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# Assuring health and safety performance on construction projects: Clients' role and influence

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## Abstract

This article presents findings from an investigation conducted in Botswana and South Africa on how construction clients could influence health and safety (H&S) performance on construction projects.

The continued poor state of construction H&S and the inability of designers and contractors to influence an industry-wide H&S culture change motivated the article. It was also recognised that one of the reasons the construction industry continued to lag in H&S performance was the way in which H&S implementation and management was organised. The article proposes a client-centred model for H&S performance improvement.

The conceptual model and its factors were developed from both literature and a Delphi survey. Structural equation modelling was applied to data collected from a questionnaire survey to design a best fit model.

The key finding was that, generally, client H&S culture impacted on project H&S performance. The influence of clients was found to be statistically significant when commitment, communication and H&S procedures were evident. This finding was encouraging as it specifically shows how clients could influence performance. However, it remains to be seen whether these results could be replicated in other datasets. If indeed that is the case, then this article contributes significantly to the body of knowledge.

**Keywords:** Botswana, construction, culture, health and safety, improvement, influence, performance, South Africa

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**Abstrak**

Hierdie artikel gee bevindinge weer van 'n ondersoek wat in Botswana en Suid-Afrika gedoen is oor hoe konstruksie-kliënte 'n invloed kan hê op die uitvoering van beroepsgesondheid en veiligheid in konstruksieprojekte.

Die aanhoudende swak toestand waarin konstruksie beroepsgesondheid en veiligheid verkeer asook die onvermoë van ontwerpers en kontrakteurs om die beroepsgesondheid en veiligheidskultuurverandering industriewyd te beïnvloed, het die ondersoek in hierdie artikel gemotiveer. Dit is ook erken dat een van die redes vir die konstruksie-industrie se gebrek aan beroepsgesondheid en veiligheid optrede is die manier waarop beroepsgesondheid en veiligheidsimplimentering en bestuur georganiseer word. Die artikel stel 'n kliëntgesentreerde model voor om beroepsgesondheid en veiligheidsoptrede te verbeter.

Die konsepmodel en die faktore is ontwikkel uit literatuur asook 'n Delphi-opname. Gestruktureerde vergelykingsmodellering is toegepas om data uit 'n vraelysopname te versamel om sodoende 'n model te ontwerp wat die beste pas.

Die sleutelbevindinge was dat kliënt beroepsgesondheid en veiligheid 'n impak het op projek beroepsgesondheid en veiligheid. Die invloed van kliënte het duidelik uitgestaan ten opsigte van toevertroue, kommunikasie en beroepsgesondheid en veiligheidsprosedures. Hierdie bevinding wys waar kliënte optrede mag beïnvloed. Nietemin, dit moet nog gesien word of hierdie resultate gerepliseer kan word in ander datastelle. Indien wel, lewer hierdie artikel 'n beduidende bydrae tot die liggaam van kennis.

**Sleutelwoorde:** Botswana, konstruksie, kultuur, beroepsgesondheid en veiligheid, verbetering, invloed, optrede, Suid-Afrika

## 1. Introduction

The construction industry has for a long time been considered the most hazardous industry (Bomel, 2001: 0.5; CIOB, 2009: 6; McDonald, Lipscomb, Bondy & Glazner, 2009: 53). Accidents cost national economies nearly 4% of gross domestic product (GDP) and there is consequently a dire need for improvement in terms of health and safety (H&S) performance (ILO, 2003: 15). Construction workers are more at risk of an accident, ill health and/or even a fatality at work than other manufacturing-based industries (Loughborough & UMIST, 2003: Vii; Hoonakker, Loushine, Carayon, Kallman, Kapp & Smith, 2005: 461). Generally, construction sites are still one of the most dangerous workplaces, because of the high incidence of accidents (Hoonakker *et al.*, 2005: 461; Teo, Ling & Chong, 2005: 329; Kines, Spangenberg & Dyreborg, 2007: 53).

The risk of a fatality in construction is at least five times more likely than in other manufacturing-based industries (Sawacha, Naum & Fong, 1999: 309; Loughborough & UMIST, 2003: Vii). According to Bomel (2001: 0.5), the construction industry is a hazardous environment where workers have direct exposure to heights, forces, and power. Workers face these risks every day of their working lives.

Of great concern, therefore, is the exposure of workers to hazards in construction projects.

The nature and organisation of the construction industry have partly compounded the problem. H&S performance improvement in the construction industry has been made difficult as a result. The construction sector is a complex industry (Teo *et al*., 2005: 329), and the complexity is compounded by the extensive use of sophisticated plant, equipment, methods of construction, as well as multidisciplinary and multitasked project work force. It is this complex nature that shapes the industry's way of functioning and performance (Sawacha *et al*., 1999: 309; Dubois & Gadde, 2001: 2).

Furthermore, the construction industry has the following unique characteristics that contribute to its complexity and pose a challenge to performance improvement:

- An industry that offers temporary employment (Pellicer & Molenaar, 2009: 44);
- Work locations for any group of workers often changing (Riley & Brown, 2001: 150; McDonald *et al*., 2009: 53);
- Temporary work sites where workers are employed by different employers but work alongside each other (Chan & Chan, 2004: 203; Pellicer & Molenaar, 2009: 44; Misnan, Mohammed, Mahmood, Mahmud & Abdullah, 2008: 1902);
- An industry comprised mostly of small employers (Pellicer & Molenaar, 2009: 44). For example, in the United Kingdom, 98% of the registered companies employ 24 workers or less in their companies (Dainty, Briscoe & Millet, 2001: 163);
- Large numbers of people are employed in this industry and have to combine a diverse range of skills to complete a project (Bomel, 2001: 2.4; Dainty *et al*., 2001: 163; Riley & Brown, 2001: 150; Pellicer & Molenaar, 2009: 44);
- A large number of subcontractors (Bomel, 2001: 2.4; Riley & Brown, 2001: 158; Pellicer & Molenaar, 2009: 44);
- Construction projects with short periods (Bomel, 2001: 2.4; Dainty *et al*., 2001: 163; Riley & Brown, 2001: 150);
- Sites evolving as construction proceeds, resulting in changing the hazards that workers face weekly (Bomel, 2001: 2.3; Riley & Brown, 2001: 150);
- A fragmented industry (Egan, 1998: 8; Chan & Chan, 2004: 203). Dainty *et al*., (2001: 163) argue that the proliferation in

subcontracting has further complicated the situation, causing further fragmentation of the production process;

- An industry subjected to cyclical economic downturns (Egan, 1998: 9; Dainty *et al*., 2001: 163), and
- An industry with a low and unreliable rate of profitability (Egan, 1998: 7; Pellicer & Molenaar, 2009: 44).

In addition, Winch (2000: 142) observed that the construction industry is largely operationalised through a professional system which requires that designs be fully specified at tender stage. Yet the assumptions regarding the competence of designers in the technical details of a wide range of construction technologies and the ability of the client to keep requirements fixed over a period of time compromise the effectiveness of the professional system. The fact is that designs are rarely fully specified (Winch, 2000: 145). This system has also contributed to the industry's lack of cooperation and integration. Egan (1998: 13) observed that the construction industry was basically an industry typically dealing with the project process as a series of sequential and largely separate operations undertaken by individual designers, contractors and suppliers who have no stake in the long-term success of the project and therefore do not have any commitment to it. Therefore, changing this culture is fundamental if performance improvement is to be realised.

