A BEHAVIOUR-BASED SAFETY APPROACH FOR CONSTRUCTION PROJECTS

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ABSTRACT

The application of behaviour-based safety in the construction industry has been limited. The objective of this research is to provide a decision support system, which will assist construction companies in implementing behaviour-based safety. The research was carried out by performing a detailed review of the existing literature on the topic and carrying out a pilot study to verify the validity of the model. As a part of the model a rating system has been developed which can quantify and evaluate the performance of different sub-contractors working for the primary contractor.

The results showed that an adequate improvement in safety performance is possible with this approach. Most of the groups participating in the study showed an improvement in at least three of the safety-based behaviours. Some groups showed improvement in more than six behaviours.

KEY WORDS

Behaviour based safety, applied behaviour analysis, behaviour modification, accidents/injuries.

INTRODUCTION

The Construction industry has an unenviable safety record. In the year 2002 an average of 7.1 non-fatal injuries per 100 workers was recorded. It recorded 1121 fatalities showing a fatality rate of 12.2 per 100,000 workers employed which was third only to mining and agriculture (Bureau of Labour Statistics, 2005). The National Institute for Occupational Safety and Health reports the leading causes of death among construction workers are falls from elevations, motor vehicle crashes, electrocution, machines, and being struck by falling objects.

Occupational injuries and fatalities are unquestionably wasteful and non-value adding events in construction production systems. These events contribute to unreliable workflow, which in turn creates havoc on any construction project. Howell and Ballard (1994) state that achieving reliable workflow is possible when sources of variability are controlled. It follows then that safeguarding construction workers from occupational hazards, is part and parcel of the lean construction ideal of maintaining reliable workflow (Abdelhamid et al 2003).

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While safety remains a concern for a lot of companies, there are companies which are showing excellent improvement in safety performance. These are recruiting expert personnel to run their safety programs; they are providing training to the workers and in fact are reporting good results. However there is a very high chance for complacency in these companies (McSween, 2003).

Therefore, the Construction industry needs radical changes in the way it approaches safety improvement. Several approaches have been implemented in the industry, each having their own benefits and limitations. Guastello (1993) carried out a comprehensive review of different occupational accident prevention programs and summarized the evaluation data. He encountered ten types of programs in his research among which behaviour based safety (BBS) showed the best effects. A behavioural approach becomes especially important in tackling safety issues since it focuses on the psychology of the human at work. The National Safety Council reports that human behaviour is the cause of 94% of all injuries and illnesses (Loafman 1996). This has pointed out the importance of focusing on employee behaviour as a critical element in achieving better safety standards. BBS interventions focus on what workers do on the job (behaviour), and on the contingencies of reinforcement that lead to safe behaviour (Grindle et al. 2000). The aim is to reinforce workers to behave safely during their activities.

Behaviour-Based Safety (BBS) is a methodology which aims at improving safety by integrating behavioural science, quality and organization development principles with safety management in order to reduce industrial injuries (Krause 2002).

There are two main features which have promoted BBS over other approaches:

- It focuses on employee behaviour which is claimed to be the main source of injuries and illness
- It encourages employee involvement in safety issues as safety is not seen solely as the management's responsibility

Although behaviour-based safety has been widely accepted in other industries it cannot be directly used "as is" in the construction industry. It needs to be adapted to suit the demands of the Construction Industry. It is very difficult to invest a large amount of money on full fledged safety programs like behaviour-based safety. Implementing new programs such as BBS need constant guidance by expert personnel making it even more challenging for small or medium-sized companies as they cannot afford to hire highly paid consultants. The construction industry therefore needs an approach which will help them in implementing the principles of behaviour-based safety without needing to spend too much money on expert personnel.

Because construction companies may not easily afford to hire consultants to implement behaviour-based safety in their companies, this research aimed at providing a tool which would enable safety personnel / companies to directly implement behaviour-based safety at their sites. The objective of the research is:

- to provide a procedure which will enable construction companies (especially small and medium-sized construction companies) to implement behaviour-based safety.

- To highlight potential problems which construction contractors are likely to face during the implementation of BBS.
- Propose a cost-effective solution without losing out any of the principles of behaviour-based safety.

