UNCOVERING THE ORIGINS OF VARIATION ORDERS

Ndihokubwayo R[1], Haupt TC[2]

[1] MTech Research Scholar, Faculty of Engineering, Department of Built Environment, Southern Africa Built Environment Research Center, Cape Peninsula University of Technology, ndihokubwayo2000@yahoo.com, Tel No. +27 21 959 6317/6637, Mobile +27 73 721 5859

[2] Research Coordinator, Southern Africa Built Environment Research Center, Faculty of Engineering, Cape Peninsula University of Technology, Tel No. +27 21 959 6845/6637, Mobile +27 82 492 9680

ABSTRACT

Purpose of this paper - This paper attempts to identify the origin of variation orders in order to determine their impact on waste. The study is part of the undergoing research analyzing the impact of variation orders on project performance.

Methodology/Scope - Extensive relevant literature review has been provided. A case study was done on two completed apartment complexes in Cape Town. Origin agents of variation orders were identified.

Findings - An exploratory study was done on residential and shopping apartment complexes. Both projects incurred delays and time for completion escalated at 33% and 9% over the original completion time on both respective projects A and B. Arguably, numerous changes during the construction stage influenced time overruns. On project A, a contractor incurred a penalty of R923,000 amounting at 3% of the original contract sum R28,315,000. A total number of 75 and 118 variation orders averaging 8% (R2,076,600) and 4% (R 2,032,919) of the contract sum occurred on both projects. On both projects, the client and consultant combined were the predominant origin agents of variation orders. On project A, the client and the consultant combined generated 89% (67 no) of variation orders. In monetary terms these corresponded to 93% (R1,928,741) of the net total sum. On project B, the client and the consultant combined generated variation orders 95% (111 no) of variation orders. In monetary terms these corresponded 92% (R1,865,862) of the net total sum.

Research limitations - The study was confined to a limited number of apartment-type construction projects. The predominant origin agent should be further investigated.

Practical implications - The findings uncovered the waste associated with variation orders and revealed the predominant source of variation orders as a proactive measure to reduce them.

Value - This paper explores the impact of variation orders on project performance.

Keywords: Origin agents, Variation Orders, Waste.

1. INTRODUCTION

A construction contract is a business agreement that is subject to variability. Contractual clauses relating to changes allow parties involved in the contract to freely initiate variation orders within the ambit of the scope of the works without alteration of the original contract. Variation orders involve additions, omissions, alterations and substitutions in terms of quality, quantity and schedule of works. Without contractual clauses, the building contractor would have to agree to erect without any change the building shown on the drawings and represented in the bills for a contract sum. Ssegawa et al (2002:89) argued that the spirit in which variation orders are permitted allows the

contract to proceed without compiling another contract to cater for the changes. Most contracts make provisions for possible variations given the nature of building construction (Finsen 1999:109; Wainwright & Wood 1983:11). A degree of change should be expected since it is difficult for clients to visualize the end product they procure (Love 2002:19). Unforeseen conditions[1] may arise which require measures that have not been provided for in the contract (Finsen 1999:109).

However, the disadvantage of the variation clause is that architects tend not to crystallize their intentions on paper before the contract is signed because they know the variation clause will permit them to finalise their intentions during the term of the contract (Wainwright & Wood 1983:11). An unfortunate aspect of the variation clause is that it tends to encourage clients to change their minds and embark on building projects without having properly thought through their project requirements (Finsen 1999:109). Traditionally, the client's *prima* perceived requirements include functionality, durability and optimality. In order to achieve these requirements, clients hire consultant teams to advise them on design and optimum use of resources. On the other hand, contractors concern themselves predominantly with construction costs and their reduction. Little recognition is given to the fact that the clients or their agents may be sources of higher construction costs. Clients and consultants typically forget that issuing numerous variation orders result in higher construction costs. For example, a client who targets a completion date may want works to start on site while the design is still at a sketchy stage. In some cases, the construction works may overlap the design where the contractor will have to wait for the detailed design. As a result, some works are put on hold and others are subject to abortion or demolition. Arguably, the costs for aborted works are wastage of resources and are typically transferred to the client. They contribute to higher construction delivery costs. The construction industry does not grasp that the reduction of the occurrence of variation orders may optimally lower construction delivery costs. Ibbs (1997:308) concluded that the greater the amount of change the greater the negative impact on both productivity and cost.

