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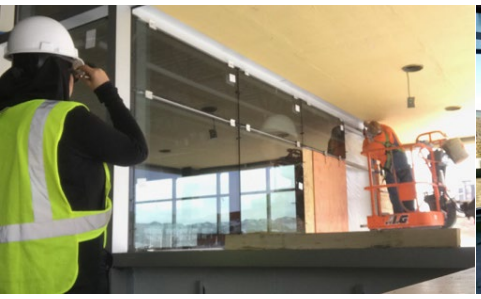


Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work

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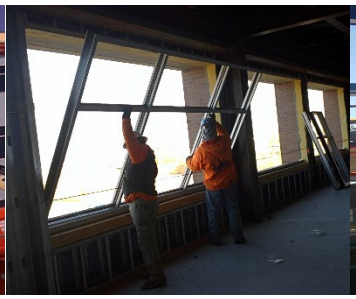

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Abstract

Construction workers regularly experience heavy workloads and various physical stressors that can result in debilitating Work-Related Musculoskeletal Disorders (WRMSDs). Construction glass and glazing (CGG) workers have high rates of WRMSDs, particularly low back injuries, but little is known about the tasks and conditions that contribute to their ergonomic risks. This study systematically evaluated this trade's work to identify problems leading to the higher incidence rates and to gather information about improvements needed to mitigate the risk. A comprehensive job description for this trade was developed through site observations and interviews. CGG job tasks were identified and classified in five categories including: general tasks, frame installation tasks, glass/panel installation tasks, finishing tasks, and loading/unloading tasks. Ergonomic task-based estimates were done using the Posture, Activity, Tools, and Handling (PATH) method and the CGG workers' level of risk of developing musculoskeletal injuries was scaled using the Rapid Entire Body Assessment (REBA) method. The results of this study provided a baseline database for future evaluations of ergonomic interventions to reduce CGG workers' risk for injury.

Acknowledgement

The following construction companies provided their interest, support, and cooperation in collecting the data for this research project. Their effort and commitment were of high value and much appreciated by the research team. The glass and glazing contractors were Lincoln Glass Inc. and Glass Edge, Inc. of Lincoln, Nebraska, and City Glass Company, Bil-Den Glass, and Keystone Glass Company of Omaha, Nebraska. Special thanks to Ayars & Ayars Construction Inc. of Lincoln, Nebraska for assistance with contractor recruitment and other research project support.

Key Findings

- CGG participants reported that manual material handling (MMH) of heavy materials for a long period of time, handling material in a dirty/muddy environment, working above head, and working in intense weather are the hardest or most challenging job tasks.
- The PATH assessment found that the major CGG ergonomic tasks included glass/panel installation, followed by frame installation, finishing jobs, and loading/unloading. MMH was a major activity for frame installation, glass/panel, and loading/unloading tasks, and carrying/holding materials ranked as the number one activity among MMH activities. Among finishing job activities, applying or pushing caulking bead ranked at the top.
- CGG workers spent 92.16% of their time standing/walking, and 27.17% of their time in non-natural trunk postures. Glaziers spent 21% of the time with one/two elbow(s) at/above shoulder height.
- Frame installation, glass/panel installation, and loading/unloading activities recorded medium and high WRMSD risk levels based on their REBA scores. The MMH activity had the highest REBA score, corresponding to a high WRMSD risk level for all frame, glass/panel and loading/unloading task activities.
- Cut/Laceration/Bruise, and back and shoulder injuries/illnesses were the most frequently reported conditions reported by participants.
- Participants provided numerous suggestions for safety and productivity improvements. For example, to reduce the risks associated with MMH, they recommended using more powered and unpowered mechanical handling equipment (if appropriate), additional worker

assistance, providing team instruction in safe work methods, and improved instruction in safe lifting techniques.

Introduction

Construction workers regularly experience heavy workloads and various physical stressors that can result in debilitating Work-Related Musculoskeletal Disorders (WRMSDs) of the upper extremities as well as lower back discomfort, pain, and injury. In 2015, the incident rate of WRMSDs in the construction industry was 34.6 compared to a rate of 32.2 per 10,000 Full-Time Employees (FTEs) for all industries combined (Bureau of Labor Statistics (BLS), 2016). Construction glass and glazing (CGG) workers had a higher rate of injuries and illnesses than the national average for all occupations (BLS, 2018). In 2010, workers employed by glass and glazing contractors reported the highest rate of back injuries, 97.8 per 10,000 full-time employees, followed next by masonry contractors with 45.3 per 10,000 full-time employees (CPWR-The Center for Construction Research and Training, 2013). Despite the high rate of injuries among CGG workers, this trade's ergonomic risks have not been adequately investigated. This study focuses on systematically evaluating this trade to identify problems leading to the higher incidence rate of work-related low back injury and gather information about improvements that the workers need in this construction subsector to mitigate the risk.

Objectives

This research was designed to answer the key research question about back discomfort, pain, and injury in construction glass and glazing workers: With a focus on work-related back discomfort, pain and injury, what are the most physically stressful work postures, work tasks, tools, equipment and material handling activities in CGG work?

The objectives of this study were as follows:

Objective 1: Conduct a work task analysis to describe in detail the types of work, work product, tasks, activities, tools, equipment, and construction environments that are the most common for CGG work.

Objective 2: Analyze CGG work tasks identified in Objective 1 to determine those ergonomic risk factors that pose the highest risk for back discomfort, pain, and injury using the Posture, Activity, Tools, and Handling (PATH) Method developed by Buchholz, Paquet, Punnett, and Moir (1996).

Objective 3: Identify the most physically stressful CGG work tasks, and systematically score and rank the tasks by risk level and required action using the Rapid Entire Body Assessment (REBA) ergonomics evaluation procedure developed by Hignett and McAtamney (2000).

Methods

Recruitment Process: An online search was conducted to find glass and glazing companies in Nebraska who could be recruited to participate in the research project. A list of companies was prepared and discussed with a local general contractor, Ayars & Ayars Inc., to finalize the roster. Ayars & Ayars helped the research team by emailing and calling CGG companies in Nebraska to inform them of this research study and recruit participants. Participation in this study was

voluntary, and small to medium-sized companies were targeted because this size range is most common in the state. Qualitative analysis methods research recommends that it is best to limit the number of cases or case organizations to no more than four or five for a single study (Creswell, 2013). Five CGG companies agreed to participate (see letters of support - Appendix A): including City Glass Company (Omaha; 70-75 employees), Bil- Den Glass (Omaha; ± 56 employees), Keystone Glass Company (Omaha, 51 employees), Glass Edge, Inc. (Lincoln; ±45 employees), and Lincoln Glass Inc. (29 employees).

All of the participating companies indicated that they perform work almost exclusively on large commercial-industrial projects. Through discussions with the companies at the beginning of the research project, specific construction projects were identified that would provide the best representative sample of workers for data gathering in the time and with the resources available. The projects were located in the Lincoln and Omaha urban areas, which account for approximately 40% of the state's population (US Census, 2015).

Since the purpose of this research was to clarify the underlying reason(s) for high rates of back injuries among CGG workers, purposeful sampling was used, which involved a combination of maximum variation and criterion sampling. All English-speaking CGG employees 19 years of age or older were eligible to participate in this study. CGG employees who volunteered to participate were required to sign an informed consent. According to BLS employment-population data, Nebraska had 400 glazing workers in May 2016. We selected a common sample size of n = 30 for each phase of the project and then calculated the marginal error for this sample size based on a total glazing CGG worker population of approximately 400 (BLS, 2016). We found that the marginal error for this sample size and the population was 2.5% with a confidence interval of 95%.

IRB Approval: Before starting the study, a research proposal was submitted in two phases to the University of Nebraska Institutional Review Board (IRB) that examined study details. The first phase was Ergonomic Back Injury Risk Factors in CGG Work – Job Description Phase that was submitted in December 2016 and approved in September 2017 (IRB # 20170216717EX). The second phase was Ergonomic Back Injury Risk Factors in CGG Work – Ergonomic Analysis Phase that was submitted in August 2017 and approved in September 2017 (IRB # 20170916968EX). Permission to enter a construction site was obtained from each participating contractor before research team members collected data on CGG workers performing construction tasks (see Appendix B for all IRB documents).

Ethical Considerations: To address the ethical issues for our study, all researchers completed the Collaborative Institutional Training Initiative (CITI) training as required by the IRB. CGG participants would benefit from their participation in the research both directly and indirectly. A direct way involved giving all participants a gift card valued around $25 to show appreciation for their cooperation. An indirect way was the knowledge participants would gain through their participation and the study findings about their job and the work-related risks that they may encounter in the workplace.

All interview sessions were recorded with the interviewee's explicit permission. All names and locations are kept anonymous by using pseudonyms to protect our research participants during data collection and data analysis process. All materials are kept confidential and secured in a locked filed cabinet stored in the locked Human Factors and Safety Laboratory (Nebraska Hall Room 121B). Digital files are stored on password-protected computers accessible only to the research project investigators. Only the research project investigators have access to the participants' information and interviews. The files will be destroyed according to the University's IRB protocol ten (10) years following the completion of the project.

Data Collection Methods

Objective 1: A qualitative case study approach was conducted to answer: What type of job tasks and work processes do you do in CGG work? Face-to-face interview sessions were held to collect the data and information. Two different groups of employees were interviewed: CGG project managers/supervisors and non-supervisory CGG workers. For each CGG company, data was collected from one (1) manager/supervisor and five (5) workers. A total of thirty interviews was held in sixteen sessions. Average years of work experience was 14.39 years (minimum ten months; maximum 32 years). Volunteer managers/supervisors from participating CGG companies were interviewed using a questionnaire designed by the research team (CGG Project Managers and Supervisors Job Description Questionnaire). The job description handbook (Mader-Clark, 2013) was the main source used to design the questionnaires. According to Mader-Clark (2013), a job description is simply a clear, concise depiction of a job's duties and requirements. Job descriptions can take many forms, but they typically have at least four parts: a job summary, a list of job functions, a requirements section, and other information such as working hours, travel requirements, and so on.

The questionnaire included eleven (11) open-ended questions and asked about the managers/supervisors' job title, the specialty of the company, job categories, essential job functions for each CGG worker job category, training opportunities, required education, skills, experience, and certificates. At the end of the interview, company managers/supervisors helped us to recruit CGG workers. Further information was gathered from workers who voluntarily participated in interview sessions (CGG Workers Job Description Questionnaire). The questionnaire included twelve (12) open-ended questions that were designed to discuss the workers' job title, years of experience, working condition/environment, job tasks, tools, required education, skill, experience, certificates, and training. Each interview lasted approximately 15-40 minutes per worker. These questionnaires were completed as in-person with audio recording (see Appendix B for all IRB documents and questionnaires).

Objective 2: The observational method called PATH was used to achieve the second objective of this study. Observation is a systematic recording of postures in a workplace (i.e., region, frequency, severity, duration) (David, 2005). The observational tools cause minimal disturbance to worker task performance, allowing for assessments of tasks in real settings and requiring minimal instrumentation for field investigations (Wang, Dai, & Ning, 2015). The PATH method is an observational method that was developed by Buchholz et al. (1996) based on an early observation tool named Ovako Working Posture Analyzing System (OWAS) and was used in the work risk assessment of highway construction workers. For PATH, a task is defined as the largest group of activities that are typically performed together by a single worker to accomplish

a common goal. PATH has also been used in industrial sectors that involve non-repetitive job activities, including retail (Pan et al., 2013), agriculture (Earle-Richardson et al., 2005), fishing (Kucera & Lipscomb, 2010), and healthcare industries (Kurowski, Boyer, Fulmer, Gore, & Punnett, 2012; Kurowski, Buchholz, ProCare, & Punnett, 2014; Park et al., 2009). The PATH method has been shown to be both reproducible, given adequate observer training (Park et al., 2009; cited in Jackson et al., 2012) and valid, when compared to results from studies using a bio instrumentation approach (Paquet et al., 2001; Tak, Punnett, Paquet, Woskie, & Buchholz, 2007; cited in Jackson et al., 2012). Further, in a review of observational exposure assessment methods, Takala et al. (2010) rated PATH as a "thoroughly developed" method with a "systematic and well-designed sampling approach." Thus, previous PATH studies do offer the user some decision support as to the performance of the method in different occupational settings and when employed for different purposes (Takala et al., 2010; cited in Jackson et al., 2012).

According to Xu, Chang, Faber, Kingma, and Dennerlein (2011), although posture observation is not as accurate or as precise as using laboratory equipment, such as cinematographic systems or electromagnetic field-based motion tracking systems, it still has been widely adopted by ergonomists to assess mechanical exposure (Juul-Kristensen, Fallentin, & Ekdahl, 1997). This broad adoption is because posture observation has a low cost, does not require specialized equipment, does not involve strong interference with the normal operations of those being surveyed, and can be done in the field (Bao, Howard, Spielholz, Silverstein, & Polissar, 2009; Hsiang, Brogmus, Martin, & Bezverkhny, 1998; Kilbom, 1994). The PATH method is more than just postures assessment. It links the posture data to the worker activity, which cannot be done merely with instrumentation. It also ties in tool and handling information that would permit biomechanical modelling. Figure 1 shows the steps involved in applying the PATH methodology.

