

CONSTRUCTION ERGONOMICS: PERSPECTIVES OF FEMALE AND MALE PRODUCTION WORKERS

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Construction is by its very nature a physical process. This is further aggravated by its reliance on labour and a low level of mechanisation. Construction requires, inter alia, bending, working in awkward or cramped positions, reaching away from the body, and overhead, repetitive movements, handling heavy materials and equipment, use of body force, exposure to vibration and noise, and climbing and descending. Furthermore, there are a diverse range of health and safety (H&S) issues, and given the transient and temporary nature of construction, welfare facilities constitute a challenge. Poor ergonomics and H&S results not only in injury and disease to persons, but impacts on their well being, and compromises cost, productivity, quality, and schedule. A study conducted among female and male production workers in a better practice health and safety general contractor investigated a number of issues: the frequency at which ergonomics problems are encountered; the suitability of various aspects which affect performance and wellness on site; the extent to which various activities and interventions could contribute to an improvement in construction ergonomics, and gender differences relative to the aforementioned. Findings include: construction activities constitute an ergonomic problem; various aspects, in particular welfare facilities, are not suitable, and various aspects would make workers' working lives easier, in particular mechanisation and lighter materials. Conclusions include: certain construction activities constitute more of an ergonomic problem than others; construction activities constitute more of an ergonomics problem to females than males; females find many work related aspects less suitable than males; welfare facilities are not deemed suitable by both females and males, and certain activities / interventions would make females' and males' working lives easier, however, more so relative to females.

Keywords: construction, ergonomics, worker.

INTRODUCTION

According to La Dou (1994) ergonomics, from the Greek *ergon*, 'to work', and *nomos*, 'study of', is literally the study of work, or the work system, including the worker, his or her tools, and his or her workplace. He states that "it is an applied science concerned with people's characteristics that need to be considered in designing and arranging things that they use in order that people and things will interact most effectively and safely."

Construction, by its very nature, is a problem in ergonomics as it requires work above shoulder level and below knee height (Schneider and Susi, 1994). Furthermore, materials may also be heavy and/or inconveniently sized and shaped, thus presenting manual materials-handling problems. According to Gibbons and Hecker (1999)

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numerous construction tasks pose significant ergonomic risks to workers. This is supported by Monk (2005) who states that construction work is physically demanding, and that much of the work is performed in poor or awkward postures, and consequently, construction workers are among those at highest risk. According to the HSE (2000) every year one-third of all construction industry accidents reported to the HSE in the United Kingdom involve manual handling, and that these only represent part of the problem, as many injuries go unreported. The HSE (2000) argues that these injuries are costly. The direct cost of lost earnings, pain, and in cases, long-term disability is borne by the workers. The costs to employers may be direct and or indirect. Direct costs arise from, inter alia, loss of production, disruption to schedules, and sickness payments. Indirect costs may arise due to inter alia, absence from work, training replacement workers, and resulting skills shortages, and increased workers compensation insurance premiums.

Although, both male and female construction workers are both faced with numerous H&S, ergonomics, and work place challenges, women face additional challenges. According to Safety and Health (2002), in 1999 the Bureau of Labor Statistics Advisory Construction Committee on Safety and Health, Washington compiled a list of issues affecting the H&S of women in construction. These are reproductive hazards, ergonomic concerns, lack of adequate sanitary facilities, a hostile workplace culture, ill-fitting personal protective equipment (PPE) and clothing, and lack of proper H&S and skills training.

The study reported on in this paper constitutes part of a continuous study directed towards investigating the role and impact of construction ergonomics in / on the construction process, related practices and influences, the objectives of this phase being to determine the:

- Extent to which activities constitute an ergonomics problem;
- Suitability of various aspects;
- Extent to which actions / interventions would make respondents' working life easier, and
- Difference in female and male workers' perceptions.

REVIEW OF THE LITERATURE

Extent to which activities constitute an ergonomics problem

The University of Iowa (Center to Protect Workers' Rights, 1995) identified job factors that constitute a major ergonomic problem based upon research conducted among 2 000 construction workers in the USA. Bending or twisting the back (25.4%), was followed by staying in the same position for long periods (21.1%), working while hurt or injured (18.7%), handling heavy materials or equipment (17.2%), working in awkward / cramped positions (16.7%), reaching overhead or away from the body (14.9%), and working in difficult environmental conditions (wet / humid, cold / hot) (13.2%).