2. NATURE OF VARIATION ORDERS

The nature of a variation order can be determined by referring to both the reasons for their occurrence and subsequent effects. (Arain & Pheng 2005:498) distinguished two types of variation orders, namely: beneficial and detrimental variation orders.

2.1 Beneficial variation orders

A beneficial variation order is one issued to improve the quality standard, reduce cost, schedule, or degree of difficulty in a project (Arain & Pheng 2005:498). It is a variation order initiated for value analysis purposes to realize a balance between the cost, functionality and durability aspects of a project to the satisfaction of clients. A beneficial variation order eliminates unnecessary costs from a project; and as a result, it optimizes the client's benefits against the resource input by eliminating unnecessary costs. However, it should be noted that regardless of how beneficial a variation order might be, non value-adding costs are likely to accrue as a result. For example a variation order to solve the discrepancies between contract documents involves the abortion of works that have already been executed. Cost for aborted works should not have been incurred if discrepancies were not found between contract documents.

2.2 Detrimental variation orders

A detrimental variation order is one that negatively impacts the client's value or project performance (Arain & Pheng 2005:498). Arguably, a detrimental variation order compromises the

[1] Such as for example adverse ground conditions affecting foundations, which become apparent only during excavation.

client's value system. A client who is experiencing financial problems may require the substitution of quality standard expensive materials to sub-standard cheap materials. For example, on a construction project situated in a salty environment, steel window frames result in steel oxidation if selected in lieu of timber, aluminium or PVC frames.

3. IMPACT OF VARIATION ORDERS ON PROJECT PERFORMANCE

Given a well-structured schedule of works, the maximum project performance would be achieved if the work invariably flows smoothly within time limits and anticipated budget. However, it is rare that projects perform precisely to their original schedule due to various reasons including for example market conditions changes and corrections to design. Arguably, the occurrence of variation orders has an adverse impact on project performance. Thomas et al (2002:144) believed that variability generally impedes project performance. Ibbs (1997:308) concluded that variation orders have tremendous effect on the project performance as they adversely affect the productivity and costs. Arain & Pheng (2005:285) argued that variation orders are unwanted but inevitable reality of any construction project. Hanna et al (2002:57) indicated that projects impacted by variation orders cause the contractor to achieve lower productivity level than planed. The discussion on the adverse impact of variation orders on project performance will cover following areas: cost overruns, time overruns, quality degradation, health and safety issues and professional relations.

3.1 Cost overruns

Various studies have revealed that variation orders contribute to construction cost overruns. The study of the effects of variation orders on institutional building projects revealed that variation orders contributed to increase in construction project cost (Arain & Pheng 2005:506). The analysis of variation orders for twelve combined sewer overflow projects revealed the cost escalation of 7% of the original projects cost (Mohamed 2001). The more the variation orders, the more they affect the overall construction delivery cost. In fact, the occurrence of variation orders has direct and indirect cost implications. Direct costs constitute the additional costs incurred to perform the activities of the current variation orders. The direct costs associated with variation orders include the following:

- Resources used including labour, material and plant to carry out the actual variation order;
- Increase in overheads-related charges and professional fees;
- Cost of resources that were used to carry out the aborted or substituted works;
- Cost of demolition of aborted or substituted works;
- Cost for resources lying idle before the ordered task restarts. Resources include charges for plant hire and paid time for labour loitering around while waiting for instruction.

While the direct costs associated with a variation order would be easily calculated, Bower (2000:264) argued that indirect costs of a variation order are difficult to quantify. Indirect costs are those incurred as a result of the occurrence of a variation order, whether they are apparently linked to it or not. These include:

- Rework and making good on affected trades other than the actual variation order. It was revealed that the cost of rework caused by variation orders accounted for more than four-fifth of the total costs of rework (Love & Li 2000:483).
- Change in cash flow due to effect on inflation and financial charges;
- Loss of productivity due to interruption of works where the gang has to familiarise with new working conditions, tools and materials;
- Cost for redesign and administration of the variation order.
- Litigation-related costs in case disputes arise due to variation order.

However, all variation orders do not increase cost of construction. Ssegawa (2002:91) indicated that omissions in most cases reduce costs while additions increase costs.

3.2 Time overruns

Various authors agree that variation orders could be one of the reasons behind project time overruns (Chan & Yeong 1995:467, Mohamed 2001:1). It is anticipated that a project finished within the shortest time achieves some monetary savings. Unfortunately, each additional day on a project implies additional money. It was revealed that the variation orders issued during various phases of construction projects negatively affected both project's completion time and cost increase (Koushki 2005:292). Hanna et al (2002:63) revealed that the more the variation order occurrence the more significant productivity losses. The productivity is the amount of output over a unit of time. Therefore, the loss productivity implies loss of time and subsequent delays.

