Reducing Ergonomic Hazards during Ceiling Module Assembly and Installation for Walsh Construction Company

Construction Occupational Health Project

WORK ENVIRONMENT

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EXECUTIVE SUMMARY

An increasing frequency of musculoskeletal injuries among Ironworkers (Local 7) in Boston's Central Artery/Tunnel (CA/T) construction project prompted Mike Joel, Site Safety Manager for Walsh Construction Company, to request an analysis of the jobs involved with the project's ceiling assembly and erection operations. Research assistants from the Construction Occupational Health Project (COHP) at the Department of Work Environment at the University of Massachusetts Lowell performed ergonomic job analyses (EJAs) for jobs tasks required for the ceiling module assembly and installation operations.

One assembly operation (East Boston - West Bound) and one installation operation (South Boston - West Bound) were evaluated. Three research assistants observed the operations for several days. The operations were divided into to job tasks. The hazardous activities for each job task were then identified.

The most important ergonomic hazards included high frequency and duration of non-neutral trunk, arm and leg postures during almost all job tasks and repetitive hand/wrist motions during bolting activities. This work demonstrates how ergonomic hazards can be systematically evaluated and provides suggestions to reduce these hazards to prevent musculoskeletal injuries in the future.

BACKGROUND

Walsh Construction Company is the general contractor responsible for most of the finishing operations in the underground construction and vent buildings of the Central Artery/Tunnel Project in Boston, MA. During the past six months there has been an increasing frequency of musculoskeletal injuries (e.g., back strain, shoulder strain) among Walsh employees. In 1994 three such injuries were recorded in the OSHA 200 logs, while in the first five months of 1995 two strained backs, two strained shoulders and four knee injuries have been recorded. Twelve of the 13 injuries recorded in the OSHA 200 logs in 1995 between January 1 and April 25 were Ironworkers (Local 7). Mike Joel, safety manager of Walsh, identified ceiling module assembly and installation operations as possibly having excessive ergonomic hazards. These hazards can lead to injuries of the low back, shoulders, knees and wrists.

Over the past three years, the Construction Occupational Health Project (COHP) at the Department of Work Environment at the University of Massachusetts Lowell has been conducting research to identify and quantify health hazards in construction work. With the cooperation of Mike Joel, the COHP has been performing research activities with Walsh Construction Company for about one year. As a result of a recent increase in the frequency of musculoskeletal injuries of Ironworkers employed by Walsh Construction Company, Mike Joel has asked the COHP to investigate the ergonomic hazards during the assembly and installation of ceiling modules.

The purposes of this report are to 1) summarize some of ergonomic hazards found in the ceiling module assembly and installation operations and 2) to provide suggestions for reducing the hazards in order to prevent future musculoskeletal injuries. Hazards of particular importance include: static non-neutral trunk, arm and leg postures, repetitive motions, heavy lifting, pushing or pulling, and contact stressors (e.g., kneeling on cement without knee pads). These hazards have been shown in scientific literature to cause various types of musculoskeletal injuries and were observed during the installation of ceiling modules.

One ceiling module assembly operation (East Boston - West Bound) and one ceiling module installation operation (South Boston - West Bound) were evaluated. Two ceiling module assembly operations (Black Falcon and East Boston - East Bound) and a number of other ceiling installation operations were not evaluated.

ERGONOMIC HAZARDS DURING CEILING MODULE ASSEMBLY

Each of the job tasks and the activities having important ergonomic hazards during the assembly of ceiling modules are described below. Some of the activities are illustrated in Figures 1-6 in the Appendix.

1. Panel Sorting

Two Ironworkers sorted the ceiling panels with a powered lifting system which operated on a monorail (one worker operated the lift, the other guided the load). The pallets were sorted in the order by which they were to be assembled. The activities in this job were not considered particularly hazardous.