Previous research conducted in South Africa investigated, inter alia, the frequency at which eighteen ergonomic problems were encountered (Smallwood, 1997; Smallwood, Deacon and Venter, 2000; Smallwood, 2002). Fourteen of the eighteen problems had a mean importance index (II) > 2.00, the midpoint of the range, which indicates that in general they can be deemed to be encountered in the construction industry. Repetitive movements predominated, followed by climbing and descending, handling heavy materials, use of body force, exposure to noise, bending or twisting

the back, reaching overhead, reaching away from the body, working in awkward positions, and handling heavy equipment. These constitute the top ten problems, meaning that with the exception of repetitive movements which are experienced between weekly to daily / daily, they are encountered between fortnightly to weekly / weekly.

Suitability of various aspects

Research conducted by Smallwood (1997) identified construction ergonomic related aspects which require attention according to management and workers. The mean percentage affirmative response is recorded within parentheses: materials handling (77.6%); working platforms (76.1%); housekeeping (74.8%); means of ascending / descending (74.7%); materials storage (71.9%); walkways (68.7%); mechanisation (57.7%); circulation paths (47.3%), and circulation roads (44.3%).

Previous research conducted by Smallwood (2003) entailed the rating of the GC, which is the subject of the study, relative to 26 aspects. The ratings in the form of an importance index were out of a maximum of 4.00 – selected aspects include: welfare facilities (3.19); housekeeping (3.50); storage (3.18), and worker attire (3.16).

‘Respect for people’ research conducted in South Africa entailed the rating of the South African construction industry relative to production workers in terms of various aspects (Smallwood, 2004). The ratings in the form of an importance index were out of a maximum of 4.00 – selected aspects include: workplaces (1.91); housekeeping (1.82); provision of PPE (1.55); WHBs (ablutions) (1.50); toilets (ablutions) (1.36); ergonomics (1.36); change rooms (1.18); canteens / mess rooms (1.09), and showers (ablutions) (1.00). The study concluded that the South African construction industry is not highly rated relative to production workers in terms of respect for people. In fact, it is rated poor to average relative to most aspects, and received particularly poor ratings relative to welfare facilities.

Improving ergonomics

Previous generic research conducted in South Africa identified various design and construction related interventions as being able to contribute to an improvement in construction ergonomics (Smallwood, 2002). Respondents were required to respond relative to a five point scale ranging from a minor to a major contribution. Thirteen aspects were deemed to be able to contribute to an improvement, inter alia, mechanisation.

Previous trade specific research conducted in the Western Cape, South Africa, among bricklayers, plasterers, painters, and their respective assistants identified a range of interventions that could contribute to an improvement in construction ergonomics, inter alia, mechanisation (Samuels, Haupt, and Shakantu, 2006).

The ‘respect for people’ research conducted in South Africa entailed the rating of the South African construction industry relative to production workers in terms of various aspects (Smallwood, 2004). The ratings in the form of an importance index were out of a maximum of 4.00 – selected aspects include: mechanisation (2.09), and limited manual handling (1.91). These findings amplify the need for mechanisation, which will reduce the amount of manual handling.

Differences in gender perceptions

Female workers have suggested that tools, materials, and equipment be available in sizes and designs appropriate for women (Goldenhar and Sweeney in Welch *et al.*,

2000). Relative to back injuries, which is as a major concern, tradeswomen have said that safe lifting techniques should be encouraged for those who have less upper-body strength than the average male construction worker. According to the revised National Institute for Occupational Safety and Health lifting equation, if the lifting demands are limited to what about 75% of women can safely lift, then most men or women should be able to perform the job without significantly increasing their risk of low back pain (Waters *et al.* in Welch *et al.*, 2000). A major concern for most female construction workers is the availability and cleanliness of toilet and hand-washing facilities. 80% of tradeswomen surveyed in the USA reported work sites with no toilets or dirty toilets (LeBreton and Loevy in Welch *et al.*, 2000). The health risks associated with the lack of adequate sanitary facilities include an increased risk of bladder infections from holding urine too long (Foxman and Frerichs in Welch *et al.*, 2000) and the transmission of illnesses from unwashed hands. Women in construction also often find it difficult to obtain properly fitting protective clothing or equipment (Goldenhar *et al.* in Welch *et al.*, 2000). During interviews conducted in the USA, tradeswomen reported that ill-fitting clothing and personal protective equipment, such as gloves and coveralls, pose safety hazards because they can get caught in machinery. Approximately half the respondents in a survey of 200 tradeswomen in the USA reported difficulty in finding appropriately sized safety shoes and gloves (Goldenhar *et al.* in Welch *et al.*, 2000).

