Productivity Improvement in Building Life Cycle

Development process, role-players and efficiency improvement

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Executive Summary

Background

The private housing sector is a key contributor to the well-being of citizens and the growth of the New Zealand economy. For instance, Infometrics (2012) finds that investment in owner-occupied dwellings accounts for 6.8 percent of the nation's GDP. Issues of a lack of supply, fragmented industry structure, overall risk-averse attitudes, a general reluctance to innovation, skills shortages, a slow take-up of sustainability and a less-than-responsive planning system are prevalent in the New Zealand housing sector as identified by the New Zealand Productivity Commission (2012). The Commission further identifies the poor performance of the building and construction industry as one of the key contributors to the prevailing housing affordability problems. The Commission was convinced that "better productivity can increase housing affordability by improving the quality of building work and by reducing construction costs which generally account for half of a typical house and land package, depending on the land value". (p. 171).

More importantly, improvement in the productivity performance of the residential construction sector has significant implication for the wider economy. For instance, a 10% increase in the productivity of the building and construction sector results in a 1% increase in the New Zealand's GDP or a lift in value of approximately $1.5 billion annually (Building and Construction Productivity Partnership, nd). Moreover, every dollar investment in the construction sector translates to three dollars of economic activity in other sectors of the New Zealand economy (Building and Construction Productivity Partnership, nd).

There is therefore the need to research the potential ways of improving productivity gains in the RBLC.

Purpose

This study aims to investigate the potential productivity increase leverage points in the phases of the multi-unit residential building life cycle (RBLC) to establish where the biggest productivity improvements could be made. The key objective of the study is to find answers to the following research questions.

1. What does productivity mean to the research participants?
2. What are the relative levels of contribution of the phases in the housing production and disposal process to the overall productivity outcomes in the RBLC?
3. What are the productivity/efficiency limiting factors at each phase and for the whole cycle, and how could these be addressed?
4. Where do the potentials for the biggest productivity improvements exist in the RBLC and how could productivity be improved, overall?

Method

The study focused on investigating how key role-players could constrain or enhance productivity in order to gain an understanding of the key productivity barriers and enablers in the cycle.

Personal interviews were conducted with 38 key role-players involved in the various phases of the RBLC. The entire research design and implementation was based on progressive focusing (Parlett and Hamilton, 1976; Anderson, 2003). This approach permitted the adjustments of the data collection process to include the investigation of new concepts or relationships as the bigger picture became clearer with additional insights gained from the interviewees' progressive feedback.

Purposive sampling (Patton, 1990; Morse, 1991) was the most appropriate for the nature and purpose of the study. This allowed the recruitment of stakeholders who could give authoritative feedback on the subject matter, who were abreast with the issues on ground through their current involvement in the building process, and "who were articulate, reflective and willing to share with the interviewer" (Coyne, 1997; p. 624). The interviewees were recruited in a snowballing fashion through leads provided by those previously interviewed, followed by visits to 24 residential building sites in different parts of the Auckland region where the researchers interviewed the owners, the builders and other key role-players.

At the end of the interviews, feedback was analysed using concept categorisation, involving content analysis, frequency counting, and descriptive statistics. The content analysis (Patoton, 1990) was used to establish the recurrence of important constructs or themes in the interviewees' feedback. The multi-attribute technique was used for the analysis of the ratings made by the interviewees (Tronchim, 2006 and Saunders et al., 2006). Both methods facilitated numerical analysis by frequency counts and graphical displays of the results for better visual appreciation and interpretations.

Results

Perceptions of productivity

In order to put participants' feedback in context, their understanding of the concept was first explored by simply asking the question: "In your role in the residential building process, what does productivity mean to you?" Analysis of the interviewees' feedback yielded the following 3 key components for a project-level definition of productivity:

- '*Efficiency*': this is the economic perspective of productivity, focusing on the optimal use of resources. This aligns with the output-input schema, where the overall focus is to "achieve more (output) with less (input)". This perspective of productivity was mentioned 39% of the time; meaning that the economic perspective on productivity is not widely shared by the stakeholders as a key component of productivity at the project level.

- '*Effectiveness*': This is the ability to achieve set objectives. In the project context, the objectives are cost/budget, time/schedule, scope and quality. This is more of a performance issue and perhaps, explains why the terms 'productivity' and 'performance' are used in tandem. This perspective was mentioned 35% of the time.
- *Sundry items*: The participants also expected productivity to involve the achievement of other indicators of performance such as safety, client satisfaction, relationships (including absence of disputes/litigations), workforce satisfaction, reputation (for performance), future job orders, and regulatory/statutory compliance. These sundry items accounted for about 26% of the recurring themes in the interviewees' expectation or understanding of the concept of productivity.

Overall, the concept of productivity was seen as a metric for assessing the extent to which value has been delivered. The 'value' in this case may mean different things to different stakeholders depending on their value system. However, a general understanding of the value is the extent to which the set targets or objectives have been achieved on one hand, and the extent to which the available resources have been optimised in the delivery process, on the other hand. To survey participants, productivity is at its optimum level if the set targets have been achieved, while utilising the minimum amount of resources possible in the process. This is important because it goes further than the output-input perspective of the economist which focuses solely on the quantum of output per unit of resource inputs (Davis, 2007). Except where the output-input ratio constitutes the objective to be achieved or the set target, the economist's perspective misses out on the 'performance' aspect of the focus on value delivery. Having a balanced view of productivity ensures that productivity improvements are not made by scarifying the quality of the finished building, which might well be the case if all that is focussed on is the having more output with less input without caring for the quality of the output.

Relative levels of contribution of the phases to the overall productivity outcomes in the RBLC

The study proceeded with the proposition that RBLC could be segregated into nine interdependent phases: the inception, design, documentation, construction, close-out/commissioning, operation & maintenance, upgrade/conversions, and decommissioning phases. However, productivity measurements in the RBLC occur at the end of four points in the cycle: 1) the development phase (which is marked by the close-out/commissioning stage), 2) the preventative and corrective maintenance stages within the operation and maintenance phases, 3) the upgrade/conversion phase, and 4) the decommissioning (i.e. deconstruction and disposal) phases. The inception and design phases of the RBLC were found to offer the greatest potentials for productivity increase leverage as the decisions made at these two phases set the parameters that define the building characteristics and the delivery outcomes at the development phase as well as the subsequent performance of the building at the operation and maintenance, conversions and decommissioning phases.

Productivity/efficiency limiting factors in the RBLC

Overall, four key role players were perceived to be the greatest influencers of the outcomes of productivity and performance in the RBLC. In order of influence, these are: the designers; building owner; project manager; and the builder, with the local councils coming in as the fifth most influential role player. The critical areas of influence of these key role players on the productivity outcomes in the RBLC are summarised as follows.

Key areas of the building owner's influence on the RBLC productivity outcomes

These comprise brief and strategic choices in 4 key areas (4Ps):

1. Place: Location characteristics and their impact on the development costs, building value and capital appreciation rate at the in-use phase.
2. Product: Building characteristics and their impact on development, operation and maintenance costs throughout the RBLC.
3. Process: Project preferences and specifications, and their impact on the development risks and costs.
4. Performance: Performance metrics (KPIs), management and outcome monitoring, and their impact on the development risks and costs at the development phases.

Key areas of the designer's influence on the RBLC productivity outcomes

1. Quality of brief articulation and design development.
2. Appropriateness of material selection and specifications.
3. Quality of design information documentation and communication.

Project management influence on the RBLC productivity outcomes

Whether performed by the building owner, the designer or the builder, the quality of the project management role could impact significantly on the productivity outcomes in the RBLC in 6 ways:

1. Quality of planning and risk management.
2. Quality of project organisation.
3. Quality of project communication/information management.
4. Quality of the monitoring, reviewing and control of the performance of the service providers.
5. Quality of the coordination and supervision of the service providers.
6. Overall quality of the project leadership.

Key areas of the builder's influence on the RBLC productivity outcomes

1. Quality of construction planning and risk management.
2. Effectiveness and efficiency of site organisation & management.
3. Effectiveness of coordination & supervision subcontractors and own workforce.
4. Quality of progress monitoring; review & control of performance.
5. Level of regulatory and statutory compliance (RMA, HSEA, codes and standards, bylaws).

External factors' influence on the RBLC productivity outcomes

The stakeholders have control over their own influences and can do something about these influences by addressing the issues highlighted in their roles and responsibilities. However, they have less control over the impact of the key external factors, which comprise the following:

- Industry characteristics:
  - Boom-bust cycle;
  - composition/structure; dominance of small firms;
  - business model, capacity & capability issues;
  - attitude, culture and resistance to change;
  - skills shortage,
  - Margins/profitability; competition.
  - technology & innovation.

- Market conditions:
  - Economic recession;
  - Business/investor confidence;
  - Demand and supply for services and outputs;
  - Availability of project finance.

- Regulatory/statutory compliance:
  - RMA, HSEA, Local Government Act; Building Act; Council bylaws;
  - Building codes, building standards;
  - Resource and building consent issues;
  - Land supply and development policies.
  - Rapid rate of regulatory reforms.

By being mindful of, and by formulating adequate contingency plans for, these critical external factors, the stakeholders would be better positioned to significantly redress the prohibiting factors and lift productivity gains in the RBLC.

Recommendations

To improve productivity in the RBLC, the following recommendations are put forward.

1. Key role players should take steps to rethink the identified key areas in which they negatively impact on productivity outcomes in the RBLC.
2. Adequate contingency plans should be put in place to cushion the negative impact of the external limiting factors.
3. The government and the industry should work together to address the key industry characteristics, market conditions and the regulatory/statutory compliance issues which limit the ability of the stakeholders to innovate and improve productivity.
4. The building owner's proclivity to design customisation and frequent change orders should be discouraged through professional advice on the negative impact on costs, scope, completion time and value of the finished property.
5. The building consent processes should be made cheaper and fast-tracked through initiatives such as online consenting, streamlined BCA operations and greater use of the standard, multi-proof building designs.
6. The owner-builder exemption to the restricted building work regime should be re-considered given its tendency to result in low productivity and a return to the era of leaky building in the near future.

7. Greater use of the CodeMark product certification scheme to provide a wider range of materials and components for use by designers to deliver more economic, flexible, innovative, productive and environmentally friendly design solutions to satisfy a variety of end-user requirements.
8. Encourage the involvement of home-builders who have in-house design, management and construction capacity to provide one-stop design and build service to the owner. This contrasts with the current domination by volume builders who do not have the technical expertise of home-building to effectively coordinate and manage the quality of work and performance of the specialist tradespeople engaged to deliver the job.
9. Greater use of off-site manufacturing system to improve quality, speed, life cycle costs, productivity and sustainability in the home building sector.

Implications of the findings for industry practice, education and research

The findings of this study provide rich insights into residential building procurement process, new house building process, productivity measurement in construction, building life cycle phases, and the key role players in the building development process and their influences on productivity at their respective phases of operation in the residential building life cycle. Key beneficiaries of the practical and theoretical knowledge provided in this report include industry practitioners, researchers, teachers and learners in tertiary education in the field of residential property development. Building Control Officers, property consultants, property researchers, project managers, building contractors, quantity surveyors, architects, teachers and learners in the field of construction management, quantity surveying, real estate, building science, architecture and town and regional planning will benefit from this work.

Keywords: Building life cycle, New Zealand building and construction industry, productivity improvement, productivity measurement, residential building.

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Introduction

This exploratory study focused on the assessment of the productivity increase leverage points in the multi-unit residential building life cycle (RBLC) phases. It was largely based on the information provided via personal interviews with a number of key stakeholders involved at the various phases of the RBLC. Insights from the literature were also added to improve clarity of the issues being discussed.

The Report presents the results of the 38 personal interviews held with key role-players in the residential building development cycle, including owners, builders, specialist tradespeople, property consultants, developers, building inspectors, architects, and engineers. The interviews were aimed at assessing the productivity limiting factors in the RBLC phases and the recommendations for productivity improvement.

The Report is divided into seven sections. Section 1 provides the background to the study; it details the terms of reference, purpose and scope of the study. Section 2 highlights the context of the study within an overarching construction systems research and the systems mapping project commissioned by Scion in collaboration with BRANZ. Section 3 focuses on the research problem and the conceptual issues that underpin the thrust of the study. Section 4 presents the research method for the study, including the scope of investigations, and how the empirical data was gathered and analysed. Section 5 is for the key results and their discussions in relation to the research objectives. The section also explores the productivity increase leverage points at each phase based on the relative levels of influence of the stakeholders at the phases. Section 6 is for the conclusions and the recommendations for actions.

Disclaimer

The report recommends actions that could be undertaken to improve productivity at each phase of the RBLC. Before these could be considered as support for formulating policy and action plan, it is recommended that the findings be validated at an industry workshop where other stakeholders will be given the opportunity to make further inputs, including confirming, disconfirming, adding to or amending the findings to improve their reliability and buy-in by the industry.

The project was exploratory in nature; the scope of the investigations was shallow and the data points were limited in size. As a result, the findings, and the conclusions and recommendations flowing them, may be used with caution, as they may not be generalised beyond the study scope. In addition, the study was a snapshot of opinions at a given point in time. The information contained in this report therefore has a high degree of uncertainty for future applications; it will be subject to change as new trends and opinions emerge.

1 Background

1.1 Terms of reference

The key task for the Massey academic staff participating in the research was to undertake a case study as part of the overarching systems mapping project aimed at identifying the points in the RBLC where potential opportunities exist for improving productivity in the cycle.

The case study involved stakeholders at the various phases of the RBLC with a focus on the following:

1. Assessing the potentials for improving productivity at each phase, and for the whole RBLC of the case study projects.
2. Identifying productivity/efficiency limiting factors at each phase, and for the whole RBLC of the case study projects.
3. Compiling a report on the outcomes of the case study, including making recommendations for improvement.

Study team

The Productivity Increase Leverage Points in the RBLC Scoping Study was led by Dr Jasper Mbachu of the School of Engineering and Advanced Study (SEAT), Massey University at Albany. Doctoral research students – Myzatul Kamarazaly and Wajiha Shahzad – assisted with the fieldwork. The Study was project-managed by Dr Jeff Seadon and funded by SCION and BRANZ.

1.2 Purpose of the study

The study report is expected to provide the Building and Construction Sector Productivity Partnership with an empirical basis on which to consider for further scrutiny, the priority actions required to improve productivity in the key phases of the RBLC, as part of the overall strategic agenda of improving the construction industry productivity by 20% by 2020.

1.3 Scope of the study

Investigations were limited to site-based personal interviews with builders and home owners on building sites, and phone interviews with developers, council officials and consultants.

As an exploratory study with no pre-determined sampling frames, snowballing technique was used to identify potential residential building sites for the site-based interviews through leads provided by participants as more building sites were visited. The first study period was from the middle of March to the first week of October 2012. The second study period was from the middle of February to end of June 2013. Follow-up interviews were carried out at random to seek further clarifications on some important concepts that emerged from the analysis.

In total the residential buildings covered in this study comprised 24 buildings/sites in Auckland. The buildings were a mix of 3–4 bedroom bungalows and duplexes grouped as follows.

- Group 1 case study buildings: residential buildings being currently developed. (10 buildings sites involved: 3 building sites comprised 18 standalone duplexes on standard designs; 7 building sites on bespoke architectural designs, comprising 4 standalone bungalows (4 sites) and 3 standalone duplexes (3 sites)).
- Group 2 case study buildings: residential buildings currently in use (6 standalone buildings);
- Group 3 projects: residential buildings currently renovated or upgraded. (5 standalone buildings involved);
- Group 4 projects: residential buildings currently decommissioned (i.e. deconstructed and recycled. 3 standalone buildings involved).

The Groups 2 to 4 buildings were constructed within the post-2000 or post-2005 era.

The standard designs in Group 1 buildings were project-managed by design and build group home builders. Two of the 7 buildings on bespoke designs in the Group 1 buildings were managed by the owners, while the 5 others were managed by small builders. The standard designs were relatively complex and comprised largely panellised offsite manufactured systems. The owner-managed bespoke designs were also complex in terms of the shapes and forms, and were largely traditional stick-built types. The builder-managed bespoke designs were not so complex; pre-nailed frames were used for the wall, floor and roof framings. The Group 2 buildings were recently completed with the owners/users moving in the 6–8 months following completion. The maintenance issues experienced were part of the emerging defects covered under the Warrantee/Guarantees. These included plumbing and electrical fixings, door hinge problems and other minor defects being fixed by plumbers, electricians and builders who completed the buildings. The Group 3 buildings were relatively old buildings. It was not possible to establish the age of the buildings from the owners who claimed they bought the buildings some years ago. The renovation or upgrade works were largely the ceiling and underfloor insulation and heating installation with financial assistance under the EECA's "Warm Up New Zealand: Heat Smart" programme. Being qualified under the scheme, the houses might have been built before 2000. The owners said they received $1,300 from the Energywise funding towards the cost of the installation. The key incentive was the ability to pay the remaining balance (about 67%) of the installation costs at a rate of $7–10 per week as part of their mortgage repayments or council rates for a 10-year payment period. In addition to the insulation installation, the renovation work in two of the houses included external wall reclad against leaky problems. The Group 4 buildings were demolished to pave way for new duplexes as at the time of conducting the survey. Though the ages of the buildings were not established, the demolition was to maximise the land value for higher quality developments. Overall, the selection of the buildings was for exploratory study and not necessarily for quantitative representations of the various classes of buildings. Patton (1990), Sage (2010) and Cresswell (2010) note that the key aim of exploratory study is to explore constructs or themes for theory-building, while quantitative studies focus on theory-testing and involve representative sampling for use in generalising outcomes beyond the study scopes.

2 Context Of The Study

2.1 Overarching research initiative

To address the issue of low productivity in the building and construction sector, the Productivity Partnership – a partnership between the industry and the government – was established in November 2010, with a goal to transform the way the sector works in order to build value and raise the sector's productivity by 20% by 2020. The partnership was established following the recommendations of the Building and Construction Sector Productivity Taskforce which identified the low productivity issues in the industry in 2009 (DBH, 2009). The taskforce was established by the Minister of Building and Construction in August 2008 with the goal of researching the issues and making recommendations on how to bring about a turn-around to the declining productivity of the building and construction sector, paying particular attention to sector skills and procurement. The taskforce concluded its mission and reported back in late July 2009 with comprehensive recommendations on issues impacting on the sector's productivity and solutions for improvement, including a suggestion for a joint industry/government approach to resolve the issues, collaboratively. The Partnership was given birth to, on account of this suggestion.

2.2 Industry processes

This research theme was motivated by lack of understanding of industry processes. This gap in information documentation has been identified as part of the barriers to improving the sector performance (Davies, 2007; DBH, 2009; Mbachu and Durdyev, 2011). A systems mapping project was commissioned to understand the construction systems involved in the production of different types of buildings at every stage of their life from their conception, client brief, design, consenting and construction through to their use, maintenance and demolition. This work also involves case study research of successful construction projects. The emphasis is on determining those aspects of individual projects that either contributed to or compromised the effectiveness and efficiency of the resources applied to the project.

3 Research Problem And Conceptual Issues

3.1 Overview

This section highlights the background, the research problem statement, the research aim, the research questions and the research objectives. The section also sets out the conceptual issues that underpinned the study based on the international literature. These insights were tested for relevance in the New Zealand context during the exploratory surveys.

3.2 Background to the research problem

The private housing sector is a key contributor to the New Zealand economy. For instance, Infometrics (2012) finds that investment in owner-occupied dwellings accounts for 6.8% of the nation's GDP. As at 2010, the New Zealand housing stock was valued at approximately $600 billion – which was 12 times greater than the $50 billion capital value of the New Zealand share market (DBH, 2010). The value as at the first quarter of 2013 was $672 billion (RBNZ, 2013); this indicated value addition of roughly $72 billion over the 3 year period from 2010 to 2013; i.e. an annual increase in value of about $24 billion. In the building and construction sector, new developments and refurbishment were expected to cost $15 billion annually (Brealey, 2012). This shows that shifts in the market dynamics contribute only $7 billion or 37 percent annually to the growth in the value of the housing stock, while physical development (i.e. land and buildings) accounts for the majority, i.e. about 63 percent – of the annual value increment. The Productivity Commission (2012) puts the section prices as 60 percent of the cost of new dwelling. That means that 40 percent is for the construction, which still accounts for a significant proportion of the total cost of new dwelling. Productivity improvement in the RBLC could therefore contribute to a significant reduction of the house development and refurbishment costs and improve value addition in the residential sector. More importantly, productivity improvement in the housing subsector could translate to improvement in the productivity of the building and construction sector as well as for the overall economy. This is evident from the fact that a 10 percent increase in the productivity of the building and construction sector results in a 1 percent increase in the New Zealand's GDP or a lift in value of approximately $1.5 billion annually (Building and Construction Productivity Partnership, nd). More over, every dollar investment in the construction sector translates to three dollars of economic activity in New Zealand (Building and Construction Productivity Partnership, nd). There is therefore the need to research the potential ways of improving productivity gains in the RBLC.

3.3 Research aim, questions and objectives

The key objective of the study is to find answers to the following research questions.

1. What are the relative levels of contribution of the phases in housing production and disposal that contribute to the overall productivity outcomes in the RBLC?
2. What are the productivity/efficiency limiting factors at each phase and for the whole cycle and how could these be addressed?
3. Where do the potentials for the biggest productivity improvements exist in the RBLC and how could productivity be improved, overall?

3.4 Productivity in context

Productivity is a complex phenomenon to define (CAPCUCI, 2009). The New Zealand Building and Construction Sector Productivity Partnership (BCSPP, 2012) identifies the key underpinnings of 'increased productivity' as including the following:

- More outputs for fewer or the same inputs.
- Better value for customers at a competitive price.
- More efficient procurement of resources.
- Increased standardisation.
- Design and build for whole-of-life.
- The right type and level of skills.
- Greater use of technology and innovation.

Though the above criteria point more to the benefits or outcomes of 'increased productivity' rather than its definition, they nonetheless provide insights to the whole essence of productivity in the context that resonates well with the industry understanding of the concept.

4 Research Method

4.1 Overview

This section presents the research method for the study. It highlights the scope of the investigations, and how the empirical data was gathered and analysed.

4.2 Conceptual framework for the study

A conceptual framework for the study is shown in Figure 1.

Through a four-step process, the framework considers the overarching aim of the study, the research questions, the nature and sources of data needed to address the questions, the required analysis and the expected outcomes that would contribute to meeting the overall research aim.

The framework considers two streams of investigations: 1) the phases of the RBLC and the key role players at each phase; 2) The external factors in the operating environment having significant impact on the RBLC productivity outcomes.

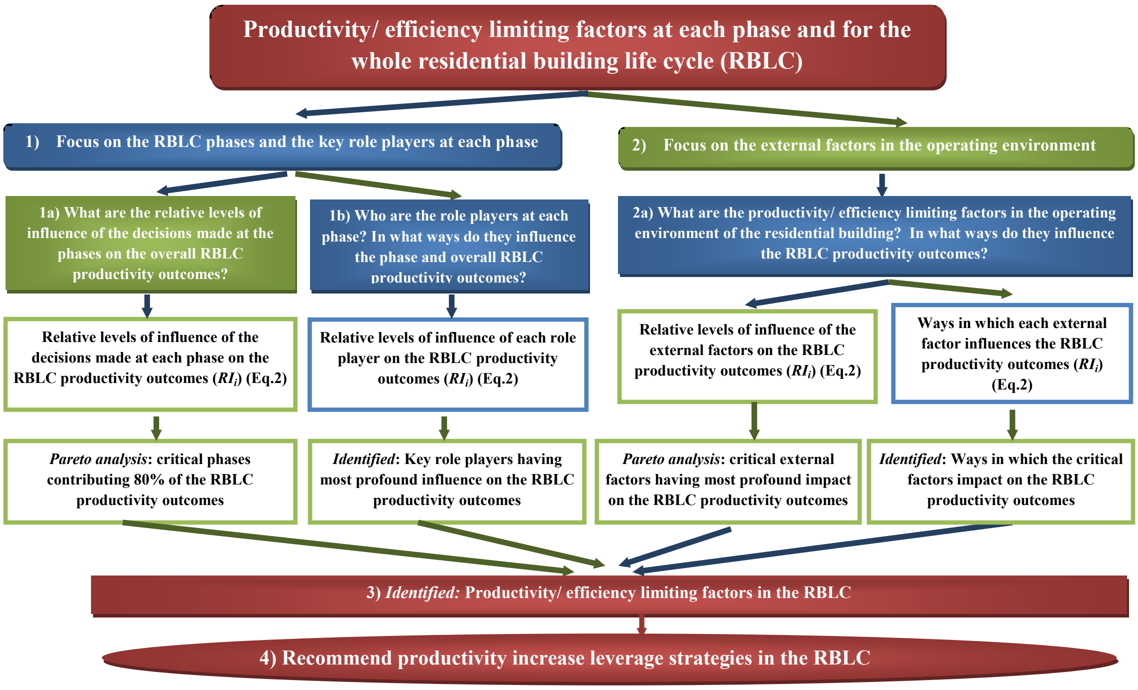


Figure 1: Conceptual framework for the study

Focus on the RBLC phases and the key role players

The focus on the RBLC phases and the key role players started by asking two key questions:

a) What are the relative levels of influence of the decisions made at the phases on the overall RBLC productivity outcomes? The data was analysed to give the relative contribution of each phase to the overall productivity outcome, using the expression for the Relativity Index (Equation 2 in the Data Analysis section The outcome of this analysis became the input data for further analysis, which further looked at the phase(s) that contributed to the 80% of the RBLC productivity outcomes;
b) Who are the role players at each phase? In what ways do they influence the phase and the overall RBLC productivity outcomes? The results of the influence analysis revealed the key role players having most profound influence on the RBLC productivity outcomes. The ways in which these key role players influence productivity then became the focus of in-depth inquiry with a view to discovering where the biggest opportunities exist for productivity increase leverage in the cycle.

