Nelson Mandela Metropolitan University
for tomorrow

# PERI WORKSHOPS

## CENTURION, 23 MAY 2017

# DESIGNING FOR CONSTRUCTION ERGONOMICS

**PROFESSOR JOHN SMALLWOOD**
**NELSON MANDELA METROPOLITAN UNIVERSITY**
**SOUTH AFRICA**
**john.smallwood@nmmu.ac.za**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Introduction (1)

- The South African Construction Regulations (2014) state that during the design stage, designers must take cognisance of ergonomic design principles in order to minimize ergonomic related hazards in all phases of the life cycle of a structure
- Amplifies the need for 'designing for safety', which Behm (2006) defines as "The consideration of construction site safety in the preparation of plans and specifications for construction projects"
- Thorpe (2006) states that there is no more important stage in the construction process than that of design, as at this stage conceptual ideas are converted into constructable realities:
  - 'Designing for H&S' being one of the designing for constructability principles

PERI®

# Introduction (2)

- A variety of considerations need to be balanced simultaneously, inter alia, designing for H&S, which is an integral part of the wider design process
- Therefore, needs to be included in design planning as doing so will result in safer construction and maintenance of structures and facilities

- Hecker *et al.* (2006) contend that H&S through design is a fundamental principle of ergonomics:
  - Architects and engineers regularly address ergonomics in their designs, but the concerns apply almost exclusively to the end-user of a facility, rather than the workers who construct it
- Gambatese (1998) states that historically, the design professions have not addressed construction H&S

# Introduction (3)

## Construction H&S occurs in a macro environment:


**Figure 1: Construction H&S – the macro environment (Smallwood, 1995)**

Nelson Mandela Metropolitan University
for tomorrow

# Construction Regulations (1)

**Clients required to:**

- **5 (1) (a) Prepare a baseline risk assessment (BRA)**
- **5 (1) (b) Prepare an H&S specification based on the BRA**
- **5 (1) (c) Provide the designer with the H&S specification**
- **5 (1) (d) Ensure that the designer takes the H&S specification into account during design**
- **5 (1) (e) Ensure that the designer carries out the duties in Regulation 6 'Duties of designers'**
- **5 (1) (f) Include the H&S specification in the tender documents (Republic of South Africa, 2014)**

**Regrettably, it is not stated that the H&S specification must be revised to include amendments required in terms of the designer report**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Construction Regulations (2)

**Designers of a structure must:**

- **(a) ensure that the H&S standards incorporated into the regulations are complied with in the design**
- **(b) take the H&S specification into consideration**
- **(c) include in a report to the client before tender stage:**
  - **all relevant H&S information about the design that may affect the pricing of the work**
  - **the geotechnical-science aspects**
  - **the loading that the structure is designed to withstand**
- **(d) inform the client of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is changed**

PERI®

# Construction Regulations (3)

- (e) modify the design or make use of substitute materials where the design necessitates the use of dangerous procedures or materials hazardous to H&S
- (f) consider hazards relating to subsequent maintenance of the structure and make provision in the design for that work to be performed to minimize the risk (Republic of South Africa, 2014)

# Designing for construction ergonomics

Hecker *et al.* (2006)

- Contend that H&S through design is a fundamental principle of ergonomics, and that the hierarchy of controls is fundamental to the process of hazard reduction i.e. elimination or substitution to mitigate hazards
- Although architects and engineers regularly address ergonomics in their designs, they do so almost exclusively relatively to the end-user of a facility, rather than the workers who undertake the construction thereof

Nelson Mandela Metropolitan University
for tomorrow

# Impact of designers on construction ergonomics

- Behm (2006) analysed 450 reports of construction workers' deaths and disabling injuries in the USA - in 151 cases (33.6%), the hazard that contributed to the incident could have been eliminated or reduced if 'design-for-H&S' measures had been implemented

PERI®

# Obstacles to designing for construction ergonomics

- Hecker *et al.* (2006) cite the following:
  - The narrow specialisation of design and construction practice
  - Limited pre-construction collaboration between the designer and constructor due to the traditional construction procurement system (TCPS)
  - The limited availability of ergonomics-in-design tools, guidelines and procedures
  - Limited education architects and engineers receive regarding construction ergonomics
- Construction Industry Development Board (cidb) (2009) report states that at the tertiary level, not all construction related programmes in South Africa include H&S within their curricula, especially designer programmes

Nelson Mandela Metropolitan University
for tomorrow

# Potential of designers to contribute to construction ergonomics

South African built environment practitioners (Smallwood, 2006a) - the extent in terms of a mean score ranging between 1.00 and 5.00 is:

- Constructability (general) (4.53)
- Awareness (4.52)
- Mechanisation (4.45)
- Prefabrication (4.31)
- General design (4.22)
- Reengineering (4.19)
- Specification (4.09)
- Details (4.03)

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Importance of H&S / ergonomics

- Historically, cost, quality, and time, have taken precedence over H&S in terms of the importance of project parameters
- An 'image of contractors' study conducted among clients by Smallwood (2010) required respondents to indicate the importance of twenty-six image related aspects. The mean scores recorded between parentheses are between 1.00 (lower limit) and 5.00 (upper limit)
  - Quality (4.75) and remaining within budget (4.75) ranked joint 1st
  - Time performance (4.25) 8th
  - Health (4.00) 11th
  - Safety (3.75) 13th