The PATH method is well suited for the characterization of ergonomic risks to the lower extremity, back, neck and shoulders. For each observation, posture, activity, and handling, PATH data are coded on a data collection sheet, which is customized for each combination of trade and operation (Buchholz et al. 1996). According to Paquet, Punnett, Woskie, and Buchholz (2005), for each task of operation, observation periods of at least 6-10 days with sampling periods of 3-4 hours per day is needed (95% CI) to obtain reliable estimates for all variables. With the development and application of PATH, it has become practical to quantify the percent of time that construction workers are exposed to awkward postures, various tasks and activities, and manual handling (Buchholz, Paquet, Wellman, & Forde, 2003; Forde & Buchholz, 2004; Fulmer, Agyem-Bediako, & Buchholz, 2004; Paquet, Punnett, & Buchholz, 1999, 2001; Paquet et al., 2005; Rosenberg, Yuan, & Fulmer, 2006; Tak, Punnett, Paquet, Woskie, & Buchholz, 2007; Jackson,

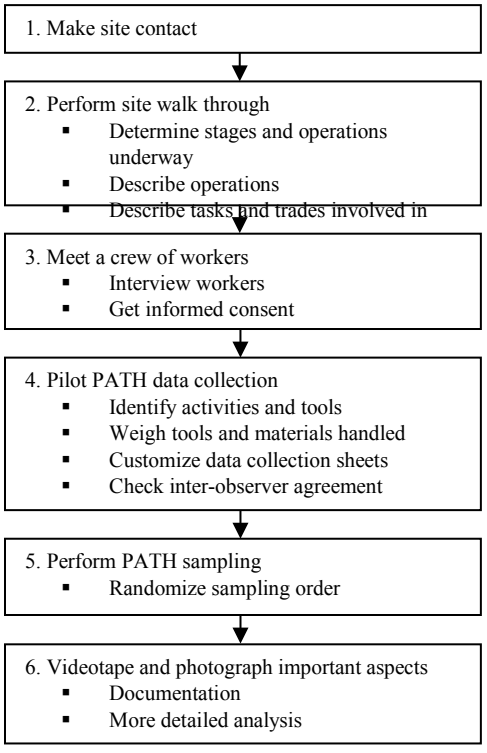

Figure 1: Procedures of the PATH Method (adopted from Buchholz et al. 1996)

Mathiassen, & Punnett, 2012; Kurowski, Boyer, Fulmer, Gore, & Punnett, 2012, Yuan, Buchholz, Punnett, & Kriebel, 2016).

The workers' selection is based on how easy it is to (i) observe what they are doing; (ii) accurately assess their postures; and (iii) follow their movements as they move from point to point in the performance of their tasks (Forde, 2002). In this objective, a quantitative exposure analysis of CGG work were provided using PATH method to:

- Provide a task-based estimate of the frequencies CGG workers spent in the various trunk, leg, and arm postures, as well as time spent doing manual material handling (MMH) activities.
- Identify which CGG task and/or activities cause or contribute to high ergonomic exposures for the workers.

Observer PATH training sessions were held from 11/12/2017 to 11/15/2017 at the University of Massachusetts Lowell before starting the observation under the supervision of Dr. Buchholz and his team. Definition of operations, tasks, and activities were discussed. The stages, operations, tasks, and a list of typical activities performed within each task of CGG work were determined and described according to supervisors/managers and workers interviews in "Objective 1". The PATH data collection sheet and cover sheet (see Appendix C) were customized to collect data during each operation. The PATH data collection sheet was designed to obtain the following information: observation information, product/operation, task, working condition, trunk posture, arm posture, leg posture, weight in hands, materials/assemblies/tools in hands, Manual Material Handling (MMH) with one hand or two hands, individual MMH task or team MMH task, types of MMH activities (e.g., move/place, carry/hold, push/pull/drag, lift, lower), frame installation activities, glass/panel installation activities, wood/foam installation activities, loading/unloading activities, finishing jobs, tool specific activities, hand tools/materials, powered equipment, hand 1 posture, and hand 2 posture. The cover sheet was designed to collect the following data: observer name, date, participating company, location, worksite, type of project, operation/product, task, observational period, workers' information (initial or workers' code, number assigned, gender, dominant hand), housekeeping, noise, dust, weather (temperature, humidity, wind), and Personal Protective Equipment (PPE). The training sessions included the validation of PATH data created by trainees (inexperienced observers) by ensuring at least 80% agreement between observational data created by experienced and inexperienced observers.

Participating CGG companies allowed work site observations for as long as the research team needed to do their ergonomic evaluation. Each participating company was informed about the process of PATH data collection through an in-person discussion. Questions and concerns were addressed at that time.

For any given data collection session, a crew of CGG workers (the number of workers was different for each operation in each company) were selected, observed, and followed. The number of CGG operations, tasks, and activities were determined after the interview session and site observations, and were discussed with presidents/managers to finalize the list. Four major operations including Curtainwall, Storefront, Paneling, and Interior Glass were selected for observation, but only three (Curtainwall, Storefront, Paneling) were observed due to time limitation. The CGG trades were observed over roughly a three-month period. For all five

companies, there were 54 observation days, of which 41 days were productive and entered to the Qualtrics software. That resulted in 19,300 observations (PATH data input) for all three operations. PATH observations were collected at regular intervals (60 seconds) to describe the percent of observed time each worker was exposed to risk factors such as non-neutral postures and heavy loads. Data were collected by taking digital images using a google glass and taking notes in the field. An application called Simple Interval Timer (SIT) was installed on the observer's iPhone, which was synchronized with an Apple watch so that the watch notified the research analysist to take photographs at the end of every 60 second interval.

Objective 3: The observational method called Rapid Entire Body Assessment (REBA) was used to achieve the third objective of this study. The REBA method was developed to primarily analyze unpredictable working postures detected in the healthcare and service industries. The method results in a final score that can range from 1 to 15 (non-existent risk to very high risk) and indicates the magnitude and priority of the measures to be taken (Hignett & McAtamney, 2000). The body parts are divided into two groups, Group A and B, in order to analyze the task and calculate the REBA score. Group A includes the trunk, neck, and legs. Using REBA tables, each body part is scored according to its position. Then by using Table A, a combined score of Group A is calculated. A "Load/Force" score is added to calculate score A (see Appendix D, Figure 3). Group B includes upper arms, lower arms, and wrists. A score of group B is calculated according to related tables and then "Coupling" score is added and score B is obtained (see Appendix D, Figure 4). Group A and B scores are combined and finally, an activity score (see Appendix D, Figure 5) is added to provide the final REBA score (Figure 2). According to the final REBA scores for tasks, appropriate action levels are required (Table 1).

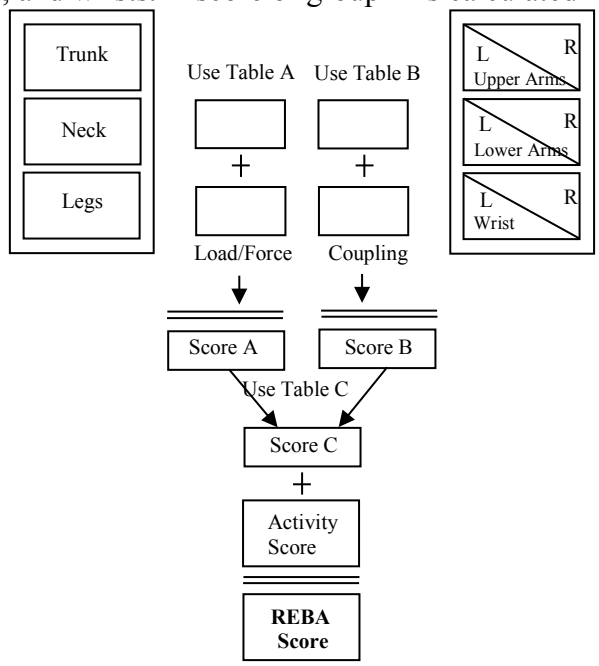

Figure 2: REBA Scoring Adopted from Hignett, S., McAtamney, L. (2000)

Several industries, including healthcare and service (Chiasson, Imbeau, Aubry, & Delisle, 2012; Carneiro, Martins, & Torres, 2015), have used the REBA method for postural assessment of jobs including construction workers (Shanahan et al., 2013; Koushik & Alphin, 2016), agriculture workers (Soheili-Fard, Rahbar, & Marzban, 2017; Widyanti, 2018; Taghavi et al., 2017), manufacturing workers (Chiasson et al., 2012; Maldonado-Macias Maldonado-Macias, Realyvasquez, Hernandez, Garcia-Alcaraz, & Maldonado-Macias, 2015; Tripathi, Rajesh , & Maiti, 2015; Sanjog, Patel, Chowdhury, & Karmakar, 2015; Yoon, Ko, & Jung, 2016), oyster culture workers (Guertler et al., 2016), firefighters (Gentzler & Stader, 2010), potters and sculptors (Sahu, Moitra, Maity, Pandit, & Roy, 2013), packaging

workers (Lasota, 2014), and sales assistants (Capodaglio, 2017).

Table 1: REBA Action Levels Adopted from Hignett and McAtamney, 2000

Action level	REBA score	Risk level	Action (including further assessment)
0	1	Negligible	None necessary
1	2-3	Low	May be necessary
2	4-7	Medium	Necessary
3	8-10	High	Necessary soon
4	11-15	Very high	Necessary NOW

For this study, the REBA method was applied to scale the workers' level of risk of developing musculoskeletal injuries. Five CGG tasks were chosen to be evaluated using REBA methods. These tasks, which were determined through in-person interviews and were assessed using PATH methods, were frame installation, glass/panel installation, finishing jobs, loading and unloading materials, and general tasks. According to Carneiro et al. (2015) the decision about the posture to analyze is based on one or more criteria such as (i) the most frequent posture, (ii) the posture maintained for longer in the working cycle, (iii) the posture that requires greater physical effort, (iv) the posture that causes most discomfort, (v) the most extreme posture, especially if it involves the application of force. The CGG tasks and related activities were determined in objective 2, and those tasks/activities with higher observation percentage (frequent) and difficulty were picked to calculate REBA scores.

The same pictures that were taken during the site observation for the objective 2 using PATH method were used for this objective, and all of the postures adopted in each activity were analyzed. Several pictures were selected to cover all possible postures for each activity. A different number of pictures were examined to include all possible postures to perform the tasks (Appendix E, Figures 6, 7, 8, 9, and 10 include examples of pictures of CGG tasks that were taken during site observations). The REBA method was applied to scale the workers' level of risk of developing musculoskeletal injuries.

Accomplishments and Results

Objective 1 - Accomplishments and Results

Both qualitative and quantitative analysis of the data was performed. The interview sessions were recorded, transcribed, and imported to the MAXQDA Analytics Pro software (12th version) to code and analyze the data. A total of 2,944 segments were coded. The following are the results for objective 1:

- **Construction Glass and Glazing Job Description (Appendix F):** A CGG job description was recommended using "the job description handbook" guideline written by Mader-Clark (2013). The job description was aimed to provide the following information: Job summary, essential functions, job requirements and qualifications (education, licenses, certifications, or specialized training programs, skills and abilities, and experience), and other information.

- **Construction Glass and Glazing Job Tasks (Appendix G):** Based on interviews and site observations, tasks were divided into two categories called "General Tasks" and "Job Specific Tasks." Job specific tasks were those tasks that CGG workers performed as a result

of their glass and glazing responsibilities while installing frame and glass or performing finishing jobs and manual material handling. Drilling, screwing, hammering, caulking, and carrying materials were examples of job specific tasks. General tasks were not specific to glass and glazing job, for instance holding material, walking, and housekeeping. See Appendix G for the detailed CGG job tasks that were determined through interviews and job site observations.

- **Interview Reported Hardest or Most Difficult Job Tasks:** The CGG workers were asked "What are the hardest job tasks you do in terms of physical demand and/or discomfort? Please describe. What makes these tasks so hard to do?" The following is a summary of the most challenging job tasks that were reported by participants (25 CGG workers).
    - Manual Material Handling (lifting, lowering, and carrying) of heavy materials for hours/whole day
    - Installing large pieces of glass while there is a limited amount of space
    - Installing curved/angles windows
    - Installing big pieces of glass that are not safety glasses, and could be dangerous if they break to shards
    - Twisting and lifting at the same time while working on a ladder
    - Pulling out a piece of glass or frame using a cup (one-point system, pressure on the shoulder)
    - Carrying glass through dirt, over the mud
    - Carrying glass with another person, fighting against each other
    - Drilling through steel and working above head
    - Working in hot/cold weather

- **Interview Reported Injuries, Discomforts, Static and/or Awkward Postures:** The CGG participants were asked if they have experienced any injury/illness because of their job. Cut/Laceration/Bruise, back and shoulder injury/illness were the most frequently reported injuries by participants. Other injuries and discomforts reported were as follows:
    - Knee strains/discomfort
    - Ankle sprains/discomfort
    - Hip injury/discomfort
    - Lower extremities injury/discomfort
    - Thumb injury/discomfort
    - Wrist injury/discomfort
    - Hearing impairment
    - Eye injury/discomfort
    - Cold temperature stress
    - Heat stress

Participants also reported awkward postures that they experienced as a result of their glazing work including bending over/down, reaching out/overhead, twisting while working on a ladder, and crawling on the knees.

