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Full Length Research Paper

Pareto analysis of on-site productivity constraints and improvement techniques in construction industry

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Productivity represents efficient and effective utilisation of scarce resources to achieve set objectives. Based on Pareto principle, this study aims to identify the nature of and improvement measures for the 20% of the factors causing 80% of the on-site productivity problems in the New Zealand construction industry. Qualitative data collected using pilot interviews formed the basis for questionnaire surveys of project managers, contractors and subcontractors in New Zealand. The quantitative data was analysed using the multi-attribute method and Pareto analysis. Results showed that the factors influencing on-site productivity comprise (in order of influence): project management/project team characteristics, project finance/cash flow, workforce characteristics, project design/characteristics, unforeseen events, technology/process, statutory compliance and wider external forces. Overall, it was found that the way a project is managed, financed and managed, coupled with the workforce and project characteristics, account for the bulk of the on-site productivity problems encountered during its implementation. The levels of impact and occurrence frequencies of the variables under the broad factor categories are reported; these are recommended as guide to optimal utilization of the available resources in addressing the constraints with a view to achieving significant on-site productivity improvement.

Key words: New Zealand construction, Pareto analysis, productivity, productivity constraints, productivity improvement.

INTRODUCTION

Productivity represents efficient and effective utilisation of scarce resources to achieve set objectives. Increase in productivity correlates well with increased profitability, competitiveness, achievement of key stakeholder value propositions as well as long-term growth and sustainability of a firm, an industry and a nation (Mbachu, 2008). Improvement in the productivity of the New Zealand construction industry is critical considering its $430b worth in investment outlay and significant contribution (of approximately 5%) to the gross domestic product (GDP). It is against this background that the report of the Building and Construction Sector Productivity Taskforce (BCSPT) (DBH, 2009) should be considered with seriousness. The report states that "productivity, especially labour productivity has been disappointing and is limiting the sector ability to respond positively to change". In an earlier study, Duncan (2002) concluded that, "an improvement in 'efficiency' of the building and construction sector – defined as a reduction in the cost of work put in place – will have a positive effect on every other sector, and consequently on the national economy".

Past studies have identified typical constraints to productivity in the construction industry. For instance, Wilkinson and Scofield (2010) identified the choice of procurement system as having significant impact on the achievement of time, cost and quality targets for a project. Mbachu and Nkado (2007) identified factors relating to the acts or omissions of the key role players including clients, consultants and contractors, as well as project characteristics and external factors. The (Egan, 1998) report, though focused on house building, points to several constraints including processes and overuse of

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materials, poor management of relationships and the workforce, unambitious targets and ineffective measurement of performance as some of the productivity constraints. As it relates to productivity, the central argument of the Egan report is that without best practice procedures and measurable indicators to help monitor the progress of improvements, the mission to produce better projects (including improvement of productivity) will not be achievable due to faulty processes and lack of benchmarks. In the New Zealand context, Page (2010) identified level of trade skills, project organisation and design detailing as the key on-site productivity constraints. The BCSPT report, DBH (2009) pointed to sector wide skill shortage, approach to procurement of construction projects, lack of innovation in the construction practices and the impact of regulations as drivers of low productivity growth of the New Zealand building and construction sector between 1997 and 2008. The report also identifies design problems, poor supervision and workmanship, and faulty materials as prime causes of defects and low productivity. However, the report admits that the identified constraints are unlikely to explain fully the sector's poor productivity performance, and therefore calls for further research in this area.

Sufficient evidence suggests that on-site productivity measurement should be the basis for making productivity improvement decisions (Carlos and Paul, 2010; McCullouch, 2007; Oglesby et al., 1989). This means that on-site productivity issues are of critical importance as they provide the bulk - if not all - of the sources of productivity constraints in the construction industry. This premise is further buttressed with a battlefield analogy, whereby the practical issues on the battlefield - without demeaning the plans on the drawing boards in the general's office - are the key determinants of whether the war will be won or lost. This is because the battlefield is where the strategies and prior plans are implemented and the tactical issues on ground may supersede the eloquent strategic formulations made at the onset. This makes listening to and taking on board the feedback from the men and women at the battlefront critical to winning the war. Based on this analogy, this study will focus on-site productivity constraints, since addressing these constraints will provide the much-needed productivity improvement in the industry. The study will seek to obtain experienced-based feedback on the key on-site productivity constraints from those at the forefront of project implementation - the contractors and consultants.