Consequently, the culture of clients could offer an opportunity for addressing the problem of H&S performance (Bomel, 2001: 5.5). The impetus for change lies with the clients of construction projects, because clients can influence contractors' H&S performance (Smallwood, 1998: 182; Bomel, 2001: 9.7; Lingard, Blismas, Cooke & Cooper, 2009: 132). The client has been overlooked in most studies with emphasis placed on the contractor or the construction process. H&S during the construction process is conventionally considered to be the contractor's responsibility. When construction accidents occur, perceived factors of causation are mostly associated with management failures on the part of the contractor or failures of site operatives to control unsafe site conditions or unsafe actions (Abdelhamid & Everett, 2000: 55; Suraji, Sulaiman, Mahyuddin & Mohamed, 2006: 49). The general perception is that construction H&S is a matter of construction management rather than the management on the part of clients and other participants in the construction process. Studies concentrating on factors that relate to the contractor create the impression that the main problem lies with contractors and, therefore, H&S performance improvement can only be achieved by addressing contractor issues. It is, however, unlikely that H&S performance improvement can be achieved in the industry by only focusing on the construction stage and the contractor specifically. This is partly due to the difficult conditions in which contractors operate, including constraints and actions of designers and clients (Suraji *et al*., 2006: 59).

The current study investigated the influence of clients on construction project H&S performance. The following hypothesis is to be tested: The H&S culture of clients defined by leadership, involvement, procedures, commitment, communication and competence impacts on project H&S performance.

Client-centred H&S performance improvement has not been investigated in sufficient detail (Lingard *et al*., 2009: 132). The study by Huang & Hinze (2006) in the U.S.A. investigated the influence of owners or clients on construction H&S performance by using the number of accidents to measure performance. To the contrary, the current study used leading indicators which better reflect H&S performance and are proactive (Carder & Ragan, 2003: 163; Jafri, Ahmad & Kamsah, 2005: 703; Cameron & Duff, 2007: 870) to characterise H&S performance. Examples are the use of indicators such as evidence of H&S inspections and audits to define performance. In addition, this study was not restricted to projects with good H&S performance only, but included other construction projects within South Africa and Botswana. In addition, the study investigated specifically the influence of the H&S culture of clients on H&S performance.

Therefore, the current study builds on Huang & Hinze's (2006) study and uses an alternative method to model the influence of client H&S culture on project H&S performance. This method involved a Delphi study and a field questionnaire survey. In addition, structural equation modelling (SEM) (Kline, 2005: 83) was used to reliably model how clients could influence project H&S performance.

## 2. Research

The study was conducted using both qualitative and quantitative data-collection methods. For the qualitative part, a Delphi technique was used, whereas a field questionnaire survey was used for the quantitative part. The Delphi survey was conducted with 11 H&S experts drawn from different parts of the world. The output from the Delphi technique was a conceptual model and the factors of client H&S culture. As for the quantitative approach, a questionnaire survey was conducted among construction professionals based in

Botswana and South Africa on the practice of H&S in the construction industry.

The analysis of the quantitative data was done using a structural equation modelling (SEM) software, Mplus version 6.0. The conceptual model analysed in the current study evolved as an output from both the literature review and the Delphi process. The conceptual model was thereafter tested using SEM of the questionnaire survey results. The SEM process was therefore undertaken as a confirmatory factor analysis (CFA) of the conceptual model.

### 2.1 Delphi study

The Delphi study involved 11 invited panellists who had been identified from three sources. The first source was the CIB W099 register of members on the CIB W099 website. The CIB W099 is a working commission, an international forum of researchers working on construction H&S. The second source was CIB W099 conference proceedings from 2005 to 2009. Individuals who had frequently appeared as authors or keynote speakers were identified as potential participants in the study. The third source was identifying individuals working in the area of H&S in the Southern African construction industry.

The Delphi panel consisted of two members from South Africa, three each from the United States of America (USA) and the United Kingdom (UK), and one each from Singapore, Hong Kong and Sweden. Of these, one of the panellists had a Doctor of Science (DSC) degree, six had Doctor of Philosophy (PhD) degrees, two had Master of Science (MSc) degrees, one had a Bachelor of Science (BSc.) degree, and one had a Diploma in Safety Management. All the panellists specialised in construction H&S. In terms of their current occupation, three of the panellists were employed by contracting organisations, one by a consulting organisation, and six by universities. All panellists held very senior positions in their organisations and were involved in community service.

The panel had a cumulative total of 243 years of experience. The lowest number of years of experience for an individual was seven and the highest was 45 years. The median number of years of experience was 15 years. Experience was an important factor in determining who an expert was and, therefore, the minimum number of years was set to be five. In terms of publications, 10 of the panellists had published in peer-reviewed journals, conference proceedings and books. Between them, they had published 57 books and monographs, 19 chapters in books, 187 peer-reviewed academic journals, 345 recent conference papers and 341 other publications comprising articles in professional journals, technical reports, policy papers, expert witness documentation and keynote addresses (Table 1). In addition, the panel had led and managed 108 funded research projects. Three panellists served on the editorial boards of 43 peer-reviewed journals and conference proceedings.

Table 1: Panellists' publications

| *Panel publications* | *No. of publications* |
|---|---|
| Books and monographs | 57 |
| Chapters in books | 19 |
| Peer-reviewed journals | 187 |
| Peer-reviewed conference proceedings | 345 |
| Funded research | 108 |
| Other publications | 341 |
| Editorial board membership | 43 |
| Referee for journals | 22 |
| Referee for conference proceedings | 30 |

### 2.1.1 Delphi process

A questionnaire was developed from literature and distributed electronically to all panel members. The questions related to the importance of the various factors of client H&S culture and the significance of client influence. The panel was asked to rate the importance of these factors on contractor and designer H&S performance. The importance of each factor was based on a 10-point rating scale ranging from 0 representing 0% or negligible or low impact to 10 representing 100% or very high impact.

The panel also rated the likelihood that contractor H&S performance would improve if the identified client culture H&S factors were evident. The likelihood or probability scale ranged from 1 to 10, representing 0% to 100%. The impact significance of each factor was thereafter obtained as a product of the rated likelihood and severity, as illustrated in equation 1.

$$\textit{Impact Significance} = \textit{Likelihood factor x Severity factor}$$

Equation 1

The Delphi process involved three iterative rounds to achieve consensus between the panel members regarding the extent of the client's influence on both contractor and designer H&S performance.

Apart from the panel rating the likelihood and severity of various factors, they were also requested to make comments on their ratings, especially if the ratings differed from those of other panel members. Comments were also made about what other factors or issues needed to be included or omitted from the theorised model.

### 2.1.2 Delphi findings

The average impact significance of all factors of client H&S culture on contractor H&S performance was found to be 6.60 while that on designer H&S performance was determined to be 6.45 (Figure 1). The significance of the impact of various factors associated with the client was categorised as being either critical, major, moderate, minor or low. A rating of one and below was considered to be low while that of seven to ten was considered to be critical (Table 2). According to the rating scale, the value of 6.60 indicated that the level of clients' impact and influence on contractors' H&S performance was of 'major impact significance'. Similarly, a rating of 6.45 on designers H&S performance was determined to be 'major'. All the factors of client H&S culture had an impact significance of more than 5.0, with client involvement being rated higher for designer H&S performance. The rating of 7.31 was considered to be 'critical impact significance'.

Table 2: Impact significance and severity rating scale

| *0>1* | *1>3* | *3>5* | *5>7* | *7>10* |
|---|---|---|---|---|
| Low/negligible | Minor | Moderate | Major | Critical |

On the other hand, client leadership had major impact significance on contractor H&S performance (Figure 1). Client competence had the least impact significance on contractor H&S performance, with a rating of 6.20. Similarly, client competence was also considered to have lower impact on designer H&S performance. The impact significance of client competence on designer H&S performance was determined to be 5.20. However, the rating of client competence was deemed to be of 'major impact' significance although, in comparison to other factors, client competence was considered to be the least significant (Table 2).