RESEARCH METHOD

The research was carried out by performing a detailed review of the existing literature on the topic and carrying out a pilot study to verify the validity of the model. Researchers have reported diverse BBS applications in various countries, from Finland (Leivo, 2001) to Australia (Walker, 1994) and in many industries ranging from construction (Lingard and Rowlinson, 1997) to nursing (Babcock et al. 1992). A total of three qualitative reviews (McAfee and Winn 1989, Grindle et al. 2000, Sulzer-Azaroff and Austin 2000) and two meta-analyses (Guastello 1993, Krispin and Hantula 1996) were found by the researchers.

Two major channels were employed during the literature search: online and bibliographical. The online search was conducted using 7 different databases and combinations of different keywords related to BBS such as “behaviour based/behaviour-based safety”, “employee driven/employee-driven safety”, etc. The databases were also scanned by using the surname of more prolific researchers in this area. This initial search produced 449 publications for potential inclusion in the systematic review.

Articles were included if they involved a BBS intervention conducted in an occupational setting that reported data about accidents or injuries. Following a strict selection criteria, the initial pool of 449 studies was reduced to 13 publications.

The Epidemiological Appraisal Instrument (EAI) (Genaidy, 2005) was employed to critically appraise the methodological quality of the studies. The EAI evaluates study quality using 43 questions under five main headings, namely; study description, subject selection, observation quality, data analysis and generalization of results, where scores between 0 and 2 can be assigned to each question.

The critical appraisal revealed that the quality of studies ranged between poor to marginal. For instance, a separate control group was not used in 12 out of the 13 studies. Eight out of the thirteen studies achieved a statistically significant reduction in accidents/injuries after conducting a BBS intervention. Two studies achieved a statistically insignificant improvement. Overall the BBS interventions achieved a statistically significant reduction in accidents/injuries at the 5% level.

The literature review showed several detailed approaches which would help in adopting a behaviour-based approach for the safety programs. Amongst them, one article worth noting was Reber et al. (1993). This article provided a ‘general paradigm’ for implementing a Safety Performance Management Program (SPMP). This program is a generic program and with modifications it could be suitable for small/medium-sized construction companies. The approach suggested here, has been greatly influenced by the SPMP- especially the comprehensive manner in which SPMP addresses the safety program of the company.

Step 1 – Study of Company Documents

Before the company begins to implement a program, a detailed analysis of the existing status of the company is essential. These can be obtained by studying the accident records of the company for the past 5 – 10 years. While doing this analysis Reber et al. (1993)

suggest finding information about the time, location, type of injuries, the demographics of the employees injured, and the costs preventive measures that could be adopted.

Step 2 – Safety Meetings

Followed by the study of the accident records, it is also necessary to look at the site safety meetings. The Safety Director should conduct surprise visits at the sites during safety meetings and verify whether that they are being carried out properly and whether every worker on the site is attending the meetings.

Step 3 – Feedback from Employees

The safety and management personnel should interact with workers in order to learn about the problems associated with the existing systems.

Step 4 – Safety Manual (Reber et al. 1993)

Most companies already have a safety manual in place and it is also fairly up-to-date. However, the safety team needs to study the safety manual very carefully. They should check for any confounding or misleading terms in the manual.

Step 5 –Develop Critical Behaviour Inventory (Reber et. al 1993)

On the basis of the information collected in all the previous steps a Critical Behaviour Inventory is prepared. The data obtained so far should be used to prepare a list of safe and unsafe behaviours. This inventory will provide an insight into which behaviours need to be targeted for improvement and which should be encouraged. These should be checked with those mentioned in the current checklists thus helping in modifying the checklist.

Step 6 –Site Selection

The construction company might find it difficult to implement the program at once in all the sites. Therefore, it would be a good idea to carry out a pilot-study of the project on one or two sites and then widen it on the basis of the results obtained from these sites.

Step 7 – Choice of Study Design

There are many settings, which the Safety Director could choose for implementing the study. However, the literature review revealed that intervention is the most commonly used kind of study design for BBS studies.

Step 8 – Actual Study Implementation

Once the Study Design has been selected, the actual implementation should begin after careful scrutiny of the work schedule. Often in construction projects, it is not possible for researchers to change the settings to match specific requirements. Therefore, the study design should allow for adjustments and modifications.

