A CONCEPTUAL CAUSATION MODEL BASED ON THE INCIDENT ROOT CAUSES

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1. INTRODUCTION

http://depletedcranium.com/were-steel-workers-really-this-reckless/

http://raclairedinc.com/about-us/safety/

Accidents are an issue in the construction industry in different countries such as USA, UK, China, Brazil (ILO, 2014; Bureau of Labour Statistics, 2014; Zou et al., 2007).

The incident rate for construction industry is 30% higher than for other industries (AWCBC, 2012).

Understanding incident causes is difficult due to project complexity.

(Wanberg et al., 2013; Hallowell, 2011; Mitropoulos et al., 2005)
1. INTRODUCTION

Accident Causation Models/Theories - Understand the factors and processes to develop strategies to avoid accidents

(Khanzode et al., 2012; McCabe et al., 2005; Brown et al., 2000)
2. PROBLEM DESCRIPTION

Complex system

Measure and control incident root causes

Incident root cause identification is subjective

Identify indicators to measure the root causes
3. OBJECTIVE

Develop a conceptual incident causation model to explain the causal diagram between the root causes and the site risk level.
4. METHODS

Case Study
- Identification of incident root causes
- Description
- Define indicators

Build conceptual models
- Company documentation
- Literature review

Hypothetical Simulation Model - System dynamics
- Empirical equations
- Model behavior
5. RESULTS

<table>
<thead>
<tr>
<th>Root Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hazard Identification and Control</td>
</tr>
<tr>
<td>2. Human Resources/Professional Development (HR/PD)</td>
</tr>
<tr>
<td>4. Leadership and Administration</td>
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<tr>
<td>5. Inspection and Audits</td>
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<tr>
<td>6. Orientation and Training</td>
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<tr>
<td>7. Site Specific Safety Plan</td>
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<tr>
<td>8. Communication Systems</td>
</tr>
<tr>
<td>10. Engineering</td>
</tr>
<tr>
<td>11. Procurement</td>
</tr>
<tr>
<td>12. Sub/Trade - Contractor Management</td>
</tr>
<tr>
<td>13. Environment</td>
</tr>
</tbody>
</table>
5. RESULTS

Root cause descriptions

- Hazard identification and control
- Orientation and training
- Leadership and administration

Worker characteristics that influence the identification and control of hazards

The orientation/training ability to transfer knowledge to the worker

Management attitudes that demonstrate commitment to safety
## 5. RESULTS

<table>
<thead>
<tr>
<th><strong>Root cause</strong></th>
<th><strong>Indicators</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard identification and control</td>
<td>Work shift; worker’s experience on the project; worker’s age</td>
</tr>
<tr>
<td>Leadership and administration</td>
<td>Management site inspection; participation in safety meetings</td>
</tr>
<tr>
<td>Orientation and training</td>
<td>Worker training hours; evaluation of workers’ learning of the course content</td>
</tr>
</tbody>
</table>
5. RESULTS

Conceptual model

3 Main loops:
R1: Site Condition
B1: Worker Knowledge
B2: Worker Intention

- Site Unsafe Conditions
- Worker Perception
- Worker Intention
- Worker Safe Behavior
- Schedule Pressure
- Congestion
- Accident
- Incident
- Site Risk Level
- Site Condition
- R1

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5. RESULTS

Both factors can increase the schedule pressure and affect the site conditions.

According to the company safety investigation, these factors affect the site conditions.

Accidents increase schedule pressure
Han et al. (2013), Mitropoulos et al. (2005)

Congestion increases workers’ exposure to struck-by or struck-against incidents (Fortunato et al 2012)
5. RESULTS

Meetings increase worker knowledge
CII, (2002)

Improvement of worker knowledge improves the perception
(Jiang et al., 2015)

Sharing incident investigations with workers can increase their knowledge
(Fortunato et al 2012)

Orientation and training

Safety Communication

HR/PD

Hazard Identification and Control

Worker Experience

Worker Perception

Worker Knowledge

Site Risk Level

Incident

Safety Investigation

Worker Safe Behavior

Worker Knowledge

B1

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5. RESULTS

Fatigue can make workers take shortcuts  
(Alvanchi et al., 2009)

Schedule pressure decreases management commitment  
(Mitropoulos et al., 2005)

Management commitment affects the safety climate  
(Chinda and Mohamed 2008)
5. RESULTS

Complete conceptual model

- Site Unsafe Condition
- Site Risk Level
- Schedule Pressure
- Crew Size
- Design
- Error
- Rework
- Safety over Schedule
- Work Overload
- Safety Climate
- Worker Experience
- Worker Perception
- Worker Knowledge
- Fatigue
- Safety Climate
- Sub-Contractor Management
- 3rd par commitment with safety
- Material not attend the safety specifications
- Schedule delay in deliver
- Crew Size
- Site Unsafe Condition
- Standard Operating Procedures
- Error
- Rework
- Schedule Pressure
- Worker Safe behavior
- Fatigue
- 3rd party commitment with safety
4 scenarios

Changing one root cause each time
- Environment
- Training
- Inspection and audits

Changing all root causes
- 1 and 0.1

Time: 90 days

Empirical Equation
5. RESULTS

Environmental effects on site risk level

Training effects on site risk level
5 RESULTS

**Inspection and audit effects on site risk level**

- **Site Risk Level**
  - Days: 0 20 40 60 80 100
  - Site Risk Level: 0 5 10 15 20 25 30
  - Lines: 1, 0.5, 0

**Influence of root causes on site risk level**

- **Site Risk Level**
  - Days: 0 20 40 60 80 100
  - Site Risk Level: -40 -20 0 20 40 60
  - Lines:
    - All Root causes = 1
    - All root causes = 0.1
5. RESULTS

Root cause indicators can affect the site risk level.

Root causes should be improved concurrently.

Root cause indicators can be further investigated.

6. CONCLUSION

Can improve the data type collected during the incident investigation and on a daily basis

Different parts of the company affect the site risk level

Conceptual model built to identify relationships, not to predict incident

Other types of simulation can be used
7. ONGOING RESEARCH

- Identify the main root causes and indicators for industrial construction
- Validate the relationship between the indicators and the site risk level
- Build simulation models combining discrete and continuous simulation
THANK YOU!!

QUESTIONS??

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