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Infrastructure project performance in the South African construction sector: Perceptions from two provinces

Peer reviewed

Abstract

In recent times, project performance improvement, especially in developing countries, has captured the interest of a number of construction management researchers, as indicated in notable journals and conferences in the domain. The quest for excellence, waste elimination, and value creation underpins such research endeavours that encompass the interest of clients, consultants, and contractors so that cost overruns, low productivity, and poor quality can be reduced in the industry. The driving force behind this discourse is the need to examine management strategies that could engender performance improvement in infrastructure construction from the South African perspective. The survey was conducted among general contractor (GC) members of the South African Federation of Civil Engineering Contractors (SAFCEC), consulting engineer members of Consulting Engineers South Africa (CESA), and selected public sector clients. Using inferential statistics such as Cronbach's *alpha*, *t* test and Cohen's *d* effect size measures for data analysis led to a range of findings. Such findings show that inadequate coordination between project partners may indeed result in high levels of defects, rework, and non-conformances in construction; poor interface between multidisciplinary designers could lead to delays in projects, and inefficient and unstable logistics management may, in fact, lead to haphazard processing of orders, storage of materials, and poor inventory management. In essence, it can be argued that being quality focused, managing construction logistics optimally and making sure that consultants who are working on a project are collaborating effectively offers significant scope for performance improvement in the construction of infrastructure projects in South Africa.

Keywords: Construction, infrastructure, project performance, South Africa

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Abstrak

Deesdae, stel 'n hele aantal konstruksiebestuurnavorsers belang in projekbestuurverbetering veral in ontwikkelende lande soos aangedui in noemenswaardige tydskrifte en konferensies in hierdie domein. Die soeke na uitnemendheid, afvaleliminaise, en die skep van waarde vorm die grondslag van sodanige pogings sodat kosteoorskryding, lae produktiwiteit en swak gehalte in die bedryf verminder kan word. Die dryfkrag agter hierdie diskoers is die behoefte om bestuursstrategieë wat prestasieverbetering in infrastruktuurkonstruksie kweek vanuit 'n Suid-Afrikaanse perspektief te ondersoek. Die opname is gedoen onder algemene kontrakteur (GC) lede van die Suid-Afrikaanse Federasie van Siviele Ingenieurskontrakteurs (SAFCEC), raadgewende ingenieurslede van Raadgewende Ingenieurs Suid-Afrika (CESA), en geselekteerde openbare sektor-kliënte. Die gebruik van inferensiële statistiek soos Cronbach se *alfa*-, *t*-toets en Cohen se *d* effekgrootte vir data-analise, het gelei tot die bevindinge. Sodanige bevindinge toon dat onvoldoende koördinasie tussen die projekvennote kan lei tot hoë vlakke van defekte, take oordoen, en nie-ooreenkoms in konstruksie; swak interaksie tussen multidissiplinêre ontwerpers kan lei tot vertragings in die projekte, en ondoeltreffend en onstabiel logistieke bestuur kan eintlik lei tot lukraak verwerking van bestellings, die berging van materiale, en swak voorraadbestuur. In wese kan daar aangevoer word dat om gefokus te wees op kwaliteit, konstruksie-logistieke optimaal te bestuur, en seker te maak dat konsultante wat aan 'n projek werk effektief saamwerk, bied 'n merkwaardige omvang vir die verbetering van prestasie in die bou van infrakstruktuurprojekte in Suid-Afrika.

Sleutelwoorde: Konstruksie, infrastruktuur, projekprestasie, Suid-Afrika

1. Introduction

It is widely recognised that time and cost overruns plague projects in the construction industry so much so that strategies for improving performance have been propagated. For example, Love, Edwards & Irani (2008: 244) proposed a model that encourages firms to embrace inter-organisational collaboration and learning so that the menace of design-induced rework can be eliminated in projects. They contend that firms should re-examine their work practices and methods in order to reduce rework and improve project performance.