2. Panel Preparation

Two Ironworkers retrieved individual ceiling panels with another powered lifting system (on the same monorail), and stacked them near the assembly line. The Ironworkers glued rubber gaskets onto the ceiling panels and then delivered the panels to the assembly using a powered lift. One of these workers also tracked the order in which the panels were assembled by listing the order on a "poster board". The panels were lowered onto plywood which lie on the assembly lines rollers. The individual panels (each weighing approximately 600-700 lb.) were pushed manually between 10 and 30 feet on the rollers. Ergonomic hazards were found for three activities:

1. Gluing the gasket onto panel
2. Cutting the excess gasket with scissors
3. Pushing panel along rollers to sub-module assembly

See Table 1.

Table 1. Ergonomic hazards during panel preparation.

Activity	Body Area	Static Non-neutral Postures	Highly Repetitive Motions	High Forces	Contact Stressors	Problems
Gluing gasket onto panel	Trunk	√				low work surface
	Legs	√				
Cutting excess gasket with scissors	Trunk	√				low work surface
	Legs	√				
Pushing panel on rollers to sub-module assembly	Trunk	√		√		winch not accessible or fast enough

3. Sub-module Assembly

Sets of 3 to 4 panels were aligned by two Ironworkers. Steel beams were aligned with a powered crane lift (not on the monorail) and bolted to the ceiling panels to form a sub-module. Ergonomic hazards were found for five activities:

1. Aligning the panels on rollers
2. Gluing gasket onto sub-module
3. Aligning the steel with the pins
4. Bolting the steel to the panels
5. Tightening bolts with the 45 lb. ratchet

See Table 2.

Table 2. Ergonomic hazards during sub-module assembly.

Activity	Body Area	Static Non-neutral Postures	Highly Repetitive Motions	High Forces	Contact Stressors	Problems
Aligning the panels on rollers	Trunk	√		√		manual alignment required and work surface is low
	Head/Neck	√				
	Shoulder	√		√		
Gluing the gaskets onto the sub-module	Trunk	√		√		low work surface
	Head/neck	√				
Aligning the steel with the pin	Trunk	√		√		low work surface
	Head/Neck					
	Legs	√		√	√	
Bolting the steel to the panels	Trunk	√		√		low work surface and tighten bolts manually
	Shoulder	√				
	Hand/Wrist		√		√	
	Legs	√			√	
Tightening the bolts with the 45 lb. ratchet	Trunk	√		√		low work surface and tighten bolts manually
	Shoulder	√				
	Hand/Wrist		√	√	√	
	Legs	√			√	

4. Module Assembly

The sub-modules were moved 20 to 60 feet on the rollers (either pushed manually by 3 to 4 ironworkers or pulled with a powered winch). Two to four Ironworkers bolted (spliced) three sub-modules together into one assembled module. The Ironworker foreman inspected the modules. The assembled panels were then lifted onto the woody (a truck having a hydraulic flat-bed) with a powered lift. Ergonomic hazards were found for three activities:

1. Pushing the sub-module from sub-module to module assembly
2. Tightening bolts
3. Operating the powered winch

See Table 3.

Table 3. Ergonomic hazards during module assembly.

Activity	Body Area	Static Non-neutral Postures	Highly Repetitive Motions	High Forces	Contact Stressors	Problems
Pushing sub-module down assembly line	Trunk	√		√		winch not accessible or fast enough
	Shoulder	√		√		
Tightening bolts	Trunk	√				low work surface and tighten bolts manually
	Head/Neck	√				
	Shoulder	√				
	Hand/Wrist		√	√	√	
	Legs	√			√	
Operating powered winch	Trunk	√				winch low
	Legs	√				

Summary of Ergonomic Hazards during Ceiling Module Assembly

From the tables it can be seen that some of the most common ergonomic hazards included:

1. **Non-neutral trunk, head/neck and leg postures caused by the low work surface height.**
2. **Heavy loading and static non-neutral trunk postures during the manual pushing of ceiling panels and sub-modules.**
3. **Repetitive/forceful wrist deviations during bolting activities.**

Suggestions for Ceiling Module Assembly

The suggestions below are intended to reduce ergonomic hazards for the prevention of future musculoskeletal injuries. Before any of the recommendations are used, the workers should first be consulted to help ensure that the recommendations will not disrupt the operation.