Focus on the external influential factors in the operating environment

The second focus on the operating environment started by asking two key questions:

a) What are the productivity/efficiency limiting factors in the operating environment of the residential building? In what ways do they influence the RBLC productivity outcomes? These questions prompted the interviewees to reflect on the nature and impact of the factors in the operating environment which were beyond the control of the stakeholders in the RBLC. A copy of the interview schedule is included in the Appendix. It should be noted that the interviews were partly by face-to-face with the site-based building owners, builders and specialist tradespeople, and by phone with the other role-placers such as the designers, council officials, developers and consultants. The questions were structured in terms of the issues for which feedback was needed. The relative levels of influence of each role player on the overall RBLC productivity outcome were analysed using Equation 2. The results of this analysis were subjected to further analysis which helped identify the top influential role players having profound influences on the RBLC productivity outcomes;
b) What tasks do the role players perform at each phase, and how does each task influence productivity outcomes at a particular phase and for the entire RBLC? This analysed the relative levels of influence of each role player's task on the productivity outcome of the associated phase, using Equation 2. The results of the influence analysis revealed the critical tasks having profound influence on their respective phase productivity levels.

1. The critical activities of the priority phases were associated to the top influential role players for accountability purposes.
2. The needed improvement in the critical activities of the priority phases were associated with the top influential role players.
3. The findings of the investigations in step 4 above informed recommendations about the productivity increase leverage strategies in the RBLC.

This scoping study identified the RBLC phases and the activities required at each phase. It has also identified the role players at each phase and their roles (Table 1).

The second stage of the project focused on obtaining feedback from interview participants. Part of the feedback included rating of the relative levels of influence of the identified phases, activities, role players and their roles on productivity at each phase and for the overall RBLC.

It should be noted that some researchers such as Babbie (2005) and Reips and Funke (2008) make an important distinction between a 'Likert scale' and a 'Likert item'. The 'Likert scale' is the sum of responses on several 'Likert items'. Thus, whereas the Likert item could be one-dimensional, the Likert scale is multi-dimensional and could be subjected to multi-variate or multi-attribute analysis. However, Reips and Funke (2008) caution about the inherent drawback in use of Likert rating scale measures for quantitative analysis, which is the assumption that the ordinal nature of the Likert scale measures are as good as interval-scale measures. However, the authors found that this assumption is permissible only where the Likert scale is symmetric or balanced with equal amounts of Likert items on opposite sides of the scale from a transition or neutral position. Otherwise, the Likert items should be rescaled to interval scale using Correspondence analysis. The 5-point Likert scale used in the study satisfies the symmetric or balanced scale which requires no rescaling to interval scale.

Further details about the data analysis are provided under the Data Analysis subsection.

4.3 Research implementation process

The research implementation followed a seven-step process as shown in Figure 2. It started with the agreement on the Terms of Reference and scope, through scoping study report to empirical study, final report and dissemination of research findings.

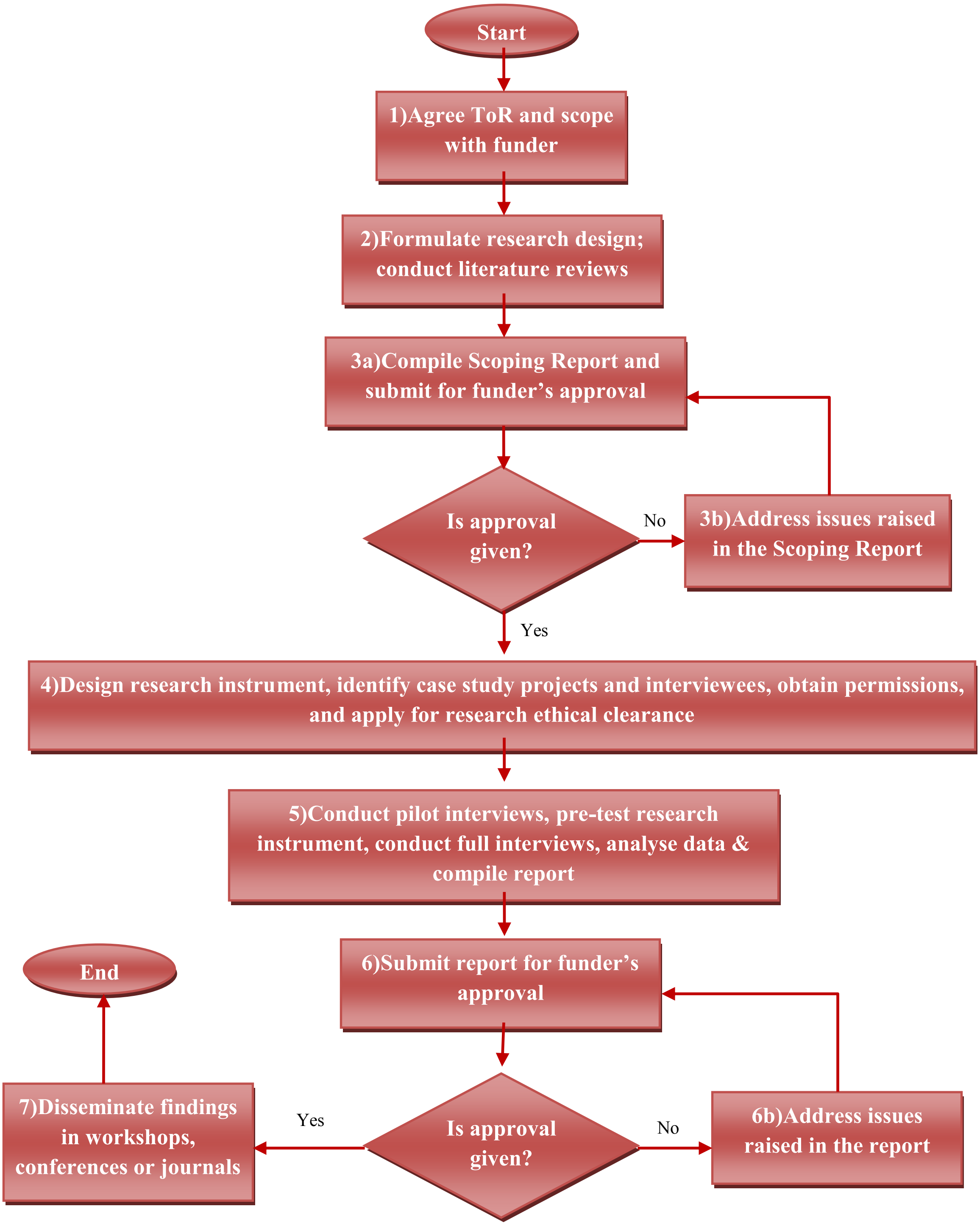


Figure 2: Flow chart of the research process

4.4 Case studies: Research strategy and action plan

Research strategy

A three-phase approach was adopted in the empirical data gathering for the study. In the first phase, pilot interviews were held with a sample of nine stakeholders involved in the RBLC. These comprised a building owner, a developer, an architect, an engineer, a builder, a specialist tradesperson, a project manager, a quantity surveyor, a building control officer, and a property manager. The purpose of the pilot interviews were to generate constructs for the design of the interview schedule for a larger survey of stakeholders as planned for the study.

In the second phase, the survey instrument was tested for clarity and relevance with another set of volunteers comprising a developer, an architect and a builder. The pre-testers' feedback formed the basis for fine-tuning the interview schedule to improve its appeal to the participants in the larger survey.

The third phase surveys involved case studies of residential buildings at the various phases of the building life cycle. For each case study project, one-on-one interviews were conducted with the key stakeholders as detailed in Table 1. Using an open-ended but structured interview schedule feedback was received from the survey participants. The interview questions sought the stakeholders' perceptions on the following:

1. The concept of productivity. This was to enable the interviewee to qualify his or her responses to the ensuing questions based on his or her understanding of the concept.
2. Productivity/efficiency limiting factors in the RBLC phases and their sources. The interviewees were prodded to reflect on three streams of issues:
   a) the role players at the RBLC phases and their influences on the productivity outcomes at their phases and the overall cycle;
   b) the external factors and their impacts on the RBLC productivity outcomes; and
   c) General comments on how to lift productivity in the cycle.

The interviewees' responses included some form of ratings on the relative levels of impact or contributions of the constraints on the phase and overall productivity outcomes in the RBLC. Aggregation of the feedback from the 19 stakeholders across the 24 case study projects plus an additional 21 interviewees at a second stage interview sessions, yielded data for analysis with a view to providing answers to the research questions, as well as insights on the productivity increase leverage points at each phase and for the overall building life cycle.

	Building life cycle phase	Key role players to be interviewed at each phase	Interviewees	
			Phase 1	Phase 2
1	Inception/conception	Building owners	3	7
2	Design & building consent approval	Architects/architectural draughtsmen, engineers and building consent authority/ building officers	4	4
3	Contract documentation, tendering, budgeting, planning and organisation	Quantity surveyor/estimator, project manager/planner	2	2
4	Construction and commissioning	Builders; specialist tradespeople; and building inspectors	5	6
5	Operation and maintenance; conversion/upgrade	Owner-managed retrofitting; maintenance contractors and building services engineer	3	2
6	Deconstruction, recycling/re-use	Demolition contractor; recycling operators.	2	
	Total number of interviewees for the building life cycle		19	21

Table 1: Interview details for the exploratory surveys

4.5 Method

Since the productivity outcomes at each phase and for the overall RBLC are influenced by the actions or inactions of the key role-players operating at the particular phase (DBIS, 2010; Mbachu and Nkado, 2007), the study focused on investigating how these key role-players could constrain or enhance productivity in order to gain an understanding of the key productivity barriers and enablers in the cycle.

The exploratory nature of the investigations necessitated the use of personal interviews with 38 key role-players involved in the various phases of the RBLC. The entire research design and implementation was based on progressive focusing (Parlett and Hamilton, 1976; Anderson, 2003). This approach permitted the adjustments of the data collection process to include the investigation of new concepts or relationships as the bigger picture became clearer with additional insights gained from the interviewees' progressive feedback.

Among the various sampling methods in qualitative research, the purposive sampling technique (Patton, 1990; Morse, 1991) was found most appropriate for the nature and purpose of the study. This allowed the recruitment of stakeholders who could give authoritative feedback on the subject matter, who were abreast with the issues on ground through their current involvement in the building process, and "who were articulate, reflective and willing to share with the interviewer" (Coyne, 1997; p. 624). With no pre-defined sampling frame for the study, the bulk of the interviewees were recruited in a snowballing fashion through leads provided by those previously interviewed, followed by visits to 24 residential building sites in different parts of the Auckland region where the researchers were able to successfully negotiate access to interview the owners the builders and other key role-players.

At the end of the interviews, feedback was analysed using two key methods of qualitative data analysis: concept categorisation using content analysis and frequency counting using descriptive statistics. The content analysis involving the conceptual and relational forms of analysis (Patoton, 1990) was used to establish the recurrence of important constructs or themes in the interviewees' feedback. The multi-attribute technique was used for the analysis of the ratings made by the interviewees. Tronchim (2006) and Saunders et al. (2006) recommend this method as a valid approach for simplifying and presenting quantitative data or feedback in a manageable form. Both methods facilitated numerical analysis by frequency counts and graphical displays of the results for better visual appreciation and interpretations. Sage (2010) recommends combining different qualitative methods to take advantage of in depth study of phenomena, yet permitting some form of quantitative analysis to enrich understanding of the meaning inherent in the qualitative data. Cresswell (2010) and Anderson (2003) prefer calling this approach the 'mixed method' of research.

4.5.1 Data analysis

As indicated above, the empirical data collected at the third phase of this study were analysed using the multi-attribute analytical technique. Two parameters were evaluated to obtain the relative contributions or the relative influences required in the conceptual framework: the mean rating (MR), and the relativity index (RI).

Mean rating (MR)

This analysis involved analysing the ratings of the survey participants to establish the mean rating (MR) for each attribute in a set that represented the combined ratings of all the respondents. The ranking of the attributes in the set was based on the MR values. Mbachu (2008) provides the generic expression for the computation of the MR value (see Equation 1).

$$MR_j = \sum_{k=1}^{5} (R_{pjki} \times \%R_{jk}) \quad (1)$$

(Where: MR_j = Mean Rating for attribute *j*; Rp_{jk} = Rating point *k* (ranging from 1–5); $R_{jk\%}$ = percentage response to rating point *k*, for attribute *j*).

Relativity Index (RI)

The relativity Index (RI) was adapted from the relative importance index (RII) devised by Mbachu and Nkado (2007). Its purpose was to evaluate how the subcomponents contributed to the component level outcome. It was computed as a unit of the sum of mean ratings (MRs) of the subcomponents within a set of variables. Equation 2 is an expression for the RI.

$$RI_j = \frac{MR_j}{\sum_{j=1}^{N} MR_J} \quad (2)$$

Where:

R_j = Relativity index for the j^{th} subcomponent in a set. This could also be expressed in %.
MR_j = Mean rating for the jth subcomponent computed using Equation 1.

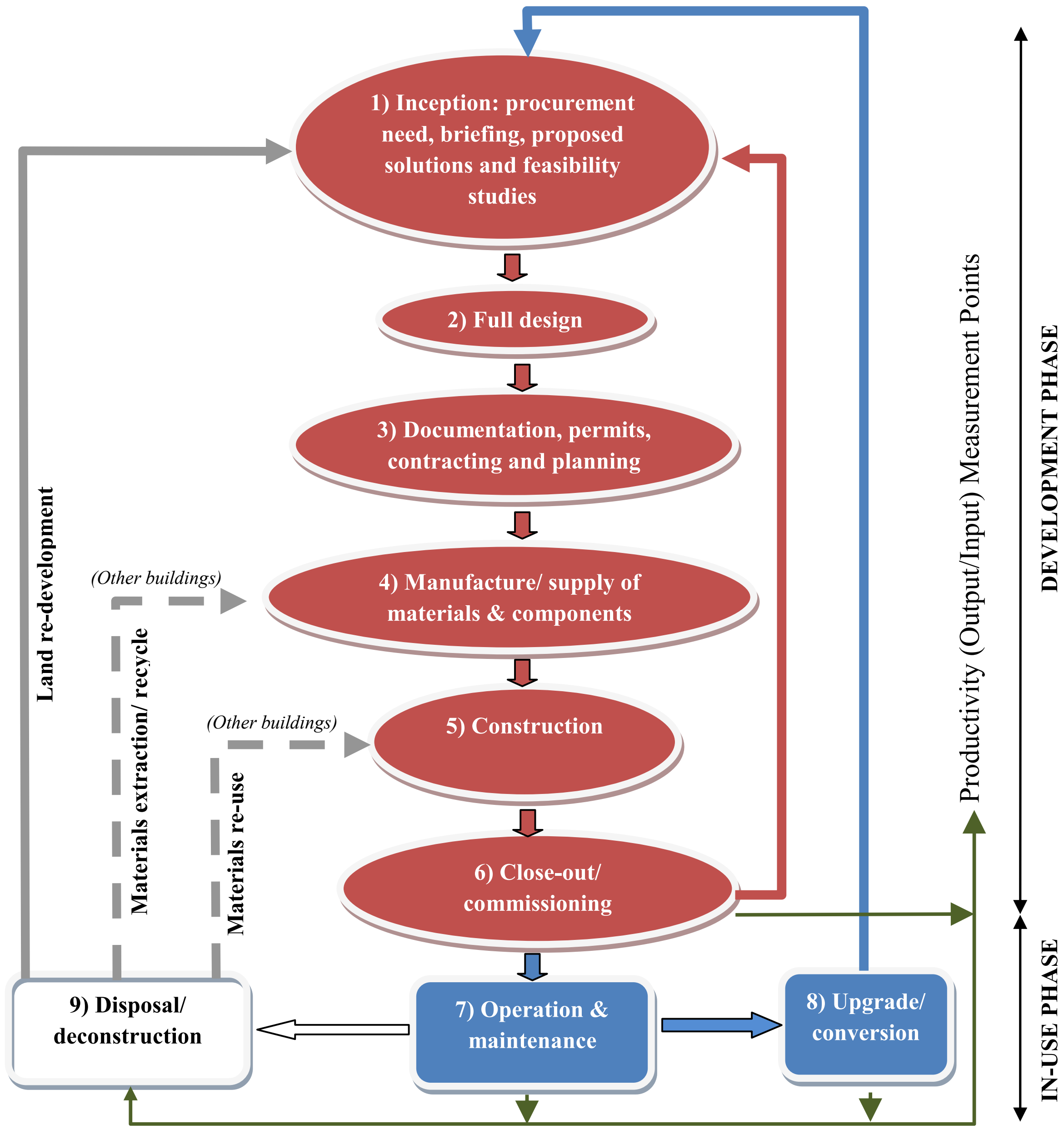
5 Results And Discussions

5.1 Overview

This section is devoted to the data analysis, key results and their discussions in relation to the research objectives. Overall, the section addresses the question on the productivity increase leverage points and where the biggest opportunities for productivity improvement lie.

5.2 Residential building life cycle

Figure 3 presents a model of the relationship between the two RBLC concepts as adapted from the PMI (2008) and Seadon (2012).



***Project life cycle*: 1) - 2) - 3) - 4) - 5) -6) - 1). *Continuous building life cycle*: 1) - 2) - 3) - 4) - 5) - 6) – 7) –8) - 1)**

***Terminal building life cycle*: 1) - 2) - 3) - 4) - 5) - 6) – 7) –9) -1).**

Figure 3: Relating project and building life cycles

Figure 3 illustrates the project (i.e. the development) cycle as a subset of the product (i.e. the residential building) life cycle. The project life cycle starts with the owner's need for a building. Mbachu and Nkado (2006) identify three categories of owners and their procurement needs as follows.

- Sell the building on completion (i.e. developer client),
- Put the building to rent or lease for investment (i.e. investor client), or
- Operate and maintain the building as a dwelling (i.e. owner-occupier).

The owner considers and communicates the type of building that could best address the need at the inception phase. The architect translates the owner's brief on the need into drawings and specifications. The project cycle proceeds through contract documentation and planning to construction and close-out/commissioning and ideally loops back to the conception phase. However, in practice, the completed building evolves from a project to a product at the end of the close-out stage. The building cycle continues beyond this stage into the operation and maintenance phase. While the project phase is relatively short (about one or two years depending on the scope and complexity of the building), the operation and maintenance phase is quite long (usually for 50 years or more). Two pathways emerge beyond the operation and maintenance phase. To maintain the true meaning of 'cycle', the building life cycle should be along the path to upgrade/conversion/renovation, which loops back to the procurement need.

The path to deconstruction/disposal marks the terminal end of the building (from a product perspective) and the inception of another life cycle phase (from a process perspective).

This study adopts the on-going building life cycle view as shown in Figure 3. This starts with the procurement need, through conception, design and construction to operation and maintenance and upgrade, and back to procurement need. The loop continues until the terminal or end of life stage when the building is decommissioned and deconstructed. Following the deconstruction, the building components could be re-used in future projects or recycled as part of the process of prefabrication or manufacture of materials and components for other buildings. The cycle continues with the re-development of the vacant land to meet the need for infrastructure in the future.

Interview participants' feedback on the RBLC model

The survey participants at the three phases of the study confirmed that the model was valid for the New Zealand residential building context. Some participants suggested slight changes in the naming of some stages to improve clarity. In particular, phase 4 of the cycle was renamed to remove the 'prefabrication' in the original model title for this phase. This is because 'prefabrication' refers to a technological approach rather than the manufacture/supply of materials and components which this phase represents.

However, a number of the survey participants suggested that the model should be qualified as one out of three or four possible approaches to procuring a residential building as described below.

5.3 New house procurement routes

Feedback from the first and second phases of the interviews revealed four alternative routes a building owner may take to achieve his or her homeownership dream in New Zealand. The routes have varying levels of impact on productivity outcomes as discussed in the following subsection.

The interviewees indicated during the phase interview phase that about 90 percent of the residential stock in New Zealand was supplied via standardised designs provided by the group homebuilders. While only about 10 percent was built as customised designs produced from scratch by an architect. [However, the outcome of the second phase interviews adjusted the proportions of the buildings procured via the four approaches as shown in Figure 4]. Overall, the interviewees pointed out that the project life cycle modelled in Figure 3 represents more of the customised design approach. They further pointed out that the bulk of the productivity limiting issues were driven by the customised design and so the model was apt to the key thrust of the research. The developers pointed out that, except for fully built house sold on cash-and-carry basis, home owners would always modify the standardised designs thereby reducing the efficiency gains this approach offers, especially in relation to minimising consenting costs and time and reaping the benefits of economies of scale offered by bulk material purchase.

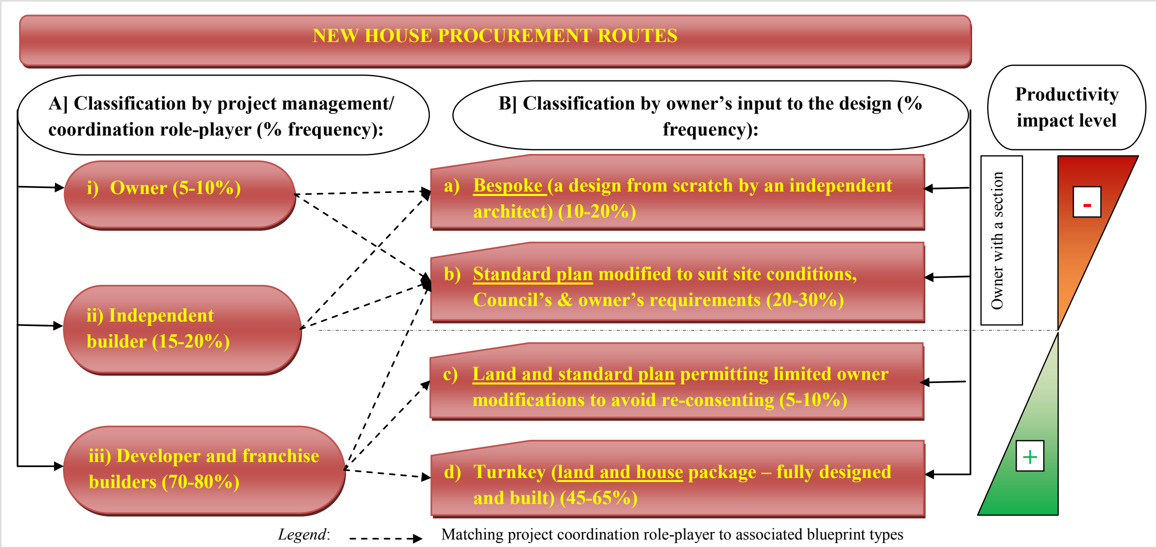


Figure 4: New house procurement routes: Classification by design type and project management role-player

5.3.1 New house procurement routes: Classification by project management role player

The alternative routes to new build procurement in the residential sector may be one of three ways as shown in Figure 4. The details and implications for productivity outcomes are discussed in the following subsections.

Owner-managed process

Feedback from the interviewees suggested that the owner-managed approach to residential building procurement used to be popular five years ago. However, this approach declined in popularity with the onset of the restricted building work regime. The interviewees generally believed that most owners lacked the technical and coordination skills required to successfully project-manage the building process and value delivery. The 5–10 percent occurrence shown in Figure 4 for this route comprised owners who had acquired experience building their own houses in the past and who felt confident of the process and the network connections involved. The owner's lack of technical and coordination skills therefore presents a problem in terms of achieving productivity outcomes in the RBLC. The interviewees claimed that no two buildings are the same due to varying ground conditions, role players and operating environment. The building owner's experience in a few instances of homebuilding is not enough to gain requisite skills in managing a diverse range of challenges in future building procurement. As a result, there will be serious project management gaps, risks and mistakes which could significantly constrain productivity outcomes in the process.

The choice of this route is set to increase in the future with the recent exemption of the owner-builder from the restricted building work regime. The recent passing of the Building Amendment Act 2012 by the Government aims, among other things, to reduce the cost of do-it-yourself (DIY) building work by removing regulatory hurdles (MBIE, 2012). The Act's amendment included cutting red tape, speeding up the building consenting process by introducing Risk-Based Consenting. It therefore encourages DIYers to build or renovate their own homes, while offering protection to future purchasers of the property. In the process, the owner-builder is allowed to carry out building work but must take responsibility for that work and the work will be notified in the Public Information File held by the local authorities for inspection by the public and prospective building owners. Whether or not the encouragement of DIY building work would result in another era of systemic failure and declining productivity trend can only be a matter of guesswork and is worthy of future investigations. By and large, a number of the interviewees were of the opinion that the exemption of the owner-builder from the restricted building work regime – even with more plan checks and inspections by the local authorities over and above the current practice – does not assure that there will be no quality issues with the owner-builder work, especially with the proposed change of the Code Compliant Certificate to Consent Compliant Certificate, which means that certificate no longer assures of the quality of the building work and its compliance with the Building Code.

Builder-led procurement approach

Feedback from the interviews suggested that homeowners usually engage small homebuilders to project-manage the building process where the owner requires significant input in the design process. This approach could have positive or negative impact on productivity, depending on the extent of the builder's involvement in the design process. The interviewees hinted that usually the builder is given a set plan to build from without prior involvement in the design development. The interviewees maintained that the approach could be counter-productive on account of several issues such as the design not taking into consideration the builder's preferred method of construction, buildability issues in the design, lack of design details, poor specifications and detailing errors. Another key concern raised was that the designers often do not do proper site investigations and analysis and adjust the design to the specific conditions of the site, especially as it relates to ground conditions. Resolving such incongruities between the design and site characteristics often results in time and cost overruns due to re-consenting, re-designing and abortive work. To avoid such problems and gain productivity, the interviewees suggested having proper geotechnical investigations of the site and also having the builders take control of or be actively involved in the entire development process from design and consenting to construction and close-out. This also helps to sort out the issues about accountability in the development process which often takes expensive and time consuming adjudication and litigation processes to resolve. Alternatively, the design and build or design and manage functions should be integrated by having the architect being in charge of the design as well as the supervision of the build process to ensure that all design issues are sorted very quickly as and when they arise. This approach may require reverting to the era where the architects used to be the 'leaders' of the building team. However, many of the interviewees were not in support of this due to the perception that architects lack practical experience of the building process and often do not have the project management, business and networking skills of the builder for proper coordination and successful delivery of the complex building process.