Step 9 – Data Analysis and Interpretations

Following the observation phase the next task would be a detailed analysis to interpret the data.

Step 10 – Conclusions and Merger into the system

Once the data is interpreted and the company starts obtaining the desired results certain elements of the steps taken will be gradually merged into the system where as others will be faded out.

CASE STUDY

The pilot study for testing the model was carried out along with a medium-sized reputed contractor in Cincinnati. The pilot study was carried out at a multi-family residential project site near downtown Cincinnati – Laurel Homes, a mixed-income, mixed-finance effort totalling over $102 million (www.cintimha.com). The trades involved in the study are listed in Table 1. It should be noted that with the exception of 1 African American Female working for the Plumbers all other study subjects were Males.

Table 1 – Subcontractors Working at the Site

#	PROFESSION	WORKER CHARACTERISTICS	NUMBER OF WORKERS
1	Framers-I	Caucasian	6 to 20
2	Framers-II	Hispanic	6 to 20
3	HVAC installers	Caucasian	3 to 8
4	Electricians	Caucasian	2 to 4
5	Excavation crew	Caucasian	1 to 4
6	Plumbers	Caucasian African American	4 to14
7	Brick Masons	African American Caucasian	4 to 20
8	Fire Protection Crew	Caucasian	2 to 4
9	Roofers	African American	2 to 4
10	Cladding crew	African American Hispanic Caucasian	2 to 6
11	Exterior Finishers	Caucasian	2 to 4
12	Interior Finishers	Hispanic	3 to 6

Step 1- Study of Company Records (Reber et al.1993): The study of the company records began in May 2004. There had not been any fatalities in the last three years of the company records. But, there had been two severe injuries both of which were related to fall protection.

Step 2- Safety Meetings: The Safety Meetings for the company were conducted at the respective sites. They were headed by the site staff, usually during the snack break. These meetings were mandatory and a sign-in sheet would be passed among all workers present at the meeting.

Step 3 – Feedback from the Employees: For the first two site visits, the Safety Director accompanied the research team and provided a "guided tour" while pointing the behaviours which needed special attention. After these two visits, the researchers began visiting the field almost daily. The workers and site staff were engaged in discussion to collect information.

Step 4 – Safety Manual: The company Safety Manual was comprehensive and very specific to the behaviours but it was not conspicuously shelved and some staff personnel were not aware of its location.

Step 5 – Critical Behaviour Inventory: A critical behaviour inventory was created from careful scrutiny of the manual, the company checklist and the observations made on the site. This checklist, shown in Figure 1, was created after the first 3 months of preparatory phase. Each behaviour included in this list was defined very clearly while also avoiding redundancy in the list. A separate category was created for "Fall Protection" because it is one of the primary causes of accidents in construction. Moreover, Fall Protection was separated because the company accident history revealed two recent injuries caused by a lack of and failure to use fall protection.

Step 6 – Site Selection: The chosen site involved a considerable amount of excavation, stick framing, plumbing work, HVAC systems and masonry work. Typical to most construction projects, most of the work was scheduled to be built in phases with some amount of overlap in terms of the activities. This overlapping of activities was good from the study point of view as a greater number of groups could be observed together for a longer period of time.

Step 7 – Choice of Study Design: In this type of design the study sample was the entire site. The researchers observed the workers in a baseline study and then provided feedback to them about their status and set goals for them. Then the research team started focusing on the intervention categories PPE, Housekeeping, Physical Environment Controls, Fall Protection and Tools & Equipment. The workers were given continuous feedback - both verbal as well as visual by posters. The control category (Body Position and Ergonomics) was mentioned only in the weekly safety meetings. Too much focus on the control measure was avoided. Body Position and Ergonomics was used as a control measure

Step 8 – Actual Study Implementation: The Pilot Study lasted for 6 weeks. The second and third weeks of August were the baseline. The month of September was the actual intervention. Observations were recorded by one external observer by means of the checklist shown in Figure 1. It was necessary for ease of handling and legibility that the checklist be no longer than one page. The observation rounds were done at random at no fixed time of the day. The timings were decided based on the complexity and amount of work. Every group of workers was typically observed for 10 minutes. All safe and unsafe behaviours observed were recorded. In order to quantify the behaviours, the following rating system was devised:

Rating = [Σ (Safe Behaviours) – Σ (Unsafe Behaviours)] / [Σ (Safe and Unsafe Behaviours)]

This value was termed as the safety rating. By this calculation, the rating would range between -1 and 1. A value of -1 indicates that the group was at the worst possible behaviour – they were very unsafe in that particular act. A value of 1 indicates that the group was at the best possible behaviour – they were safe as suggested by the standards of the company. A Value of 0 indicates that the group exhibited an equal number of safe and unsafe behaviours.