1. **Raise the height of the rollers and add stairs.** Increase the height of the rollers to approximately 36 inches (slightly below average waist height). Install stairs to allow workers to get on/off of the rollers. This design is similar to what already exists at the Black Falcon ceiling module assembly operation. This design change should reduce the frequency and duration of non-neutral trunk and leg postures during the sub-module and module assembly job tasks.

2. **Possible use of powered ratchets.** Investigate the possibility of using powered ratchets, calibrated to 45 and 350 lb. Workers currently tighten the bolts manually, and wrist deviations during bolting are highly repetitive. Powered ratchets would greatly reduce the frequency of wrist motions during the sub-module and module assembly job tasks, may help reduce some of the loading placed on the shoulders, and may reduce the duration in which workers are in non-neutral trunk postures.

3. **Raise the height of the working surface for panel preparation.** Provide a surface of approximately 36" for the panel gluing activity during panel preparation. Such a surface may help reduce the frequency and duration of non-neutral trunk and leg postures during the panel preparation job task.

4. **Provide ergonomics training.** Provide the workers with basic ergonomics training that explains the importance of maintaining neutral postures while working and of minimizing heavy manual material handling (e.g., pushing of ceiling sub-modules).

5. **Improve the design of the powered winch.** The powered winch was not always used to move sub-modules for sub-module assembly. This may be because the winch was not functioning properly, was not easy to use or was not fast enough. The winch should be raised to about 36 inches from the floor. If feasible, the speed at which the winch pulls the sub-modules should be increased. A back-up winch should be purchased to replace the winch when it is not functioning properly.

ERGONOMIC HAZARDS DURING CEILING MODULE INSTALLATION

Ceiling module installation involves connecting the ceiling modules to the struts which hang from the ceiling of the tunnel. The struts are aligned with the module which lies on the woody's bed. When the ceiling module is positioned, the space between the ceiling module and ceiling ranges from 4 feet 6 inches to 5 feet 4 inches. The Ironworkers worked in this limited space while connecting the ceiling module to the struts. Activities included: connecting dozens of bolts for each ceiling module installed and performing manual material handling activities (e.g., carrying tools, brackets and bolts).

Ergonomic hazards were observed during practically all installation activities because the low ceiling height forced workers to perform activities in non-neutral trunk, head/neck and leg postures. For activities during which high forces were also required (e.g., heavy lifting, pushing or pulling) the ergonomic hazards were further exacerbated. The most hazardous activities included:

1. Tightening bolts
2. Handling equipment (e.g., c-clamp, sledge hammer) and materials

See Table 4.

Table 4. Ergonomic hazards during module installation.

Activity	Body Area	Static Non-neutral Postures	Highly Repetitive Motions	High Forces	Contact Stressors	Problems
Tightening bolts	Trunk	√				low ceiling height, low work surface, and tighten bolts manually
	Head/Neck	√				
	Shoulder	√				
	Hand/Wrist		√	√	√	
	Legs	√			√	
Handling equipment	Trunk	√		√		low ceiling height
	Head/Neck	√				

Suggestions for Ceiling Module Installation

1. **Add mechanical assistance.** Provide the workers with pull carts to transport equipment across the ceiling panels. These could reduce the loading on the spine when equipment and materials are moved. Such carts are currently being used in similar operations (e.g. duct panel installation.).

2. **Possible use of powered ratchets.** Investigate the possibility of using powered ratchets for tightening bolts.