- **Interview Reported Recommendations for Job Improvement and Lower Injury/Discomfort Potential:** All interview responses were subjectively reviewed.

Participants suggested ways to improve job safety and reduce the potential for injury, pain, and discomfort. Table 2 shows a summary of the most important suggestions.

Table 2: Interview Reported Recommendations for Job Improvement

Category	Reported Recommendations
MMH	• Powered and unpowered mechanical handling equipment • Additional worker assistance
Safer Design	• Making lighter glass • Making smaller glass
Training Programs	• Providing team instruction in safe work methods • Improved instruction in safe lifting techniques • Apprenticeship program needs for new, inexperienced employees
Safe Work Behaviors	• Worksite organization • Switch side • Right proper body position • Accident prevention plan • Dust and particulates control • Wearing appropriate PPE • More hot weather hydration and cold weather warm-up rest breaks
Management Role	• Job coordination and management • Job rotation/task variety • Warm-ups and stretching programs

- **Interview Reported Personal Fall Protection Systems (PFAS) Issues:** Although some participants were comfortable wearing harnesses, some were not because they sometimes got twisted up in the lanyard, tripped over it, and their leg got caught on it. Wearing a harness properly can cause some discomfort due to the tight fit required. Another issue that was mentioned is that because some harnesses have too much padding in the summer, they get hot. "The new ones have like more stuff on them, they got lot more pads, and there is bulkier, … they just got me a new one; I prefer wearing my old one, it's lighter … a lot of people don't like the new one. "…wearing a harness all day, I mean it's kind of weights on your shoulders, a bit." "…usually when we are in our harness, it feels good but then whatever we attached to us, it's always pulling against you." "It was uncomfortable because it's a constant pull on your back and sort of fighting that as you were moving around if you were working next to somebody, he has got one on too, and sometimes you get your stuff crossed…so, I recalled that being not the most pleasant situations, but we were safe having those on."

Objective 2 - Accomplishments and Results

Data collected from the PATH method were statistically analyzed using Qualtrics software and Microsoft Excel. Frequencies and percentage of work time spent working in various postures, activities, manual material handling activities, and different work heights were determined by analyzing imported data from the data collection sheets (coding sheets). Table 3 shows significant results of this objective.

Table 3: PATH Method Results Summary

Work Conditions	The CGG workers spent large proportions of time working on the ground (53.94%) followed by working on a boom lift (31.48%).
Tasks	Glass/panel/temporary materials installation was the major CGG task (41.92%) followed by frame installation, finishing jobs, and loading/unloading (25.87%, 20.68%, and 11.53% respectively).
Task Specific Activities	• Manual material handling was a major activity for frame installation, glass/panel and loading/unloading tasks (9.45%, 17.26%, and 28.75% respectively); • Applying/pushing caulk bead ranked number one (1) among all finishing jobs activities (10.65%) followed by taping/removing tape activity (8.26%).
General Activities	The CGG workers spent about 57% of their time on general activities such as waiting/standing for materials/instructions (18.89%), walking (13.23%), holding materials (10.37%), communicating/supervising (9.67%), and operating a lift (4.90%).
Tool Specific Activities	• 41.59% of the time CGG workers had tools/powered equipment in their hands, and most of the time they were operating the tools (62.60%); • Suction cup, manual caulking gun, and caulking knife/tool were the most frequent hand tools used by workers; • Impact drill and regular cordless drill were the most frequent powered tools used by CGG workers.
Manual Material Handling Activity	• MMH with two hands was more common compared to one hand; • Carry/hold materials ranked as the number one activity (45.87%) among MMH activities followed by move/place activity (18.89%); • Team lifts were used by workers performing manual materials handling 50.87% of the time. A team of two individuals was the preferable team size accounting for 55.75% of team MMH. Teams of three and four individuals were also observed when they were preforming heavy MMH (19.14%, 25.11% respectively).
Weight in Hands (lbs.)	A large proportion of time (47.31%), field CGG workers had some weights in their hands with the following categories: Weight < 10 lbs. (36.88%), 10 lbs. ≤ Weight < 50 lbs. (5.44%), 50 lbs.≤ Weight<100 lbs. (4.30%), and Weight ≥ 100 lbs. (0.69 %).
Postures (Trunk, Arm, Hand, and Leg)	• CGG workers spent 27.17% of their time in non-natural trunk postures including the following postures: 20 ≤ Flex ≤45 (8.80%), Flex ≥ 45 (3.66%), Twist neutral (6.66%), Lateral bend (2.10%), Lateral bend/twist neutral (0.29%), Lateral bend/twist flexed (2.52%), and bend backward (3.14%); • 21% of the time CGG workers had one/two elbow(s) at/above shoulder; • Most of the time CGG workers were griping and pressing with their hands (Right hand (65.23%) and Left hand (60.58%)); • 92.16% of the time CGG workers were standing/walking. However, they also experienced other leg postures such as one leg in the air, lunge, shallow/deep squat, vertical/sitting kneel, sit, and crawl.

Objective 3 - Accomplishments and Results

The work tasks identified and described in Objective 1 were evaluated by calculating the REBA score for each task. REBA scores for tasks with "medium", "high", and "very high-risk" levels were identified to determine the appropriate action levels required. Data collected from the REBA method were statistically analyzed using Microsoft Excel. Table 4 shows significant results of this objective.

Table 4: REBA Method Results Summary

Tasks	Results
Frame Installation Task	• Activities REBA scores ranged between 6 and 9 corresponding to a medium and high WRMSD risk level; • Manual material handling activity obtained the highest REBA score of 8.82 corresponding to a high WRMSD risk level; this refers to a REBA action level of 3 (Table 1), indicating that action is necessary soon to further assess this task with the aim of reducing the risk level; • "Shim", "Screw/unscrew/Drill", and "Caulk" activities got REBA scores of 7.18, 7.17, and 6.3 respectively, which refer to REBA action level of 2 (Table 1), indicating a medium risk of injury to the CGG workers and action level of two (necessary). • Trunk posture (bend and twist), upper arm posture (at/above shoulder height), and load/force score were the contributory factors to the high and medium scores.
Glass/Panel Installation Task	• Activities REBA score ranged between 4 and 9 corresponding to a medium and high WRMSD risk level; • The manual material handling activity REBA score was 8.52, this refers to a REBA action level of 3 (Table 1), indicating a high risk of injury to the CGG workers and that action is necessary soon to further assess this task with the aim of reducing the risk level. • "Screw/Unscrew/Drill" activity ranked number two with a REBA score of 5.53 followed by "Attach/Detach suction cup", "Put vinyl/gasket", "Shim", and "Pinch and pull cover" activities (5.07, 4.74, 4.33, and 3.86 respectively) corresponding to a medium risk level that shows "necessary" action level is required. • Trunk posture (bend and twist), upper arm posture (at/above shoulder height), and load/force score were contributory factors to the high and medium scores.

Table 4 – REBA Method Results Summary (Cont.)

Tasks	Results
Finishing Jobs Task	• Activities REBA scores ranged between 5 and 6 corresponding to a medium WRMSD risk level; • "Tape/Remove tape" activity ranked number one with a REBA score of 6.21 followed by "Smooth the bead with a wet finger", "Apply/Push the caulk bead", "Smooth the bead of caulking with a finishing tool", "Fill the perimeter with the backer rod", and "Screw/Unscrew/Drill" activities (6, 5.63, 5.38, 4.89, and 4.75 respectively) corresponding to a medium risk level that shows the "necessary" action level is required. • Upper arm posture (at/above shoulder height), wrist posture, and neck posture were the contributory factors to the medium REBA scores.
Loading and Unloading Task	• Activities REBA scores ranged between 5 and 8 corresponding to a medium and high WRMSD risk level; • The manual material handling activity REBA score was 7.53 that refers to a REBA action level of 3 (Table 1), indicating a high risk of injury to the CGG workers and that action is necessary soon to further assess this task with the aim of reducing the risk level; • Trunk posture (bend and twist), upper arm posture (at/above shoulder height), and load/force score were the contributory factors to the high REBA score.
General Task	• REBA scores for the "Hold", "fasten/unfasten", and "Operate lift" activities ranged between 2 and 3 corresponding to a low WRMSD risk level with the action level of "May be necessary."

Future Funding Plans

The results of this study provided a baseline database for future evaluations of ergonomic interventions that can eliminate or reduce the risk of WRMSDs in CGG work. The results of this study will also help in the composition and dissemination of ergonomics training materials that can help workers and contractors in preventing back injuries in CGG work more efficiently. Work-sampling approaches such as PATH and REBA can be used to evaluate whether future interventions are successful in reducing the rate of musculoskeletal risk factors. Focusing on back injuries, the Lumbar Motion Monitor (iLMM4) by NexGen can be used to investigate the efficacy of ergonomic interventions. The following are potential future research areas to improve job safety and reduce injury, pain, and discomfort.

- Aerial lift vibration/stability
- Mechanical lift for heavy objects
- Improved gloves for cold protection and fine manual dexterity
- Improved caulking gun tips
- Improved comfort for PFAS

- Better pre-fabrication assembly designs that require significantly less overhead drilling, screwing, holding posture and force application.

Dissemination Plan

The results of this study contributed to the fundamental knowledge of WRMSD risks in CGG tasks, which will be critical in designing effective ergonomic interventions to reduce the potential for physical stress and back injury. This valuable information is not currently available in government publications, published research, or job training materials for CGG workers and contractors. The results of the ergonomics job analysis revealed novel ergonomic intervention approaches that can be designed, tested, and reported in future research studies so that job safety and productivity improvements can be disseminated to CGG workers and contractors. The results of this study will be submitted and presented for possible publication in occupational safety and health-related journals or conferences. The results of this study, final report and publications, will be distributed and discussed among CGG companies that participated in this research and through CPWR's r2p initiatives, including social media postings and links on CPWR's family of websites (cpwr.com, eLCOSH, etc.).

List of Planned Presentation /Publications

Planned Presentation:

- Durham School of Architectural Engineering and Construction, College of Engineering, University of Nebraska-Lincoln Graduate Research Seminar, February 22, 2019
- Research Seminar Presentation at Texas A&M University, Apr 8, 2019
- Association of Nebraska Glass and Glazing Contractors: Annual Conference
- National Association of Glass and Glazing Contractors: Annual Conference

Planned Poster Presentation:

- Associated Schools of Construction Annual Conference (Poster Presentation) – Mixed Methods Ergonomics Job Analysis for Construction Glass and Glazing Work, April 11, 2019
- University of Nebraska Lincoln Graduate Poster Session and Creative Exhibition – Observational Ergonomic Assessment of Construction Glass and Glazing Work, April 15, 2019

Planned Journal Publication:

- Journal of Mixed Methods Research (JMMR) – Ergonomic Assessment among Construction Glass and Glazing Trade – A Mixed Methods Study
- Journal of Work and Occupation – Construction Glass and Glazing Job Description – A Case Study
- Applied Ergonomics – Assessment of Physical Risk Factors Using the Posture, Activity, Tools, and Handling (PATH) Method in Construction Glass and Glazing Work: A mixed methods study
- Applied Ergonomics/Ergonomics – Ergonomic investigation of workers in construction glass and glazing trade using REBA method: A mixed methods study
- The journal of the Human Factors and Ergonomics Society – Reported Injuries, Discomforts, Static and/or Awkward Postures among Construction Glass and Glazing Workers: A Case Study