3.3 Quality degradation

If variation orders are frequent, they may affect the quality of works. Quality may be compromised because contractors tend to compensate for the losses incurred to variation orders.

3.4 Health and Safety

The occurrence of variation orders can affect health and safety condition. This is because change in construction methods, materials and equipment may require additional health and safety measures (Arain & Pheng 2005:500).

3.5 Professional relations

A construction project is not a mere brick and mortar brought together. Rather, it creates professional relationships between parties to the contract. Each project successfully completed constitutes an added experience to participants and their reputation builds up. But disputes may arise between parties to the contract owing the occurrence of variation orders. Misunderstanding may arise when the contractor is not satisfied with the judgment of the consultant in terms of a fair valuation of a variation order. Bower (2000:264) argued that parties to a contract have been left to argue over the cost, time effects and due compensation of a variation order. Since the contractors are pessimist of the outcome of the negotiations, they usually allow higher value than the really cost incurred. Bower (2000:264) opined that this causes the contention between parties as the contractor continually push the client to settle the claim for additional costs while invariably feeling that the reimbursement has been insufficient. As a consequence, this can be very damaging to relationship between all parties' representatives (Bower 2000:264). Charoenngam et al (2003:197) remarked that disputes between the client and the contractor can occur if the variation order undertaking is not managed carefully. Harbans (2003:42) warned that unless a mutually acceptable solution is agreed by the parties, valuation of variation would remain at the forefront of disputes and claims making their way ultimately to arbitral tribunals or the corridors of justice. Ssegawa (2002:92) revealed that more than one-third of disputes occurs pertain to how to ascertain losses arising from variation orders. The excessive occurrence of variation orders due to design errors or omission may undermine the professionalism of the designer. Further more, workers get demoralised when they demolish a portion of work that has already been done.

4. WASTE ASSOCIATED WITH VARIATION ORDERS

4.1 Concept of waste vis-à-vis variability

The paradigm of waste as used in construction has various meanings depending on one's point of view. Very often, waste has been referred to as physical losses of material occurring during the construction process. Formoso et al (1999:327) argued that most studies on waste are based on conversion model in which material losses are considered to be synonymously to waste. According to Formoso et al (1999:328), waste is defined as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantity than those considered as necessary in the production of the building. However, it should be understood that the contractor recognises allowable waste as the percentage for losses of material allocated to bill rate components by the

estimator at tender stage and it varies from one material to another. Unfortunate the existing estimating and contact valuation techniques do not provide a clear breakdown of losses of materials resulting from variation orders. For example cement that hardens into the stores following a variation order to stop works is not allocated to variation orders account. Waste of materials resulting from the occurrence of variation orders may be incurred in following circumstances:

- Compensating waste arising when material ordered for one specific purpose is used for another. For example, facing bricks ordered for external wall erection may be used for internal plastered walls when there is a shortage of common bricks.
- Waste due to the uneconomic use of plant arising when the plant lies idle on site as a result of a variation order. Saukkoriipi & Josephson (2006:292) estimated the waste for non-productive use of resources at more than 10% of a project's production cost.
- Waste of materials due incorrect decision, indecision or inconsistence inspection of works by the project consultant.
- Waste of materials after demolition of a portion of work caused by the variation order to change a trade. For example waste for breaking a wall to accommodate a new door.
- Waste due to wrong use of material or waste stemming from materials wrongly specified.

Some authors defined waste beyond physical losses of materials. Al-Hakim (2005:1) defined waste as anything that adds no value to producing the required services. The value consists of two components: production performance and freedom from defects (Koskela 1992:38). The production of services requires resources and flow of activities over a certain portion of time. According to Koskela (1992:2), the [2]new philosophy of production consists of both conversion and flows: since only conversions add value, the improvement of flow activities should primarily be focused on reducing or eliminating them, whereas conversion activities have to be made more efficient. Therefore, waste reduction is enhanced by avoiding flow variability.