Developer-led approach to new house procurement

This approach normally involves the developers offering to the prospective building owner standard plans only, standard plans plus specific sections, or land and fully built house.

The interviewees indicated that on account of the robust marketing strategies and the land development knowledge of the developers, this approach to new house procurement is gaining prominence in New Zealand and is perceived to be the homeowner's increasingly preferred route, especially where they are not too fussy about making lifestyle changes to the standard plans or having significant input to the design and development process. Some interviewees hinted that the key driver for this is the developer's ability to better manage and resolve issues around property unit titles, easements/right of access, and cross-lease terms, which often present serious productivity issues in the other approaches which are managed by the owner or the smaller builder.

The interviewees confirmed that the design and build process that is based on standard plans with little or no significant changes to the plans resolves some of the risks involved in the development process and ensures greater clarity around cost estimates and completion times. It also offers the greatest opportunity for productivity gains. On the other hand, the approach involving significant change to the standard designs (i.e. changes requiring new consenting) is still being followed in 20–30 percent of the cases. This was said to be driven by tendency of the owners to ask for the designs to be adapted to suit their unique tastes and preferences. However, the use of the standard plans with little or no modification to the design is likely going to increase in the future with the recent streamlined National Multiple-use Approval Service (NMAS) for volume builders, which was launched by the Government in 2010 (MBIE, 2012). The NMAS involves fast-tracking the building consents for standard, multiple-proof building designs. This saves time and money for the end-users/consumers and the builders. With the MultiProof designs, only site-specific conditions such as the substructure works need to be checked by local councils for code compliance. The MultiProof approval is usually given for standardised plan which is intended to be replicated for more than nine times within a period of 2 years. However, a building consent application involving the MultiProof design still requires a separate Certificate of Design Work by a certified design professional for any relevant site-specific parts of the design, and any customisations made to the MultiProof design.

It was envisaged that this could halve the timeframe for building consent decisions from 20 to 10 days (MBIE, 2012). As a result, prospective building owners might be encouraged to avoid tweaking the standard designs in order to fully avail of the cost and time-savings offered by the use of the Multi-proof designs, thereby improving productivity significantly in the RBLC.

On the flipside, the interviewees indicated that the developer-led approach has some short-comings where it comes to implementing the standard designs. These shortcomings were claimed to be rooted in the developers being investors with marketing and general management skills. They often do not have in-depth technical building and construction management skills. They were viewed as having a hands-off position when it comes to the actual building development process, with the technical services being subcontracted to franchise builders. The interviewees maintained that the resultant technical project management skills gap present some productivity issues, especially in relation to the project coordination, milestone tracking and quality assurance of the complex residential developments. These shortcomings could be addressed by engaging franchise builders who have a wealth of experience and the authority to resolve the challenges involved in the complex residential development cases. Overall, a number of the interviewees saw the developer as a middleman who merely increases costs through mark ups, while reducing the franchise builder's margin. The offset to low margin is the assurance of steady work without the hassle of marketing and tending for jobs, which may be a waste of money at times, with the tender success rates being as low as 1 out of 10 jobs tendered for.

5.3.2 New house procurement routes: Classification by level of owner's input into the design process

From the interviewees' feedback, new house procurement route options may also be classified by the level of the prospective building owner's input into the design process. As shown in Figure 4 the routes comprise the following:

- Bespoke design
- Standard plan only
- Land and standard plan package
- Land and house package.

In the first phase of the interviews, the standard plan only and the land and standard plan package were considered as one approach. However, the second phase interviews revealed the subtle difference between the two, being that the standard design of the latter is specific to a particular section or plot of land for which building consent has been issued. The details are briefly described in the following subsections.

Bespoke design approach

This is the preferred approach to a prospective owner who desires to have the design tailored to his or her unique lifestyle preferences and for those would like to have a significant influence on the design process. The approach will involve the owner engaging an architect, an architectural draughtsman, a builder or a developer to design the building from the scratch to incorporate the owner's requirements, site specific characteristics and the council requirements. The interviewees hinted that in this approach, the owners' requirements usually conflict with the district and regional plan requirements, often requiring protracted and expensive building and resource consenting processes. Feedback from the interviewees suggested that the building owners – especially the first time and one-off procurers – often are not clear as to what is it they want at the onset; they usually find it difficult to make up their minds and often make frequent changes even after the concept design has been frozen. The interviewees pointed out that the owners' delays in making and communicating critical decisions as to their requirements, and the frequent changes they make at critical stages of the design and construction process are at the root of the disputes, quality issues and the time and cost overruns which significantly impact on productivity outcomes in this procurement approach.

The interviewees acknowledged that the owner's inclination to customisation is understandable, given that for the majority of New Zealanders, homebuilding is the greatest investment of a lifetime and so they rightly deserve the right to influence the design to meet their lifestyle preferences. Notwithstanding the negative impact of the bespoke design on productivity outcomes, this approach to homebuilding is set to continue in the future and presents a hard challenge to deal with. However, educating and enlightening the prospective building owner on the negative implications may help reduce the degree of customisation and the rate and timing of changes in the implementation process. More importantly, the interviewees pointed out that the building owners do not understand blueprints and so the use of physical or computer models to convey the concept design solutions to the owner would aid understanding of the complex blueprint and enable them to make early decisions on whether or not the proposed design solutions meet their needs.

Standard plan only approach

The interviewees indicated that this approach is more popular than the bespoke design route. It involves the prospective building owner buying a standard plan from a builder or developer; the plan then gets modified to suit the owner's desired changes, site characteristics and the local council requirements. However, the issue here is that the owner's modifications might be to such an excessive extent as to make the bespoke design approach more economical. This is evident in the design resources that are wasted when significant part of the standard design is discarded, as well as the time and the associated costs involved in re-designing to suit.

Land and standard plan package

This approach is gaining momentum in Auckland and Christchurch with the group home builders and speculative developers responding to the increasing demand and prevailing acute shortage of houses in the New Zealand property market. It involves the owner buying land and standard plan package from the group home builder or speculative developer. The standard plan has been designed to meet a specific section site characteristics and local council requirements, and would normally have the building consent issued to the developer or group home builder. The prospective home owner may have the opportunity to make cosmetic changes that would not require amendments to the original consent that has been issued. This approach offers greater opportunity for productivity gains in the home building process by reducing the risks and time involved in the design and consenting process. The risks that may present in this approach are largely those of the construction process and the time and costs involved in the transfer of title to the new building owner. However, the productivity gains could be reduced where the owner prefers to make significant changes to the standard design as to require an amendment to the original consent.

Turnkey/land and house package

As with the land and standard plan package, this approach is also gaining momentum as the group home builders and speculative developers respond to the increasing demand and prevailing acute shortage of house supply in New Zealand. The approach is also largely driven by the new streamlined National Multiple-use Approval Service (NMAS) for volume builders. It involves the prospective building owner buying a completed land and house package from a volume builder. As the name suggests, the prospective owner's input in the procurement process is only to 'turn the house keys' after paying for it and having the conveyance deed completed. The interviewees acknowledged that this approach optimises productivity in the new home procurement process in three key ways:

1. It leverages off the economies of scale which volume house building offers in terms of the discounts from bulk material purchases and the reduction in the unit costs per house when the overhead costs are spread over a sufficient number of units. This helps to achieve a significant reduction in the development costs and improvement in housing affordability, as long as the developer is not intent on recouping all the gains as profit.
2. It eliminates the risks/uncertainties and the time and cost overruns involved in implementing a standard design. The only delay that could stand between the home owner and his or her home ownership dream is the timeframe taken to seal the deal including completing the deed of conveyance.
3. The approach also lends to standardisation, prefabrication and manufacturing processes in the home building sector. These novel approaches improve productivity through quality gains, reduction in wastages and environmental impact, improvement of health and safety and minimisation of the adverse effect of weather, all of which often constrain productivity gains in the other approaches to home building.

However, the downside of the approach is that the prospective building owner is not given the opportunity to bring to the table his or her unique lifestyle preferences in the building design, except where what is on offer meets these preferences – which is a rare occurrence. Also, the interviewees pointed out that such turnkey houses are designed and constructed to meet the threshold requirements of the building code and are targeted to minimise the capital development costs without caring much about the operation and running costs except to the extent required in the code and the warranties/guarantees. As a result, the building owner is not given the opportunity to modify the design to minimise the in-use costs and may therefore involve in expense running or retrofitting costs which impact significantly on the life cycle productivity outcomes. The solution to this is for the volume builders to aim for green star accreditation of the houses, but the price to the prospective owner may be prohibitive.

5.4 New house building process involving designing from scratch

The interviewees confirmed that the new building procurement approach involving designing from the scratch presents the greatest challenge to the productivity improvement in the RBLC. This approach is further discussed in the following subsections to highlight the details involved in the two cases of simple/standard and the complex house building cases, and how they could impact on productivity outcomes.

5.4.1 New house building process (simple/standard house)

Essentially, the following 8 steps are involved in the development process for a simple or standard house designed from the scratch. Figure 5 presents the 8 stages as part of the overall RBLC for a simple residential building designed from the scratch. Feedback from the interviewees suggested that the overall development phase could range from 26 to 40 weeks, but this could be reduced through parallel execution of the stages. Each stage is briefly described in the following subsection.

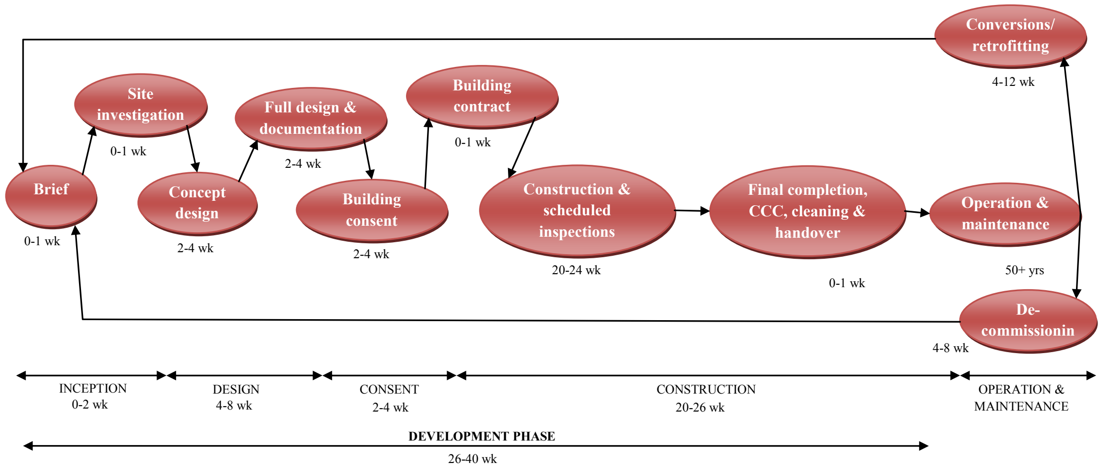


Figure 5: Residential building life cycle (simple building)

a) *Briefing*

At the briefing stage, the prospective home owner articulates his or her ideas and wish list to the designer in terms of his or her preferences in the new house. These may include space requirements, aesthetics, development cost target, functionalities, running costs and futureproofing needs, especially for energy efficiency, flexibility of use or technological advancement. The ability of the owner to be able to articulate these needs and requirements upfront and the tenacity of the brief over the design and development period could enhance or constrain productivity in the downstream design and construction phases. The interviewees stated that in real life, the owners, especially the first-time one-off procurers, often do not know what they want at the onset and are likely to make unexpected changes frequently even at the critical stages of the design and construction phases.

The interviewees suggested that the designers should be able to manage the owner's variation orders by anticipating and making provisions for the changes and by using computerised design process to respond quickly to the changes as and when they happen. The computerised 3D models and visual walkthroughs could be generated to assist the owner gain better understanding of the design solutions and make early changes. However, there is no way around it if the construction work has already started.

b) *Site investigations/analysis*

Prior to the concept design, the designer visits the site and checks on the local Council district plan as well as the regional plan to identify issues relating to building and resource consent requirements. Investigations will include soil types, property title issues, consent notices, conveyances, right of access, and wider issues. The bulk of the information about the site and the requirements of the Building Act and other legislations that might be relevant to proposed building work is available in the Project Information Memorandum (PIM) obtained from the local councils. Part of the qualifications of a building as simple or standard is the absence of complex site characteristics and subsoil conditions; hence, there may not be a need for detailed soil tests and geotechnical investigations, especially for level sections on stable soil.

Time-wise, the interviewees suggested that the site investigation stage may take up to a week depending on the nature of the site and issues around building and resource consent, where applicable.

c) *Concept design*

Based on the owner's brief and the outcome of the site investigations, the designer prepares the concept design that optimises the value of the site and the needs of the building owner within the confines of the site characteristics and the requirements of the district (and where applicable, the regional) plans. Usually a number of alternative designs are presented to the owner for evaluation. The preferred concept plan may be modified to incorporate changes required by the owner. Usually the prospective owner puts down 10–12 percent of the design and documentation costs to enable the designer carry on with the concept and full designs and documentation.

The interviewees indicated that two key issues that may limit productivity gains at the concept design stage. The first is due to the owner not being clear and upfront with his requirements, the delay in decision making and the frequent changes the owner makes, all of which could prolong this stage beyond the normal duration expected. The second could be the designer's inability to manage well the owner's brief and the changes he or she often makes. The interviewees indicated that often times, the designer fails to capture the key requirements of the owner in the design and is unable to anticipate the likely changes the owner makes and to proactively respond to these changes as and when they occur. To minimise the productivity limiting issues, the interviewees suggested that the designer should be experienced enough to understand the building owner, especially the first time homeseekers, and use computerised design process to anticipate and respond to the flurry of changes that may happen. Also they suggested the use of physical or 3D models of the new house to enable the building owner visualize the design and the interior spaces. These will help the building owner make quick evaluation of the extent to which his or her needs have been addressed by the concept design and so advise the needed changes fairly quickly.

The duration for the concept design varies depending on the ability of the building owner to provide on time the information and preferences required to freeze the concept design and get on with the full design development. The interviewees indicated a time range of 2–4 weeks as being typical.

d) *Full design and documentation*

Having frozen the concept design, the designer proceeds to full design of the house and produce the working drawings and specifications for consenting and building contract documentations. Usually, the owner is required to make a deposit payment (usually 10–12% of the full design costs) before the full design and documentation process could start. Where the site characteristics and the owner's requirements are such that the design is able to be based on the recommendations of the NZS 3604: 2011 Timber-Framed Buildings Standard, there may not be a need for specific engineering design (SED). In this case, the full design and consenting processes are fairly quickly and less costly. The requirement for SED not only adds to the costs and time required for the full designs, but also brings about delayed consenting, as the council officials spend more time to scrutinise the designs to ensure compliance with the Building Code. To minimise the delay in obtaining the building consent, one or two pre-lodgement meetings may be required with the council officials to sort out issues about weathertightness and additional information required to demonstrate compliance with the code.

Overall, the interviewees pointed out buildability issues, poor specifications, design and detailing errors/omissions and a potential discrepancy between the design and the site characteristics as the key productivity limiting issues which this stage can introduce at the construction phase. To mitigate these issues, the interviewees suggested early involvement of the builders and specialist tradespeople at the full design stage. The aim is to leverage the in-depth experience of the builders and the specialist tradespeople, particularly the plumbers, drainlayers and the electricians to sort out early any design-related issues before the design could be firmed up.

Timewise, the full design could take 2–4 weeks for simple standard house, but could be more for complex designs, depending on the level of complexity involved.

e) *Consenting stage*

Following the completion of the full design and documentation stage, and before a building contract agreement is entered into with the builder, the designer obtains quote for the value of the building work from the selected builders who are invited to tender for the job. A builder is selected and the contract price negotiated and agreed. The contract price becomes the basis for the BCA to determine the fee to be charged for the processing of the consent. In effect, the designer lodges a building consent application to the local city or district council on behalf of the building owner. A number of the interviewees referred the researcher to the MBIE's website (http://www.dbh.govt.nz/blc-building-consentinspect-process) or the Consumer Build's website (http://www.consumerbuild.org.nz/publish/bact/buildingact-consents-application.php) for full details of the information required for the building consent lodgement. There is no value repeating the checklist in this document. The builder or developer may also take on this responsibility if engaged for a design and build contract. As part of the application lodgement, an appointment is made with the Building Consent Authority (BCA). At the appointment, the council receiving officer checks the application, the house plans, specifications and other submittals to make sure that all the details required to evaluate compliance with the performance requirements of the Building Code have been supplied. Following this, the building consent processing fee will be charged often based on the agreed contract price for the building work or the envisaged time required to process the application. Also the number of inspections required for the work will be advised and at what stage of the house building process the inspections should occur. The fees are higher where SED or other verification methods are used in the design process. For such cases, the interviewees hinted that the BCAs usually outsource the assessment to the specialist consultants. This approach was perceived to have improved the duration for the consenting, though nowhere near the statutory 20 working days in majority of the cases. The interviewees admitted that, to be fair on the BCAs, the delay is usually due to the BCAs not having all the information they require to make decisions, especially in relation to weathertightness details. However, some interviewees pointed out that, on account of the prevailing leaky building issues and the associated litigations, the BCAs are overly risk-averse in terms of approving plans and issuing the consent within the 20 day statutory timeframe.

To this end, the recent proposed amendment to the Building Act which seeks to introduce stepped risk-based consenting system was perceived by some of the interviewees in the second phase interviews as a possible solution to the prevailing risk-averse climate surrounding the building consenting application processing and the associated delays. In relation to the residential building consenting process, the MBIE (2012c) highlights the key elements of the proposed stepped building consent system as follows:

- "a simplified and more prescribed consenting process for certain simple residential building work at the lower-risk end of the spectrum (such as a simple single-storey house built using proven methods and design with low structural and weathertightness risks)"
- "existing consent and inspection requirements for moderate- to high-risk residential building work, such as a multi-storey house of complex design, and for lower-risk building work not involving a suitably qualified building practitioner".

MBIE (2012c) stated that some prescribed quality assurance measures are pre-conditions for the implementation of the proposed risk-based consenting process.

However, a number of the interviewees expressed doubts about the ability of the proposed amendments to truly "contribute to a more productive, efficient and accountable building construction sector"[1]. To many of the interviewees, it could escalate the builders and designers' insurance costs of liability protection for defective work; and the costs will be passed on to the homeowner in the form of higher building costs, thereby exacerbating the already spiralling construction costs to all time highs. So in the end, the expected potential compliance cost savings might actually result in building cost increases tripling any envisaged savings.

From a different perspective, some interviewees saw the real intention of the proposed amendments as largely serving to shift the BCAs' exposure to liability for defective building work to designers and builders, who would then be expected to take greater accountability for ensuring that their work is Code compliant. This is in view of the preponderance of the joint and several liability judgements against the BCAs by the courts in several weathertightness cases.

The interviewees queried the rationale of accepting the building consent as valid evidence of the BCA's satisfaction with the design plans and specifications being Building Code compliant, but not accepting the final Consent Completion Certificate (CCC) as valid evidence of the building being Code compliant, whereas the CCC certifies that the building has been constructed and inspected to comply with the building consent as issued.

Another productivity limiting issue at the consenting stage relates to the differences in the way the various territorial authorities interpret and apply the same provisions of the Building Act in the consenting process. This issue introduces a lot of risks and unnecessary redesign work when replicating similar designs for building sections sited on different local council lands. This adds to the costs and time for full design development. The proposed streamlined online consenting process was believed to contribute to mitigating this issue.

Timewise, the interviewees indicated that the consenting timeframe could vary depending on several issues; on the average, the consenting time for simple standard house designed solely from the Acceptable Solutions could take 2–4 weeks. For complex designs, it could take up to 8 weeks. The majority of the interviewees said that the 20 day statutory timeframe for processing the building consent was never realised in 95 percent of the time, even for simple and straightforward plans that were based solely on the Acceptable Solutions. Part of the delay could be due to the workload of the BCA at the time of lodging the application; high workload could make the BCA prolong the start of the time ticking by giving a long appointment date for receiving the lodgement. To avoid the indictment of not being able to meet the 20 day statutory timeframe, they could 'force the clock to stop ticking' by requesting for unnecessary details. Experienced builders and developers were said to have good rapport with the BCAs and would usually spend the least amount of time getting their consent issued, sometimes achieving 2–3 weeks of consenting timeframe for simple standard house plan.

It should be noted that the Building Act review acknowledged that the BCAs take a risk-averse approach to building consenting because of concerns about their liability, resulting in "unnecessary checks and inspections for certain building work where the risk to public health and safety is relatively low" (Office of the Minister for Building and Construction, OMBC, 2011, p. 2).

f) *Building agreement and contract signing*

After the building consent has been obtained, the owner negotiates with the builder whose quote was accepted earlier on, and on the basis of which the BCA charged a fee for processing the building consent application. The builder usually provides the building contract and agreement, which the owner signs if Okayed by his or her solicitor. It should be noted that the building contract signed at this stage is conditional upon the issuance of the Code Compliance Certificate where the owner is not responsible for the full project management role. The interviewees indicated that the builder may be contracted for labour only services where the owner wishes to be involved or retain the services of the architect or architectural draughtsperson for the supervision role, though this is rare. The norm is the full contractual engagement where the builder oversees the entire construction process including material supplies and employment of the specialist tradespeople. On a number of occasions, the builder could be engaged to manage the construction process, including the coordination of the specialist tradespeople employed directly by the owner, who also supplies the materials.

The interviewees hinted that not all building contracts are written contracts; a number of residential building contracts could be verbal, depending on the size of the project, and the level of rapport or trust between the owner and the builder. The interviewees indicated that the verbal contracts were used for small building works, while the written contracts were normally used for large scale jobs. However, they pointed out that the written contracts are increasingly being used due to the current litigious climate of the building industry. It should be noted that the Building Act 2004 will be amended to require written contract between building contractors and consumers for all building projects above $20,000, together with more information disclosure, clearer obligations and new legal remedies (MBIE, nd).

The builders indicated that several forms of written building contracts are in use, with many building companies and independent builders having their own forms. In addition, there are standard forms of building contract. These include the following:

- Standards New Zealand's (NZS 3902:2004) Housing, Alterations and Small Building Contract.
- The New Zealand Institute of Architect's (NZIA's) standard forms:

- Standard Conditions of Contract Short Form (SCC SF 2009): for use between the builder and the owner when the architect is commissioned to administer the contract for small or less complex building projects.
- National Building Contract Small Works (NBC SW 2010): for use between the builder and the owner for small or less complex building projects when an architect is not involved in the contract administration.
- The Registered Master Builders Federation's (RMBF's) standard form of contract.
- The Certified Builders Association of New Zealand's (CBANZ's) standard form of contract.

The interviewees indicated that the use of the standard forms could minimise disputes in the residential building contracts. Such standard forms of contract were perceived to be fair on all parties, except where the standard clauses were modified to serve the interest of one party to the detriment of the other. The feedback was that the RMBF and the CBANZ standard forms were popular among the independent builders, while the developers and volume builders use their own forms of contract. On the other hand, the NZS 3902, and to a lesser extent the NBC SW 2010 were the preferred choices for owner-managed projects, while the SCC SF 2009 is the default contract where the architect is engaged to manage the contract. The relative frequencies of use of these contract forms would therefore align with those of the new house procurement routes shown in Figure 4.

Overall, the use of the verbal contracts was indicated as one of the causes of the high incidence of disputes in the residential building sector as well as a key barrier to productivity and performance in the sector. There was recurring affirmation that written contracts clearly spell out terms and conditions that govern the contractual relationships between parties. This helps to minimise arguments and disputes about rights and responsibilities of the parties.

At the building agreement and contract signing stage, the interviewees also raised the issue of project finance as another key barrier to progress and productivity, if not property dealt with at this stage. They were of the view that, prior to signing the building agreement, the owner must first sort out the funding for the project. As soon as the owner receives a quote from a preferred builder, the owner must ensure that he or she has arranged for the finance, which should be an amount over and above the quote given by the builder. The extra amount serves as the contingency against cost escalations due to change orders, unforeseen ground conditions and other unexpected cost increases which are not due to the fault of the builder. Some interviewees advised 15–30 percent contingencies depending on the complexity and scale of the project, including variability of the subsoil conditions. The NZS 3902: 2004 recommends 10 percent of the building contract price as typical contingency sum.

The interviewees indicated that most written residential building contracts are fixed price contracts. The owner is required to pay up to 10 percent deposit after the contract has been signed. All other payments are claimed by the builder at the completion of each of 6 stages. The contract agreement will include the agreed completion date, the stages of the project and the payment regime. The builder provides the cash flow forecast that represents the agreed stages of the building work and the amount due from the owner, if properly completed. This helps the owner to arrange for the project finance early so as to avoid cash flow problems which could stall progress and derail the agreed plans. The stage and cash flow forecast is usually based on agreed regular time interval (e.g. monthly) or a staged process of work completion. Table 2 presents a summary of the interviewees' feedback on a typical staged process and payment schedule for a simple standard residential building.

