Knowledge-Based Competencies Necessary for the Frontline Construction Supervisor:

Improving Safety through Knowledge

by

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Evaluating supervisor competency levels has been a management challenge since the beginning of supervisory roles in the construction process. Supervisors perform a critical role in the workplace with respect to workplace safety and health. Supervisors are the driving component of the operational aspects of management systems and often convey messages from upper level management directly to line level work force. As a supervisor serves as a liaison for the line level work force, it is vitally important supervisors have a clear understanding of his roles and responsibilities within his organization. As upper level management strives to improve the safety record of an organization, the supervisor must be valued as a key component of an organizations struggle to help establish a proactive safety culture. The issue presents itself when the true level of supervisor competency cannot be determined by management. The purpose of this paper is to identify the key knowledge-based competencies that are suggested to be the most important to the construction supervisor with respect to improving construction site safety performance.

Knowledge-Based Competencies Necessary for the Front-Line Construction Supervisor: Improving Safety through Knowledge

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CHAPTER 1: BACKGROUND

Impacting construction site safety is a difficult and multi-dimensional task. Influences on eventual site safety develop from multiple sources. Often the responsibility for construction site safety is handed down from upper level management to the line level or site supervisor/foreman (Swuste, Frijters&Guldenmund, 2012). Early work by Hinze (Hinze& Gordon, 1979; Hinze& Parker, 1978) demonstrated that the foreman's attitude towards safety programs and the psychological environmental they create positively impacts injury rates. Recently, research during the London 2012 Olympics construction projects revealed that supervisor competence enhanced effective site safety practices and is a key to border construction industry impact (Cheyne, Finneran, Hartley & Gibb, 2011).

The Occupational Safety and Health Administration's (OSHA) 30-hour Construction outreach class is a hazards-based class and is intended to provide a variety of training to workers with some safety responsibility (OSHA, 2011). Recently, Nevada state law (NRS 618.983) now requires all construction supervisors must complete the OSHA 30-hour Outreach Training within 15 days of hire and renewal of every 5 years (NRS 618.983). The Center for Construction Research and Training (CPWR) recommends the OSHA 10-hour training as a baseline standard for workers and that all supervisors and on-site management possess the OSHA 30-hour training (The Center for Construction Research and Training, 2012).

Literature supports the importance of the supervisor to construction site safety and health performance. However, the supervisors' necessary competencies are not clear. For example, Cheyne et al. (2011) report that "supervisors need technical, interpersonal and communication skills", but the details of these competencies are not described. This is the point of departure for our research and its contribution. When management has a clear understanding of what knowledge base is necessary for the supervisor to possess in order to improve safety performance, efforts can then be centered on the necessary training and educational methods to strengthen that knowledge base. The purpose of this research is to identify the necessary knowledge based competencies that are most important for the front

line construction supervisor. In this study a comprehensive list of knowledge based competencies was developed from a literature review and tested against a panel of construction safety experts. The end result shows the top fifteen (15) knowledge based competencies selected by the expert panel. This paper provides insight to management of construction organizations by helping to better understand what knowledge is required of line level supervisors/foreman to possess in order to improve job site safety.

CHAPTER 2: REVIEW OF THE LITERATURE

Competencies

A site supervisor/foreman, for the rest of this paper, will be referenced as "supervisor"; supervisor is defined as one who serves an organization as a planner, organizer, and facilitator of daily construction management systems (Shohet&Laufer, 1991). The importance of the construction supervisor for proper implementation of safety and health programs on construction sites has long been given attention (for example, Huang et al., 2004; Hoffmann &Morgeson, 1999; Peterson, 1999; Hinze & Gordon, 1979; Hinze & Parker, 1978).

Early research by Hinze and Gordon (1979) revealed that, if safety programs are to be effective, the psychological environment of worker must be considered; they emphasize the important role of the supervisor in attaining this and recommend training for supervisors to develop managerial style congruent with enhancing the psychological environment. Hinze (1981) also found that supervisors that openly showed respect for workers and incorporated their suggestions also had safer work crews. Shohet&Laufer (1991) found that enhanced planning by the construction foreman/supervisor leads to improved productivity (and they specifically included safety) at the construction site. Lingard, Cooke, &Blismas, (2009) found that supervisors are more likely to have a significant impact upon safety, compared to top managers and safety managers.

The state of Nevada defines the "Supervisory employee" as "Any person having authority in the interest of the employer to hire, transfer, suspend, lay off, recall, promote, discharge, assign, reward or discipline other employees or responsibility to direct them, to adjust their grievances or effectively to recommend such action, if in connection with the foregoing, the exercise of such authority is not of a merely routine or clerical nature but requires the use of independent judgment" (NRS 618.967, 2012).

A supervisor/foreman serves an organization as a planner, organizer, and facilitator of daily construction management systems (Shohet&Laufer, 1991; Peterson, 1999). It has been said that the line level supervisor is the key driver of work place safety and has both the responsibility and authority to

manage the safety of the line level workforce (Huang, Chen, Krauss, and Rogers, 2004; Hoffmann&Morgeson, 1999; Peterson, 1999; Hinze& Parker, 1978). Several factors, such as knowledge, skill, experience, training, etc., build the level of competency in the construction supervisor(Mohamed, 2002; Peterson, 1999) Many times the responsibility of construction site safety is handed down from upper level management to the line level supervisor/foreman (Swuste, Frijters, &Guldenmund, 2012; Peterson 1999).

Today's supervisors have many tasks to perform. As part of middle management, it may be the supervisor's responsibility to train the line level employees on work related processes, company procedures, and to notify and educate employees about prevalent hazards in the work place (Odiorne, 1991). A line level supervisor may need todirectly perform work related tasks in efforts to improve productivity, or improve productivity indirectlythrough administrative procedures and controls(Murugappa&Sirinvasan, 2007). In today's construction industry the supervisor serves as a liaison between the workers and upper level management (Murugappa&Sirinvasan, 2007). As an administrative liaison, it is the supervisor's responsibility to report all safety related hazards, incidents, and near misses to upper level management (Peterson, 1999).

With management's commitment to workplace safety and health, the supervisor has the potential to become the driving force of an organizations safety culture (Peterson, 1999; Hinze, 1981). High management commitment is a key dimension of safety climate (Flin, Mearns, O'Connor,&Bryden, 2000). Safety culture/climate and management commitment to safety related issues address the larger scope of decreasing an organizations incident rate(Michael, Guo, Wiedenbeckt& Ray, 2006).

The literature focused on identifyingknowledge-based competencies that are necessary for the front-line construction supervisor/foreman. Some of the competencies identified through the literature are more closely related to attributes and personal skills while others are closely related to the technical aspects of construction work. *Table 1.0*lists the non-technical knowledge-based competencies that are

necessary for the supervisor/foreman as identified from peer reviewed literature. Each of these competencies isdiscussed in the following paragraphs.

Table 1.0 *– List of non-technical knowledge-based competencies (See paragraph(s) Below)*

Knowledge-Based Competencies
1. Establishing effective communication
2. Leader member exchanges
3. Knowledge of routine/non-routine work tasks
4. Knowledge and application of effective team building skills
5. Assessing employee stress levels
6. Setting worker tasks and responsibilities
7. Disciplinary procedures and conflict resolution
8. Job planning and organization of work flow
9. Methods of safety promotion

Establishing Effective Communication

Effective safety communication possesses the potential to have a positive effect on safety performance within an organization(Burke, Smith-Crowe, Salvador & Chan-Serafin, Smith, &Sonesh2011;Torner&Pousette, 2009; Dinsdag, Biggs &Sheahan, 2008; Leather, 2007; Hopkins, 2005; Edum-Fotwe&McCaffer, 2000; Langford, Rowlinson, &Sawacha, 2000; Hoffman and Morgeson 1999; Peterson, 1999; Simard&Marchand, 1994;Odiorne 1991). It has been stated "Only when employees talk of safety as an overriding priority in an organization, can an organization be considered to have a proactive safety culture" (Hopkins, 2005, p. 11). It would be safe to say that in order for an organization to have a proactive safety culture and talk of safety as an "Overriding priority," the organization must have effective safety communication throughout all levels of the management systems (Hopkins, 2005). Odiorne (1991) suggests that employee's safety related performance should increase when the supervisors explain all operating procedures and consequences of unsafe behaviors; and when there is organizational commitment to continually improve work processes and to reduce risks to a reasonable level among affected employees.

Leader Member Exchanges

Exchange relations between employees and supervisors are vitally important to the safety performance of an organization (Swuste et al., 2012; Burke et al., 2011; Lingard, Cooke, &Blismas, 2009; Torner&Pousette, 2009; Dinsdag et al., 2008;Edum-Fotwe&McCaffer, 2000; Hoffman and Morgeson 1999; Peterson, 1999;Simard&Marchand, 1994; Odiorne 1991; Hinze, 1981).Hofmann&Morgeson (1999) states that "If an organization attempts to demonstrate that it values and cares for its workers, employees should perceive that management would be open to the raising of safety concerns."Supervisors must strive to establish positive exchange relations among employees in efforts to improve job performance, job satisfaction, and safety performance (Michaelet al., 2006). Huang et al.(2004) and Hofmann and Morgeson (1999) suggest when positive exchange relationships are established between line level employees and supervisors, workers may be more willing to follow safety related policies and procedures leading to fewer injuries in the workplace.

Knowledge of routine/non-routine work tasks

Lingard, Cooke, &Blismas (2009), Mitropoulos &Cupido(2009),and Manuele(2008)suggest that high numbers of accidents occur when non-routine work tasks, requiring high levels of energy, are being performed. The implementation of a pre job planning and initial hazard analysis is the key to preventing serious accidents that occur due to unusual and non-routine work (Manuele, 2008). This pre job planning and initial hazard analysis is to be done before the work commences, occupational safety and health hazard exposures are to be assessed, and operational changes should be planned for ahead of time (Manuele, 2008).

