Formative Evaluation of a Rapid Universal Safety and Health (RUSH) System for Construction

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Rapid construction projects and processes will become increasingly important in the aftermath of natural and/or unnatural disasters. For use in expedited projects (as well as traditional projects), a Rapid Universal Safety and Health system (RUSH) was designed, developed and deployed. For its inaugural application, the RUSH was applied to a 106 hour residential construction project. This paper presents the formative evaluation based upon on-site data collection and a survey instruments administered just after the project to trades, managers and safety team members. No major incidents were recorded. The results will be discussed in terms of the observational and survey results.

INTRODUCTION

A Rapid Universal Safety and Health (RUSH) system was designed and prototyped to meet the construction needs from natural and unnatural disasters and other expedited projects.

A site specific safety plan, properly developed, should be aligned with the company (contractor) plan. This project plan is specific enough to address risks posed by the project, but generic and value-centric enough to be supported and implemented by that all subs and volunteer work crews.

Rapid build construction projects, like the example discussed here, compress the typical schedule while continuing the focus on safety and performance. A typical organizational structure for a rapid build project might include workers, leads (i.e. of trades), superintendents and project manager(s). Other roles, such as safety personnel, should be part of the structure. Such personnel would support the superintendents and/or project manager. Design decisions made during conceptual and preliminary design can greatly affect subsequent building process. Thus, ideally, building processes should be considered during the design phases. Even if a building process is considered after a design solution is completed, there are often alternatives regarding how a particular architectural design is executed. The major project-specific safety hazards can be identified at this time and form the basis for safety awareness planning and risk mitigation consciousness. These major hazards can then be projected forward to the safety signage and job aids focus. Due to the dynamic nature of the industry, this process should be iterative, flexible and sensitive to project changes.

RUSH Components

The RUSH system was designed to incorporate a safety process for rapid build construction projects. The system addresses constraints introduced by the increased human resource allocation, expedited schedule, and risk management (Refer to Figure 1 for component breakdown). The projects are heavily resourced, introducing an increased number of workers on site simultaneously. Additionally, work that is typically done sequentially will be completed simultaneously. Personnel will include volunteers from different backgrounds and expertise. The system should provide a common safety baseline knowledge and management system for a volunteer group which is typical of Habitat for Humanity and similar programs. In a systems safety approach, the focus is on changing (i.e. designing) the system to minimize risk and maximize performance and well-being of the workers. Training is viewed as an important support function, but it is mostly an off-line function. Signage is one way to reinforce the knowledge learned in training and the values inherent to a safety culture. Signage should not be patronizing or presumptive, in the sense that they imply workers intentionally commit unsafe acts. General reminders of the importance of safety are especially valuable in a rapid build environment where it could be easy to neglect safety and health in favor of expedition and performance. Specific effective warnings regarding specific equipment risk are also vital to a safe environment. An effective warning sign captures attention, communicates the hazard, consequences if exposed to the hazard, and provides instructions to avoid the hazard or presents protective measures (Wogalter, DeJoy, and Laughery, 1999).

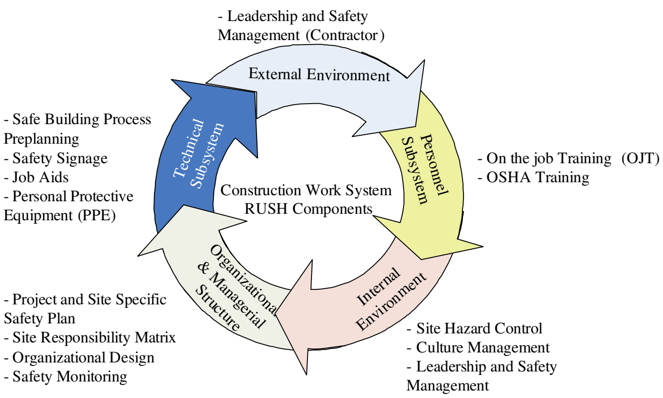

Figure 1.Rapid Universal Safety and Health System

Beyond signage, job aids can be provided to support workers, superintendents, safety personnel and any volunteers. As previously mentioned, risks are increased due to the expedited schedule and due to the fact that trades normally working sequentially, will work in parallel in a rapid build environment.

While hard hats have been generally accepted in construction cultures (albeit worn incorrectly in many cases), other personal protective equipment (PPE) have not been similarly embraced and thus proper PPE identification and usage is part of the System. Training to support the safety function is a vital component of the system. Under the auspices of the lead builder, the subcontractors should receive training to compliment the project-specific safety plan. In particular, subcontractors who will be working in an unusual concurrent workflow with other subcontractors need to be briefed about overhead, noise, chemical, and particulate risks they would not normally encounter or be equipped for protection. The training will provide a baseline for all subcontractors, regardless of their background. In addition, the on-site safety monitors should be OSHA certified. Once a rapid build project is underway, safety is at risk of being ignored or forgotten. Safety training embedded in processes and project management plans will increase awareness.

