CONSTRUCTION ACCIDENT CAUSATION: AN EXPLORATORY ANALYSIS

Kajal Seevaparsaid-Mansingh, M.Tech: Construction Management student, Cape Peninsula University of Technology, Mobile: +27 82 770 4042, Facsimile: +27 11 315 6688, South Africa, E-mail: kajal.mansingh@eskom.co.za

Dr Theo Haupt, Co-ordinator, Southern African Built Environment Research Centre (SABERC), Cape Peninsula University of Technology, Mobile: +27 82 492 9680, Facsimile: +27 12 959 6870, South Africa, E-mail: hauptt@cput.ac.za

ABSTRACT

The construction sector has poor health and safety performance in most countries. Accidents occur in almost all construction related activities. These accidents are multi-causal in nature with combinations of factors needing to coincide to give rise to an incident. This study is premised on the principle that all accidents are preventable and reviews several of the existing causation theories. A sample of accidents drawn from the records of a multi-national/parastatal organisation was examined to determine their recorded causes. These were compared against the theories reviewed. The findings suggest that the true cause of the accidents are incorrectly recorded, requiring a possible revision of the instrument used for investigation and recordkeeping.

Keywords: Causation, Construction, Accident, Theories, Prevention, Investigations

1. INTRODUCTION

Many recent accidents involving loss of life and limb have occurred on construction sites around South Africa. These have created negative impressions of the industry and sector (Haupt and Smallwood, 2005). Construction represents ‘a challenging regime in which to manage health and safety’ (HSE, 2001) and includes enormous diversity in terms of the size and range of its activities. Construction activities occur in a hazardous environment with direct exposure to many hazards.

Compared to relatively stable manufacturing or retail environments, construction projects involve constant change. Consequently, legislators battle to legislate for the enormous variations in the nature of construction projects. It is expected that unitary health and safety regulations apply generically across the entire industry, from domestic extensions to major infrastructure projects. The widespread use of sub-contractors and self-employed workers creates a situation where multiple approaches to health and safety exist on the same site, resulting in a ‘complex communication chain’ (HSE, 2001). One of the greatest problems faced by those responsible for the overall management of a
project is the need to integrate a wide variety of contractor ‘styles’ within the overall project.

The findings of a recent study in South Africa during which 252 industry stakeholders were surveyed indicated a need for the following:
- Endeavors to enhance the health and safety culture of the industry; and
- The realization that all accidents can be prevented (Smallwood and Haupt, 2004).

There are a number of theories relative to the causation of accidents on construction sites. Despite these theories and others, accidents have continued unabated. Typically, these theories have focused on the construction worker as being the primary cause of accidents – a basic tenet of the behavioural safety approach espoused by Geller, Krause and others.

Emphasis on individual failures ‘results in a reliance on short term solutions rather than any attempt to uncover more fundamental management or organisational problems’ (Whittington et al, 1992). The remedy targets a specific event or operative, such that no effort is made to uncover the underlying cause of the accident. HSE research (2001) observes that ‘changes at the direct level alone will not deliver the degree of change being sought, nor would the improvement be sustained’.

Accidents are preventable and should be regarded as failures of management. None of the theories comprehensively address these issues. However, in line with the modern accident theory, the aim of organisations should be to shift the emphasis from errors on the part of the individual to the management and organisational errors that cause poor health and safety performance.

2. THEORIES OF CAUSATION

There are a number of accident causation theories, which Hinze (1997) refers to, that relate to construction sites which are typically regarded as dangerous and hazardous. These include, inter alia:

a) Accident Proneness Theory
There are 2 views, namely an old and new view.

Old view: Injuries happen to people who have a genetic predisposition to being injured. This suggests that certain individuals have inherent characteristics that predispose them to a greater probability of being involved in accidents.

New view: Accident proneness is being increasingly viewed as being associated with the propensity of individuals to take risks or to take chances. This view is more positive for health and safety, given that behaviour can be altered.