Rework and defects are not the only major issue in construction in terms of performance, as most construction industry indicators (CII) in South Africa have recently called for drastic improvement relative to quality, client satisfaction, payment to contractors and profitability (Emuze & Smallwood, 2011a: 111).

In particular, selected GCs in the Eastern Cape perceive that the extent and frequency of rework in South African construction can be considered to be average, while the top three causes of rework include unclear design information, poor supervision, and poor site management (Emuze & Smallwood, 2011b: 106). In fact, it can be argued that, in South Africa, performance-related issues do exist in construction. Based on this observation, it was decided to seek remedies that could improve the situation. While a number of management interventions rooted in lean construction, supply chain management and system dynamics were explored in the empirical study, interventions rooted in general management formed the basis of this discourse.

The research objectives include:

- The assessment of performance improvement management strategies, and
- The recommendation of robust ways in which these management strategies can be used in order to improve the construction of infrastructure projects in South Africa.

In an attempt to realise these objectives, eight hypotheses related to management strategies that are being propagated in the construction management research (CMR) domain were postulated (Emuze, 2012: 11-13, 17-55). The hypotheses pertaining to this article include:

1. Unacceptable coordination and regard for health and safety (H&S) upstream and downstream of the construction supply chain may indeed result in recurrent accidents, injuries, and ill-health on construction site.
2. Inadequate coordination and integration of quality standard requirements within the supply chain may result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.
3. Poor interface between multidisciplinary design advisors/ consultants leads to delay and rework relative to construction activities.
4. Inefficient and unstable logistics management leads to haphazard processing of orders, storage of materials, and poor inventory management.

2. Management strategies

In order to take effective management actions/decisions, actions should be analysed at both the strategic and operational levels, as effectiveness is mainly dependent on how well the strategic perspective and operational details of a project are not mismatched (Pena-Mora, Han, Lee & Park, 2008: 701). In other words, a mismatch between strategic and operational analysis is one of the major reasons for poor performance in construction (Pena-Mora *et al*., 2008: 701). Based on this assumption, the study examined management strategies such as health and safety (H&S), quality management, collaboration among designers, and logistics management that entail perspectives in both the strategic and operational management of projects.

2.1 Management of H&S

The 2003 Construction Regulations provide a legislative platform for addressing H&S in South Africa, and have implications for all stakeholders involved in construction. The philosophy behind the regulations is to inculcate optimum H&S practices among clients, consultants in the form of designers and project managers, contractors, subcontractors, suppliers, and other stakeholders in the construction process. This implies that all the participants in a project undertaking are responsible for on-site and off-site construction H&S. Therefore, the coordination, respect for, and implementation of H&S are significant elements of the construction process. However, the recently published construction H&S status report in South Africa indicates, *inter-alia*, that (CIDB, 2009: 9):

- The fatality rate in the construction industry is approximately 20 per 100.000 workers, or approximately 150 fatalities per year, excluding construction-related motor vehicle accidents.
- There is a high rate of non-compliance with the requirements of the Construction Regulations manifested in approximately 50% of construction sites found to be non-compliant during the August 2007 'construction blitz inspections'.
- H&S in the construction industry in South Africa lags significantly behind that in developed countries.
- The construction industry currently has the third highest prevalence of HIV-positive workers, and the industry faces increasing lost workdays due to absenteeism and productivity decreases, coupled with skills shortages and increased costs of construction, due to rising overheads.
- The cost of accidents (CoA) is estimated to be approximately 5% of the value of construction costs, which ultimately are passed onto clients.
- Inadequate or lack of H&S negatively affects other project parameters such as productivity, quality, and cost.
- The total CoA exceeds the cost of H&S and, therefore, H&S is in essence a profit centre.

The above findings from the CIDB report attest to the suboptimal performance of construction H&S in South Africa and underscore the persistent call for improvement.

