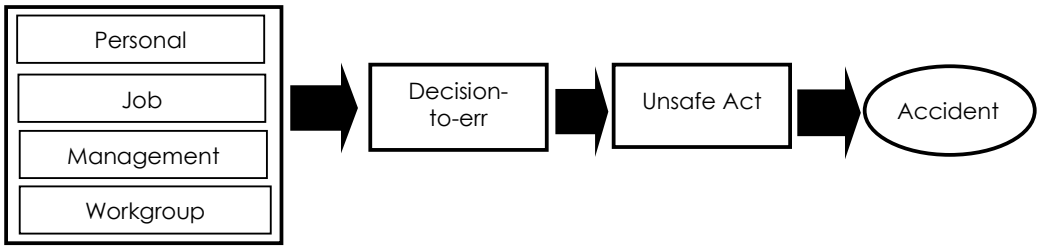

Figure1. Illustration of the Four Major Factors Contributing to the Decision-to-Err

PERSONAL FACTORS

Laziness

Hall (1995) stated that most workers prefer to take shortcuts to save time because they want to avoid supportive activities. Workers oftentimes prefer to work with the wrong tools because they feel that it is too much trouble getting the right one, e.g. workers could climb or stand on rebars (an inadequate working platform) instead of using a proper ladder.

Past Experience

Some workers, having performed a job in a familiar way for many years are very reluctant to give up their old way of doing things. However, these old habits could prevent them from noticing the prevailing hazards, thereby increasing the possibility of accidents occurrence (Kittleson, 1995).

Being in a Hurry

Stice (1995) stated that pressure from supervisors to get jobs done quickly can cause the workers to work in hurry. As a result of such pressures, workers may disregard good safety practices to save time for completing the jobs.

Showing Off

"Watch me" is usually heard from workers who like to display their manhood in order to gain the admiration of their colleagues. Kittleson (1995) stated that some "macho" types of workers like to show off their capability to their peer improperly. This "show-off" behavior can, and often does, results in accidents.

Being Angry

Kittleson (1995) mentioned that being angry can lead to accidents because anger nearly always rules over caution. When someone gets angry, he or she will start to sweat, tremble, get knots in the stomach, or grind his/her teeth. Unresolved anger could cause distraction, proneness to accidents, anxiety, violence and rage.

Being Uncomfortable

The International Labour Organization (ILO, undated) revealed that PPE can be uncomfortable, can decrease work performance and can create new health and safety hazards. Some workers for instance, reject the wearing of earmuff because it makes them feel hot, especially when it is used in hot regions.

Effects of Using Drugs and Alcohol

Michuad (1995) stated that workers who use drugs and alcohol have the tendency to distort or block their decision-making capability. In general, experimental research has shown that alcohol has a delirious effect on performance due to its effects on judgement, reasoning and memory. Drugs users and drinkers often experience reduced levels unawareness, a situation which could lead to decision errors and unsafe working. When the influence of the drug or alcohol is over, a worker might wonder why he did the unsafe act.

Supervisor's and Co-workers' Acceptance

In order to gain the acceptance of supervisors or co-workers, a worker could choose to perform a job unsafely. For example, a worker could decide to unload some materials faster so as to save time for completing the job and thereby gain the acceptance, approval or the admiration of his/her supervisor or co-workers.

Overconfidence

Confidence is a good thing, but overconfidence would oftentimes do more harm than good. "It will never happen to me" attitude could lead to improper procedures or methods that could cause injury (Hirsch, 1998).

JOB FACTORS

Stress has been defined as human's reaction against a threatening situation (Goetsch, 2005). Schermerhorn (2001) further defined stress as "the state of tension experienced by individuals who are facing extraordinary demands, constraints, or opportunities." Some potential factors that could contribute to job stress in the construction industry are:

Too Much Work (Work Overload)

Asking workers to do more than they could handle may result in the workers developing high stress, especially when deadline pressures are put on them. According to Greenberg and Baron (2000), there are two different forms of work overload: quantitative overload, which occurs when individuals are asked to do more and qualitative overload, which refers to employees' belief that they lack of the required skills or abilities to perform the work.

Too Little Work (Work Underload)

Similarly, being asked to do too little could also be as stressful as being asked to do too much. Greenberg and Baron (2000) proposed that there are two types of work underload: quantitative underload, which refers to the boredom arising from having too little work to do, and

qualitative underload, which is the lack of mental stimulation, such as routines, and repetitive jobs.

Time Pressure

When workers are unable to meet deadlines, they instantly get overwhelmed and begin to worry (Timm and Peterson, 1986; Stranks, 2000). In addition, when the work process is changed and the workers are not given enough time to complete the job, they easily become stressed.

MANAGEMENT FACTORS

Management Pressure

Stranks (1994) stated that supervisors who are in charge of low-producing units normally tend to spend more time with their subordinates. These supervisors usually divide job times into many short periods to give specific instructions such as, "do this", "do that", or "do it this way", to their subordinates, hoping to increase productivity. However, supervisors' pressure may cause subordinates to work unsafely while trying to satisfy the supervisors' objectives, such as completing the work within unreasonable time schedule.