This theory focuses on personal factors related to accident causation and is based on the assumption that when many persons are placed in similar working conditions some would
be more likely than others to sustain an injury suggesting that accidents are not randomly distributed.

b) Goals-Freedom-Alertness Theory
This theory suggests that accidents are the result of unsafe behavior resulting from an unrewarding psychological climate that does not contribute to mental alertness. Accidents are therefore attributed to low-quality work behaviour occurring in an unrewarding psychological environment.

c) Adjustment Stress Theory
Any complications or negative stresses imposed on an individual either by the internal environment (e.g. fatigue; lack of sleep; or psychological stresses such as worry, personal problems) or by the external environment (e.g. noise; temperature; excessive physical strain) will increase accident occurrence. If the worker cannot adjust to the stress, the chance of injury is increased.

d) Chain of events (Domino theory)
This theory is not truly a theory of accident causation, but is often referred to as one. It is based on accidents being characterized as occurrences that result from a series of events which are all linked in that each event is followed by yet another event. It is really a conceptual portrayal of how accidents occur. The chain of events states that there is not a single cause of an accident but rather many causes.

In general, every accident is preceded by a series of events or activities. If any one event or activity had been done differently, the accident would not have occurred (“break the chain to avoid the accident”). Different people may be associated with the different links in the chain. There are many links in the chain and only one link needs to be broken to prevent an accident.

e) Distractions Theory

The Distractions Theory suggests that health and safety is situational, namely that workers perform tasks in an environment that is known to be hazardous. This theory states that accidents are caused when workers are distracted when they are performing their work tasks. There are two types of distractions:

i) Jobsite Hazards - Workers will try to avoid being injured. They will naturally focus on the hazard. Pressure to get the task done may cause the worker to be distracted and to ignore the hazard, resulting in an injury – Figure 1.

![Figure 1: Distractions Theory – Jobsite Hazards](image-url)
ii) Mental worries - Workers will try to focus on the work to be done, but may be
distracted by worries caused by personal or job-related concerns. Failure to be able to
focus on the work increases the likelihood of being injured.

More modern accident theories have shifted the emphasis from errors on the part of the
individual to the management and organisational errors that cause poor health and safety
performance. There are 2 of these theories (HSA, 2002), namely:

f) Reason’s Framework for Accident Causation
Professor James Reason at the University of Manchester developed a theory of accident
causation that spans the entire accident sequence from organisational to individual levels.
The theory follows modern trends in seeking causal factors that are removed in both time
and space from the onset of the incident. Previously, accident investigations tended to
highlight the role of the frontline operator as the most obvious and immediate instigator
of the accident. Accidents in the construction industry are particularly prone to such
interpretations – incidents regularly occur to individuals acting alone. Reason’s theory
incorporates an organisational level analysis that takes into account the input of
management and decision-makers.

![Figure 2: James Reason (1990) – Accident Causation Model](image)

The model divides active and latent failures. Active failures are “those errors and
violations that have an immediate adverse effect. These are generally associated with the
activities of ‘front-line’ operators” (Reason 1990) which correspond to the activities of
construction personnel on-site such as driving into contact with overhead power lines or
failure to wear PPE. Many health and safety interventions aim at the level of the general
operative e.g. programmes to encourage the wearing of hard hats or instituting health
check campaigns. However, there are an infinite number of unsafe acts that can
precipitate accidents on a construction site – “the vast majority of them are unforeseeable
and occasionally quite bizarre” (Reason, 1990). Attempts to reduce the number of unsafe
acts can only have limited value. It would be more beneficial to aim at the level of latent
failures.

Latent failures correspond to errors at the Head Office and Site Management levels.
They are “decisions or actions, the damaging consequences of which may lie dormant for
a long time, only becoming evident when they combine with local triggering factors.
Their defining feature is that they were present in the system well before the onset of a recognisable accident sequence” (Reason 1990). Research by the HSE (1992) found that many of the preconditions of unsafe behaviour originate in poor management decisions or an organisational culture in which health and safety goals may be considered subordinate to production goals. This research also noted that “violations are known to occur more frequently in situations where responsibilities are ambiguous or ill-defined, training poor and time pressures high – not atypical conditions for the construction industry.”

g) Constraint-Response Theory

Suraji, Duff and Peckitt (2001) of University of Manchester Institute of Science and Technology (UMIST) and the Health and Safety Executive in the UK, developed a causal model specific to construction accidents. They cite Reason’s model as a theoretical description but note the lack of specific detail necessary to guide practical investigation and intervention – “the effective mitigation of causal factors requires better knowledge of which factors are most influential, who may reasonably be expected to control those factors and how such control may most effectively be achieved” (Suraji, Duff and Peckitt, 2001).