Research conducted in South Africa and Tanzania (English *et al.*, 2006) required respondents to indicate the extent to which they concurred with a range of statements on a scale of 'strongly disagree' to 'strongly agree'. Selected statements include the following, the mean score being between 1.00 and 5.00, a mean score > 3.00 indicating concurrence: current welfare facilities for women are inadequate (3.82); women have 'special' personal hygiene issues / requirements (3.74); some construction materials present a manual materials handling problem to women (3.53); mechanisation of the construction process will promote participation by women (3.53); women are not as physically capable as men (3.28); women are less likely to accept inadequate welfare facilities than men (3.21); appropriate work attire is not readily available for women (3.01); women are as physically capable as men (2.91), and generally personal protective equipment (PPE) is not suited to women (2.44).

These findings indicate that welfare facilities are perceived to be inadequate, and there are aspects perceived to require more attention relative to women than to men.

METHODOLOGY

The objectives of the study were to determine the:

- Extent to which activities constitute an ergonomics problem;
- Suitability of various aspects;
- Extent to which actions / interventions would make respondents' working life easier, and
- Difference in female and male workers' perceptions.

The questionnaire consisted of three primary questions. The first question addressed the extent to which eighteen activities constitute an ergonomics problem. The activities included in the questionnaire have been included in previous questionnaires used in South African ergonomics studies. The second question addressed the suitability of various aspects, which aspects were a combination of aspects which impact on ergonomics and a range of aspects pertaining to welfare facilities. These too were included in previous questionnaires. The aspects / interventions which could

make workers' working life easier, which the third question addressed, were also included in previous questionnaires.

Twelve male and fourteen female workers were surveyed using a self-administered questionnaire on construction projects being undertaken by NMC, a general contractor based in Cape Town, South Africa. The projects were selected on the basis of female workers working thereon.

RESULTS

Table 1: Extent to which activities constitute an ergonomics problem (Comparison of female and male)

Activities	Female		Male		Mean		Diff
	MS	Rank	MS	Rank	MS	Rank	
Working in humid conditions	3.21	6	2.08	14	2.65	11	1.13
Working in cold conditions	3.43	4	2.33	10	2.88	6	1.10
Handling heavy equipment	3.71	2	2.73	4	3.22	3	0.98
Exposure to noise	3.67	3	2.75	3	3.21	4	0.92
Use of body force	2.93	11	2.08	15	2.50	13	0.85
Vibrating tools and equipment	2.79	14	2.00	17	2.39	14	0.79
Working in awkward positions	3.29	5	2.58	7	2.93	5	0.71
Repetitive movements	2.69	15	2.00	16	2.35	15	0.69
Working in hot conditions	3.00	9	2.33	11	2.67	10	0.67
Climbing and descending	2.62	16	2.00	18	2.31	17	0.62
Handling heavy materials	3.77	1	3.17	2	3.47	1	0.60
Staying in same position for long periods	3.07	7	2.58	8	2.83	8	0.49
Bending or twisting the back	2.86	12	2.42	9	2.64	12	0.44
Working in wet conditions	3.07	8	2.67	5	2.87	7	0.40
Working in cramped positions	2.86	13	2.58	6	2.72	9	0.28
Reaching overhead	2.38	17	2.25	12	2.32	16	0.13
Reaching away from the body	2.07	18	2.08	13	2.08	18	-0.01
Working while hurt or injured	3.00	10	3.50	1	3.25	2	-0.50

Table 1 indicates the extent to which activities constitute an ergonomics problem according to female and male construction workers in terms of a mean score ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (minor) to 5 (major). It is notable that eight of the eighteen (44.4%) of the female and only two of the eighteen (11.1%) male mean scores are above the midpoint score of 3.00, which indicates that the said activities can be deemed to be more of a major than a minor ergonomics problem. The extent to which the female mean scores exceed the male mean scores is presented in the extreme right hand column.

