RESILIENT PRODUCTIVITY-PERFORMANCE CONSTRAINTS IN NEW ZEALAND ROAD MAINTENANCE AND REHABILITATION PROJECTS

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ABSTRACT

Road pavement maintenance and rehabilitation contractors (RPMRCs) face challenges inherent in performance-based rewards which seek to maximize tax dollar through whole-of-life best value in the project delivery process. To be successful, contractor's productivity and performance should remain high and resilient to internal and external constraints in the project environment. There is little research on the priority constraints to productivity and performance in the New Zealand (NZ) roading sector. This paper presents preliminary findings of a study which aimed to investigate the key productivity constraints faced by RMRCs and the associated mitigation measures. Senior managers and directors of medium- to large-sized NZ roading contracting firms were interviewed in the process of an exploratory survey. Feedabck was analysed using the multi-attribute technique.

Results revealed 70 productivity constraints faced by RPMRCs in New Zealand; In diminishing order of influence, these were aggregated into eight broad categories as follows: finance, workforce, technology/process, statutory/regulatory compliance, project characteristics, project management/project team characteristics, unforeseen circumstances, and other/ external factors.The report highlights the most influential constraints in the eight broad categories.

The findings contribute to knowledge by revealing critical factors constraining productivity performance of NZ RMRCs and the associated improvement measures. New and more enriching perspectives were provided on how contractors could leverage their limited resources to addressing the identified key constraints.

Keywords: Performance resilience, productivity, road maintenance, road rehabilitation, road pavement

INTRODUCTION

Soundly constructed, well operated and routinely maintained road network is a key facilitator of economic growth (NZTA, 2014a). This is because a well-maintained road network enhances and sustains national and regional communications in a more effective, efficient and safe manner, which in turn, helps support a thriving New Zealand.

Recent study by McPherson and Olsen (2016) suggested that the annual investment by the New Zealand Transport Agency (NZTA) in the operation and maintenance of state highway network is around $500 million, with annual rehabilitation/ upgrading costs amounting to $1.5 billion (NZTA, 2014b). Transit New Zealand (Transit NZ, 2000) reported that more than 56% of its annual budget is allocated to general maintenance, reseal and pavement rehabilitation works in order to provide an acceptable level of service to road users and to counter rapid pavement deterioration rate.

With the New Zealand road network asset currently valued at approximately $26 billion, one of the biggest concerns for decision makers in the New Zealand roading industry is on how to ensure that every dollar of investment in road infrastructure development, operation and maintenance maximizes value to the taxpayers. As a result, service providers are expected to do so much work with so little resources. Consequently, road contractors responsible for designing, constructing and maintaining the road infrastructure networks are put under enormous pressure to optimise their work in order to maximize value delivery in the process.

However, contractors who are at the forefront of road infrastructure asset development face enormous constraints that hinder their productivity and performance – and resultantly, the extent of value they can deliver. The productivity constraints have brought about major setbacks to infrastructure project delivery such as cost overruns, delays and poor quality of work (Pell et al., 2015). To help the roading contractors improve their productivity, it is therefore imperative to provide information on the constraints they face in their day-to-day project implementation role and effective ways of mitigating the constraints.

Several studies have looked at the challenges faced by contractors in the infrastructure asset delivery and maintenance. For instance, the UK's Network Rail (2014) identified issues such as capacity limitations, poor performance management and progress tracking, poor safety management, unproductive organizational culture, weather and climate as some of the constraints faced by service providers in infrastructure asset development and maintenance. Other issues included poor asset strategic planning, policies and communication, as well as supply chain limitations (Assaf and Al-Hejji, 2006). McKinsey (2013) noted that a major problem for contractors at the tendering and contract signing stage is that they take on higher risks that are disproportionate to their reward in the contract, and this often results in serious resource constraints during the implementation phase. The Controller and Auditor General's Office (2011) identified New Zealand specific challenges in public infrastructure asset development and management to include issues such as acute skill shortage, unrealistic public expectations, the fiscally constrained environment within which infrastructure asset is procured and managed, and the type of procurement and contracting strategies adopted for infrastructure development which are not necessarily the most appropriate for collaborative relationships and successful project delivery.

Though a number of studies have investigated constraints faced by roading contractors, there is a lack of prioritization of these challenges – especially in the context of the New Zealand roading sector. Are the challenges identified in overseas countries applicable in New Zealand? What specific constraints are faced by the New Zealand contractors in the road pavement maintenance and rehabilitation projects? What mitigation measures are applicable to the New Zealand roading sector? While overseas studies are robust in regards to addressing some of these questions, there is a lack of empirical study in the New Zealand context. This study will aim to contribute to bridging the existing information gap. Empirical data will comprise structured interview-based feedback provided by experienced roading contractors who were involved in road pavement design, construction, maintenance and rehabilitation projects.