Many rapid build projects make use of volunteer laborers. Since it is assumed there would be no opportunity for advanced training of such helpers, the important need to train them is discussed as an on-the-job training issue. Additionally, sub-contractor workers, many of whom could be day laborers, should be briefed on-site. Traditional training is usually conducted off-line. In a rapid build project, there may be workers who are unaccustomed to rapid builds and whom missed the off-line training. In addition, naïve volunteers may be on site and media and/or dignitaries could be present if the project has high visibility. These two constituencies are examples of personnel who would need on-site, "just-in-time" training.

Traditional controls and safeguards such as taping hazardous areas, using appropriate scaffolding, and tying off workers are not to be ignored in rapid build projects. Safety personnel or other support people can help with such activities, including the removal of trip/fall hazards that occur due to the dominant mindset for production. Unless the builder and therefore, project manager, believe in safety and drive the process, the safety system will break down. Embracing safety as part of the solution, not a problem to overcome exemplifies safety as a core value and offers positive influence on the external environment. Leadership in fostering project values Leadership is also known to be a key factor in developing a desirable culture (Schein, 1985).

Prototype

The RUSH system was prototyped on a unique rapid build project. "Project 316", labeled due to confidentiality requirements, was the focus of a television production. The objective was to design and build a customized house for a deserving family with donated labor and materials in under 106 continuous hours. The opportunity for Project 316 was presented with a unique challenge- less than a three week planning horizon. Several constraints were also identified: the need for confidentiality until two days before demolition and training of safety personnel.

Implementation

While the safety team was not able to implement the envisioned RUSH system completely, it is important that no serious incidents resulted on this project. It is also instructive to evaluate what worked and why and which aspects of the system could not be implemented and why this was the case. A clear and visible authority structure was established and symbolized through hard hat color. Workers (both skilled and unskilled), including volunteers, wore white hats. Trade leads wore yellow. Superintendents and the project manager wore blue and the team of safety monitors wore orange. In addition, a special decal was designed for the orange safety hard hats that read, "VT" Extreme Safety" as a visual reminder of the safety value and objective.

A team of 50 faculty and upper level students was created to serve as safety monitors for Project 316. Faculty volunteered from departments involved in the Center for Innovation in Construction Safety and Health: Civil and Environmental Engineering, Building Construction, Industrial and Systems Engineering and Wood Science and Forest Products. Volunteers were faculty, seniors and graduate students from these departments. Members received the developed safety plan and training. A monitoring schedule was created to provide a minimum of one faculty supervisor and two student observers on site at all times. The monitoring schedule was staggered to provide continuity throughout the continuous build period. The safety priority was visible through safety core personnel, orange hard hats, and signage.

Workers, trades and volunteers all checked in at a centralized location. A simple sign that read, "SAFETY", was placed immediately behind the check-in table. In addition, the "VT Extreme Safety" decal was located on the orange safety hard hats worn by safety team members. Three additional safety banners were located on bicycle barriers, along side other company banners. To support safety team member training, On the Job Training (OJT) materials were created. Risk and PPE considerations per project activity were placed on 5" X 7" laminated cards. Cards were color-coded, provided visual identity of PPE needs and were linked to scheduled project activities to allow monitors an awareness of planned activity and equipment needs in preparation for their monitoring shifts.

An attempt was made to design a safe building process. As the schedule developed, the wall panels were to be in place six hours after the slab was poured. To enhance productivity (maximize the number of concurrent construction processes underway during all phases of the project) the team proposed assembling the roof trusses, roofing paper and shingles on the ground, and lifting the larger, stable assemblies onto the braced wall panels. The designers supported this effort by designing the roof assembly to include glue-laminated beams below the trusses to act as strongbacks supporting and aligning the trusses above with the walls below. The safety team assisted the design team with preparations for offsite prefabrication and onsite preassembly operations by reviewing provisions for temporary structures, bracing of wall and column elements for roof installation, and onsite power and PPE availability for their student-based build team. Substantially free from review by television production personnel, this in-process collaboration was successful in integrating process efficiency and safety while meeting quality and design goals.

PERFORMANCE RESULTS AND SURVEY METHODOLOGY

Given the number of person hours compressed into 106 hours, there was ample opportunity for accidents, injuries, health maladies and fatalities. However, overall, there were no major safety incidents. A total of 4200 workers constructed this residence. Dozens of unskilled volunteers populated the site at any given time. Additionally, spectators and other distractions (e.g. production crew, onlookers) were evident.

At the conclusion of the project, volunteers were asked to participate in a follow up survey of their experiences related to the project safety. The survey was administered through mailings since many construction workers do not use computers. Data were then manually entered into an on-line version through the Virginia Tech Survey service (https://survey.vt.edu). The survey included total of 25 questions, a mixed design of 22 closed ended questions and three open ended questions. A cover letter explained the importance of the information.

The target population included all personnel who had participated in the project (and provided contact information). Participants for the survey were self selected. Questions targeted several components of the RUSH System. The survey was completed by 57 participants (Refer to Figure 2 for role breakdown). From the participants who responded, 68% obtained or read a copy of the safety plan. Of those who received the plan, 67% (total of strongly agree and agree) felt the plan was valuable in creating a project that was safe.