Similar to Reason’s model, the Constraint-Response Model extends the scope of the accident causation process to include management and organisational aspects. The model classifies two types of factors – distal and proximal, equivalent to latent and active failures in Reason’s configuration – see Figure 3.

**Distal factors** are at management level and include
- Project conception restraints;
- Project design constraints; and
- Project management constraints

**Proximal factors** operate at site management and injured person levels and include
- Inappropriate construction planning;
- Inappropriate construction control;
- Inappropriate site condition;
- Inappropriate construction operation; and
- Inappropriate operative action

**Figure 3: Suraji, et al. (2001) – Accident Causation Model**
The premise of the theory is that each participant experiences constraints on their activity such as a client facing difficulties in obtaining funding. The responses to these constraints in turn create a set of constraints for subsequent participants. For example, a client may reduce the project budget such that the designer is constrained by inadequate design budget. The designer may respond by reducing the design resources for the contract. The project management team may in turn be constrained by the late delivery of the design detail, and so on throughout the project chain. The sequence of constraints and responses ultimately create situations where the proximal factors are manifest such as ‘unsuitable existing topography’ (inappropriate site conditions) or inadequate supervision of operative work (inappropriate construction control).

Both theories offer a framework in which to locate the contributory factors that may be identified in this exploratory study. They represent a systemic approach to identifying the underlying causes of accidents, taking into account decisions and actions upstream of the accident event. The models also facilitate the description of accidents with multiple causes at various levels. While Reason (1990) presents a generic model, Suraji et al (2001) have tailored the model to include actors and conditions relevant to the construction sector.

3. RESEARCH DESIGN

A comprehensive review of construction related accidents was done using the accident database of one of the divisions within a large energy utility in Southern Africa, where major capital expansion is being undertaken, of approximately 150 billion ZAR (about $25 billion) over the next 5 years.

The period of review was 1 April 2006 to 21 December 2007, where 1321 accidents (first aid, medical and lost time incidents) were reported and recorded. Graph 1 illustrates the distribution of the various types of accidents that have occurred during this period. A random sample was then drawn using systematic random sampling, where an accident was randomly chosen and then every 15th accident was selected in order to obtain 10 accidents for selection and analysis for this exploratory study.
4. FINDINGS AND DISCUSSION

The final 10 selected accidents for this study were analysed in terms of the actual causes identified and recorded during their investigation, namely immediate, contributory and root causes and then the analysis was compared to the seven theories of causation, previously described. The theories were annotated as shown in Table 1 for easy reference and comparison.

Table 1: Annotation of Theories of Causation

<table>
<thead>
<tr>
<th>Theory</th>
<th>Focus In Terms of Accident Causation</th>
<th>Annotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident Proneness Theory</td>
<td>On the worker</td>
<td>A</td>
</tr>
<tr>
<td>Goals-Freedom-Alertness Theory</td>
<td>On the worker</td>
<td>B</td>
</tr>
<tr>
<td>Adjustment Stress Theory</td>
<td>On the worker</td>
<td>C</td>
</tr>
<tr>
<td>Chain of events (Domino theory)</td>
<td>On the worker</td>
<td>D</td>
</tr>
<tr>
<td>Distractions Theory</td>
<td>On the worker</td>
<td>E</td>
</tr>
<tr>
<td>Reason’s Framework for Accident Causation</td>
<td>Active Failures - associated with the activities of the ‘front-line’ operators</td>
<td>FA</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>Latent Failures - associated with Head Office and Site Management levels</td>
<td>FL</td>
</tr>
<tr>
<td>Constraint-Response Theory</td>
<td>Distal factors are at management level and include Project conception restraints; Project design and Project management constraints;</td>
<td>DP</td>
</tr>
<tr>
<td></td>
<td>Proximal factors operate at site management and injured person levels</td>
<td>GP</td>
</tr>
</tbody>
</table>

The comparison of causes is indicated in Tables 2 and 3.
Table 2: Comparison of the Causes of 10 Randomly Selected Construction Accidents to the Various Causation Theories