RESEARCH AIM AND OBJECTIVES

The aim of the study was to investigate issues surrounding the productivity and performance of contractors handling road pavement maintenance and rehabilitation projects in New Zealand. The study also looked at practical and innovative ways of resolving the issues.

The key objectives of the study were as follows.

To identify and prioritise the factors constraining contractors' productivity and performance in the road pavement maintenance and rehabilitation (RPMR) process.

To explore measures for mitigating the identified constraints with a view to improving efficiency and productivity in the RPMR.

LITERATURE REVIEW

Productivity in context

'Productivity' is a complex concept that is interpreted in a variety of ways depending on the context and the objectives sought. From a production system perspective, Bjork (2003) defined productivity as the ability of a system to convert input resources into outputs. This efficiency perspective of productivity expresses the concept as a quantitative relationship between output and input. It does not address the effectiveness criterion, which evaluates the extent of achievement of set goals or objectives (Mbachu, 2011). Unfortunately, this efficiency perspective is widely adopted by economists. For instance, Schreyer (2001), while relaying the economists' perspective of the concept defined it as the ratio of a measure of output to a measure of resource input.

The economist's or efficiency perspective of productivity is not quite helpful to the construction industry stakeholders in terms of offering a quantitative tool for measuring and benchmarking project performance. The Statistics New Zealand (2016) corroborated the inadequacies of the efficiency-only perspective of the concept and its lack of effectiveness focus by noting that "the economist's perspective of the concept (i.e. the output to input ratio outcome) is not a measure of effectiveness because it reflects only how much extra output is produced per unit of input, not whether that input has an effective outcome. To provide a more relevant definition that is consistent with the project performance measurement and benchmarking needs of the industry, a number of authors have come up with some definitions. For instance Chan and Chan (2004) defined the concept as a measure of the extent of achievement of project goals or objectives, namely time, cost, quality and scope accomplishments.

A more holistic definition that is widely accepted – especially among construction industry stakeholders – expresses productivity in the context of performance measurement – i.e. as a measure of how well resources are leveraged to achieve set targets or desired outputs (Durdyev and Mbachu, 2011). This definition is adopted in this study as it is consistent with the research objectives.

Productivity and performance in the context of road pavement maintenance and rehabilitation – the NZTA's perspective

As the client or employer to roading contractors in New Zealand, the NZTA specified seven criteria for assessing contractors' performance of the work category they are prequalified to undertake. The seven performance criteria as set out in the Contractor Prequalification Application (NZTA, 2016) are as follows:

Quality assurance
Traffic management
Environmental management
Health and safety
Project management
Quantum or size of work
Co-operative and pro-active partnering.

Contractors are required to meet or exceed the classification level input requirements for all the above seven performance criteria as a condition to maintain the classification level for their prequalified work category. Therefore, from the perspective of the NZTA, contractor's productivity and performance is assessed based on the extent to which the contractor is able to perform in relation to the above seven criteria. As some of the criteria do not have objective measures of accomplishment and therefore require subjective assessment, it is uncertain how NZTA conducts the assessment. However, in its document that sets forth the bases for contractor payment in the Network Outcomes Contract (NZTA, 2015), it is evident that productivity and performance is largely based on accomplishment of the schedule, cost and quality targets, but with compliance of the seven criteria being constraints that must be managed to the threshold level.

Constraints in road pavement maintenance and rehabilitation projects

Identifying key constraints in improving productivity and performance in the RPMR is important so as to be able to direct available resources towards eliminating, mitigating, or transferring the risks involved (Diewert, 2001; Dunston et al., 2000). A few studies have looked at productivity constraints in road pavement maintenance and rehabilitation projects. Durdyev and Mbachu (2011) provided a holistic model of internal and external productivity constraints that is based on a global framework, 'PESTELI' (Political, Economical, Socio-Cultural, Technology, Legal/Political, and Industrial constraints). Also, internal constraints can be modeled from the scope of the '6 Ms' of the business process improvement: money/finance, management of the workforce, manpower, machinery, materials, and method process (McKinsey, 2013). Also, a study by Chan et al. (2001) listed numerous factors related to improving productivity and performance in road pavement maintenance. The authors showed that proper management of the identified potential delay factors can improve productivity rates. However, none of these studies provided a prioritized list of measures for mitigating the constraints.