PERI®

# Accidents and related issues (1)

- Schwartz (1995) cites a traffic engineer's contention that there is no such a thing as a true accident
- An accident is a result of human or mechanical failure, or a combination of both – nothing happens without a cause
- Mainstream literature, invariably defines an accident as an unplanned event
- Given that management is responsible for planning, organising, leading, controlling, and coordinating, and accidents are unplanned events, then accidents effectively constitute a failure of management
- Hinze (2006) contends that all accidents are preventable and that construction is not inherently dangerous

# Accidents and related issues (2)

- Strategies, systems, procedures, and protocol can mitigate or eliminate 'accidents'
- A multi-stakeholder approach and 'designing for H&S' are examples of strategies
- Documented H&S management systems and quality management systems are examples of systems
- The provision of an H&S specification to designers by clients, a report to clients by designers, and the provision of an H&S specification to the PC is an example of a procedure. Design HIRAs are a further example
- The protocol of including H&S as the first item on a project progress meeting agenda raises the status of H&S

# The Cost of Accidents (COA) and the benefits of optimum H&S

- Costs:
  - COA is estimated to be between 4.3% and 5.4% of the value of completed construction
  - Cost of implementing H&S is estimated to be between 0.5% and 3% of project costs
  - Clearly H&S is a 'profit centre' (Smallwood, 2004)
- The synergy between construction H&S and the other eleven project parameters results in further financial benefits: environment; cost; developmental criteria; environment; productivity; public H&S; quality; time; client satisfaction; design team satisfaction, and worker satisfaction (Smallwood, 2006b)

# Reduction of risk through design and specification (1)

(Steel Construction, 2004)

Nelson Mandela Metropolitan University
for tomorrow

# Reduction of risk through design and specification (2)

**(Steel Construction, 2004)**

Nelson Mandela Metropolitan University
for tomorrow

# Reduction of risk through design and specification (3)

(Steel Construction, 2004)

Nelson Mandela Metropolitan University
for tomorrow

# Reduction of risk through design and specification (4)

**Precast concrete stair flights, Port Elizabeth (Smallwood)**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Reduction of risk through design and specification (5)

**Precast concrete stair flights, Port Elizabeth (Smallwood)**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Reduction of risk through design and specification (6)

‘Bush-hammered’ concrete, Port Elizabeth (Smallwood)

PERI®

# Reduction of risk through design and specification (7)

Thermal Lance, Mount Road Police Station, Port Elizabeth (Smallwood, 1987)