In terms of the mean of the mean scores:

- the first is $> 3.40 \leq 4.20$, and thus it can be deemed to be between a problem to a near major / near major problem;
- second to twelfth are $> 2.60 \leq 3.40$, and thus they can be deemed to be between a near minor problem to a problem / problem, and
- thirteenth and eighteenth are $> 1.80 \leq 2.60$, and thus they can be deemed to be between a minor problem to a near minor problem / near minor problem.

It is notable that with the exception of two activities, the female mean scores exceed the male mean scores.

In terms of previous studies it is notable that based upon a mean of three studies, fourteen of the eighteen (77.8%) activities were deemed to constitute more of a major

than a minor ergonomics problem (Smallwood *et al.*, 2000), whereas the current study determined only four of the eighteen (22.2%) to be thus. Furthermore, the following previous and current rankings are notable: handling heavy materials previously ranked third is ranked first; working while hurt or injured, previously ranked eighteenth is ranked second; handling heavy equipment previously ranked tenth is ranked third; exposure to noise previously ranked fifth is ranked fourth; working in awkward positions previously ranked ninth is ranked fifth; working in cold conditions previously ranked sixteenth is ranked sixth.

Table 2: Suitability of various aspects (Comparison of female and male)

Aspect	Female		Male		Mean		Diff
	MS	Rank	MS	Rank	MS	Rank	
Lighting	2.62	14	3.92	3	3.27	12	-1.30
Canteen / Mess room	2.07	16	2.83	14	2.45	16	-0.76
Materials storage	3.21	10	3.92	4	3.57	8	-0.71
Tools	3.14	11	3.83	6	3.49	10	-0.69
Site layout	3.29	9	3.75	7	3.52	9	-0.46
Change room facilities	2.31	15	2.75	16	2.53	15	-0.44
Wash facilities	1.85	17	2.25	17	2.05	17	-0.40
Organisation of work area	3.50	8	3.75	8	3.63	6	-0.25
Circulation paths	3.00	12	3.25	13	3.13	13	-0.25
Toilet facilities	2.64	13	2.82	15	2.73	14	-0.18
Equipment	3.69	5	3.67	9	3.68	4	0.02
Vertical access	3.62	6	3.55	11	3.58	7	0.07
Personal protective equipment	4.29	2	4.17	1	4.23	1	0.12
Plant	3.71	4	3.58	10	3.65	5	0.13
Housekeeping	4.00	3	3.83	5	3.92	3	0.17
Work / Access platforms	3.62	7	3.33	12	3.47	11	0.29
Attire (Work clothing)	4.46	1	4.00	2	4.23	2	0.46

Table 2 indicates the suitability of various aspects according to female and male construction workers in terms of mean scores ranging between 1.00 and 5.00 based upon percentage responses to a scale of 1 (unsuitable) to 5 (suitable). It is notable that eleven of the seventeen (64.7%) female and thirteen of the seventeen (76.5%) male mean scores are above the midpoint score of 3.00, which indicates that the aspects can be deemed to be more suitable than unsuitable. The extent to which the female mean scores exceed the male mean scores in terms of the suitability of various aspects is presented in the extreme right hand column.

In terms of the mean of the mean scores, the aspects ranked:

- first to second are $> 4.20 \leq 5.00$, and thus can be deemed to be between near suitable to suitable / suitable
- third to eleventh are $> 3.40 \leq 4.20$, and thus can be deemed to be between average to near suitable / near suitable;
- twelfth to fourteenth are $> 2.60 \leq 3.40$, and thus can be deemed to be near unsuitable to average / average, and
- fifteenth to seventeenth are $> 1.80 \leq 2.60$, and thus they can be deemed to be unsuitable to near unsuitable / near unsuitable.