4.2 Identification of the origin and cost of variation orders

Although none can ensure that variation orders can be avoided completely (Mohamed, 2001) their occurrence and subsequent waste can be prevented if their origin and causes were clearly known. A variation order is a transfer of information from one part to another indicating a needed change. The identification of the root causer consists into the revelation of the initiator of a variation order. Arain & Pheng (2006) identified four origin agents of variation orders. These included "client', "consultant", "contractor" and "others". In addition to knowing the origin agent of a variation order, it is imperative to know what might have been the incident for a variation order to be issued. A classification of categories/types rework (Love & Sohal, 2003) revealed the causes or the circumstances under which variation orders could be initiated as follows:

1. Design change: change that arises from the client/consultant, contractor, occupier and supplier/manufacturer or change initiated for improvement purpose.
2. Design error: errors are mistakes made in the design.
3. Design omission: design omission results when an item or component is omitted from the design.
4. Construction change: a change in method of construction in order to improve constructability or due to site conditions. Change may be made by the client, the consultant or the occupier after some work has been performed on site. Change may be made if the process or product needs` to be altered/rectified or if there is a need to improve quality.
5. Construction error: construction errors are the result of erroneous construction methods procedures.
6. Construction omission: construction omissions are those activities that occur due to omission of some activities during the construction.

[2] New philosophy of production refers to an evolving set of methodologies, techniques and tools, the genesis of which was in the Japanese JIT (Just In Time) and TQC (Total Quality Costs) effort in car manufacturing (Koskela 1992)

7. Damage: damage may be caused by accident or inclement weather.

5. SCOPE OF THE STUDY

The study is undertaken in South Africa, a developing country where the construction industry is booming. While existing infrastructures and buildings are upgraded with newly built ones; the backlog in housing and infrastructure delivery, the deficit of skills, the high construction delivery costs and quality standards related problems are the current challenges faced by the construction industry. While there is a great concern that construction delivery costs are too high; recently, studies have been initiated in Sweden to investigate the existence of non value-adding (waste) activities into all phases of construction phases that give rise to construction costs. Subsequently, similar studies are undertaken in South Africa in order to uncover waste within various activities/practice in construction projects. It is anticipated that the reduction of waste would contribute to reduction of construction delivery costs.

6. METHODOLOGY

A comparative analysis of cost variability was done on two completed apartment complexes. Primary data was obtained from a reputable cost consultant company in South Africa. The company kept comprehensive records including short descriptions, monetary values and reasons for cost variability. The contractor and the consultant team involved into the projects were not reachable for interview.

Cost variations were recorded in a table according to the four origin agents and seven causes of variations identified from the literature. Namely the origin agents included the "client", the "consultant", the "contractor" and "others". In this context, "client" included the development initiator and occupiers/tenants who financed the projects. "Consultant" included the whole professional team that represented the client. "Contractor" included the main contractor and his subcontractors. "Others" included weather conditions, state regulations or any other conditions beyond control of either party to the contract. Seven causes included design change, design error, design omission, construction change, construction error, construction omission and damage. Additional preliminary and general (P&G) costs were added as an eighth cause of cost variations. The occurrence of variation orders were first grouped by number and secondly by value.

7. FINDINGS AND DISCUSSIONS

The tender sum for the residential apartment hereby known as project A was R28,315,000 and the original planned works duration was 9 months. The tender sum for the shopping apartment hereby known as project B was R61,617,996 and the original planned works duration was 11 months. On project A, there were numerous additional works associated with the continuously revised electrical works. The reinforcement for concrete slabs changed from post-tensioned to conventional rebar. As the contractor could not finish on agreed time, the extension of time of 25 days was granted. Unfortunately, due to a further failure to complete works during the revised completion period, the contractor was charged a penalty of R13,000 per day totaling R923,000 in 71 days. Penalty charge amount was 3% of the contract sum and the actual completion period was 12 months with an escalation of 33% above the original time schedule. Arguably, the numerous changes of electrical works contributed to delay. On project B, the contractor was granted an extension of time of 26 days which is a time overrun of 9% over the planned works duration. No penalty was charged to the contractor and the consultant's records did not show in details the reason behind such an extension.