These multiple sources of evidence will help to achieve triangulation of the research information for a more reliable outcome.

Productivity in context

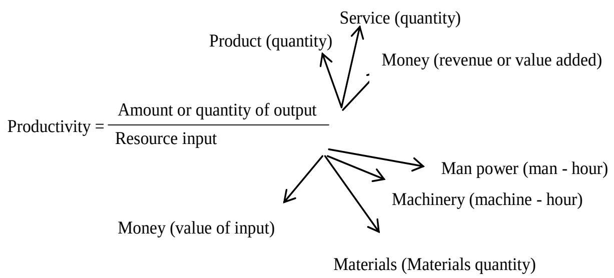
Generally, productivity is a measure of how well resources are leveraged to achieve set objectives or desired outputs. It emphasizes creativity and innovativeness, which target on achieving' more outputs with less resources' by re-engineering the production or service delivery process and optimising the resource leverage. Ideally, productivity is a complex concept that could be interpreted in varied contexts depending on the objectives sought; the objectives in turn determine the measures to be employed in its assessment in relation to the benchmark used for its comparison. The benchmark for comparison is critically important because, productivity outcome in itself is meaningless except if it can be compared with a benchmark. The comparison could be intra-entity that is, comparing productivity outcomes within a given entity across a time period with a view to gaining insights into the implicit trend; it could also be inter-entities that is, comparing productivity outcomes across similar entities with a view to determining the relative levels of productivity of the entities at a snapshot or across a time horizon.

The objectives to be achieved, the resources employed, the measures adopted and the benchmarks used for comparison give rise to different definitions of or perspectives on productivity. Whatever the definition or perspective adopted the common thread in all definitions or contextual interpretations relate to:

1) Effectiveness: That is, how effective is the leveraging of the resources to achieve the set objectives? For example, a system can be adjudged productive in effectiveness context, if the set objectives are achieved through the resource leverage.
2) Efficiency: That is, in achieving the set objectives, how efficient was the utilization of the scarce resources in the implementation process?

Using cost as the denominator in the efficiency measure of productivity, both dimensions of effectiveness and efficiency can be combined in one coinage to represent productivity: 'cost-effectiveness'; cost in this context refers to the optimisation of the use of scarce resources, while effectiveness refers to the achievement of the set objectives. 'Cost-effectiveness' as an indicator of productivity therefore targets maximizing the extent of achievement of the set objectives while minimizing the scarce resources employed in the process. This perspective has given rise to several buzzwords such as lean production (which targets waste reduction as a means of optimising the use of resources), total quality management (TQM) (which targets achieving value through a total re-engineering of the production process rather than the ad-hoc quality assurance measures), and value management (which targets maximising utility output, while minimizing the resources expended in the process). Overall, an operational definition of productivity that fits well with the various approaches to defining the concept - which draws upon the output-input paradigm - is the 'amount or quantity of output of a process per unit of resource input'. This aligns with similar definitions by

Page (2010) and other authors. Equation 1 summarises the key features embodied in this definition.



(1)

The nature of the resource input or a combination of inputs also informs the type of productivity and the measures used to evaluate it as shown in Equation 1. Thus, labour productivity refers to the amount or quantity of work output (that is, quantity or dollar value of products, service or revenue generated) per unit of man-hours employed. Machine productivity can also be defined in the same way as labour productivity with the measure being output per machine-hours. In some instances, both labour and machine could be combined as one resource input known as the ‘equipped labour’. Capital productivity is the amount or quantity of output per dollar capital input. Overall measure of productivity looks at the total output versus total input expressed in the units of the benchmark; alternatively, an index overall measure of productivity expresses the output and input in common unit.

As highlighted earlier, the thrust of this study is on the key productivity constraints in the New Zealand construction industry. In order to put the study in context, operational definitions of productivity were attempted. However, the common operational definitions or interpretations of productivity given above focus on the efficiency limb of productivity and are silent on the effectiveness limb; the latter being focused on the achievement of set objectives. The objective-oriented effectiveness provides measures, which industry operators can use to measure performance and improve on productivity.

METHODOLOGY

Research design

The research methodology adopted in the study is the descriptive survey method comprising qualitative data gathering through pilot interviews and quantitative data gathering through questionnaire surveys. The questionnaires were structured using the constructs sourced from the literature, but with open-ended sections for further inputs by respondents.

The questionnaire used in the survey contained two broad categories of constraints, which are internal and external constrains. In the questionnaire surveys, respondents were asked to rate on a five point Likert scale, the levels of impact and frequency of occurrence of each sub-constraint source based on their experience.