Knowledge and application of effective team building skills

In the construction industry, management selects and appoints supervisors to be the leaders of the work crew(Peterson, 1999). It is vitally important that the supervisor build a positive atmosphere in which his employees work (Swuste et al., 2012; Lingard, Cooke, &Blismas, 2009; Peterson, 1999; Hinze, 1981). A positive atmosphere will decrease group tension and will help create a willingness to consider new

ideas that may help establish a mindset of safety on the job (Swuste et al., 2012; Lingard,Cooke, &Blismas, 2009; Peterson, 1999; Hinze, 1981). Several team-building skills can have a positive effect on building a pleasant atmosphere for employees to work in (Swuste et al., 2012; Lingard, Cooke, &Blismas, 2009; Peterson, 1999; Hinze, 1981).

Assessing Employee Stress Levels

Job related stress has the potential to create worker negligence, carelessness, ignorance, and lack of attention to the work tasks being performed (Hinze& Parker, 1978). Worker stress can come from both on and off the job pressures and should be noticed by the line level supervisors (Hinze& Parker, 1978). Work related on the job pressures primarily arise from conflicting job demands, extreme time pressures, and poor basic rates of pay along with worker incentives for maximizing productivity by cutting corners and risk taking (Leather, 2007; Langford et al., 2000). A former study performed by Hinze& Parker (1978) suggest that safety and productivity do not conflict on construction sites and that job sites under less productivity pressures from upper management have a lower incident rate. Stress level assessment of the line level workforce is an important tool for the supervisor to possess in the context of increasing job satisfaction and improving employee safety behaviors (Mitropoulos and Cupido, 2009; Leather, 2007; Huang et al., 2004;Edum-Fotwe&McCaffer, 2000;Peterson, 1999; Hinze, 1981).

Setting worker tasks and responsibilities

It is especially important that the supervisor be competent in the methods of setting worker tasks and responsibilities in a matter that his operating line can be the most effective (Michael et al., 2006; Hoffman and Morgeson, 1999; Peterson, 1999;Odiorne 1991). Mitropoulos and Cupido (2009) suggest assigning experienced construction crews the more demanding and challenging tasks as a way to help improve both productivity and safety performance. Setting worker tasks and responsibilities is a key component to increasing the safety performance of the line level work force (Murugappa&Sirinivasan, 2007; Michael et al., 2006; Hoffman and Morgeson, 1999; Peterson, 1999;Odiorne 1991).

Disciplinary procedures and conflict resolution

One disrespectful and non-professional attempt at a behavioral/performance change has the ability to crush the positive atmosphere of a workplace (Peterson 1999). This being said, it is important for the supervisor to understand the correct and ethical way to reprimand employees for their unsafe actions. Treating an employee as a person rather than a number is the best way to achieve effective employee discipline (Peterson, 1999).Conchie, Taylor & Charlton (2011) andOdiorne(1991)suggests that a supervisor must also facilitate relationships between employees and must possess the authority and knowledge of understanding disruptive behaviors in workers in order to resolve conflict and discipline when necessary.

Job planning and organization of workflow

Failure to plan ahead for daily work activities creates conditions that can be detrimental to the safety performance of line level workers(Mitropoulos and Cupido, 2009; Peterson 1999). For this reason it is important that supervisors manage the progression of both work flow and work related tasks (Leather, 2007). A study conducted by Sohet and Laufer (2006) found that US construction supervisors spent 36.9% of their time dealing with planning and coordination of workflow.The supervisors are the individuals who are expected to be proficient in solving problems within the work related tasks on construction sites (Peterson, 1999; Odiorne, 1991).Planning reduces confusion with respect to both routine and non-routine work tasks that can put employees in error provocative situations (Mitropoulos and Cupido, 2009).“*If the design of the work place or work methods is error provocative, you can be sure that human errors will occur*” (Manuele, 2008, p. 71).

Methods of Safety Promotion

The way that supervisors promote safety within their organization shows the supervisors true commitment to safety (Lingard, Cooke, &Blismas, 2009; Leather, 2007; Huang et al., 2004; Peterson 1999). A study performed by Gillen, Baltz, Gassel, &Vaccaro (2002) found that when workers perceived less support from the supervisor, the job site was thought to be less safe. When supervisors actively participate in safety policies (ex. personal protective equipment, enthusiasm during safety training, and

commitment to hazard abatement) they are demonstrating the organizations commitment to safety and help build a culture within the organization that places safety as an overriding priority (Peterson 1999). It is important for organizations to act in a matter that portrays their commitment and support of workplace safety and health (Lingard, Cooke, &Blismas 2009; Leather, 2007; Huang et al., 2004; Peterson 1999).

Effective Training

Building an understanding of potential hazards, OH&S requirements,andknowledge of the hazard abatement process is vitally important for job site safety (Dinsdaget al., 2008). In order for supervisory training to be truly effective it must target specific competencies that will increase the safety culture of the organization as a whole (Dinsdaget al., 2008). Examples of specific training that have the potential to increase safety culture are communication, risk control, work task/process planning, and leader/member exchange training (Dinsdaget al., 2008). Professional competence in safety is a combination of acquired knowledge through training and experience (Edum-Fotwe&McCaffer, 2000). Since the training of the supervisors from upper level management normally contains no safety component, many organizations may have supervisors with little or no knowledge of construction site safety (Dinsdag et al., 2008). The issue associated with a lack of supervisory knowledge is that, supervisors may enforce work related safety policies but may miss the safety principles than need to be integrated into the training to have an effective proactive safety culture (Dinsdag et al., 2008).

Definition of Competent

American National Standards Institute/American Industrial Hygiene Association (ANSI/AIHA) Z10-2005: The American National Standard for Occupational Health and Safety Management Systems, states that “Competence is normally achieved or demonstrated through one or more of the following: education, training, mentoring, experience, certification, licensing, and performance assessment” (American Industrial Hygiene Association & American National Standards Institute, 2005).

The Occupational Safety and Health Administration (OSHA) defines a competent person as "One who is capable of identifying existing and predictable hazards in the surroundings or working conditions

which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them" (OSHA, 2012).

OSHA Outreach Training

The OSHA 30 Hour Outreach training is taught by government trainers and is more in depth than the 10 Hour certification course and is intended for personnel with supervisory authority over workplace safety and health(Occupational Safety and Health Administration [OSHA], 2011). This outreach course covers OSHA policies, procedures, and standards, as well as construction safety and health principles (OSHA, 2011). The training objectives of the 30 Hour Outreach Trainingincludes scope and application of the OSHA construction standards*29 CFR 1926*, special emphasis being placed on the recognition, avoidance, abatement, and prevention of workplace hazards (OSHA, 2011).OSHA states that the 30 Hour Outreach Training does not meet the training requirements for any OSHA standard but suggests that the training is a method of contributing to the body of knowledge of those workers with supervisory authority (OSHA, 2011).

Since 2008, Massachusetts state law requires all workers on publicly funded project to complete the OSHA 10 Hour Outreach Training program (The Center for Construction Research and Training, 2012).The Center for Construction Research and Training (CPWR) suggest that the OSHA 10 is a "baseline" standard for worker training and further suggest that all supervisors and on site management possess the OSHA 30 training (The Center for Construction Research and Training, 2012).

Currently Nevada state law requires all workers to complete the OSHA 10 Hour Outreach Training and all construction supervisors must complete the OSHA 30 Hour Outreach Training (NRS 618.983State of Nevada, 2012). Both workers and supervisors must complete the training within 15 days of hire and renewal of 30 Hour Card every 5 years (NRS 618.983State of Nevada, 2012).

Topics of Outreach Training

Below, in (Table 2.0), is the list of the training topics covered through the OSHA 30 Hour Outreach training course.

Table 2.0 *– Topics of OSHA 30 Hour Outreach Training (OSHA, 2011)*

1. Introduction to OSHA	2. Electrical Hazards
3. Fall Protection	4. Struck By
5. Caught In Between	6. Stairs and Ladders
7. Health Hazards in Construction	8. Concrete and Masonry
9. Cranes, derricks, hoists, elevators, conveyors	10. Steel Erection
11. Managing Safety and Health	12. Hand and Power Tools
13. Fire Protection and Prevention	14. Welding and Hot Work
15. Personal Protective and Lifesaving Equipment	16. Signs, Signals and Barricades
17. Material Handling, Storage, Use, and Disposal	18. Scaffolding
19. Excavations	20. Powered Industrial Vehicles
21. Contractors Safety and Health program	22. Ergonomics
23. Motor vehicles, mechanical equipment and marine operations; rollover protection structures and overhead protection	

Literature supports the importance of the supervisor to construction site safety and health performance. However, the supervisors' necessary competencies are not clear. This is the point of departure for our research and its contribution. When management has a clear understanding of what knowledge base is necessary for the supervisor to possess in order to improve safety performance, efforts can then be centered on the necessary training and educational methods to strengthen that knowledge base. The purpose of this research is to identify the necessary general knowledge based competencies that are most important for the front line construction supervisor. This paper provides insight to management of construction organizations by helping to better understand what knowledge is required of line level supervisors/foreman to possess in order to improve job site safety. What has been identified through this study is that the OSHA 30 Hour card should not be considered the "defacto" for the knowledge base of a supervisor with respect to controlling construction safety and health risks. There are other managerial and interpersonal competencies that can be taught through traditional educational methods (i.e. classroom,

hands-on, job site training) that can strengthen the knowledge base of the supervisor. Nevada and Massachusetts should consider this study's findings with respect to their current policies and other states should consider this researches' finding when considering options such as Nevada and Massachusetts.