	Stage of the building contract	% of the contract price payable	Details of the payment
1	Contract signing and deposit	10%	Builder's mobilisation fee (this could be 2–10% depending on the builder's estimate of the preliminaries work. Some developers involved in the design and land package were quoted as taking as low as 2% deposit because they want to encourage homebuyers with less upfront payment and also because having built other sections, the development risks were lesser].
2	Foundation and ground floor	15%	Setting up and establishing, temporary services, site preparation, excavations, electrical 1st fix (conduits); plumbing & drainage 1st fix (subfloor plumbing and drainage), foundation concrete and brickwork, ground floor concreting/framing, flooring. [Where extensive ground work is required, this stage may cost up to 20% of the contract price].
3	Frame and insulation	15%	Wall frames, structural framing (where applicable), bracings, roof framing; electrical 2nd fix (wiring); plumbing 2nd fix (pipe works); drainage 2nd fix (flashings).
4	Exterior cladding, doors and windows, and roofing	25%	Roof covering and rainwater goods; Windows and external doors and framing, glazing, flashings & building wrap. External cladding and glazing & flashing.
5	Internal finishes, appliances, fixtures and fittings	25%	Gib board linings and insulations, internal partitions, stopping and painting/wall finishes, floor and ceiling finishes; electrical 3rd fix (appliances, fixtures and fittings such as heating, power & lighting), plumbing 3rd fix (appliances, fixtures and fittings); joinery, fire & smoke alarm.
6	External works, completion and handover	10%	External works (including fences, driveway and retaining walls where applicable), hard and landscaping, electrical, plumbing and drainage final fixes; cleaning and handover. (The costs may vary from 10–30% depending on the complexity involved)
	Total:	100%	

Table 2: Master Builder's staged process and payment schedule for typical residential building (simple building)

It should be noted that each of the stages 2 and 6 may be split into two if the ground works and external works, respectively, are complex.

Furthermore, the interviewees viewed the labour only and the managed labour contract forms of builder engagement as being some of causes of disputes, defective work, time and cost overruns in the residential building process. They argued that productivity could further be improved if these contract forms are avoided. They advised that the most productive arrangement is where the builder is given total control of the building process. This also ensures greater clarity around accountability for the contract works.

g) *Construction and routine inspection stage*

Usually within 10 days after signing the contract, the builder must start work, except if agreed otherwise with the owner. The building consent expires after 12 months if the work has not started, unless special arrangement is made with the BCA. The builder notifies the BCA before the project work begins and arranges for building inspections by the BCA or an independent Licensed Building Practitioner (LBP). The interviewees indicated that the number of inspections required at various stages of the building process may vary depending on the confidence reposed on the builder, the complexity and scale of the project and the overall risk profile of the project. For a standard residential building project, 6–8 inspections may be carried out at the following stages:

- Foundations, including excavations, service ducting, reinforcing steel and concreting (usually 2–3 inspections)
- Framing,
- Plumbing
- Drainage (including roofing)
- Cladding, flashings and insulation.
- Completed building.

Usually, the owner and the builder arrange for insurance covers as means of managing their share of the risks involved in building work. Regular monthly site meetings are held to discuss progress, and resolve conflicts and disputes and other issues. The builder submits progress payment claims to the owner at agreed intervals or milestones as work progresses.

The interviewees hinted that, for a complex residential project, the builder should prepare a master programme for integrating and coordinating the works of the specialist tradespeople and to monitor progress. He or she should also prepare a safety plan for monitoring health and safety, as well as a quality assurance plan for monitoring quality. The interviewees were convinced that following such best practice approach, even for a simple standard residential project has huge productivity benefits in terms of ensuring a safe and defects-free work completed on time and within budget. The interviewees further stated that the residential building process is often fraught with disputes, quality issues and time and cost overruns because, 70–80 percent of the time the builders do not follow this best practice approach.

Depending on the scale and complexity of the project and how the owner and the builder fulfil their contractual obligations, the interviewees estimated the construction stage to take about 20–24 weeks for a simple house on a level section, if weather and other constraints do not present.

h) *Final completion, certification and handover*

On completion of the work, the owner and the independent certifier inspect the work to ensure that it has been completed to plan, specifications and quality requirements. If there are any defects, the builder rectifies them to the satisfaction of the owner. At the same time, an independent building inspector makes a final inspection and may issue a Notice-To-Fix if there are non-Code-compliant or weathertightness issues.

Finally, an application is made to the BCA to issue a Code Compliance Certificate (CCC). The BCA issues the CCC if satisfied that the completed work was carried out in accordance with the consent documentation, and that due inspections were carried out as scheduled for the consent that was issued. In addition, if the inspections were carried out by an LBP, his or her Record of Work forms must be provided to the BCA. Further requirements for issuing the CCC include the owner's payment of the development contribution levy, as well as the Energy Work Certificate for the project, which must be provided by the electrician and gasfitter.

While handing over the completed building to the owner, the builder and the specialist tradespeople will be required to provide to the owner their guarantees and warranties for their own portions of the work. If a Registered Master Builder was in charge of the house building, he or she will offer the building owner a Master Build 7 Year Guarantee[2] as a standard practice required by the Registered Master Builders Federation of New Zealand. This is in lieu of the 5–10 percent retention monies which may be held back by the owner at each payment stage, if the guarantee is not in place. The interviewees referred the researcher to the Master Builders' Master Build Guarantee (RMBF, 2013) for details. The RMBF's guarantee covers the following items, which are compared with those of the Certified Builders Association of New Zealand (CBANZ, nd):

	RMBF Guarantee covers	CBANZ Guarantee covers:
1	Owner's deposit (up to $20,000 inclusive of GST),	Reimbursement of any deposit paid to the builder where the builder is unable to continue beyond site preparation, not exceeding 20% of the contract price, or 450,000, whichever is the less
2	Non completion of the building work (up to $30,000),	Completion of the dwelling where the builder is unable to complete, not exceeding 20% of the contract price, or $100,000, whichever is the less.
3	Defects in qualifying materials up to 2 years,	Rectification of non-structural defects that the builder is unable to rectify for 2 years
4	defects in workmanship up to 2 years, and	
5	Major structural defects for a further 5 years.	Rectification of structural defects that the builder is unable to rectify for 10 years.
6		Other covers/benefits.

It should be noted that both groups of builders have different types of Builders Guarantees.

5.4.2 New house building process (complex building)

The development process for complex residential buildings follow the same process for the simple or standard building as outlined in section 5.4.1. However, the higher level of complexity involved may require additional activities to be carried out, as well as increase the time and costs required for completing activities that are similar to those of the simple buildings. Feedback from the interviewees indicated six additional activities to those required for the simple building. The additional activities also could result in the development phase requiring 41–76 weeks to complete, which is about double the timeframe for simple building. The additional activities are highlighted in Figure 6 and are briefly discussed in the following subsections.

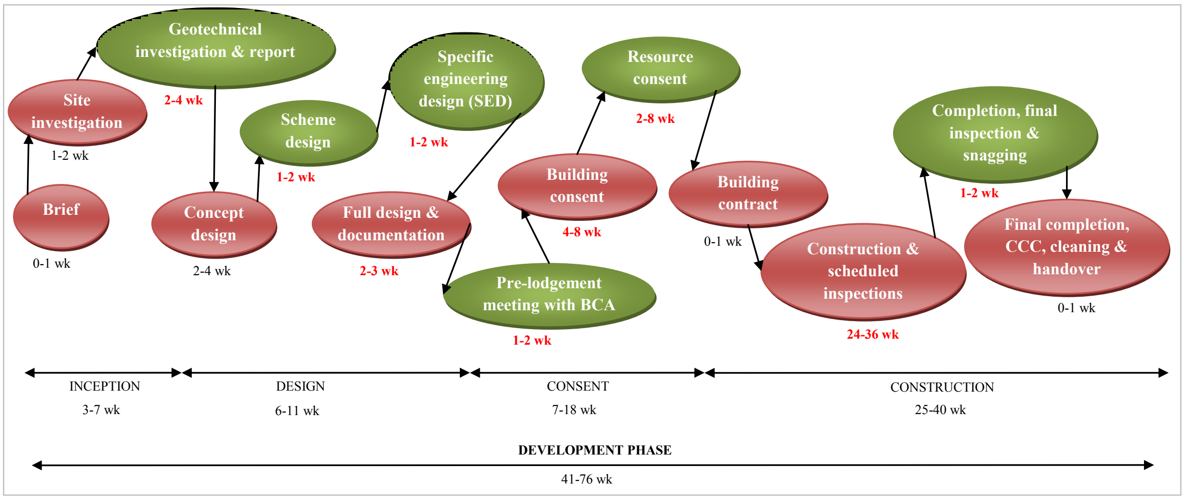


Figure 6: New house development process (complex building)

a) *Geotechnical investigations and report*

The interviewees indicated that one of the issues that add to the complexity of the residential building is the condition of the site, including the stability of the subsoil layers. The bulk of the information about the site and the requirements of the Building Act (2004) and other legislation that might be relevant to proposed building work is available in the Project Information Memorandum (PIM) or the Land Information Memorandum (LIM) obtainable from the local council. The PIM or LIM document would provide information about the site that could suggest carrying out detailed soil tests and geotechnical investigations as part of the site analysis. The need for detailed soil tests and geotechnical investigations is to ensure that the site characteristics have been captured as the basis for the ensuing design development. This would help to minimise issues, particularly variations to the foundation designs and drainage works, which often give rise to cost and time escalations, disputes and barriers to productivity gains at the construction phase. The interviewees indicated that majority of the unforeseen ground conditions that cause variations, delays and escalation of the building costs were driven by lack of proper site investigations. The key issue at this stage is that often not much time is devoted to detailed site analysis by the designers and/or the owner. The assumption is that the information on the PIM or the LIM is sufficient to inform the design. But in real life, recent developments or changes in the ground conditions may have altered the original conditions recorded in the PIM or LIM and could often give rise to productivity limiting issues later on at the implementation phase. The interviewees maintained that the extra cost for having a detailed geotechnical investigation and report is nothing compared to the costs, delays and productivity issues which could arise during the construction phase due to unexpected variations in ground conditions which may require significant changes to the designs.

Timewise, the interviewees suggested that geotechnical investigations and reporting could take 2–4 weeks, depending on the scale of the project and the nature of the ground conditions.

b) *Scheme design*

The interviewees pointed out that if the outcome of the detailed geotechnical investigations reveals some abnormal ground conditions that would not suit simple design solutions, complex engineering designs will be needed. To enable the structural engineers carry out the complex designs, the architect would need to prepare a scheme design after 'freezing' (or finalising) the concept design approved by the building owner. These are general arrangement drawings that provide the basis for the structural engineering design and detailing.

Timewise, this could take 1–2 weeks, depending on the scale of the project and the experience of, and the approach taken by, the architect.

c) *Specific engineering design (SED)*

The interviewees suggested that the challenging site conditions that underpin complexity of some residential buildings and that inform the need for detailed geotechnical investigations more often than not imply that specific engineering designs (SED) may likely be required. These are designs that do not match the Acceptable Solutions prescribed in the Clause B1 of the Building Code. To find feasible solution to the complex engineering problem presented by the subsoil or site conditions, the engineer may design outside the Acceptable Solutions and therefore needs to demonstrate how the design complies with the Code through the Verification Method or the Alternative or Performance Based Solutions. The interviewees hinted that the prevailing climate of several and joint liability litigations now cause the Building Consent Authorities (BCAs) to view with suspicion any design that departs from the Acceptable Solutions. The BCAs must be satisfied that the design is Code compliant and so often apply rigorous scrutiny involving different levels of review and audit to the drawings and specification – some by consultants. As a result, the consenting process could involve back and forth iterations between the BCAs and the designer involving numerous requests for additional information. At the end, the consenting process could be very costly and protracted resulting in delay and loss of productivity. The interviewees hinted that this phase could take 1–2 weeks depending on the complexity of the design, the experience of the designer and the approach taken in the design process.

d) *Pre-lodgement meeting with the BCA*

The interviewees hinted that where designs are based on the Verification or Alternative Solutions, a pre-lodgement meeting is scheduled with the BCA after the completion of the full design and documentation process. The purpose is for an official of the BCA to check through the drawings and specifications and advise what needs to be changed or what additional information is required to demonstrate compliance with the Building Code. However, some interviewees pointed out that this may still not be a perfect solution to the consenting delay problem. They argued that the advice given by the BCA officials during the pre-lodgement meeting does not guarantee that the bona fide application will not be subjected to full scrutiny when lodged. This is because, whereas the BCA officials may give advice at the pre-lodgement meeting, the actual application is often scrutinised by independent consultants who will do full checks without considering whether or not prior advice had been given during the pre-lodgement meetings. However, it was indicated that if this process is effectively utilised, the time for the consenting process could be greatly reduced.

e) *Completion, final inspection and snagging*

On completion of the work, the owner or the architect engaged by the owner will inspect the work to ensure that it has been completed to plan, specifications and quality requirements. For a large scale or complex residential building project, a snag list is usually presented to the builder if there are defects to be fixed before practical completion could be certified for the project. This process is not as formalised for the simple building project. The interviewees hinted that this inspection is additional to the final inspection carried out by the building inspector or the independent certifier. The latter is a condition for the issuance of the Code Compliance Certificate (CCC). The building inspector may issue a Notice-To-Fix if there are non-Code-compliant or weathertightness issues to be resolved; the issues must be satisfactorily resolved before the CCC can be issued on application. A number of the interviewees welcomed the proposed changes to the building control processes, whereby the building inspector's final inspection would be substituted with the inspection by the LBP, usually the engineer or the architect, who designed the works. The interviewees indicated that this approach would be more productive in the sense that the designer is able to verify and confirm the alignment of the works with the design assumptions much quicker than the BCA building official or an independent certifier who may not know the design assumptions and who may go overboard in scrutinising the works just to avoid liability to risk of defects as is currently being experienced. The interviewees believed that productivity suffers due to time-consuming scrutiny and delay to work progress by the inspectors who were not part of the design process.

5.4.3 New house building process: Construction phase of the complex buildings

Feedback from the second phase of the interviewees confirmed the findings at the earlier phase that the construction stage, especially for large scale and complex residential buildings, present significant barriers to efficiency gains in the RBLC. At the same time, the stage also offers numerous opportunities for productivity improvement in the cycle.

Interviews held at the first phase with five site managers involved in residential developments within Auckland identified eight key stages of the construction phase as being typical of most large scale or complex residential development projects as shown in Figure 7. These contrast with the six typical stages for the simple or standard residential building project as highlighted in Table 2.

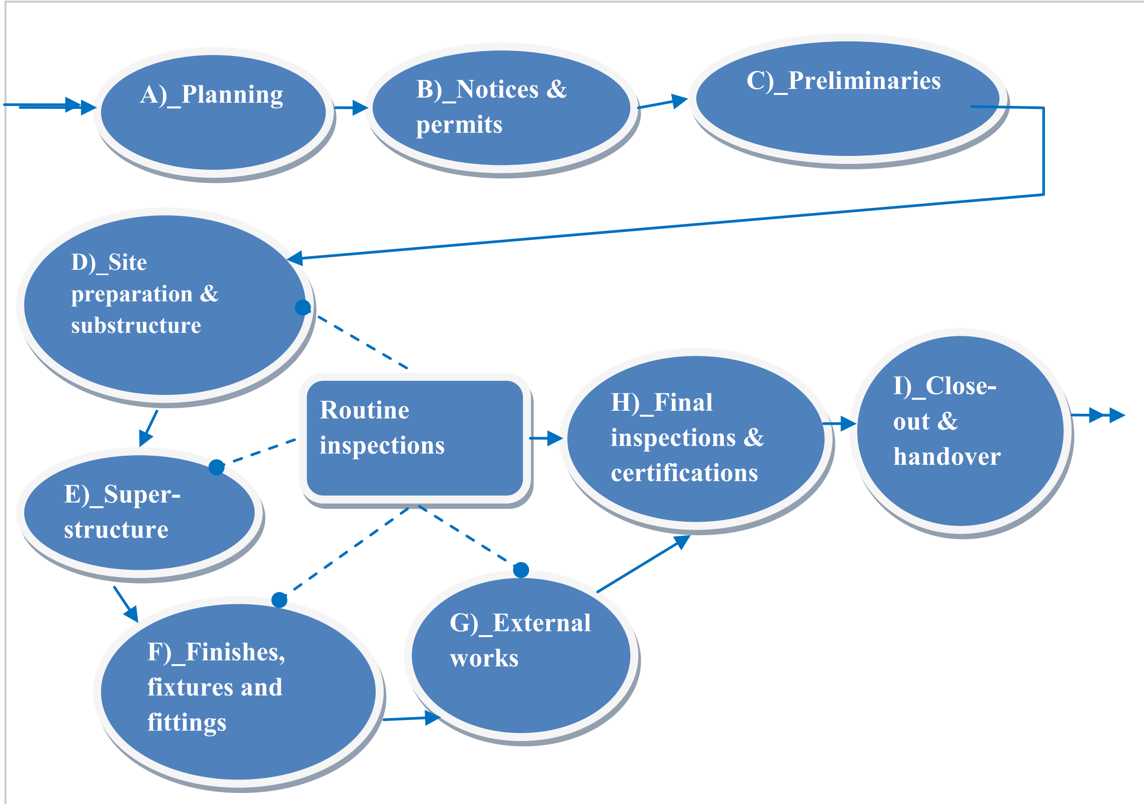


Figure 7: Typical stages of the construction phase of a complex residential project development

The following subsections provide detailed insights into the construction process for the complex residential buildings, where the barriers exist and how productivity could be improved in the process.

A) The planning stage

The construction phase starts with a more detailed planning of the ensuing operations. This is more detailed than the pre-contract planning required for establishing the likely duration of the project, and which informs the tender price and completion date at the tender stage. During the planning meeting, the entire construction work is broken down into chunks of interrelated activities based on a project-specific Work Breakdown Structure (WBS). Where the project is largely executed by subcontractors, the WBS could be aligned with the trades or work packages. It should be noted that this aspect of the planning is quite similar with the planning for commercial building project. Perhaps, this aligns with the recent proposed amendments to the Construction Contracts Act, which include removing the distinction between residential and commercial construction contracts (Beehive, 2013).

The desired logical sequence for the execution of the activities is agreed upon, along with the estimated durations and resource requirements (i.e. costs, labour, plant/equipment and supervision/coordination). The resource estimates are largely based on the quotations provided by the material suppliers and the subcontractors plus some risk margins for safety or buffers. The WBS and the planning parameters (i.e. sequence, duration and resource estimates) provide the basis for compiling the Method Statement (MS). The MS details the sequence of the planned operations against the quantities and rates of outputs, durations, construction method, resources (plant, labour and subcontractor) and the temporary works needed for each operation, as well as the applicable legislations and compliance requirements. It provides for each activity, the preferred method of execution, the volume of work involved, the man-hours, the machine-hours, the types and number of required equipment/plant, the optimum gang size, and the responsibility for supervision and control. The MS needs to be approved by the building owner or his/her project representative. The designers in particular would want to be assured that the construction method outlined in the MS is such that would align with the design assumptions and that would deliver the required quality of work.

The MS also provides the inputs for the project risk analysis and the network analysis (especially for complex projects). The outcomes of the risk analysis and the method statement details are used to compile the project implementation plans. On a large project, these may comprise six plans:

a) the master programme: This takes the form of a bar chart or a Gantt chart. The master programme (and the weekly programmes drawn up from it) provides the baseline for monitoring and controlling the actual progress of work and the cost expenditure.
b) the risk plan and contingencies: this identifies the various risk scenarios that could affect the key project objectives, their risk profiles, mitigation measures and contingencies.
c) the quality assurance plan: This details the key quality expectations and the measures for achieving them;
d) the health and safety plan: this details the health and safety issues and the measures for addressing them in line with the Health & Safety in Employment (H&SE) Act;
e) the environmental management plan (EMP): this details the environmental and resource management issues and the measures for complying with the RMA 1991.
f) the temporary traffic management plan (TTMP): this details the potential impact of the operations on the traffic and how this could be addressed to meet the NZTA requirements.

Figure 8 shows the key components of a typical planning stage for the construction phase of a large scale residential development as advised by the site managers.

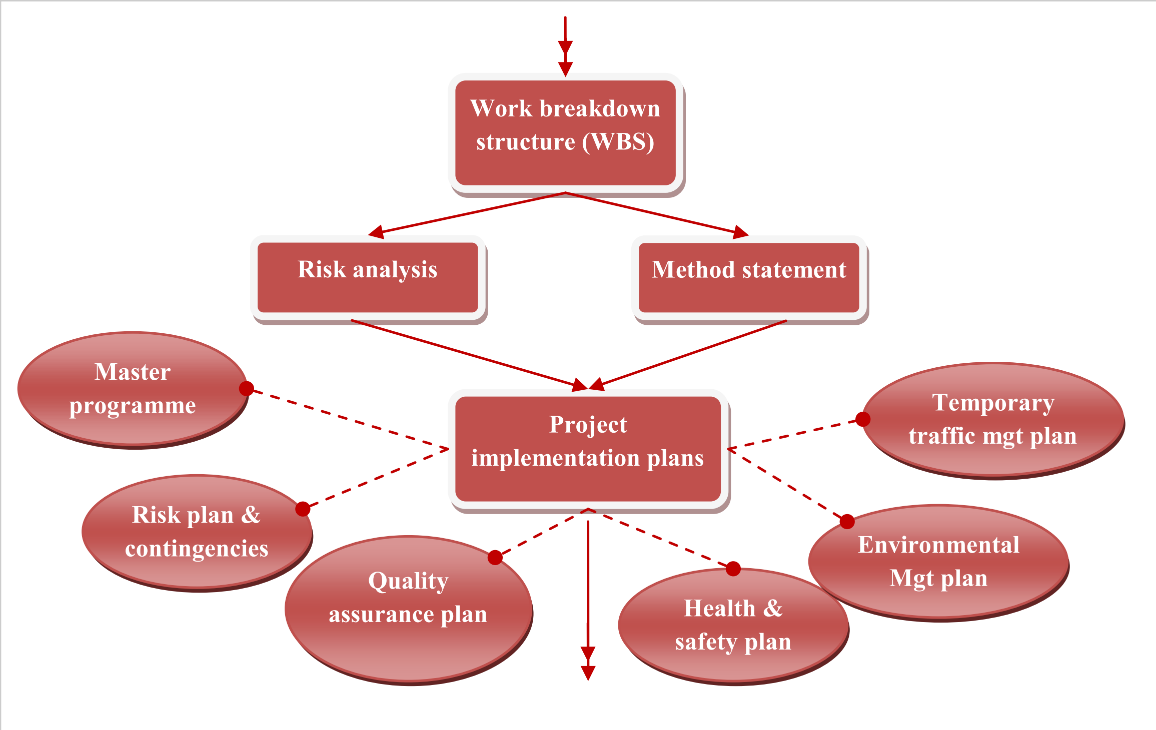


Figure 8: Subcomponents of the construction planning phase for a typical large scale residential development

It should be noted that the accuracy and robustness of the risk analysis and the method statement reflect on the project implementation plans. These in turn determine the level of accuracy and the outcomes of the monitoring and control of the actual execution of the works and the productivity and performance level that could be achieved in the process. The site managers believed that by spending quality time in doing proper risk analysis and drawing up a detailed method statement, a large proportion of the uncertainties and constraints to productivity and performance could be detected and resolved or budgeted for at the planning stage, thereby improving productivity outcomes.

B) Notices and permits

The notices and permits at the construction phase are distinct from the building and resource consents which are applied for and issued at the design and documentation phase. These notices include those required for demolition of existing structures on the building site (where applicable), tree removal, and existing site services relocation. Also, given the large scale of the development and the impact on traffic in the neighbourhood, notices may be required from the New Zealand Transport Agency (NZTA) for temporary traffic management and control which must be supported by the temporary traffic management plan compiled during the planning phase. Above all, the BCA requires that the building inspection schedules which are noted on the issued building consents must be booked well ahead of time.

The lead times required for issuing the notices and the time lag involved in obtaining the permits, especially from the Councils, contribute to increased duration of the construction project. In addition to the fees charged in the process, the increased durations affect the cost of the project finance and the required resources. These result in higher construction costs, and reduced productivity outputs. To guard against these, the site managers advised that proper documentation must be prepared to accompany the notices and permits in concert with the BCA officials to ensure that all information is provided and that there will be no delays in the processing of the notices and permits.

C) Preliminaries

The preliminaries comprise the fundamental operations that must be carried out before the actual building erection commences. Depending on the scope and complexity of the project and the site characteristics, the preliminaries could involve the creation of temporary access roads (where applicable), the identification and relocation of existing services on the site such as water mains and sewers, electricity, telecommunication, etc. In some contaminated sites, the LIM offers information on the nature of the contaminations and how these could be properly dealt with. Also, the LIM could provide information about other risk aspects such as site erosion and made-up grounds which must be resolved before anything else is built on the lot. The site is fenced and appropriate signage is put in place for public information. Dust screens and effluent control must also be in place as part of the approved environmental management plan (EMP) for the project.

Next, a detailed site layout plan is drawn up to identify optimum locations of the various preliminary and general (P&G) items on site such as the site accommodation, material stockpiles, storage spaces, hard-standing for the crane and its installation (where multi storey residential units are involved), etc. Subsequently, the set-up and establish operations are implemented following the site layout plan.

Some of the key issues about the preliminaries which may significantly affect productivity outcomes at the construction phase relate mostly to the site layout plan. If the site layout planning process and the resultant site layout plan were not properly implemented, the work flow on site and the safety of the construction operations could be significantly constrained. This in turn would impact negatively on site operational efficiency, safety and productivity outcomes. This usually presents a major challenge in congested sites, especially in the cities. The solution to this, as proffered by two of the site managers was to rent a storage space outside of the site to keep the site free for improved work flow. Also the use of decked containers as site offices and storage spaces was suggested to maximise the limited ground space for improved manoeuvrability on site. Figure 9 shows the subcomponents of the preliminaries work stage of the construction phase. This differs slightly from the cost-only approach adopted in the New Zealand Institute of Quantity Surveyor's (NZIQS, 1992) Elemental Analysis of Costs of Building Projects.