The target population for the study comprised project management consultants, contractors and subcontractors in the New Zealand building industry. The questionnaires ware self-administered; participation was voluntary. Six pilot interviews were conducted in Auckland – two interviews each with project managers, contractors and subcontractors – to identify the productivity constraints in the New Zealand construction industry and to evaluate the relevance of additional insights gained from the review of literature in the New Zealand context. The constructs generated during the pilot interviews were used to design structured but open-ended questionnaire which was pre-tested with four interviewees comprising two project managers, one contractor and one subcontractor.

In the quantitative surveys, emails were sent to the remaining 150 respondents in the database inviting them to participate in the online survey.

Data gathering

The secondary data for the study were sourced from the relevant literature including journal articles, conference papers and completed thesis and research reports from reputable tertiary institutions.

The primary data for the study were opinions of project manager consultants, contractors and subcontractors in New Zealand building industry. These were obtained through questionnaire surveys involving self-administered open-ended questionnaires.

Data analysis

The responses received by the cut-off date were analyzed using the multi-attribute and the Pareto analytical techniques.

The multi-attribute analytical technique was essentially used to analyse the ratings of the respondents with a view to establishing a representative or mean rating (MR) point for each group of respondents. Pareto analysis provided rational grounds for optimum disbursement of resources to addressing the 20% of the factors, which cause 80% of the productivity problems.

The multi-attribute analysis was based on the approach taken by Chang and Ive (2002) and involved the evaluation of the MR for each constraint factor under a subset. The MR indicates the mean or average rating point assigned by the respondents as the level of importance of an attribute within a subset of attributes. In each computation, the total number of respondents (TR) rating each attribute was used to calculate the percentage ages of the number of respondents associating a particular rating point to each attribute as shown in Equation 2.

$$MR_j = \sum_{k=1}^{5} \left(R_{p_{jki}} x \% R_{jk} \right) \quad (2)$$

Where, MR_j = Mean rating for constraint factor j; R_{pjk} = Rating point k (ranging from 1 to 5); $R_{jk\%}$ = percentage age response to rating point k, for constraint factor j.

DATA PRESENTATION AND RESULTS

Survey responses

A total of 150 e-mail invitations were dispatched to the respondents in the database, which provided the target

Table 1. Factors ranked under project finance set of constraints.

S/No.	Internal constraint	[a]Level of impact VH 5 %	H 4 %	M 3 %	L 2 %	VL 1 %	[b]TR	[c]MR	Remark
A	**Project finance: Cash flow problems arising from:**								
1	Reworks	20.00	40.00	28.57	5.71	5.71	35.00	3.63	
2	Inadequate supply or high cost of needed resources: money, men, materials and machinery	22.58	22.58	38.7	12.9	3.23	31.0	3.48	Significant
3	Under-valued work;	14.71	32.35	35.29	11.76	5.88	34.00	3.38	
4	Late payments;	14.29	31.43	25.71	14.29	14.29	35.00	3.17	
5	Dispute and litigation costs	12.90	25.81	9.68	38.71	12.90	31.00	2.87	
6	Lenders' high interest charges	0.00	13.79	24.14	51.72	10.34	29.00	2.41	
7	High insurance premiums bonds/ retentions.	0.00	5.56	30.5	38.8	25.00	36.0	2.17	

[a]Levels of impact: VH, Very high (5); H, high (4); M, medium (3); L, low (2); VL, very low (1); [b]TR, total responses; [c]MR, mean responses (Equation 3).

population for the study. Only 37 usable responses were received by the cut-off date, representing 24% overall effective response rates.

The survey feedback was from the project management consultants (39%), contractors (53%) and subcontractors (8%). The findings from the analyzed data therefore, were largely influenced by the opinions of the contractors and less by the subcontractors. Perhaps, this skew could be welcomed since contractors are the key role players in the procurement process whose performance underpins productivity and project success. A key limitation here is the absence of the opinions of the clients and designers who equally influence outcomes in the procurement process. Nevertheless, the scope of the study focuses only on those key role players that are active at the coalface of the construction implementation process and who are expected to provide more authoritative feedback on the subject matter.

Over half of the respondents (77%) had at least 15 years of experience in the construction industry. This profile means that the respondents` extensive experience contributes to the quality of the responses received, and to the reliability of the conclusions to be drawn from the research findings. Most of the respondents (that is, 83%) were high-ranking personnel in the capacities of director/ executive director and manager/associate director. This again reinforces the quality of the feedback as being from those who make decisions and control performance on productivity in the construction industry.