Step 9 – Data Analysis and Interpretation: The ratings collected over the 6 week study were standardized to represent 5 days of work and an equal number of observations.

Safety Observation Checklist

Observer	Date	Time	Block
Sub-contractor	No.of workers	Team	Floor

Instructions: Enter the number of safe and unsafe behaviors observed for each team.

I	PPE	Safe	Unsafe
1	Hard Hats		
2	Safety Glasses		
3	Hearing Protection		
4	Respiratory Protection		
6	Protective Clothing		
7	Gloves Hand/Arm Protection		
8	Other (write remarks)		

II	Housekeeping	Safe	Unsafe
1	Electrical cords/hoses stored properly		
2	Access to the site		
3	Access to the work area		
4	Area free of slip and trip hazards		
5	Necessary Signs/Posters		
6	Route marks for excavators		
7	Protruding Rebar (caps)		
8	Uncovered/Unbent nails		

III	Physical Environment Controls	Safe	Unsafe
1	Use of tags/locks		
2	Equipment de-energized		
3	Barricading / Canopies		
4	Fire/Emergency Equipment		
5	Adequate Lighting indoors		
6	Ventilation indoors		

IV	Fall Protection	Safe	Unsafe
1	Safety Harness		
2	Other Fall protection		
3	All Openings covered		

V	Tools and Equipment	Safe	Unsafe
1	Scaffolding		
	Connections secure		
	Tied into structure		
	Clean, free of debris		
	Guard rails, toe boards		
	Overhead protection		
	Cross braced		
	Other (write remarks)		
2	Ladders		
	Properly secured		
	Extend > 36" above landing		
	Good condition		
	Not metal ladders		
	Proper use of step ladders		
	Other (write remarks)		
3	Selection of tools		
4	Proper grounding		
5	Proper use of tools/equipment		
6	Condition of tools/equipment		
7	Location/storage of tools/equipment		
8	Use of vehicles		
9	Guards in place		
10	Terminal boxes covered		

VI	Body Position and Ergonomics	Safe	Unsafe
1	Proper lifting carrying mechanism		
2	Proper pulling, carrying mechanism		
3	Clear of "line of fire"		
4	Eyes on path		
5	Eyes on work		
6	Appropriate pace		
7	Clear of pinch joints		
8	Clear of sharp edges		
9	Clear of hot surfaces or materials		
10	Maintains 3 points of contact		
11	Ergonomics/repetitive motion		
12	Stays on paths and walkways		

Remarks:

Figure 1. Safety Observation Checklist

FINDINGS

PPE

In this study, PPE trends were mainly visible in 2 behaviours; 'hard hats' and 'protective clothing.' All the workers were aware of the necessity of wearing a hard hat. However, some groups have continued to show poor ratings in this behaviour. HVAC installers showed a downward trend in the study. One of the reasons for this is that most of their work was done between the beams / rafters where a hard hat obstructed the sight as well as cramped the worker. 'Gloves and Hand/Arm Protection' was not very vital to most of the groups. The one group, which deserved special attention for this behaviour, was the brick masons. They showed relatively poor start in terms of the ratings. This is primarily because the ratings were recorded very strictly and anybody who seemed to be working with mortar or cement without wearing gloves was immediately recorded. Gloves were usually worn by the chief masons and mostly the helpers did not wear gloves. The behaviour continued in the unsafe region until the last week during which it crossed into the safe region. A longer study would have most probably seen a great improvement in this aspect.