Management Support

Hammer and Price (2001) proposed that in order to ensure construction site safety, management should fully support and ensure that safety devices and temporary structures are in good conditions, allocate sufficient budgets for establishing safe works, and establish an effective program to monitor and audit operational activities for their safety.

Supervision

LaDou (1994) stated that it is very obvious that any successful safety program must necessary involve the supervisors. Supervisors should closely control all the workers activities. If supervisors could convince workers that safety has to be considered all the time, then the workers will do everything to prevent accidents.

Reward and Penalty

Motivational factors from the management could have negative impact on inspiring workers to work safely as inappropriate ways of giving rewards and penalties could motivate workers to work unsafely. For example, a worker may decide to work unsafely because he/she thinks that doing this can speed up the work, which would mean getting more reward such as bonus. Penalty could also

motivate workers to work unsafely, e.g. a worker who is physically unfit could force himself/herself to go to work, out of the fear of being penalized.

WORKGROUP FACTORS

Group Norms

Each employee is not just an individual, but a member of a group as well (Stranks, 1994; Gibson et al., 2000). Each group has its own norms, sets its own work goals, moral standards, and makes its own decisions. The norms also incorporate the behavior of workers towards their boss, and how workers react towards safety regulations. Kittleson (1995) stated that it is easier for the workers to base their behavior on others than to do the right thing. For example, a worker may hear, "everyone else does it that way" and therefore follow the group in working in a similar way even though it is an unsafe method.

Group Pressure

Ellis and Fisher (1994) stated that certain groups pressure their members to conform to their established norms, otherwise, erring members will be penalized.

Table 2. Identification of Decision-to-err Factors and Coding

Coding	List of Factors
	Personal Factors (PF)
PF-01	Laziness
PF-02	Past experience
PF-03	Being in hurry
PF-04	Showing off
PF-05	Being angry
PF-06	Being uncomfortable
PF-07	Effects of using drugs and alcohol
PF-08	Supervisor's acceptance
PF-09	Co-worker's acceptance
PF-10	Overconfidence
	Job Factors (JF)
JF-01	Too much work
JF-02	Too little work
JF-03	Time pressure
	Management Factors (MF)
MF-01	Management pressure
MF-02	Management support
MF-03	Supervision
MF-04	Reward
MF-05	Penalty
	Workgroup Factors (WF)
WF-01	Group norms
WF-02	Group pressure

RESEARCH METHODOLOGY

The research commended by reviewing the relevant literature on construction safety as well as conducting exploratory interviews with 20 construction workers to obtain variables related to unsafe acts and decision-to-err factors. Prior to including them in the questionnaire, the defined variables were validated by a panel of construction safety experts. In this study, construction safety experts are defined as construction safety managers, safety engineers and senior safety officers who are or have been involved in managing safety in construction projects for at least 10 years. The experts were asked to indicate the degree of agreement (i.e., 1 = disagree, 2 = somewhat agree, 3 = moderately agree, and 4 = strongly agree) for a set of defined variables whether they are applicable to be used as unsafe act variables and decision-to-err variables. A variable was considered applicable if the mean value is greater than 3 or moderately agree in the measurement scale and the standard deviation (SD) is less than 1.00. A first draft of questionnaire was designed by incorporating those validated variables and disseminated to a few respondents for pilot test. The purpose of pilot test was to check the appropriateness of questionnaire such as wording, instruction, measurement scale and layout. Certain modifications were made to the pilot study and a questionnaire was then finalized. In actual data collection, the questionnaire survey was carried out on medium and large scale building construction projects in Thailand. A project was differentiated as "medium" when its total project cost ranged between 20–100 million Baht with a total employed workforce of 50–200 workers, and considered as "large" when the total project cost was greater than 100 million Baht with a workforce larger than 200 workers. In other words, the projects located in Bangkok and the surrounding areas were selected for this research based on purposive sampling in nature. To select the target respondents who are construction workers, accidental sampling was preferable due to time limitation at construction site. A face-to-face questionnaire cum interview was used to ensure high response rate and undistorted information. Jaselskis and Suazo (1994) proposed that face-to-face interview could prevent interviewees from misunderstanding the questions, and thus, ensure the accuracy of the data, as well as avoid embarrassment to illiterate workers. In total, 214 workers have participated in the survey.

During the interviews, the authors read out all the questions and marked the scores as rated by the respondents. The questions had to be read out to the respondents because the workers are usually uneducated. As a result, a total of 214 workers from 20 building construction projects were individually interviewed, and questions on all 19 unsafe acts were put to each worker to determine the frequency at which he/she has committed

them. For each unsafe act, a worker had to indicate the degree of influence for the 20 decision-to-err factors. This would require each worker to answer the questionnaire, which could take about one and a half hour to complete. In order to reduce the lengths of survey, the structure of the questionnaire was rearranged to make it easier for the workers to answer the questions by using two forced-choice items. By this method, a worker basically had to choose only the first two unsafe acts which he/she mostly committed, and indicated the degree of influence of decision-to-err factors for the selected two unsafe acts. By applying the forced choice technique, the researchers could interview a worker within 20 to 25 minutes, and thus, more data could be collected to enhance the reliability of the findings.