Nelson Mandela Metropolitan University
for tomorrow

# Reduction of risk through design and specification (8)

**Crow's-nest, Mt Isa, Australia (Mount Isa Mines Limited and National Safety Council of Australia, 1992)**

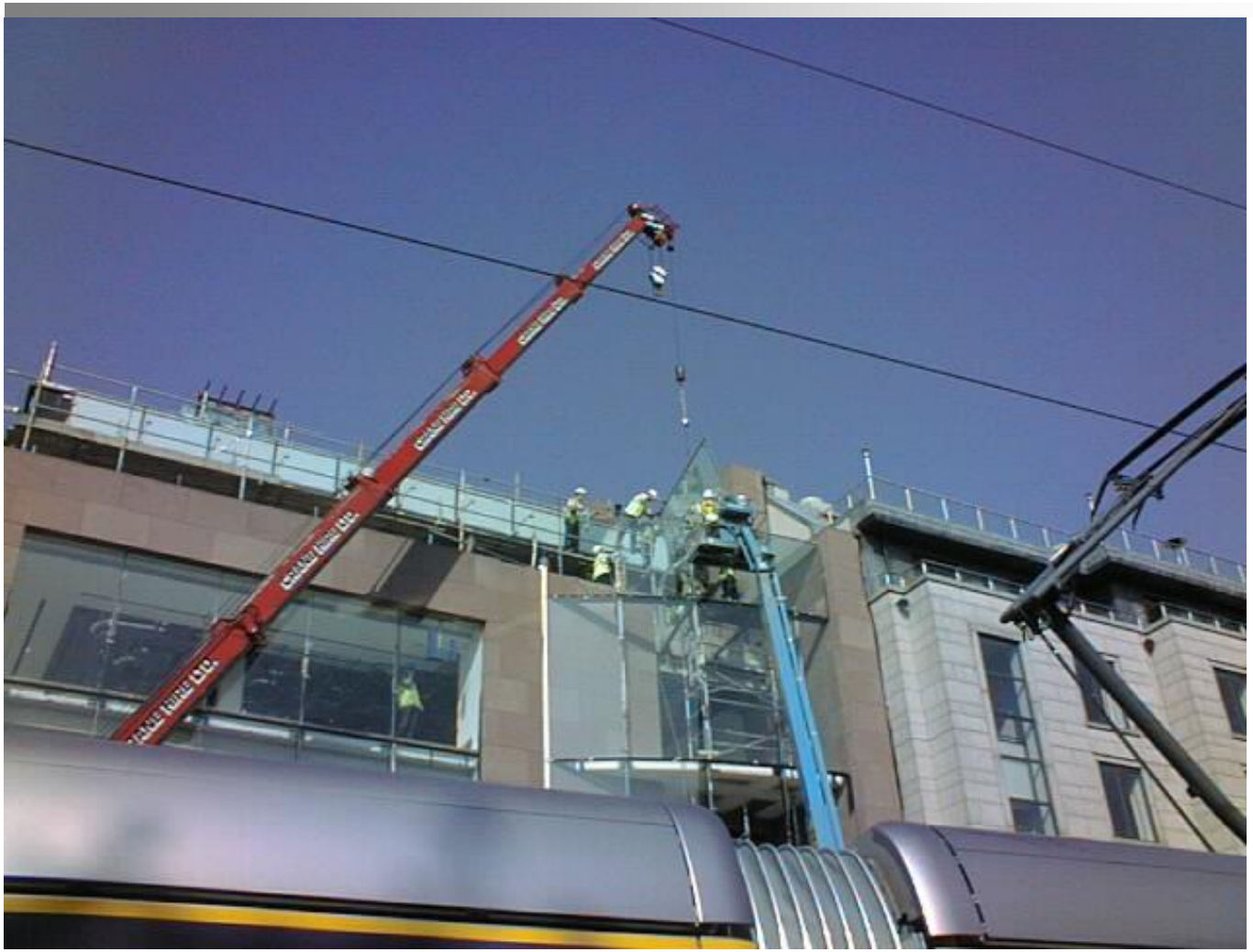


PERI®

# Reduction of risk through design and specification (9)

Externally installed full fenestration, Dublin (Smallwood, 2004)

# Reduction of risk through design and specification (10)



Externally installed full fenestration, Dublin (Smallwood, 2004)

Nelson Mandela Metropolitan University
for tomorrow

# Reduction of risk through design and specification (11)

'Melting' mastic asphalt, Canal Walk, Cape Town (Smallwood, 2000)



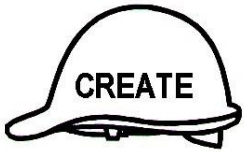
PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Designing for ergonomics (1)

Plank and hollow-block composite slab, Plettenberg Bay (Hamp-Adams, 1994)

# Designing for ergonomics (2)




| An example of a generic risk assessment form (GRA) | | | | |
|---|---|---|---|---|
| NAME OF ORGANISATION | | | | |
| NAME OF PROJECT | | | | |
| ACTIVITY COVERED | Erecting precast plank and hollow block composite slab | | | |
| SIGNIFICANT HAZARDS | | ASSESSMENT OF RISK | | |
| | | LOW | MEDIUM | HIGH |
| 1 | People falling | | | 3 X 3 = 9 |
| 2 | Materials falling | | | 3 X 2 = 6 |
| 3 | Collapse of structure | 1 X 3 = 3 | | |
| 4 | Pinching | 3 X 1 = 3 | | |
| 5 | Manual handling | | | 3 x 2 = 6 |
| 6 | Tripping | | | 3 x 2 = 6 |
| 7 | Failure of blocks (material) | | | 2 X 3 = 6 |

**Figure 1: Design HIRA for erecting precast plank and hollow block composite slab**

Nelson Mandela Metropolitan University
for tomorrow

# Designing for ergonomics (3)

**Pre-cast pre-stressed hollow core slab section (SA Builder Bouer, 2004a)**

# Designing for ergonomics (4)


**Pre-cast pre-stressed hollow core slab section (SA Builder Bouer, 2004b)**

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 – Sample stratum and method

- 19 Delegates attending a one-day ‘designing for construction H&S’ seminar in Port Elizabeth, South Africa
- Effectively constituted a convenience or captive sample
- A 28 five-point likert scale type question questionnaire survey was conducted at the inception and the end of the seminar
- Objective being to determine the culture of the delegates prior to the training intervention, and whether the training intervention had an impact or not
- Mean scores (MSs), a measure of central tendency, are between 1.00 (lower end) and 5.00 (upper end), 3.00 being the midpoint

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 - Findings (1)

| Statement | Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|---|
| | Unsure | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | |
| Designers should consider their designs relative to construction | 0.0 | 0.0 | 0.0 | 0.0 | 68.4 | 31.6 | 4.32 |
| Evaluation of project performance should include H&S | 0.0 | 0.0 | 0.0 | 0.0 | 73.7 | 26.3 | 4.26 |
| H&S is concerned with preventing injuries | 0.0 | 0.0 | 0.0 | 5.3 | 68.4 | 26.3 | 4.21 |
| Tertiary designer education should include construction H&S | 0.0 | 0.0 | 0.0 | 0.0 | 78.9 | 21.1 | 4.21 |
| Design influences construction | 0.0 | 0.0 | 5.3 | 0.0 | 68.4 | 26.3 | 4.16 |
| Design influences H&S | 0.0 | 0.0 | 0.0 | 10.5 | 78.9 | 10.5 | 4.00 |
| Design can positively influence H&S | 0.0 | 0.0 | 0.0 | 10.5 | 89.5 | 0.0 | 3.89 |
| Designers can mitigate hazards at design stage | 0.0 | 0.0 | 0.0 | 15.8 | 78.9 | 5.3 | 3.89 |
| H&S is related to constructability | 0.0 | 0.0 | 0.0 | 15.8 | 84.2 | 0.0 | 3.84 |
| Designers should conduct constructability reviews | 5.3 | 0.0 | 0.0 | 15.8 | 63.2 | 15.8 | 3.79 |
| Design can negatively influence H&S | 0.0 | 0.0 | 0.0 | 21.1 | 78.9 | 0.0 | 3.79 |
| Construction is inherently dangerous | 0.0 | 5.3 | 10.5 | 10.5 | 52.6 | 21.1 | 3.74 |
| Designers can identify hazards at design stage | 5.3 | 0.0 | 5.3 | 10.5 | 68.4 | 10.5 | 3.68 |
| 'Designing for H&S' is a designer competency | 0.0 | 0.0 | 5.3 | 26.3 | 63.2 | 5.3 | 3.68 |

