protection equipment (4 ft. lanyard with class E4 energy absorber, body harness) and a 1.2m free fall height at the center of the HLL span. The line tension, lanyard tension, total fall distance of the wooden dummy, cable sag and anchorage deformation are monitored in real-time with a 1200 Hz acquisition system. The varying parameters, both for the computer model and laboratory tests, are as follows: cable diameter, initial line tension, anchorage flexibility (by varying both the height from the fixed support and section of the hollow steel sections) and HLL span.

Results: Comparison between the static SAP2000 model and analytical model shows a maximum difference of 2.3% in the line tension and deflection. The experimental results show that the proposed analytical method is a bit conservative and overestimates the line tension and deflection. The experimental results show that the proposed analytical method is a bit conservative and overestimates the line tension and deflection by about 10 to 15%.

Conclusion: In conclusion, the proposed analytical model seems to give a good estimate of the line tension and deflection considering its ease of use and the fact that it takes into account anchorage flexibility

A3.2
Title: **Evaluation of a horizontal lifeline system used during residential roofing**
Authors: André Lan, Bertrand Galy

Objectives: Residential roofing is considered as one of the most risky occupations, more than six times as risky as the common trade in the construction industry. To protect workers against falls from height during roof installation, a building contractor has developed a horizontal lifeline system (HLLS) made up of 3 aluminum HSS 2"x6"x¼" welded together, 18' posts, assembled to end trusses of the roof, with the cable at 5 feet above the ridge. The HLLS is heavy (> 200 lb) and has never been tested with on-site braced trusses as the host structure. This paper presents the results of a study that has been carried out following a request from the Association of Master Roofers of Quebec to evaluate the HLLS and to verify the strength of on-site braced trusses as the host structure of the HLLS.

Methods: Structural analysis with CAN/CSA S 157 - Strength Design in Aluminum code shows that the 3 HSS 2"x6"x¼" can be replaced by a HSS 5"x5"x¼" to reduce its' weight by 40%. The strength of the HLLS' components has been verified with CAN/CSA Z 259 dynamic performance fall tests with a 1.2 m lanyard, an E4 energy absorber with a 1.2 m free fall of a 100 kg torso and dynamic resistance fall tests with a nylon lanyard and a 1.2 m free fall of a rigid 100 kg mass. The strength of braced trusses as host structure has been verified by CAN/CSA Z259 dynamic fall tests on a reconstructed wood frame of 24'x36' made up of 2"x6" at 16" c/c and 26' trusses at 24" c/c.

Results: Tests results show the HLLS and the braced trusses passed all dynamic fall tests and are strong enough to withstand all forces generated during the arrest of an accidental fall.

Conclusions: During roof installation, workers can be protected against falls by a HLLS that has been evaluated by CAN/CSAZ259 fall tests. It is user-friendly, efficient and reliable and allows mobility and easy access to all parts of the roof and protects workers against falls from the beginning to the end of their task.

A3.3
Title: **A biomechanically based approach for optimal design of construction helmets**
Authors: Christopher Pan, John Wu, Bryan Wimer, Richard Whisler, Nancy Romano, Darlene Weaver

Traumatic brain injuries (TBI) are among the most common severely disabling injuries in the United States. Construction is the leading industry for serious TBI. Approximately 500,000 new cases occur annually. Of those, 30%-50% are moderate to fatal head injuries. Helmets used by construction site workers are the basic, essential personal protection equipment to reduce the risks of TBI. In the current study, we proposed a biomechanically based approach to optimize the design of the construction helmet by using a finite element (FE) model. The FE models were constructed using the commercially available software ABAQUS (version 6.9). The head-brain-neck complex consists of scalp, skin tissues, skull, cervical vertebra (C1, C2, and C3), discs, brain, brain stem, cerebrospinal fluid (CFS), and spinal cord. The brain includes the cerebrum and cerebellum; and the brain stem contains the midbrain, pons, and medulla oblongata. For this simulation, we considered the spinal cord to include the surrounding pia mater. The CFS is considered to cover over the entire external surface of the brain, brain stem, and the spinal cord. The discs contain both annulus fibrosus and nucleus pulposus. Within each of these anatomical components (i.e., brain, brain stem, CFS, spinal cord, and discs), the material was considered as uniform and isotropic. The FE model of the protective helmet consists in a shell and a suspension system. The FE model was applied to a practical problem: the "struck by" issue in various industrial settings. To test the protection afforded by a helmet, a cylindrical object was dropped from different heights and impacted the top of the helmet. The simulations were performed using an implicit dynamic procedure. We calculated the head accelerations and pressures at different locations within the brain tissue in response to the impacts. The proposed biomechanical model would provide a tool to improve the design of the construction helmet.