In order to investigate the unsafe acts, the 214 workers were asked to rate scores to indicate the frequency of the unsafe acts which they commit on the construction site where they were then engaged. The five points rating scale (i.e., 1 = never performed, 2 = rarely performed, 3 = occasionally performed, 4 = often performed, and 5 = usually performed) was used to measure the frequency. Thereafter, each respondent was asked to indicate the reasons for doing such unsafe acts, and to rate the degree of influence. The four rating scale (i.e., 1 = not influential, 2 = little influential, 3 = moderately influential, and 4 = strongly influential) was used.

The obtained data was coded into a data file and analyzed using the Statistical Package for Social Science (SPSS). Several statistical techniques were used in this study. Descriptive data analysis (i.e., mean score) was used to summarize and describe information about variables in the dataset. The Kruskal-Wallis test, a nonparametric technique, was applied to test whether or not the several groups of workers have similar patterns of unsafe practices in doing jobs. The one-sample t-test was used to examine which factors highly influence the workers' decisions to commit unsafe acts. Furthermore, the multiple-regression analysis was employed to derive the relationships among several decision-to-err factors and unsafe acts. This technique is helpful in removing insignificant factors which have less effect on the occurrences of unsafe acts and remaining the significant ones. In addition, the level of significance chosen for the study was $\propto = 0.05$.

ANALYSIS AND FINDINGS

Prior to the further statistical analysis conducted, the reliability analysis was undertaken to determine the consistency of the questionnaire. The reliability was tested by using Cronbach's alpha coefficient (α) which is a measurement of the internal consistency. In this study, the values of the Cronbach's alpha coefficient are 0.701

suggesting that the reliability is acceptable (Nunnally, 1978) and implying that further analysis can be performed.

Unsafe Acts on Construction Sites in Thailand

Table 3 shows the overall mean scores and breakdown of the responses from different groups of respondents' characteristics classified by age, experience, and job position. The mean score indicates the degree of frequency of unsafe acts committed by the respondents.

According to Table 3, ignoring to wear PPE was rated as the most frequent unsafe act (mean score = 3.95). The result is similar to a study conducted by Jaselskis and Suazo (1994) who reported that construction workers in Honduras rarely wear PPE. In fact, only 5% of the workers were found to wear hardhat. Moreover, Suraji et al. (2001), who conducted a study on 500 construction accidents in the UK, revealed that 29.80% of construction accidents are caused by inappropriate operative actions (unsafe acts), and the major contributor was improper or inadequate use of PPE.

The next most frequent unsafe act is improper lifting, handling and moving of objects and materials (mean score = 3.25), which was interpreted as occasional degree. From the interviews, it was discovered that the workers usually carry heavy objects without using any lifting device. Also, the workers are usually unaware of the safe methods for handling the objects. Under these conditions, improper handling manners could cause serious back injury to the workers.

The third most frequent unsafe act is leaving nails or sharp objects in dangerous locations (mean score = 2.67). This type of unsafe act can be interpreted as an occasional degree. By observing the workers' practice, it is very easy to see that they do not pay attention to keeping sharp objects properly in the baskets provided. Most of them mentioned that "nobody cares to keep them there, so we just follow suit".

In fact, individuals differ from one another, particularly in terms of their effectiveness in performing tasks. According to Stranks (1994), factors such as age, experience, occupation, and education, have the effect of producing unique individuals with their own particular attitude towards health and safety. Likewise, Takala (2000) confirmed that a set of personal characteristics including the worker's age, experience and job position can provide a background to possible accidents. From the survey, Table 2 also summarizes the mean scores of three major groups of workers categorized by worker's age, experience, and the type of job, for each type of unsafe act. Three tasks were identified as been the most frequently performed in areas where workers across the

Table 3. Mean Score of Unsafe Acts Grouped by Overall, Age, Experience and Job Position of Workers