<table>
<thead>
<tr>
<th>Accident No.</th>
<th>Accident Description</th>
<th>Construction Accident Data – Actual Causes Identified from Investigation Reports</th>
</tr>
</thead>
</table>
| 1            | Construction of Transmission tower. Injured worker was using a size 30 spanner to tighten bolts on the monopole (T186/187) for the attachment of ladder units, when the spanner he was working with snapped and he fell forward onto the structure and his ribs struck one of the extended bolts of the ladder unit causing bruising of the ribs and pain. | Direct Cause/s: 1] Incorrect/inadequate tool (D; F^A; G^P)  
Contributory Cause/s: 1] Lighting (D; F^A; G^P)  
2] Visibility (D; F^A; G^P)  
3] Footing (D; F^A; G^P)  
4] Ventilation (D; F^A; G^P)  
5] Temperature (D; F^A; G^P)  
6] Noise level (D; F^A; G^P)  
7] Clearances (D; F^A; G^P)  
Root Cause/s: 1] Failure of a hand tool (D; F^A; G^P) |
| 2            | The injured worker was busy breaking down a concrete plinth with a jack-hammer. In the concrete there were three steel reinforcing rods standing upright. The jackhammer slipped from the area where the injured worker was working. | Direct Cause/s: 1] Jackhammer slipped (D; F^A; G^P)  
2] Reinforcing was in the way when the jackhammer slipped  
Contributory Cause/s: None identified  
Root Cause/s: 1] Inadequate risk analysis conducted (D; F^A; G^P)  
2] Inadequate method statement (D; F^A; G^P) |
<table>
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<tr>
<td>3</td>
<td>The injured worker and workers A and B were in the process of inserting a drill rod (4.2m long) into one of the booms of a 2 boom Seco Drill Rig. While the injured worker and worker A were feeding the drill rod through the guides and as the end of the rod approached the Drifter (Chuck), worker B engaged the Drifter, as this would have locked onto the rod and the rod would commence rotation. Worker B shouted, “stop” assuming that the injured worker and worker B will stop pushing the rod and stand clear, which worker A did do, however the injured stopped pushing the rod, but still held on to the rod. As the rod started rotating, the injured’s glove became snagged on the rod and he shouted, but before worker B could disengage the Drifter, the injured worker’s arm had been twisted to such an extent that his shoulder was dislocated.</td>
<td>Arm lodged in moving machinery (D; F(^A); G(^P))</td>
<td>Deviation by individuals (A; D; F(^L); G(^P))</td>
<td>Inadequate identification of critical safe behaviours (D; F(^L); G(^P))</td>
</tr>
<tr>
<td>4</td>
<td>While pulling down on the damper blade, the Fitter pushed against the scaffold toe-board with his one foot to support himself, causing the kick-plate to dislodge and fall down, landing on the injured’s left foot, causing a fracture.</td>
<td>A falling scaffold toe board (D; F(^A); G(^P))</td>
<td>None identified</td>
<td>Hazards not identified correctly by scaffold builders and Contractors personnel as far as the scaffold is concerned (D; F(^A); G(^P))</td>
</tr>
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</table>