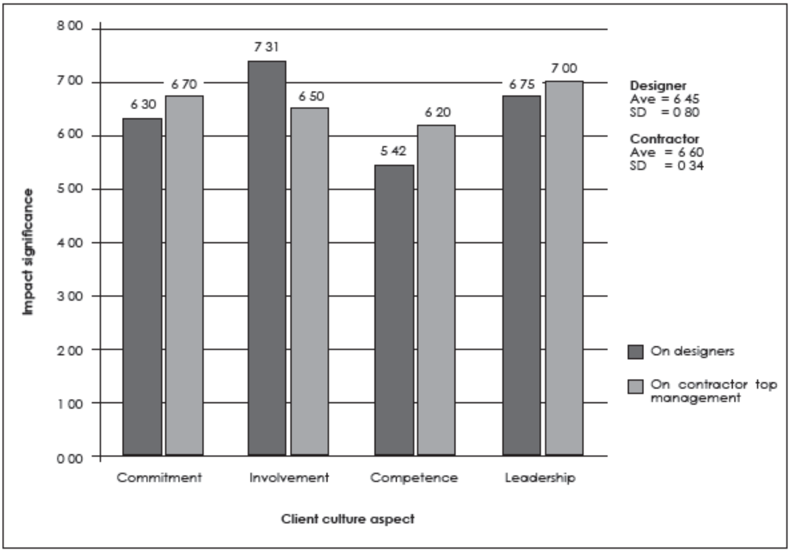
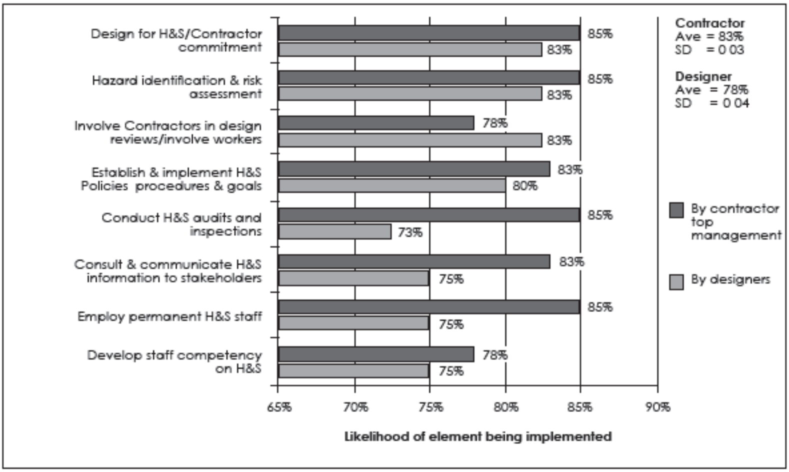



Figure 1: Impact significance of factors of client H&S culture on contractor and designer H&S performance

The mean likelihood of contractors and designers implementing various H&S elements due to client influence was 83% and 78%, respectively (Figure 2). This finding suggested that the implementation of H&S elements by contractors was 'very likely to occur' with client influence whereas that of designers was considered to be 'likely to occur'.

The Delphi study findings indicated that clients could significantly influence both contractor and designer H&S performance, given that contractors and designers were more likely to implement H&S elements with client influence. In addition, when the client H&S culture was evident in a project, a major impact on contractor and designer H&S performance was likely. Other aspects of H&S culture such as H&S programmes, goals, policies, rules and communication were important and would have a significant impact on both contractor and designer H&S performance.

Considering these findings, it was conceptualised that client H&S culture impacted on overall project H&S performance. In addition, aspects of client H&S culture such as leadership (CLLP), involvement (CLIP), procedures (CLPP), communication (CLNP), commitment (CLTP) and competence (CLCE) had to be evident in client organisations for the client to have a significant influence on project H&S performance.




| 0>20% | 20>40% | 40>60% | 60>80% | 80%>100% |
|---|---|---|---|---|
| Very unlikely | Unlikely | May occur half the time | Likely to occur | Very likely to occur |

Figure 2: Likelihood of contractors and designers implementing H&S elements due to client influence

### 2.1.3 Conceptual model of client H&S influence on project H&S performance

The conceptual model in Figure 3 depicts the relationships between client H&S culture, contractor, designer, and overall project H&S performance. The postulated relationships in the conceptualised model were that:

H1 client H&S culture has a direct positive influence on contractor H&S performance;

H2 client H&S culture has a direct positive influence on designer H&S performance;

H3 client H&S culture has a direct positive influence on project H&S performance;

H4 contractor H&S performance has a direct positive influence on project H&S performance, and

H5 designer H&S performance has a direct positive influence on project H&S performance

The second stage of model development entailed testing or validating this conceptualised model by means of a field questionnaire survey and analysing the data using SEM in order to achieve a desirable level of both internal and external validity.

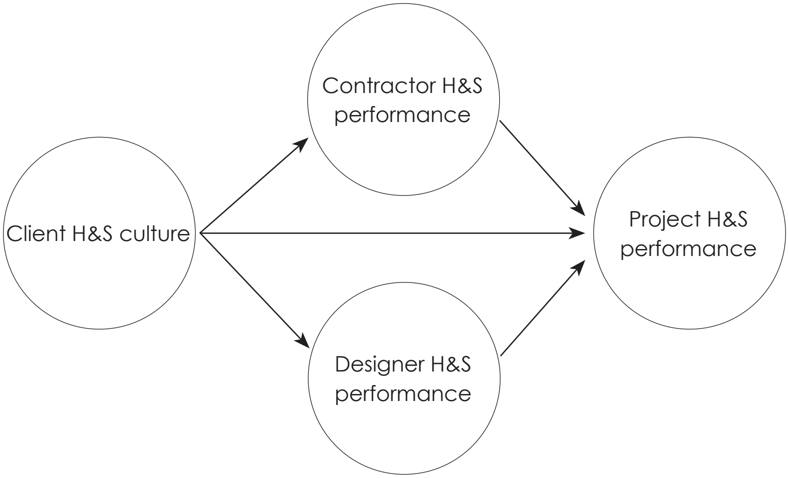



Figure 3: Conceptual model – Client H&S culture influence on project H&S performance

## 2.2 Field questionnaire survey

A questionnaire survey was conducted among 281 construction professionals in South Africa and Botswana. Raw data from the questionnaire survey was analysed using structural equation modelling (SEM) with EQS and MPlus software packages. The measurement model was analysed using EQS version 6.1, while the full structural model was analysed using MPlus version 6.0. According to Kline (2005: 15), a sample size of 281 is classified as large. A small sample of less than 100 cases tended to be problematic when it came to SEM analysis (Kline, 2005: 5).

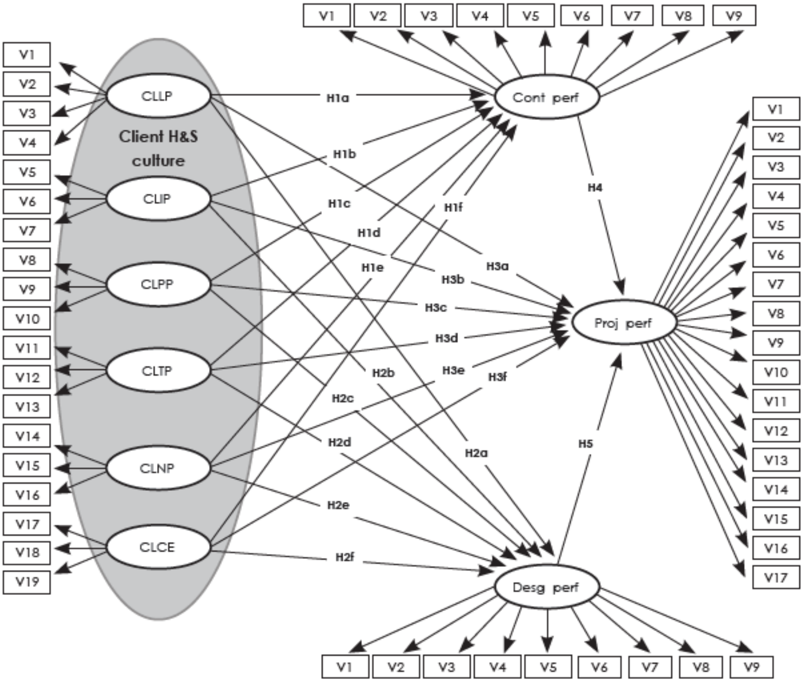



Figure 4: SEM model for client H&S culture influence on project H&S performance

The pre-analysis statistics of the data revealed that there were some missing values and the distribution characteristics indicated non-normality. The values of Mardia's coefficient, as shown in Table 3, for all constructs were found to be high. Table 3 shows that Mardia's coefficient for client culture was the highest with 443.7814, while that of contractor H&S performance was the lowest with 41.029. Consequently, a more robust analysis method, the robust maximum likelihood (RML), was selected for the analysis of the data. The RML gives several robust fit indices that take care of the distribution characteristics of the data (Bartholomew, Loukas, Jowers & Allua, 2006: 72). According to Byrne (2006: 22), one of the outputs from the RML estimation method is the robust *chi*-square statistic ($\chi^2$), referred to as the Satorra-Bentler scaled statistic ($S - B\chi^2$), and the robust standard errors which are corrected for non-normality in large samples. SEM is based on the assumption that the data is normal.