A3.4

Title: **Online fall protection equipment resource for residential construction**

Authors: Vicki Kaskutas, Huiping Lieser, Stelzer Barry, Bradley Evanoff

Falls continue to account for nearly all residential construction worker fatalities despite technological advancements in fall protection equipment. As a result, OSHA recently enacted more stringent residential construction fall protection standards. In order to comply, residential contractors must institute major, rapid revision of their building methods. Resources are needed to help contractors choose fall prevention devices appropriate for their contexts and use these devices in a safe manner.

Objective: To develop a comprehensive inventory of fall protection technologies for home construction that can be easily accessed from computers and mobile devices, to widely disseminate this resource, and to track outreach and effectiveness. The long term goal is to decrease construction worker falls.

Method: We identified fall protection devices appropriate for residential construction and compiled detailed information about each device into a user-friendly website developed using responsive web design; including purpose, installation procedures, photographs/videos, cost, and vendors. We matched each device to the stage(s) of construction when it may be utilized. Users can explore devices by construction stage or device type. The website was iteratively revised based on advisory panel feedback and user testing. Links to the website were posted on government-sponsored and private national organizations known to construction professionals and communications were distributed through these organizations' newsletters and social media outlets. Dissemination efforts and effectiveness were tracked.

Results: Over 150 devices from 24 manufacturers are described in detail on the website. Users reported that the website increased their awareness of fall prevention devices; some noted they will use fall protection devices more often and consider purchasing new devices after visiting the website. OSHA has embraced the website, distributing it through numerous venues. In the first month after release, 1,700 individuals visited the website, spending 4 minutes and viewing 8 pages on average.

Conclusion: This website provides a timely resource to help residential contractors identify fall prevention technologies and comply with new OSHA standards. The resource has been rapidly adopted; challenges now are to more widely disseminate this information, sustain the site over time, and keep the information current in order to decrease construction worker morbidity and mortality due to falls.

Session A4.0

Title: **Analysis of Workers' Compensation Data**

Moderator: Letitia Davis

A4.1

Title: **Comparison of temporary worker Illinois Workers' Compensation Commission filings from 2007-2012 with direct hire employees**

Authors: Dana Madigan, Linda Forst, Lee Friedman

Objectives: Temporary employment has been associated with increased workplace injury and the current labor market has shifted towards an increased demand for contingent laborers. While there is an increasing public health focus on identifying strategies to prevent injury, this study examines if temporary workers may be vulnerable to unfair compensation when injuries have already occurred.

Methods: This analysis examines Illinois Workers' Compensation Commission filings from 2007 through 2012 to compare litigated claim rates, total cost of the decision, days of work missed, and percent disability of employees of temporary agencies with a one-to-one random sample of direct hire claims.

Results**:** There were a total of 9,184 claims filed by employees of temporary agencies during this time period with an average litigated claim rate of 11.2 per 1,000 workers. Temporary workers were more likely to be male, younger at time of injury, single, have more dependents, and use attorney representation. Average weekly wage for temporary workers was approximately 51% of that of the direct hire employees ($420±206 compared to $824±478, $p<0.0001$). Mean days between accident and filing was 135 days less for temporary workers ($p<0.001$) and mean days between accident and decision was 112 days less for temporary workers ($p<0.0001$). Temporary workers were more likely to have upper extremity injuries ($p<0.0001$) and less likely to have head and neck ($p=0.0402$) or lower extremity injuries ($p<0.0001$) compared to direct hire employees. Total award average was $17,533±36,798 for direct hire employees and $9,382±25,197 for temporary workers ($p<0.0001$). Of those employees claiming time off from work, total time off averaged 3.2±6.4 weeks for direct hire employees (39.1%) compared to 2.6±4.9 weeks for temporary workers (32.5%). Total percent disability was 18.6%±15.7 for direct hire (56.6%) and 16.9%±17.2 for temporary employees (58.9%).

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