CONCLUSION

Some of the ergonomic hazards for the assembly and installation of ceiling modules in the CA/T construction project have been identified. The suggestions provided in this report may help reduce musculoskeletal injuries of workers without disrupting the operations. The COHP hopes that Walsh will consider the suggestions when performing similar operations in the future. COHP is now in the process of evaluating other finishing processes and welcomes any comments about this report.

Send written comments to:

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APPENDIX

SOME COMMON ACTIVITIES DURING CEILING MODULE ASSEMBLY

Figure 1. Cutting the excess gasket during panel preparation.

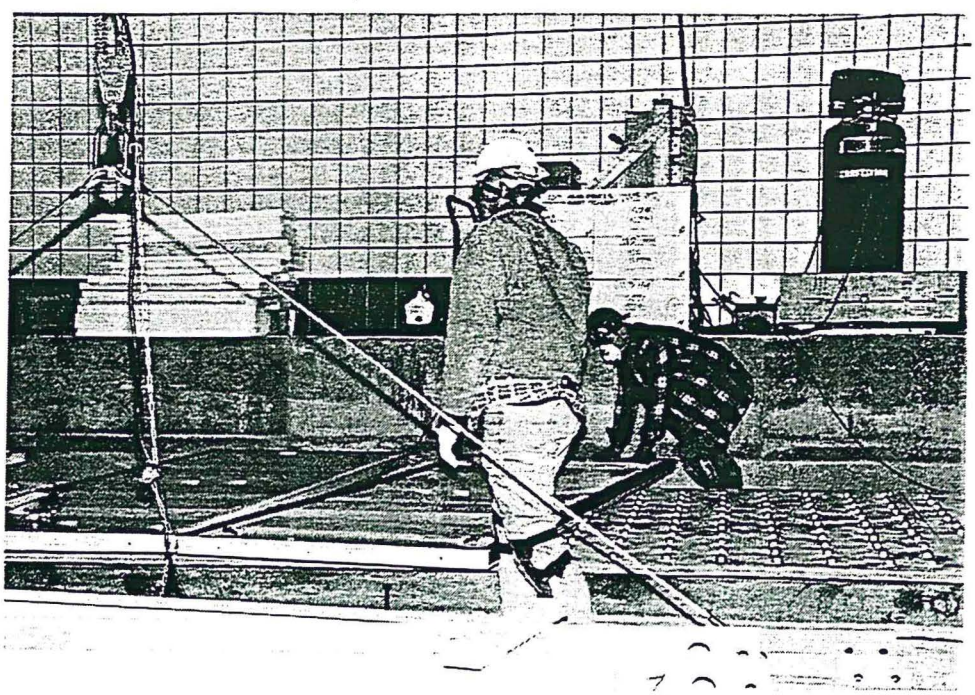

Figure 2. Aligning the panel for sub-module assembly.