CHAPTER 3: METHODS

Identifying the Research Question

Following a comprehensiveexamination of peer reviewed literature focused onthe topics that aid to the knowledge base and strengthen the competence of a construction supervisor/foreman with respect to improving the safety performance of a constructionsite, a list of ideal knowledge-based competencies for the construction supervisor/foreman has been developed. Following the development of this list, the research question was identified as follows: "What are the most importantknowledge-basedcompetencies for the construction supervisor/foreman with respect to improving construction site safety performance."The findings through this study will add to the body of knowledge by determining which knowledge-based competencies that construction managers should look for in their supervisors when either hiring a new supervisor or increasing the knowledge base through safety training.This study will also help determine the strength that the OSHA 30 Hour Cards knowledge based training topics have on the underlying factors of incident causality.This study tests the knowledge based training topics covered in the OSHA 30 Hour Course against the most important knowledge-based competencies identified by a panel of construction safety experts. The knowledge-based competencies that are identified through this study are thought to be the most important competencies for a front-line supervisor to possess in order to improve safety performance.

Due to the large list of factors that make supervisors competent to manage safety on construction sites, this study focuses only on knowledge-based competencies that can be addressed through training (i.e. classroom, hands on, or a combination thereof that is to be administered to the supervisor/foreman in efforts to build a better understanding of managing safety related to the topic being addressed through the training session).Below, Table3.0 contains thecomprehensive list of knowledge-based competencies, as found from the literature review along with each accompanying sources(s).

Table 3.0*Comprehensive list of knowledge-based competencies*

Competency – Supervisors are to be competent in the following topics	**Source**
1. Establishing effective communication	(Burke, Smith-Crowe, Salvador & Chan-Serafin, Smith, &Sonesh2011;Torner&Pousette, 2009; Dinsdag, Biggs &Sheahan, 2008; Leather, 2007; Hopkins, 2005; Edum-Fotwe&McCaffer, 2000; Langford, Rowlinson, and Sawacha, 2000; Hoffman and Morgeson 1999; Peterson, 1999; Simard&Marchand, 1994; Odiorne 1991). Odiorne (1991)
2. Establishing positive leader/member exchanges	(Swuste et al., 2012; Burke et al., 2011; Lingard, Cooke, &Blismas, 2009; Torner&Pousette, 2009; Dinsdag et al., 2008; Michael et al, 2006; Huang et al., 2004; Edum-Fotwe&McCaffer, 2000; Hoffman and Morgeson 1999; Peterson, 1999;Simard&Marchand, 1994; Odiorne 1991; Hinze, 1981)
3. Knowledge of routine/non-routine work tasks	(Lingard, Cooke, &Blismas, 2009; Mitropoulos &Cupido, 2009; Manuele, 2008)
4. Knowledge and application of effective team building skills	(Swuste et al., 2012; Lingard, Cooke, &Blismas, 2009; Peterson, 1999; Hinze, 1981).
5. Assessing employee stress levels	(Mitropoulos and Cupido, 2009; Leather, 2007; Huang et al., 2004;Edum-Fotwe&McCaffer, 2000; Langford et al., 2000; Peterson, 1999; Hinze, 1981; Hinze& Parker, 1978)
6. Setting worker tasks and responsibilities	(Mitropoulos and Cupido, 2009; Murugappa&Sirinivasan, 2007; Michael et al., 2006; Hoffman and Morgeson, 1999; Peterson, 1999;Odiorne 1991)
7. Disciplinary procedures and conflict resolution	Conchie, Taylor & Charlton2011; Peterson, 1999;Odiorne, 1991)
8. Job planning and organization of workflow	(Mitropoulos and Cupido, 2009; Manuel, 2008; Leather, 2007; Sohet and Laufer, 2006; Peterson 1999; Odiorne, 1991)
9. Methods of safety promotion	(Lingard, Cooke, &Blismas 2009; Leather, 2007; Huang et al., 2004; Gillen, Baltz, Gassel, &Vaccaro, 2002; Peterson 1999)
10. Understanding of OSHA policies/concepts	(OSHA, 2011)
11. Knowledge an application of electrical hazards	(OSHA, 2011)
12. Knowledge and application of fall protection	(OSHA, 2011)

13. Identification of "Struck by" hazards	(OSHA, 2011)
14. Identification of "Caught in between" hazards	(OSHA, 2011)
15. Health hazards in construction	(OSHA, 2011)
16. Managing safety and health	(OSHA, 2011)
17. Contractors safety and health program	(OSHA, 2011)
18. Personal protective and lifesaving equipment	(OSHA, 2011)
19. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Stairs and ladders**"	(OSHA, 2011)
20. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Concrete and masonry**"	(OSHA, 2011)
21. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Cranes, derricks, hoists, elevators, conveyors**"	(OSHA, 2011)
22. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Steel erection**"	(OSHA, 2011)
23. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Hand and power tools**"	(OSHA, 2011)
24. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Fire prevention and protection**"	(OSHA, 2011)
25. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Welding and hot work**"	(OSHA, 2011)
26. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Signs, signals, and barricades**"	(OSHA, 2011)
27. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Materials handling, storage, use, and disposal**"	(OSHA, 2011)
28. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Scaffolding**"	(OSHA, 2011)

29. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Excavations**"	(OSHA, 2011)
30. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Powered industrial vehicles**"	(OSHA, 2011)
31. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Ergonomics**"	(OSHA, 2011)
32. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Motor vehicles, mechanical Equipment and marine Operations; Rollover protection structures and Overhead protection**"	(OSHA, 2011)

Delphi Technique

The Delphi technique is a structured and interactive process for gaining the consensus of a panel of industry experts on a particular topic (Hallowell&Gambatese, 2010). This technique utilizessurvey basedresearch that is administered through subsequent rounds of data collection that include controlled and anonymous feedback. In this study, survey based questionnaireswere delivered to a panel of industry experts that wassystematically formed to best answer the proposed research question based on pre-determined criteria for panel member selection. The purpose of the Delphi technique, utilized in this research project, is to allow the panel of experts to review the opinions of their counterparts from previous rounds in efforts to reduce the variability of future rounds and meet a predetermined level of consensus as a group (Hallowell&Gambatese, 2010).

Hallowell &Gambatese (2010) suggested that the Delphi process is concluded after a predefined criterion (number of rounds or the achievement of consensus). Holey et al. (2007) found that "There is no general agreement in the literature that defines specific criteria to use to determine when consensus has been achieved, i.e. when to stop a Delphi study. Evidence on the evaluation of Delphi consensus is limited; researchers have not yet described how to determine when an exact level of the consensus is reached in Delphi." In order to ensure an adequate level of strictness placed on the panel members with

respect to coming into consensus, the predetermined level of consensus for this study was set at 80%. Smith et al. (2011) used a consensus level of 80%.

Due to the complex and challenging nature of construction, engineering, and management research, in which scientific methods of quantitative data collection may not be applicable, the Delphi Technique is suitable to gather answers to survey and brain-storming based research techniques (Hallowell&Gambatese, 2010).In survey research, bias can surface due to a number of factors. When individuals within a group are allowed to converse about the study, bias may potentially harm the results of the study when trying to get the panel members to agree on a particular issue (Hallowell&Gambatese, 2010). The Delphi technique, best addresses this type of bias by eliminating dominant influence of particular panel members participating in the study (Hallowell&Gambatese, 2010). Dominant influence is controlled in the Delphi process by having the panel members remain anonymous throughout the entire research project (Hallowell&Gambatese, 2010).

Selection of panel members

Once the research question was identified, the next phase of the project was to identify and assemble the panel of industry experts to participate in the study. The Delphi technique differs from other forms of survey based research because research participants must meet a pre-determined level of criteria to be involved in Delphi studies (Hallowell&Gambatese, 2010). "*In the Delphi process the most important facet of a panel member is their level of expertise*" (Hallowell&Gambatese, 2010, p. 101).In efforts to assure a healthy balance of academic and professional experience and ensure that panelists have distinguished themselves as experts in construction safety and health, predetermined criteria for panel member selection was required of potential panel members in order to participate in the study. This pre-determined expertise requirements placed on participants allows the study to be generalizeable to the safety and health sector of the construction industry. Panel member selection is very important with respect to ensuring that the results of the study are generalizeable to the safety and health sector of the construction industry. Because of the wide use of technology among

environmental, safety, and health professional's; social media was thought to be the best method available of identifying potential experts that best suited the projects goals.

In order to gain access to construction industry professionals and a potential unbiased pool of experts, efforts were placed into invitations being delivered through the *American Society of Safety Engineers Construction Practice Specialty*list serve on LinkedIn.com. The group had over 2900 members in August 2012. An original posting stating "*Attention Construction Safety Experts: Research Opportunity*" was posted along with a brief project description and a link to cloud server storage. Contained in cloud server storage was aninvitation document, located in *Appendix A.* This invitation document described the project goals, project definitions, participant qualification requirements, participant expectations, project timeline, submission instructions, and contact information. Potential panel members were asked to download the document from the cloud server to their computers hard drive, answer the questionnaire that outlined the qualifications for participation, re-save the document to their computers hard drive, and email the completed document to the researchers personal email address using the subject line of "*Invitation Letter*." A two-week time frame was allotted to gather the expert panelmembers before other options were to be considered.