# 3. Questionnaire survey results

## 3.1 Structural model pre-analysis results

Results from the analysis of the measurement models indicated that all measurement models worked well and satisfied the requirement that the models should be over-identified. It is also a requirement for SEM analysis that the conditions of model identification are met. Boomsma (2000: 486) argues that it is the duty of a researcher to examine whether a model is theoretically identified or not. Kline (2005: 105) explains that a model is said to be identified if it is theoretically possible to derive a unique estimate of each parameter. Consequently, it is desirable to have an over-identified model. Byrne (2006: 31) explains that an over-identified model is one in which the number of parameters to be estimated is less than the number of data variances and covariances of the observed variables, resulting in a positive degree of freedom.

The significance of model over-identification is that it allows for a model to be rejected, rendering it of scientific value (Byrne, 2006: 31). A just-identified model cannot be rejected and it is impossible to obtain a solution for an under-identified model.

Examination of the results in Table 3 indicated that the lowest value for the degree of freedom was 24 and the highest was 137. These values were indicative of a positive value of degree of freedom and suggestive of an over-identified model.

Table 3: Measurement model statistics on distribution and fit

| *Construct* | *Mardia's coefficient* | $S-Bx^2$ | *Df* | *CFI* | *SRMR* | *RMSEA* | *RMSEA 90% CI* |
|---|---|---|---|---|---|---|---|
| Client culture | 443.7814 | 219.323 | 137 | 0.979 | 0.025 | 0.047 | 0.035: 0.058 |
| Contractor H&S performance | 41.0290 | 25.0664 | 24 | 0.999 | 0.009 | 0.013 | 0.000: 0.051 |
| Designer H&S performance | 225.6381 | 35.6033 | 24 | 0.994 | 0.010 | 0.042 | 0.000: 0.070 |
| Project H&S performance | 179.4860 | 294.515 | 119 | 0.923 | 0.048 | 0.075 | 0.064: 0.086 |

In addition, the results revealed that there were no convergence problems in the analysis, because all parameter estimates for client H&S culture, designer H&S performance, contractor H&S performance and project H&S performance constructs stabilised in fewer than 10 iterations each. The desired circumstance is the situation whereby only a few iterations are needed to reach convergence and these should not exceed the value of 30 (Byrne, 2006: 102). According to Byrne (2006: 102), the number of iterations exceeding 30 results in non-convergence and the output may not be trusted.

The measurement model specifications were also found to be adequate. Fit indices presented in Table 3 indicated that the measurement models worked well. All the fit indices fell within the acceptable limits for a good fit. The minimum comparative fit index (CFI) was 0.923 for the project H&S performance construct. A value greater than 0.900 is acceptable and a value greater than 0.950 is described as being good fit (Bartholomew *et al*., 2006: 73; Schreiber, Stage & King, 2006: 330; Dion, 2008: 367). The CFI values for client culture, contractor and designer H&S performance constructs were all above 0.95 (see Table 3). Similarly, the root mean square error of approximation (RMSEA) values for all constructs fell within the acceptable limits. A good fit model has RMSEA values of less than 0.050, while values of less than 0.080 indicate an acceptable model fit (Hu & Bentler, 1999: 27; Kline, 2005: 139; Bartholomew *et al*., 2006: 73; Dion, 2008: 367). The ranges for RMSEA with 90% confidence interval were also not large, indicating acceptable approximations. In addition, the standardised root mean squared residual (SRMR) values were all less than 0.050 and, therefore, the models were considered to be of good fit (Kline, 2005: 141; Schreiber *et al*., 2006: 330).

It was necessary to ensure that the measurement models worked well before the structural model could be analysed. Therefore, having been satisfied that the pre-analysis test of SEM assumptions result did not reveal any significant problems, the full structural model was analysed.

### 3.2 Structural model's goodness-of-fit statistics

The structural model, as presented in Figure 4, was analysed using MPlus software. The indicator variables for the client H&S culture, contractor and designer H&S performance were analysed in parcels, while those of project H&S performance were analysed as individual indicator variables. From a total sample of 281 responses, 259 cases were analysed. The number of cases that were skipped was 22, because they had missing variables. Only complete cases were analysed for the model. The model was analysed using the robust maximum likelihood method. The covariance matrix was analysed as opposed to the correlation matrix.

As shown in Table 4, the sample data yielded a *chi*-square statistic ($\chi^2$) of 2,966.661 with 1,342 degrees of freedom. The associated p-value was determined to be 0.000. From these values, the normed *chi*-square value was determined to be 2.211. The normed *chi*-square is the procedure of dividing the *chi*-square by the degrees of freedom. The normed values of up to 3.0 or even 5.0 are recommended. Therefore, since the value of 2.211 obtained for the postulated model was lower than 3.0, the result suggested an acceptable fit of the model. However, the *chi*-square statistic is only indicative of fit and, therefore, other goodness-of-fit indices were reviewed.

Table 4 presents the fit indices for the postulated model. The root mean square error of approximation (RMSEA) with 90% confidence interval was found to be 0.068 (lower bound value = 0.065 and upper bound value = 0.072). The RMSEA index was just above the upper limit value of 0.050 for the model to be described as having a good fit. However, a value of 0.068 was indicative of an adequate fit. A model with RMSEA values of up to 0.080 is considered to be acceptable (Hu & Bentler, 1999: 27; Kline, 2005: 139; Bartholomew *et al*., 2006: 73; Dion, 2008: 367). In addition, the upper confidence interval of 0.072 did not exceed the upper acceptable value of 0.08, as recommended by Hu & Bentler (1999: 27).

In addition, the standardised root mean square residual (SRMR) was found to be 0.045. The SRMR of 0.045 was much lower than the cut-off value of 0.05. Therefore, the SRMR value also indicated that the postulated model had a good fit. On the other hand, the comparative fit index (CFI) yielded a value that was close to the lower limit value of 0.90 at 0.88. The CFI index was not greater than 0.90 which is the lower limit value for model acceptance if the CFI is considered in the combination rules. However, in the current study, a two statistic model fit evaluation strategy, as proposed by Hu & Bentler (1999: 16), was followed. The decision on model fit was, therefore, based on the SRMR and the RMSEA fit indices.

An evaluation of the SRMR, RMSEA and the CFI fit indices indicated that the postulated model reasonably fits the sample data. Therefore, having been satisfied with the model fit to the sample data, it was feasible to evaluate the statistical significance of the hypothesised relationships between the factors of client H&S culture and the overall project H&S performance. The results are presented in Table 4.