2.2 Management of quality

The CIDB report entitled *Construction quality in South Africa: A client perspective* revealed that public-sector clients are neutral or dissatisfied with the quality of construction on approximately 20% of all projects. Approximately 12% of the projects surveyed had levels of defects considered to be inappropriate (CIDB, 2011: 1-7). The report noted that client dissatisfaction with the quality of completed works on approximately 2% of the projects surveyed in 2009 translates to dissatisfaction on completed work in the public sector to a value of approximately R3.5 billion per year.

The report then postulated that the majority of those cases in which clients were not satisfied with construction quality could probably be attributed mainly to procurement-related barriers, including fraud and corruption in the appointment of contractors who were not capable of undertaking the required works (CIDB, 2011: 32). It further postulates that the majority of those cases in which clients are neither satisfied nor dissatisfied with construction quality could probably be attributed chiefly to design- or construction-related barriers, or to barriers in the role of the client's agent not ensuring quality. In terms of construction-related barriers to quality, the report indicates that key barriers to quality include poor site management; focus on time and cost; skills and competence issues; lack of quality improvement processes, and lack of worker participation in quality circles and quality improvement teams (CIDB, 2011: 31). Clearly, the report amplifies the argument that the achievement of optimum quality in South African construction is confronted with a range of barriers.

2.3 Management of the interface between designers

Information that is classified as a key resource in the construction process gives supply chain members unique advantages in decision-making (Ugwu, Anumba & Thorpe, 2005: 102). However, presently delays, rework, and errors occur, because most construction tasks and projects are not only geographically dispersed, but the exchange of information is also slow and unreliable. It is notable that, despite the advantages of information and communication technology (ICT), the use of paper as a form of communication is still the main medium of information transfer and sharing within the industry.

This medium of communication exposes an organisation and the entire supply chain to errors, because it is extremely difficult for clients and contractors to obtain up-to-date information and virtually impossible to resolve processes such as requests for information (RFIs) within the required time (Sommerville & Craig, 2006: 89). During times of uncertainty and crisis, previous research indicates that communication breakdown often occurs between project team members (Emmitt & Gorse, 2003: 10). Therefore, it can be argued that communication breakdowns, which can either be minor or major, portend negative consequences for projects.

2.4 Management of construction logistics

In general, construction logistics can be divided into supply logistics and site logistics. Supply logistics are related to cyclic activities in the production process such as the specification of supply resources such as materials, equipment, and labour, supply planning, acquisition of resources, transport to a site, and delivery and storage control. Site logistics are related to the physical flow of on-site processes such as the management of handling systems, H&S equipment, site layout, defining activity sequence, and resolving conflicts among various production teams related to the on-site activities (Jang, Russell & Yi, 2003: 1 134).

The importance of construction logistics to project managers in the industry cannot be overemphasised. The work of Jang *et al*. (2003: 1-141) demonstrates this importance, when they report that key construction material logistics factors such as personnel, material flow, schedule adherence, contractors' organisations, and information flow have significant relationships between the construction logistics process and satisfaction of project managers. However, the situation in the South African construction industry relative to logistics and its management is in need of improvement. In particular, based upon multi-case study research conducted in Cape Town, Shakantu, Tookey, Muya & Bowen (2007: 437) point out that the logistics of building materials in terms of construction and demolition (C&D) waste are not integrated and that the movements for both material delivery and C&D waste are suboptimal. They contend that integration of incongruent logistics would not only provide scope for utilisation of spare capacity, but also improve logistics in the industry.

3. The research

The descriptive survey method was employed to process the data obtained through observation. Leedy & Ormond (2005: 179) suggest that this type of research involves either identifying the characteristics of an observed phenomenon or exploring possible correlations among two or more phenomena. The survey was designed with closed-ended questions and one open-ended question so that respondents could identify performance impediments and their effects based on the literature reviewed, and offer general comments. The questions related to the previously mentioned hypotheses pertain to how the operations inherent in the physical transformation/conversion processes that occur on site can be improved. On-site processes in construction are often diligently managed in order to enhance performance concerning H&S, quality, logistics and so on. Thus, it can be argued that the improvement of the operational dynamics, as opposed to the strategic project requirements of a construction undertaking, significantly motivated the questions that were compiled for the study.