For this study, a points system is used for the classification of expertsdue to the fact that it allowed for some flexibility with respect to both academic and field experience. Both academic experience and field experience are vital to the application of the final study results. The Delphi process addresses this potential issue with a well rounded panel of experts that will review the groups' collective opinion about the research topic. This point system is based on the relative time commitment required to successfully complete each of the achievements or experiences and is based on the best judgment of the writers and practices of professional licensing agencies (Hallowell&Gambatese, 2010). In order to meet a minimum level of qualification using the point system shown, it is suggested that panelists score at least one (1) point in four (4) different

achievement or experience categories and possess a minimum of eighteen (18) total points in order to qualify for participation.Hallowell&Gambatese (2010) suggests that participants score eleven (11) points using this qualification system. In efforts to keep this study specificto the construction industry there was a requirement that panel members have a minimum of seven (7) years professional experience in the construction industry (i.e. Seven (7) years' experience relating to, suitable for, or engaged in the construction industry).Setting prequalification requirements at eighteen (18) total points allows this research project to fit both the requirements of Hallowell&Gambatese (2010) and the minimum of seven (7) years professional experience. Therefore to participate the participants must score eighteen (18) total points to meet the prequalification requirements.

Number of Panelists

Previous research studies suggest using 10-12 panelists for Delphi studies (Hallowell&Gambatese, 2010). For the course of this study, fourteen (14) panelistswere utilized in efforts to account for a potential two (2) paneliststo dropout from the study. In order to be fair to all potential expert participants, the first fourteen (14) applicable candidates that submitted the invitation letter within the two-week time frame were selected and the posting was removed from LinkedIn.com.Table 4.0 describes the point system utilized for distinguishing expertise in the field of Occupational Safety and Health in the construction industry.

Table 4.0 *Criteria for selection of expert panel members. Note study requirement of construction industry experience*.

Achievement or Experience	**Points (Each)**	**My Point total**
Years of professional experience	7 (minimum of 7 points)	
Professional registration such as Professional Engineer (PE), Licensed Architect (AIA), Certified Safety Professional (CSP), Associated Risk Manager (ARM)	3	
Invited to present at a conference	0.5	

Member of a nationally recognized committee	1	
Chair of a nationally recognized committee	3	
Peer-reviewed journal article (Primary or Secondary Writer)	2	
Faculty member at an accredited university	3	
Writer/editor of a book	4	
Writer of a book chapter	2	
Advanced Degrees:		
BS (Civil engineering, CEM, Occupational Safety, or other related fields)	4	
MS (Civil engineering, CEM, Occupational Safety, or other related fields)	2	
Ph.D. (Civil engineering, CEM, Occupational Safety, or other related fields)	4	
TOTAL		

Panel Member Demographics

In the two weeks following the original posting on LinkedIn.com, fourteen (14) social media users responded to the posting and submitted their document containing their completed qualification questionnaire. Of the fourteen (14) responses, 100% of total respondents' met the predetermined qualification requirements and wereclassified as constructionsafety industry experts for the purposes of claiming expertise to participate in this study, and according to Delphi technique literature in the construction industry. The posting was then removed from LinkedIn.com and personal emails were sent back to all fourteen (14) panel members as a thank you for their agreement to participate along with "Round 1" of the study. The following *Tables(5.0, 6.0,& 7.0)*show the demographics of the group members.

Table 5.0 *Average points based on categories of experience*

Category of Experience	Number of participants within this category	Average # Points
Years of professional experience per participant	14	26.18
Participants holding professional registration such as Professional Engineer (PE), Licensed Architect (AIA), Certified Safety Professional (CSP), Associated Risk Manager (ARM)	12	3.79
Participants invited to present at a conference	13	3.46
Participants who are an active member of a nationally recognized committee	12	1.29
Participants that are an active chair of a nationally recognized committee	5	2.14
Participants who author peer-reviewed journal article (Primary or Secondary Writer)	4	2.29
Participants serving as a faculty member at an accredited university	2	0.43
Participants who are a writer/ editor of a book	1	0.29
Participants who are a writer of a book chapter	1	0.14
Participants holding BS (Civil engineering, CEM, Occupational Safety, or other related fields)	11	3.14
Participants holding MS (Civil engineering, CEM, Occupational Safety, or other related fields)	9	1.29
Participants holding Ph.D. (Civil engineering, CEM, Occupational Safety, or other related fields)	2	0.57

Table 6.0 *Percentage based on educational level*

Category of Experience	Percentage
Percentage of participants holding no post secondary education	21.43%
Percentage of participants holding BS (Civil engineering, CEM, Occupational Safety, or other related fields)	78.57%
Percentage of participants holding MS (Civil engineering, CEM, Occupational Safety, or other related fields)	64.29%
Percentage of participants holding Ph.D. (Civil engineering, CEM, Occupational Safety, or other related fields)	14.29%

Table 7.0 *Average years of experience among educational levels*

Educational level	Average Years of Experience
Participants holding no post secondary education	32.0
Participants holding BS (Civil engineering, CEM, Occupational Safety, or other related fields)	24.6
Participants holding MS (Civil engineering, CEM, Occupational Safety, or other related fields)	25.4
Participants holding Ph.D. (Civil engineering, CEM, Occupational Safety, or other related fields)	22.8

Table 8.0 *Demographics of the panel members' construction sector.*

Industry Sector	Count	Count
Construction Industry Consultation	4	28.57%
Commercial/Industrial Construction	4	28.57%
Industrial Mechanical Fabrication/Installation	1	7.14%
Water Treatment/ Waste Water Treatment Facility Construction	1	7.14%
Construction Safety and Health Training Services	1	7.14%
No Response from Participant	3	21.43%

Round 1

In effortsto answer the research question and identify the most important knowledge-basedcompetencies for the frontline supervisor/foreman with respect to improving job site safety performance, participants were asked to reducethe comprehensivelist of knowledge-based competencies to a reasonably attainable number during the first round of data collection. During "Round 1"participants were asked to select twenty (20) of the thirty-two (32) available knowledge-based competencies. "Round 1" is located in *Appendix A*.

Twenty (20) out of thirty-two (32) was the number requested that the panelists select due the statistical values of the available knowledge-based competencies for selection. Almost 60% of the total potential selections fall under the knowledge-based competencies from the peer reviewed literature along with 40.62% of the total potential selections encompassing the list of OSHA 30 Hour Outreach Training topics. Selecting twenty (20) out of thirty-two (32) competencies allows for a 62.5% chance of each potential variable being selected. With twenty (20) possible selections allowed, participants were forced

to make a decision based on a "cost benefit" approach. Participants had to weigh the cost and benefit of each potential selection in efforts to make a judgment about the most important twenty (20) knowledge-based competencies. Having a close to 50/50 split of highly technical (OSHA 30 Hour topics) and more managerial/personal competencies (Competencies from literature), participants were forced to select competencies from either source or a combination of the two. Participants were not asked to order rank the selections because of the impracticality and burdensomeness the request would have placed on participants. The purpose of the research was therefore not to rank competencies.

The comprehensive list of knowledge-based competencies, included in *Table 2.0*,was randomized in efforts to control bias.Personal emails were then sent to each participants email address along with "Round 1" that included definitions, survey instructions, project schedule, survey questionnaire, submission instructions, and researcher contact information. Participants were allotted a two-week time frame to complete the document. Two reminder emails were sent out at seven (7) and ten (10) days. Participants were asked todenoteeach of their individual twenty (20) selections by placing an "X" into the column beside each of the chosen selections and were also asked to provide a brief 1-2 sentence explanation of each selection. These explanations for each selection were complied and used as feedback in efforts to allow the groups collective insight to weigh in on the individual perspectives of participants during "Round 2."By administering controlled feedback,the variability of future responses throughout upcoming "Rounds (2-3)"decreased and allowed the group to come closer to the target consensus.

Round 1 Result

The results from "Round 1" show the upper twenty (20) knowledge-based competencies selected by the expert panel.As shown in *Table 8.0*; four (4) competencies were selected 100% of the time, one (1) was selected 92.86%, four (4) 85.71%, three (3) 78.57%, one (1) 71.43%, four (4) 62.49%,two (2) 57.14%, and one (1) selected 50.00% of the time amongst all panel members. *Figure 2.0* shows a graphical representation of the "Round 1" results along with the relationship of the four-way tie.The four-way tie is a tie for individual competencies that were selected 62.49% by all panel members and is

particularly important for the implementation of "Round 2." Since all four of these knowledge-based competencies hold the same value in percent chosen they must all be included in the upcoming round(s).

As part of the Delphi process, participants were asked to provide a brief 1-2 sentence explanation for each variable selected. A listing, located in *Appendix C*, contains each of the competencies selected by the expert panel and displays each comment/feedback that was received along with the corresponding selection.