Item	Overall Mean Scores	Mean Scores Grouped by Age of Worker (Year)				Mean Scores Grouped by Experience of Worker (Year)				Mean Scores Grouped by Job Position of Worker				
		< 20	20–30	31–40	> 40	< 1	1–5	6–10	> 10	Carpenter	Mason	Steel	Unskilled	Others
US-01	2.23	2.37	2.26	2.06	2.34	2.59	2.26	2.12	2.16	2.66	2.22	1.95	1.72	2.31
US-02	1.89	2.37	1.95	1.82	1.76	2.14	2.03	2.02	1.61	1.93	1.63	2.24	1.71	2.13
US-03	2.15	2.00	2.15	2.30	2.03	2.00	2.18	2.24	2.11	2.25	2.00	2.19	1.90	2.47
US-04	3.25	3.00	3.23	3.24	3.35	3.23	3.37	2.96	3.33	3.39	3.59	2.86	3.45	2.50
US-05	2.43	2.42	2.55	2.45	2.31	2.68	2.47	2.45	2.32	2.50	2.85	2.52	2.10	2.34
US-06	1.75	1.74	1.77	1.87	1.60	1.68	1.78	1.80	1.71	1.75	1.44	1.57	1.72	2.16
US-07	1.93	1.89	2.08	1.99	1.74	1.86	2.10	1.78	1.91	1.83	2.19	1.33	1.98	2.28
US-08	1.64	2.11	1.88	1.58	1.32	1.73	1.72	1.76	1.48	1.54	1.74	2.19	1.31	2.06
US-09	3.95	3.74	3.94	4.10	3.87	4.32	3.99	3.98	3.80	4.05	4.26	2.29	4.45	3.66
US-10	1.25	1.26	1.29	1.12	1.34	1.09	1.22	1.29	1.29	1.21	1.11	1.52	1.17	1.41
US-11	1.25	1.00	1.26	1.30	1.26	1.18	1.21	1.35	1.24	1.30	1.19	1.29	1.17	1.28
US-12	2.67	2.79	2.41	2.61	2.98	2.86	2.69	3.12	2.31	3.33	2.93	2.62	2.00	2.16
US-13	1.67	2.05	1.64	1.82	1.44	1.86	1.65	1.82	1.55	1.78	2.15	1.29	1.47	1.66
US-14	1.45	1.16	1.44	1.57	1.44	1.14	1.32	1.53	1.61	1.58	1.41	1.57	1.19	1.59
US-15	2.38	2.21	2.42	2.42	2.35	2.95	2.13	2.43	2.41	2.34	2.52	1.62	2.53	2.59
US-16	2.04	2.21	2.18	2.10	1.77	2.09	2.07	2.24	1.87	1.95	2.26	2.19	2.00	2.06
US-17	1.08	1.00	1.18	1.01	1.06	1.23	1.06	1.08	1.05	1.04	1.07	1.19	1.02	1.22
US-18	1.90	2.26	1.92	1.84	1.82	1.95	2.00	1.86	1.81	1.83	2.00	2.10	1.97	1.72
US-19	2.49	2.58	2.47	2.63	2.34	2.32	2.66	2.43	2.43	2.57	2.63	2.14	2.50	2.41

Note: The mean scores were categorized into interval as follows:

Mean Score	Description
1.00–1.50	Never performed
1.51–2.50	Rarely performed
2.51–3.50	Occasionally performed
3.51–4.50	Often performed
4.51–5.00	Usually performed

different groups commit more unsafe acts. These are variables US-09, US-04, and US-12. The mean scores of variables US-09, US-04 and US-12 vary from 2.29–4.45, 2.50–3.59, and 2.00–3.33, respectively.

In order to investigate which subgroups of workers are different in performing unsafe acts, the median test method, Kruskal-Wallis test, was used for the null hypothesis. The null hypothesis and the alternative hypothesis were employed as follows:

H_0 = the median of all subgroups of sample are equal in performing unsafe acts.

H_1 = at least the median of two subgroups of samples are not equal in performing unsafe acts.

To test the hypothesis, the significant level of 99 and 95% confidence (α = 0.01 and 0.05) was selected. Note that if the Kruskal-Wallis test shows p-value larger than the desired significant level (α = 0.01 and 0.05), then the null hypothesis is accepted. The results of analysis are shown in Table 4.

The statistics in Table 4 indicates one significant difference among the four subgroups of workers classified by age in terms of making annoyance and horseplay at the workplace (US-08) variable. According to the data in Table 3, the mean score of the young age group (below 20 years old) in this unsafe act is 2.11, which is higher than the rest of the group. This means that the young age group tends to do this unsafe act more than the older group.

Table 4. Statistical Results of Compared Groups by Kruskal-Wallis Test

Code	Age of Worker (Year)	Experience of Worker (Year)	Job Position of Worker
US-01	0.614	0.448	0.001 **
US-02	0.302	0.012 *	0.115
US-03	0.503	0.842	0.171
US-04	0.839	0.320	0.001 **
US-05	0.615	0.504	0.122
US-06	0.529	0.817	0.152
US-07	0.409	0.484	0.190
US-08	0.012 *	0.555	0.004 **
US-09	0.632	0.630	0.000 **
US-10	0.217	0.602	0.035 *
US-11	0.371	0.244	0.756
US-12	0.180	0.030 *	0.000 **
US-13	0.117	0.470	0.002 **
US-14	0.532	0.090	0.127
US-15	0.955	0.041 *	0.060
US-16	0.161	0.354	0.673
US-17	0.253	0.657	0.282
US-18	0.326	0.633	0.626
US-19	0.574	0.464	0.579

Note: a value with ** and * denotes that the difference is significant at 0.01and 0.05 level respectively.