Table 4: Robust fit indices for the postulated model

| *Fit index* | *Cut-off value* | *Model 1.0* | *Comment* |
|---|---|---|---|
| $x^2$ | | 2966.661 | |
| *Df* | 0 | 1342 | Acceptable |
| *CFI* | 0.9 acceptable<br>0.95good fit | 0.88 | Barely acceptable |
| *SRMR* | 0.08acceptable<br>0.05 good fit | 0.045 | Good fit |
| *RMSEA* | 0.08acceptable<br>0.05good fit | 0.068 | Acceptable |
| *RMSEA 90% CI* | 0.08 | 0.065:0.072 | Acceptable range |

### 3.3 Hypotheses testing

Rejection of the hypotheses depended on how reasonable the parameter estimates were in terms of their magnitude, signs and statistical significance. In addition, if in the output there were estimates that had correlation values greater than 1.00, had negative variances and the correlation or covariances were not definitely positive, they were said to be exhibiting unreasonable estimates (Byrne, 2006: 103). In addition, the test statistic had to be greater than 1.96 based on the *p*-value of > 0.005 before the hypothesis could be rejected (Byrne, 2006: 103). The test statistic reported in this study was the parameter estimate divided by its standard error and, therefore, it functioned as a Z-statistic to test that the estimate was statistically different from zero. The significance test was used to evaluate the general hypotheses H1 to H5.

#### 3.3.1 Testing the direct influence of client H&S culture on contractor H&S performance

It was generally hypothesised that client H&S culture had a direct positive influence on contractor H&S performance. Specifically, the hypotheses, which collectively formed hypothesis H1, were:

H1a leadership, had a direct positive influence on contractor H&S performance;

H1b Involvement, had a direct positive influence on contractor H&S performance;

H1c procedures, had a direct positive influence on contractor H&S performance;

H1d commitment, had a direct positive influence on contractor H&S performance;

H1e communication, had a direct positive influence on contractor H&S performance, and

H1f competence, had a direct positive influence on contractor H&S performance.

Results from the confirmatory factor analysis of the full structural model, presented in Table 5, yielded support for hypothesis $H1_c$ (procedures) and $H1_d$ (commitment) but did not support the hypothesis $H1_a$ (leadership), $H1_b$, (Involvement), $H1_e$ (communication) and $H1_f$. (competence). The relationship between the factor, procedures, and contractor H&S performance was found to be significant at the probability level of 5% ($\lambda = 0.494$, $Z = 4.407$ and $P = 0.000$). Similarly, the hypothesised relationship between the factor, commitment, and contractor H&S performance was found to be statistically significant. That relationship yielded significant parameter estimates at 5% probability level with $\lambda = 0.616$ (parameter estimate), $Z = 2.393$ and $P = 0.017$.

On the other hand, although the hypothesised relationship between the factor involvement and contractor H&S performance was significant at 5% probability level ($\lambda = -0.663$, $Z = -2.402$, $P = 0.016$), the direction was not positive definite. The result seemed to indicate that, with the increase in client H&S involvement, contractor H&S performance decreased by 0.663 units. This result was interesting, because it was expected that, with an increase in client involvement, there would be an increase in contractor performance. However, the measurement model on client H&S culture revealed high collinearity between commitment and involvement factors of client H&S culture. The high collinearity may probably explain the unreasonable parameter estimate exhibited for hypothesis $H1_b$, (involvement).

The influence of other factors, namely client leadership, communication and competence, on contractor H&S performance was found to be evident despite these relationships not being statistically significant. The parameter estimates for these relationships were found to be as follows: between the client competence factor and contractor H&S performance ($\lambda = 0.081$, $Z = 0.675$ and $P = 0.500$), leadership factor and contractor H&S performance ($\lambda = 0.204$, $Z = 1.720$, $P = 0.086$), and communication factor and contractor H&S performance ($\lambda = 0.026$, $Z = 0.212$, $P = 0.832$). Therefore, although the relationships between these client factors and contractor H&S

performance were evident, they were found to be not statistically significant and consequently meant that the postulated specific hypotheses for these relationships were not supported. However, since influence from these factors was evident, the relationship was considered to be practically significant.

Therefore, the general hypothesis H1, which postulated that client H&S culture had a direct positive influence on contractor H&S performance, could not be rejected, because two of the six specific hypotheses were found to be statistically significant and were positive. In addition, the other specific hypotheses were found to be practically significant, because the influence was evident albeit not statistically significant.

### 3.3.2 Testing the direct influence of client H&S culture on designer H&S performance

The second general hypothesis was that client H&S culture had a direct positive influence on designer H&S performance. Specifically, the hypotheses were that the factors of client H&S culture, namely:

- H2a leadership, had a direct positive influence on designer H&S performance;
- H2b involvement, had a direct positive influence on designer H&S performance;
- H2c procedures, had a direct positive influence on designer H&S performance;
- H2d commitment, had a direct positive influence on designer H&S performance;
- H2e communication, had a direct positive influence on designer H&S performance, and
- H2f competence, had a direct positive influence on designer H&S performance.

Results from the confirmatory factor analysis of the full structural model, presented in Table 5, yielded support for $H2_c$ (procedures) and $H2_e$ (communication), but did not support the hypothesis $H2_a$ (leadership), $H2_b$ (Involvement), $H2_d$ (commitment) and $H2_f$ (competence). The relationship between the procedures factor and designer H&S performance was found to be significant at 5% probability level with $\lambda = 0.439$ (factor loading), $Z = 3.009$ and $P = 0.003$. Similarly, the hypothesised relationship between the communication factor and designer H&S performance was found to be statistically significant. This relationship yielded significant estimates at the 5% probability level of λ = 0.348, *Z* = 3.346 and *P* = 0.001. The parameter estimates for the two factors of client H&S culture, namely procedures and communication, indicated that, with an increase of one unit in procedures, designer H&S performance increased by about 0.439. Similarly, an improvement of one unit in client communication caused an improvement of 0.348 in designer H&S performance.

The insignificant relationships were found to be those between the competence factor and designer H&S performance (λ = -0.196, *Z* = -1.747, *P* = 0.081), the leadership factor and designer H&S performance (λ = 0.182, *Z* = 1.618, *P* = 0.106), and the commitment factor and designer H&S performance (λ = 0.188, *Z* = 0.681, *P* = 0.496). The strength of these relationships was not statistically significant, although the findings revealed that there was evidence of relationship. In addition, the factors competence and involvement were found to have a negative relationship with designer H&S performance. This result was surprising, because it was expected that an increase in client competence and involvement would result in an increase in designer H&S performance.

Nonetheless, the general hypothesis H2, which postulated that client H&S culture had a positive direct influence on designer H&S performance, could not be rejected, because two of the six specific hypotheses were found to be statistically significant. In addition, the four other specific hypotheses were found to be practically significant, because the influence was evident albeit not statistically significant.

### 3.3.3 Testing the direct influence of contractor H&S performance on project H&S performance

Results of the SEM analysis yielded support for the hypothesis that contractor H&S performance had a direct positive influence on project H&S performance. The test statistics were found to be significantly different from zero (λ = 0.546, *Z* = 8.02, *P* = 0.000). Given these results, the hypothesis H4 could not be rejected, because contractor H&S performance had a direct positive influence on project H&S performance. The parameter estimate between contractor H&S performance and project H&S performance indicated that, for every unit improvement in contractor H&S performance, project H&S performance would improve by 0.546 units. The contractor in this case referred to upper management.