Respondents were able to identify performance impediments, using a five-point scale: (1) Minor extent; (2) Near minor extent; (3) Some extent; (4) Near major extent; (5) Major extent. In order to score the effects of the impediments, respondents were provided with a five-point scale: (1) Totally disagree; (2) Disagree; (3) Neutral; (4) Agree; (5) Totally agree. In all instances in which the Likert-scale type question was used, an 'unsure' option was provided for the respondents.

One hundred and fifty-four (154) clients, consultants and general contracting organisations that are active in the South African infrastructure sector constituted the sample size. The respondents were mainly sourced from the Eastern and Western Cape provinces. After the survey period that spanned eleven weeks, only fifty-four (54) validly completed questionnaires were returned and included in the analysis of the data, which equates to a response rate of 35.1% (Table 1).

Table 1: Survey response rate

Respondent group	*Sample size (No.)*	*Response (No.)*	*Response rate (%)*
Public sector clients	42	11	26.2
Members of SAFCEC	56	15	26.8
Members of CESA	56	28	50.0
Total	154	54	35.1

4. Interpretation of the results

Inferential statistics related to the hypotheses include Cronbach's *alpha* internal reliability test, average inter-item correlation, and the test of means against a reference constant. Cronbach's *alpha* is used for combining items in Likert-type scales that use each individual item to measure an observable fact that has an original quantitative measurement range (Gliem & Gliem, 2003: 82).

Although there is no lower limit to the coefficient, Cronbach's *alpha* reliability coefficient normally ranges between 0.0 and 1.0 (Gliem & Gliem, 2003: 87). The closer Cronbach's *alpha* is to 1.0, the greater the internal consistency of the items in the scale, that is, the higher the *alpha* coefficient, the more reliable the test (Yu, 2001: 3; Gliem & Gliem, 2003: 87). To be succinct, George & Mallery (2003: 231) provide the following rules of thumb: > .9 - Excellent; > .8 - Good; > .7 - Acceptable; > .6 - Questionable; > .5 - Poor, and < .5 - Unacceptable for interpreting Cronbach's *alpha* coefficients.

In addition, a statistical significance test only means that the probability of rejecting the null hypothesis when it is true is very small (less than 0.05), without providing information about the size and practical importance of the difference or relationship between variables despite the fact that Cohen (1990, cited in LeCroy & Krysik, 2007: 243) argues that the main product of a research inquiry is one of measures of effect size as opposed to measures of *p* values. This realisation led to the inclusion of effect size measures in the analysis.

LeCroy & Krysik (2007: 243) argue that measures of effect size provide vitally different information from *alpha* levels, as they address the practical importance of the results through the assessment of the size of the effect. In other words, one reason to use effect size measures is that they provide a platform whereby the practical importance of research findings can be considered apart from the statistical significance (LeCroy & Krysik, 2007: 243; Meline & Wang, 2004: 204). Therefore, reliability tables and test of means against a reference constant table are provided to support the test of each hypothesis in this study. Although there are other effect size measures, the Cohen's *d* was used. According to LeCroy & Krysik (2007: 245) and Meline & Wang (2004: 205), Cohen's *d* is the most prevalent method used for reporting effect sizes and interpreting their value range between small effect size (≤ 0.35), medium effect size (≤ 0.65), and large effect size (> 0.65). In brief, in terms of this particular study:

The null hypothesis is H_0: $p = 3$, and

The alternative hypothesis is H_1: $p > 3$.

5. The results

5.1 Hypothesis 1

Table 2 shows that the individual mean scores of the variables relative to unacceptable coordination and regard for H&S can be safely combined into a single mean with an excellent internal reliability of 0.91, and the variables can also be deemed to be properly correlated with average inter-item correlation of 0.68.