**Table 1A: Pre-seminar responses (MS: 1.00 – 5.00) (Smallwood, 2015).**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 - Findings (2)

| Statement | Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|---|
| | Unsure | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | |
| Accidents are unplanned events | 0.0 | 0.0 | 16.7 | 11.1 | 61.1 | 11.1 | 3.67 |
| H&S is concerned with compliance with legislation | 0.0 | 0.0 | 15.8 | 10.5 | 68.4 | 5.3 | 3.63 |
| H&S is more important than cost, quality, and time | 0.0 | 0.0 | 26.3 | 10.5 | 47.4 | 15.8 | 3.53 |
| Procurement influences construction H&S | 15.8 | 0.0 | 0.0 | 10.5 | 52.6 | 21.1 | 3.47 |
| 'I am my brother's keeper' | 15.8 | 0.0 | 0.0 | 15.8 | 63.2 | 5.3 | 3.26 |
| The benefits of H&S exceed the costs thereof | 10.5 | 5.3 | 10.5 | 5.3 | 57.9 | 10.5 | 3.26 |
| Designers can quantify risk at design stage | 10.5 | 0.0 | 5.3 | 26.3 | 52.6 | 5.3 | 3.26 |
| Design contributes to accidents | 0.0 | 0.0 | 21.1 | 36.8 | 36.8 | 5.3 | 3.26 |
| H&S is concerned with the sustainability of the industry | 21.1 | 0.0 | 0.0 | 5.3 | 68.4 | 5.3 | 3.16 |
| Designers can eliminate hazards at design stage | 10.5 | 0.0 | 10.5 | 21.1 | 57.9 | 0.0 | 3.16 |
| All accidents are preventable | 5.3 | 5.3 | 36.8 | 5.3 | 31.6 | 15.8 | 3.00 |
| H&S should be a value and not a priority | 5.3 | 5.3 | 42.1 | 21.1 | 15.8 | 10.5 | 2.68 |
| Accidents are part of the job | 0.0 | 15.8 | 42.1 | 26.3 | 15.8 | 0.0 | 2.42 |
| Cost, quality, and time are more important than H&S | 0.0 | 15.8 | 73.7 | 10.5 | 0.0 | 0.0 | 1.95 |

Table 1B: Pre-seminar responses (MS: 1.00 – 5.00) (Smallwood, 2015).

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 - Findings (3)

| Statement | Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|---|
| | Unsure | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | |
| Tertiary designer education should include construction H&S | 0.0 | 0.0 | 0.0 | 0.0 | 52.6 | 47.4 | 4.47 |
| 'I am my brother's keeper' | 0.0 | 0.0 | 0.0 | 0.0 | 57.9 | 42.1 | 4.42 |
| Evaluation of project performance should include H&S | 0.0 | 0.0 | 0.0 | 0.0 | 63.2 | 36.8 | 4.37 |
| Design influences construction | 0.0 | 0.0 | 0.0 | 0.0 | 63.2 | 36.8 | 4.37 |
| H&S is concerned with the sustainability of the industry | 0.0 | 0.0 | 0.0 | 5.3 | 57.9 | 36.8 | 4.32 |
| Design influences H&S | 0.0 | 0.0 | 0.0 | 0.0 | 68.4 | 31.6 | 4.32 |
| Designers should conduct constructability reviews | 0.0 | 0.0 | 0.0 | 0.0 | 73.7 | 26.3 | 4.26 |
| Designers should consider their designs relative to construction | 0.0 | 0.0 | 0.0 | 0.0 | 78.9 | 21.1 | 4.21 |
| Design can positively influence H&S | 0.0 | 0.0 | 0.0 | 5.3 | 68.4 | 26.3 | 4.21 |
| Designers can identify hazards at design stage | 0.0 | 0.0 | 0.0 | 0.0 | 78.9 | 21.1 | 4.21 |
| Designers can mitigate hazards at design stage | 0.0 | 0.0 | 0.0 | 5.3 | 73.7 | 21.1 | 4.16 |
| Procurement influences construction H&S | 0.0 | 0.0 | 0.0 | 5.3 | 73.7 | 21.1 | 4.16 |
| All accidents are preventable | 0.0 | 0.0 | 5.3 | 5.3 | 63.2 | 26.3 | 4.11 |
| H&S is concerned with preventing injuries | 0.0 | 5.3 | 0.0 | 5.3 | 57.9 | 31.6 | 4.11 |