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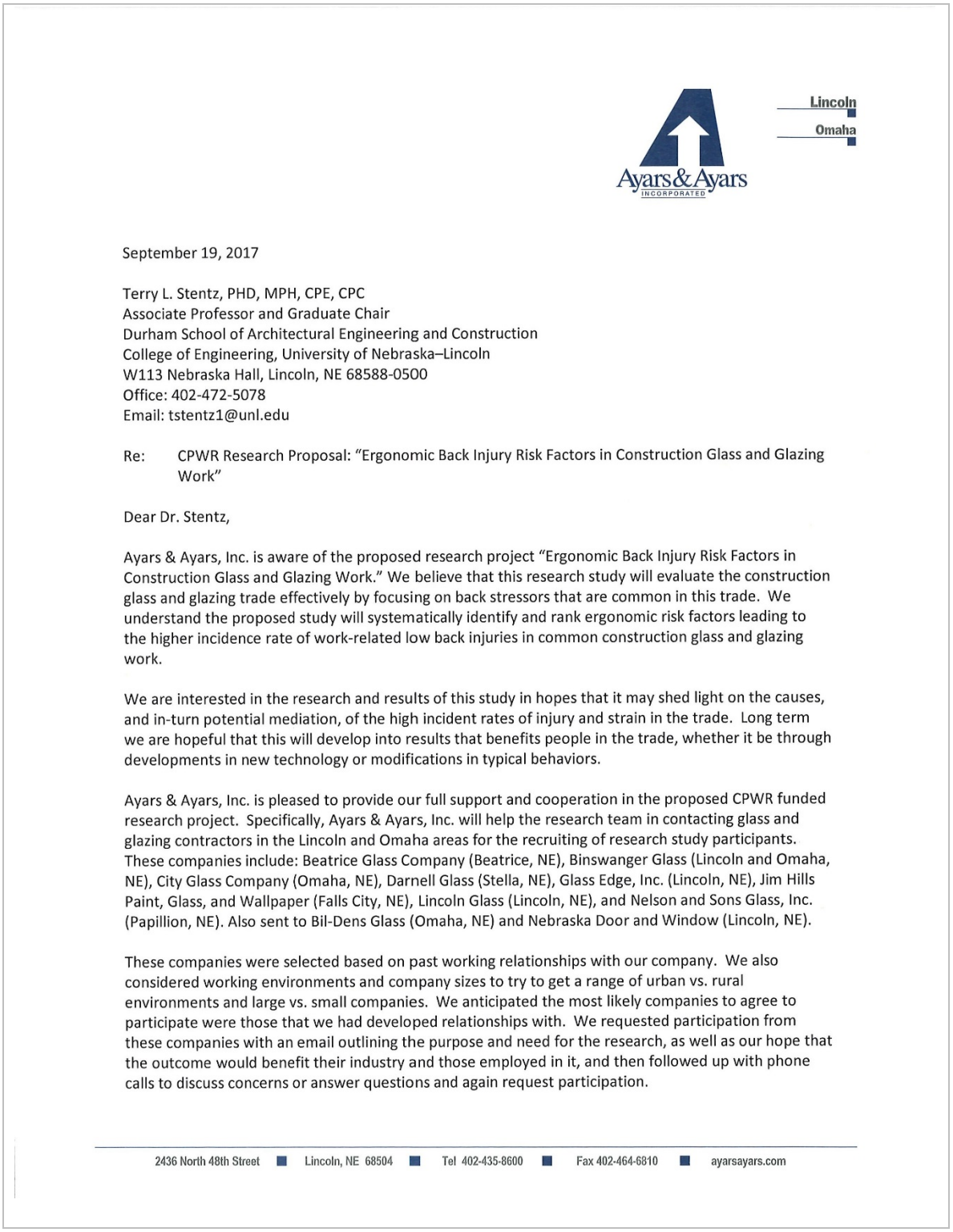
Appendices

Appendix A: Letters of Support



Lincoln
Omaha

Ayars & Ayars
INCORPORATED

September 19, 2017

Terry L. Stentz, PHD, MPH, CPE, CPC
Associate Professor and Graduate Chair
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College of Engineering, University of Nebraska–Lincoln
W113 Nebraska Hall, Lincoln, NE 68588-0500
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Re: CPWR Research Proposal: "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work"

Dear Dr. Stentz,

Ayars & Ayars, Inc. is aware of the proposed research project "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work." We believe that this research study will evaluate the construction glass and glazing trade effectively by focusing on back stressors that are common in this trade. We understand the proposed study will systematically identify and rank ergonomic risk factors leading to the higher incidence rate of work-related low back injuries in common construction glass and glazing work.

We are interested in the research and results of this study in hopes that it may shed light on the causes, and in-turn potential mediation, of the high incident rates of injury and strain in the trade. Long term we are hopeful that this will develop into results that benefits people in the trade, whether it be through developments in new technology or modifications in typical behaviors.

Ayars & Ayars, Inc. is pleased to provide our full support and cooperation in the proposed CPWR funded research project. Specifically, Ayars & Ayars, Inc. will help the research team in contacting glass and glazing contractors in the Lincoln and Omaha areas for the recruiting of research study participants. These companies include: Beatrice Glass Company (Beatrice, NE), Binswanger Glass (Lincoln and Omaha, NE), City Glass Company (Omaha, NE), Darnell Glass (Stella, NE), Glass Edge, Inc. (Lincoln, NE), Jim Hills Paint, Glass, and Wallpaper (Falls City, NE), Lincoln Glass (Lincoln, NE), and Nelson and Sons Glass, Inc. (Papillion, NE). Also sent to Bil-Dens Glass (Omaha, NE) and Nebraska Door and Window (Lincoln, NE).

These companies were selected based on past working relationships with our company. We also considered working environments and company sizes to try to get a range of urban vs. rural environments and large vs. small companies. We anticipated the most likely companies to agree to participate were those that we had developed relationships with. We requested participation from these companies with an email outlining the purpose and need for the research, as well as our hope that the outcome would benefit their industry and those employed in it, and then followed up with phone calls to discuss concerns or answer questions and again request participation.

2436 North 48th Street ■ Lincoln, NE 68504 ■ Tel 402-435-8600 ■ Fax 402-464-6810 ■ ayarsayars.com

Ayars & Ayars, Inc. will assist the research team in analysis of the research data and provide input/ interpretation of the results. We will also be available for discussion regarding any further information on industry related topics that the team may need. We will evaluate and provide comments and recommendations on the team's research in an effort to help the team achieve results that positively impact the glass and glazing industry.

We look forward to a successful and productive research relationship with the Durham School of Architectural Engineering and Construction, College of Engineering, University of Nebraska, Lincoln, NE. Please feel free to contact us should you require additional information or documentation.

Very truly yours,

Mike Ayars
Ayars & Ayars, Inc.

Robert Wittler
Ayars & Ayars, Inc.

CITY GLASS COMPANY 8037 H Street Omaha, NE 68127 (402) 593-1242 (402) 593-0806 Fax www.cityglasscompany.com

August 21, 2017

Terry L. Stentz, PHD, MPH, CPE, CPC
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Re: CPWR Research Proposal: "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work."

Dear Dr. Stentz,

City Glass Company is aware of the proposed research project "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work." We understand that this research study will evaluate the glass and glazing construction trade effectively by focusing on back stressors that are common in our trade. We understand the proposed study will systematically identify and rank ergonomic risk factors leading to the higher incidence rate of work-related low back injuries in common construction glass and glazing work.

City Glass Company is pleased to provide our support and cooperation in the proposed CPWR funded research project. Specifically, City Glass Company will participate in this valuable research study by helping the research team conduct ergonomic evaluations for glass and glazing work by means of the following actions:

- Provide interview candidates from all skill levels of our team of field glaziers.
- Candidates will be scheduled for interviews as needed by the study team, preferably toward the end normal working hours.
- Interviewed candidates will participate in interpreting the results of the study and offer any feedback and/or participate in any interventions that may result from the outcome(s).

We look forward to a successful and productive research relationship with the Durham School of Architectural Engineering and Construction, College of Engineering, University of Nebraska, Lincoln, NE. Please feel free to contact us should you require additional information or documentation.

Very truly yours,

Bryan Bush
City Glass Company

Terry L. Stentz, PHD, MPH, CPE, CPC
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Durham School of Architectural Engineering and Construction
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Re: CPWR Funded Research Project: "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work"

Dear Dr. Stentz,

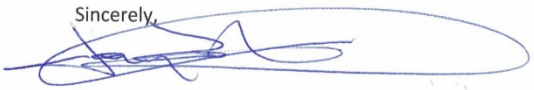
This letter confirms our company's intention to participate in your funded research project at the University of Nebraska-Lincoln, College of Engineering, Durham School of Architectural Engineering and Construction. Lincoln Glass Inc. understands that the proposed research project's title is "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work". We are aware that the main research goal is to conduct an ergonomic back stressor analysis in construction glass and glazing work. We also understand that the research team is trying to identify, rank, and analyze ergonomic risk factors that could contribute to work-related back discomfort and possible injury in construction glass and glazing work.

As part of our support and cooperation in the proposed CPWR funded research project, Lincoln Glass Inc. will participate in this valuable study by providing employee research subjects including managers and construction field glaziers from all skill levels of our construction team for job task interviews. Interview sessions will be toward the end normal working hours to minimize productivity disruption. In addition, we will allow construction work site job observations for as long as the research team needs to identify and evaluate ergonomics job stressors especially back stressors.

Lincoln Glass, Inc. would be pleased to assist the research team in the interpretation and discussion of the results of the study as well as offer feedback, ideas, and additional information that would be helpful in formulating future research and the testing of effective construction glass and glazing back injury risk reduction interventions.

Lincoln Glass Inc. looks forward to a successful and productive participation and research relationship with the Durham School of Architectural Engineering and Construction, College of Engineering, University of Nebraska, Lincoln, NE. If you have any questions, please feel free to contact us at 402-475-6785.

Sincerely,



President
Lincoln Glass Inc.

Bil-Den Glass

August 29, 2017

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Re: CPWR Research Proposal: "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work."

Dear Dr. Stentz,

Bil-Den Glass is aware of the proposed research project "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work." I understand that this research study will evaluate the glass and glazing construction trade effectively by focusing on back stressors that are common in our trade. I understand the proposed study will systematically identify and rank ergonomic risk factors leading to the higher incidence rate of work-related low back injuries in common construction glass and glazing work.

The most common type of injury for Glaziers at Bil-Den Glass are soft tissue injuries. The most common soft tissue injury is low back strain. I believe that the results of this research will help us identify the root problem or problems that lead to low back strain. In turn, this knowledge will help us make changes in how we handle and install our products.

Interviewing the glaziers from Bil-Den Glass will be a critical part of your research. You are welcome to speak with any of the glaziers or other employees to collect the data you need. The interviews would need to be done during normal working hours as part of our employee's job. Glaziers will most likely be interviewed at a jobsite. Those that participate will need to do so voluntarily. I have selected three glaziers that I believe have the background and experience to answer your questions and are willing to do so. I have given each participant a copy of the interview questions and have asked them to answer openly and honestly. In addition, I have told them that their interviews would be confidential and that I would not see the answers given. If you would like to broaden the sample or provide criteria to select others to participate please let me know.

I will make myself available to the research team to help in any way that I can. I am not knowledgeable about how a study like this comes together. The probable benefits to our employees and the glazing industry, causes me to want to do whatever I can to help with the study. If I am unable to help I will find someone at Bil-Den Glass who will be able to assist you.

6110 Irvington Road • Omaha, Nebraska 68134 • Phone (402) 397-7812 • Fax (402) 397-2113

Bil-Den Glass is pleased to provide our support and cooperation in the proposed CPWR funded research project. Specifically, Bil-Den Glass will participate in this valuable research study by helping the research team conduct ergonomic evaluations for glass and glazing work.

We look forward to a successful and productive research relationship with the Durham School of Architectural Engineering and Construction, College of Engineering, University of Nebraska, Lincoln, NE. Please feel free to contact us should you require additional information or documentation.

Very truly yours,

Cary Farrington
Operations Manager
Bil-Den Glass

KEYSTONE GLASS COMPANY

4330 South 87th Street · Omaha, Nebraska 68127 · (402) 339-4140 · www.keystoneglass.com

August 22, 2017

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Office: 402-472-5078
Email: tstentz1@unl.edu

Re: CPWR Research Proposal: "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work"

Dear Dr. Stentz,

Keystone Glass Company is aware of the proposed research project "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work". We understand that this research study will evaluate the glass and glazing construction trade effectively by focusing on back stressors that are common in our trade. We understand the proposed study will systematically identify and rank ergonomic risk factors leading to the higher incidence rate of work-related low back injuries in common construction glass and glazing work.

Keystone Glass Company is pleased to provide our support and cooperation in the proposed CPWR funded research project. Specifically, Keystone Glass Company will participate in this valuable research study by helping the research team conduct ergonomic evaluations for glass and glazing work. We will provide the following support and collaboration items and activities:

- Provide employee research subjects from all skill levels of our team of construction field glaziers including supervision and management, for job task interviews.
- Assist in the scheduling of employee research subjects for structured job task interviews as needed by the study team, preferably toward the end normal working hours.
- Allow work site job observations for as long as the research team needs to identify and evaluate ergonomics job stressors especially back stressors.
- Allow and encourage interviewed and observed employees to participate with the research team in interpreting the results of the study as well as offer feedback, ideas, and additional information that would be helpful in formulating future research and effective back injury risk reduction interventions.

We look forward to a successful and productive research relationship with the Durham School of Architectural Engineering and Construction, College of Engineering, University of Nebraska, Lincoln, NE. Please feel free to contact us should you require additional information or documentation.

Sincerely,

Jason Epstein
President
Keystone Glass Company

GLASS EDGE INC

8240 Cody Drive • Lincoln, NE 68512
Phone: (402) 420-7155 • Fax: (402) 420-7157

August 29, 2017

Terry Stentz, PHD, MPH, CPE, CPC
Associate Professor of Architectural Engineering and Construction College of Engineering,
University of Nebraska- Lincoln
W113 Nebraska Hall, Lincoln NE 68588-0500
Email: tstentz1@unl.edu

RE: CPWR Research Proposal: "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work"

Dear Dr. Stentz,

We have been in communication with Ms. Zahra Jabbarani Torghabeh in regards to the proposed research project "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work." We understand that this research will focus on back stressors, their potential causes and risk factors that might potentially address why the glazing trade faces higher incidence rates of work-related lower back issues in comparison to other trades and professions.

We are aware that work-related lower-back injuries in our trade has been identified as the highest rate amongst all construction workers. We are obviously greatly affected by these injuries not only from a dollars and cents standpoint as they relate to our insurance and labor costs, but more importantly we are happy to assist in order to potentially gain a better understanding of the issues and how it can improve the quality of life for our workers.