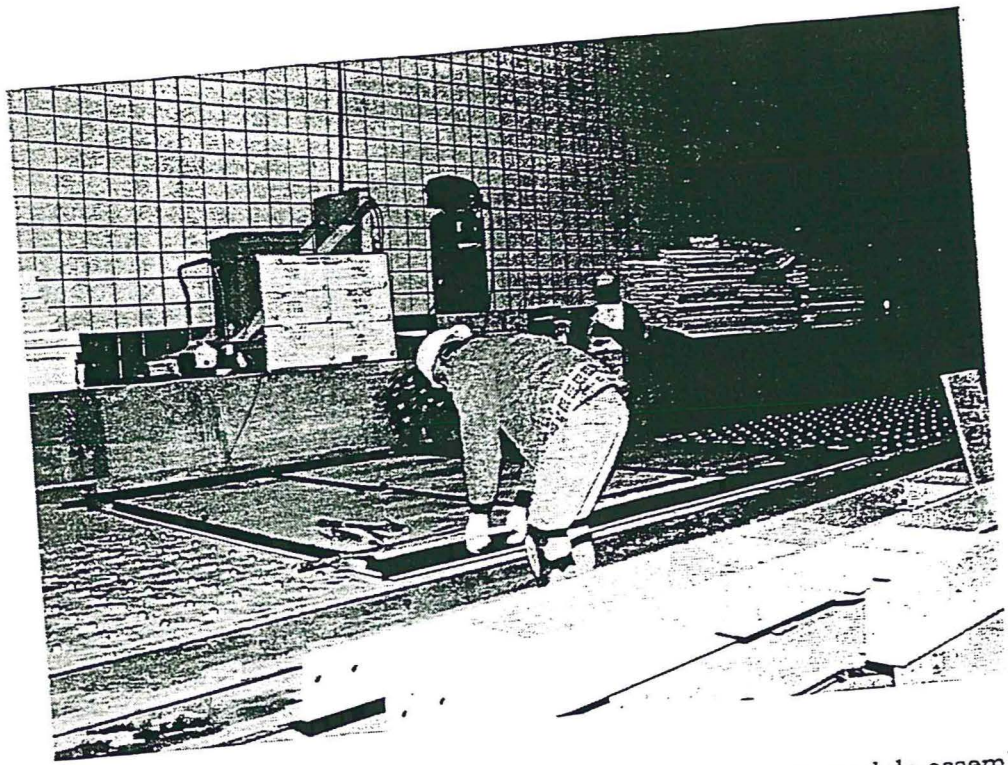

Figure 3. Gluing the gaskets onto the sub-module during sub-module assembly.

Figure 4. Aligning the I-beam with the pins during sub-module assembly.

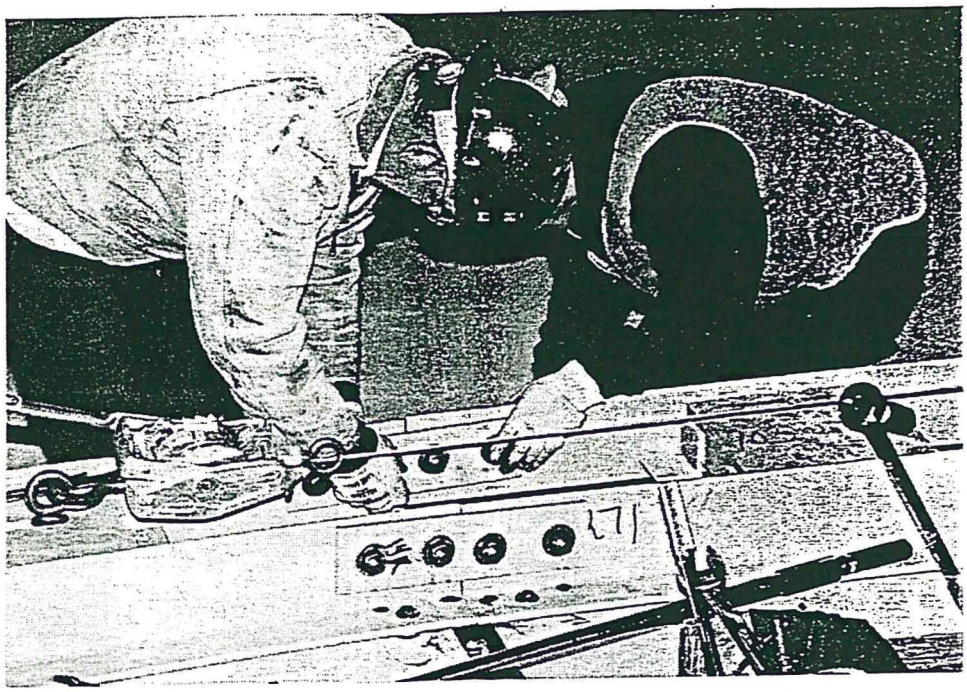

Figure 5. Tightening bolts during module assembly.

Figure 6. Operating the powered winch during module assembly.