Summary of review of literature and gap in knowledge

Review of literature to date has provided insights into the key concepts that underpin this research and the extent to which the research objectives have been addressed in previous studies. It was found that while several studies have been completed in the research area, few studies exist in the New Zealand context. The New Zealand roading sector is unique in many respects, such as socio-cultural dynamics, regulations, industry characteristics, and legislations. Therefore overseas findings relating to the topic may not be wholly applicable in the New Zealand context given its unique settings. In addition, the productivity constraints identified in other countries were largely unprioritised. This study will address this knowledge gap by investigating productivity constraints and improvement measures that are unique to the New Zealand roading sector. In addition, the constraints will be prioritised in order of their relative influences, so contractors can focus their limited resources on addressing those constraint factors and improvement measures having the highest impact on productivity outcomes.

RESEARCH METHOD

A two-stage descriptive survey method involving pilot and structured interviews was adopted for this phase of the study; this is consistent with the exploratory nature of the research goal (Ellis & Kumar, 2015).

Scope of data sources was limited to views expressed by senior managers and directors of contracting firms involved in road pavement design, construction, maintenance and rehabilitation in New Zealand as provided in the 30 April 2016 edition of the NZTA Register of

Prequalified Contractors (NZTA, 2016). The NZTA register provided the sampling frame for the study.

Pilot interviews

The first stage of empirical data gathering involved the use of in-depth pilot interviews conducted with experienced contractors in the roading industry. A selective and purposive sampling method (Bernard, 2011) was used to select convenience samples of senior managers and directors of contracting firms that make up the sampling frame. Participation was on the basis of willingness to grant approximately one hour for an in-depth interview. Six contractors agreed to be interviewed. These were recruited from each of the three main New Zealand cities – Auckland, Christchurch and Wellington. The aim of the interviews was to explore the key factors constraining productivity performance in road pavement maintenance and rehabilitation projects in New Zealand. Also questions were asked about the key improvement measures which the interviewees believed could enhance success in the delivery of road pavement maintenance and rehabilitation projects.

Structured interviews

An open-ended questionnaire was developed using the constructs identified at the pilot interviews. Before being used for the structured interviews, the questionnaire was pre-tested for clarity and relevance. Subsequently, invitations were extended to 60 convenience samples of senior managers and directors of contracting firms in the sampling frame who were based in Auckland, Wellington and Christchurch; the invitees did not participate in the pilot interviews and the questionnaire pre-tests. The intention was to recruit about 60 contractors who could grant quality time for the structured interview, comprising 20 from each of the three cities. The open-ended sections of the structured questionnaire served to elicit from the interviewees further constructs that were not included in the list identified during the pilot interviews.

Data analysis

The multi-attribute analytic technique was used to analyse the quantitative data obtained from the structured interviews. The use of this technique was deemed appropriate because the aim was to prioritise the relative levels of influence or effectiveness of the individual items in subsets based on the mean ratings assigned by the raters (Chang and Ive (2002). The analysis involved computing the mean rating (MR), as the average of raters' collective ratings of a variable in a subset based on the 5-point rating scale used. MR was computed as the sum of the product of each rating point (P) assigned to the i^{th} item in the subset, and the corresponding proportion of raters assigning the rating point to the item (i.e. $R_{\%}$). Mbachu (2011) provided a modified form of Chang and Ive (2002) expression for computing the mean rating as shown in Equation 1.

$$MR_i = \sum_{i=1}^{5} (P_i \times R_i\%) \qquad (1)$$

Where: MR_i = mean rating point computed for the ith item in the subset; P_i = Rating point *i* ($1 \leq i \leq 5$ – for 5-point Likert scale); $R_i\%$ = Percentage response to rating point, *i*, out of the total number of respondents in the survey.

RESULTS AND DISCUSSIONS

Survey Responses

Out of 60 prospective interviewees invited to participate in the structured interviews, only 41 agreed. 39 out of the 41 provided usable responses. Two responses were discarded for being grossly incomplete. These were from two of the five interviewees who chose to complete the online version of the questionnaire rather than participating in the face-to-face or phone interviews. The survey responses confirmed that the constructs generated at the pilot interviews were robust and provided a comprehensive list of the productivity constraint factors and their mitigation measures. The few additional factors supplied in the open-ended sections of the completed questionnaire were largely re-wordings of the constructs in the list provided for rating.

Demographic Profiles

NZTA's prequalification categories of the interviewees' firms

Analysis of the demographic profiles of the interview participants showed that out of the NZTA's four prequalification categories for contractors, majority (i.e. 50%) worked for contracting firms in the road surfacing work category. Others worked for contracting firms in the categories of general road construction (40%) and bridge construction (10%). None of the participants worked for contracting firms in the routine and minor works category. The findings at this stage of the research were therefore largely influenced by the opinions of senior managers and directors of contracting firms that specialized in road surfacing jobs. The greater proportion of interviewees in this category was a positive outcome, given their direct relevance to the focus of the research.