Project finance related constraints

The relative levels of impact of the sub-factors under this category of productivity constraint are shown in Table 1. Results show that reworks has the most impacting factor on on-site productivity. This aligns with the earlier findings of Makulsawatudom et al. (2004) that rework was one of the critical factors effecting construction productivity in Thailand. Another study, (Love et al., 1999, 2000) found the cost of rework ranged from 2 to 12% of total contract value.

Workforce related constraints

Table 2 shows the analysis of the relative levels of impact of the sub-factors under the workforce broad category of on-site productivity constraints. Results show that the level of skill and experience of the workforce has the most impact on on-site productivity in New Zealand building industry. This could be because construction is a labour-intensive industry. The result is supported by work of Mojahed and Aghazadeh (2007) who equally concluded that skills and experience of the workforce have significant influence on construction site productivity performance. According to Enshassi et al. (2007) experience improves both the intellectual and physical abilities of labour, which consequently increase labour productivity.

Technology/process related constraints

Analysis of the sub-factors under the technology/process related category of on-site productivity constraints is shown in Table 3. It was found that adequacy of method of construction has the greatest impact on on-site

Table 2. Factors ranked under workforce group.

S/No.	Internal constraint	[a]Level of impact					[b]TR	[c]MR	Remark
		VH	H	M	L	VL			
		5	4	3	2	1			
		%	%	%	%	%			
B	**Workforce: productivity constraints arising from:**								
1	Level of skill and experience of the workforce;	25.71	40.00	25.71	8.57	0.00	35.0	3.83	
2	Level of motivation/commitment	20.00	40.00	22.86	14.29	2.86	35.0	3.60	
3	Level of familiarity with current job and conditions	8.57	45.71	31.43	8.57	5.71	35.0	3.43	
4	Level of empowerment (training and resourcing)	11.43	42.86	22.86	22.86	0.00	35.0	3.43	Significant
5	Level of involvement of direct labour or subcontract	11.76	29.41	35.29	23.53	0.00	34.0	3.29	
6	Workforce absenteeism	8.82	17.65	44.12	23.53	5.88	34.0	3.00	
7	Level of staff turnover/churn rate	2.86	20.00	42.86	25.71	8.57	35.0	2.83	
8	Health of the workforce	0.00	21.21	42.42	30.30	6.06	33.0	2.79	

productivity. This result concurs with similar findings of Alinaitwe et al. (2007) that construction method is an important factor influencing construction on-site productivity. Planning in pre-construction phase plays an important role in determining an adequate method of construction for a successful project outcome.

Project characteristics related constraints

Table 4 shows the analysis of the relative levels of influence of the sub-factors under the project characteristics constraints. Results show that buildability issues are most significant source of onsite productivity constraint. This finding buttresses the conclusions in several studies that buildability has a remarkable influence on construction process (Jarkas, 2010; Lam and Wong, 2009; Saghatforoush et al., 2009; Lam et al., 2007).

Project management/project team characteristics related constraints

With the highest MR of 4,43, coordination, supervision and performance monitoring and control set of constraints was found to be the most influential on-site productivity constraint factor under project management/project team characteristics broad category in Table 5. This result was supported by Kazaz et al. (2008) who noted that the level of supervision is key to on-site construction productivity performance. Also, Jergeas (2009) found supervision as the top ten areas for construction productivity improvement.

Statutory compliance related constraints

As shown in Table 6, under the statutory compliance category the Resource Management Act (RMA) was rated as the most influential sub-factor on on-site productivity. The report by McShane (1996) hinted that the impact of RMA on construction productivity is profound especially in relation to resource consent issues.

Unforeseen events

Table 7 shows that ground condition as a sub-factor under unforeseen events, has the greatest impact on construction on-site productivity in New Zealand. The same result was found by Clayton (2001) who equally noted that ground related problems and conditions can affect adversely construction process and productivity in terms of costs and completion time in a project of any scale. If the survey was conducted during the recent earthquake in Christchurch, perhaps, natural disasters would have been perceived as the most influential sub-factor given the loss of lives and the $40 billion

Table 3. Factors ranked under technology/process group.