Table 1 Origin-Causes of variation order matrix - Project A

Origin Agent	Cost variation occurrence by number								Tot (no)	Percentage
	Causes									
	1	2	3	4	5	6	7	8		
1. Client	2							1	**3**	**4%**
2. Consultant	44	3	13	4					**64**	**85%**
3. Contractor					1		1		**2**	**3%**
4. Others	3			3					**6**	**8%**
Net tot	49	3	13	7	1	0	1	1	**75**	**100%**
Origin Agent	Cost variation occurrence by value								Tot net amount	Percentage
	Causes									
	1	2	3	4	5	6	7	8		
1. Client	R98,327							R171,825	**R270,152**	**13%**
2. Consultant	R1,596,768	R83,360	-R101,208	R79,669					**R1,658,589**	**80%**
3. Contractor					R3,738		?		**R3,738**	**0%**
4. Others	R89,593			R54,582					**R144,121**	**7%**
Net tot	R1,784,634	R83,360	-R101,208	R134,251	R3,738	R0	R0	R171,825	**R2,076,600**	**100%**

Keys: 1. Design change, 2. Design error, 3. Design omission, 4. Construction change, 5. Construction error, 6. Construction omission, 7. Damage, 8. Preliminary &Generals

Table 2 Origin-Causes of variation order matrix - Project B

Origin Agent	Cost variation occurrence by number								Tot (no)	Percentage
	Causes									
	1	2	3	4	5	6	7	8		
1. Clients	28		10			1		2	**41**	**35%**
2. Consultant	53	4	3	11					**71**	**60%**
3. Contractor					1				**1**	**1%**
4. Others				2	2	1			**5**	**4%**
Net tot	81	4	13	13	3	2	0	2	**118**	**100%**
Origin Agent	Cost variation occurrence by value								Tot net amount	Percentage
	Causes									
	1	2	3	4	5	6	7			
1. Clients	R314,385		-R444,661			R1,640		590,000	**R461,364**	**23%**
2. Consultant	R1,049,009	R82,135	-R17,100	R290,456					**R1,404,500**	**69%**
3. Contractor					R12,395				**R12,395**	**1%**
4. Others				R120,000	R34,660				**R154,660**	**7%**
Net tot	R1,363,394	R82,135	-R461,761	R410,456	R47,055	R1,640	R0	R590,000	**R2,032,919**	**100%**

Keys: 1. Design change, 2. Design error, 3. Design omission, 4. Construction change, 5. Construction error, 6. Construction omission, 7. Damage, 8. Preliminary &Generals

Table 1 and 2, records the cost of variation orders, grouped by origin agents and causes in respective projects A and B. The consecutive breakdowns of cost variability into the origin agent and causes were done following the listing provided into the literature review. 75 and 118 variation orders occurred in respective projects A and B. On project A, 85% (64 no) variation orders originated from the consultant. Their value corresponded to 80% (R1,658,589) of the net total sum (R2,076,600) of variation orders. Arguably, this origin agent might be overestimated. These in reality originated with the client since the consultant issued instructions on behalf of the client. A discussion with parties that were directly involved into the projects would have revealed the exact origin agent. The client and the consultant combined generated 89% (67 no) of variation orders. In monetary terms these corresponded to 93% (R1,928,741) of the net total sum. On project B, 60% (71 no) variation orders originated from the consultant. Their value corresponded to 69%

(R1,404,500) of the net total sum (R2,032,919) of variation orders. As earlier argued, this origin agent might be overestimated. The client and the consultant combined generated 95% (111 no) variation orders. In monetary terms these corresponded to 92% (R1,865,862) of the net total sum. It is evident that on both projects A and B the client and the consultant were the predominant origin agents of variation orders.

8. CONCLUSIONS

The extensive literature review uncovered waste associated with variation orders. It was revealed that variation orders cannot be avoided completely since construction works involve complex operations that cannot be accurately determined in advance. It was argued that whenever a variation order is issued, unnecessary costs are likely to occur and these constitute a waste of resources and as a result, they contribute to higher construction delivery cost. The costs of a variation order include direct and indirect cost.

An exploratory study was done on residential and shopping apartment complexes. Both projects incurred delays of and time for completion that escalated at 33% and 9% of the original completion time on both respective projects A and B. Arguably, numerous changes during the construction stage influenced time overruns. On project A, a contractor incurred a penalty amounting at 3% of the original contract sum. A total number of 75 (R2,076,600) and 118 (R 2,032,919) variation orders averaging 8% and 4% of the contract sum occurred on respective projects. On both projects, the client and consultant combined were the predominant origin agents of variation orders. On project A, the client and the consultant combined generated 89% (67 no) of variation orders. In monetary terms these corresponded to 93% (R1,928,741) of the net total sum of variation orders. On project B, the client and the consultant combined generated 95% (111 no) variation orders. In monetary terms these corresponded to 92% (R1,865,862) of the net total sum of variation orders. Further studies should focus on what could be done to minimize variation orders by taking particular attention to predominant origin agents including the client and consultant.