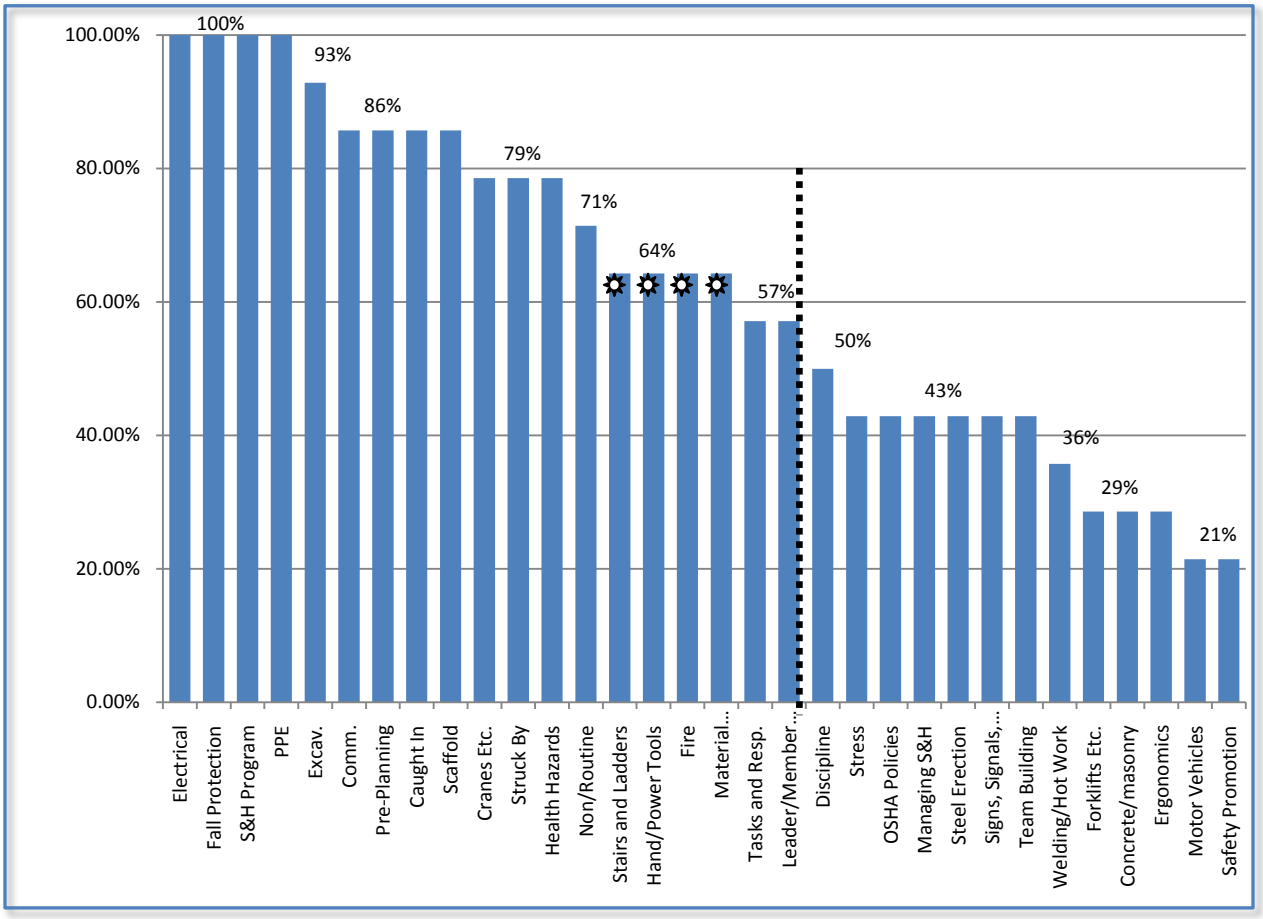

Figure 1.0– *Competencies selected by percentage (shown high to low percentage of selection).The dashed line denotes the upper twenty (20). The asterisks (*) show the relationship of the four-way tie. The four way tie relationship is particularly important to the implementation of 'Round 2."*

Table 9.0 *– Upper twenty (20) knowledge-based competencies selected in "Round 1" with accompanying percentages of selection.*

Number of Times Selected	**Upper fifteen (15) knowledge-based competencies**
14	12 - Knowledge and application of electrical hazards 13 - Knowledge and application of fall protection 18 - Knowledge of their contractors safety and healthprogram 19 - Knowledge of use and selection of personal protective and lifesaving equipment
13	30 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Excavations***"
12	2 - Establishing effective communication 9 - Knowledge of effective pre job planning and the organization of daily workflow 15 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Caught in Between***" hazards 29 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Scaffolding***"
11	7 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Cranes, derricks, hoists, elevators, conveyors***" 14 - Competent in hazard identification, avoidance, control and prevention "***Struck by***" hazards 16 - Knowledge of managing health hazards in construction
10	4 - Knowledge of routine/non-routine work tasks
9	1 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Stairs and ladders***" 5 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Hand and power tools***" 11 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Fire prevention and protection***" 28 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Materials handling, storage, use, and disposal***"
8	24 - Setting worker tasks and responsibilities 25 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Welding and hot work**"
7	8 – Job planning and the organization of workflow

Round Two

The purpose of "Round 2," was to have the panel members narrow down the list from twenty (20) knowledge-based competencies to fifteen (15) in no specific order. In "Round 2" participants had to eliminate five (5) competencies that were previously selected in "Round 1." During "Round 2," collective feedback of the group was vitally importantfor panelist to utilize with regard for making this determination and was used in efforts to allow participants to review anonymous counterparts' decisions regarding their reasoning's for selecting specific competencies. Fifteen (15)out of thirty-two (32) was the number requested that the panelists select due the statistical values of the available knowledge-based competencies for selection. Fifteen allowed for a fair chance of each competency to be chosen.

During this round, the comprehensive list of knowledge-based competencies from "Round 1," was restructured in efforts to reflect the results of "Round 1" and allow the panelist to better understand which knowledge-basedcompetencies were most important based on the collective insight of the group. This was accomplished by arranging each selection by its order of importance, from the top down. The competencies that had the highest percentage of selection by the panel members were placed at the beginning of the list, and followed down the listing in descending order of selection."Round 2" included project definitions, survey instructions, project schedule, the graphical representation of the values based on the completion of "Round 1," anonymous feedback, submission instructions, and contact information. Participants were allowed a two week time frame to complete the document. Two reminder emails were sent out at seven (7) and ten (10) days.

During "Round 2," panel members were asked to review the compilation of feedback along with graphical representation of the values based on the completion of "Round 1"and were asked to denote each of their fifteen (15) selections by placing an "X" into the column beside each of their individual selections. Panelists were also asked to provide a brief 1-2 sentence explanation for each selection only if the collective insight from the group caused the panelist to change his/her mind about a particular decision. During "Round 2," there was a space allotted for text entry that was auto formatted within the

listing to underline the text when the panelist gave feedback in "Round 2." This was done in efforts to differentiate the feedback between rounds "1 & 2." The results, including feedback, were to be the basis for each panelist decision regarding the selection of the upper fifteen (15)knowledge-based competencies again in "Round 3."

Round 2 Results

During the two-week time frame following the implementation of "Round 2," all potential participants completed the questionnaire. As the results show, the collective insight of the group did in fact persuade individuals' decisions in "Round 2" and has tightened the level of the groups' consensus. With the Delphi technique, the process is complete when the study reaches target consensus (Hallowell&Gambatese, 2010). There are two methods to determine the "Consensus" of the group (Hallowell&Gambatese, 2010). Both "Stability" and "Target Consensus" are used to make this determination (Hallowell&Gambatese, 2010). "Stability" is based on the percent of change of variables within the top fifteen competencies between two subsequent rounds and "Consensus" is measured by averaging the percent chosen values of each competency within the final top fifteen selections (Hallowell&Gambatese, 2010). The results of "Round 2" show that the group is 93.6% "Stable" with a "Consensus" level of 95.23%. Two (2) competencies were selected 100% of the time, three (3) 92.31%, three (3) 84.62%, three (3) 76.92%, four (4) 69.23%, and one (1) competency was selected by 61.54% of all participants. The results of "Round 2" are shown below in *Figure 3.0.*Comments from "Round 2" are written in underlined font and located in *Appendix C.Table 9.0 shows the competencies selected in "Round 2" and their accompanying percentages.*

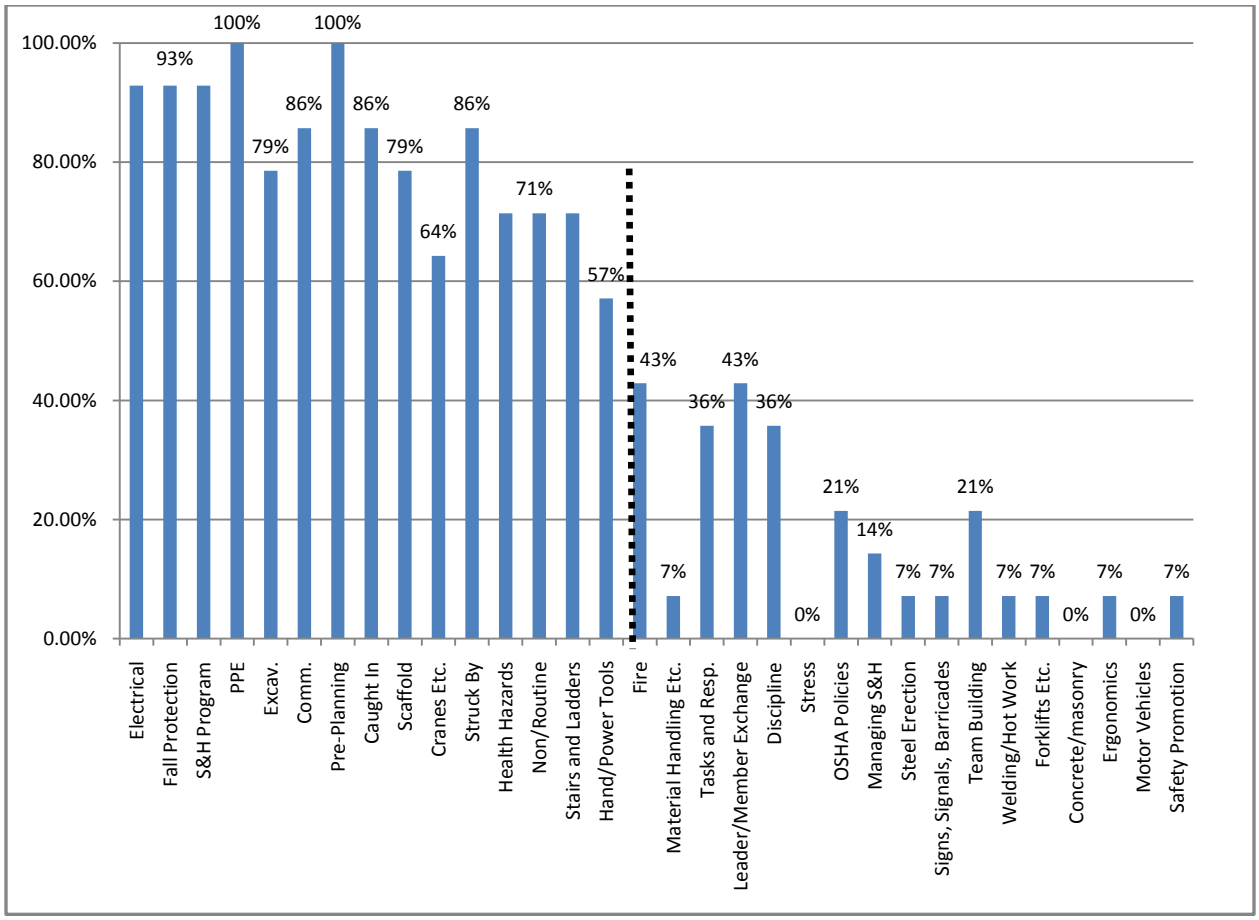

Figure 2.0 *– Competencies selected by percentage. (Values are arranged in the order as shown from "Round 1" results for consistency and to better show the movement in percent chosen of each variable.)The dashed line denotes the upper fifteen (15).*