Table 4 also indicates three significant differences among the four subgroups of workers classified by experience. The subgroups are different in the failure to warn or to secure members out of danger (US-02), leaving nails or sharp objects in dangerous locations (US-12), and working in dangerous positions (US-15). In Table 3, inexperienced workers (below 1 year experience) display the highest mean score among the four subgroups for both US-02 (2.14) and US-15 (2.95), whereas, the mean score, 3.12 of workers who have 6–10 years experience is higher than the rest of the subgroups of variable US-12.

Furthermore, Table 4 exhibits seven significant differences among the five subgroups of workers classified by workers' job position. The workers are different in performing jobs without authority and skills (US-01), improper lifting, handling and moving materials (US-04), making annoyance and horseplay (US-08), ignoring to wear PPE (US-09), removing safety guards (US-10), leaving nails or sharp objects in dangerous locations (US-12), and throwing and dropping materials from high levels (US-13). The mean scores in Table 3 show that carpenters commit more unsafe acts: US-01 (2.66) and US-12 (3.33), than the other subgroups; while masons do more unsafe acts: US-04 (3.59) and US-13 (2.15), than other subgroups. The mean scores of steel workers show that they commit slightly higher unsafe acts: US-08 (2.19) and US-10 (1.52), than the rest of the subgroups. Furthermore, the unskilled workers show the highest mean score of variable US-09 (4.45) compared to any other subgroup.

Decisions-to-Err Factors Affecting Unsafe Acts

According to the research method concept, to ensure that the obtained data is normally distributed, a large sample is required. This has a need of minimum number of respondents for each data set is larger than 30 ($n > 30$). In line with the results of the two forced choices, only three unsafe acts meet the requirement, US-09 ($n = 140$), US-04 ($n = 58$), and US-12 ($n = 34$). The statistical analysis results are shown in Table 5.

The data from the interviews was used for testing the research hypothesis. The null hypothesis and alternative hypothesis were formulated as follows:

H_0 = the mean score of each factor is not less than 3 ($\mu_0 \geq 3$, value of moderate degree in rating scale).

H_1 = the mean score of each factor is less than 3 ($\mu_0 < 3$, value of moderate degree in rating scale).

Table 5. Statistical Results of Workers' Decision-to-Err Factors

Factor		Type of unsafe act								
		US-09: Failure to wear PPE (rated by 140 workers)			**US-04: Improper lifting, handling and moving of objects (rated by 58 workers)**			**US-12: Leaving nails or sharp objects in dangerous locations (rated by 34 workers)**		
		Mean	***t***	***P*-value (1-tailed)**	**Mean**	***t***	***P*-value (1-tailed)**	**Mean**	***t***	***P*-value (1-tailed)**
PF-01	Laziness	1.84	– 12.15	0.000*	1.43	–13.27	0.000*	3.62	4.41	0.000
PF-02	Past experience	2.97	– 0.273	0.393	2.55	–2.55	0.007*	3.18	0.92	0.181
PF-03	Being in hurry	1.51	– 18.48	0.000*	1.97	–6.49	0.000*	3.03	0.13	0.448
PF-04	Showing off	1.00	–	–	1.03	–81.33	0.000*	1.12	– 20.43	0.000*
PF-05	Being angry	1.00	–	–	1.03	–57.00	0.000*	1.24	– 14.72	0.000*
PF-06	Being uncomfortable	3.01	0.64	0.475	1.00	–	–	1.00	–	–
PF-07	Effects of using drugs and alcohol	1.00	–	–	1.00	–	–	1.00	–	–
PF-08	Supervisor' s acceptance	1.00	–	–	1.57	–11.85	0.000*	1.09	– 21.67	0.000*
PF-09	Co-worker's acceptance	1.02	– 92.33	0.000*	1.62	–10.10	0.000*	1.00	–	–
PF-10	Overconfidence	3.01	0.134	0.447	3.05	0.34	0.368	3.44	3.27	0.001
JF-01	Too much work	1.00	–	–	1.47	–12.95	0.000*	1.50	– 9.10	0.000*
JF-02	Too little work	1.00	–	–	1.00	–	–	1.00	–	–
JF-03	Time pressure	1.19	– 31.56	0.000*	2.05	–5.33	0.000*	2.85	– 0.60	0.278
MF-01	Management pressure	1.00	–	–	2.76	–1.32	0.096	1.38	– 10.62	0.000*
MF-02	Management support	3.26	2.41	0.009	1.71	–8.76	0.000*	1.68	– 6.18	0.000*
MF-03	Supervision	1.84	– 11.76	0.000*	1.95	–7.63	0.000*	2.47	– 2.79	0.005*
MF-04	Reward	1.00	–	–	1.00	–	–	1.00	–	–
MF-05	Penalty	1.00	–	–	1.91	–7.14	0.000*	1.00	–	–
WF-01	Group norms	3.14	1.47	0.072	3.48	4.26	0.000	3.71	7.86	0.000
WF-02	Group pressure	1.12	– 50.49	0.000*	1.83	–7.52	0.000*	1.18	– 16.98	0.000*

Notes: *p*-value with * denotes that the null hypothesis is rejected when the *p*-value < 0.05 and *t* < 0
A variable with missing *t*-value indicates that the value of the *t*-test cannot be computed because the standard deviation is 0

For testing the null hypothesis, the test value was set at 3 (the value of moderate degree in the rating scales). The hypothesis was tested by using one sample t-test (1-tailed) technique. The p-value was compared with a significance level of $\alpha = 0.05$. Note that if the p-value (1-tailed) is less than 0.05, and t-value is also less than 0, then the null hypothesis would be rejected.