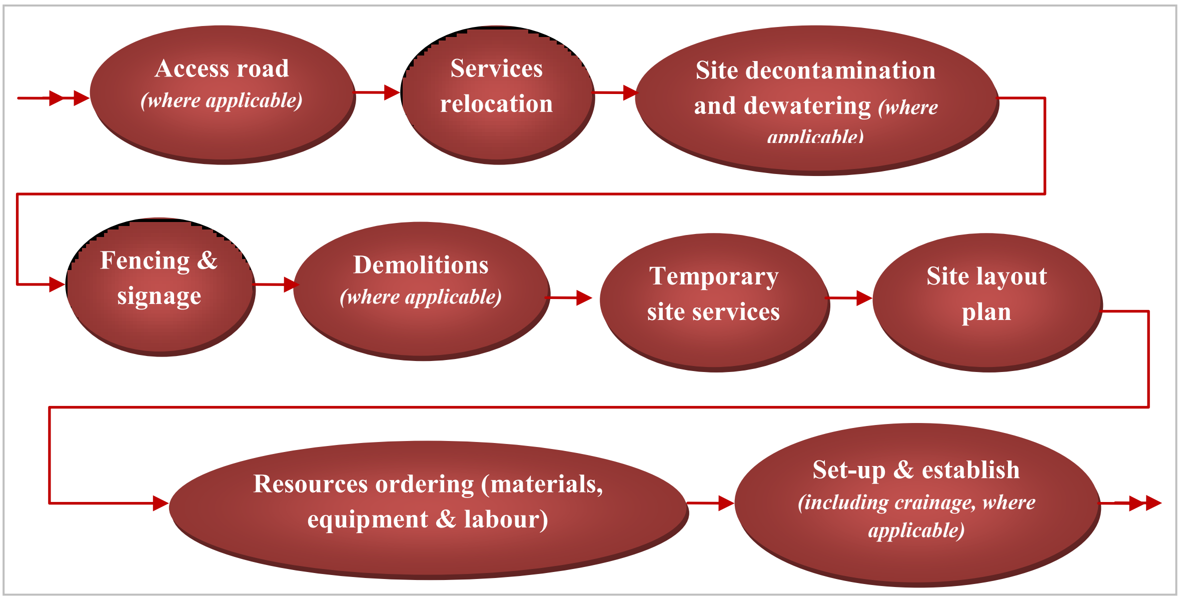


Figure 9: Sub-parts of the preliminaries work stage of the construction phase

Another key issue with the preliminaries is that contractors (whether building companies or developers) generally underestimate the scope and cost of the preliminaries items while pricing the jobs. The site managers indicated that majority of the contractors use a rule of thumb to assign a mark-up of 5–10% of the base cost of the project without actually costing the details of preliminaries and general (P&G) requirements. Depending on the site characteristics, the scope of work and the complexity of the project, the P&G could cost up to 50% of the base costs, especially where cost-intensive operations need to be carried out before the actual construction starts, such as dewatering, erosion control, access road and site decontamination. Due to the stiff competition for jobs during economic recessions, contractors deliberately underprice the P&G items to lower their bids and improve their chances of winning the tenders. They do this with the intention of making up their potential losses through variation claims on the P&G components when the actual construction work starts. However, the building owner often queries such variation claims on the grounds that the contractor ought to have ascertained all project costs and include these in the pricing of the tender. This often results in costly and time-consuming dispute resolution processes that undermine productivity, relationships and overall project outcomes. To guard against this, the site managers advised that contractors should carefully scrutinise the site geological reports and the drawings in addition to visiting the site to verify all issues that may affect cost and factor these in the pricing of the job. Adhering to this advice may be a problem for some contractors on three grounds: the first is the time and resource commitments required to do proper site analysis and pricing of the preliminaries; the second is that the contractor is not sure of winning the job and the time and resources spent on researching the issues and submitting a bona fide tender may go down the drain, if the bid is unsuccessful. Thirdly, pricing the preliminaries correctly may escalate the tender price and makes the bid uncompetitive. Overall the site managers agreed that the solution to the preliminaries problems, especially where the site characteristics, scope of work and the complexity of the project indicate huge P&G cost implication is to be upfront with the pricing, have a negotiated contract, insist on a cost-reimbursement contract or partner with the building owner for a win-win contractual arrangement.

D) Site preparations and substructure

The site managers' accounts of the typical constituents of the site preparation and substructure work at the construction phase of a large scale residential development project varied, depending on the project and site features. Overall, the feedback showed that typical constituents include all work within the confines of the new building footprint from the foundations up to the underside of the lowest floor finish. Again, this differs slightly from the approach adopted in the New Zealand Institute of Quantity Surveyor's (NZIQS, 1992) Elemental Analysis of Costs of Building Projects. The key differences are the exclusion of demolitions, dewatering and diversion/termination of existing services and water courses, all of which form part of the preliminaries work as discussed in the earlier subsection.

Depending on the nature of the project and the site conditions, the site preparations may include the site clearance, tree removal, temporary ground retainment, underpinning and shoring of the nearby buildings/structures which may be affected by the excavation of the new construction. On the other hand, the substructure work may comprise the excavations (including basement excavations, where applicable), drainage and piling (where applicable), bulk filling and consolidation, foundations, underfloor walls/retaining walls, ground floor slab or timber floor construction, tanking/waterproofing, underfloor service ducts, lift pit (where applicable), and permanent ground retainment. Figure 10 shows typical constituents and construction sequence for the site preparations and substructure work.

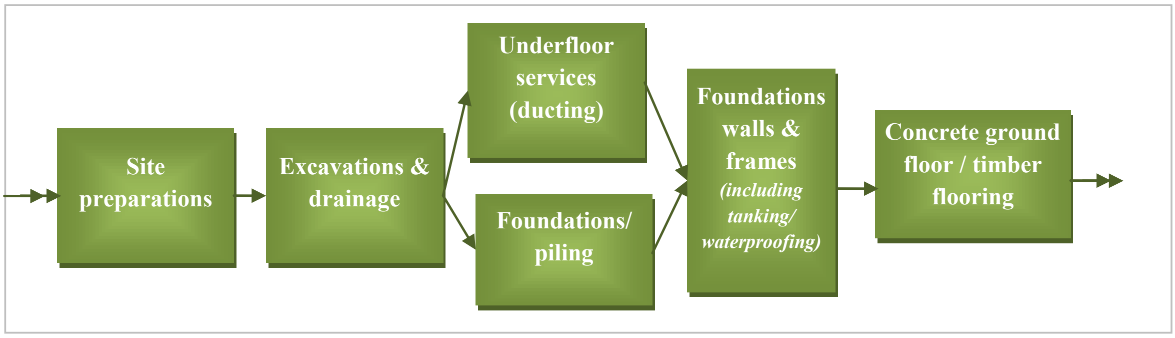


Figure 10: Typical subcomponents of the site preparations and substructure work

Depending on the variability of the ground conditions, the site characteristics and the scope of work, the substructural issues may account for 20–30 percent of the variation claims and cost overruns in the residential development. These issues are prevalent on most sites, notwithstanding the availability of information on the soil test results and the geological reports. The issues relate mostly to excavations.

E) Superstructure

The superstructure comprises the balance of the construction work from the substructure to completion, excluding the finishes, fixtures and fittings, and the external works. Depending on the nature of the building, typical superstructure work as shown in Figure 11, may include the frame, structural walls, suspended floors and roofs; stairs and lift (where applicable); external cladding; doors and windows; and services (second fix: cabling, piping or ducting for plumbing, HVAC, fire services, electrical services, telecommunications/data and special services).

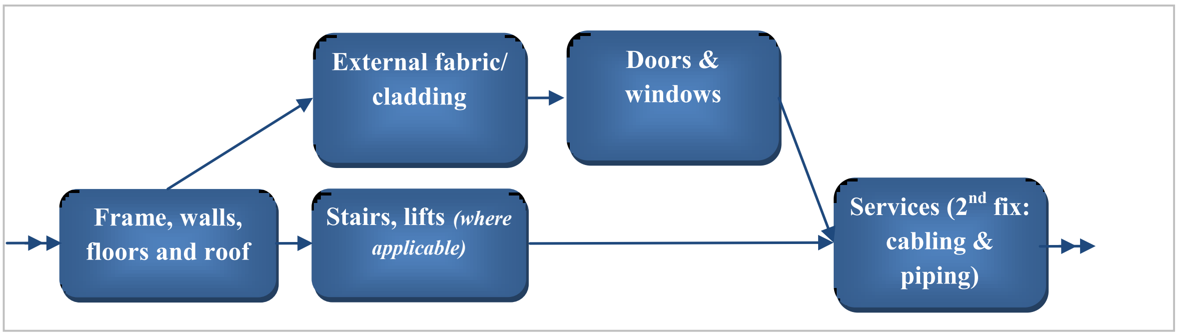


Figure 11: Typical subcomponents of the site preparations and substructure work

The superstructure represents a significant proportion of the construction phase, especially for high rise residential buildings. It therefore has potential for influencing productivity and performance outcomes in the construction phase. The site managers hinted that the key issues around the superstructure work and which may impact on efficiency and productivity relate mostly to the coordination of the various trade interfaces involved. They were of the view that, depending on the scope and complexity of the work and the number of these interfaces, effective project coordination role relies heavily on sound project management skills and knowledge and in-depth experience. These underpin the effectiveness of the planning, scheduling, communication, supervision, monitoring and control processes.

F) Finishes fixtures and fittings

The finishes comprise the external and internal protective coatings or treatments to the surfaces of walls, frames, ceilings, floors, parapets, etc. The external finishes may be applied or in-situ such as rendering, painting or decorations.

The finishes, fixtures and fittings stage could influence the maintenance frequency of the completed building in the operation stage, if they are not properly installed or if the quality of work is shoddy. Also, if not properly supervised, a lot of wastage may be encountered over and above the allowances in the tender price, which could result in cost overruns and poor productivity outcomes. Figure 12 shows typical components and sequence of the finishes, fixtures and fittings at the construction phase.

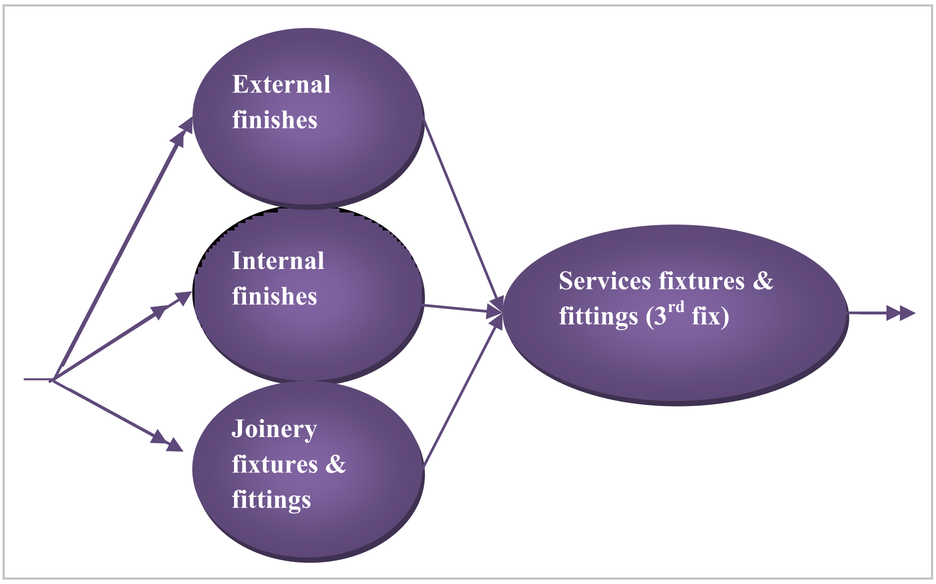


Figure 12: Typical components of finishes, fixtures and fittings

G) External works

The external works are the last of the construction works prior to the close-out and handover stage. Theoretically, they include site works beyond the line of the exterior face of the building structure (NZIQS, 1992). Depending on the site characteristics, and the scale and complexity of the project, typical subcomponents and sequence of execution of external works are as shown in Figure 12.

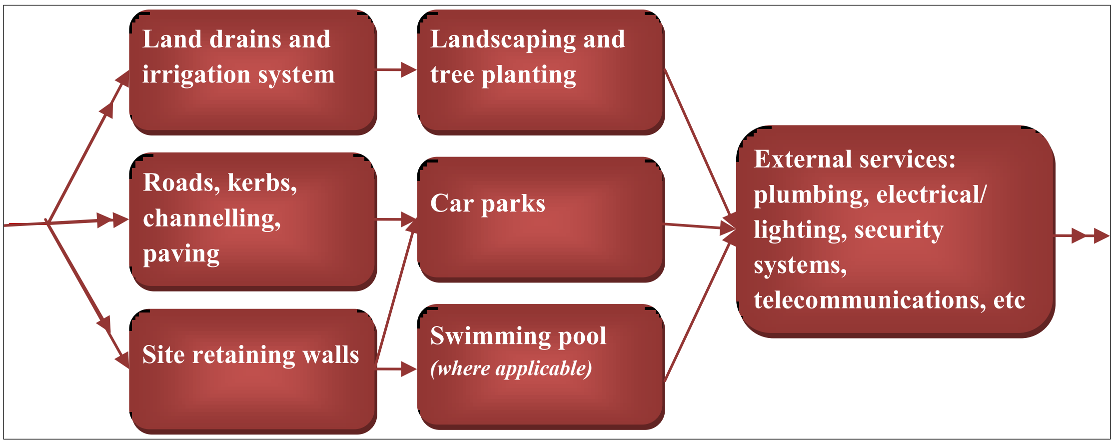


Figure 13: Typical components of external works for large scale residential development

Being the last major construction operation before the close-out stage, the external works may present productivity issues due to the tendency to divert the project resources (workers, equipment and supervision) to commence other projects which have just been won by the contractor. As a result, a lot of issues around 'snagging' (i.e. a list of identified defects) are usually encountered at this stage, which may further delay the practical completion period and undermine the desired productivity outcomes on the project. However, it could be argued that if certain components of the external works, such as hard landscaping, are required for issuing Code Compliance Certificate (CCC) and where final payment is tied to CCC being issued, there is every incentive for the contractor to deploy sufficient resources to finish the work quickly and efficiently (Berry, 2013).

H) Close out and handover

The close-out and handover stage is the last operation following the issuance of the practical completion for the project. Typical subcomponents of this stage are as shown in Figure 13.

Ideally, this stage of the construction phase should not present any productivity challenge. However, being the last operation, the quality inspections and the compliance scrutiny conducted here are the strictest. Defects or mistakes which were not noticed during the earlier stage inspections are more likely to be captured here. The stage therefore may likely experience a lot of snagging issues or 'notices to fix' following the last building inspections. Given that the bulk of the project resources such as workers, subcontractors, scaffolds and other plant and equipment would have been deployed elsewhere at this stage, fixing any identified defects usually becomes a big issue for most contractors. More so that this is the stage where the last impression is created, which may affect the building owner's perceptions of quality for the whole project and a key decider of whether or not the building owner would want to re-use the contractor for future contracts, where applicable. Getting it right the first time is the best way of guarding against the quality issues which may be picked up at this stage.

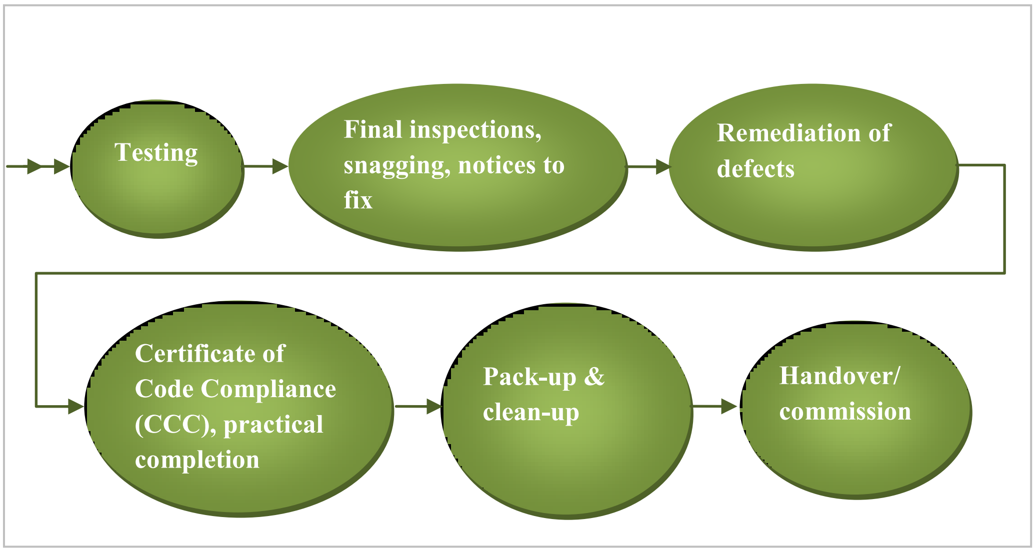


Figure 14: Typical subcomponents of the close-out and handover stage

Typical project plan and schedule

Figure 14 is a simplified version of a typical project plan and schedule for the construction phase of a residential development project. It highlights the key operational stages, the planned durations and their scheduling on a timescale. This is used to compare actual progress on site against the initial plan. Through this comparison, any noted discrepancies are investigated to establish the underlying causes and hence the resolution strategies. In practice, the project plan is revised whenever any major variation occurs that has the potential of affecting the overall project cost and completion time. The revision re-establishes a set of benchmarks and completion date for subsequent progress monitoring. Similar plans are established for the project cost and control purposes.

However, the industry's approach to monitoring the costs and schedule performance separately is not very effective. This is because, while the project may be within schedule as planned at any point in time, the budget would have been exceeded.

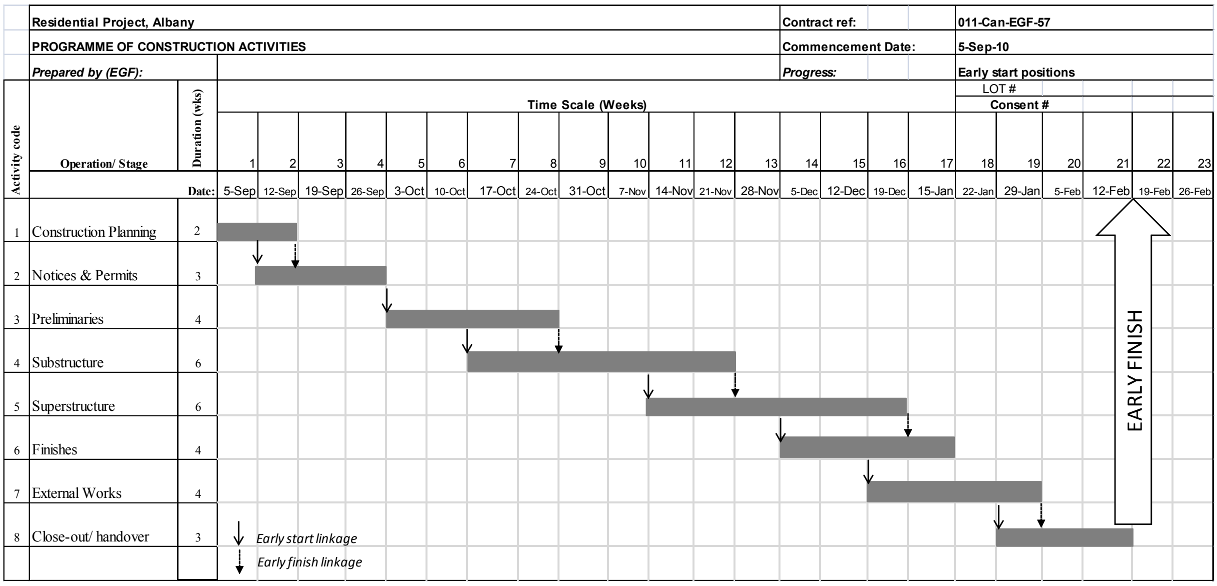


Figure 15: Typical Gantt chart for the construction phase of a residential project development

5.4.4 Construction phase productivity improvement measures

The site managers' general overview of the productivity improvement measures at the construction phase called for concerted efforts by all stakeholders – the building owner, the designers, the contractor and the third parties.

The key requirement from the building owner is a clearly articulated and firmed-up statement about his or her requirements in the building process. This may be possible for experienced building owners who procure buildings regularly. The truth is that most building owners – especially the first-time or one-off residential building procurers – do not have adequate knowledge of the building construction process to be able to articulate their needs early in the procurement process. It is the responsibility of the project team – the designers and the contractors – to enlighten them on the key issues and how their decisions and need preferences could impact on quality, cost and productivity at the development phase as well as the entire RBLC. This may help to reduce the owner-driven change orders, especially at the critical stages of the construction process.

The key requirement from the architects and the engineers is accurate, comprehensive and timely information on the details for implementing the building project efficiently and effectively. Alternatively, the contract should provide for the contractor to develop the design further to address his or her needs for operational details about some tricky aspects of the construction work. This will minimise the designers' detailing errors or lack of sufficient information, and hence mitigate delays and rework issues.

The contractor needs to have the right experience, capacity and capability to undertake the project. He or she should have adequate project management and organisational skills to effectively coordinate the various subcontractor interfaces. In addition, the workers need to be skilled and experienced in the type of work at hand. They need to be adequately equipped with the right tools and be well motivated to deliver the expected outcomes. The environment within which they work needs to be safe and conducive for productive outputs. They need to be well supervised and rewarded for going the extra mile in delivering to or surpassing expectations. However, in practice, the contractors often lack the project and organisational skills and knowledge for these interface coordination roles. Where changes occur due to variations to the contract, the master programme is hardly updated to reflect the new scope of work. The result is that proper progress monitoring involving the benchmarking of the actual performance against the planned targets is not followed. Consequently, idle times, excessive wastages, and ill-motivation of workforce become the order of the day, giving rise to poor productivity and performance at this stage. To guard against this problem, the interviewees recommended the contractor's engagement of an experienced and qualified construction manager to be in charge of the project execution; alternatively he or she could upskill in project planning, project management and human resources management to be able to deliver sustainable and successful project outcomes.

5.3 Productivity measurement points in the building life cycle

Generally, productivity measures the overall efficiency of the production unit in utilising resource inputs to produce outputs of goods and services (Mawson et al. 2003; Calderon, 2010). Statistics New Zealand (2012a) concurs to this by defining 'production' as "the act of combining the inputs (labour and capital) to produce outputs of goods and services. Mawson et al. (2003) argues that, as 'outputs', the goods and services produced by the production unit for productivity evaluation purposes must be those available for use by the other/external production units.

It should be noted that the productivity outcome in a phase of the RLBC or in one of its subparts, does influence productivity outcomes in other phases. For instance, an architect's poor design at the design phase could present buildability problems and poor productivity in the construction phase. In the operation and maintenance phase, the architect's poor design could also result in poor building performance including high energy costs and frequent maintenance. Also by not taking into consideration the ease with which the building components could be decoupled for re-use at the decommissioning phase, the architect's design results in expensive and destructive deconstruction with little or no prospects for materials and components re-use or recycling; this further diminishes productivity at this phase.

However, the productivity measures computed at the measurement points in the building life cycle may not take into consideration the inter-phase relationship due to difficulties in accurately tracking and quantifying the inter-phase influences. The way around it is to consider the down stream influences of one phase in evaluating the output value of the phase. For instance, the value of the poorly designed and constructed building at the end of the commissioning stage of the development phase could be significantly diminished by the implied high maintenance and running costs at the operation and maintenance phase. This way, the inter-phase productivity influences could be accounted for at the point of measurement. Figure 7 shows the stages in the RBLC.

Interview participants' feedback on the productivity measurement points in the RBLC

The essence of the foregoing section was to clearly identify where the productivity measurement points exist in the RBLC so as to understand the groupings of the role players that contribute to the outcomes in each measurement point. The interview participants were all in agreement with this concept. The outcomes of the subsequent investigations on the relative levels of influence of the role players on productivity therefore helped to identify the key role players who are in the position to make a difference in the productivity improvement at the key stages and for the overall building life cycle.

5.5 Role of stakeholders in the building life cycle

One of the objectives of this study was to identify the key role players in the phases of the RBLC and how they influence productivity at their phases of operation and for the whole cycle. The information compiled in relation to this objective at the scoping study phase provided the starting point of inquiry at the empirical surveys. The participants were asked to validate, modify or add to the information as they saw fit. Overall, the interview participants approved of the information as being valid in practice. Table 2 presents the final version of the information, as modified by the interview participants.

The information in Table 2 should be viewed with caution; this is because only a few interviewees were prepared to provide feedback on the intra-phase and inter phase influence of each role player as initially planned for in the scoping study report. The interviewees were rather more comfortable with feedback on the productivity influencing role/input of the role players and the other role players whose productivity output might be affected in the other phases of the RBLC. Perhaps, this could be due to lack of detailed knowledge of the intra and interphase activities and influences and the interviewees' reluctance to provide feedback on issues outside their sphere of competency. Their feedback in relation to the productivity influencing role/input of the role players was documented in Table 3. The information was presented from the role player focus, as distinct from the phase-focus of Table 4.