Table 10.0 *– Upper fifteen (15) knowledge-based competencies selected in "Round 2" with accompanying percentages of selection.*

Percent Selected	Upper fifteen (15) knowledge-based competencies
14	19 - Knowledge of use and selection of personal protective and lifesaving equipment 9 - Knowledge of effective pre job planning and the organization of daily workflow
13	12 - Knowledge an application of electrical hazards 13 - Knowledge and application of fall protection 18 - Knowledge of their contractors safety and health program
12	15 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Caught in Between***" hazards 14 - Competent in hazard identification, avoidance, control and prevention "***Struck by***" hazards 2 - Establishing effective communication

11	29 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Scaffolding***" 30 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Excavations***"
10	7 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Cranes, derricks, hoists, elevators, conveyors***" 16 - Knowledge of managing health hazards in construction 4 - Knowledge of routine/non-routine work tasks 1 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Stairs and ladders***"
9	11 - Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Fire prevention and protection***"

Other Questions

Having already met the consensus requirements post "Round 2," other questions were thought to be of importance with respect to the application of this study. T*able 10.0* shows three questions that were asked post "Round 2". For the purpose of future research, participants were asked to give comments on the Delphi process and lessons learned through this research project. Participants were also asked to give their professional opinion on whether or not they consider the OSHA 30 Hour Outreach Training to be sufficient knowledge-based training for the line level supervisor.

Table 11.0*Other questions asked*

Questions Utilized in Round 3
Comments about the "Delphi" process and lessons learned?
Do you consider the OSHA 30 Hour Outreach Training/Card to be sufficient knowledge-based training for the front-line construction supervisor? Please answer yes or no and provide reasoning.

Participation took a slight downturn when the final two questions were asked. Several reminder emails were sent out in the three weeks following implementation of the third round. Eleven (78.6%) of the 14potential panelists responded to other questions. Participants were asked to gather information on the thoughts of the Delphi Technique as viewed from the expert panel. This information will be particularly beneficial to future researchers to whom may wish to utilize the Delphi

technique.Participants' were asked to provide a brief 1-2 sentence comment about their opinions of the Delphi technique and lessons they (the participants) learned through the study.

Eleven of the fourteen participants unanimously agreed that the Delphi process is applicable to Construction, Engineering, and Management research. Participants said that it was good to be able to see the judgments of their anonymous counterparts and that the feedback helped them come to consensus. Participants expressed value in clear communication about project goals and expectations. Panelists saw the Delphi process to be a beneficial way to summarize and prioritize things based on multiple professional's opinions and experience. .

In efforts to attempt to gain insight on the panel members opinion about the OSHA 30 Hour Card being an industry standard, panelists were asked to give comment on their opinion of whether or not they considered the OSHA 30 Hour Card to be sufficient knowledge-based safety training for the front-line construction supervisor.

Eleven of the fourteen participants that responded to the question unanimously agreed that the OSHA 30 Hour Outreach Training is necessary, but is only baseline knowledge-based training for the construction supervisor. All twelve participants consider the training to be good for the supervisor to possess, but agree that there are others that must be incorporated into the training for the training to be effective at educating the supervisors on the root causes of workplace accidents (i.e. effective communication, pre job planning, and non routine work). Participants' stated the following in the questionnaire:

No. 30 hour is only basic general knowledge that should be required of every supervisor. Need full understanding of safety program and site-specific safety plans.

No. It solves the compliance side not the overall quality of leader. OSHA 30 should be part of every supervisor though,

Yes and no. In addition to the technical knowledge provided thru 10-30 hr training, supervisor must have training to direct and manage those she/he supervises.

CHAPTER 4: CONCLUSIONS AND DISCUSSION

The role of supervisory management is vital to both safety and productivity of a construction sites line level workforce. Through this study, a predetermined level of consensus was established among the expert panel with regard to the fifteen most important knowledge-based competencies for the front-line supervisor/foreman to possess in efforts to improve construction site safety performance.Panel experts also reached an agreement regarding the 30 Hour OSHA Card as being an important training tool for the supervisor but suggest that it is only a minimum for knowledge-based supervisory safety training. Meeting the intended research goals, this study has provided guidance on necessary competencies relating to work/task specifics, job planning, organizing of workflow, establishing effective communication, and a knowledge of routine and non routine work tasks as being vitalknowledge-based components of training that have the potential to improve the safety performance of a construction site.

Throughout this research, bias and group influence were both minimized in efforts to strengthen the validity of the study. The data from the resulting final survey questionnaires are only as strong as individual panel member commitment to completing each questionnaire. If research participants simply picked randomly or blindly at values, rushed because of time constraints, or had inadequate instruction and/or expectations, the completed questionnaires would lack true professional judgment and therefore bias would result. The consequences of minimizing bias in this study make the results valid to the construction industry. The results of this research should be given consideration when trying to develop knowledge-based training programs for construction supervisors/foremen. Involving the competencies identified throughout this research study has the potential to increase a construction sites safety performance.

The primary strength of this study was the anonymity of the expert panel members throughout the research, clear guidance and instruction, and adequate time allowed for the completion of each round. This anonymity reduced dominant influence and helped minimize the desire for harmony within the panel of experts that has the potential to override true professional judgment. Keeping all research participants

anonymous also allowed all opinions to be stated as desired because professional colleagues have no way to determine "who said what" in the feedback section of the study questionnaires. During this study, conflicting arguments arose in which some participants disagreed strongly with other participants about specific competencies. However, participants also freely expressed agreement about others. These agreements and disagreements helped influenceother participants both towards and away from selecting specific competencies in future rounds. Proof of this is identified in the tightening of both stability and consensus between rounds one and two.The results of "Round 2" show that the groups' final results are 93.6% "Stable" with a "Consensus" level of 95.23%.

The primary weakness of this study lies in the bias of the invitational methods of the panel members. In this research study, the expert panel was assembled from one social media source. Although social media is a great channel to gain access to construction industry experts for participation in research studies, multiple channels should be used in efforts to obtain research participants. This study only obtained the judgments of construction industry experts that utilized a singular social media site and, as designed, had little opportunity of reaching other construction industry experts that, for unknown reasons, do not participate in the social media used. In efforts to better control bias, multiple sites on LinkedIn.com could have been useful along with other means of outreach into the construction industry that would have allowed for a broader panel of construction safety experts.

Future researchers are encouraged to utilize the Delphi approach to meet research goals that require obtaining consensus based results. An interesting outcome of this study was the drop in participation after the implementation of the second round of the study. The number of participants dropped from fourteen (14) to eleven (11) (22.4%) in the third round of subsequent data collection along with an increase in turnaround time of the third round. It is important that there be adequate participation in future Delphi studies to account for a high dropout rate after the third round. This dropout rate may be related to either participant's personal commitment or disinterest. Although personal and conflicting commitments cannot be controlled by the researcher, it is suggested that efforts be placed on all

communication being clear and concise with respect to what is being requested. Clear and concise information/direction allows participants to be able to participate with minimal confusion about project goals and expectations and has the potential to minimize disinterest among participants.

Nevada state law requires construction supervisors to obtain a 30 Hour OSHA card based. The 30 Hour OSHA Card, as identified through this Delphi study, is not sufficient knowledge-based training for the construction supervisor. Research participants viewed the 30 Hour Card as a minimum that should include training to strengthen communication, leadership, and problem solving skills. Furthermore, the 30 Hour OSHA Card should not be allowed as the prerequisite for new employees taking on roles and responsibilities relating to managing workplace safety and health issues. Many undergraduate construction management college curriculums include the OSHA 30 Hour card as a prerequisite to graduation. Gambatese (2003) surveyed construction and civil engineering programs and found an emphasis on OSHA regulations; the OSHA 30-hour certification is earned in 61% of the courses, while OSHA 10-hour certification is earned in 28% of the courses. As a standard construction industry practice students are often placed into roles of safety and health management upon college graduation. It is especially important to understand that the industry's standard practice of considering the 30 Hour Card as prerequisite into safety management is only the minimum for knowledge-based training and must be improved.

In conclusion, this project has contributed to the body of knowledge by obtaining necessary knowledge-based competencies that should be incorporated into knowledge-based supervisory training aimed at strengthening the competency of the frontline construction supervisor/foreman. As with most research, the findings uncover other questions only to be answered by future research. It would be useful to perform a study that identifies the most important knowledge-based competencies for the construction supervisor through the judgment of the line level workforce. When management understands the needs of the line level workforce, management can tailor the safety management systems of an organization to encompass an equal mix of efforts that have the potential to affect all levels of the workforce. Utilizing

results from such a study, emphasis may be place on blending the judgments of both construction safety experts and the line level workforce. This could help understand whether or not there exists a gap between the perceptions of both workers and construction safety experts with respect to the research topic. Furthermore, it would be of value to evaluate which knowledge-based competencies construction supervisors/foremen feel are most important with respect to improving the safety performance of construction sites under their daily supervision.