Table 5: Parameter estimates and test statistic for model 2.0

| *Hypo-thesis* | *Parameter* | *Un-standardised* | | *Standardised estimates* | | |
|---|---|---|---|---|---|---|
| | | *Estimate (λ)* | *Z-statistic* | *Estimate (λ)* | *Z-statistic* | *P value* |
| $H1_a$ | CLLP→ CONT H&S PERFORMANCE | 0.228 | 1.738 | 0.204 | 1.720 | 0.086 |
| $H1_b$ | CLIP→ CONT H&S PERFORMANCE | -0.608 | -2 348 | -0.663 | -2.402 | 0.016 |
| $H1_c$ | CLPP→ CONT H&S PERFORMANCE | 0.474 | 4.282 | 0.494 | 4.407 | 0.000 |
| $H1_d$ | CLTP→ CONT H&S PERFORMANCE | 0.618 | 2.324 | 0.616 | 2.393 | 0.017 |
| $H1_e$ | CLNP→ CONT H&S PERFORMANCE | 0.024 | 0.212 | 0.026 | 0.212 | 0.832 |
| $H1_f$ | CLCP→ CONT H&S PERFORMANCE | 0.090 | 0.675 | 0.081 | 0.675 | 0.500 |
| $H2_a$ | CLLP→ DESG H&S PERFORMANCE | 0.188 | 1.665 | 0.182 | 1.618 | 0.106 |
| $H2_b$ | CLIP→ DESG H&S PERFORMANCE | -0.132 | -0 538 | -0.155 | -0.540 | 0.589 |
| $H2_c$ | CLPP→ DESG H&S PERFORMANCE | 0.388 | 2.744 | 0.439 | 3.009 | 0.003 |
| $H2_d$ | CLTP→ DESG H&S PERFORMANCE | 0.175 | 0.674 | 0.188 | 0.681 | 0.496 |
| $H2_e$ | CLNP→ DESG H&S PERFORMANCE | 0.298 | 3.299 | 0.348 | 3.346 | 0.001 |
| $H2_f$ | CLCP→ DESG H&S PERFORMANCE | -0.202 | -1.750 | -0.196 | -1.747 | 0.081 |
| $H3_a$ | CLLP→ PROJ H&S PERFORMANCE | 0.018 | 0.270 | 0.016 | 0.270 | 0.787 |
| $H3_b$ | CLIP→ PROJ H&S PERFORMANCE | -0.137 | -0.968 | -0.158 | -0.965 | 0.334 |
| $H3_c$ | CLPP→ PROJ H&S PERFORMANCE | 0.127 | 1.359 | 0.139 | 1.371 | 0.171 |
| $H3_d$ | CLTP→ PROJ H&S PERFORMANCE | 0.219 | 1.481 | 0.231 | 1.502 | 0.133 |
| $H3_e$ | CLNP→ PROJ H&S PERFORMANCE | 0.033 | 0.442 | 0.038 | 0.445 | 0.656 |
| $H3_f$ | CLCP→ PROJ H&S PERFORMANCE | 0.095 | 1.122 | 0.090 | 1.141 | 0.254 |
| *H4* | CONT → PROJ H&S PERFORMANCE | 0.518 | 7.124 | 0.546 | 8.021 | 0.000 |
| *H5* | DESG → PROJ H&S PERFORMANCE | 0.163 | 2.636 | 0.159 | 2.582 | 0.010 |

(Robust statistical significance at 5% level)

### 3.3.4 Testing the direct influence of designer H&S performance on project H&S performance

The results from the SEM analysis yielded support for the hypothesis that designer H&S performance had a direct positive influence on project H&S performance. The test statistics were found to be significantly different from zero ($\lambda = 0.159$, $Z = 2.582$, $P = 0.010$). Therefore, the hypothesis H5 could not be rejected, given these parameter estimates. The parameter estimate between designer H&S performance and project H&S performance indicated that, for every unit improvement in designer H&S performance, project H&S performance would improve by 0.159. This coefficient was, however, lower than the desired 0.400. Nonetheless, the relationship was found to be significantly different from zero, indicating that designer H&S performance had a significant influence on project H&S performance.

### 3.3.5 Testing the direct influence of client H&S culture on project H&S performance

The general hypothesis was that client H&S culture had a direct positive influence on construction project H&S performance. Specifically, the hypotheses, which collectively formed the hypothesis H3, were that the factors of client H&S culture, namely:

- H3a leadership, had a direct positive influence on project H&S performance;
- H3b involvement, had a direct positive influence on project H&S performance;
- H3c involvement, had a direct positive influence on project H&S performance;
- H3d commitment, had a direct positive influence on project H&S performance;
- H3e communication, had a direct positive influence on project H&S performance, and
- H3f competence, had a direct positive influence on project H&S performance.

The results for these specific hypotheses, presented in Table 6, did not yield support for all hypothesised direct relationships between the factors of client H&S culture and project H&S performance. The test statistics revealed that the direct relationships between the factor leadership and project H&S performance had a parameter coefficient λ = 0.016 and the test statistic $Z = 0.270$. The probability $P$ was found to be 0.787 for this relationship. The relationship between the factor involvement and project H&S performance yielded λ = -0.158, $Z = -0.965$ and $P = 0.334$. On the other hand, parameter estimates for the relationship between the factor procedures and project H&S performance were λ = 0.139, $Z = 1.371$ and $P = 0.171$. The relationships between the factor commitment and project H&S performance (λ = 0.231, $Z = 1.502$, $P = 0.133$) and between communication and project H&S performance (λ = 0.038, $Z = 0.445$, $P = 0.656$) were also not significantly different from zero or the null hypothesis. Therefore, the general hypothesis (H3) that client H&S culture had a direct positive influence on project H&S performance was rejected.

### 3.3.6 Testing indirect influence of client H&S culture on project H&S performance

An indirect relationship is said to exist between two variables if the direct relationship between the two is completely insignificant or tends to diminish in the face of an increased indirect significance. The direct relationship between client H&S culture and project H&S performance was found to be insignificant (Table 6). However, the direct relationship between client H&S culture and contractor H&S performance was found to be significant. Similarly, the relationship between client H&S culture and designer H&S performance was also significant. In addition, the direct influences of contractor and designer H&S performance on project H&S performance were found to be significant (Table 6).

The indirect effects on project H&S performance by three factors of client H&S culture, namely involvement, procedures and commitment, mediated by contractor H&S performance, were found to be significant at 5% probability level. The standardised indirect effects of the involvement factor yielded parameter estimates λ = -0.362, $Z = -2.335$ and $P = 0.020$. As for the factor procedures, the estimates were λ = 0.270, $Z = 3.877$ and $P = 0.000$, indicating that the effect was significant. The specific standardised indirect effects of the commitment factor on project H&S performance, mediated by contractor H&S performance, yielded parameter estimates λ = 0.337, $Z = 2.303$ and $P = 0.021$. These estimates indicated a significant effect. The effects of three factors of client H&S culture, namely communication, leadership and competence, were found to be statistically insignificant when client influence on project H&S performance was mediated by contractor H&S performance (Table 6).

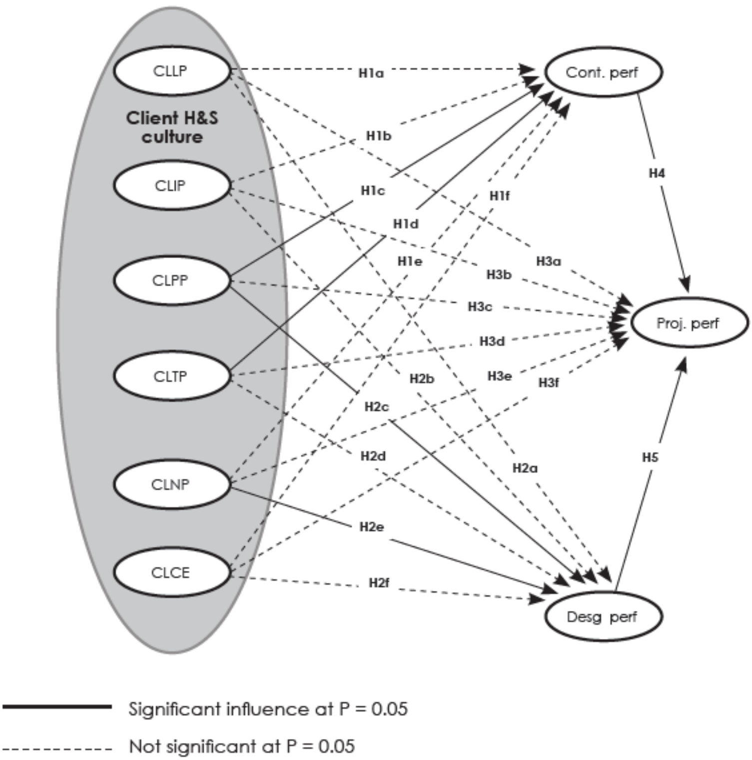



Figure 5: Influence of factors of client H&S culture

Further examination of the indirect influence of client H&S culture on project H&S performance, mediated by designers, revealed that two relationships were significant. The indirect effect of the factor communication on project H&S performance, mediated by designer H&S performance, was found to be significant. The standardised parameter estimates of the indirect relationship were $\lambda = 0.055$, $Z = 1.977$ and $P = 0.048$. The indirect effect of the procedures factor had un-standardised parameter estimates of $\lambda = 0.063$, $Z = 1.968$ and $P = 0.049$. However, the standardised estimates for the factor procedures were found to be insignificant (Table 6).