Decision-to-Err Factors for US-09 (Ignoring to Wear PPE)

According to Table 5, there are five influential factors for which statistical evidences indicate the mean score to be greater than the value of line moderate degree (i.e, greater greater than 3). These five factors are summarized as follows:

1. Lack of management support (MF-02*):* The mean score of this factor is 3.26. From the interviews, the workers confirmed that they care about their safety and they are willingly to wear PPE if they are available. However, most of the workers frequently blame the management for not providing PPE. In fact, some construction sites require workers to bring their own PPE such as safety helmets, and on some project sites where safety helmets are provided, the workers are charged more than the market prices. The findings of this study tallies with the study conducted by Jaselskis and Suazo (1994) in Honduras which revealed that workers rarely wear PPE because the management did not provide them.

2. Group norms (WF-01): The mean score of this factor is 3.14. The workers usually ignore wearing PPE if they see that other workers do not wear them. The workers often claim that "everyone does it that way". The workers also indicated that since the group was important to them, they need to be loyal to the group, or else, they would be expelled.

3. Overconfidence (PF-10): The mean score of this factor is 3.01. Most workers believe that the possibility of getting an accident is very low, and should there be one, it would not be so serious.

4. Being uncomfortable (PF-06): The mean score of this factor is 3.01. The workers mentioned that they feel uncomfortable wearing PPE. Their common complaints include heavy weight of the PPE, headache, heat, annoyance and unfamiliarity with the protective equipment.

5. Past experience (PF-02): The mean score of this factor is 2.97. The workers never wear any PPE since they have been working on construction sites, and overtime, this has become a habit which they are reluctant to change.

Decision-to-Err Factors for US-04 (Improper Lifting, Handling and Moving Objects and Materials)

According to Table 5, there are three influential factors for which statistical evidences indicate the mean score to be greater than the value of the moderate degree (i.e., greater than 3). Each factor is now discussed as follows:

1. Group norms (WF-01): The mean score of this factor is 3.48. The workers mentioned that they never used any equipment for lifting heavy objects mainly because their co-workers did not use them, a practice that could easily result in back injury. The workers explained that because they have seen other workers repeating this habit over a long period of time, it become their norm as well.

2. Overconfidence (PF-10): The mean score for this factor is 3.05. The interview revealed that almost all workers were overconfident that they would not have accidents. The workers emphatically stated that accidents would not happen to them. Overconfidence could lead to improper procedures in working, which in turn raises the likelihood of accidents occurrence (Hirsch, 1998).

3. Management pressure (MF-01): The mean score for this factor is 2.76. The workers complained that their supervisors pressured them to finish jobs, and that unreasonable pressures could lead them to work in unsafe manners. For example, supervisors may ask workers to lift heavy objects without providing any safety device. The workers however, have to comply for the fear of being dismissed from the job.

Decision-to-Err Factors for US-12 (Leaving Nails or Other Sharp Objects in a Dangerous Location)

Table 5 shows that there are six influential factors for which statistical evidences indicate that the mean scores are greater than the value of the moderate degree (i.e., greater than 3). These factors are discussed as follows:

1. Group norms (WF-01): The mean score for this factor is 3.71. The workers explained that they copy their co-workers in not properly keeping and removing nails or sharp objects from dangerous locations. Besides, the workers stated that "everyone do it that way ", therefore, they just follow what others do.

2. Laziness (PF-01): The mean score for this factor is 3.62. Due to the boredom and repletion of tasks, workers decide at times to forsake safety issues. They mentioned that it is troublesome for them to keep such objects in the baskets provided.

3. Overconfidence (PF-10): The mean score for this factor is 3.44. The workers were confident that accidents would not occur to anybody, even themselves.

4. Past experience (PF-02): The mean score for this factor is 3.18. The workers said that they have been performing this unsafe act for many years, and have never experience any accident.

5. Being in hurry (PF-03): The mean score for this factor is 3.03. The workers revealed that they always want to get the jobs done as quickly as possible. Therefore, they would not like to waste time in keeping such hazardous objects in the baskets, more so, as this was considered as only a supportive task.

6. Time pressure (JF-03): The mean score for this factor is 2.85. The workers mentioned that under the limited time given for completing their jobs, they have no time to put such hazardous objects into the baskets provided. Consequently, such objects are left as they are, while they move on to attend to other jobs.