FA; FA; GP; FL; GP; \(D; F\(^A\); G\(^P\)\); \(D; F\(^L\); G\(^P\)\); \(D; F\(^A\); G\(^P\)\)
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| 5          | The injured worker was part of a team working on the Boiler steam drum refurbishment. On the specific morning this team was instructed to perform housekeeping tasks to clean the area where they were working. In the process of moving some of the baffle plates, to stack it next to a work bench, the injured worker stepped on top of previously stacked material. (Uneven plates with protruding steel brackets.) As he stepped away from the stack of plates his foot got caught on one of the protruding brackets and he fell on the floor (grating). He twisted his ankle causing him to collapse and hit his hip on one of the protruding flanges. He sustained a fractured hip. | 1] Improper stacking. The injured did not adhere to proper stacking process and procedures *(A; D; F^A; G^P)*  
2] Improper positioning: Taking up unsafe position, the injured worker was fully aware of the protruding bracket from the baffle as he participated in the stacking process *(A; D; F^A; G^P)* | 1] Hazardous arrangement or lay out - Poor stacking and housekeeping in working area *(D; F^A; G^P)*  
2] Personal factors: There was a lack of concentration on the part of the injured. He did not comply with safety awareness | 1] No proper risk assessment conducted before they could remove the steel material *(D; F^A; G^P)*  
2] Inadequate supervision: The supervisor failed to respond to the Client’s request to stack steel material and barricade area two weeks prior to the incident *(D; F^I; G^P)* |
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| 6           | The injured worker who was conducting inspections, was standing on a scaffold platform at 46m level. The scaffold platform gave way, resulting in the worker falling through 4 platforms (where there was openings), approximately 12m, where he finally landed on the platform at 35m level. | 1] Injured was not wearing safety harness (A; D; F\(^A\); G\(^P\))  
2] No risk assessment (D; F\(^A\); G\(^P\))  
3] Supervisor not there to supervise job (D; F\(^L\); G\(^P\)) | 1] No risk assessment (D; F\(^A\); G\(^P\))  
2] No training on fall protection (D; F\(^L\); G\(^P\))  
3] Insufficient lighting (D; F\(^A\); G\(^P\))  
4] Modified scaffolding to install Spring supports on the main steams (D; F\(^A\); G\(^P\)) | 1] No supervisor on site to do site workplace risk assessment (D; F\(^L\); G\(^P\))  
2] Unsafe scaffolding (D; F\(^L\); G\(^P\))  
3] Injured worker did not stop going up the scaffolding even though he could see that the scaffolding was unsafe (D; F\(^A\); G\(^P\)) |
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<td>7</td>
<td>The injured worker was inter-connecting a bank of eighteen 12 volt batteries under the direct supervision of his supervisor. Later in the day, 2 contractor employees from another company entered the battery room and asked the supervisor what they were doing. The injured worker, turned to greet the contractor employees and in doing so, touched an open terminal of another battery with the bare end of the interconnecting cable, thus creating a temporary short circuit across 6 batteries. The flash resulted in 1st degree burns of 2 fingers and 2nd degree burns of 3 fingers of his left hand.</td>
<td>1] Loss of concentration due to distraction (A; B; D; E; F⁴; G⁴) 2] Lack of adequate training in handling distractions (D; F⁴; G⁴) 3] Lack of sufficient experience (D; F⁴; G⁴)</td>
<td>None identified</td>
<td>1] Failure to secure work area (D; F⁴; G⁴)</td>
</tr>
<tr>
<td>8</td>
<td>While busy with the marking of the roof bolts at the exploratory tunnel for a pump storage scheme project, the Bolter Technician and a Team Leader were stuck by a rock (800mmx500mmx100mm) that came loose from the hanging wall, hitting the Bolter Technician on the head, and the Team Leader on his left shoulder.</td>
<td>None identified</td>
<td>None identified</td>
<td>1] Inadequate work standards – The current procedure requires the operator to make the hanging and the face safe, before marking of the roof bolts, forcing him to work under unsupported roof (D; F⁴; G⁴) 2] Inadequate Leadership and Supervision – The current system could not demonstrate that leadership is actively participating in the hazard identification and risk assessment process (Planned Task</td>
</tr>
<tr>
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<td>Root Cause/s</td>
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| 9           | Installation of a Latchway unit at a transmission tower: Worker A climbed up the tower and was followed by the injured worker. Worker A had to loosen the step bolt so that the bracket that holds the Latchway cable could be installed between the step bolt’s nut and the member. Due to the way that the step bolts were tightened, by the previous team, worker A could only loosen the nut of the step by using a hammer. After the step bolts were loosened, worker A took one of the brackets out of his bag, for installation. As he removed the bracket, the hammer had caught onto the bracket in the bag. The hammer then fell and bounced off a lower step bolt and struck the injured worker in his left eye. | 1] Taking unsafe position; (A; D; F; G)
2] Using unsafe equipment (Equipment was not attached to harness) (D; F; G) | None identified                                                                 | 1] Deviation from requirements (D; F; G)
2] Taking unsafe position (A; D; F; G)
3] Using unsafe equipment (equipment not attached to harness) (D; F; G) |
| 10          | The crew was busy rigging a clean gas chamber inside the precipitator into its final position. The chamber has a mass of 14.5 ton and was rigged by two 10 ton chain blocks.                                                                 | 1] Mechanical failure of chain block (D; F; G)  
2] Inadequate Planning - The planning was not comprehensive (D; F; G) | 1] Inadequate Planning
1] Inadequate Program Standards - The elements of the contractor were not clearly defined (D; F; G) |
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<tr>
<td></td>
<td>blocks which were hand operated by the crew. The crew consists of two teams of six people each who in turn operated the two chain blocks. The crew were standing on top of the clean gas chamber with their safety harnesses tied onto two 2, 5 ton electric hoists and crawls which are independent of the main structure. When the chamber was ±300mm from its final position, one of the chain blocks failed. The chain block that failed was in use for the first time after it was returned from a service provider where it had undergone servicing and a load test. The chamber fell and came to a standstill at an angle of ± 45°. The crew members were hanging from their safety harnesses and were lowered onto the chamber with the electric hoist. The most severe injury (compound fracture of the arm), was sustained by the person operating the chain block at the time of the failure. The rest of the injuries were sustained as the sudden (violent) movement of the falling chamber caused the people to pendulum swing from their harness lanyards, bringing them into contact with surrounding structures such as hand railing and scaffolding.</td>
<td>possibility of a chain block failing under these rigging conditions was very remote. Yet, the fact that people were required to work on top of a structure being lifted, the “What If” test could have been applied and back-up safety measures could have been in place (D; F^L; G^P) 2] Inadequate Job Analysis (D; F^L; G^P) 3] Inadequate Job Observation (D; F^L; G^P)</td>
<td>S.H.E plan such as risk assessments, method statements, and training etc is of an acceptable standard. The programme however does not cover items such as managing change and new tasks / jobs (D; F^L; G^P)</td>
</tr>
</tbody>
</table>
Table 3: Total number of Causation Theories per Type of Cause