The sum of indirect effects of client H&S culture on project H&S performance revealed that two factors, namely procedures and commitment, had a statistically significant total indirect effect on project H&S performance. This indirect effect was mediated by both contractor and designer H&S performance. The standardised estimates for the total indirect effect were found to be λ = 0.340, *Z* = 4.619 and *P* = 0.000 for the procedures factor. The standardised estimates of the total indirect effect of the commitment factor were found to be λ = 0.366, Z = 2.052 and P = 0.040.

The finding on the indirect effect of client H&S culture on project H&S performance confirmed the mediatory role that contractor and designer H&S performance played in the postulated model. In addition, the findings also confirmed that, although the client H&S culture did not exhibit a direct positive influence on project H&S performance, its indirect influence on project H&S performance was significant.

Therefore, the hypothesis that client H&S culture generally had an indirect positive influence on project H&S performance, mediated by contractor and designer H&S performance, could not be rejected. Specifically, the influence of the procedures and commitment factors was found to be statistically significant at 5% probability level and the indirect influence of the other factors was found to be evident.

Table 6: Specific indirect effects of client H&S culture on project H&S performance

| *Parameter* | *Un-standardised* | | | *Standardised estimates* | | |
|---|---|---|---|---|---|---|
| | *Indirect effect (λ)* | *Z-statistic* | *P value* | *Indirect effect (λ)* | *Z-statistic* | *P value* |
| CLLP→ CONT →PROJ. H&S | 0.118 | 1.738 | 0.082 | 0.111 | 1.738 | 0.082 |
| CLIP→ CONT →PROJ. H&S | -0.315 | -2 258 | 0.024 | -0.362 | -2.335 | 0.020 |
| CLPP→ CONT →PROJ. H&S | 0.245 | 3.748 | 0.000 | 0.270 | 3 877 | 0.000 |
| CLTP→ CONT →PROJ. H&S | 0.320 | 2.216 | 0.027 | 0.337 | 2 303 | 0.021 |
| CLNP→ CONT →PROJ. H&S | 0.012 | 0.211 | 0.833 | 0.014 | 0 211 | 0.833 |
| CLCE→ CONT →PROJ. H&S | 0.047 | 0.667 | 0.505 | 0.044 | 0 667 | 0.505 |
| CLLP→ DESG →PROJ. H&S | 0.031 | 1.412 | 0.158 | 0.029 | 1.413 | 0.158 |
| CLIP→ DESG →PROJ. H&S | -0.021 | -0 533 | 0.594 | -0.025 | -0.534 | 0.593 |
| CLPP→ DESG →PROJ. H&S | 0.063 | 1.968 | 0.049 | 0.070 | 1.948 | 0.051 |
| CLTP→ DESG →PROJ. H&S | 0.028 | 0.662 | 0.508 | 0.030 | 0 665 | 0.506 |
| CLNP→ DESG →PROJ. H&S | 0.049 | 1.999 | 0.046 | 0.055 | 1.977 | 0.048 |
| CLCE→ DESG →PROJ. H&S | -0.033 | -1.488 | 0.137 | -0.031 | -1.427 | 0.153 |

## 4. Discussion

### 4.1 Influence of client H&S culture on contractor H&S performance

The findings suggested that client H&S culture had an influence on the H&S performance of the upper management of contractors. Two of the six specific hypotheses, which collectively formed the hypothesis that client H&S culture had a direct positive influence on contractor H&S performance, were found to be statistically significant. The two hypotheses related to the influence of client H&S culture, namely procedures and commitment. The indicator variables for the factor procedures were for the client to:

- have programmes to monitor and analyse H&S implementation;
- have clear project H&S goals;
- schedule H&S as a key contract prequalification criterion for all parties to be involved in a project;
- schedule H&S in all contracts;
- conduct regular H&S performance measurement;
- have their own H&S committee, and
- conduct hazard identification and risk assessments (HIRAs).

The study found the influence of the procedures factor of client H&S culture on contractor H&S performance to be statistically significant. This finding supports those of the study by Huang & Hinze (2006: 171) who observed that projects where owners or clients tracked the individual H&S performances of each contractor on their project site had significantly better H&S performances.

Although Huang & Hinze (2006: 171) only referred to one indicator variable, namely performance measurement, their study supports the current study finding that clients needed to have clear procedures if they were to influence contractor H&S performance. The indicator variables for the commitment factor were for the client to:

- demonstrate a positive H&S attitude;
- actively promote H&S;
- provide adequate resources for H&S implementation;
- put in effort to routinely evaluate H&S in all work schedules;
- set up incentives for good H&S behaviour;
- set H&S as a major agenda item in project meetings;

- actively monitor H&S programmes;
- always attend H&S meetings on the construction site;
- conduct H&S inspections and audits, and
- be involved always in accident or incident investigations.

The commitment factor of client H&S culture had a statistically significant influence on contractor H&S performance. The findings of this study support the observations made by Toellner (2001: 47), Wiegmann, Zhang, Thaden, Sharma & Mitchell (2002: 11), Mohamed (2003: 82), Ng, Cheng & Skitmore (2005: 6), Cameron & Duff (2007: 870), and Choudry, Fang & Mohamed (2009: 209) who found that management commitment was key to H&S performance and culture. To date there have been few studies on evaluating the effect of client commitment on contractor H&S performance.

The influence of leadership, involvement, communication and competence were found to be statistically insignificant. This finding was surprising, because these factors were expected to have an influence on contractor H&S performance. In addition, the Delphi panel found them to have high impact significance. However, since statistical significance can be greatly affected by the sample size and the type of population that is sampled, it would be useful to learn whether the results would be different in another study with a different sample type and size. Notwithstanding this, the influence of these factors was found to be evident and therefore practically significant.

Client involvement was found to have a negative relationship with contractor H&S performance. Client involvement was defined by the following indicator variables which required the client to:

- personally be active in critical project H&S activities;
- always be present in project H&S meetings;
- contribute to H&S training;
- actively oversee H&S on critical operations;
- constantly stay in touch on H&S issues;
- always communicate information on H&S to all parties, and
- conduct regular audits and inspections.

The study found that, if clients increased their involvement in activities that defined client involvement, the H&S performance of contractors deteriorated. However, it was realised during the study that there was a thin differentiating line between the factors involvement and commitment. The current study reported high collinearity between these two factors. The involvement factor had a correlation value higher than 0.9 with the commitment factor. Therefore, it was speculated that the unreasonable result where client involvement caused deterioration in contractor H&S performance may probably have been a result of the high collinearity between the two factors. This may, in fact, be the reason why some authors use and refer to the two factors as being one factor, namely commitment and involvement (Mohamed, 2003: 82).

The findings relative to the hypothesis that client H&S culture had a direct positive influence on contractor H&S performance entailed that the minimum that the client could do in order to significantly influence contractor H&S performance was to have procedures in place and to be committed to H&S performance.

The findings offer a minimum requirement that could be used by clients seeking to influence contractor H&S performance. A checklist of items defining the factors of procedures and commitment could ensure that clients satisfied the basic required criteria to influence contractor H&S performance.