S/No.	Internal constraint	[a]Level of impact VH 5 %	H 4 %	M 3 %	L 2 %	VL 1 %	[b]TR	[c]MR	Remark
C	**Technology/process: productivity constraints arising from:**								
1	Adequacy of method of construction	19.44	33.33	33.33	13.89	0.00	36.00	3.58	Significant
2	Suitability or adequacy of the plant and equipment employed	8.57	37.14	28.57	20.00	5.71	35.00	3.23	
3	Resistance to accept new technologies	5.88	29.41	38.24	26.47	0.00	34.00	3.15	
4	Adequacy of technology employed	5.71	37.14	22.86	31.43	2.86	35.00	3.11	
5	Lack of training and education to implement and operate new technologies	2.86	25.71	48.57	22.86	0.00	35.00	3.09	
6	Inadequate IT infrastructure and application in construction industry	0.00	37.14	34.29	25.71	2.86	35.00	3.06	
7	Adequacy of site layout	3.03	18.18	33.33	42.42	3.03	33.00	2.76	

Table 4. Factors ranked under project characteristics set of constraints.

S/No.	Internal constraint	[a]Level of impact VH 5 %	H 4 %	M 3 %	L 2 %	VL 1 %	[b]TR	[c]MR	Remark
D	**Project characteristics: productivity constraints arising from:**								
1	Buildability issues	20.00	40.00	34.29	2.86	2.86	35.00	3.71	Significant
2	Project complexity: scale and design	20.59	35.29	32.35	11.76	0.00	34.00	3.65	
3	Site conditions: access, subsoil, topography	17.65	41.18	20.59	20.59	0.00	34.00	3.56	
4	Site location and environment	11.76	26.47	35.29	20.59	5.88	34.00	3.18	
5	Type of procurement adopted.	8.82	26.47	35.29	23.53	5.88	34.00	3.09	

Table 5. Factors ranked under project management/project team characteristics group.

S/No.	Internal constraint	[a]Level of impact VH 5 %	H 4 %	M 3 %	L 2 %	VL 1 %	[b]TR	[c]MR	Remark
E	**Project management/project team characteristics: productivity constraints arising from:**								
1	Coordination, supervision, performance monitoring and control	54.29	34.29	11.43	0.00	0.00	35.00	4.43	Significant
2	Clients' over influence on the construction process	41.18	50.00	5.88	2.94	0.00	34.00	4.29	

Table 5 Contd.

3	Relationship management/degree of harmony, trust and cooperation	37.14	45.71	11.43	2.86	2.86	35.00	4.11	
4	Adequacy of planning and risk management process	31.43	51.43	11.43	5.71	0.00	35.00	4.09	
5	Project organisational culture	35.29	26.47	35.29	0.00	2.94	34.00	3.91	
6	Project management style	22.86	40.00	31.43	2.86	2.86	35.00	3.77	
7	Competencies of the project team	26.47	29.41	35.29	5.88	2.94	34.00	3.71	
8	Frequency of design changes/change orders	17.14	31.43	42.86	8.57	0.00	35.00	3.57	

Table 6. Factors ranked under statutory compliance category.

S/No.	External constraint	[a]Level of impact					[b]TR	[c]MR	Remark
		VH	H	M	L	VL			
		5	4	3	2	1			
		%	%	%	%	%			
A	**Statutory compliance: productivity impediment arising from compliance with:**								
1	Resource Management Act	8.82	29.41	38.24	17.65	5.88	34.00	3.18	
2	Building Act/Building Consent/Building regulations	9.09	27.27	27.27	33.33	3.03	33.00	3.06	Significant
3	Health and Safety in Employment Act	2.63	23.68	44.74	10.53	18.42	38.00	2.82	
4	Local Authority Bylaws,	0.00	20.59	38.24	35.29	5.88	34.00	2.74	
5	Employment Relations Act	0.00	0.00	33.33	57.58	9.09	33.00	2.24	
6	Construction Contracts Act	0.00	12.50	15.63	50.00	21.88	32.00	2.19	
7	Arbitration Act	3.57	0.00	10.71	39.29	46.43	28.00	1.75	
8	Consumer Guarantees Act	0.00	3.33	10.00	33.33	53.33	30.00	1.63	
9	Fair Trading Act	0.00	3.45	6.90	34.48	55.17	29.00	1.59	

reconstruction work left in the aftermath of the earthquake on 22 February, 2011.