<table>
<thead>
<tr>
<th>Causation Theories</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F^A</th>
<th>F^L</th>
<th>G^D</th>
<th>G^P</th>
<th>Total No. of Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Cause Number</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>17</td>
<td>1</td>
<td>14</td>
<td>4</td>
<td>1</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>Contributory Cause Number</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>22</td>
<td>1</td>
<td>16</td>
<td>6</td>
<td>0</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Root Cause Number</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>16</td>
<td>9</td>
<td>1</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Overall Total No. per Theory</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>64</td>
<td>2</td>
<td>46</td>
<td>19</td>
<td>2</td>
<td>63</td>
<td>65</td>
</tr>
</tbody>
</table>

It can be noted from Table 3, above, that out of a total of 65 causes, the following theories ranked, from highest to lowest: D, G^P, F^A, F^L, A, B, E, G^D, C. However, with specific focus on root causes, as it these causes that corrective active action are based on so as to avoid repeat accidents, the following theories ranked from highest to lowest: D, G^P, F^A, F^L, B, A, G^D, C, E.

An interesting observation can be seen with reference to Table 1, where theories A, B, C, D, E, F^A, and G^P are focused on the worker in terms of causation of accidents, with exception of theory G^P, whose focus ranges from worker to site management. Theories F^L and G^D focus on causal factors upstream of the project lifecycle model and failures at head office/site management. The findings in Tables 2 and 3 suggest that the accident investigators have categorised the causes of most of the accidents in terms of the worker being the agent. Further, there is no recorded evidence of management or organisational contribution. Rather, the “trigger event” is analysed.

Given that the intent of any accident investigation should be to prevent its recurrence, all root causes need to be investigated. Clearly the present system of accident investigation and recordkeeping focuses on the downstream event or the last domino in the chain. Arguably, this approach by only addressing the final trigger event will not prevent repeat accidents from occurring.

The authors argue, based on the evidence, that behavioural health and safety interventions, as part of a safety, health and environmental management system, would not necessarily prevent accidents. Rather they might reduce accidents but not prevent them. Considering that the ultimate goal for any construction stakeholder is to strive for zero accidents, any approach which does not prevent accidents is seriously flawed.
5. CONCLUSION

The findings suggest that the true causes of accidents are incorrectly recorded. Consequently it is likely that remedial interventions could be misdirected and as a result fail to prevent their reoccurrence. Therefore, a new approach to investigation is required. Possible restructuring of the investigation team and revision of the instrument used for investigation and recordkeeping are consideration for a new approach.

In line with modern theories of accident causation, which emphasise the importance of factors upstream of the accident event, it is proposed that future legislation and campaigns should focus on events and decisions made at the management level. The causes of failures suggest that remedial action at the early phases of a project lifecycle model could pre-empt errors further along the project lifecycle.

Time and thought invested at the start of a project lifecycle model, according to the HSE (2006), will pay dividends not only in health and safety, but also in:
- reductions in the overall cost of ownership;
- reduced delays;
- more reliable costings and completion dates;
- improved communication and co-operation between key parties; and
- improved quality of the finished product.

6. REFERENCES


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