Findings in Relation to the First Research Objective

The first objective of this study was to identify and prioritise the factors that could constrain contractors' productivity performance in the road pavement maintenance and rehabilitation (RPMR) process. Results in relation to this first objective are discussed as follows.

Broad- and sub-categories of factors constraining contractors' productivity performance

Findings from the first phase pilot interviews revealed 70 constraint factors which were aggregated into eight themes: finance, workforce, technology/ process, statutory/regulatory compliance, project characteristics, project management/project team characteristics, unforeseen circumstances, and other/ external factors. The broad categories and the sub-constraint factors are summarised in Table 1. The table also provides the sub-constraints under each broad category; these are listed in diminishing order of influence.

Table 18: Broad- and sub-categories of factors constraining contractors' productivity performance in road pavement maintenance and rehabilitation projects in New Zealand

Broad constraint category	Sub-constraints
Project Finance Issues	Inaccurate estimate Lack of collaboration between consultant & contractor Inadequate supply or high cost of needed resources: money, men, materials, & machinery Construction-phase defective or non-compliant work Under-valued work Late payments Dispute and litigation costs Lenders' high interest charges Financial capacity for the scale and complexity of work involved
Workforce	Lack of good leadership/management capability Low level of motivation/commitment Low level of skill and experience of the workforce Poor monitoring or appraisal of performance Overly long working hours with insufficient rest periods, especially during night work Inadequate empowerment (training and resourcing) Poor resource levelling Lack of experience of current job and operational conditions Workforce health issues Workforce absenteeism
Technology/ Process	Resistance to accept new technologies in road maintenance projects (include new methods & materials) Ineffective approach to road maintenance Lack of adequate training on new process and technologies Inadequate road failure detection system Inadequate IT infrastructure and application in road maintenance industry Suitability or adequacy of the plant & equipment employed Insufficient monitoring process for road failure detection
Project characteristics	Site location and environmental constraints (e.g. traffic volume, climate, subsoil, and topography) Planning & logistic issues impacting on continuous work flow (e.g. non-closure period) Un-conducive time frames within which most road works must be carried out Public notification issues (e.g. community and environmentalists' resistance to infrastructure development plans) Type of procurement adopted

	Project complexity: scale, design Relation between rehabilitation scale and plant utilisation Nature and significance of road in the road hierarchy
Project management/ Project team characteristics	Frequency of design changes/change orders/late changes Lack of sufficient planning from the outset Lack of effective communication/ clarifications of expectations among key stakeholders Relationship management/degree of harmony, trust, and cooperation between contractor, consultant, and council Lack of organisational learning: Learning from previous projects Client's overt influence on the project process Lack of proper and regular coordination, supervision, performance monitoring, and control Experience and competencies of the project team Lack of project organisational culture that supports high productivity and performance Poor project management and risk management process Poor collaboration and supply chain management, especially as it relates to "just-in-time" supply principles Supplier related issues (delays, inferior goods)
Statutory/ Regulatory compliance	Health & Safety in Employment Act Resource Management Act Local Authority Bylaws ISO 9001-Quality ISO 14001-Environmental standards Construction Contracts Act Employment Relationship Act Consumer Guarantees Act Fair trading Act
Unforeseen circumstances	Inclement weather Unforeseeable ground conditions forcing design revisions On-site accidents Natural disasters/Acts of God
Other/ external factors	Market conditions and level of competition in the industry for jobs Inflation/ fluctuations in material prices Energy crises/ rising costs Frequent changes in government policies/ legislation impacting on construction Interest rate/ cost of capital Fluctuations in exchange rate Post-construction defective or non-compliant work User/Client value perceptions Durability of completed work within the defects liability period or warranty/ guarantee Post completion deterioration rate relating to rough use In-use conditions being at variance with prior production assumption

Discussions

The following subsections present discussions on the findings in relation to the eight broad categories of constraints highlighted in Table 1.

Project finance related constraints

Table 1 shows that out of the nine subconstraint factors identified under the project finance broad category, the most influential constraint to roading contractors' productivity and performance is the problem of inaccurate estimates. This finding is consistent with Peshkin et al.

(2007) conclusion that contractors themselves cause their problems by not accurately estimating the full costs of work prior to coming up with a tender figure. Perhaps, this problem is prevalent because of the competitive tendering process that is often based on lowest conforming tender which is mostly used for public sector contracts (Lee et al., 2002).