Glass Edge will be willing to help assist this research in a variety of means depending on the needs of the research team. Specifically are aware of and will gladly assist in the following:

- Provide employee candidates that perform a variety of glass-related tasks on a daily basis for interviews and questionnaires.
- Assist in scheduling requested employees during normal working hours for the aforementioned functions.
- Arrange for work-site observations to help evaluate various job functions. Many construction sites will require notification of the General Contractor and possibly site-training in order to be allowed on site.
- Review of findings and potential participation in helping to identify specific risks and how best to help alleviate and ideally eliminate future back injuries.

We look forward to a successful research endeavor and are happy to assist the University in whatever capacity suits its best interests.

Respectfully,

David A. Stamper
President
Glass Edge of Lincoln, Inc.

Appendix B: IRB Documents

University of Nebraska Lincoln

THE DURHAM SCHOOL OF ARCHITECTURAL ENGINEERING AND CONSTRUCTION

Offering Programs in Omaha and Lincoln
COLLEGE OF ENGINEERING

Informed Consent Form for construction glass and glazing employees who we are inviting to participate in research "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work - Job Description Phase".

IRB Approval Number:

Investigators:
Terry L. Stentz (tstentz1@unl.edu)
Zahra Jabbarani Torghabeh (z.jabbarani@huskers.unl.edu)
Kelli R. Herstein (kelliherstein@unl.edu)

Organization: University of Nebraska Lincoln

This Informed Consent Form has two parts:

- Information Sheet (to share information about the study with you)
- Certificate of Consent (for signatures if you choose to participate)

You will be given a copy of the full Informed Consent Form

Part I: Information Sheet

Introduction

Today, we are going to ask you questions about your job and related tasks of glass and glazing trade. We would be grateful for any thoughts and information that you may share with us today. We are going to give you information and invite you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words that you do not understand. Please ask us to stop as we go through the information and we will take time to explain.

Purpose of the research

Building construction is a labor-intensive and physically demanding in an everyday context of challenging and changing work environments. Construction workers are frequently exposed to heavy workloads and various physical stressors which can result in debilitating work-related musculoskeletal disorders (WRMSDs) of the upper extremities as well as lower back discomfort, pain, and injury. Lower back injuries can result in high medical cost, lost time, reduced productivity, and temporary or even permanent disability. In 2013, the incident rate of WMSDs in construction industry was 41.9 compared to a rate of 32.8 per 10,000 Full-Time Employees (FTEs) for all industries combined (BLS 2013).

The back is the most frequent anatomical injury location accounting for 16% of nonfatal injuries in construction. These back injuries result in a Days Away from Work incidence rate of 24.5 per 10,000 full-time employees (FTEs) compared to a rate of 21.4 per 10,000 full-time workers for all U.S. industries combined. In 2010, glass and glazing contractors reported the highest rate of back injuries, 97.8 per 10,000 FTEs, followed next by masonry contractors with 45.3 per 10,000 FTEs (CPWR, 2010). We conducted a thorough literature search and could find no published research on back injuries, back injury prevention, or ergonomics for construction glass and glazing work. The proposed study aimed to provide job description in common construction glass and glazing work to support future ergonomic analysis of this trade.

Type of Research Intervention

We ask you to contribute to this research project by completing a survey questionnaire or participating in an interview session. During the interview session, we are going to ask you questions about your job and job-related tasks in the glass and glazing trade. We will record our conversation. You can withdraw from the interview at any time if you are feeling uncomfortable with anything in the interview. We will not ask you anything of a personal nature. The entire interview is about construction glass and glazing work.

Participant Selection

You are being invited to take part in this research because we feel that your experience can contribute much to our understanding and knowledge of safety and health issues in construction glass and glazing job. You must be an English-speaking construction glass and glazing employee who is 19 years of age or older to participate in this study.

Voluntary Participation

Your participation in this research is voluntary. It is your choice whether to participate or not. The choice that you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed to participate in the research earlier.

Procedures

We are asking you to help us learn more about safety and health issues in construction glass and glazing trade. We are inviting you to take part in this research project; If you agree to take part in the research, you will be asked to participate in an interview session or complete a survey questionnaire. We will record our conversation during the interview. You can withdraw from the interview at any time if you are feeling uncomfortable with what we are asking.

Duration
The research takes place over two months in total. During that time, we ask you to complete a survey questionnaire or participate in an interview session according to your availability and willingness. Each session will last for 30-40 minutes.

Risks
There are no risks or discomforts that are anticipated from your participation in the study. You do not have to answer any question or take part in the discussion/interview/survey if you feel the question(s) are too personal or if talking about them makes you uncomfortable.

Benefits
You would benefit from your research participation in both direct and indirect ways. Regarding direct way, we would offer each participant a gift card valued at $25 or cash (as approved) to appreciate your voluntary time and participation. You will also my benefit indirectly since your participation is likely to help us find out more about how to prevent and treat musculoskeletal disorders in your community.

Confidentiality
We will not be sharing information about you to anyone outside of the research team. In order to protect the participants during data collection and data analysis process, all names and locations will be kept anonymous by using pseudonyms terminology. All materials will be kept confidential and secured by locking the storage and providing password for digital files on computers. Only the researchers will know what your number is and we will lock that information up with a lock and key.

Sharing the Results
We will share the results of this research with you and your community before it is made widely available to the public. You will receive a copy of the results and we will publish the results after discussion with you and you community and nothing will be attributed to you by name.

Right to Refuse or Withdraw
You do not have to participate in this research and choosing to participate will not affect your job or job-related evaluations in any way. You may stop participating at any time that you wish without your job being affected. You will have an opportunity at the end of the discussion to review and modify your remarks.

The University of Nebraska-Lincoln wants to know about your research experience. This 14 question, multiple-choice survey is anonymous; however, you can provide your contact information if you want someone to follow-up with you. This survey should be completed after your participation in this research. Please complete this optional online survey at: https://ssp.qualtrics.com/SE/?SID=SV_aVvlNCf0U1vse5n

Who to Contact
If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact any of the following:

Terry L. Stentz, PHD, MPH, CPE, CPC
Associate Professor and Graduate Chair
Durham School of Architectural Engineering & Construction
College of Engineering - University of Nebraska Lincoln
113 Nebraska Hall, P.O. Box 880500, Lincoln, NE 68588-0500
Office: 402-472-5078
Email: tstentz1@unl.edu

Zahra Jabbarani Torghabeh, MSc.
Ph.D. Candidate
Durham School of Architectural Engineering and Construction
College of Engineering - University of Nebraska Lincoln
Email: z.jabbarani@huskers.unl.edu

Kelli R. Herstein, Ph.D.
Post Doctorate Research Associate
Durham School of Architectural Engineering and Construction
College of Engineering, University of Nebraska–Lincoln
113 Nebraska Hall, P.O. Box 880500, Lincoln, NE 68588-0500
Office: 402-472-3725
Email: kelliherstein@unl.edu

Part II: Certificate of Consent

I have been invited to participate in research about "**Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work - Job Description Phase**".

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

Print Name of Participant_____

Signature of Participant _____

Date _____

Day/month/year

If illiterate [1]

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness _____ Thumb print of participant

Signature of witness _____

Date _____

Day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands that the following will be done:

1.
2.
3.

IRB# 20170216717EX
Date Approved: 09/07/2017
Valid Until: 02/03/2022

[1] A literate witness must sign (if possible, this person should be selected by the participant and should have no connection to the research team). Participants who are illiterate should include their thumb print as well.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

Print Name of Researcher/person taking the consent_____

Signature of Researcher /person taking the consent_____

Date _____
Day/month/year

Dear....

Ayars & Ayars, Inc. has agreed to help the research team by contacting glass and glazing companies that we work with in Nebraska to recruit research study participants. We are looking for contractors who will be volunteer collaborators in a study focused on an issue specific to your trade described in more detail below, and that have construction projects currently in progress for job and worker observation and data gathering.

The Durham School of Architectural Engineering & Construction at the University of Nebraska-Lincoln (UNL) submitted a funded research proposal to the Center for Construction Research and Training (CPWR) Small Studies Program tentatively titled "Ergonomic Stressors and Back Injury Risk Factors in Construction Glass and Glazing Work".

According to Bureau of Labor Statistics (BLS) construction injuries data for 2010, glass and glazing contractors reported the highest rate of back injuries, 97.8 per 10,000 full-time employees (CPWR, 2010). This is the highest rate of back injuries for all construction trades. The UNL research team conducted a thorough literature search and could find no published research on back injuries, back injury prevention, or ergonomics for construction glass and glazing work.

The research team is seeking industry support for conducting an ergonomics evaluation of work-related physical stressors in construction affecting glass and glazing workers. The proposed study will systematically identify and rank ergonomic risk factors in common glass and glazing work. Data gathering and analysis will focus on back stressors that can produce work-related discomfort and injury. The ultimate goal of this research is to help contractors reduce back injury risks for their construction glass and glazing workers.

Ayars & Ayars, Inc. and the University of Nebraska-Lincoln would appreciate your commitment to participate in this valuable research study. If you agree to be part of this research study, we ask that you send us a letter of support from your company that shows you are willing to help the research team conduct the ergonomic evaluation for glass and glazing work.

If you agree to participate, you will be asked to support the research study by completing their survey, interview sessions, participant recruitment, and allowing them to do observation in order to collect data.

We appreciate your time and assistance in this matter, and hope this will lead to results that benefit our industry.

Sincerely,

The script for Interview Questionnaires (Job Description interviews)

Dear Participant,

We invite you to participate in a study entitled: "**Ergonomic Stressors and Back Injury Risk Factors in Construction Glass and Glazing Work - Job Description Phase**".

This interview session has been designed to collect information on: Construction Glass and Glazing Trade.

We would like to thank you for taking the time to talk to us today. Today, we are going to ask you questions about your job and related tasks of glass and glazing trade. You are being invited to take part in this study because we feel that your experience can contribute much to our understanding and knowledge of safety and health issues in construction glass and glazing trade. We would be grateful for any thoughts and information that you may share with us today. We would like you to know that your names and other personal information will be considered as confidential. We will record our conversation. Please let us know if, at any time during our conversation, you would like to take a break. Your participation in this study is entirely voluntary. You can withdraw from the interview at any time if you are feeling uncomfortable with anything that we are asking. It should take approximately 30-40 Minutes to complete. Now, do We have your permission to begin recording?

Do you have any questions before we begin?

We really appreciate your cooperation and interest in making this research successful.

All information/data in this questionnaire are solely used for academic purposes in research.

Sincerely,

The UNL research team

Date: _____ ID Number: _____

Dear Participant,

We invite you to participate in a study entitled: "**Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work - Job Description Phase**".

The enclosed questionnaire has been designed to collect information on: Construction Glass and Glazing Trade.

You are being invited to take part in this study because we feel that your experience can contribute much to our understanding and knowledge of safety and health issues in construction glass and glazing trade. Your participation in this study is entirely voluntary. The choice that you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed earlier. Your name will not be used in any way; your answers will be anonymous.

If you agree to participate in this project, please answer the questions on the questionnaire as best you can. If you do not wish to answer any of the questions included in the survey, you may skip them and move on to the next question. Remember that your answers will be kept confidential. It should take approximately 30-40 Minutes to complete.

We really appreciate your cooperation and interest in making this research successful.

All information/data in this questionnaire are solely used for academic purposes in research.

Sincerely,

The UNL Research Team

University of Nebraska Lincoln

THE DURHAM SCHOOL
OF ARCHITECTURAL ENGINEERING AND CONSTRUCTION

Offering Programs in Omaha and Lincoln
COLLEGE OF ENGINEERING

Date: _____ ID Number: _____

Dear Participant,

We invite you to participate in a study entitled: "**Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work - Job Description Phase**".

This interview session has been designed to collect information on: Construction Glass and Glazing Trade.

We would like to thank you for taking the time to talk to us today. Today, we are going to ask you questions about your job and related tasks of glass and glazing trade. You are being invited to take part in this study because we feel that your experience can contribute much to our understanding and knowledge of safety and health issues in construction glass and glazing trade. We would be grateful for any thoughts and information that you may share with us today. We would like you to know that your names and other personal information will be considered as confidential. We will record our conversation. Please let us know if, at any time during our conversation, you would like to take a break. Your participation in this study is entirely voluntary. You can withdraw from the interview at any time if you are feeling uncomfortable with anything that we are asking. It should take approximately 30-40 Minutes to complete. Now, do we have your permission to begin recording?

Do you have any questions before we begin?

We really appreciate your cooperation and interest in making this research successful.

All information/data in this questionnaire are solely used for academic purposes in research.

Sincerely,

The UNL research team

The Charles W. Durham School of Architectural Engineering and Construction

Scott Campus: The Peter Kiewit Institute / 1110 South 67th Street / Omaha, NE 68182-0816 / 402-554-2460
City Campus: 113 Nebraska Hall / Lincoln, NE 68588-0500 / 402-472-3742
www.durhamschool.unl.edu

Construction Glass and Glazing Project Managers and Supervisors Job Description Questionnaire (Interview)

Location: _____ **Time**: _____

Interviewer: _____ **Interviewee**: _____

Questions:

1. What is your job title and your job function in your company?

2. What types of projects/construction are your specialties?

3. What are the glass and glazing worker job categories/job titles in your company?

4. What are the essential job functions for each glass and glazing worker job category/job position in your company? Can you rank order the essential job functions from most important to least important? If yes, please proceed.