Table 2: Reliability for unacceptable coordination and regard for H&S (Q6)

Practices	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Inadequate knowledge relative to nature of work	51	3.76	1.1	1
H&S competence of project participants	52	3.60	1.2	2
Collective organisation values relative to H&S	49	3.43	1.3	3
H&S management procedures/systems	52	3.35	1.4	4
Poor comprehension of project characteristics	49	3.27	1.2	5
Cronbach's *alpha*: 0.91				
Average inter-item correlation: 0.68				

Table 3 shows that the individual MSs of the variables relative to the effect of unacceptable coordination and regard for H&S can be safely combined into a single mean with an excellent internal reliability of 0.93, and the variables can also be deemed to be properly correlated with average inter-tem correlation of 0.76.

Table 3: Reliability for effect of unacceptable coordination and regard for H&S (Q7)

Situations	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Ineffective H&S monitoring and inspection	52	3.40	1.4	1
Poor status of H&S within the construction process	52	3.27	1.5	2
Work stoppages, injuries, and fatalities	52	3.23	1.5	3
Lack of project-specific H&S specification	52	3.13	1.3	4
Lack of project-specific H&S plan	52	3.10	1.3	5
Cronbach's *alpha*: 0.93				
Average inter-item correlation: 0.76				

Therefore, based on the statistics in Table 4, it can be assumed that for hypothesis 1:

- In terms of Q6, the mean is significantly greater than the reference constant; hence, H_0 can be deemed rejected, while H_1 can be deemed accepted, and
- In terms of Q7, the mean is not significantly greater than the reference constant; hence, H_0 cannot be deemed rejected, and H_1 cannot be deemed accepted.

It is equally notable that, while the results for Q6 have medium effect size measures with Cohen's *d* value of 0.48, the results for Q7 have small effect size measures with Cohen's *d* value of 0.19. In other words, the results relative to hypothesis 1 are of medium and small practical importance. Specifically, results for Q6 indicate that it is statistically significant and practically important, while those for Q7 indicate that it is statistically non-significant and of little practical importance. Therefore, in practical terms:

H_0 = Unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain does not result in recurrent accidents, injuries, and ill-health on construction site.

H_1 = Unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain may indeed result in recurrent accidents, injuries, and ill-health on construction site.

Consequently, Table 4 shows that unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain may or may not result in recurrent accidents, injuries, and ill-health on construction sites. There may be other contributing factors to the occurrence of poor H&S on construction sites. Nevertheless, Q6 suggests that unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain may indeed result in recurrent accidents, injuries, and accidents, while Q7 can be deemed to suggest that the results are not conclusive.

Table 4: Test of means against reference constant relative to hypothesis 1

Question	*Mean*	*Std. Dv.*	*Number*	*RC*	*t-value*	*df*	*p-value*	*Cohen's d*	
Q6_ave	3.49	1.02	52	3	3.46	51	0.00110	0.48	M
Q7_ave	3.23	1.23	53	3	1.37	52	0.17697	0.19	S

5.2 Hypothesis 2

Table 5 shows that the individual MSs of the variables relative to inadequate management of quality can be safely combined into a single mean with a good reliability of 0.84, and the variables can also be deemed to be properly correlated with average inter-item correlation of 0.53.

Table 5: Reliability for inadequate management of quality (Q8)

Practices/Situations	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Poor work procedures/methods	54	3.89	1.1	1
Poor understanding of quality	54	3.85	1.3	2
Poor project specifications	54	3.65	1.3	3
Poor exchange of project information	54	3.52	1.2	4
Poor project cost and schedule data	53	3.42	1.2	5
Cronbach's *alpha*: 0.84				
Average inter-item correlation: 0.53				

Table 6 shows that the individual MSs of the variables relative to the effect of inadequate management of quality can be safely combined into a single mean with a good internal reliability of 0.89, and the variables can also be deemed to be properly correlated with average inter-item correlation of 0.64.