Workforce related constraints

Ten subconstraints were analysed under the workforce broad category. The most influential is the contractor's lack of good leadership/management capability. Müller and Turner (2010) argued that poor project management capability has huge impact on project outcomes due largely to poor coordination of the various stakeholders' inputs in the project delivery process.

Technology/process related constraints

Under this broad category, resistance to accept new technologies in road maintenance projects featured as the most influential out of the eight constraints in the group. This result is in agreement with Peshkin et al. (2007) conclusion that resistance to technology-driven change is usually due to the time and resources involved in training staff on the use of new technologies or simply because contractors are not convinced that the benefits are worth the investment. This is largely on account of a short-term view of the benefits of technology.

Project characteristics related constraints

Table 1 showed that the broad category of project characteristics comprised eight constraints. The most influential in the group relates to site location and associated environmental constraints such as traffic congestion, climate, subsoil, and topography. These findings are consistent with Lee et al. (2002) statement that location-based construction logistics issues such as road restrictions and traffic volume can significantly influence productivity and performance in road maintenance projects. In addition, Phillips and Kazmierowski (2010) found that subsoil condition could have a high level of impact on productivity rate in road projects.

Project management/ project team characteristics

Out of the 12 constraints identified under the broad category of project management/project team characteristics, issues relating to frequency of design changes or late change orders exert the highest influence. This finding agrees with the conclusions of Alinaitwe et al. (2007) that late change orders – especially at critical stages of the project implementation – could slow down progress; and if the Principal to the contract refuses to accept the changes as true variation under the contract conditions, the contractor bears the full risks, which could constrain the cash flow and completion time.

Statutory/ regulatory compliance
Nine factors were analysed under the broad category of statutory compliance. Issues related to compliance with the Health and Safety in Employment Act (now called Health and Safety At Work Act 2015) featured as the most influential out of the nine subconstraints. This should be expected because of the huge penalties associated with violation under the new Act. For instance, Work Safe New Zealand (WorkSafe NZ, 2016) advised that Category 1 offence under the new Act attracts the highest penalty for a company (up to $3 million), for an officer ($600,00 or five year years in jail or both) and for an ordinary worker ($300,000 or five year years in jail or both).

Unforeseen circumstances
Only four constraints were identified under this broad category. Inclement weather was rated as the highest influential factor among the four constraints. The New Zealand Standard 3910 includes inclement weather as part of conditions for variation entitlements only if a reasonable contractor is not able to foresee the weather pattern during the weather-constrained period of work; however the variation entitlements are not an option under lump sum fixed price contracts with no allowance for contract adjustment.

Other external factors
Eleven factors were identified under this group, with the highest influencing factor being issues relating to market conditions and level of competition in the industry. This finding should be expected given that the New Zealand construction industry in general is prone to boom-bust cycle which has been identified as one of the greatest problems hindering productivity and growth of the industry (Academy of Constructing Excellence New Zealand, CAENZ, 2015). The issues stemmed from cash flow problems associated with under-pricing during periods of stiff competition or resource problems associated with taking on too many jobs beyond company’s resource capacity during the boom phase.

Relative levels of impact of the broad categories of constraint factors on contractors’ productivity and performance
Table 2 presents the result of multi-attribute analysis of the participants’ ratings on the relative levels of impact of the broad categories of constraint factors on RPMR contractors’ productivity and performance. The table shows that out of the eight broad constraint factors, only the workforce constraint category was rated as being ‘High’ with a mean rating of 3.45. In diminishing order of impact, the following six constraint categories were rated as being ‘Moderate’: Project management/project team characteristics, project characteristics,

project finance, technology/process, unforeseen events, and statutory compliance.

In many respect, this result is not consistent with related findings in previous studies. For instance, Lee et al. (2002) and Peshkin et al. (2007) concluded that cash flow or project finance – being the lifeblood of the business – has the potential to exert the most profound influence on productivity and performance of contractors handling public and private sector projects. Also statutory/ regulatory compliance issues should have received very high rating given the increasingly over-regulated environment within which contractors operate in New Zealand, especially in relation to the new Health and Safety At Work Act 2015.

Perhaps, the perception that workforce related issues encapsulate all other issues could contribute to this result. For instance, statutory penalties occur when workers fail to do what they are supposed to do in terms of adhering to the specified compliance standards for the work. Cash flow or financial issues arise when workers fail to be prudent in their work processes or involve in excessive wastage, shoddy work or idleness.