5. What are the formal educational requirements for each glass and glazing worker job category/job title in your company? If a job candidate doesn't meet the educational requirements what do you do?

6. What kinds of certifications, licenses, registrations, or specialized training programs do you look for in the job candidates?

7. What types of job training opportunities do you have for your glass and glazing workers?

8. What kinds of skills and abilities do you prefer in the glass and glazing workers you hire and retain?

9. What kinds of experience do you look for in the workers you want to hire?

10. Describe job requirements glass and glazing worker job applicants should know such as travel requirements, physical demands, unusual working hours and/or working conditions, shiftwork, on-call situations, etc.

11. Is there anything that we have not talked about that you think is important for us to know about glass and glazing work in your company?

Exit Comments:

We would like to thank you again for participating in this interview. Once again, we assure you that your responses will be kept confidential.

Date: _____ ID Number: _____

Dear Participant,

We invite you to participate in a study entitled: "**Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work - Job Description Phase**".

This interview session has been designed to collect information on: Construction Glass and Glazing Trade.

We would like to thank you for taking the time to talk to us today. Today, we are going to ask you questions about your job and related tasks of glass and glazing trade. You are being invited to take part in this study because we feel that your experience can contribute much to our understanding and knowledge of safety and health issues in construction glass and glazing trade. We would be grateful for any thoughts and information that you may share with us today. We would like you to know that your names and other personal information will be considered as confidential. We will record our conversation. Please let us know if, at any time during our conversation, you would like to take a break. Your participation in this study is entirely voluntary. You can withdraw from the interview at any time if you are feeling uncomfortable with anything that we are asking. It should take approximately 30-40 Minutes to complete. Now, do we have your permission to begin recording?

Do you have any questions before we begin?

We really appreciate your cooperation and interest in making this research successful.

All information/data in this questionnaire are solely used for academic purposes in research.

Sincerely,

The UNL Research Team

Construction Glass and Glazing Workers Job Description Questionnaire (Interview)

Location: _____ **Time:** _____

Interviewer: _____ **Interviewee:** _____

Questions:

1. What is your job title/job function?
2. How long have you been employed as a glass and glazing worker?
3. What are the usual working conditions/working environment for your job?
4. What are your various job tasks? Describe a typical day in terms of your job tasks, work schedule, type of construction project, and location.
5. What types of hand tools, powered equipment, and other things do you use in your job?
6. What are the educational requirements of your job?
7. How were you trained to do your job?
8. What kinds of certifications, licenses, or specialized training do you need to perform your job?
9. What kinds of skills and abilities do you need to perform your job?
10. What kinds of experience do you need to perform your job well?
11. What are the hardest job tasks you do in terms of physical demand and/or discomfort? Please describe and what makes these tasks so hard to do.
12. Is there anything that we have not talked about that you think is important for us to know about your glass and glazing work?

Exit Comments:

I would like to thank you again for participating in this interview. Once again, I assure you that your responses will be kept confidential.

Informed Consent Form for construction glass and glazing employees who we are inviting to participate in research "Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work - Ergonomic Analysis Phase".

IRB Approval Number:

Investigators:
Terry L. Stentz (tstentz1@unl.edu)
Zahra Jabbarani Torghabeh (z.jabbarani@huskers.unl.edu)
Kelli R. Herstein (kelliherstein@unl.edu)

Organization: University of Nebraska Lincoln

This Informed Consent Form has two parts:

- Information Sheet (to share information about the study with you)
- Certificate of Consent (for signatures if you choose to participate)

You will be given a copy of the full Informed Consent Form

Part I: Information Sheet

Introduction

Today, we are going to give you information and invite you to be part of this research. The aim of our study is to systematically evaluate the ergonomics and back injury risk factors for the construction glass and glazing trade to help identify problems that can explain the higher incidence rate of work-related low back injury. We are grateful for any thoughts and information that you will share with us today. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words that you do not understand. Please ask us to stop as we go through the information and we will take time to explain.

Purpose of the research

The construction industry is a heavy manual and labor-intensive industry. Construction workers are frequently exposed to heavy workloads and various physical stressors which can result in debilitating work-related musculoskeletal disorders (WRMSDs) of the upper extremities as well as lower back discomfort, pain, and injury. Lower back injuries can result in high medical cost, lost time, reduced productivity, and temporary or even permanent disability. In 2013, the incident rate of WMSDs in construction industry was 41.9 compared to a rate of 32.8 per 10,000 full-time employees (FTEs) for all industries combined (Bureau of Labor Statistics, 2013).

The back is the most frequent anatomical injury location accounting for 16% of nonfatal injuries in construction. These back injuries result in a days away from work incidence rate of 24.5 per 10,000 full-time employees (FTEs) compared to a rate of 21.4 per 10,000 full-time workers for all U.S. industries combined. In 2010, glass and glazing contractors reported the highest rate of back injuries, 97.8 per 10,000 FTEs, followed next by masonry contractors with 45.3 per 10,000 FTEs (Center for Construction Research and Training (CPWR), 2010). We conducted a thorough literature search and could find no published research on back injuries, back injury prevention, or ergonomics for construction glass and glazing work. The proposed study aims to analyze the glass and glazing work tasks to determine those ergonomic risk factors that pose the greatest risk for back discomfort, pain, and injury using observational methods.

Procedures

We are asking you to contribute to this research project by letting us observe you while you are performing your routine tasks. If you agree to participate in this study, the researcher observes your everyday construction glass and glazing activities. The observation may last from few hours to several days. We will take pictures and videos during the observation. The researcher may ask you questions and take notes about your activities while observing. You are welcome to ask questions at any time. You can withdraw at any time if you are feeling uncomfortable with anything during data collection. The entire data collection process is about construction glass and glazing tasks.

Participant Selection

You are being invited to take part in this research because we feel that your experience can contribute much to our understanding and knowledge of safety and health issues in construction glass and glazing job. You must be an English-speaking construction glass and glazing employee who is 19 years of age or older to participate in this study.

Voluntary Participation

Your participation in this research is voluntary. It is your choice whether to participate or not. The choice that you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed to participate in the research earlier.

Duration

The observation may last from few hours to several days. During that time, we ask you to perform your job as before and the observer will collect required data while you are performing your routine construction glass and glazing job.

Risks/ Benefits

There are no risks or discomforts that are anticipated from your participation in the study. You would benefit from your research participation in both direct and indirect ways. Regarding the direct way, each participant receives a gift card valued at $25 or cash (as approved) to appreciate your voluntary time and participation. You will also benefit indirectly because your participation is likely to help us find out more about how to prevent and treat musculoskeletal disorders in your community.

Confidentiality

We will not share information about you to anyone outside of the research team. In order to protect the participants during data collection and data analysis process, all names and locations will be kept anonymous by using pseudonyms terminology. Photos and videos will be taken from workers' postures while you are performing your routine construction glass and glazing tasks to do further analysis if needed and also there is a possibility of using pictures for future publications. The participants' faces will not be captured and if it happens, we will blur your faces in the case of using pictures.

All materials will be kept confidential and secured by locked storage and digital files on computers or other digital media are password–protected. The research project investigators have access to the participants' information and photographs and the files will be destroyed after ten (10) years.

Sharing the Results

We will share the aggregated results of this research with you and your community before it is made widely available to the public. You will receive a copy of the results and we will publish the results after discussion with you and you community. Nothing will be attributed to you by name.

Right to Refuse or Withdraw

You do not have to participate in this research and choosing to participate will not affect your job or job-related evaluations in any way. You have the right to ask questions at any time. You may stop participating at any time that you wish without your job being affected. You will have an opportunity at the end of the discussion to review and modify your remarks.

The University of Nebraska-Lincoln wants to know about your research experience. This 14 question, multiple-choice survey is anonymous; however, you can provide your contact information if you want someone to follow-up with you. This survey should be completed after your participation in this research. Please complete this optional online survey at: https://ssp.qualtrics.com/SE/?SID=SV_aVvlNCf0U1vse5n

Who to Contact
If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact any of the following:

Terry L. Stentz, PHD, MPH, CPE, CPC
Associate Professor and Graduate Chair
Durham School of Architectural Engineering & Construction
College of Engineering - University of Nebraska Lincoln
113 Nebraska Hall, P.O. Box 880500, Lincoln, NE 68588-0500
Office: 402-472-5078
Email: tstentz1@unl.edu

Zahra Jabbarani Torghabeh, MSc.
Ph.D. Candidate
Durham School of Architectural Engineering and Construction
College of Engineering - University of Nebraska Lincoln
Email: z.jabbarani@huskers.unl.edu

Kelli R. Herstein, Ph.D.
Post Doctorate Research Associate
Durham School of Architectural Engineering and Construction
College of Engineering, University of Nebraska–Lincoln
113 Nebraska Hall, P.O. Box 880500, Lincoln, NE 68588-0500
Office: 402-472-3725
Email: kelliherstein@unl.edu

Part II: Certificate of Consent

I have been invited to participate in research about "**Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work - Ergonomic Analysis Phase**".
I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

Print Name of Participant _____

Signature of Participant _____

Date _____
Month /day/year

Statement by the researcher/person taking consent
I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands that the following will be done:

1.
2.
3.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

Print Name of Researcher/person taking the consent_____

Signature of Researcher /person taking the consent_____

Date _____
Month /day/year

Appendix C: PATH Surveys

Pre-Observation

Q1. **Study Title:** Ergonomic Back Injury Risk Factors in Construction Glass and Glazing Work

Coder : Zahra Jabbarani Torghabeh

Descriptive Data

Q2. Observer name

Q3. Date

Q4. Participating Company

Q5. Location

Q6. Worksite

Q7. Type of project

Taxonomy

Q8. Operation/Product

Q9. Template/Task

Observation Data

Q10. Observation Period (Number)

- 1
- 2
- 3
- 4

Q11. Observation period (Time)

	Start Time	End Time
Period 1		
Period 2		
Period 3		
Period 4		

Q12. Total number in crew

- 1
- 2
- 3
- 4

- ○ 5
- ○ 6
- ○ 7
- ○ 8

Q13. Workers' information

	Worker#1	Worker#2	Worker#3	Worker#4	Worker#5	Worker#6	Worker#7	Worker#8
Initial or worker's Code								
Number Assigned								
Gender								
Dominant Hand								

Working Condition / Environment

Q14. Housekeeping

	Good (Well-organized, uncluttered, cleared, and hazard-free work area.)	Fair (Semi-organized, some clutter around due to existence of different contractors.)	Poor (No organized, cluttered, uncleared, and hazardous work area.)
Housekeeping	○	○	○

Q15. Noise

	Someone could comfortably hear you use a whisper/ very quiet voice from 1 meter away(e.g., library)	You could easily hold a conversation with someone 1 meter away from you without raising your voice.	Conversation is possible with someone 1 meter away, but requires you to raise your voice (e.g., noisy cafe)	You need to shout to be heard by someone 1 meter away. Difficult to hold a conversation.	Cannot be heard by someone 1 meter away, even when shouting. Volume level may be uncomfortable after a short time,
Noise	○	○	○	○	○

Q16. Dust

	Visible/No mask need	Bad enough to use mask	Need a respirator
Dust	○	○	○

Q17. Weather

	Temperature (°F), Humidity (%), Wind (mph)
Temperature	
Humidity	
Wind Speed	

Personal Protective Equipment

Q18. Click to write the question text

	Head Protection	Hearing Protection	Respiratory Protection	Fall Protection
Worker 1	▼	▼	▼	▼
Worker 2	▼	▼	▼	▼
Worker 3	▼	▼	▼	▼

	Head Protection	Hearing Protection	Respiratory Protection	Fall Protection
Worker 4	▼	▼	▼	▼
Worker 5	▼	▼	▼	▼
Worker 6	▼	▼	▼	▼
Worker 7	▼	▼	▼	▼
Worker 8	▼	▼	▼	▼

Default Question Block

Observation Info

☐ _____ Participant's number

Product/Operation

- ○ Curtainwall
- ○ Storefront
- ○ Interior glass
- ○ Panelling

Task

- ○ Frame installation
- ○ Glass/Panel installation
- ○ Wood/Foam installation (temporary)
- ○ Finishing jobs
- ○ Loading/Unloading

Working Condition

- ○ Working on the ground
- ○ Working on a ladder
- ○ Working on a scissor lift
- ○ Working on a boom lift
- ○ Not Obs/Not sure

Trunk Posture

- Neutral (Flex <20)
- Mild (20 ≤ Flex ≤45)
- Severe (Flex ≥ 45)
- Twist neutral
- Lateral bend
- Lateral bend/twist neutral
- Lateral bend/twist flexed
- Bend backwad
- Not Obs/Not sure

Arm Posture

- Elbows below shoulder height
- One elbow at/above shoulder height
- Two elbows at/above shoulder height
- Not Obs/Not sure