Table 6: Reliability for effect of inadequate management of quality (Q9)

Situations	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Defects and rework	54	4.06	1.1	1
Increased project duration and cost	52	3.85	1.1	2
Client dissatisfaction	53	3.83	1.3	3
High built asset maintenance cost	51	3.31	1.3	4
Injuries and fatalities	53	2.89	1.2	5
Cronbach's *alpha*: 0.89				
Average inter-item correlation: 0.64				

Therefore, based on the statistics in Table 7, it can be assumed that for hypothesis 2:

- In terms of Q8, the mean is significantly greater than the reference constant; hence, H_0 can be deemed rejected, while H_1 can be deemed accepted, and
- In terms of Q9, the mean is significantly greater than the reference constant; hence, H_0 can be deemed rejected, while H_1 can be deemed accepted.

It is equally notable that the results for Q8 have large effect size with Cohen's *d* value of 0.73, while those for Q9 have medium effect size measures with Cohen's *d* value of 0.60. In other words, the results relative to hypothesis 2 are of large and medium practical importance. Thus, in practical terms:

H_0 = Inadequate coordination and integration of quality standard requirements within the supply chain does not result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.

H_1 = Inadequate coordination and integration of quality standard requirements within the supply chain may result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.

Consequently, Table 7 shows that inadequate coordination and integration of quality standard requirements within the supply chain may indeed result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion.

Table 7: Test of means against reference constant relative to hypothesis 2

Question	*Mean*	*Std. Dv.*	*Number*	*RC*	*t-value*	*df*	*p-value*	*Cohen's d*	
Q8_ave	3.67	0.92	54	3	5.33	53	0.00000	0.73	L
Q9_ave	3.59	0.99	54	3	4.40	53	0.00005	0.60	M

5.3 Hypothesis 3

Table 8 shows that the individual MSs of the variables relative to poor multidisciplinary interface between consultants can be safely combined into a single mean with a questionable internal reliability of 0.65, and the variables can also be deemed correlated with average inter-item correlation of 0.28.

Table 8: Reliability for poor multidisciplinary interface between consultants (Q13)

Practices	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Unequal design expertise	11	4.00	0.6	1
Change in personnel during the project duration	13	3.77	0.7	2
Behavioural tendencies within project teams	13	3.77	0.8	3
Commitment to different project objectives	11	3.73	0.9	4
Paper transmission of project information	12	3.33	1.0	5
Cronbach's *alpha*: 0.65				
Average inter-item correlation: 0.28				

Table 9 shows that the individual MSs of the variables relative to the effect of poor multidisciplinary interface between consultants can be safely combined into a single mean with a good internal reliability of 0.82, and the variables can also be deemed to be properly correlated with average inter-item correlation of 0.54.

Table 9: Reliability for effect of poor multidisciplinary interface between consultants (Q14)

Practices	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Delay and rework on site	13	4.38	0.8	1
Unclear design and specification	13	4.38	0.8	2
Extensive revisions of design	13	4.38	0.8	3
Constant RFIs from site management	12	4.17	0.8	4
Costly design changes	12	4.08	1.0	5
Cronbach's *alpha*: 0.82				
Average inter-item correlation: 0.54				

Therefore, based on the statistics in Table 10, it can be assumed that for hypothesis 3:

- In terms of Q13, the mean is significantly greater than the reference constant; hence, H_0 can be deemed rejected, while H_1 can be deemed accepted, and
- In terms of Q14, the mean is significantly greater than the reference constant; hence, H_0 can be deemed rejected, while H_1 can be deemed accepted.

It is equally notable that the results for Q13 and Q14 have large effect size measures with Cohen's *d* value of 1.41 and 2.14, respectively. In other words, the results relative to hypothesis 3 are of large practical importance. Therefore, in practical terms:

H_0 = Poor interface between multidisciplinary design advisors/ consultants does not lead to delay and rework relative to construction activities.

H_1 = Poor interface between multidisciplinary design advisors/ consultants leads to delay and rework relative to construction activities.

