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# 2ND INTERNATIONAL CONFERENCE ON ERGONOMICS IN DESIGN

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# MASS AND DENSITY OF MATERIALS: QUANTITY SURVEYING STUDENTS' KNOWLEDGE AND PERCEPTIONS


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# Introduction (1)

- Materials may be heavy and / or inconveniently sized and shaped, thus presenting manual materials handling problems (Schneider & Susi, 1994; Monk, 2005)
- 62% of back injuries are attributable to manual materials handling (Construction Safety Association of Ontario,1993)
- One-third of all construction industry accidents reported to the HSE in the United Kingdom involve manual handling (Health & Safety Executive) (2000)
- South African Construction Regulations (Republic of South Africa, 2014):
  - Designer means, inter alia, a surveyor specifying articles or drawing up specifications
  - Regulation 5 (1) (g) requires that clients ensure that potential principal contractors (PCs) have made provision for the cost of H&S in their tenders. Clearly QSs need to facilitate such provision

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# Introduction (2)

- Structures 6 (1) designers of a structure must, inter alia:
  - 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, and the geotechnical-science aspects. Therefore, QSs in turn need to take cognisance and integrate the aforementioned in the bills of quantities
  - Furthermore, designers are required to modify the design or make use of substitute materials where the design necessitates the use of dangerous procedures or materials hazardous to H&S. Consequently designers, quantity surveyors included, need to conduct design hazard identification and risk assessments (HIRAs) before finalising a design, bills of quantities, and contract documentation
  - However, a pre-requisite for conducting of design HIRAs is knowledge of the mass and density of materials

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# Introduction (3)

- Handling heavy materials – ranked 3 / 18 ergonomics problems in three previous self-administered questionnaire based research studies conducted in South Africa (Smallwood, 1997; Smallwood *et al.*, 2000; Smallwood, 2002)
- Ergonomic aspects requiring attention - 92.6% of workers indentified materials handling (ranked 1 / 9) (Smallwood *et al.*, 2000)

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# Objective(s)

**Given the role of manual materials handling, and in particular, heavy materials, in the occurrence of injuries, the role of Quantity Surveyors in mitigating, reducing, and controlling such injuries, and the importance of knowledge of the mass and density of materials in terms of conducting risk assessments, a study was conducted to determine students' knowledge of the mass and density of materials**

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# Research – Sample stratum

**The sample stratum consisted of BSc (Construction Economics) students registered for the Quantity Surveying programme**

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# Research – Method

- The questionnaire consisted of seven closed ended questions, two of which consisted of five and four sub-questions pertaining to the mass and density of materials respectively
- The other five questions were five-point likert scale type questions.
- The survey was administered at the inception of the presentation of a special health and safety (H&S) lecture series at third year level in 2013
- 32 Responses were included in the analysis of the data
- Mean scores (MSs) are between 1.00 (lower end) and 5.00 (upper end), 3.00 being the midpoint

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# Summary of mass and density responses

| Material | Response (%) | No response (%) |
|---|---|---|
| Solid clay brick | 96.9 | 3.1 |
| Two-cell concrete block | 90.6 | 9.4 |
| Precast concrete kerb | 93.8 | 6.2 |
| Double Roman concrete roof tile | 93.8 | 6.2 |
| $m^2$ glass 5 mm thick | 84.4 | 15.6 |
| Concrete | 100.0 | 0.0 |
| Marble | 100.0 | 0.0 |
| Sandstone | 96.9 | 3.1 |
| Steel | 93.8 | 6.2 |
| Mean | 94.5 | 5.5 |

**Table 1: Summary of mass and density of materials responses**

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# Analysis of mass and density responses

| Material | Actual | Mean response | Difference (%) | Responses within range (%) |
|---|---|---|---|---|
| Solid clay brick (kg) | 3.0 – 3.5 | 5.0 | 152.3 | 31 |
| Two-cell concrete block (kg) | 17.5 | 11.0 | 159.1 | 9 |
| Precast concrete kerb (kg) | 95 | 113.5 | 119.5 | 25 |
| Double Roman concrete roof tile (kg) | 4.8 | 4.3 | (10.4) | 16 |
| $m^2$ glass 5 mm thick (kg) | 13.5 | 18.5 | 137.0 | 0 |
| Concrete (kg / $m^3$) | 2 400 | 1757 | (26.8) | 31 |
| Marble (kg / $m^3$) | 2 755 | 2295 | (16.7) | 25 |
| Sandstone (kg / $m^3$) | 2 323 | 1428 | (38.5) | 13 |
| Steel (kg / $m^3$) | 2 393 | 2204 | (7.9) | 6 |
| Mean | | | 52.0 | 17.3 |

**Table 2: Actual and mean response mass / density, percentage difference, and summary of responses within a 10% range of the actual mass or density**

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# Extent of impact of mass and density of materials

| Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|
| Unsure | Minor…….…….. Major | | | | | |
| | 1 | 2 | 3 | 4 | 5 | |
| 0.0 | 0.0 | 0.0 | 3.1 | 31.3 | 65.6 | 4.63 |

**Table 3: Extent to which the mass and density of materials impacts on ergonomics**

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# Knowledge of the mass and density of materials

| Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|
| Unsure | Limited……Extensive | | | | | |
| | 1 | 2 | 3 | 4 | 5 | |
| 9.4 | 43.8 | 34.4 | 12.5 | 0.0 | 0.0 | 1.66 |

**Table 4: Respondents' rating of their knowledge of the mass and density of materials**

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# Consideration of mass and density of materials (1)

| Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|
| Unsure | Never…….....Always | | | | | |
| | 1 | 2 | 3 | 4 | 5 | |
| 3.1 | 0.0 | 0.0 | 0.0 | 34.4 | 62.5 | 4.65 |

**Table 5: Frequency at which construction managers should consider the mass and density of materials when managing projects**

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# Consideration of mass and density of materials (2)

| Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|
| Unsure | Never…….....Always | | | | | |
| | 1 | 2 | 3 | 4 | 5 | |
| 12.5 | 0.0 | 6.3 | 31.3 | 28.1 | 21.9 | 3.75 |

Table 6: Frequency at which quantity surveyors should consider the mass and density of materials when preparing bills of quantities and other project documentation

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# Potential of the consideration of the mass and density of materials to contribute to an improvement

| Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|
| Unsure | Minor….. ……..…Major | | | | | |
| | 1 | 2 | 3 | 4 | 5 | |
| 9.4 | 0.0 | 0.0 | 9.4 | 43.8 | 37.5 | 4.31 |

**Table 7: Potential of the consideration of the mass and density of materials to contribute to an improvement in construction ergonomics**

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# Conclusions

- Respondents are lacking in knowledge relative to the mass and density of materials:
  - 94.5% of respondents attempted to record a mass or density
  - Only 17.3% of the 94.5% were within a 10% range of the actual mass or density
  - Reinforced by the respondents' rating of their knowledge of the mass and density of materials, namely 1.66 (between limited to below average / below average)
- Respondents appreciate, to a degree, the extent to which the mass and density of materials impact on construction ergonomics:
  - Actual impact
  - Extent to which Construction Managers should consider
  - Extent to which Quantity Surveyors should consider
  - Potential of the consideration of the mass and density of materials to contribute to an improvement

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# Recommendations

- Tertiary built environment education should:
  - Address construction ergonomics, in particular quantity surveying
  - Engender an awareness of the mass and density of common construction materials
  - Optimise the level of awareness relative to construction ergonomics, and the role of mass and density of materials
- Continuing professional development (CPD) should address construction ergonomics and the role of mass and density of materials

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