**Table 2A: Post-seminar responses (MS: 1.00 – 5.00) (Smallwood, 2015).**

PERI®

# Research 1 - Findings (4)

| Statement | Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|---|
| | Unsure | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | |
| H&S is more important than cost, quality, and time | 0.0 | 0.0 | 5.3 | 15.8 | 47.4 | 31.6 | 4.05 |
| Designers can quantify risk at design stage | 0.0 | 0.0 | 0.0 | 5.3 | 84.2 | 10.5 | 4.05 |
| H&S is related to constructability | 5.6 | 0.0 | 0.0 | 0.0 | 77.8 | 16.7 | 3.94 |
| The benefits of H&S exceed the costs thereof | 5.3 | 0.0 | 5.3 | 0.0 | 68.4 | 21.1 | 3.89 |
| Designers can eliminate hazards at design stage | 5.3 | 0.0 | 5.3 | 5.3 | 63.2 | 21.1 | 3.84 |
| 'Designing for H&S' is a designer competency | 0.0 | 0.0 | 5.3 | 15.8 | 68.4 | 10.5 | 3.84 |
| Design can negatively influence H&S | 0.0 | 0.0 | 15.8 | 10.5 | 63.2 | 10.5 | 3.68 |
| Design contributes to accidents | 0.0 | 0.0 | 15.8 | 26.3 | 52.6 | 5.3 | 3.47 |
| H&S is concerned with compliance with legislation | 0.0 | 15.8 | 15.8 | 0.0 | 52.6 | 15.8 | 3.37 |
| Accidents are unplanned events | 0.0 | 11.1 | 22.2 | 5.6 | 44.4 | 16.7 | 3.33 |
| Construction is inherently dangerous | 0.0 | 5.6 | 33.3 | 0.0 | 44.4 | 16.7 | 3.33 |
| H&S should be a value and not a priority | 0.0 | 10.5 | 31.6 | 10.5 | 26.3 | 21.1 | 3.16 |
| Accidents are part of the job | 0.0 | 15.8 | 63.2 | 21.1 | 0.0 | 0.0 | 2.05 |
| Cost, quality, and time are more important than H&S | 0.0 | 31.6 | 63.2 | 0.0 | 5.3 | 0.0 | 1.79 |

Table 2B: Post-seminar responses (MS: 1.00 – 5.00) (Smallwood, 2015).

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 - Findings (5)

| Statement | MS | | Diff |
|---|---|---|---|
| | Pre | Post | (%) |
| All accidents are preventable | 3.00 | 4.11 | 37.0 |
| H&S is concerned with the sustainability of the industry | 3.16 | 4.32 | 36.7 |
| 'I am my brother's keeper' | 3.26 | 4.42 | 35.6 |
| Designers can quantify risk at design stage | 3.26 | 4.05 | 24.2 |
| Designers can eliminate hazards at design stage | 3.16 | 3.84 | 21.5 |
| Procurement influences construction H&S | 3.47 | 4.16 | 19.9 |
| The benefits of H&S exceed the costs thereof | 3.26 | 3.89 | 19.3 |
| H&S should be a value and not a priority | 2.68 | 3.16 | 17.9 |
| H&S is more important than cost, quality, and time | 3.53 | 4.05 | 14.7 |
| Designers can identify hazards at design stage | 3.68 | 4.21 | 14.4 |
| Designers should conduct constructability reviews | 3.79 | 4.26 | 12.4 |
| Design can positively influence H&S | 3.89 | 4.21 | 8.2 |
| Design influences H&S | 4.00 | 4.32 | 8.0 |
| Designers can mitigate hazards at design stage | 3.89 | 4.16 | 6.9 |

**Table 3A: Pre-seminar versus post-seminar responses (MS: 1.00 – 5.00) (Smallwood, 2015).**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 - Findings (6)

| Statement | MS | | Diff (%) |
|---|---|---|---|
| | Pre | Post | |
| Design contributes to accidents | 3.26 | 3.47 | 6.4 |
| Tertiary designer education should include construction H&S | 4.21 | 4.47 | 6.2 |
| Design influences construction | 4.16 | 4.37 | 5.0 |
| 'Designing for H&S' is a designer competency | 3.68 | 3.84 | 4.3 |
| Evaluation of project performance should include H&S | 4.26 | 4.37 | 2.6 |
| H&S is related to constructability | 3.84 | 3.94 | 2.6 |
| H&S is concerned with preventing injuries | 4.21 | 4.11 | (2.4) |
| Designers should consider their designs relative to construction | 4.32 | 4.21 | (2.5) |
| Design can negatively influence H&S | 3.79 | 3.68 | (2.9) |
| H&S is concerned with compliance with legislation | 3.63 | 3.37 | (7.2) |
| Cost, quality, and time are more important than H&S | 1.95 | 1.79 | (8.2) |
| Accidents are unplanned events | 3.67 | 3.33 | (9.3) |
| Construction is inherently dangerous | 3.74 | 3.33 | (11.0) |
| Accidents are part of the job | 2.42 | 2.05 | (15.3) |

Table 3B: Pre-seminar versus post-seminar responses (MS: 1.00 – 5.00) (Smallwood, 2015).

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 - Conclusions

- Given the pre-seminar MSs, delegates did have an understanding and appreciation of construction H&S and the role of designing for construction H&S
- However, given that they attended the seminar they are likely to constitute the more committed and possibly more knowledgeable designers in terms of construction H&S and ergonomics
- The seminar did have an impact in terms of inducing a change in the delegates' culture - training can induce a change in culture
- However, training needs to identify misperceptions and focus on correcting such misperceptions
- Important to quantify the impact of training interventions as it is important to assess the impact of H&S induction

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 1 - Recommendations

- Tertiary designer built environment education should address construction H&S and ergonomics, and highlight the role thereof in overall project performance
- 'Designing for construction H&S and ergonomics' should be included in such programmes, and the assessment and evaluation of design projects should include construction H&S and ergonomics as a criterion
- Accreditation panels should review the extent to which construction H&S and ergonomics is addressed in such programmes
- Design practices should evolve a formal 'designing for construction H&S and ergonomics' process:
  - Follow a documented process in terms of design HIRAs
  - Record the residual risk remaining after the raw risk has been addressed in the 'design' report submitted to the client for amendment of the client's H&S Specification