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APPENDIX A

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **www.ecu.edu/irb**

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: Dylan Hardison
CC: Michael Behm
Date: 5/18/2012
Re: UMCIRB 12-000571
Evaluating Supervisor/ Foreman Competency: A Delphi Study

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 5/17/2012 to 5/16/2013. The research study is eligible for review under expedited category #7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

The approval includes the following items:

Name	Description
Appendix A.docx | History	Recruitment Documents/Scripts
Letter of Invitation and Consent | History	Consent Forms
Round 1.docx | History	Surveys and Questionnaires
Supervisor safety.docx | History	Study Protocol or Grant Application

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418 IRB00004973
East Carolina U IRB #4 (Behavioral/SS Summer) IORG0000418

APPENDIX B

Dear Future Research Participant,

My name is Dylan Hardison and I am a graduate student in the Occupational Safety Program at East Carolina University under the guidance of Dr. Michael Behm. I am currently conducting research in fulfillment of a Master of Science in Occupational Safety. I am currently searching for participants to assist with my graduate research entitled: "Evaluating Supervisor/ Foreman Competency: A Delphi Study."

ANSI/AIHA Z10-2005: The American National Standard for Occupational Health and Safety Management Systems, states that "Competence is normally achieved or demonstrated through one or more of the following: Education, training, mentoring, experience, certification, licensing, and performance assessment" (AIHA, 2005).For the purpose of this study, supervisor/foreman will be defined as any individual, on the jobsite, to whom responsibility and authority is given over the workers in efforts to meet the production demands set by upper level management. The objective of this study is to determine the most desirableknowledge-based competencies for the construction supervisor/foreman based on the judgment of an expert panel. This research will utilize input provided by an expert (Delphi) panel. I am currently searching for professionals and academics that have experience in construction safety to serve as experts and provide their insights and opinions.

Requirements of the panel members will include the following:

Action	Time Commitment	Turn-around
Intro/Participation	5-10 minutes	2 weeks
Round 1 Input (Begin first of April)	20 minutes	3 weeks
Round 2 Input (Begin middle of April)	15 minutes	3 weeks
Round 3 Input (Begin first of May)	15 minutes	3 weeks

Unlike many research methods, the Delphi approach requires the strict dedication of the members. Member default can have detrimental impacts on the study. The total time commitment for participation on the panel should be less than 60 minutes over the course of 2 ½ months.

A two week response period is allotted for each round and one week down time will be allotted between each round for data collection, analysis, and feedback. A reminder will be sent out one week after the start of each round.

In efforts to assure a healthy balance of academic and professional experience and ensure that panelists have distinguished themselves as experts on thisparticular topic, a predetermined set of panel member criteria for selection must be met in order to participate in the study. Below in Table 1.0 lies a point system for distinguishing expertise in the field of Occupational Safety and Health expertise in the construction industry. This point system is based on the relative time commitment required to successfully complete each of the achievements or experiences and is based on the best judgment of the writers and practices of professional licensing agencies. In

order to meet a minimum level of qualification using the point system shown, it is suggested that panelists score **at least one point in four different achievement or experience categories and a minimum of 18 total points in order to qualify for participation**. In efforts to keep this study generalizeable to the construction industry there is a requirement that panel members have a **minimum of seven (7) years professional experience** in the construction industry (i.e. Seven (7) years experience relating to, suitable for, or engaged in the construction industry.)

Instructions: Download this word.docx to your computer's hard drive using the download button that will appear on the right side of the screen just above the document, complete the table, calculate your total number of points, resave to your computer's hard drive, and email the completed form to hardisond08@students.ecu.eduunder the subject line of "Participant Qualification".

Table 1.0*Participant qualification requirements*

Achievement or Experience	**Points (Each)**	**My Point Total**
Years of professional experience	1	
Professional registration such as Professional Engineer (PE), Licensed Architect (AIA), Certified Safety Professional (CSP), Associated Risk Manager (ARM)	3 (maximum of 6 points)	
Invited to present at a conference	0.5	
Member of a nationally recognized committee	1	
Chair of a nationally recognized committee	3	
Peer-reviewed journal article (Primary or Secondary Writer)	2	
Faculty member at an accredited university	3	
Writer/editor of a book	4	
Writer of a book chapter	2	
Advanced Degrees:		
BS (Civil engineering, CEM, Occupational Safety, or other related fields)	4	
MS (Civil engineering, CEM, Occupational Safety, or other related fields)	2	
Ph.D. (Civil engineering, CEM, Occupational Safety, or other related fields)	4	
TOTAL		

Please note that all individual responses will be kept confidential and will not be used for anything unrelated to this study. Summarized data will never identify individual participants. In appreciation of your participation, a summary of the findings will be provided when the study concludes.

I hope that you will be willing to serve on this panel and take an opportunity to provide your unique insight. If you have any questions about the study you may contact me or my advisor, Dr. Michael Behm, using the contact information provided below.

I appreciate your time.

Sincerely,

Dylan C. Hardison

Dylan Hardison
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APPENDIX C

Competency	Selection (Place X beside each selection)	Reasoning (This is a bulleted list of the groups collective reasoning for each competency previously selected in "Round 1." Each item is as written in the feedback of "Round 1")
19. Knowledge of use and selection of personal protective and lifesaving equipment		• Unanimous – we all agree. • Written into the Site Safety and Health Program are PPE requirements and use of lifesaving equipment, location of Urgent Care facilities, etc. The PPE is often our defense to reduce assigned/assumed risk to an acceptable level, and emergency response is necessary to have a Plan in place to get someone into the System in an expeditious manner. An Activity Hazard Analysis will help determine the selection, while supervision is required to train on Use, Maintenance, Storage and Disposal of PPE. • Minimal OSHA requirement • Effective choices not only of what but when PPE is required is an essential knowledge base for supervisors. • Construction doesn't always have ways to engineer, substitute, etc., so often PPE is only defense • General • Even though PPE is the last hierarchy of control, their use is critical to success. • We cannot engineer out all the hazards in this industry, therefore we rely heavily on PPE. Knowledge on the use and selection is paramount. • In order for it to protect people, the supervisor must spot when it is not used or used improperly. • Being able to select appropriate PPE and lifesaving equipment will foster accident prevention and can increase employee participation in the HSE programs provided that the supervisor seeks out employee feedback on selected equipment. • Unfortunately, this is, many times, the primary means of worker protection. • The front-line supervisor is often the primary or only source of information on the subject for many workers • This is required by law and is critical for enabling supervisors and employees to make good decisions and knowledge in how to protect themselves and others. • Critical responsibility requiring extensive experience and knowledge.
9. Knowledge of effective pre job planning and the organization of daily workflow		• Still think this is important • Especially with Government work, pre-planning is necessary. Whether looking ahead at a three-week, next week, or project completion, materials and coordination have to meet detailed and desired time frames for workflow and progress. We meet daily with all subs to discuss workflow, coordination, and any activity that may have safety

		implications. • Needs effective control of work practices for safety • Flow process, allocation of resources, flag critical elements • General • Effectively planning safety in to a project has shown to be one of the greatest accident prevention techniques utilized. • This is probably the most important factor in terms of safely management a job; workflow avoids conflict or incompatible activities. • Effective planning provides for a clearer sense of direction for all team members and will foster a better environment for managing risk • This is required to perform an adequate pre-task planning. • That knowledge allows supervisors to plan ahead for safety and health needs and requirements. • Key characteristic of front-line supervisor function, which can pre-empt many safety hazards. • Pre task hazard recognition and mitigation planning are key methods for preventing/reducing workplace injuries and incidents by ensuring both the worker and supervisor is involved in the processes
12.Knowledge and application of electrical hazards		• Unanimous – we all agree. • Minimal OSHA requirement • Focus 4 item as major cause of injury/fatality in construction • No live work, LOTO, outages, coordination of trades • General • Electrical hazards are not understood by very many supervisors in the field today and this needs to be improved on. • Electricity is a hazard, among the top fatal four. • High risk and high potential item that should be addressed pre-job and throughout job progression. • No matter what trade, this a serious issue, and foreman has to knowledge to control these hazards. • Part of what we call the "Big Four" causes of fatalities and citations. • One of OSHA's "focus four" hazards which account for high proportion of construction fatalities. • Second leading cause of death in construction… critical knowledge of both electrical safety practices, energized electrical work and NFPA 70E compliance are minimum requirements of supervisors… and one that most are not competent in. • Complex and high risk issue.
13. Knowledge and application of fall		• Unanimous – we all agree. • Minimal OSHA requirement

protection		• Focus 4 and leading cause of fatalities in construction • High hazard evaluation and competent involvement • General • Falls continue to be the leading cause of fatalities in the construction industry • Elevated falls – the leading cause of death in construction. Have to manage that properly. • High risk and high potential item that should be addressed pre-job and throughout job progression. • No matter what trade, this a serious issue, and foreman has to knowledge to control these hazards. • Part of what we call the "Big Four" causes of fatalities and citations. • One of OSHA's focus four hazards which account for high proportion of construction fatalities • Leading cause of death in construction and 100% preventable. Since the majority of fall victims today are wearing a harness, but failed to connect/tie off... with the root cause being the lack of supervisory enforcement and effective discipline for lack of compliance. • Complex and high risk issue.
18. Knowledge of their contractors safety and health program		• Unanimous – we all agree. • The seven items that make up the IIPP must be in the Sub Safety Manual, which is reviewed by Safety Manager and used by PM/SS to hold sub accountable per their own directives. • I did not select this one again because I believe the other skills and knowledge base are more important. As a General Contractor we have the ability to force the subcontractor to follow our safety program as a way to help mitigate the risk. • Company may have requirements beyond OSHA (best practices) • Essential to company-specific commitments and overall safety program. • Establishing partners in safety, especially with Multi-Employer laws • General • Provides basis and resource for training and monitoring work. • A project is only as safe as the weakest contractor onsite. A supervisor must know and be aware of the hazards that a subcontractor brings to the site • All managers need to know their own employers safety program. • Their contractor safety and health program provides a supervisor the roadmap related to his/her company policy, procedures and expectations. • This is the most critical aspect of any company safety