Life cycle phase	Key tasks	Key role players	Productivity influencing role/ output	Intra phase influence	Inter phase influence
1) Inception	Identification of procurement need & requirements, briefing, proposed solutions and feasibility studies	1a) Owner	Project brief (detailing needs and preferences)	1b, 1c, 1d.	2a–2d; 3a–3d; 4a–4i; 5a–5e; 6a–6d; 7a–7i; 8a–8c.
		1b) Investment advisor/Financier/ Project manager	Strategic/economic advice (on returns on investment); feasibility (financial, legal & technical); development plan	1a, 1d.	2a–2d.
		1c) Architect	Concept designs (outline proposals)	1a, 1b, 1d.	2,4,6,7,8
		1d) Quantity Surveyor	Cost advice	1a, 1c	2a.
2) Design	Architectural and engineering designs and services, cost planning & cost checks, value analysis	2a) Architect	Detailed architectural designs, drawings and specifications	2b, 2c, 2d.	
		2b) Design engineer	Detailed engineering/ services designs, drawings and specifications	2a, 2c, 2d.	
		2c) Quantity Surveyor	Cost plan, cost estimates, cost checks, value analysis/value engineering, life cycle costing.	2a, 2c, 2d.	
		2d) Project manager/main contractor	Design coordination plan, design audit (buildability checks)	2a, 2b.	
		2e) Contractor (if design & build contract)	Construction advice	2a, 2b, 2c, 2d.	
		2f) Local Council.	Project Information Memoranda (PIM), Land Information Memoranda (LIM), advice on building & resource and code compliance	2a, 2b, 2c, 2d, 2f.	
3) Documentation	Project documentation, permits, contracting and planning.	3a) Architect	Design documentation (architectural designs, drawings and specifications)	3c, 3d, 3e.	4c–4j.
		3b) Design engineer	Design documentation (engineering/services designs, drawings and specifications, engineering reports)	3c, 3d, 3e.	4c–4j.
		3c) Quantity Surveyor	Contract/tender documentation, tender estimate, schedule of quantities, budget, cash flow forecast.	3d, 3e.	4d–4j.
		3d) Project manager	Project management plan, risk plan, H&S, method statement, master plan, quality assurance plan, project coordination plan, environ mgt plan (EMP)	3c, 3e.	4e–4i.
		3e) Local Council.	Building consent, resource consent.	3a, 3b, 3d.	4a–4i.

Life cycle phase	Key tasks	Key role players	Productivity influencing role/output	Intra phase influence	Inter phase influence
4) Construction	Construction	4a) Architect	Architectural design details (RFI); revisions and change orders, work approvals	4b, 4c, 4d, 4e, 4f, 4g, 4h, 4i, 4j.	6, 7, 8
		4b) Design & services engineers	Engineering/services design details (RFI); revisions, change orders, work approval.	4a, 4c, 4d, 4e, 4f, 4g, 4h 4i, 4j.	
		4c) Quantity Surveyor	Cost/value reconciliations, cost control & financial report, valuations, progress payments and certifications.	4d, 4e, 4f, 4g, 4h, 4i, 4j.	
		4d) Project manager	Plan revisions, change orders, work approvals, progress payments and certifications.	4a, 4b, 4c, 4e, 4f, 4g, 4f, 4h, 4i.	
		4e) Head contractor	Construction management plan, risk plan, H&S, method statement, master plan, quality assurance, subcontract supervision and coordination plan, EMP, material & equipment ordering and logistic management, code and statutory compliance, subcontract revisions, change orders, work approvals, progress payments and certifications.	4c, 4d, 4f, 4g, 4h, 4i, 4j.	
		4f) Subcontractors	Subcontract works, plan, method statement, quality assurance, progress claims.	4c, 4e, 4g.	
		4g) Suppliers	Materials, plant & equipment supplies.	4c, 4e, 4f	
		4h) Project financiers	Project finance.	4c, 4d, 4e, 4f, 4g, 4i.	
		4i) Project insurers	Insurance cover, performance bond sureties.	4c, 4d, 4e, 4f, 4g, 4h.	
		4j) Local Council.	Certification checks, building inspections, code compliance checks, Notice to Fix.	4a, 4b, 4c, 4d, 4e, 4f, 4g, 4h, 4i.	

Life cycle phase	Key tasks	Key role players	Productivity influencing role/ output	Intra phase influence	Inter phase influence
5) Close-out/commissioning	Quality checks, snagging, testing, certification, manuals, user-training	5a) Architect	As-built architectural drawings	5b, 5c, 5d, 5e, 5f	6a–6h
		5b) Engineers	As-built engineering drawings; supervision of services installation; operation & maintenance manual	5c, 5d, 5e, 5f	6a–6h
		5c) Quantity Surveyor	Final valuations and payments; retention releases, financial reports; cost study.	5e	
		5d) Project manager	Quality checks, issuing of Practical Completion Certificate; retention/ bond releases; final project report; user-training	5c, 5d, 5e	
		5e) Contractors	Service installation; testing; permit applications; snagging; producer statement; guarantees; clean up and close out.	5c, 5d, 5f	6a–6d
		5f) Local Council (Authority)	Certification checks, building inspections, code compliance checks; project information documentation.	5a, 5b, 5c, 5d, 5e	6a–6d
6) Operation & maintenance	Operation and maintenance of the facility	6a) Facilities/ property manager (or owner in the owner-occupier setting)	Operation & Maintenance Plan (OMP); maintenance schedule (preventative and corrective); outsourcing/procurement; on-going facilities management.	6b, 6c, 6d	
		6b) Building surveyors (or owner in the owner-occupier setting)	Building surveys and condition reports.	6c, 6e, 6f, 6h.	7a–7j.
		6c) Maintenance contractors	Plant and equipment checks; preventative and corrective maintenance.	6d, 6e, 6f	
		6d) Users (or owner in the owner-occupier setting)	Facility use and care via rent/lease agreements.	6d.	
		6e) Insurers	Insurance cover, performance bond sureties	6a, 6c, 6f.	
		6f) Financiers (or owner in the owner-occupier setting)	Operations & maintenance project financing.	6a, 6c, 6e.	
		6g) Public agencies	Services (data, telephone, electricity, water and gas) metering and billing.	6d.	
		6h) Local Council (Authority)	Building and equipment warrant of fitness (WOF), rates, and valuations.	6a, 6b, 6c, 6e, 6f, 6g.	

Life cycle phase	Key tasks	Key role players	Productivity influencing role/ output	Intra phase influence	Inter phase influence
7) Upgrade/conversions	Renovations, alterations, conversions	7a) Facilities/ property manager	Upgrade/conversions plan; project brief; owner/client representation.	7b, 7c, 7d, 7e, 7f, 7g, 7h, 7i.	
		7b) Architect	Architectural designs, drawings and specifications; architectural work supervision	7a, 7c, 7d, 7e, 7f, 7g, 7h, 7i, 7j.	8a–8c
		7c) Design & services engineers	Engineering/services designs, drawings and specifications, engineering work supervisions	7a, 7b, 7d, 7e, 7f, 7g, 7h, 7i, 7j.	8a–8c
		7d) Quantity Surveyor	Project estimate, tender documentation/management; contract & financial administration of the upgrade/conversions project.	7a, 7b, 7c, 7e, 7f, 7g, 7h, 7i, 7j.	
		7e) Project manager	Project management plan, risk plan, H&S, method statement, master plan, quality assurance, project coordination plan, EMP, revisions, change orders, work approvals, progress payments and certifications.	7a, 7b, 7c, 7d, 7f, 7g, 7h, 7i.	
		7f) Contractors	Construction management plan, risk plan, H&S, method statement, master plan, quality assurance, subcontract supervision and coordination plan, EMP, material & equipment ordering and logistic management, code and statutory compliance, subcontract revisions, change orders, work approvals, progress payments and certifications.	7g	
		7g) Suppliers	Materials, plant & equipment supplies.	7f	
		7h) Project financiers	Project finance.	7e, 7f, 7g.	
		7i) Project insurers	Insurance cover, performance bond sureties.	7e, 7f, 7g.	
		7j) Local Council.	Building consent; certification checks, building inspections, code compliance checks, Notice to Fix.	7a, 7b, 7c, 7d, 7f, 7g, 7h, 7i.	

Life cycle phase	Key tasks	Key role players	Productivity influencing role/output	Intra phase influence	Inter phase influence
7) Upgrade/conversions	Renovations, alterations, conversions	7a) Facilities/ property manager	Upgrade/conversions plan; project brief; owner/client representation.	7b, 7c, 7d, 7e, 7f, 7g, 7h, 7i.	
		7b) Architect	Architectural designs, drawings and specifications; architectural work supervision	7a, 7c, 7d, 7e, 7f, 7g, 7h, 7i, 7j.	8a–8c
		7c) Design & services engineers	Engineering/services designs, drawings and specifications, engineering work supervisions	7a, 7b, 7d, 7e, 7f, 7g, 7h, 7i, 7j.	8a–8c
		7d) Quantity Surveyor	Project estimate, tender documentation/ management; contract & financial administration of the upgrade/ conversions project.	7a, 7b, 7c, 7e, 7f, 7g, 7h, 7i, 7j.	
		7e) Project manager	Project management plan, risk plan, H&S, method statement, master plan, quality assurance, project coordination plan, EMP, revisions, change orders, work approvals, progress payments and certifications.	7a, 7b, 7c, 7d, 7f, 7g, 7h, 7i.	
		7f) Contractors	Construction management plan, risk plan, H&S, method statement, master plan, quality assurance, subcontract supervision and coordination plan, EMP, material & equipment ordering and logistic management, code and statutory compliance, subcontract revisions, change orders, work approvals, progress payments and certifications.	7g	
		7g) Suppliers	Materials, plant & equipment supplies.	7f	
		7h) Project financiers	Project finance.	7e, 7f, 7g.	
		7i) Project insurers	Insurance cover, performance bond sureties.	7e, 7f, 7g.	
		7j) Local Council.	Building consent; certification checks, building inspections, code compliance checks, Notice to Fix.	7a, 7b, 7c, 7d, 7f, 7g, 7h, 7i.	
8) Decommissioning	Deconstruction, recycling, re-use, disposal	8a) Facility/ property manager	Decommissioning plan; deconstruction, recycling and disposal contract management; environmental management plan	8b, 8c.	
		8b) Deconstruction contractor	De-construction and haulage.	8c.	
		8c) Recycling contractor	Recycling, haulage, storage and disposal	8b.	

Table 3: Influences of key role players on productivity at the building life cycle phases of complex residential building project (focusing on phases)

	Role player	Building life cycle phase	Productivity influencing role/output	Other role players whose productivity may be affected
1	Owner	Conception	Initial brief	Architect
		All other phases	Needs preferences	All
2	Project manager	Conception	Development advice; strategic plan; risk analysis	Owner, quantity surveyor
		Design	Design coordination	Owner, quantity surveyor, engineer, contractor, Building Consent Authority.
		Construction	Construction project planning and coordination	Owner, quantity surveyor, engineer, contractor, Building Consent Authority.
		Commissioning	As-built drawings	Owner, users, facilities managers/ property managers, Building Consent Authority
3	Architect	Conception	Brief documentation; sketch designs/outline proposals	Owner, quantity surveyor
		Design	Detailed design, drawings and specifications	Owner, quantity surveyor, engineer, contractor, Building Consent Authority.
		Construction	Revised drawings & specifications	Owner, quantity surveyor, engineer, contractor, Building Consent Authority.
		Commissioning	As-built drawings	Owner, users, facilities managers/ property managers, Building Consent Authority
4	Design engineer	Design	Drawings	Architect, quantity surveyor, contractor, Building Consent Authority.
		Construction	Revised drawings	Architect, quantity surveyor, contractor, Building Consent Authority.
		Commissioning	Operating/maintenance manual	Owner, users, facilities managers/ property managers,
5	Quantity surveyor	Feasibility	Feasibility report, preliminary estimates	Owner, architect.
		Design	Cost plan, cost estimates, bills of quantities, tender documents	Owner, architect, contractors
		Construction	Cost report, final accounts.	Owner, architect, contractor,
6	Building consenting authorities	Design	Building consent; resource consent	Owner, architect, engineer, contractor
		Construction	Building inspection; Code Compliant Certificate	Owner, architect, engineer, contractor
		Upgrade/ conversions	Building consent; resource consent	Owner, architect, engineer, contractor

	Role player	Building life cycle phase	Productivity influencing role/output	Other role players whose productivity may be affected
7	Contractors	Construction	Project plan, progress report, contractual claims.	Owner, architect, quantity surveyor
		Commissioning	Maintenance manual	Owner, users, facilities/property managers
		Upgrade/ conversions	Upgrade/conversions plan; progress report, contractual claims	Owner, architect, facilities/ property manager
8	Specialist trades contractors	Construction	Specialist/subcontract services	Owner, contractors
		Upgrade/ conversions	Specialist/subcontract services	Owner, facility/property manager, contractors
9	Manufacturers/ suppliers (components, materials, plant/ equipment)	Construction	Material and equipment availability and supply report; pricing and reliability of supplies	Contractors and specialist trade contractors
		Upgrade/ conversions	"	Owner, contractors and specialist trade contractors
10	Project financiers	Construction	Project finance	Owner, contractors and specialist trades contractors
		Upgrade/ conversions	Project finance	Owner, contractors and specialist trades contractors
11	Project insurers	Construction	Insurance cover; bond surety	Owner, architects, engineers, contractors, specialist trades contractors.
		Operation and maintenance	Insurance cover; bond surety	Owner
		Upgrade/ conversions	Insurance cover; bond surety	Owner, architects, engineers, contractors and specialist trades contractors
12	Facilities/ property manager	Operations & maintenance	Operations and maintenance plan (planned, preventative & restorative/remedial works)	Users
		Upgrade/ conversions	Upgrade/conversions plan	Architects, engineers, contractors and specialist trades contractors
13	Users	Operations & maintenance	User needs and preferences; asset use and care	Owner, facilities/property manager
14	Disposal/ deconstruction contractor	Disposal/ deconstruction	Reduce, re-use and recycle plan	Owner, contractor

Table 4: Influences of key role players on productivity at the building life cycle phases of complex residential building projects (focusing on role players)

5.6 Stakeholder perceptions of the concept of productivity

There was some sort of an agreement among the participants on the meaning of 'productivity' from their individual viewpoints. Feedback was consistent on the concept being a metric for assessing the extent to which value has been delivered in any undertaking that has set objectives or targets to be achieved, and pre-determined amount of resources for accomplishing the set targets. The 'value' in this case may mean different things to different stakeholders depending on their value system. However, a general understanding of the value is the extent to which the set targets or objectives have been achieved on one hand, and the extent to which the available resources have been optimised in the delivery process, on the other hand. To survey participants, productivity is at its optimum level if the set targets have been achieved, while utilising the minimum amount of resources possible in the process. While this perspective on productivity aligns with the generic understanding of 'value' in the value management circle (Shen and Chung, 2002), it is important in two respects:

First, it goes further than the output-input perspective of the economist which focuses solely on the quantum of output per unit of resource inputs (Davis, 2007). Except where the output-input ratio constitutes the objective to be achieved or the set target, the economist's perspective misses out on the 'performance' aspect of the focus on value delivery. Having a balanced view of productivity ensures that productivity improvements are not made by sacrificing the quality of the completed building, which might well be the case if all that is focussed on is having more output with less input, without caring for the quality of the output.

It should be noted that for a number of the interviewees, the economic perspective, particularly the total factor productivity model, is essential, as the sole purpose of being in business is to make profit. However, they argued that making quick money may not be a key motivator to productivity and performance in all cases. They cited an instance where a contractor envisages further jobs coming from a building owner. In this instance, the contractor may be prepared to trade off profit on the current job with the hope of recouping it in the subsequent jobs. The contractor could therefore manage the change orders in the current job solely to the owner's terms without disputing the owner's approach to valuing the variation orders; the motivation here is to build good owner-working relationship that is fundamental to winning subsequent jobs.

Overall, the key components of project-level definitions of productivity as analysed from interviewees' feedback comprised three limbs as follows:

- '*Efficiency*': this is the economic perspective of productivity, focusing on the optimal use of resources. This aligns with the output-input schema, where the overall focus is to "achieve (output) more with less (input)". Table 4 and Figure 15 show that this perspective of productivity was mentioned 39% of the time. This means that the economic perspective on productivity is not widely shared by the stakeholders as a key component of productivity at the project level.

- '*Effectiveness*': This is the ability to achieve set objectives. In the project context, the objectives are cost/budget, time/schedule, scope and quality. This is more of a performance issue and perhaps, explains why the terms 'productivity' and 'performance' are used in tandem. Figure 15 shows that this perspective was mentioned 35% of the time. A holistic view of productivity at the project level therefore encompasses wider issues.
- *Sundry items*: A closer look at the key components of the various definitions of productivity provided by the survey participants suggests that, over and above issues relating to efficiency and effectiveness, the participants expected productivity to involve the achievement of other indicators of performance such as safety, client satisfaction, relationships (including absence of disputes/litigations), workforce satisfaction, reputation (for performance), future job orders, and regulatory/statutory compliance. These sundry items accounted for about 26% of the recurring themes in the interviewees' expectation or understanding of the concept of productivity.

A holistic view of productivity at the project level should therefore comprise efficiency, effectiveness and wider issues which can be referred to as 'add-ons'.

However, it was surprising to note that sustainability was not considered by the participants as being a key component of the productivity definition, in spite of the growing emphasis on the subject. Perhaps, this aligns with the Beacon Pathway's (2008) observation that, quite unlike the UK and other developed economies where the government drives the sustainability initiatives in the new build through massive financial support (often in the social housing sector) and through the Building Code, such financial support is not part of the government agenda for the private sector, which is entirely market driven. Beacon Pathway (2008) research suggests that many people would find it easier to build and retrofit their homes sustainably if council policies, plans and processes were more supportive of sustainable design, arguing that "even when policies are neutral or supportive of sustainable building, Council administrative processes can be a disincentive. Currently, there are limited resources, knowledge gaps, and a generally piecemeal approach to policy initiatives to support sustainable residential building. Over and above the threshold provided in the current Building Code, sustainability is only considered in the retrofitting sector through the various financial incentives provided by the central and local governments. Furthermore, Sharman (2013) notes that building sustainably is seen as being more expensive, as only first costs are usually considered, rather than lifetime costs.

Overall, an ideal definition of productivity at the project level must include effectiveness (i.e. achievement of set targets or objectives, usually costs, schedule, scope and quality), efficiency (i.e. optimal use of the available resources in achieving the set targets), and sundry issues such as client satisfaction, safety and statutory/regulatory compliance.

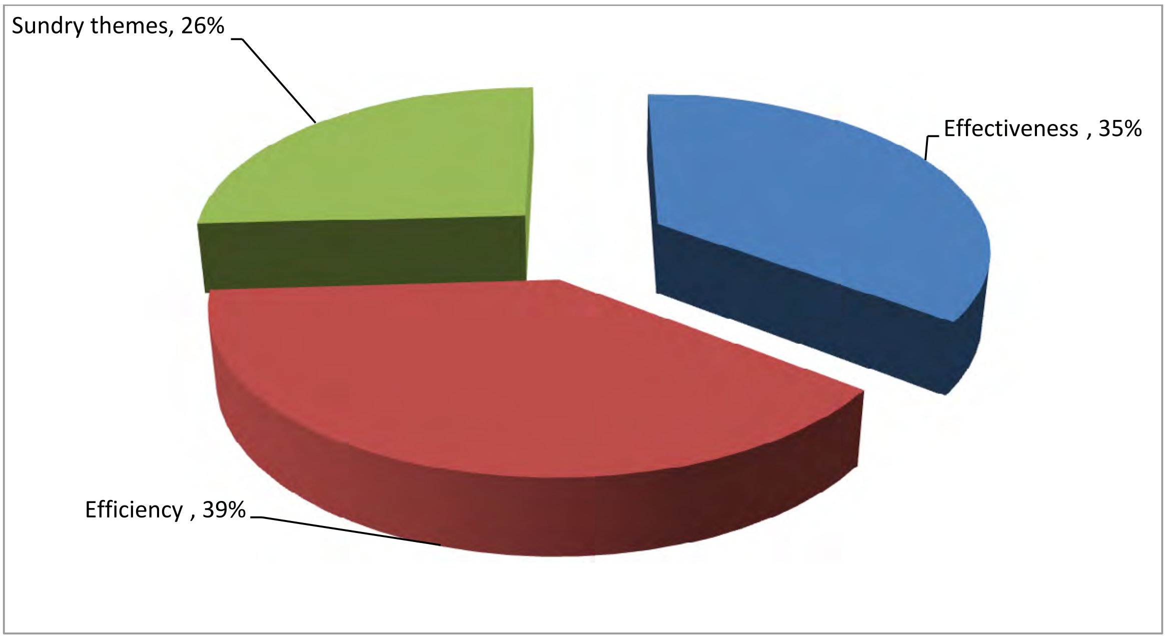
Implications for research

The feedback provided by the participants was therefore wrapped around the above definition of productivity, which is a huge contrast from the economic perspective usually adopted by the government and government agencies. It should be noted that the agencies adopt the economic perspective of productivity for international comparability purposes (UN, 2009).

	Respondents' descriptions of the concept of productivity	Key themes implied in the descriptions		
		Effectiveness	Efficiency	Sundry themes
1	"It's all about getting results – getting the work completed on time, within budget and with no call-backs".			
2	"You are productive, if you are not losing money on the job and the margin is good".		1	
3	"It's about pushing the job as fast and as safely as you can go, and ensuring that you are getting paid for the work".	1		1
4	"It's more of a labour thing: that the contractor and subcontractors are doing their job as required without any reworks and safety issues".	1		1
5	"That you are achieving the outputs and keeping your client happy so that you can get signed on for any future job".	1		1
6	"Getting it right the first time with zero tolerance to wastes and defects".			
7	"Achieving time, cost and quality targets and with no disputes with your clients and subcontractors".			1
8	"An indication of how well you are accomplishing the targets you set for the job, including making reasonable profit and avoiding call-backs".			
9	"I think the key is 'client relationship management'; if you are satisfying your client, every other thing falls in place, including speed, budget and quality and with the prospects for good reference or future job orders".			1
10	"It's a word for 'build it right the first time, every time'; you won't go wrong if you achieve this".	1		
11	"Productivity means that you have the necessary resources to deliver to expectations, such as good workforce, good supervision, adequate funding and cash flow".			
12	"Four words: time, quality, cost and safety".			
13	"It means you are optimising the use of your resources to the greatest advantage".			
14	"It means that everyone is happy on the project – that your workers are well motivated and well rewarded, your client is happy with the speed and quality of the work, you are having no compliance issues with the building code, contract specifications and health & safety; and above all, you are making enough profit on the job".			1
15	"It could be summed up in two words: 'cash flow' and 'profit'; that when you submit an interim or final payment claim, nothing is withheld, there are no contra charges, your cash flow is good and the margin is as expected".		1	
16	"It means that the contractor is doing the job as expected and with no defective work, less disputes and good safety records".			1
17	"It means maximising the output and/or minimising the input; it means doing more with less"		1	

18	"When you are accomplishing so much with minimal resources"		1	
19	"It's like an odometer that tells how fast you are going in the direction of your destination; when productivity is low, it means you are wasting efforts, time and money and not achieving results".			
20	"That's the word for 'efficiency'; i.e. you are utilising your resources well with little or no wastages; it is like the 'lean construction' where you target to eliminate all forms of waste in the system and improve operational efficiency"		1	
	∑ (Frequency of mentions for the key themes):	4	5	7
	%	35%	39%	26%

Table 5: Content analysis of the respondents' descriptions of the concept of productivity at the project level



**Sundry themes*: client satisfaction, worker motivation, safety records and good relationship management with little or no incidence of disputes

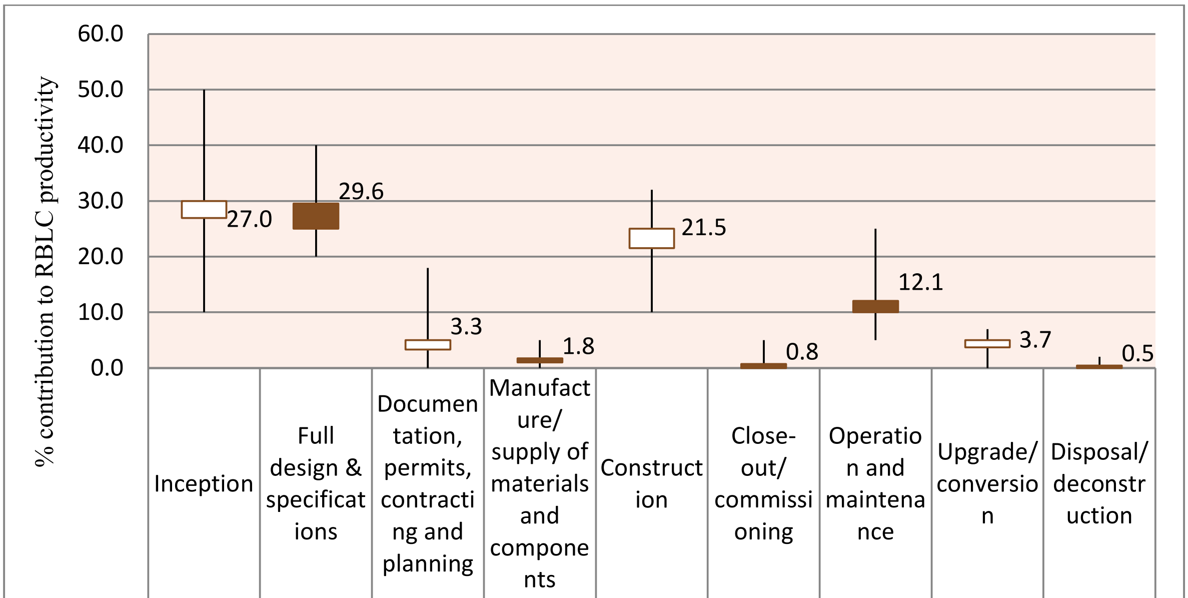
Figure 16: Key components of project-level definition of productivity as analysed from interviewees' feedback

5.7 Relative influence of the phases to the overall productivity outcomes

Participants were asked to rate the relative levels of influence of the decisions made at each phase to the overall productivity outcomes in the RBLC. The rating was such that the total percentage influence/contributions of the phases summed up to 100. Table 6 presents the analysis of the relative influences of the phases. Figure 16 summarises the results of the analysis of the participants' feedback.