HOUSEKEEPING

This category of behaviours is usually not just a reflection of the site safety but also about the organized nature of the site. However, this site was showing some poor ratings for some behaviours. This was observed soon after the baseline observations. Immediately following the first week of interventions, most groups were showing poor ratings for 'access to the site' and 'access to the work area'. However, 'access to the site' is typically the responsibility of the site management staff. Soon after pointing this issue to the general contractor, access to the site changed and the site access was made convenient and safe. This prompted one sub-contractor to question why the general contractor was not a part of the safety rating system. The exclusion of the general contractor from the study was intentional because the research focus was on the work behaviours of workers performing production activities rather than the general administrative work responsibilities of the general contractor. Future studies should carefully evaluate the scope of work that the general contractor provides and include those parts that have a direct effect on the construction work.

Electrical cords and hoses were usually well-maintained and generally showing good behaviours or improvement. It is worth noting that there were no negative trends for the first four behaviours in housekeeping with almost all the subcontractors showing some improvement. This provides evidence that the study was having some effect on the groups.

PHYSICAL ENVIRONMENT AND CONTROLS

Most of the behaviours in this category were not applicable to the site. The behaviours – 'barricading and canopies' and 'fire protection and emergency equipment' were again recorded very strictly to almost a theoretical level which is difficult to achieve in construction sites. Besides, it was believed that pushing for this behaviour in a short time might put undue pressure on the already over-burdened site staff. More about this behaviour was addressed in the Fall Protection category. Barricading and Canopies was very important for the excavation group which showed slight improvement in this respect moving from negative values toward 0. Fire Protection was especially important for those workers who would be working in confined spaces on upper stories or roofs without more than one access.

FALL PROTECTION

These are among the most important behaviours but unfortunately there was a lack of observable readings to assess the trends in these behaviours. These behaviours were a constant cause of concern among Framers-II who were predominantly Hispanic. A lot of changes in the attitudes could be observed after two of the workers were sent home by the Safety Director for not wearing safety harnesses. However no such changes were observed for this category in the ratings for Fall Protection or All openings Covered.

TOOLS AND EQUIPMENT:

Behaviours related to scaffolding were observed only in the brick masons. They usually maintained a reasonable level of safety standards. Selection of tools and other behaviours such as proper grounding and proper use of tools and equipment was largely worker dependent. The usual trend was that more experienced workers tended to take proper care of their tools and themselves. Most of them had also received some form of safety training (usually about OSHA regulations). Hence they were usually observed to show good safety ratings. 'Use of vehicles' was largely satisfactory apart from a few exceptions. The excavation group had ratings different from the rest of the groups primarily because of the frequency of use. Understandably, the excavation group would be using vehicles a lot more than others. Yet they have shown an improvement over the study phases. Framers-II had poor values in this regard during the baseline observations. This was mainly because the group did not use expert operators in this period. Later on during the intervention, the framers' vehicles were operated by more experienced personnel.

BODY POSITION AND ERGONOMICS

This control measure was not anticipated to show much improvement in the behaviours of this category. However, contrary to this expectation, improvements for most of the behaviours were observed. This was mainly because most of the behaviours of this category are inter-related. For example, proper use of ladders, proper choice of tools, proper conditioning of the tools would directly or indirectly contribute to better body position and ergonomic behaviours. Some poor and negative trends were also observed in this category. For example, the framer groups, I and II, have shown poor ratings and a negative trend in 'lifting and carrying' and 'reaching and pulling'. While the Framers group generally had good productivity on the site, the ergonomic issues identified for this group clearly puts them at risk of construction related Musculo-Skeletal Disorders (MSDs) and back pain.

CONCLUSION

This study presented results of incipient research into the implementation of behaviour-based safety in construction. The 6-week pilot study indicated that body position and ergonomics continue to be a major issue for construction workers and if ignored can lead to severe problems later for the industry. The pilot study also confirmed, through the safety rating values, that failures to adhere to fall protection requirements continues to be a common cause for concern in construction.

In general, the findings of this research reveal that it is possible to achieve improvement in worker behaviours by using a simple safety checklist and rating system. More importantly it has demonstrated that the workers began to show better ratings after being introduced to the program and provided with feedback on their safety performance. The program instigated a competitive spirit in the site as well as a sense of responsibility on the part of the workers. With very minor modifications the program can be implemented at other sites in the industry, which will guide process improvement initiatives and efforts to improve safety performance on construction sites.

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