Other external forces

Market conditions and the level of competitions in the industry for jobs was rated by the respondents as having the highest impact on construction on-site productivity as shown in Table 8. (Davis, 2008) stated in his building and construction industry summary report that competition is widely regarded as an important determinant of productivity. One important aspect of the market condition could be the boom-burst cycle which has profound impact on a range of issues including skills, available of jobs, profitability and morale.

Broad categories

At the level of the broad categories of internal and external constraints as analyzed in Table 9, project management/team characteristic was found to have the most significant impact on on-site productivity. This result is radical departures from the widely held believe that statutory compliance is the most influential factor constraining a range of issues in the construction industry.

Conclusions

Productivity is the key determinant of the performance and success in the construction industry. Given the reported steady decline of labour productivity trend in the

Table 7. Factors ranked under unforeseen events.

S/No.	External constraint	[a]Level of impact					[b]TR	[c]MR	Remark
		VH	H	M	L	VL			
		5	4	3	2	1			
		%	%	%	%	%			
B	**Unforeseen events: productivity impediments arising from unforseen events**								
1	Ground conditions	20.59	44.12	29.41	5.88	0.00	34.00	3.79	Significant
2	Inclement weather	14.71	41.18	35.29	8.82	0.00	34.00	3.62	
3	On-site accidents/Acts of God	13.89	25.00	30.56	30.56	0.00	36.00	3.22	
4	Natural disasters	32.35	14.71	8.82	17.65	26.47	34.00	3.09	

Table 8. Factors ranked under other external forces.

S/No.	External constraint	[a]Level of impact					[b]TR	[c]MR	Remark
		VH	H	M	L	VL			
		5	4	3	2	1			
		%	%	%	%	%			
C	**Other external forces: productivity constraints arising from miscellaneous sources Including:**								
1	Market conditions and level of competitions in the industry	0.00	54.84	29.03	12.90	3.23	31.00	3.35	Significant
2	Inflation / fluctuations in material prices	6.06	21.21	51.52	15.15	6.06	33.00	3.06	
3	Frequent changes in government policies/ legislations impacting on construction	0.00	12.12	27.27	54.55	6.06	33.00	2.45	
4	Increase in industry or society-wide litigations/adversarial relations	3.45	6.90	24.14	62.07	3.45	29.00	2.45	
5	Interest rate/cost of capital	0.00	6.06	30.30	57.58	6.06	33.00	2.36	
6	Rapid technological advances	0.00	3.03	30.30	63.64	3.03	33.00	2.33	
7	Fluctuations in exchange rate	0.00	0.00	38.24	52.94	8.82	34.00	2.29	
8	Energy crises/costs	0.00	6.06	21.21	66.67	6.06	33.00	2.27	

Table 9. Factors ranked under broad constraint categories.

S/No.	Broad categories of internal and external constraints	[a]Level of impact VH 5 %	H 4 %	M 3 %	L 2 %	VL 1 %	[b]TR	[c]MR	Remark
1	Project management/project team characteristics	17.14	40.00	28.57	11.43	2.86	35.00	3.57	Significant
2	Project finance	14.71	50.00	17.65	11.76	5.88	34.00	3.56	
3	Project characteristics	2.94	41.18	41.18	14.71	0.00	34.00	3.53	
4	Workforce	11.76	44.12	32.35	8.82	2.94	34.00	3.32	
5	Unforeseen events	11.76	14.71	38.24	29.41	5.88	34.00	2.97	
6	Technology/process	0.00	18.18	57.58	24.24	0.00	33.00	2.94	
7	Statutory compliance	0.00	20.59	47.06	26.47	5.88	34.00	2.82	
8	Other external forces (economic, political, industry, etc)	3.03	6.06	39.39	45.45	6.06	33.00	2.55	

New Zealand construction industry, this research aimed to identify the key constraints to on-site productivity and to prioritise them in accordance with their levels of impact based on the views of project management consultants, contractors and subcontractors. In this study, 56 factors were identified in total, which were divided into two groups: internal and external constraints.

Results of multi-attribute analysis showed that within the internal constraints, reworks, level of skill and experience of the workforce, adequacy of method of construction, buildability issues, supervision and coordination were the most significant constraint factors. RMA, ground conditions, market conditions and level of competition in the industry were the most influential external constraints. Through Pareto analysis, it was found that the way a project is managed and financed, in addition to the workforce and project characteristics, account for the bulk of the on-site productivity problems encountered during its implementation. It is recommended that by addressing the identified constraints in line with their relative levels of influence, scarce resources could be more effectively utilized in addressing the productivity constraint factors with a view to improving productivity performance in the construction industry.

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