Leg Posture

- Stand (Flex <35)
- Walk/Run
- One leg in the air/ One foot not supported
- Lunge (1 Knee >35)
- Shallow squat (35 < Knees <80)
- Deep squat (Both knees > 80)
- Vertical kneel (1 or both)
- Sitting kneel
- Sit on a raised seat
- Sit on the ground
- Crawl
- Lie on the chest
- Lie on either side
- Lean forward
- Lean to either side
- Legs not supporting, body worker supported by something (e.g. Harness) other than legs
- Not Obs/Not sure

Weight in Hands (lb)

- No weight in hands
- Weight < 10 lbs
- 10 lbs ≤ Weight < 50 lbs
- 50 lbs ≤ Weight < 100 lbs
- Weight ≥ 100 lbs
- Not Obs/Not sure

Materials/Assemblies/Tools in hands

- [ ] No materials/tools in hands
- [ ] Preassembled Frame
- [ ] Glass
- [ ] Door
- [ ] Panel
- [ ] Foam
- [ ] Wood
- [ ] Mullion
- [ ] Horizontal
- [ ] Pressure plate
- [ ] Temporary retainer clips
- [ ] Snap on beauty trim
- [ ] Hand tool/Powered equipment
- [ ] Other

Manual Material Handling (MMH)

- ○ No MMH
- ○ 1 Hand
- ○ 2 Hands
- ○ Not Obs/Not sure

Team Manual Material Handling

- ○ Yes (Number in team)
- ○ No
- ○ Not Obs/Not sure

Manual Material Handling Activities

- ○ Move/Place
- ○ Carry/Hold
- ○ Push/Pull/Drag
- ○ Lift
- ○ Lower
- ○ Not Obs/Not sure

General Activities

- [ ] No general activity
- [ ] Hold: Steady/Maintain
- [ ] Hold: Steady/Maintain resting on shoes
- [ ] Operate lift
- [ ] Read blueprint/instruction
- [ ] Communicate/Supervise

- [ ] Point/Direct
- [ ] Reach
- [ ] Climb/Descend
- [ ] Gloves on/off
- [ ] Harness on/off
- [ ] Attach/Detach land yard
- [ ] Walk
- [ ] Drive truck/lift
- [ ] Monitor
- [ ] Housekeeping
- [ ] Rest
- [ ] Fasten/Unfasten
- [ ] Watch/Wait/Idle
- [ ] In between tasks
- [ ] Other
- [ ] Not Obs/Not sure

Frame Installation Activities

- ○ No task specific activity
- ○ MMH
- ○ Measure
- ○ Grind
- ○ Mark
- ○ Attach/Remove clamp
- ○ Hammer
- ○ Drill
- ○ Screw/Unscrew
- ○ Level
- ○ Shim
- ○ Clean/Wipe
- ○ Caulk
- ○ Cut
- ○ Snap frames
- ○ Put vinyl/gasket
- ○ In between tasks
- ○ Other
- ○ Not Obs/Not sure

Glass/Panel Installation Activities

- ○ No task specific activity
- ○ MMH
- ○ Clean/Wipe
- ○ Attach/Detach suction cups
- ○ Drill
- ○ Screw/Unscrew
- ○ Shim
- ○ Hammer
- ○ Level
- ○ Place temporary retainer clips
- ○ In between tasks
- ○ Other

- Put vinyl/gasket
- Not Obs/Not sure

Wood/Foam Installation Activities

- No task specific activity
- MMH
- Measure
- Mark
- Cut
- Clean
- Drill
- Screw/Unscrew
- Hammer
- Place temporary retainer clips
- Put vinyl/gasket
- In between tasks
- Other
- Not Obs/Not sure

Loading/Unloading Activities

- No task specific activity
- MMH
- Measure
- Mark
- Hammer
- Drill
- Screw/Unscrew
- Clean/Wipe
- Cut
- In between tasks
- Other
- Not Obs/Not sure

Finishing Jobs

- No task specific activity
- Put vinyl/gasket
- Hammer
- Drill
- Screw/Unscrew
- Smooth the bead of caulking with a wet finger
- Spray (glass cleaner)
- Smooth the bead of caulking with a finishing tool
- Install pressure plate
- Install snap on beauty trim/face

- ○ Clean/Wipe
- ○ Fill the perimeter with backer rod
- ○ Cut
- ○ Tape/Remove tape
- ○ Apply/Push the caulk bead
- ○ Level
- ○ In between tasks
- ○ Other
- ○ Not Obs/Not sure

Tool Specific Activities

- ○ No hand tool/powered equipment in hands
- ○ Operate tool
- ○ Hold tool not operate
- ○ Adjust tool
- ○ Carry tool
- ○ Not Obs/Not sure

Hand Tools/Materials

- ☐ No hand tool in hands
- ☐ Bar hand tools
- ☐ Caulking tools/materials
- ☐ Cutter/Plier hand tools
- ☐ Marking tools
- ☐ Miscellaneous hand tools/materials
- ☐ Shim
- ☐ Other
- ☐ Not Obs/Not sure

Bar hand tools

- ☐ Paddle Shovel Wedge Packer
- ☐ Flat Bar
- ☐ Pry Bar
- ☐ Crowbar
- ☐ Other

Caulking tools/materials

- [ ] Manual caulking gun
- [ ] Caulking knife/Tooling knife
- [ ] Glass cleaner spray/liquid
- [ ] Multi-function glazing knife
- [ ] Putty knife
- [ ] Sealant sausage/tube
- [ ] Paper towel/rags
- [ ] Masking tape
- [ ] Other

Cutter/Plier hand tools

- [ ] Utility knife
- [ ] Razor
- [ ] Snip
- [ ] Wire stripper
- [ ] Plier
- [ ] Other

Marking Tools

- [ ] Chalk line
- [ ] Marker/Pencil
- [ ] Square
- [ ] Tape measure
- [ ] Other

Miscellaneous Hand Tools/Materials

- [ ] Suction cup
- [ ] Vinyl roller
- [ ] Screwdriver
- [ ] Allen wrenches
- [ ] Clamp
- [ ] Hammer/Mallet
- [ ] Block/Temps/Clips
- [ ] Glass installation hook tool
- [ ] Hacksaw
- [ ] Level
- [ ] Cleaning brush
- [ ] Screw
- [ ] Gasket
- [ ] Backer rod
- [ ] Setting block
- [ ] Other

Shim

- ○ Plastic shim
- ○ Wood shim

Powered Equipment

- ☐ No powered equipment
- ☐ Drill
- ☐ Saw
- ☐ Battery powered grinder/Side grinder
- ☐ Gun
- ☐ Compressor
- ☐ Laser
- ☐ Other
- ☐ Not Obs/Not sure

Drill

- ☐ Hammer drill
- ☐ Impact drill
- ☐ Regular cordless drill
- ☐ Right angle driver
- ☐ Other

Saw

- ☐ Skilsaw
- ☐ Chop saw
- ☐ Sawzall
- ☐ Jig saw
- ☐ Portable band saw
- ☐ Circular saw
- ☐ Bingen saw
- ☐ Chicksaw
- ☐ Contour saw
- ☐ Miter saw
- ☐ Oscillating saw
- ☐ Other

Gun

- [ ] Battery powered screw gun
- [ ] Battery powered caulking gun
- [ ] Cut gun
- [ ] Other
- [ ] Nailer

Hand 1

- ○ Empty hand
- ○ Fingers Press
- ○ Power grasp
- ○ Not Obs/Not sure
- ○ Precision grasp
- ○ Other

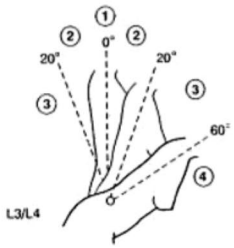
Hand 2

- ○ Empty hand
- ○ Fingers press
- ○ Power grasp
- ○ Not Obs/Not sure
- ○ Precision grasp
- ○ Other

Appendix D: REBA Tables

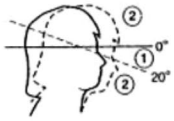
Trunk

Movement	Score	Change score:
Upright	1	+1 if twisting or side flexed
0°–20° flexion 0°–20° extension	2	
20°–60° flexion >20° extension	3	
>60° flexion	4	



Neck

Movement	Score	Change score:
0°–20° flexion	1	+1 if twisting or side flexed
>20° flexion or in extension	2	



Legs

Position	Score	Change score:
Bilateral weight bearing, walking or sitting	1	+1 if knee(s) between 30° and 60° flexion
Unilateral weight bearing Feather weight bearing or an unstable posture	2	+2 if knee(s) are >60° flexion (n.b. Not for sitting)

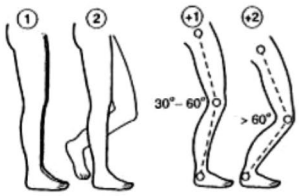


Table A and Load

Table A

Trunk		Neck 1				Neck 2				Neck 3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
1		1	2	3	4	1	2	3	4	3	3	5	6
2		2	3	4	5	3	4	5	6	4	5	6	7
3		2	4	5	6	4	5	6	7	5	6	7	8
4		3	5	6	7	5	6	7	8	6	7	8	9
5		4	6	7	8	6	7	8	9	7	8	9	9

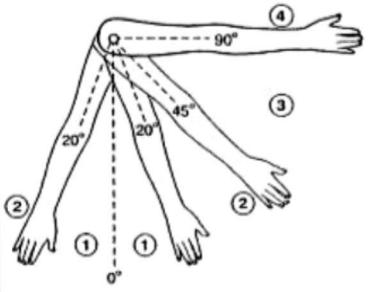
Load/Force

0	1	2	+1
< 5 kg	5–10 kg	> 10 kg	Shock or rapid build up of force

Figure 3: REBA Score "A" Related Tables Adopted from Hignett and McAtamney (2000)

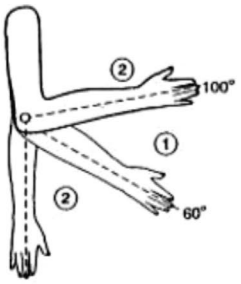
Upper arms

Position	Score	Change score:
20° extension to 20° flexion	1	+1 if arm is: • abducted • rotated
>20° extension 20°–45° flexion	2	+1 if shoulder is raised
45°–90° flexion	3	–1 if leaning, supporting weight of arm or if posture is gravity assisted
>90° flexion	4	



Lower arms

Movement	Score
60°–100° flexion	1
<60° flexion or >100° flexion	2



Wrists

Movement	Score	Change score:
0°–15° flexion/ extension	1	+1 if wrist is deviated or twisted
>15° flexion/ extension	2	

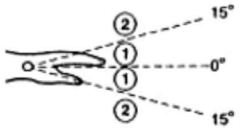


Table B

Table B							
		Lower arm					
Upper arm		1			2		
	Wrist	1	2	3	1	2	3
1		1	2	2	1	2	3
2		1	2	3	2	3	4
3		3	4	5	4	5	5
4		4	5	5	5	6	7
5		6	7	8	7	8	8
6		7	8	8	8	9	9

Coupling

0 Good	1 Fair	2 Poor	3 Unacceptable
Well-fitting handle and a mid-range, power grip	Hand hold acceptable but not ideal or coupling is acceptable via another part of the body	Hand hold not acceptable although possible	Awkward, unsafe grip, no handles Coupling is unacceptable using other parts of the body

Figure 4: REBA Score "B" Related Tables Adopted from Hignett and McAtamney (2000)

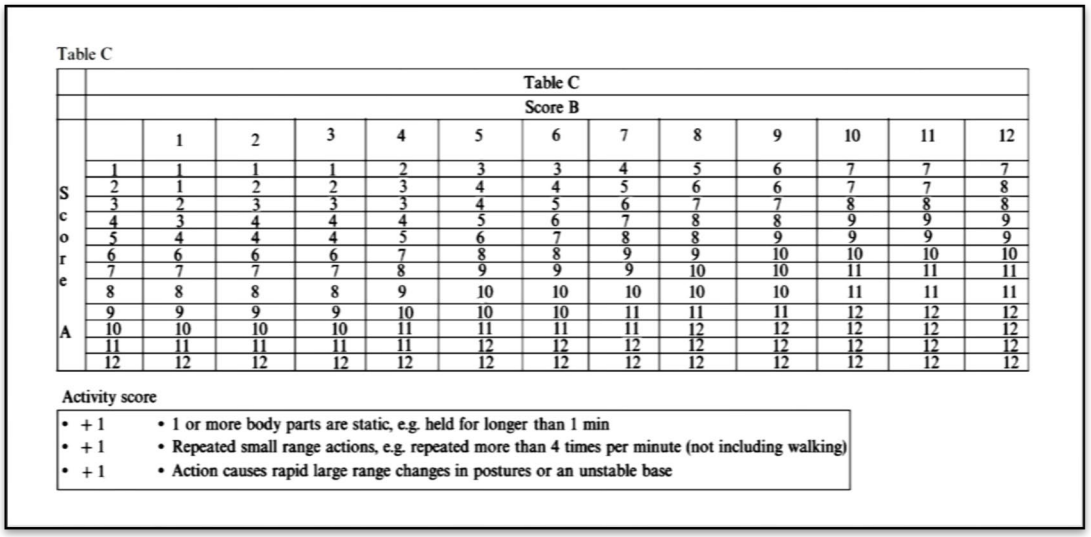


Table C

	Table C												
	Score B												
Score A		1	2	3	4	5	6	7	8	9	10	11	12
	1	1	1	1	2	3	3	4	5	6	7	7	7
	2	1	2	2	3	4	4	5	6	6	7	7	8
	3	2	3	3	3	4	5	6	7	7	8	8	8
	4	3	4	4	4	5	6	7	8	8	9	9	9
	5	4	4	4	5	6	7	8	8	9	9	9	9
	6	6	6	6	7	8	8	9	9	10	10	10	10
	7	7	7	7	8	9	9	9	10	10	11	11	11
	8	8	8	8	9	10	10	10	10	10	11	11	11
	9	9	9	9	10	10	10	11	11	11	12	12	12
	10	10	10	10	11	11	11	11	12	12	12	12	12
	11	11	11	11	11	12	12	12	12	12	12	12	12
	12	12	12	12	12	12	12	12	12	12	12	12	12