Table 19: Relative levels of impact of the broad categories of constraint factors on contractors' productivity and performance

Broad categories of constraint factors	Ratings on relative levels of impact					Mean rating (Eq.5)	Level of Impact	Responses
	Very Low	Low	Moderate	High	Very High			
1. Workforce	2.6% (1)	10.5% (4)	36.8% (14)	39.5% (15)	10.5% (4)	3.45	High	38
2. Project management/ project team characteristics	0.0% (0)	10.8% (4)	54.1% (20)	27.0% (10)	8.1% (3)	3.32	Moderate	37
3. Project characteristics	0.0% (0)	15.8% (6)	44.7% (17)	36.8% (14)	2.6% (1)	3.26	Moderate	38
4. Project finance	7.9% (3)	26.3% (10)	34.2% (13)	23.7% (9)	7.9% (3)	2.97	Moderate	38
5. Technology/process	2.6% (1)	26.3% (10)	47.4% (18)	21.1% (8)	2.6% (1)	2.95	Moderate	38
6. Unforeseen events	2.7% (1)	40.5% (15)	32.4% (12)	16.2% (6)	8.1% (3)	2.86	Moderate	37
7. Statutory compliance	15.8% (6)	21.1% (8)	31.6% (12)	28.9% (11)	2.6% (1)	2.82	Moderate	38
8. Other external forces	24.3% (9)	35.1% (13)	27.0% (10)	8.1% (3)	5.4% (2)	2.35	Low	37

Findings Related to the Second Objective
Table 3 presents findings in relation to mitigation measures for addressing the identified constraints faced by RPMR contractors.

Table 20: Measures for improving productivity in the road maintenance and rehabilitation projects

	Constraint mitigating/ productivity Improvement measures	Response	Mean rating	Remarks
1	*Planning*: Proper planning should be done upfront to establish the benchmarks for downstream performance reviews and progress update; also provide plans for other challenges such as risks for statutory compliance (health and safety, environmental impact, traffic management, etc)	40	4.78	Very high
2	*Funding/ resourcing*: Provide adequate funding and cash flow to ensure good progress and quality of work; ensure adequate level of resources to suit work demands and optimise efficiency and utilisation (i.e. not too much or too little plant and people resource)	39	3.98	High
3	*Scheduling*: Proper scheduling of operations to smoothen peaks and troughs in resource demand in line with resource ceilings/ capacity. Schedule work to minimise impact of weather; e.g. weather affected works should not be planned in winter	38	3.88	High
4	*Communication*: Ensure effective communication network to permit adequate information flow for clarity and prompt decision-making and to minimise duplication of efforts due to communication gap to the 'frontline' people.	38	3.73	High
5	*Worker empowerment through engagement*: Involve all those that will implement the project in the planning and decision-making process so everyone knows the goals and expectations and can take ownership and commit to overall outcome achievement, as well get updated on changes.	38	3.68	High
6	*Teamwork/ collaboration through coordination*: Use good coordination skills to foster collaboration among key stakeholders - client, contractor, consultants, suppliers, etc - to work collaboratively and ensure maximum value delivery from design through production and construction to operation and maintenance.	40	3.63	High
7	*Procurement and contract strategies*: Clients should rethink preference for lowest price conforming tenders and traditional system approaches to more collaborative procurement and contract strategies that focus on life cycle value and win-win outcomes for all stakeholders.	37	3.59	High
8	*Skilled workforce*: Ensuring only qualified and experienced workers are employed to mitigate poor quality of workmanship and accidents on sites	38	3.55	High
9	*Staff training*: Provide adequate training programme to update and broaden staff skills on current best practices and trends, e.g. new occupational health and safety requirements on site. Up-skill the people making the decisions – i.e. engineers, clients and contractors.	39	3.52	High
10	*Early contractor involvement*: Encourage early contractor involvement in the design and planning and planning phase to ensure buildability and more innovation that can reduce costly and time-consuming variation and rework associated with design solutions not aligning with practical site	36	3.49	High

conditions.

11	*Supervision*: Proper supervision of the workforce to minimise idle time, poor productivity and work progress	38	3.46	High
12	*Project review and experiential learning*: Revisiting completed projects and learning from mistakes or better ways of achieving things outside the square -	36	3.44	High
13	*Innovation and win-win outcomes*: Minimise red-tape and bureaucracy in decision-making processes; encourage innovation and share equally any associated rewards for cost and time savings among contributors.	36	3.42	High
14	*Staff motivation*: Provide adequate incentives to motivate staff for peak performance	38	3.40	Mod
15	*Information technology (IT)*: Integration of IT in the work processes to improve efficiencies, productivity and performance, using minimal resource inputs.	37	3.38	Mod
16	*Technical and management competencies of decision-makers:* Improve technical/practical knowledge and management capability of road authority engineers & consultants to align their decisions to practical realities and in line with contractors' innovative processes for optimum productivity and outcomes.	39	3.37	Mod
17	*Outcome- rather than process-focused*: Focus on outcomes rather than process to avoid the current practice of missing the goal and 'covering of tracks just in case things might go wrong'	38	3.35	Mod
18	*More competitive market structure*: Resolve oligopoly to improve efficiencies through fostering competition and innovation. Encourage smaller work packages to enable small to medium competitors to compete for jobs rather than having gigantic projects that only the few big companies have capacity to compete for, which excludes the majority of the SMEs.	37	3.34	Mod
19	*Minimising over-regulation*: Minimise regulatory and statutory controls that inhibit innovation and creativity towards efficiencies and productivity. The regulators should be in partnership with the service providers, get on-board and work as teams, guiding each other along the way rather than waiting for mistakes and passing on blames.	35	3.33	Mod