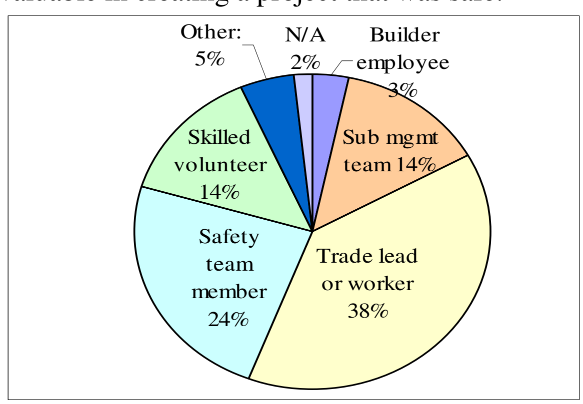

Figure 2. Role Breakdown of Survey Participants

The results for two safety personnel questions show a 93% and 98% total of "Strongly Agree" and "Agree" for the value of having the colored hard hats and safety personnel presence, respectively, in the project (Refer to Figure 3).

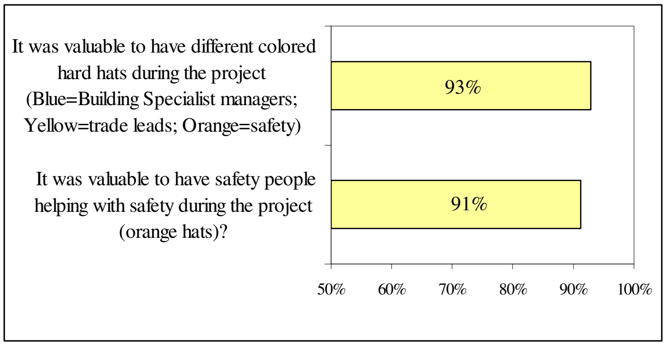

Figure 3. Total % of "Strongly Agree" and "Agree" Responses for Safety Personnel Survey Questions

Questions addressing signage and safety controls also received upwards of 90% for "Strongly Agree" and "Agree" results (refer to Figure 4). Note the item regarding the presence of cameras and its effect on safety only yielded a 47% total. This is important as several efforts are underway in the industry to use web cams and other monitoring technology to manage site safety. Overall, preliminary results for the informal application of the RUSH system for Project 316 show positive feedback from the users.

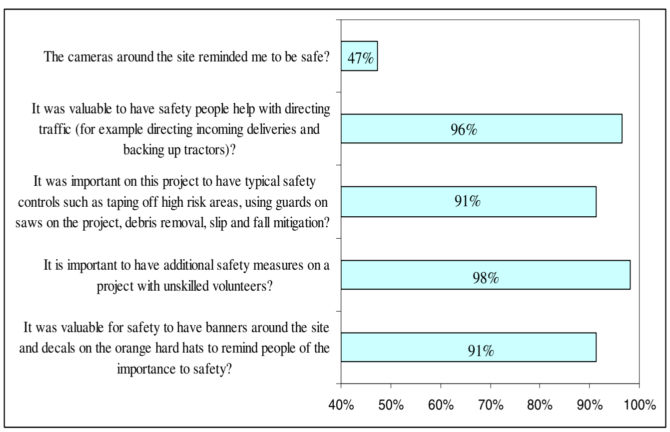

Figure 4. Total % of "Strongly Agree" and "Agree" Responses for Signage and Safety Controls Questions

Discussion and Conclusion

Given the short planning horizon, a pre-OSHA certification course was created and delivered to safety team members. In an abbreviated, yet focused manner, most of the relevant content from the OSHA ten hour course was covered. As discussed previously, the training program was supported by OJT materials and process. A progressive-part training scheme was employed in which the trainee learns the content on the first card, moves to the second, returns to the first, studies 1-2, then on to the third card etc. (Kleiner and Drury, 1993). To create a safety culture, a variety of strategies was employed. The project leaders (General Contractor CEO, Project Manager and Superintendents) were used to stress the importance of safety on the project. The signage also reminded workers of the safety value and training provided the specific skills and knowledge to create and maintain a safe environment. The safety team, wearing orange hard hats marked as "Extreme Safety", maintained high visibility 24 hours per day. This presented a dynamically usable on-site safety presence. Safety controls and the other interventions previously discussed completed the System.

Survey results yielded positive feedback to the application of the RUSH prototype system in a rapid build project. Results from a survey including 57 participants, balanced across roles, showed "Strongly Agree" and "Agree" totals upwards of 90% for safety personnel presence importance, effectiveness of color coded hard hats, signage and controls. Survey results showed a 98% total for the importance of safety measures in a project with unskilled personnel. This OJT program support provides safety awareness for all involved in the project.

Safety continues to be a serious concern in the construction industry. Rapid build projects are important strategically, although in theory, they could increase safety risk due to the time pressures, additional resource loading and the concurrent scheduling of activities that otherwise would be sequentially scheduled. As demonstrated on a five day rapid build demonstration project, through a Rapid Universal Safety and Health (RUSH) system, a rapid build construction project can be as safe as it is productive and fast.

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