		program. • On most worksites, the (frontline) supervisors are responsible for compliance and enforcement of contractor's safety and health program. • Must know own S&H program to be effective and competent and to be able to convey to subordinates • This also almost didn't get checked as a good program and associated training in its contents is critical… however, as a safety consultant, I have found that the vast majority of safety plans are incomplete, unused and a CYA document for government compliance.
2. Establishing effective communication		• I decided to change to "effective communication" instead of my prior answer of 31 Team building, as team building could be considered a subset of communications. Good communication is critical to avoiding errors and mishaps on the jobsite • Communication is key. All the knowledge, education, and experience are not worth anything if you cannot share it. A policy on a shelf is a bookend, a policy communicated is a work ethic and policy. • Can't achieve safe work w/o communicating effectively w/workers • Ineffective safety communication leads to accidents • Organization, coordination, workflow/process, hazard ID • Communication is key for any industry and any professional in the workplace. • Clear, concise and effective direction should be given to any team member under ones authority. • Foremen are leaders and have to have good communication to ensure their crew follows them. • Ability to connect with the crew and for the crew to be comfortable with being honest in return is key to creating a safe work environment. • One of the keys to promoting a positive safety culture. • Ineffective communication from supervision to the work force of required safety procedures and expectations is a factor in many incident investigations and a factor in even more near miss incidents. • Necessary for team building.
15. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Caught in**		• Still think this is important • One of four primary hazards of industry • Focus 4 as in 12 above • General • Pinch point hazards are very prevalent on most construction sites and can be avoided with the proper recognition.

Between" hazards		• As with all of these fatal fours, the supervisor must be able to recognize the hazard and act to control it. • High risk and high potential item that should be addressed pre-job and throughout job progression. • No matter what trade, this a serious issue, and foreman has to knowledge to control these hazards. • Part of what we call the "Big Four" causes of fatalities and citations. • One of OSHA's focus four hazards which account for high proportion of construction fatalities. • Caught between and struck by are the third and fourth leading causes of death. This hazard recognition and mitigation training must be taught to supervisors with emphasis on a "what if" approach since many of these types of incidents are due to the failure of the supervisor and/or victim to identify changing conditions or potential hazards. • Lot of exposure and usually easy to mitigate.
14. Competent in hazard identification, avoidance, control and prevention "**Struck by**" hazards		• One of four primary hazards of industry • Focus 4 as in 12 above • General • A construction site has numerous pieces of heavy equipment in use, and struck by hazards are prevalent. • Getting hit by stuff is also important to manage. • High risk and high potential item that should be addressed pre-job and throughout job progression. • No matter what trade, this a serious issue, and foreman has to knowledge to control these hazards. • Part of what we call the "Big Four" causes of fatalities and citations. • One of OSHA's focus four hazards which account for high proportion of construction fatalities. • Lot of exposure and usually easy to mitigate.
30. Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Excavations***"		• Although excavations can be deadly, they are only typically present during the early stages of building construction. The other hazards/issues can be present during all phases • All excavations must be designed and performed under the direction of a Competent Person, as defined by OSHA. The PM/SS must have knowledge to ensure compliance as often the Competent Person is not competent. A good Activity Hazard Analysis should identify all the hazards and means of reducing or mitigating the hazards. The Safety Manager reviews all the Excavation plans. • Minimal OSHA requirement • See requirements for caught in between. Fatalities from stupid mistakes need addressing.

		• Non-routine task that required Competent Person and has extreme high hazards. • General • Excavation activities can lead to severe hazards being present that are not well understood across the industry. • Critical severity exposure: the supervisor, if there are excavations, must work to control these exposures. • High risk and high potential item that should be addressed pre-job and throughout job progression. • A commonly violated standard. A low frequency but high severity hazard. • Excavations are a major source of serious injury/fatal accidents, and supervisor must be able to recognize/control exposure. • Excavations are one of the highest risk activities on a jobsite and all supervisors should be a competent person in excavations and all associated hazards and mitigations. • Lot of exposure and usually easy to mitigate.
29. Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Scaffolding***"		• Competent Person as defined by OSHA must design and supervise erection of scaffolding. All my PM/SS have had bothOSHA 30-Hour training, on-line training, and personal training to know the hazards and proper erection of scaffolding. An AHA is developed for all scaffolding and the Safety Manager reviews the plans. • Minimal OSHA requirement • 17% of fall fatalities from scaffolding; most common multi-employer citation exposures. • Non-routine task that required Competent Person and has extreme high hazards. • General • There are frequently improperly erected scaffolding and the supervisor must recognize and control this hazard. • Every trade uses scaffold for work or access, hence it is critical. • Falls from scaffolding is a leading cause of fatalities and injuries in construction and the OSHA Scaffolding standard is a commonly cited standard. • Common construction apparatus with significant fall and other hazards. • Since scaffolding, fixed and mobile, are present on all projects supervisors should be a competent person in their safe construction, use and removal. • High hazard and high exposure activity.
7. Competent in		• To make room for more general competencies I deleted prior

hazard identification, avoidance, control and prevention of hazards associated with "***Cranes, derricks, hoists, elevators, conveyors***"		references to hazard specific items (e.g. cranes, welding). Whatever the trade or type of construction, the Supervisor must be competent in the recognition and control of the specific hazards from their operations. Cranes ARE important and I agree with everyone below. • Minimal OSHA requirement • Cranes, the single most costly and most dangerous piece of equipment on a construction site. New OSHA rules require significant management attention. • Required Pick Plans, Activity Hazard Analysis, protection of the public and customer recourses • General and Specific • Cranes are not only involved in some of the most severe construction related accidents, but they are now a focal point of OSHA . • If present cranes and associated equipment is a big exposure that must be safely managed • High risk and high potential item that should be addressed pre-job and throughout job progression. • Failure to identify and control hazards in this area can result in fatal injuries. • Cranes, especially. One mistake with a crane can result in significant damage, injuries, fatalities to both employees and the public. • High risk activities
16. Knowledge of managing health hazards in construction		• I changed my mind – while traumatic acute hazards like falls or struck bys are more or less managed many construction supervisors and employees are not accepting of their exposure to health hazards. I am thinking of a great supervisor who said, when I pointed out that a material might be asbestos, said 'I don't care about that s%&*'. He changed his mind because his company told him to. This should also include ergonomics for preventive of *cumulative* trauma disorders. • I did not select this one again. Although extremely important, as an industry we do not have our arms around this topic, so how can we expect our supervisors too. • Specific exposures (hearing, silicosis, asbestosis, etc.) • Most abused element of safety management in construction • Long term effects not always easy to detect, short term protection of public and crews • General • Not readily visible hazard that requires special skills and knowledge. • The health hazards in construction are an up-and-coming topic and may lead to additional regulations. • Health part of construction is ignored most times due to high latency period; foreman has to have knowledge to

		control health hazards. • Most supervisors are aware of the safety hazards but very few aware of the health implications of construction tasks. • Very common exposures in all types of construction • Health hazards in construction are a serious chronic health concern that all supervisors must be trained in prevention and held accountable too… since the majority of workers do not realize or have concern until their health is negatively impacted
4. Knowledge of routine/non-routine work tasks		• Essential to being a supervisor (Have to know in order to perform.) • Too General • Emphasis required on AHA for non-routine • Many injuries are caused by non-routine tasks where proper planning has not occurred • Supervisors must know what work tasks are to be done • Will provide a better understanding for which tasks need more planning or oversight. • This is required to perform an adequate pre-task planning. • In construction, an important aspect of gaining respect of the crew is the supervisor's ability to demonstrate familiarity, if not mastery, of work tasks being assigned. • Complacency is a factor in many injuries and incidents and the education and training of the workforce in safe work methods for all work tasks is a critical element in eliminating work place injuries.
1. Competent in hazard identification, avoidance, control and prevention of hazards associated with "**Stairs and ladders**"		• <u>OSHA 30-Hour training and additional guarding and fall protection training, along with AHA development have addressed all such issued on the sites.</u> • Minimal requirement to comply w/ OSHA standard • General • Ladders and stairs on virtually every job, and an injury source if used improperly. • Anytime incident associated with ladder, and stairs are always serious. • Falls from ladders are a leading cause of fatalities and injuries in construction and ladder violations are commonly cited. • Very common exposures in construction, which account for significant number of slips trips and falls • Stairs and ladder hazards are common on most jobsites and workplaces and account for many serious injuries. Supervisors must be cognizant of these risks, the minimum safety requirements (laws) and additional mitigations that are required for the safe execution of construction projects.

		• Lot of exposure and usually easy to mitigate.
11. Competent in hazard identification, avoidance, control and prevention of hazards associated with "***Fire prevention and protection***"		• Welding rolled into this. As the commenter's below state, this is a common problem that must be controlled. • I would have rated this higher than #5 (Hand and Power Tools). • Always a concern, is addressed on AHA and SSHP and a point of inspection/audit daily. • Minimal OSHA requirement • Most common problem on job site. Necessary to prevent injury and significant property losses • Pre-planning emergency response and safety of hazards that might be fire related • General • Fire hazards are abundant in the construction industry. • No matter what trade, this a serious issue, and foreman has to knowledge to control these hazards • Nearly every construction site has fire hazards and exposures that must be controlled. • Fire prevention techniques (working around flammables and combustibles) is a critical skill set for anyone, especially those that manage and work in the construction industry.