Consequently, Table 10 shows that poor interface between multidisciplinary design advisors/consultants leads to delay and rework relative to construction activities in South African construction.

Table 10: Test of means against reference constant relative to hypothesis 3

Question	*Mean*	*Std. Dv.*	*Number*	*RC*	*t-value*	*df*	*p-value*	*Cohen's d*	
Q13_ave	3.72	0.51	13	3	5.08	12	0.00027	1.41	L
Q14_ave	4.28	0.60	13	3	7.72	12	0.00001	2.14	L

5.4 Hypothesis 4

Table 11 shows that the individual MSs of the variables relative to inadequate management of logistics can be safely combined into a single mean with an acceptable internal reliability of 0.77, and the variables can also be deemed correlated with average inter-item correlation of 0.39.

Table 11: Reliability for inadequate management of logistics (Q15)

Practices	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Lack of site management competence relative to logistics	13	4.46	0.8	1
Lack of formal training relative to logistics	13	4.00	0.9	2
Poor site material flow management	14	3.93	0.7	3
Poor work schedule control	14	3.86	0.7	4
Poor material supply, storage, and handling	14	3.50	0.8	5
Poor infrastructure and equipment location	14	3.50	1.3	6
Poor site layout	14	2.79	1.2	7
Cronbach's *alpha*: 0.77				
Average inter-item correlation: 0.39				

Table 12 shows that the individual MSs of the variables relative to the effect of inadequate management of logistics can be safely combined into a single mean with a good internal reliability of 0.83, and the variables can also be deemed correlated with average inter-item correlation of 0.42.

Table 12: Reliability for effect of inadequate management of logistics (Q16)

Situations	*Valid N*	*MS*	*Std. Dv.*	*Rank*
Poor quality and time management	14	4.43	0.6	1
Added cost in the project	14	4.29	0.9	2
Under-utilisation of construction vehicles	14	4.14	0.8	3
Material loss due to defects and theft	14	4.07	0.9	4
High level of construction waste on site	14	4.07	1.1	5
Added risks relative to H&S	14	3.64	1.1	6
Poor image of the industry in terms of climate change	11	3.45	1.1	7
Long material offloading time on site	14	3.29	1.2	8
Cronbach's *alpha*: 0.83				
Average inter-item correlation: 0.42				

Therefore, based on the statistics in Table 13, it can be assumed that for hypothesis 4:

- In terms of Q15, the mean is significantly greater than the reference constant; hence, H_0 can be deemed rejected, while H_1 can be deemed accepted, and
- In terms of Q16, the mean is significantly greater than the reference constant; hence, H_0 can be deemed rejected, while H_1 can be deemed accepted.

It is notable that the results for Q15 and Q16 have large effect size measures with Cohen's *d* value of 1.10 and 1.51, respectively. In other words, the results relative to hypothesis 4 are of large practical importance. Therefore, in practical terms:

H_0 = Inefficient and unstable logistics management does not lead to haphazard processing of orders, storage of materials, and poor inventory management.

H_1 = Inefficient and unstable logistics management leads to haphazard processing of orders, storage of materials, and poor inventory management.

As a result, Table 13 shows that inefficient and unstable logistics management may, in fact, lead to haphazard processing of orders, storage of materials, and poor inventory management.

Table 13: Test of means against reference constant relative to hypothesis 6

Question	*Mean*	*Std. Dv.*	*Number*	*RC*	*t-value*	*df*	*p-value*	*Cohen's d*	
Q15_ave	3.69	0.63	14	3	4.10	13	0.00126	1.10	L
Q16_ave	3.99	0.66	14	3	5.64	13	0.00008	1.51	L

6. Discussion and conclusions

As indicated in Table 4, the findings relative to hypothesis 1 are inconclusive. Particularly, the findings indicate that unacceptable coordination and regard for H&S upstream and downstream of the construction supply chain may or may not necessarily result in recurrent accidents, injuries, and ill-health on sites, due to other contributing factors that were not considered in the study. However, practices such as inadequate knowledge relative to nature of work, H&S competence of project participants and collective organisational values relative to H&S contributing to unacceptable coordination and regard for H&S support the hypothesis. Nevertheless, it is important to address H&S-related issues as H&S performance in South African construction can still be improved.