Table 3 shows that none of the 19 mitigation measures identified during the pilot interviews was perceived as being ineffective for mitigating productivity constraints in the road pavement maintenance and rehabilitation projects. However, only one mitigation measure – i.e. proper upfront planning – was perceived as having ‘Very High’ level of effectiveness. This result is consistent with Alinaitwe et al. (2007) conclusions that proper planning which is based on accurate project data at the onset could prevent problems encountered at critical stages of the project implementation. This is because plans developed upfront provide the benchmarks for downstream performance measurement. It is surprising, though, to note that planning is superior to adequate funding and cash flow as productivity constraint measure. This contrasts with the findings of other authors such as Mbachu (2011) to the end that, as the lifeblood of the project execution process, cash flow is the key driver of success or failure in project delivery. Perhaps the study participants rated planning as the most effective mitigation measure on the understanding that proper planning should address all other issues including cash flow and resourcing.

Broad categories of the constraint mitigation measures
As an outcome of thematic analysis, the 19 sets of constraint mitigation measures presented in Table 3 were clustered under five broad categories. Figure 1 highlights the broad categories as technology/ process, human resources management, leadership/ project management, contract and financial management and external measures. Leadership/ project management should be the most effective mitigation measures since this cluster comprises the most effective mitigation measures presented in Table 3. This is consistent with KPMG's (2013) advice that the role of project leadership is to formulate a robust project delivery strategy; this typically drives every other aspect of the project including quality of design, cost construction and project completion date.