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Sample stratum and method

- A convenience sample of 88 predominantly architectural, but also engineering designers based in the Nelson Mandela Metropolitan metropole
- A self-administered 12-question questionnaire was delivered to the potential respondents per e-mail
- Six demographic questions, five Likert scale type questions, and one open-ended question
- Ten e-mail messages RTS
- Ten completed questionnaires were returned and included in the analysis of the data, which equates to a response rate of 13.5%
- Two further e-mail requests were sent, but failed to elicit further responses
- Mean scores (MSs) – a measure of central tendency, between 1.00 (lower) and 5.00 (upper), 3.00 being the midpoint

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Findings (1)

| Stage | Response (%) | | | | | | MS | Rank |
|---|---|---|---|---|---|---|---|---|
| | Unsure | Never | Rarely | Some-times | Often | Always | | |
| Construction documentation and management | 0.0 | 0.0 | 10.0 | 30.0 | 20.0 | 40.0 | 3.90 | 1 |
| Tender documentation and procurement | 0.0 | 0.0 | 20.0 | 30.0 | 20.0 | 30.0 | 3.60 | 2 |
| Design development | 0.0 | 10.0 | 20.0 | 20.0 | 20.0 | 30.0 | 3.40 | 3 |
| Concept and feasibility | 0.0 | 20.0 | 10.0 | 30.0 | 20.0 | 20.0 | 3.10 | 4 |
| Project initiation and briefing | 0.0 | 20.0 | 10.0 | 30.0 | 30.0 | 10.0 | 3.00 | 5 |
| Project close out | 0.0 | 40.0 | 20.0 | 10.0 | 0.0 | 30.0 | 2.60 | 6 |

Table 2: Frequency respondents' practices conduct design HIRAs during the stages of projects (MS = 1.00 – 5.00) (Smallwood, 2016).

PERI®

# Research 2 - Findings (2)

| Aspect | Response (%) | | | | | | MS | Rank |
|---|---|---|---|---|---|---|---|---|
| | Unsure | Never | Rarely | Some-times | Often | Always | | |
| Design (general) | 0.0 | 0.0 | 10.0 | 40.0 | 20.0 | 30.0 | 3.70 | 1 |
| Site location | 0.0 | 0.0 | 20.0 | 30.0 | 20.0 | 30.0 | 3.60 | 2 |
| Specification | 0.0 | 0.0 | 30.0 | 30.0 | 0.0 | 40.0 | 3.50 | 3 |
| Finishes | 10.0 | 0.0 | 20.0 | 40.0 | 0.0 | 30.0 | 3.44 | 4 |
| Method of fixing | 0.0 | 10.0 | 10.0 | 30.0 | 30.0 | 20.0 | 3.40 | 5 |
| Details | 0.0 | 20.0 | 0.0 | 30.0 | 20.0 | 30.0 | 3.40 | 6 |
| Schedule | 0.0 | 20.0 | 10.0 | 20.0 | 10.0 | 40.0 | 3.40 | 7 |
| Type of structural frame | 10.0 | 20.0 | 20.0 | 0.0 | 10.0 | 40.0 | 3.33 | 8 |
| Elevations | 0.0 | 20.0 | 10.0 | 30.0 | 10.0 | 30.0 | 3.20 | 9 |
| Position of components | 0.0 | 10.0 | 20.0 | 40.0 | 10.0 | 20.0 | 3.10 | 10 |
| Plan layout | 0.0 | 20.0 | 30.0 | 0.0 | 20.0 | 30.0 | 3.10 | 11 |
| Mass of materials | 0.0 | 20.0 | 10.0 | 30.0 | 30.0 | 10.0 | 3.00 | 12 |
| Content of material | 0.0 | 20.0 | 10.0 | 40.0 | 20.0 | 10.0 | 2.90 | 13 |
| Texture of materials | 0.0 | 20.0 | 20.0 | 40.0 | 0.0 | 20.0 | 2.80 | 14 |
| Edge of materials | 11.1 | 22.2 | 22.2 | 22.2 | 0.0 | 22.2 | 2.75 | 15 |
| Surface area of materials | 0.0 | 20.0 | 30.0 | 30.0 | 10.0 | 10.0 | 2.60 | 16 |

Table 3: Frequency respondents' practices consider / refer to aspects when conducting design HIRAs (MS = 1.00 – 5.00) (Smallwood, 2016).

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Findings (3)

| Action | Response (%) | | | | | | MS | Rank |
|---|---|---|---|---|---|---|---|---|
| | Unsure | Never | Rarely | Some-times | Often | Always | | |
| Amend details | 0.0 | 0.0 | 0.0 | 33.3 | 22.2 | 44.4 | 4.11 | 1 |
| Review the client H&S specification | 0.0 | 0.0 | 0.0 | 20.0 | 50.0 | 30.0 | 4.10 | 2 |
| Amend designs | 0.0 | 0.0 | 0.0 | 30.0 | 30.0 | 40.0 | 4.10 | 3 |
| Avoid / Eliminate hazards | 10.0 | 0.0 | 10.0 | 20.0 | 30.0 | 30.0 | 3.89 | 4 |
| Focus on significant / unusual / difficult risks | 0.0 | 10.0 | 0.0 | 30.0 | 30.0 | 30.0 | 3.70 | 5 |
| Identify hazards | 0.0 | 0.0 | 20.0 | 30.0 | 20.0 | 30.0 | 3.60 | 6 |
| Revisit the process if the design changes at any point | 0.0 | 10.0 | 10.0 | 20.0 | 30.0 | 30.0 | 3.60 | 7 |
| Assemble H&S expertise e.g. consult an H&S Agent | 0.0 | 0.0 | 20.0 | 20.0 | 50.0 | 10.0 | 3.50 | 8 |
| Monitor construction activities relative to design HIRAs | 0.0 | 20.0 | 20.0 | 10.0 | 0.0 | 50.0 | 3.40 | 9 |
| Substitute materials | 0.0 | 0.0 | 20.0 | 50.0 | 10.0 | 20.0 | 3.30 | 10 |
| Review the construction phase H&S plan | 0.0 | 0.0 | 30.0 | 40.0 | 0.0 | 30.0 | 3.30 | 11 |
| Gather H&S information relative to projects | 0.0 | 20.0 | 10.0 | 20.0 | 20.0 | 30.0 | 3.30 | 12 |
| Provide H&S information for tender documentation | 0.0 | 10.0 | 30.0 | 20.0 | 0.0 | 40.0 | 3.30 | 13 |