Multiple Regression Analysis to Study the Combined Effect of Decision-to-Err Factors on the Three Investigated Unsafe Acts

Multiple regression analysis is a statistical technique for understanding the relationship of two or more variables. The stepwise technique was applied to remove the insignificant variables which have less effect on dependent variable. In this study, the result show only factors which are statistically significant on the occurances of unsafe acts.

The results of multiple regression analysis of the effects of significant decision-to-err factors on the frequency of US-09 (ignoring to wear PPE), US-04 (improper lifting, handling and moving objects and materials) and US-12 (leaving nails or other sharp objects, in a dangerous location) are summarized in Tables 6, 7 and 8 respectively. Based on the regression coefficient, the factors that affect each unsafe act can be ranked in terms of how significant the factors influence and unsafe act.

Table 6. Results of the Regression Coefficients: US-09

Variable	Unstandardized regression coefficients	Standardized regression coefficients	Order of contribution to frequency of US-09
Constant	2.177		
Lack of management support	0.224	0.417	1
Being uncomfortable	0.138	0.271	2
Group norms	0.120	0.205	3
Overconfidence	0.107	0.201	4
Past experience	0.093	0.171	5

Notes: The regression model is statistically significant since *P*-value of the *F* distribution < 0.05. Adjusted R^2 is 0.393.

Table 7. Results of the Regression Coefficients: US-04

Variable	Unstandardized regression coefficients	Standardized regression coefficients	Order of contribution to frequency of US-04
Constant	2.404		
Group norms	0.249	0.418	1
Overconfidence	0.147	0.334	2
Pressure from management	0.108	0.294	3

Notes: The regression model is statistically significant since *P*-value of the *F* distribution < 0.05. Adjusted R^2 is 0.335

Table 8. Results of the Regression Coefficients: US-12

Variable	Unstandardized regression coefficients	Standardized regression coefficients	Order of contribution to frequency of US-12
Constant	0.134		
Group norms	0.521	0.398	1
Overconfidence	0.286	0.328	2
Laziness	0.230	0.274	3

Notes: The regression model is statistically significant since *P*-value of the *F* distribution < 0.05. Adjusted R^2 is 0.374.

CONCLUSIONS

The unsafe acts practices and the decision-to-err factors influencing workers' unsafe acts on construction sites in Thailand were explored in this study. Nevertheless, there are some limitations of the study need to be elucidated. It should be noted that the ranking of frequencies of unsafe acts was obtained from the workers' recall. The frequencies did not come from actual field observation, therefore, the ranking does not necessarily correspond to the current situation of unsafe acts. Additionally, a number of unsafe acts were limited to the workers since a list already provided by the authors. The results revealed that the most frequent unsafe acts committed by construction workers are: (1) the workers rarely wear PPE while doing their jobs, (2) the workers lift or handle objects or materials improperly, and (3) the workers leave nails and other sharp objects in dangerous locations.

Our study also indicated that there are some relationships between the workers' characteristics (i.e., age, occupation and experience) and the unsafe acts. The four subgroups of workers classified by age are different in making annoyance and horseplay in the workplace. The young workers tend to commit this unsafe act more often than the older group. The four subgroups of workers classified by their experience differ in wearing PPE, leaving nails or sharp objects in dangerous locations, and working

in dangerous positions. Inexperienced workers tend to ignore wearing PPE, and work in dangerous positions rather than the experienced ones, whereas, experienced workers tend to be more frequent in leaving nails or other sharp objects in dangerous locations. Moreover, the five subgroups of workers classified by their job occupation are different in seven types of unsafe acts. The results indicated that carpenters are more often in working without authority and skills, and in leaving nails or sharp objects in dangerous locations. Masons tend to be more in improper lifting, handling and moving materials, and in throwing and dropping materials from high levels compared to others. Furthermore, steel workers tend to be more in making annoyance and horseplay, and removing safety guards; while, unskilled workers tend to be more in ignoring to wear PPE at the workplace.

In order to explain why the unsafe acts happen, the decision-to-err factors were also explored. It was determined that there are many potential decision-to-err factors causing unsafe acts, the stepwise multiple regression analysis was then employed to remove insignificant factors. The most frequent unsafe acts rated by more than 30 respondents were selected. The minimum of 30 respondents is the requirement for parametric test of statistical analysis. The first unsafe act, rated by 140 workers, was the failure to wear PPE. This unsafe act was statistically correlated with five factors: lack of management support, group norms, overconfidence, being uncomfortable, and past experience. The second unsafe act, rated by 58 workers, was improper lifting, handling and moving objects. This unsafe act was statistically associated with three main factors: group norms, overconfidence, and management pressure. The third unsafe act, rated by 34 workers, was leaving nails or other sharp objects in dangerous locations. This unsafe act was statistically associated with three main factors: group norms, laziness and overconfidence.