	RBLC phase	Mean %	High %	Low %	Mode %	Cum %
1	Full design & specifications	30	40	20	25	30
2	Inception	27	50	10	30	57
3	Construction	22	32	10	25	78
4	Operation and maintenance	12	25	5	10	90
5	Upgrade/conversion	3.7	7	0	5	94
6	Documentation, permits, contracting and planning	3.3	18	0	5	97
7	Manufacture/supply of materials and components	1.8	5	0	1	99
8	Close-out/commissioning	0.8	5	0	0	100
9	Disposal/deconstruction	0.5	2	0	0	100
	Σ	100				

Table 6: Analysis of the phases with the most critical decision influences on the RBLC productivity outcomes



	Inception	Full design & specifications	Documentation, permits, contracting and planning	Manufacture/supply of materials and components	Construction	Close-out/commissioning	Operation and maintenance	Upgrade/conversion	Disposal/deconstruction
Mean	27.0	29.6	3.3	1.8	21.5	0.8	12.1	3.7	0.5
High	50.0	40.0	18.0	5.0	32.0	5.0	25.0	7.0	2.0
Low	10.0	20.0	0.0	0.0	10.0	0.0	5.0	0.0	0.0
Mode	30.0	25.0	5.0	1.0	25.0	0.0	10.0	5.0	0.0

Figure 17: Relative influences of the decisions made at the phases to the overall productivity outcomes in the residential building life cycle (RBLC)

The box plots in Figure 16 show that, on the basis of the average values, decisions made at the full design and specification phase have the highest influence on the overall productivity outcome in the RBLC, accounting for about 30% of the total outcome. This result contrasts with earlier studies (Mbachu, 2008) which found that the decisions made by the client at the inception phase exert the most profound influence on the productivity outcomes in the down stream phases and for the overall life cycle. Perhaps, this is a reflection of the general feeling that the designers in New Zealand have so much influence on the choices made by the building owners, especially in relation to the form, structure and fabric of the building, and therefore control the downstream productivity outcomes, albeit, indirectly. Overall, the industry believes that the construction phase would be a lot more straightforward and less problematic if the design is right from the start Sharman (2013).

Table 5 shows that, overall, the decisions made at the design, conception/inception and construction phases account for about 80% of the productivity outcomes in the RBLC. The biggest opportunities for productivity increase leverage in the cycle could therefore be in the shaping of the decisions the role players at these phase make to ensure a positive influence in the productivity outcomes for the whole cycle. This task is explored in the next section.

5.8 Key role players' influence on productivity outcomes

As stated in the conceptual framework for the study, establishing the productivity/efficiency constraints in the RBLC and where the opportunities for greatest improvement exist in the cycle requires focus internally on the stakeholders' roles and responsibilities at each phase as well as the consideration of the influence of the external factors in the operating environment. This subsection presents feedback and results on the relative levels of influence of the key role players on the RBLC productivity outcomes as well as the various ways in which they bring about those influences.

Key role players' relative levels of influence on the RBLC productivity outcomes

With the traditional procurement approach involving customised designs being the greatest obstacle to productivity outcomes in the RBLC, the first phase of the interviews focused on this procurement approach. The 'turnkey' approach and the standardised design (with no significant owner-modifications) were later covered in the second phase of the study to ensure a holistic coverage of the entire spectrum of the residential building development from simple to complex buildings.

To determine the relative levels of influence of the role players, the participants were asked to rate their relative levels of influence on a 5-point Likert scale. Multi-attribute analysis was used to establish the mean ratings as given in Equations 1 and 2 under the Research Method section. Table 7 shows the results of the analysis. Figure 17 provides the graphical plots for better visual clarity.

Results showed that the architect was perceived as the most influential role player in the RBLC as far as the customised design procurement route is concerned. The next 'very high' influencers are the owner, the project manager and the contractor. The consenting authorities were rated as being 'high' influencers. It should be noted that the interviewees rated the 'project manager' as a function rather than a role player. In other words, the architect, developer or contractor could perform this role depending on the contractual arrangement with owner. Some experienced owners could also retain this function. The various ways through which these role players influence productivity outcomes in the RBLC are discussed in the following subsection.

	Key role players in the RBLC phases	[a]Rating of the roleplayer's level of influence on the RBLC productivity outcome								
		VH	H	M	L	VL				
		5	4	3	2	1	[b]TR		[c]MR	
1	Architect	65%	20%	15%	0%	0%	20	4.500	Very High	Significant influencers
2	Owner	60%	25%	10%	5%	0%	20	4.300		
3	Project manager	55%	30%	10%	5%	0%	20	4.250		
4	Builder/contractor	50%	35%	10%	5%	0%	20	4.200		
5	Building consenting authorities (Councils)	25%	30%	40%	5%	0%	20	3.650	High	
6	Engineer	20%	25%	45%	10%	0%	20	3.350		
7	Specialist trades contractors	15%	25%	40%	20%	0%	20	2.950	Moderate	
8	Project financiers	9%	23%	41%	23%	5%	22	2.612		Insignificant influencers
9	Project insurers	9%	30%	22%	35%	4%	23	2.335	Low	
10	Manufacturers/suppliers (components, materials, plant/ equipment)	5%	11%	53%	21%	11%	19	2.307		
11	Facilities/property manager	10%	5%	40%	35%	10%	20	1.970		
12	Quantity surveyor	5%	10%	25%	50%	10%	20	1.500	Very Low	
13	Users	5%	10%	20%	40%	25%	20	1.450		
14	Disposal/deconstruction contractor	0%	5%	15%	60%	20%	20	0.890		

a) Rating: 5 = Very high (VH); 4 = High (H); 3 = Moderate (M); 2 = Low (L); 1 = Very low (VL).

b) TR = Total responses; c) MR = Mean rating (see Equation 2).

Table 7: Key role players' relative levels of influence on the RBLC productivity outcomes (for traditional procurement involving customised design)

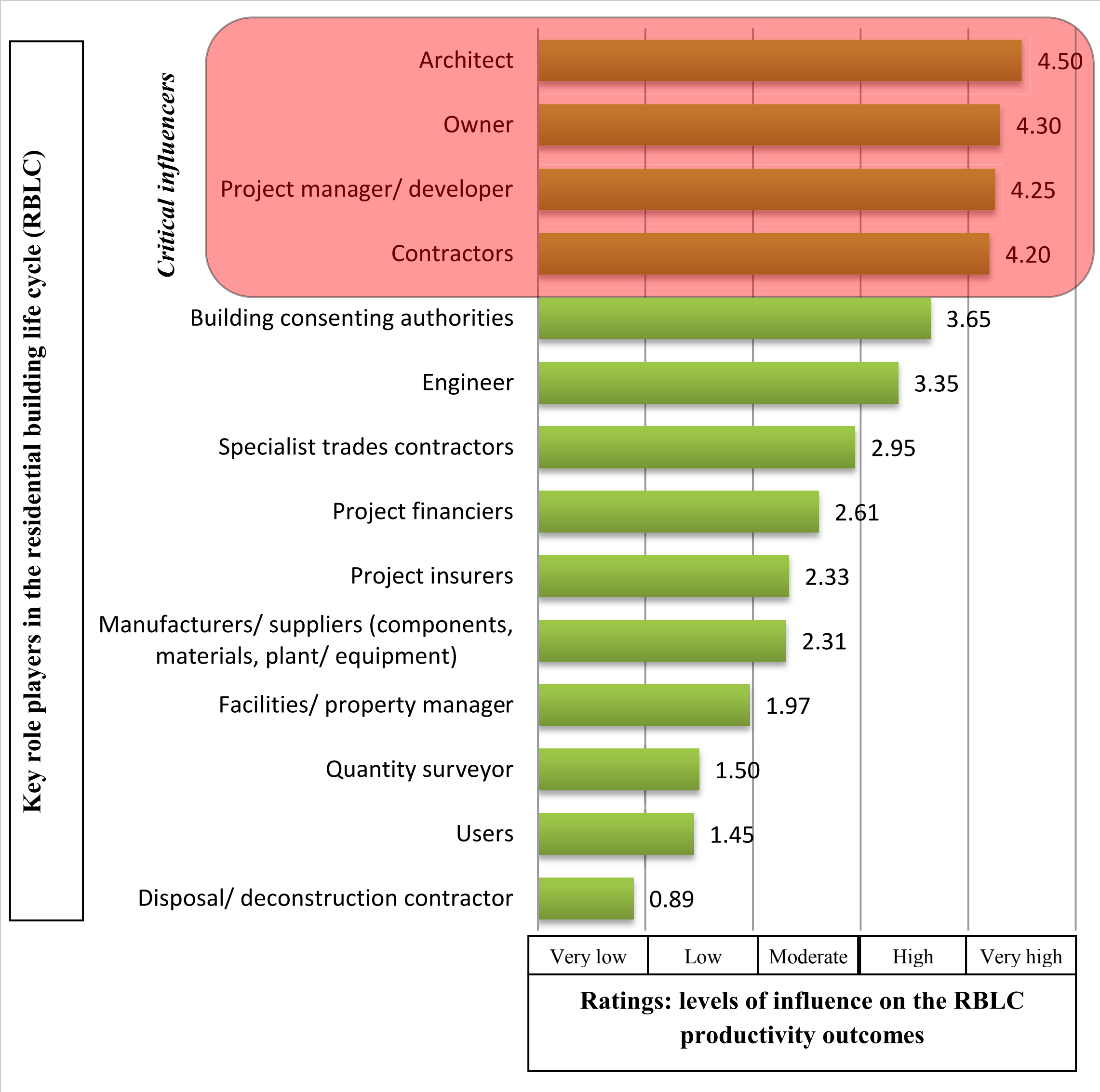


Figure 18: Key role players' relative levels of influence on the RBLC productivity outcomes (for traditional procurement involving customised design)

Influences

At the interviews, the key role players were asked to comment on the various ways the key stakeholders could influence productivity at their phases of operation and for the whole of the building life cycle. They were also asked to suggest ways in which the influence of the role players could be leveraged to improve productivity and performance in the RBLC. The following subsections detail the outcome of the analysed feedback of the interviewees using content analysis.

A) Building owner

The interviewees were unanimous in their feedback that the building owner is the most influential role-player in the RBLC productivity outcomes. Their feedback, as modelled in Figure 18, suggested that the building owner's influence is underpinned by the strategic choices he or she specifies in the design brief in relation to 4 key areas: place (i.e. location), product (i.e. the building), process (i.e. project characteristics), and performance (i.e. the performance criteria/benchmarks). The strategic choices in these key areas are interdependent and have profound influences in all stages of the RBLC as shown in the figure below.

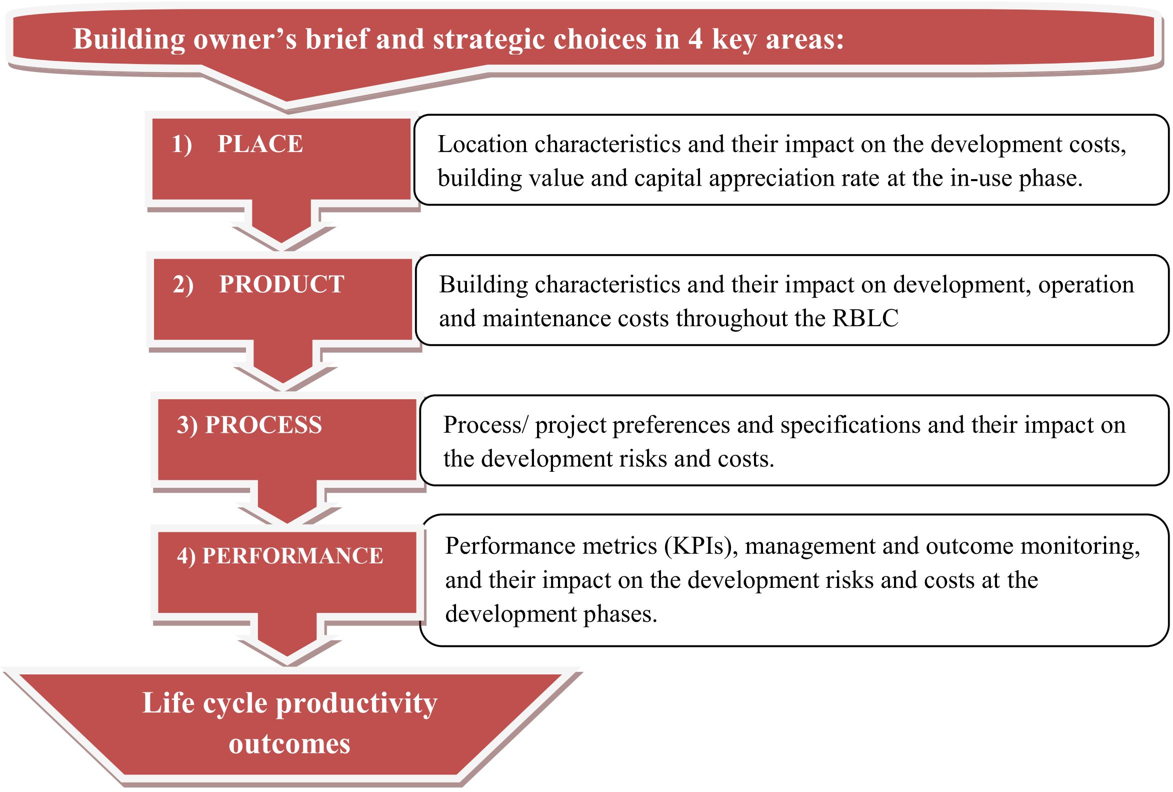


Figure 19: Building owner's brief and strategic choice in 4 key areas and their influence on the RBLC phases and productivity outcomes.

1) Location

The interviewees believed that, no matter how defined (whether from the economic/efficiency or the strategic/effectiveness perspective), the building owner's choice of location for the building development has the greatest influence on the productivity and performance at the individual and overall phases of the RBLC. At the development phases, the location parameters having profound influence on productivity and performance include the following:

- site/topographical characteristics, including subsoil profiles,
- neighbourhood characteristics including city/district plan restrictions, permissible noise/ pollution levels, traffic congestion, parking availability and permits,
- Logistics and supply, including proximity to material supply and waste disposal centres, haulage distances and freight restrictions.

Overall, these location parameters have a profound influence on the design solutions, specifications for materials and workmanship, planning approvals and permits, project site layout and planning, and the choice of construction method and implementation, including onsite material handling and storage. The most profound influence was perceived to be the city/district plan's compliance requirements for the residential zone into which the location falls; these place serious restrictions on the nature and size of the development thereby limiting the extent to which the building owner's expected value on the land development could be realised. Some examples cited by the interviewees included the council plan's restrictions on the use and characteristics of the proposed building, and the building envelope's provisions for building coverage/intensity level, recession planes, boundary setbacks and structure heights. These restrict the building features such as the number of floors that can be permitted as per the council plan's building envelope. Ideally, the height limits are intended to reflect the physical qualities, characteristics and aesthetic coherence of the areas to which they have been applied (Auckland Council, 2012a). Where the proposed building or upgrade fails to meet the council plan's provisions, resource consent is required. Overall, Seadon (2013) opines that the city/district plan's compliance requirements become issues under intensification, as proposed by the Auckland Council.

The interviewees noted that, under the Resource Management Act 1991, the resource consent application would include the assessment of the potential environmental effects and the proposed measures to mitigate the effects. More importantly, if the potential environmental effects were assessed by the Council as being more than minor, public notices or limited notices must be given, allowing interested parties to make submissions in support or opposition of the application. The interviewees further noted that it could take about one to two months to process a non-notified resource consent application and about four months for publicly notified applications. They added that the consenting application could be quite tedious, costly and time-consuming, and with the prospect that the application may not be approved in the end, resulting in a waste of resource and time. These issues constrain productivity and performance, especially at the design and upgrade/conversion phases. To minimise the delays in the consent application processing, Seadon (2013) advises the designers to work with the BCAs during the design production stage and to prepare well prior to application lodgement, ensuring that all the information required is provided.

The location features also impact significantly on the development and operation phase productivity outcomes in several other ways. For instance, some of the interviewees explained that if the location is such that the project will be carried out on a sloping or highly restricted site, it presents a lot of problems with the site planning, onsite material storage and handling, manoeuvrability, work flows and site safety; these escalate construction costs and completion times, thereby constraining productivity and performance. The location could expose the building fabric to harsh environmental conditions that may raise durability issues thereby necessitating costly design specifications and/or high operation and maintenance costs. Examples cited included locations in high wind zones (that require more costly structural stabilisation) or in tectonic hotspots (that require more expensive seismic strengthening) or corrosion zone (that require special treatment to façade). For instance, one of the interviewee hinted that if the site is located in a high wind, earthquake or corrosion zone, the building code provides that homes built in these locations would require extra protections in terms of engineering, bracing and finish. The extra protections impact significantly on costs and completion times, and hence could reduce productivity outputs at the construction stage, though, this may improve productivity over the life cycle due to improved durability and resistance of the building to severe environmental conditions.

Overall, the location features present positive and negative impacts on the productivity outcomes in the RBLC phases. A good number of the interviewees advised that a more proactive approach to choosing the right location for optimum productivity in the RBLC is to focus more on the impact over the long term (such as the impact on the market value of the completed building and the capital appreciation rate in the chosen location) and less on the short term impacts (such as the impact of the land purchase price and the site restrictions on the development costs). However, an issue that may require weighing both positive and negative location impacts to evaluate which location would given a more productive net effect is the impact of the city or district plan restrictions on what is achievable in each alternative location in terms of the maximum value to be derived from the land development and the net present value of the capital appreciation rate or revenue streams (for the case of investment property) over the 50 year life cycle of an average residential building.

2) Product/building characteristics

The building characteristics may include parameters such as aesthetics, quality/durability, size/scope/complexity, materials and components, services, and building use. The interviewees believed that, in the case of a building designed by the architect from the scratch, the brief set down by the building owner communicates the desired functional requirements and performance characteristics for the proposed building. The designers job is to propose design solutions or alternatives to meet the owner's needs, based on their interpretation of the owner's brief and preferences on the one hand, and on the other hand, their understanding of the regulatory compliance and limitations as set out in the building code and the city/district plan. Within the regulatory allowances, the strategic choices made by the owner in relation to the building functionality and characteristics therefore dictate the productivity outcomes in the design, planning, construction and in-use phases of the RBLC. Earlier studies concur to this by arguing that the owner's brief to the architect defines the parameters within which the building must be designed (Kwakye, 1997), planned for (Mbachu, 2008) and constructed (Rowlinson, 1999). The parameters of the completed building in turn inform its performance in the operation and maintenance phase as well as in the upgrade/conversion and the disposal phases. An example of the owner's preferences in relation to the building characteristics as cited by some of the interviewees is the choice for curved shapes as opposed to straight edges. Though aesthetically pleasing, the curved shapes could present buildability problems. As a result, the completion time could be longer and the development costs could escalate by 20–30 percent compared to an alternative design with straight edges.

The opportunity for productivity increase at this stage presents if the building owner could specify the building characteristics that have potentials for maximising productivity in the RBLC phases. A typical example cited by one of the interviewees was the choice of the design proposal with straight edges as against curves.

In the case of the standard plans, interviewees at the second interview phase believed that 70-80 percent of the time, the owners would modify the plans to suit their unique requirements or preferences. This follows the general understanding that, for most New Zealanders, home ownership represents their greatest life-time investments. The owners would therefore like to exercise control over the design solutions to suit their current and future lifestyle needs. The key issue here is that such significant modifications to the standard plans and specifications could increase the costs and completion times of the building by 30-50 percent when compared to the outcomes for a similar building built with little or no modified standard plan. The significant design changes represent enormous wastage of design resources, and hence raise serious productivity issues at the design phase of the RBLC.

3) Process/project preferences and specifications

The process/project preferences and specifications as cited by the interviewees included the owner's preferences for the construction method and technology, the procurement system, the contract strategy, the risk and reward scheme, the project team and the project culture.

The interviewees confirmed that the owner's brief about the project specifications set the contractual framework and boundaries within which the project team members are contractually bound to deliver. The key issue here, as stated by some of the interviewees, was that the New Zealand building owners are so risk-averse that they are usually reluctant to accept innovative solutions that have not been tried and tested, and which could provide huge opportunities for cost-savings and productivity improvement. Building owners would rather prefer the traditional systems, in spite of their many shortcomings. This also extends to the consenting stage where the Building Consent Authorities view with suspicion any innovative material or building solution that is not part of the Acceptable Solutions. In relation to this, Sharman (2013) remarks that, given the Auckland weathertightness experience this is not surprising, adding that BCAs are very loathe to accept innovations they have no experience of as they perceive it increases their risk if the house subsequently fails to perform. A number of the interviewees observed that the time and cost involved in demonstrating compliance of the innovative solutions to the Building Code is quite discouraging, and is a key barrier to the uptake of innovation and productivity in the industry.

In terms of innovative solutions, two opportunities for productivity improvement at this stage, which were mentioned by a good number of the interviewees included the following:

- the use of prefabrication technology (as opposed to onsite fabrication), and
- the use of partnering and integrative management procurement routes (as opposed to the traditional design-bid-build approach which is the current norm and which introduces fragmentation between the design and construction roles, thereby impeding seamless flow of value in the RBLC value stream. The integrative management procurement route such as design and build (D&B) and project management (PM) entails a central and integrated coordination role for managing the design and construction functions so that value flows uninterruptedly from start to finish thereby avoiding the patch-protection tendencies of the service providers, minimising interface frictions and transaction costs, and assuring a central point for accountability, risks and outcomes in the development process.

The interviewees believed that these two strategies have the potentials to reduce the construction costs by 20–25 percent as well as reduce the completion time by 30–40 percent. However, getting the building owners to adopt these two strategies would first, require them to give up their penchant for bespoke designs and risk-averse dispositions. Further research is recommended to gain understanding of what drives building owners' risk-aversion and preference for bespoke designs.

4) Performance metrics (KPIs), management and outcome monitoring

Some of the interviewees indicated that the building owner's strategic choice does include specifications of the benchmarks for evaluating performance of the service providers in the proposed project delivery process and beyond. The key project benchmark specifications are budget, schedule and quality targets to be achieved. Other project benchmarks could include safety, environmental impact and service attitude, depending on the building owner's values and goals. These key performance indicators (KPIs) vary in weights depending on the building owner's preferences. For short-term interest owners such as developers, the schedule and budget benchmarks are weighted heavier than the other KPIs. On the other hand, the long-term interest owners such as the owner-occupiers would place more emphasis on quality/durability and in-use performance. The interviewees believed that these KPIs provide the productivity measurement criteria from the building owner's point of view. Invariably, if the benchmarks were unrealistic, the service providers would struggle to achieve them. This means the productivity target would not be realised. However, the key issue here, as pointed out by some of the interviewees, is that the benchmarks conflict with one another, meaning that focusing on one benchmark may undermine achievement of the others. One of the interviewees alluded this to the "devil's square balancing act". An example cited was that where the emphasis is disproportionately focused on speed of completion, the budget is likely going to be exceeded and the quality may be comprised as well. On the other hand, focusing on quality may mean longer construction time and higher costs. Each of these scenarios impairs productivity at the development phase. The interviewees believed that the solution to this challenge is the use of technology and innovation in leveraging and optimising the available resources to achieving the benchmarks in ways that are quite impossible to accomplish using the business-as-usual approach. Sharman (2013) opines that for innovation and technology to thrive, the risk-averse tendencies of the key role players – the owner, the BCAs and builders – need to be addressed. This is a no mean task, but it is worth working towards through collaboration and gradual incremental change approach.. Another solution lies in the use of partnering clauses in the building contract agreements between the owner and the service providers; the aim is to achieve win-win situations for all, rather than the prevailing win or lose scenario. It should be noted that a recent BRANZ-sponsored Value Stream Mapping (VSM) workshop found that although technology was one solution worthy of exploration, communication between the building owner, the builder and the designer, were also key, as was professional skills in pricing (Berry, 2013).

Overall, the interviewees confirmed that the strategic decisions the building owner makes at the onset have profound impact on the actions and performance of the service providers in the remaining phases of the building life cycle. This finding accords with earlier research (Rowlinsons, 1999; Folk, 2005; Mbachu and Nkado, 2007), which has rated the owner as the most influential figure in the procurement process and performance outcomes.

In terms of the management of the residential building process, the interviewees believed that the owner plays a significant role in shaping outcomes in this direction. The key expectations included meeting own contractual obligations to the building contract such as the following:

- responding to crucial requests for information (RFI) as and when needed,
- being clear about his or her needs in the building process and communicating these unequivocally at the onset,
- avoiding or minimising disruptive and costly change orders especially at critical stages of the building process,
- maintaining reasonable expectations from the service providers, and
- having adequate funding arrangement in place to minimise cash flow problems for the service providers.

B) Design consultants

At the interview sessions, the majority of the interviewees agreed that design consultants play a major role in shaping the productivity and performance outcomes in the RBLC. Content analysis of the interviewees' feedback revealed six major areas through which the designer could influence productivity outcomes in the RBLC. These were perceived as the potential leverage points for productivity improvement by the designers at the inception, design and other phases of the RBLC. Figure 19 highlights the six areas. The details are discussed in the following subsections.