### 4.2 Influence of client H&S culture on designer H&S performance

Client H&S culture was found to have an influence on designer H&S performance. Two of the six specific hypotheses, which collectively formed the hypothesis that client H&S culture had a direct positive influence on designer H&S performance, were found to be statistically significant. The two specific hypotheses were that the procedures and communication factors had direct positive influence on designer H&S performance.

The finding in the current study validated a proposal by Bomel (2004: 149) that designers could design for H&S with the mobilisation of client influence. It would appear that, if clients had clear programmes on H&S, it would be easier for designers to perform their H&S obligations.

The communication factor was defined by the client having to:

- have formal reporting system of incidents and accidents;
- involve all parties in planning for H&S on the project;
- involve all parties to review H&S;
- provide timely feedback on reported accidents and incidents;
- communicate risk findings to all parties on the project;
- have clearly outlined H&S roles and responsibilities;

- have clearly communicated expected performance on H&S to all, and
- provide information on H&S risk control to all parties.

The effect on designer H&S performance by the client communicating was found to be statistically significant.

The findings relative to the hypothesis that client H&S culture had a direct positive influence on designer H&S performance entailed that the minimum that the client could do in order to significantly influence designer H&S performance was to have procedures in place and to provide effective communication on H&S. However, although the influence of leadership, involvement, commitment and competence factors was not statistically significant, their influence was evident and therefore practically significant.

The findings only offer a minimum requirement that could be used by clients seeking to influence designers' H&S performance. A checklist of items defining the factors, procedures and communication, could ensure that clients satisfied the basic required criteria to influence designer H&S performance. Designer H&S performance, especially designing for H&S, was critical to the overall project H&S performance (Bomel, 2004: X).

### 4.3 Influence of client H&S culture on project H&S performance

Client H&S culture was found to have an indirect positive influence on project H&S performance. This influence was mediated by contractor and designer H&S performance. The effects on project H&S performance of procedures and commitment were found to be statistically significant. However, the direct positive influence of client H&S culture on project H&S performance was found to be statistically insignificant. None of leadership, involvement, procedures, commitment, communication and competence factors had a statistically significant direct positive influence on project H&S performance.

The study found that client H&S culture was important to project H&S performance, particularly procedures and commitment. The finding that client H&S culture had an indirect positive influence on project H&S performance validated an observation made by Bomel (2004: 102) that clients' culture offered an opportunity upon which H&S performance could be improved on construction projects. The findings also suggested that project H&S performance and improvement may not be achieved by focusing only on one party such as the contractor, or designer, or indeed the client. However, the findings seemed to suggest that the participation of all parties was critical to achieving the desired H&S performance. The influence of client H&S culture on project H&S performance was found to be an indirect one and was mediated by both designer and contractor H&S performance.

In addition, although the direct influence of designers and contractors was found to be significant, the results suggested that these two factors also needed influence from client H&S culture. In order to continuously achieve or improve project H&S performance, client H&S culture was found to be necessary.

The importance of having conducted a structural equation modelling analysis to determine the influence of client H&S culture on the contractor, designer and project H&S performance was that it was possible to identify specifically which factors of client H&S culture had a statistical significant causal effect and direction of that effect as opposed to a general blanket statement that client H&S culture had an influence on project H&S performance. With this analysis, it was easier to operationalise in terms of what the client needed to do in order to assure project H&S performance.

### 4.4 Influence of contractor and designer H&S performance on project H&S performance

Contractor H&S performance in terms of upper management had a direct positive influence on project H&S performance. This finding was consistent with the Lin & Mills (2001: 135) study which found that, when contractors scored highly in management responsibility and H&S system elements, their total H&S standards tended to be higher. The study findings highlighted the role of contractors to influence overall project H&S performance. It also highlighted that it was beneficial for H&S performance improvement to commence with the involvement and commitment of the upper management of contractors as opposed to concentrating on factors found during the construction stage only. This significance was also highlighted by Jaselkis, Anderson & Russell (1996: 69) who argued that management characteristics, H&S meetings and budget allocations improved H&S performance. These aspects had to do with upper management.

Designer H&S performance had a direct positive influence on project H&S performance. This finding was consistent with that of Behm (2006: 7) and Gambatese, Behm & Hinze. (2005: 1035) who found a link between the design and construction site injury and fatality incidents and concluded that designing for H&S was a viable intervention in the construction industry.

The current study highlighted the role of designers to influence overall project H&S performance. This finding confirmed a typical lack of understanding by some designers as to the extent of their influence on H&S performance (Gambatese, 1997: 32; Toole, 2005: 206). Therefore, the finding that designers have a significant influence on project H&S performance was noteworthy in that it provides designers with the knowledge that they had an influence on H&S performance.

For clients, who were employers of designers, designer H&S performance could constitute a checklist of activities to supervise designers to ensure project H&S performance. Similarly for designers, they could know which activities needed to be implemented or engaged with by them to ensure project H&S performance. These activities could also constitute leading indicators for all stakeholders involved in a project.

## 5. Conclusions

A model was developed based on findings from a review of literature and the Delphi study. The conceptual model postulated that client H&S culture had an influence on construction project H&S performance. The model further postulated that client H&S culture had an influence on contractor and designer H&S performance.

The postulated model was analysed using EQS version 6.1 and Mplus version 6.0 SEM software packages. The fit statistics for the measurement and structural models had an adequate fit to the sample data. The final model, presented in Figure 5, showed that client H&S culture had an influence on contractor, designer and project H&S performance. Specifically, the factors of procedures and commitment were found to have a statistically significant influence on contractor H&S performance, while the factors of procedures and communication had a statistically significant influence on designers. Client H&S culture was found to have an indirect influence on project H&S performance. This influence was mediated by contractor and designer H&S performance. Procedures and commitment had a statistically significant influence on project H&S performance.

The findings had theoretical value, because respondents were drawn from client, contractor, designer and subcontractor organisations. Respondents had working knowledge of the projects on which they were reporting. In addition, the questionnaire survey, whose results were modelled using the SEM, validated the conceptual model developed from synthesised theories established from literature and, more importantly, from the Delphi study. The current study was supported by other studies that had used other research methods on the influence of clients on project H&S performance. However, the current study utilised a robust modelling method of SEM to specifically identify client H&S factors with significant influence.

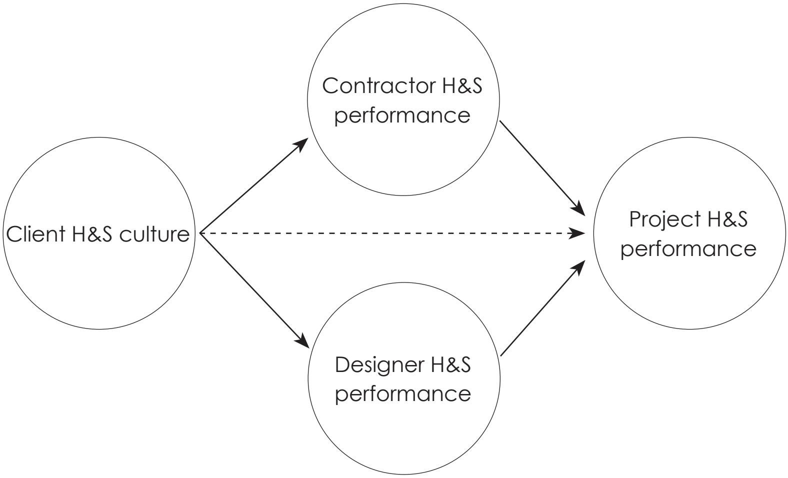



Figure 6: Final model of client influence on project H&S performance

The study found that better project H&S performance was possible when the factors of client H&S culture were evident. The influence of client H&S culture assured contractor, designer and project H&S performance. It would seem that project H&S performance would be assured by ensuring that the client H&S culture remained positive and that all the factors of client H&S were evident.

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