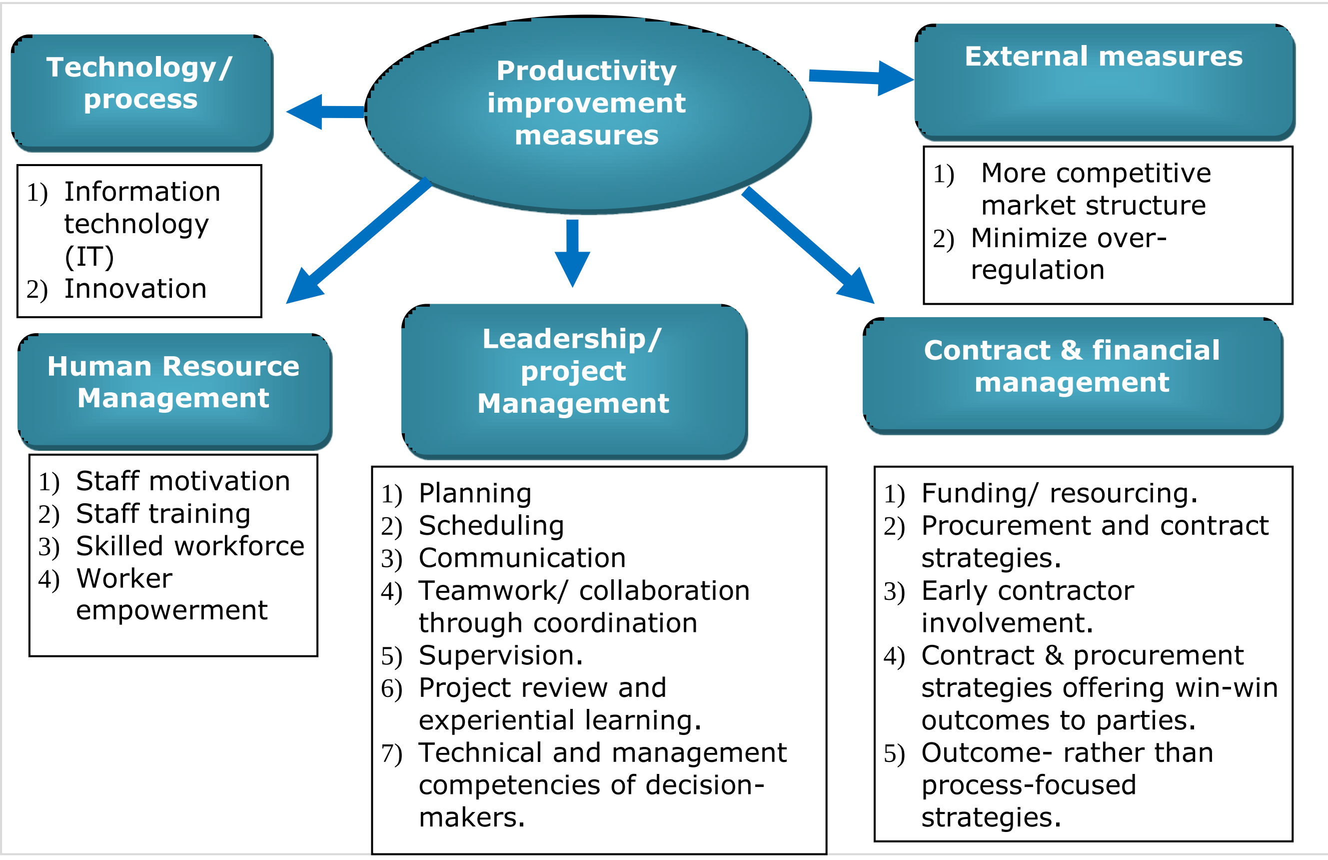

Figure 15: Measures for mitigating constraints and improving productivity and performance in the road pavement maintenance and rehabilitation projects

Extra suggestions

In the open-ended sections of the questionnaire, the interviewees provided extra suggestions for mitigating constraints and improving productivity and performance of the contractors in the road pavement maintenance and rehabilitation projects. The unedited suggestions are as follows.

"Currently jobs have to be milled, filled, and finished in one day. This means for every site you need a traffic management team, milling, and paving crew. If you could have independent milling and paving crews, you could double the output. Each crew could mill or pave for 8-10 hours per shift, instead of 4-6 hours each. The number of crews could be reduced and cost per ton laid would be significantly reduced".

"Allow for greater disturbance to public in order to have projects completed more efficiently and cheaper. Timing and availability of road closures is important - if we had full closures we could complete a whole lot more work".

"Across the board realisation that financial difficulties on smaller to medium contractors (i.e. not the big four main contractors in NZ) are reducing actual competition in the industry (which helps the big four). Genuine competition needs to occur and packages that suit contractors other than the big four need to be considered. Large companies are underbidding maintenance contracts to remove local competition".

"Use of more effective and efficient materials: e.g. use more SBS modified binders in place of current materials; and emulsion based products in place of current products".

"Use of partnering in the project procurement to achieve win-win outcomes for all".

CONCLUSIONS

This study aimed to investigate the priority constraints road pavement maintenance and rehabilitation (RPMR) contractors face in New Zealand (NZ) as well as strategies for improvement. Preliminary findings of interview-based qualitative survey of medium- to large-sized roading contractors in NZ revealed 70 productivity constraints which were aggregated into eight broad categories as follows: finance, workforce, technology/process, statutory/regulatory compliance, project characteristics, project management/project team characteristics, unforeseen circumstances, and other/ external factors.

Result of multi-attribute analysis of the relative levels of influence of the broad constraint categories on RPMR contractors' productivity and performance shows that only the workforce related constraint category was rated as being 'High' on a 5-point influence rating scale. In diminishing order of influence, the following six constraint categories were rated as being 'Moderate': Project management/ project team characteristics, project characteristics, project finance, technology/process, unforeseen events, and statutory compliance. Other external factors were perceived as being of low influence, indicating that the bulk of the constraints faced by the contractors stemmed from sources internal to the project environment.

Nineteen sets of measures were identified for mitigating the productivity constraints with a view to improving the contractors' productivity and performance. The most effective measure related to proper planning at the outset. The 19 sets of constraint mitigation measures were clustered under five broad categories, comprising technology/ process, human resources management, leadership/ project management, contract and financial management and external measures. Leadership/ project management was found as the most effective set of mitigation measures since this cluster comprises the majority of mitigation measures that received 'High' to 'Very high' ratings.
The findings have advanced existing knowledge by revealing critical factors constraining productivity performance of RPMR contractors in New Zealand, as well as effective measures for improvement. The key limitation of the findings at this stage of the research is that it is based on feedback from a limited number of participants which were not representative of the potential participants in the sampling frame for the study. As a result, the findings cannot be reliably generalised beyond the scope of the data used. Further research on the subject is recommended to ensure that representation of the views of the individuals and companies that comprised the sampling frame is achieved. The current findings will provide the starting point for the future research.

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2016