9. REFERENCES

Al-Hakim, L. 2005. Identification of Waste Zones Associated with Supply Chain Integration, *SAPICS 27th Annual Conference and Exhibition*, Sun City, South Africa. Retrieved June 29, 2007, from http://eprints.usq.edu.au/archive/00000209/01/042_alhakim4.pdf

Arain, F.M. & Pheng, L.S. 2005. The potential effects of variation orders on institutional building projects, *Facilities*, 23(11/12). p. 496-510

Arain, F.M. & Pheng, L.S. 2006. Developers' views of potential causes of variation orders for institutional buildings in Singapore, *Architectural Science Review*, 49(1). p. 59-74

Bower, D. 2000. A Systematic Approach to the Evaluation of Indirect Costs of Contract Variations, *Construction Management and Economics,* 18(3). p. 263-268

Chan, A.P.C. & Yeong, C.M. 1995. A Comparison of Strategies for Reducing Variations, *Construction Management and Economics,* 13(6). p. 467-473

Charoenngam, C., Coquinco, S.T. & Hadikusumo, B.H.W. 2003. Web-Based Application for Managing Change Orders in Construction Projects, *Construction Innovation,* 3. p. 197-215

Finsen, E. 1999. *The Building Contract - A Commentary on the JBCC Agreements*, 1st ed., Cape Town: Juta & Co, Ltd.

Fomoso, T.C., Isatto, E.L., Hirota, E.H. 1999. Method for Waste Control in the Building Industry, *Proceedings,* 26-28 July 1999, University of California, Berkeley, CA, USA, p. 325-334

Hanna, A.S.P.E., Calmic, R., Peterson, P.A., Nordheim, E.V. 2002. Quantitative Definition of Projects Impacted by Change Orders, *Journal of Construction Engineering and Management,* 128(1), p. 57-64

Harbans, S.K.S. 2003. Valuation of Varied Work: A Commentary, In: Buletin Ingenieur, *The Board of Engineers Malaysia*, 20(3), p. 32-42

Ibbs, C.W. 1997. Quantitative Impacts of Project Change: Size Issies, *Journal of Construction Engineering and Management,* 123(3). p. 308-311

Koskela, L. 1992. Application of the New Philosophy of Production in Construction, *Technical Report #72, Centre for Integrated Faculty Engineering,* Stanford University, Finland. Retrieved Nov 24, 2007, from http://www.byggeevaluering.dk/db/files/koskela1992_tr72.pdf

Koushki, P.A., Al-Rashid, K. & Kartam, N. 2005. Delays and Cost Increases in the Construction of Private Residential Projects in Kuwait, *Construction Management and Economics,* 23(3), p. 285-294

Love, P.E.D. 2002. Influence of Project Type and Procurement Method on Rework Costs in Building Construction Projects, *Journal of Construction Engineering and Management,* 128(1), p. 1-29

Love, P.E.D. & Li, H. 2000. Quantifying the Causes and Costs of Rework in Construction, *Construction Management and Economics*, 18(4), p. 479-490

Love, P.E.D. & Sohal, A.S. 2003. Capturing Rework in Projects, *Managerial Auditing Journal,* 18(4). p. 329-339

Mohamed, A.A. 2001. Analysis and Management of Change Orders for combined Sewer over flow construction projects, *Dissertation,* Wayne State University

Saukkoriipi, L. & Josephson, P.E. 2006. Waste in Construction Projects: A client Perspective, p. 292-293, In: Pietroforte, R., De Angelis, E. & Polverino, F. 2006. Construction in the XXI Century: Local and Global Chalenges, Joint 2006 CIB W065/W055/W086 Symposium Proceedings, 18-20 October 2006, Rome, Italy.

Ssegawa, J.K., Mfolwe, K.M., Makuke, B. & Kutua, B. 2002. Construction Variations: A Scourge or a Necessity?, *Proceedings of the First International Conference of CIB W107*, 11-13 November 2002, Cape Town, South Africa, p.87-96

Thomas, H.R., Horman, M.J., De Souza, U.E.L., Zavřski, I. 2002. Reducing Variability to Improve Performance as a Lean Construction Principle, *Journal of Construction Engineering and Management,* 128(2) pp. 144-154

Wainwright, W.H. & Wood A.A.B. 1983. *Variation and Final Account Procedure,* 4th ed. Hutchinson: Nelson Thornes ltd.