FURTHER RESEARCH

This study could be broadened to include a larger workforce sample to enhance the level of reliability of the research. This study can be more complete if the limitations of the study are overcome. It is suggested that the frequency of unsafe acts should be obtained from field observation. The results of observation will be most likely to represent actual state of unsafe acts that occur on sites. As a result of time constraint, this study could not obtain decision-to-err factors for all identified unsafe acts. If it is possible, more research should be carried out to investigate decision-to-err factors for all types of unsafe acts. As a result, managers can develop appropriate preventive measures to reduce the occurrences of those unsafe acts. Finally, it may be of interest to perform a boarder study to investigate the relationships between the

occurrences of unsafe acts and site safety performance (e.g., accident rate). By doing this, the managers will know which types of unsafe practices have greater impact on safety performance.

REFERENCES

Abdelhamid, T.S. and Everett, J.G. (2000). Identifying root cause of construction accidents. *Journal of Construction Engineering and Management*, 126(1): 52–60.

Anton, T.J. (1989). *Occupational Safety and Health Management*, 2nd Ed. New York: McGraw-Hill.

Ellis, D.G. and Fisher, A.B. (1994). *Small Group Decision Making: Communication and the Group Process.* Singapore: McGraw-Hill.

Gibson, J.L., Ivancevich, J.M. and Donnelly, J.H. Jr. (2000). *Organizations: Behaviors, Structure, Process*, 10th Edition. Boston: McGraw-Hill.

Goetsch, D.L. (2005). *Occupational Safety and Health: For Technologists, Engineers, and Managers*. 5th Ed. New Jersey: Prentice-Hall.

Greenberg, J. and Baron, R.A. (2000). *Behavior in Organization*, 7th Edition. New Jersey: Prentice Hall Inc.

Hall, L. (1995). *General Safety: Unsafe Acts.* http://www.eig.com/ (Accessed 16 September 2003).

Hammer, W. and Price, D. (2001). *Occupational Safety Management and Engineering*, 5th Ed. New Jersey: Prentice-Hall.

Haupt, T.C. (2001). *The Performance Approach to Construction Worker Safety and Health*. PhD Dissertation. University of Florida.

Hirsch, D. (1998). *Seven Common Accidents Causes*. http://www.eig.com/ (Accessed 18 September 2003).

Holt, St. J.A. (2001). *Principle of Construction Safety.* London: Blackwell Science.

International Labour Organization (ILO) (2005). *Thailand – Occupational Safety and Health in the Construction Industry*. http://www.ilo.org/public/english/region/asro/bangkok/download/background/osh/conth05.pdf/ (Accessed 12 May 2006).

Your health and Safety at Work: Controlling Hazards. http://www.itcilo.it/english/actrav/telearn/osh/hazard/controlb.html/ (Accessed 5 March 2003).

Jaselskis, J.E. and Suazo, A.R.G. (1994). A survey of construction site safety in Honduras. *Construction Management and Economics*, 12: 245–255.

Kittleson, C. (1995). *Identifying and Correcting Unsafe Employee Attitudes and Behavior.* http://www.eig.com/ (Accessed 16 September 2005).

LaDou, J. (1994). *Occupational Health & Safety*, 2nd Edition. Illinois: National Safety Council.

Michuad, P.A. (1995). *Accident Prevention and OSHA Compliance.* Florida: CRC Press.

Nunnally, J.C. (1978). *Psychometric Theory*, 3nd Edition. New York: McGraw-Hill.

Petersen, D. (1984). *Human-Error Reduction and Safety Management.* New York: Aloray Inc.

Reason, J. (1990). *Human Error*. New York: Cambridge University Press.

Sawacha, E., Naoum, S. and Fong, D. (1999). Factors affecting safety performance on construction sites. *International Journal of Project Management*, 17(5): 309–315.

Schermerhorn, J.R. Jr. (2001). *Management*, 6th Ed. New York: John Wiley & Sons.

Simachokdee, V. (1994). *Safety Engineering*. Bangkok: Physics Center Press.

Stice, M. (1995). *General Safety: Attitude and Behavior.* http://www.eig.com/ (Accessed 16 September 2004).

Stranks, J. (1994). *Human Factors and Safety*. London: Pitman Publishing.

Stranks, J. (2000). *The Handbook of Health and Safety Practice*, 5th Ed. London: Prentice Hall.

Suraji, A., Duff, A.R. and Peckitt, S.J. (2001). Development of casual model of construction accident causation. *Journal of Construction Engineering and Management*, 127(4): 337–344.

Takala, J. (2000). *Occupational Safety and Health*. Paper of Seminar on Measurement of the Quality of Employment. http://www.unece.org/stats/documents/ces/sem.41/17.e.pdf/(Accessed 14 September 2005).

Timm, P.R. and Peterson, B.D. (1986). *People at Work: Human Relations in Organization, 2*nd Ed. St. Paul: West Publishing.

Wiegmann, D.A., Shappell, S.A., Bouquet, A., Detwiler, C., Holcomb, K. and Faaborg, T. (2005). *Human Error and General Aviation Accidents: A Comprehensive, Fine-Grained Analysis Using HFACS*. http://www.humanfactors.uiuc.edu/Reports & Papers PDFs/TechReport/05-8.pdf/ (accessed 24 September 2005).