**Table 4A: Frequency respondents' practices undertake actions relative to projects / their practice (MS = 1.00 – 5.00) (Smallwood, 2016).**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Findings (4)

| Action | Response (%) | | | | | | MS | Rank |
|---|---|---|---|---|---|---|---|---|
| | Unsure | Never | Rarely | Some-times | Often | Always | | |
| Maintain a register of project hazards and risk | 0.0 | 20.0 | 20.0 | 10.0 | 10.0 | 40.0 | 3.30 | 14 |
| Identify residual hazards | 10.0 | 10.0 | 10.0 | 40.0 | 10.0 | 20.0 | 3.22 | 15 |
| Identify risks from residual hazards | 10.0 | 10.0 | 10.0 | 40.0 | 10.0 | 20.0 | 3.22 | 16 |
| Consider H&S during maintenance | 0.0 | 10.0 | 10.0 | 50.0 | 10.0 | 20.0 | 3.20 | 17 |
| Contribute to the H&S file | 0.0 | 0.0 | 50.0 | 10.0 | 10.0 | 30.0 | 3.20 | 18 |
| Prepare design and construction method statements | 0.0 | 22.2 | 11.1 | 22.2 | 22.2 | 22.2 | 3.11 | 19 |
| Assess / Prioritise / Investigate selected risks | 0.0 | 20.0 | 10.0 | 30.0 | 20.0 | 20.0 | 3.10 | 20 |
| Conduct site risk assessments and actions / directions | 0.0 | 20.0 | 30.0 | 0.0 | 20.0 | 30.0 | 3.10 | 21 |
| Document the design HIRA process | 0.0 | 30.0 | 10.0 | 10.0 | 20.0 | 30.0 | 3.10 | 22 |
| Prepare a 'design loop' for temporary works | 20.0 | 10.0 | 30.0 | 10.0 | 10.0 | 20.0 | 3.00 | 23 |
| Provide information on residual risks e.g. on drawings | 0.0 | 20.0 | 20.0 | 30.0 | 10.0 | 20.0 | 2.90 | 24 |
| Compile a project H&S 'lessons learnt' report | 0.0 | 40.0 | 10.0 | 10.0 | 10.0 | 30.0 | 2.80 | 25 |
| Maintain a practice register of hazards and risk | 0.0 | 30.0 | 20.0 | 10.0 | 30.0 | 10.0 | 2.70 | 26 |
| Prepare a 'designer report' (H&S) for clients | 0.0 | 33.3 | 33.3 | 0.0 | 0.0 | 33.3 | 2.67 | 27 |

Table 4B: Frequency respondents' practices undertake actions relative to projects / their practice (MS = 1.00 – 5.00) (Smallwood, 2016).

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Findings (5)

| Aspect | Response (%) | | | | | | MS | Rank |
|---|---|---|---|---|---|---|---|---|
| | Un-sure | Limited……..……Extensive | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | | |
| Prevention through design | 0.0 | 0.0 | 20.0 | 20.0 | 60.0 | 0.0 | 3.40 | 1 |
| Designing for construction H&S | 0.0 | 0.0 | 20.0 | 30.0 | 50.0 | 0.0 | 3.30 | 2 |
| Design HIRAs | 0.0 | 20.0 | 10.0 | 10.0 | 60.0 | 0.0 | 3.10 | 3 |

Table 5: Respondents' rating of their knowledge relative to aspects (MS = 1.00 – 5.00) (Smallwood, 2016).

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Conclusions (1)

- Given the small sample stratum and the response rate the study can best be described as exploratory
- Respondents are likely to constitute the more committed designers in terms of construction H&S and 'designing for construction H&S'
- Low response rate may also be attributable to the 'non-respondents' not considering construction H&S, which correlates with anecdotal evidence
- Findings provide an important first indication of designer commitment and practices related to 'designing for construction H&S'
- The focus of design HIRAs is during the stages of 'construction documentation and management' and 'tender documentation and procurement', and thereafter 'design development':

PERI®

# Research 2 - Conclusions (2)

- Therefore, it can be concluded that there is more focus on design HIRAs during procurement and construction, than design
- **Designers do consider / refer to various design related aspects when conducting design HIRA:**
  - However, between rarely to sometimes / sometimes, and sometimes to often/ often, and in the case of the former frequency, certainly relative to materials related issues
- **Designers do undertake H&S related actions relative to projects and their practice, particularly amendment of designs and details:**
  - However, the frequency relative to formal documentation in terms of communication of hazards and risks, including the 'designer report', the HIRA process, and 'lessons learnt', and registers, is less frequent