In terms of hypothesis 2, the findings show that inadequate coordination and integration of quality standard requirements within the supply chain may indeed result in an unusually high level of defects, rework, and non-conformance relative to quality at construction project completion. This is supported by the results such as poor work procedures/methods; poor understanding of quality; poor project specifications; poor exchange of project information, and poor project cost and schedule data, which can be deemed to be practices contributing to inadequate management of quality in South African construction. Based on these practices and other related factors, defects and rework, increased project duration and cost, and client dissatisfaction may eventuate. Therefore, it is imperative to address the management of quality in South African construction.

The results indicate that poor interface between multidisciplinary design advisors/consultants leads to delay and rework in construction.

The importance of hypothesis 3 cannot be overemphasised, as the construction management literature is inundated with publications linking design with the occurrence of rework in construction. The hypothesis is further supported by the findings presented in Tables 8 and 9. In particular, practices such as disparity in design expertise, change in personnel during the project duration, behavioural tendencies within project teams, and commitment to different project objectives must be addressed. In addition, consequences of poor multidisciplinary interface between consultants such as delays and rework on site, unclear design and specification, extensive revisions of design, constant RFIs from site management, and costly design changes strengthen the need to improve the interface between consultants involved in projects.

Findings emanating from the study indicate that logistics management-related issues could be problematic in South African construction. The statistical test relative to hypothesis 4 is not only significant, but its effect size can also be deemed large in terms of practical importance. In addition, practices such as lack of site management competence relative to logistics, lack of formal training relative to logistics, poor site material flow management, poor work schedule control, poor infrastructure and equipment location, and poor material supply, storage, and handling can be deemed to contribute to inadequate management of logistics in South African construction. In addition, consequences of inadequate management of logistics such as poor quality and time management, added cost in the project, under-utilisation of construction vehicles, material loss due to defects and theft, high level of construction waste on site, and added risks relative to H&S support the argument that inefficient and unstable logistics management may, in fact, lead to haphazard processing of orders, storage of materials, and poor inventory management in construction.

7. Recommendations

With respect to H&S (hypothesis 1), although the hypothesis result can be deemed inconclusive, the findings in the literature suggest that efforts devoted to H&S improvement are not wasted (see CIDB, 2009: 37-40). In particular, it is recommended that project stakeholders should collectively value H&S and regard a minor H&S oversight by any party as having the potential to lead to accidents, and even fatalities.

Findings relative to quality suggest that, in order to prevent defects, rework, increased project duration and cost, as well as client dissatisfaction from marginalising projects, it is important to address problematic areas such as poor work procedures/methods and poor understanding of quality in South African construction (hypothesis 2). It is thus recommended that project stakeholders should adopt principles of total quality management (TQM), and ensure that standard work procedures/methods are used in construction. In addition, it is important that all employees in an organisation should understand quality; that project specifications should be produced without mistakes, and that information exchange between project partners should be correct, adequate, timely and consistent.

According to the results, it is imperative to address the poor interface between designers involved in the realisation of a project. The interface should be examined and improved upon so as to prevent delays and rework on construction sites, unclear design and specifications, extensive revisions of design, constant RFIs emanating from site, and costly design changes. It is further suggested that consistent design expertise among designers, avoidance of changes in personnel during project execution, elimination of negative behavioural tendencies among project teams, and the alignment of project objectives offer improvement opportunities with respect to the interface between consultants (hypothesis 3).

In addition, in order to halt the consequences of poor logistics management such as poor quality and time management, it is imperative to address a number of practices that perpetrate inadequate management of logistics in South Africa. For instance, it is vital that site management should be competent in terms of logistics. They should undergo some form of logistics-related training so as to ensure adequate management of the flow of material on site (hypothesis 4).

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