It is notable, that the findings relative to welfare facilities reflect the findings of previous studies conducted in South Africa (Smallwood, 2003; Smallwood, 2004). Furthermore, it is also notable that in the case of ten (58.8%) aspects, the male mean scores exceed the female mean scores, and thus the aspects are deemed less suitable to female than they are to male workers. These aspects include: lighting; welfare

facilities such as canteen / mess room, change room facilities, and toilet facilities; tools, and then common aspects such as materials storage, site layout, organisation of work area, and circulation paths. It is also notable that where aspects are deemed more suitable to female than they are to male workers, the difference in mean scores is generally not profound – with the exception of work / access platforms, and attire (work clothing). These findings reinforce the findings reported by Welch *et al.* (2000).

Table 3 indicates the extent to which actions / interventions would make respondents' working life easier according to female and male workers in terms of a mean score ranging between 1.00 and 5.00 based upon percentage responses to a scale of 1 (minor) to 5 (major). It is notable that six of the seven (85.7%) female and only two of the seven (28.5%) mean scores are above the midpoint score of 3.00, which indicates the actions / interventions would make respondents' working life easier more to a major than a minor extent. The extent to which the female mean scores exceed the male mean scores is presented in the extreme right hand column.

In terms of the mean of the mean scores, the action(s) / intervention(s) ranked:

- first to third are $> 3.40 \leq 4.20$, and thus the extent can be deemed to be between some to near major / near major;
- fourth to sixth are $> 2.60 \leq 3.40$, and thus the extent can be deemed to be between near minor to some / some, and
- seventh is $> 1.80 \leq 2.60$, the extent can be deemed to be between minor to near minor / near minor.

The high mean scores achieved by mechanisation, lighter materials, and less manual handling are notable, as these constitute the primary interventions proposed to improve ergonomics (Smallwood, 2004; Samuels, Haupt, and Shakantu, 2006).

It is notable that in all cases the female mean scores exceed the male mean scores, and thus the females can be deemed to perceive that the actions / interventions would make their working life easier than males perceive they would.

Table 3: Extent to which actions / interventions would make respondents' working life easier (Comparison of female and male)

Actions / Interventions	Female		Male		Mean		Diff
	MS	Rank	MS	Rank	MS	Rank	
Task rotation (shorter shifts)	3.58	5	2.33	6	2.96	6	1.25
Less manual handling (lifting and carrying)	4.07	2	2.92	3	3.50	3	1.15
Less climbing	3.43	6	2.58	5	3.00	5	0.85
More help (extra hands)	3.62	4	2.83	4	3.22	4	0.79
Mechanisation (use of machines)	4.25	1	3.58	1	3.92	1	0.67
Less walking	2.86	7	2.25	7	2.55	7	0.61
Lighter materials (bending and lifting)	3.93	3	3.50	2	3.71	2	0.43

CONCLUSIONS

With the exception of four activities, a range of activities constitute more a minor than a major ergonomics problem. Given that this finding does not coincide with the findings of previous studies conducted in South Africa, it can be concluded that it is likely to be attributable to the focus on H&S and ergonomics by a GC that has received numerous industry awards for H&S performance. However, activities are

perceived to be more of a problem to female than male workers. Thus it can be concluded that the integration of women into the actual construction process needs to be facilitated.

In general, a range of aspects were deemed to be more suitable than unsuitable. This finding does not reflect the findings of other South African studies. However, the aspects are deemed less suitable to female than they are to male workers. Furthermore, given that welfare and related facilities are still perceived to be unsuitable, leads to the conclusion that more emphasis needs to be placed on 'respect for people'.

A range of actions / interventions were perceived to make respondents' working life easier. However, the females can be deemed to perceive that the actions / interventions would make their working life easier than males perceive they would. Given that mechanisation, lighter materials, and less manual handling predominate, the following can be concluded relative to the South African construction industry. Designers continue to specify heavy materials, and contractors need to make a paradigm shift from 'manual handling' to 'mechanisation'. Furthermore, the prior conclusion that the integration of women into the actual construction process needs to be facilitated is reinforced.

Finally, it must be borne in mind that the findings emanate from a small sample of twenty-six workers in the employ of a single GC, and therefore are not representative. Secondly, given that the GC concerned has received numerous industry awards for H&S performance, the findings are likely to be biased as the situation throughout the general industry is likely to be worse or differ i.e. activities may constitute more of an ergonomics problem; the various aspects are more unsuitable; the various actions / interventions would make workers' working life substantially more easier, and a greater difference between female and male workers' perceptions.

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