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Conclusions (3)

- Can be concluded that designers do have an understanding and appreciation of the concept of 'designing for construction H&S', design HIRAs included, but that there needs to be focus on the formalisation of the process
- This is underscored by the respondents' rating of their knowledge relative to aspects, which rating is between below average to average / average, which implies there is a need for continuing professional development (CPD)

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Research 2 - Recommendations

- Tertiary designer built environment education should address construction H&S
- 'Designing for construction H&S' should be included in such programmes, and the assessment and evaluation of design projects should include construction H&S as a criterion
- Accreditation panels should review the extent to which construction H&S is addressed in such programmes
- Design practices should evolve a formal 'designing for construction H&S' process:
  - Follow a documented process in terms of design HIRAs
  - Record the residual risk remaining after the raw risk has been addressed in the 'design' report submitted to the client for amendment of the client's H&S Specification

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# Major forthcoming event

**Joint CIB W099 and TG59 International Safety, Health,**
**and**
**People in Construction Conference**

***Towards better Safety, Health, Wellbeing, and Life in Construction***

**Cape Town, South Africa**

**11-13 June 2017**

**http://www.cibw099.com**
**http://www.cut.ac.za/construction-conference-2017-sa/**

PERI®

Nelson Mandela Metropolitan University
for tomorrow

# References (1)


- Behm, M. 2006. An Analysis of Construction Accidents from a Design Perspective. Silver Spring: The Center to Protect Workers' Rights.
- Construction Industry Development Board (cidb). 2009. Construction Health & Safety Status & Recommendations. Pretoria: cidb.
- Gambatese, J.A. 1998. Liability in designing for construction worker safety, Journal of Architectural Engineering, 4(3), September, 107-112.
- Hecker, S.F., Gambatese, J.A. and Weinstein, M. 2006. Designing for construction safety in the US: Progress, needs, and future directions. In: Proceedings of the 16th Triennial Congress of the International Ergonomics Association, Maastricht, The Netherlands, 10-14 July 2006, D:\data\pdfs\art0563.pdf


PERI®

Nelson Mandela Metropolitan University
for tomorrow

# References (2)


- Hinze, J.W. 2006. Construction Safety, Second edition. New Jersey: Prentice Hall Inc.
- Mount Isa Mines Limited (MIML) and National Safety Council of Australia (NSC). 1992. Practical, Effective Construction Safety. Brisbane: MIML and NSC.
- Republic of South Africa. 2014. No. R. 84 Occupational Health and Safety Act, 1993 Construction Regulations 2014. Government Gazette No. 37305. Pretoria.
- SA Builder Bouer. 2004a. Cover story. Echo marks 20 years of achievement. SA Builder Bouer, Nov / Dec, pp. 46-47.
- SA Builder Bouer. 2004b. Cover story. Concrete flooring excellence. SA Builder Bouer, Nov / Dec, p. 46.
- Schwartz, D.J. 1995. The Magic of Thinking Big. London: Pocket Books.


PERI®

Nelson Mandela Metropolitan University
for tomorrow

# References (3)


- Smallwood, J.J. 1995. The Influence of management on the occurrence of loss causative incidents in the South African construction industry. Unpublished MSc (Constr Man) Dissertation, University of Port Elizabeth, Port Elizabeth.
- Smallwood, J.J. 2004. Optimum cost: The role of health and safety (H&S). In: JJP Verster, ed. Proceedings International Cost Engineering Council 4th World Congress, Cape Town, April 2004. International Cost Engineering Council, 2004: CD-Rom Smallwood-J- Optimum Cost-Health & Safety.
- Smallwood, J.J. 2006a. Ergonomics in construction: South African perspectives. In: Proceedings of CIB W107 Construction in Developing Countries International Symposium on Construction in Developing Economies: NewIssues and Challenges, Santiago, Chile, 18-20 January, D:\4.6.pdf.


PERI®

Nelson Mandela Metropolitan University
for tomorrow

# References (4)


- Smallwood, J.J. 2006b. The Practice of Construction Management. Acta Structilia. 13(2), 62-89.
- Smallwood, J.J. 2010. The Image of Contractors: A South African Case Study. In: C. Egbu (ed) Proceedings of 26th Annual Conference of ARCOM, Leeds, United Kingdom, 6-8 September 2010. Reading: ARCOM, 939-946.
- Steel Construction. 2004. Mining Engineering Category Winner 12 North Shaft Headgear – Impala Platinum. Steel Construction, August 2004, pp. 32-34.
- Smallwood, J.J. 2015. Designing for Construction Ergonomics. In: G. Lindgaard and D. Moore (eds.) Proceedings 19th Triennial Congress of the International Ergonomics Association (IEA), Melbourne, Australia, 9-14 August 2015, ???: The University of Queensland, Paper 327.Pdf


PERI®

Nelson Mandela Metropolitan University
for tomorrow

# References (5)


- Smallwood, J.J. 2016. Design Hazard Identification and Risk Assessment (HIRA). In: P. Hájek, J. Tywoniak, A Lupíšek, and K Sojková (eds.) Proceedings Central Europe Towards Sustainable Building 2016 Conference, Prague, Czech Republic, 22-24 June 2016, Prague: Grada Publishing, 903-910.
- Thorpe, B. 2006. Health and Safety in Construction Design. Aldershot: Gower Publishing Limited.


PERI®