Activity score

• +1	• 1 or more body parts are static, e.g. held for longer than 1 min
• +1	• Repeated small range actions, e.g. repeated more than 4 times per minute (not including walking)
• +1	• Action causes rapid large range changes in postures or an unstable base

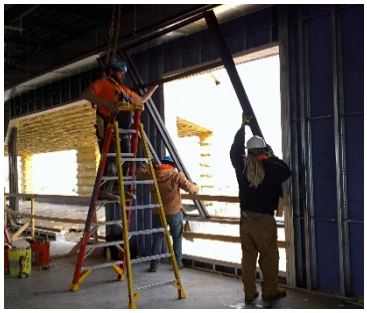
Figure 5: REBA Score "C" Table and Activity Score Adopted from Hignett and McAtamney (2000)

Appendix E: Construction Glass and Glazing Tasks and Activities (Examples)

6a- Curtain Wall Installation

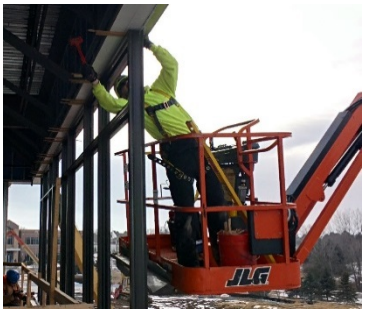
6b- Curtain Wall/Drilling

6c-Storefront/Carrying



6d-Frame Installation/Lifting

6e- Frame Installation/Placing



6f- Storefront Installation/Shimming

Figure 6: Frame Installation

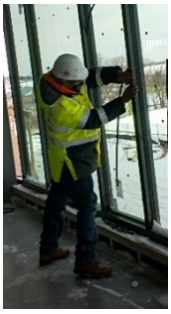
7a- MMH / Carrying

7b- Attach Suction Cup

7c-MMH / Lowering

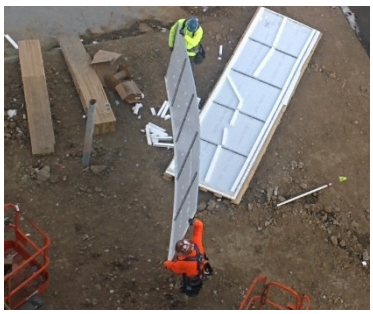
7d- MMH / Lifting

7e- MMH / Placing

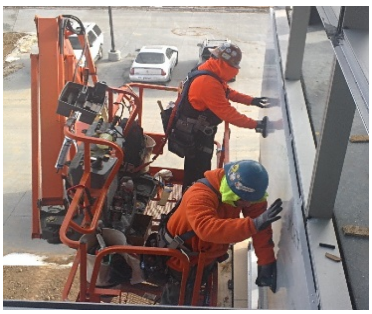


7f -Put Vinyl/Gasket

Figure 7: Glass Installation



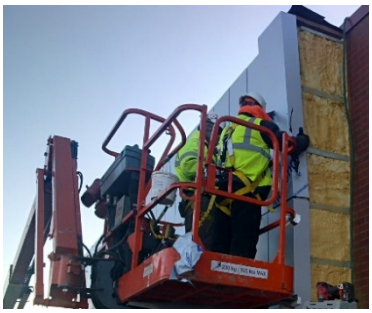
8a- MMH / Carrying



8b - MMH / Placing

8c- Screwing

8d- Panel Installation



8e- MMH / Placing

8f-Pull Panel Cover

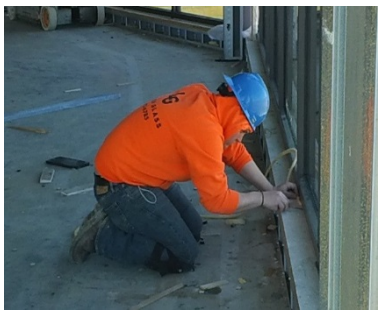
Figure 8: Panel Installation

10a- MMH / Lifting

10b- MMH / Carrying

10c- MMH / Lowering

Figure 9: Manual Material Handling / Unloading



9a- Fill Perimeter with Backer Rod

9b- Apply /Push the Caulk Bead

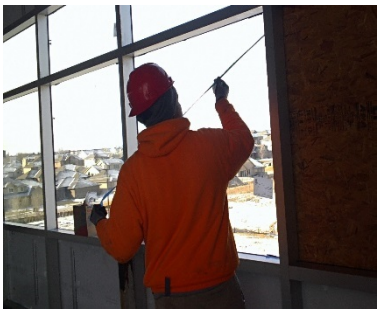
9c- Apply /Push the Caulk Bead

9d- Fill Perimeter with Backer Rod

9e- Smooth the Bead with Finishing Tool

9f- Smooth the Bead with Wet Finger

9g- Taping



9h- Removing Tape

9i- Screwing

Figure 10: Finishing Jobs

Appendix F: Job Description

RECOMMENDED JOB DESCRIPTION *

CONSTRUCTION GLASS AND GLAZING JOB

JOB SUMMARY

Construction Glass and Glazing (CGG) workers are frame fabricators and frame/glass installers who install frames, anchor the frames, shim the frames, screw the frame, carry the glass, put the glass in place, install the glass, and caulk the glass. They also involve in lots of manual material handling while they are loading and unloading materials. It could be a small project like a street shop or a high-rise building that they use basket lifts, scissor lifts, and all kinds of heavy machinery to get up in the air.

ESSENTIAL FUNCTIONS

- Loading/Unloading the truck (fabricated metals/glass) that gets to the job site
- Staging the material where they needed
- Carrying the frames to the openings
- Installing the fabricated frames
- Anchoring the frames
- Shimming the frames
- Screwing the frames
- Carrying the glass
- Putting the glass in place
- Installing the glass
- Caulking

JOB REQUIREMENTS AND QUALIFICATIONS

EDUCATION

- No formal education is required.
- Ability read (being able to read a tape measure) and write and do basic math functions such as fractions, add, subtract, multiply, divide, and angles.
- Ability to follow instructions is required.

LICENCE, CERTIFICATIONS, OR SPECIALIZED TRAINING PROGRAMS

- OSHA 10- or 30-hours card is preferred.
- Lifts (Lull, JLG lift, boom lift, forklift, basket swing stage, scissor lift, aerial lift) certification is preferred but not required.
- Specific tools (a specific type of saw and pneumatic nail gun, power actuated gun) certification is preferred.
- First aid certification (CPR) is preferred.
- Valid driver's license and good driving record.

SKILLS AND ABILITIES

Physical Abilities

- Being able to lift, carry, bend, reach, and kneel frequently.
- Be able to execute medium lifting (21-50 lbs.) on a frequent basis.
- Be able to lift, up to 10 pounds frequently, jumping down to 51-100 pounds which would be considered heavy, occasionally.
- Be able to lift 75-100 lbs. or more than that, occasionally.
- Being able to walk and stand to work.
- Be able to climb stairs, ladders, scaffolding unassisted.
- Be able to use hands for repetitive action such as grasping, grasping and turning, fine manipulation.
- Be able to work at height, not be afraid of heights.

Skills

- Be able to work with others and have communication skills.
- Have management skills.
- Have the desire to work hard.
- Be Positive, motivated, patient and have some intelligence.
- Have good hand-eye coordination.
- Be able to read, write, and understand instructions, shop drawings.
- Know how to add and subtract fractions, multiply and divide, all your basic math we use every single day.
- Be an observant person and have situational awareness of what's going on around you.
- Have common sense and learn from people.
- Be able to be good with powered tools (drills and saw) and hand tools (Suction cup, tape measure, cutting hand tools, level, caulking gun/tools, bars, etc.).

EXPERIENCE

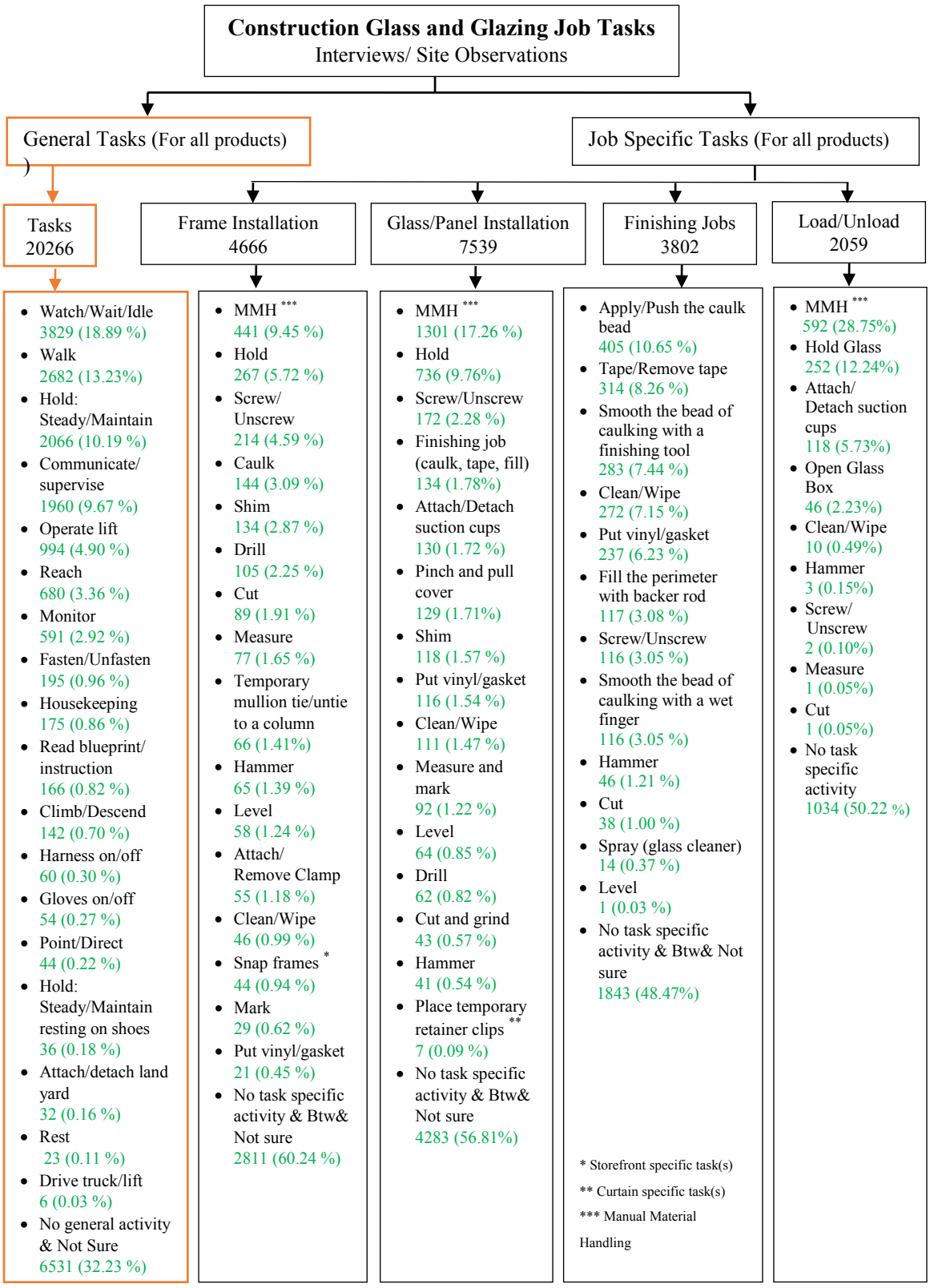
- Having construction experience or at least have done some kind of construction.
- Having knowledge about Personal Protective Equipment (PPE) and know how to use them.

OTHER INFORMATION

- Full-time job (Usually work eight hours a day, five days a week, Monday through Friday and 7:00 am to 3:30 pm or 8 am to 4:30 pm).
- Occasional travel is possible.
- Occasional working overtime.
- No on-call situations.
- No shift works.
- No weird working hours.
- Occasional (two days a month) tenuous working condition when receiving a big load of glass.
- Possession of required hand tools is required.

*Based on "The Job Description Handbook" guideline written by Margie Mader-Clark (2013)

Appendix G: Construction Glass and Glazing Tasks



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