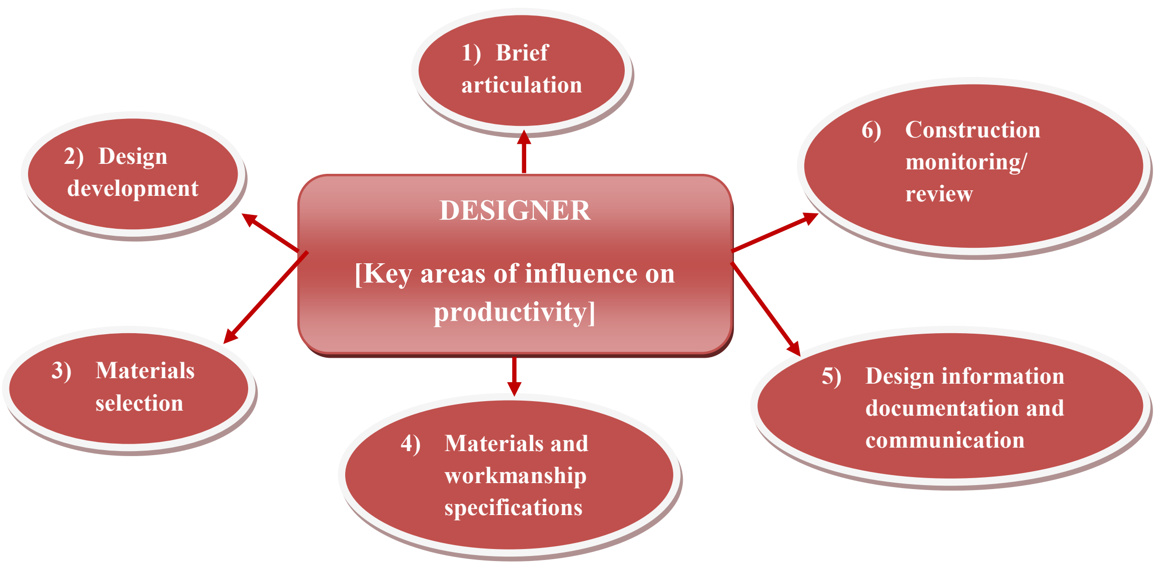
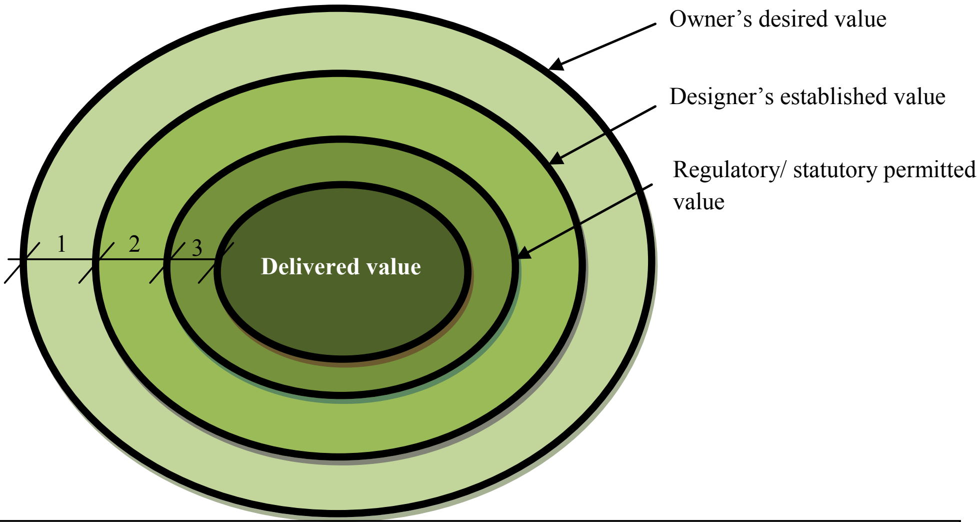


Figure 20: Designer's key areas of influence and potential leverage points for productivity improvement in the residential building life cycle

1) Quality of brief articulation and design development

A number of the interviewees believed that the designer's ability to correctly and comprehensively establish and translate into a final design and specification the owner's needs and requirements at the inception stage goes a long way to determine the extent of value that could be delivered by operators in the downstream phases of the RBLC. This is subject to the limitations imposed by some statutory/regulatory compliance requirements such as the city/district plan rules and the RMA. One of the interviewees reasoned that productivity could be thought of as the quantum of value delivered to the building owner or developer in the development process. The interviewee went further to explain that three gaps exist between the owner's/developer's desired value and the delivered value. Figure 20 models these gaps.



Gaps: Value loss due to:
1) Owner's insufficient brief or the designer's inefficiency (e.g. poor design or misinterpretation of, or failure to fully capture, the owner's desired value in the procurement process);
2) Regulatory/ statutory compliance restrictions;
3) Constructor's inefficiencies and/ or systemic (i.e. external) constraints.

Figure 21: Gaps between the owner's desired procurement value and the value delivered during the development phase of the building life cycle

Gaps 1 and 2 fall within the role and responsibilities of the designer in the development process; these are discussed in the following subsections.

Gap 1: Value loss due to owner's insufficient brief or designer's inefficiencies

The first gap that shrinks the desired value to the designed value is due to the owner's inability to state in sufficient details his or her needs and requirements for the project during the brief. This inability may be due to lack of experience or knowledge of the project development process or perhaps, as in the case of the developer, lack of clarity around the real owner or user's needs and preferences. This gap could also be attributed to the designer's inefficiencies, usually in terms of not being able to fully capture the owner's needs and requirements for the building and translate these in the blueprint; it could also be due to poor design or misinterpretation of the owner's brief.

As a result of this gap, the designed value therefore falls short of what the owner desires in wanting to procure the building. The interviewee believes that this gap is the reason for the prevalent costly and time-consuming change orders, which often happen during critical stages of the construction phase, thereby causing resource wastage, time and cost overruns and drastic reduction in productivity gains.

To improve productivity at this stage, this gap needs to be filled by educating the owner in the briefing process or involving an expert who knows in sufficient depth the owner's business and/or personal circumstances to be able to provide comprehensive advice on his or her stated and evolving needs for the building and the development process. The interviewee criticised the practice of having a static brief captured only at the inception of the development process, arguing that briefs should be an on-going thing and that the evolving design should be flexible enough to permit later changes which can easily be accommodated at any phase of the development process without incurring so much wastage, delay and cost to the implementation of the project. This is crucial in the case of inexperienced owners or for developers who will need to incorporate future users' requirements when the building development gets to a certain stage.

Other productivity improvement leverage strategies at this stage include having fit-for-purpose designs; ability to verify design assumptions on site to minimise costly and time-consuming downstream change orders and variations; consideration of resource use efficiency social and environmental impact of the design solutions; use of quality assurance techniques in performing design activities such as checklists, design reviews and peer reviews; and ensuring code compliant designs.

Overall, the interviewees believed that by adopting innovation, flexibility in design and economy, the designer could not only fill the gap but extend the value envelope to deliver more value than initially envisaged by the owner/developer.

Gap 2: Regulatory/statutory compliance restrictions

The interviewee explained that the building owner does not always get what he or she desired in the building due to the limitations imposed on the design solutions by the city/district plan rules and the Resource Management Act (RMA) 1991. These limitations vary according to the location of the building on the planned zones and include boundary setbacks, recession plane and height restrictions, and building coverage, neighbourhood characteristics, density, etc. The designer factors these limitations in the design, which may result in a gap between what the owner or developer desires and what is statutorily allowable. The interviewee hinted that is usually the case for customised design where the owner's requirements may be at odds with the statutory provisions. In this, if there is a decision to go ahead and design to the owner's full requirements, resource consent will be needed, often involving public notifications. This process is uncertain in terms of outcomes and is usually costly and time-consuming, especially where there is a need to take the matter to the Environment Court to appeal against the Council's decisions. In this situation, productivity is determined by the client's decisions.

The interviewee and a number of others hinted that the regulatory/statutory compliance constraints to productivity are outside the control of the project team; there is nothing much anybody could do about it. However, through innovation, experience and design efficiency, the designer is able to mitigate the statutory compliance issues and deliver better value to the building owner. Overall, economic and strategic selection of land for the building development can help to avoid the choice of zones where statutory compliance requirements could seriously limit the owner's requirements in the design solutions and result in more productive outcomes.

2) Appropriateness of material selection and specifications

The interviewees indicated that designers could influence productivity in the RBLC through their choice and specification of materials and components for the building. They believed that significant productivity gains could be achieved by selecting and incorporating into the design durable, code-compliant, environmentally-sustainable and energy-saving materials and components that are easy to install without so much wastage at the construction phase, that could be durable enough to minimise frequent maintenance and the associated costs and disruptions at the operation and maintenance phase, and that could be easily deconstructed and recycled without losing much to the landfills. The interviewees maintained that productivity suffers at the construction and operation phases when material selection process excludes the above criteria. To guard against this, the designer should consider whole-of-life costs and environmental impact assessment of the materials and components, and avoid focusing on capital costs alone. The designers need to educate their clients accordingly, so they could tailor their preferences to improve overall productivity and value delivery.

In a fresh round of interviews, some designers pointed to the limited range of materials and components as a key factor limiting choice of materials for whole-of-life performance, economy and sustainability. They indicated that only few materials and components are available to meet the Building Code Acceptable Solutions. Though in theory designers are not obliged to use Acceptable Solutions, opting for the Verification Method or the Alternative Solution proposal, more often than not, would mean a delayed consenting process under the current risk-averse consenting climate. The key solution proffered to this issue is having more materials and components being 'CodeMark' certified. This will give the designers more flexibility and a range of options for delivering more innovative, productive and environmentally friendly solutions for varied applications.

3) Quality of design information documentation and communication

The interviewees also believed that designers could influence productivity at the consenting and construction phases through clear, comprehensive and unambiguous documentation and the communication of the design information as and when needed by other stakeholders. A number of the interviewees argued that a lot of delays and productivity issues have arisen due to the designers not supplying on time and comprehensively the information needed for speedy processing of consents and permits by the councils. Also the construction progress is undermined when the request for information (RFI) was not attended to as quickly as needed by the contractor to make progress. Some of the key drivers of non-compliance and rework include incomplete design information, incorrect or unclear specifications, detailing error or lack of sufficient details to enable accurate interpretation of designs and specifications.

Gap 3: Constructors' inefficiencies and systemic constraints

The regulatory/statutory permitted value implicit in the design solution could be further reduced due to the constructors' inefficiencies and wider systemic constraints. Some of these inefficiencies include poor planning and coordination; inadequate supervision and motivation of the workforce; poor quality assurance, poor workmanship, defects and rework; disputes and litigation; low margins; poor contractual risk allocation; and high wastage.

To narrow this gap and improve productivity, the interviewee suggested guarding against the above highlighted inefficiency drivers through the use of the lean construction principles and practice which target waste elimination and continuous value improvement.

C) Influence of the quality of project management role

Figure 21 summarises the recurring themes from the survey participants' feedback on the various ways in which the quality of the project management role – whether performed by the owner, the designer or the builder – could positively or negatively influence productivity outcomes in the RBLC cycle. These are broadly categorised into 6 themes:

- Planning & risk management – including scope management (definition, change and control).
- Project organisation (including site organisational structure, recommending recruitment of experienced service providers, site layout, site organisation, etc.
- Project coordination and supervision (including design, construction and interfaces).
- Monitoring, review & control of performance on cost, quality, scope, schedule and statutory compliance, particularly site safety and code compliance.
- Communication – management and coordination of the project information.
- Overall project leadership, including motivation/empowerment, incentivisation, and maintenance of transparency, trust and win-win approach for all.

The survey participants acknowledged that, depending on the scale of the residential building project, the procurement system adopted and the applicable phases of contractual engagement, the project manager's role may be an extension of the architect's or the engineer's role (in the traditional procurement system) or that of a construction project management consultant (in the project management procurement system). The quality of the project management role could have significant impact on the productivity at various phases of the RBLC. If engaged at the inception phase, the project manager's role could include strategic advice on the technical feasibility of the project as conceived by the owner.

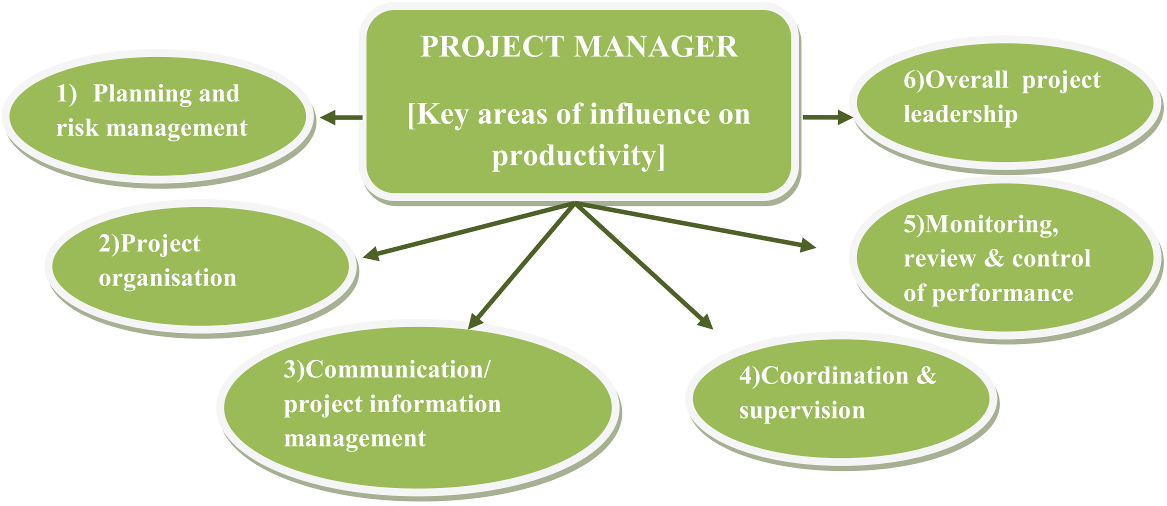


Figure 22: Project manager's key areas of influence on the RBLC productivity outcomes

D) Builder's influence

The survey participants confirmed that as most large and complex residential building projects are highly susceptible to unknowns and uncertainties, it is the builder's duty to carry out proper risk management or risk assessment process prior to the implementation process and make reasonable allowances for contingencies.

As the key role player in the construction phase, the builder could exert profound impact on the value of the completed building at the operation phase through quality construction or lack of it.

Figure 22 details the recurring themes in the survey participants' feedback as the key areas through which the builder could positively or negatively influence productivity outcomes in the RBLC. Positive influence results when these responsibilities are discharged to best practice standards. On the other hand, negative influence results when the builder is negligent in some of these aspects. Monitoring of activities in these key areas therefore presents opportunities for significant improvement on productivity from the builder's side. In the area of site organisation and management, Sharman (2013) advises on-time ordering and taking delivery of materials and products as and when needed on site could also help to improve the builder's influence on productivity at the construction phase.

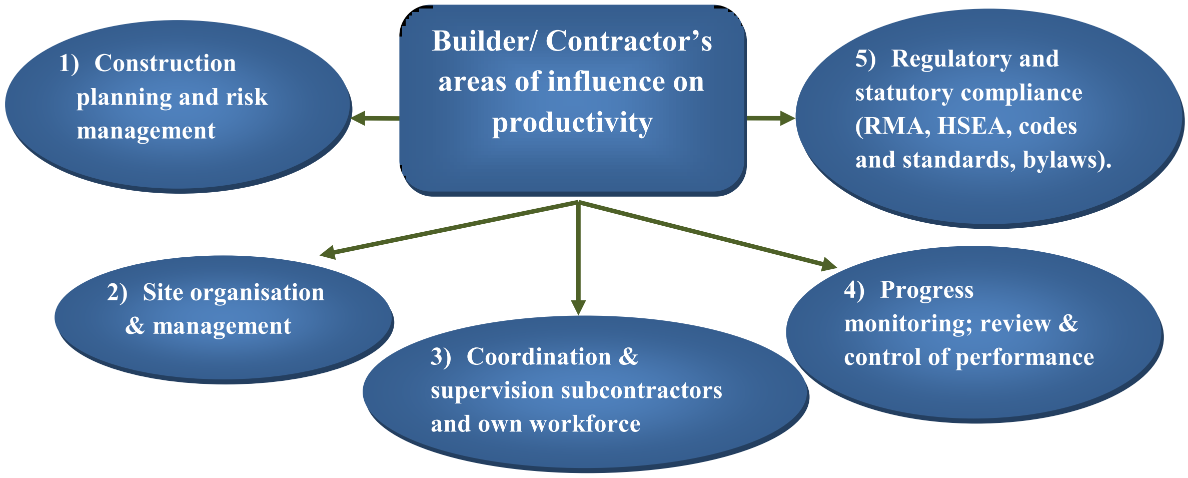


Figure 23: Contractor's key areas of influence on the RBLC productivity outcomes

E) Consenting authorities' (BCAs') influence

A number of the survey participants doubted whether the influences of the BCAs should be included under the stakeholder roles or as part of the external constraints, given that the project team has no control over their influences. However, a good number of the participants supported including them here since they are key roleplayers and the authorities are also looking at ways in which their productivity limiting actions could be addressed to improve productivity in the industry. Berry (2013) observes that, for a residential building project, the project team can influence the outcome of the consenting process through the use of mechanisms such as pre-application meetings with the BCA, being familiar with the Code and the consenting authority's requirements. Sharman (2013) adds to this by noting that the BCAs are a factor that must be taken into account as far as productivity is concerned, adding that, the better the quality of information provided to the BCAs, and the better the project team's management of the BCAs' requirements, the less obstructive they will be to on-time consenting process and to the overall productivity outcomes in the RBLC.

Role of the Local Councils

Almost all the survey participants acknowledged that the BCAs play a significant part in influencing productivity outcomes in the RBLC, especially at the design, construction, close-out and upgrade/conversion phases. The key influence is on the time to process applications, the fees charged, and their suspicion for new and innovative solutions which do not fall within the 'Acceptable Solutions. The interviewees confirmed that the BCA's risk-averse position on the 'Alternative Solutions' was largely due to the aftermath of the systemic leaky building problems and the associated litigations. Such risk-averse positions of the BCAs inhibit flexibility and innovation in the residential building sector thereby limiting the prospects for productivity improvement.

However, one of the survey participants argued that the BCAs may not be solely to blame as many people would want to believe. Part of the problem is the inability of the designers and homebuilders who go for the Alternative Solutions to demonstrate compliance with the Code. As the participant pointed out, the Building Code is a performance-based standard which truly allows for innovation and uniqueness. It allows designers the freedom to come up with a proposal for an innovative solution which – though may not align with the Acceptable Solutions/– provides a better outcome for the project. However, the onus is on the designer to provide detailed information and supporting evidence to convince the BCA that the proposal will comply with the Code

Content analysis of the survey participants' feedback suggest that, from the perspective of the Councils' role, productivity increase leverage can be achieved by the Councils making improvement in six key areas through which they influence productivity and performance of the operators in the RBLC. Figure 23 highlights these areas.

A number of the interviewees believed that the area of the Council's role and responsibilities having the most profound influence on productivity and performance in the RBLC relates to land development policies and regulations. It could be argued that this impacts on the land development level and not necessarily the residential building construction (Berry, 2013). However, a holistic view of the productivity outcomes in the RBLC would require a consideration of the productivity limiting issues in the land development as well as the residential building development and operation phases. A number of the interviewees believed that section prices and availability are an issue around Auckland because the Council has left the infrastructure development of the greenfields to the land developers who now charge a premium to cover their investments on subdividing and servicing the sections thereby pushing up section prices in the region. A number of the interviewees cited the Bay of Plenty region where the Council's intervention in the land supply and infrastructure development of the sites has resulted in very affordable sections with lots of residential development activities going on in the area. Within the Auckland region where the bulk of residential development is needed, the key issue is the Council's reluctance to open up green fields (i.e. farmlands) for large scale residential developments. The Auckland Council's Unitary Plan policies favour urban intensification programme which focuses on infill, multi storey redevelopment of existing plots or brown field sites within the urban boundaries. Within the plan, only 30% of developments will be green fields with the 70% balance being within the existing urban boundaries. The interviewees pointed out that land values within the urban boundaries are exorbitantly high, resulting in higher development costs and the development contribution levy charged by the Council. Invariably, the high development costs increases the resource input (i.e. the denominator side of the productivity equation) and by implication, a lower productivity outcome.

To improve the Council's productivity in these areas, the interviewees suggested the re-engineering of the Council's operations and processes through the application of smart technology and online consenting and approval processes. Another suggestion made by one of the interviewees was the outsourcing of the key services of the Councils to consultants to improve operational efficiency and accountability. However, this was not supported by other interviewees as viable option as the monitoring and performance evaluation of the consultants will present a fresh mix of problems to the already existing ones. Some suggested the government doing more with the private sector partners in providing affordable accommodation such as the targets of the Housing New Zealand Corporation and the Auckland Council Property Ltd.

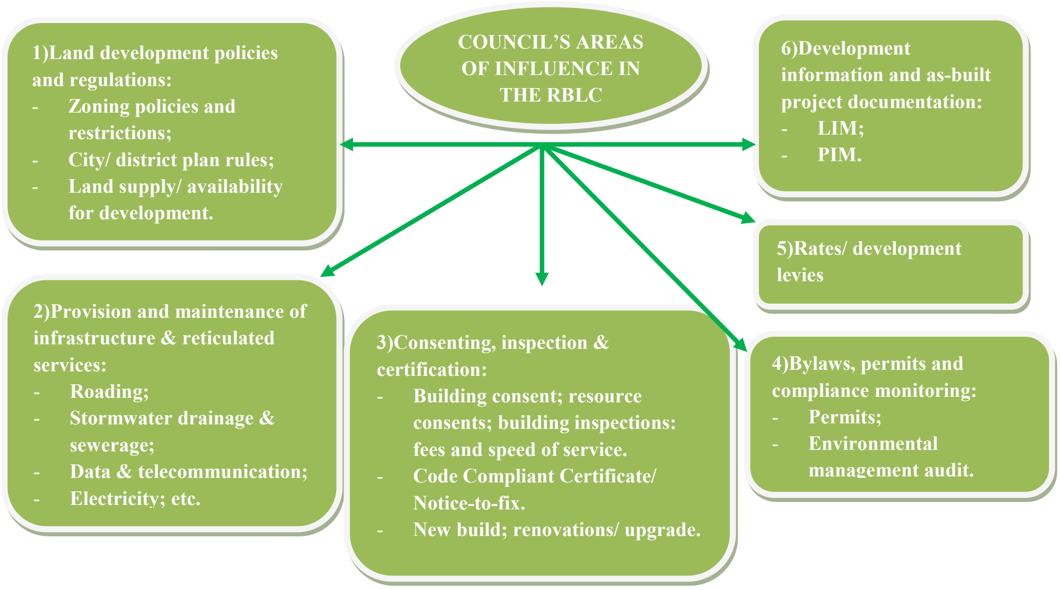


Figure 24: Council's areas of influence on productivity in the large scale residential building life cycle

5.9 External factors impacting on the productivity outcomes in the RBLC

This subsection presents the survey participants' feedback on the relative levels of influence of the external factors impacting on the RBLC productivity outcomes, as well as the various ways through which these occur.

Relative levels of impact of the key external factors on the RBLC productivity outcomes

Table 8 presents the analysis of the interviewees' feedback on the relative levels of impact of the key external factors, based on a 5-point Likert rating scale. The results, as highlighted in Figure 24 show that industry characteristics, regulatory/statutory controls and market conditions, were perceived as the critical external factors impacting on the RBLC productivity outcomes. It would have been expected that technology advances should rate higher than the critical factors identified in Figure 24. Perhaps, this could be because the construction sector is yet to deeply embrace technology and innovation generally (Sharman, 2013).

The industry characteristics – the most critical of the factors – comprise the following:

- Boom-bust cycle;
- Composition/structure; dominance of small firms;
- Business model, capacity & capability issues;
- Attitude, culture and resistance to change;
- Skills shortage,
- Margins/profitability; competition.
- Technology & innovation.

The regulatory/statutory compliance issues include the following:

- RMA, HSEA, Local Government Act; Council bylaws;
- Building codes, building standards;
- Resource and building consent issues;
- Land supply and development policies.
- Rapid rate of regulatory reforms.

The market conditions include the following constraints:

- Economic recession;
- Business/investor confidence;
- Demand and supply for services and outputs;
- Availability of project finance.

	Key external factors impacting on the RBLC productivity outcomes	[a]Ratings of the external factors' levels of impact on the RBLC productivity outcome VH 5	H 4	M 3	L 2	VL 1	[b]TR	[c]MR		
1	Industry characteristics (composition/structure, small firms, capacity & capability, attitudes, culture, etc.).	70%	30%	0%	0%	0%	20	4.7	Very High	Significant factors
2	Regulatory/statutory compliance (RMA, HSEA, codes/standards, bylaws, consenting; land & development polices; keeping up with rapid regulatory reforms, etc.)	60%	30%	10%	0%	0%	20	4.5	Very High	Significant factors
3	Market conditions (demand and supply, economic recession, business & investor confidence – impacts on demand and supply of services, materials and costs; availability of project finance; etc.)	50%	35%	10%	5%	0%	20	4.2	Very High	Significant factors
4	Political/government interventions (fiscal & economic policies, investment/spending, legislations, etc.)	55%	25%	10%	10%	0%	20	4.05	High	Significant factors
5	Micro and macro economic (exchange rate, inflation, fiscal policies, taxation,)	45%	40%	5%	10%	0%	20	4	High	Significant factors
6	Socio-cultural issues (skill shortage; 'Ausie pull' , attitudes, 'Kiwi' culture, risk tolerance, resistance to change; etc.)	40%	20%	15%	15%	10%	20	3.28	Moderate	Significant factors
7	Natural forces (earth quakes, Tsunami, inclement weather, etc.)	25%	25%	25%	15%	10%	20	3.03	Moderate	Significant factors
8	Global dynamics (energy crisis, influence of emerging economies on global commodity prices, etc.)	10%	15%	25%	40%	10%	20	1.93	Low	Insignificant factors
9	Technology advances (rapid changes, technological obsolescence and costs).	5%	20%	25%	40%	10%	20	1.88	Low	Insignificant factors

a) Rating: 5 = Very high (VH); 4 = High (H); 3 = Moderate (M); 2 = Low (L); 1 = Very low (VL).

b) TR = Total responses; c) MR = Mean rating (see Equation 2).

Table 8: Relative levels of impact of the key external factors on the productivity outcomes in the RBLC

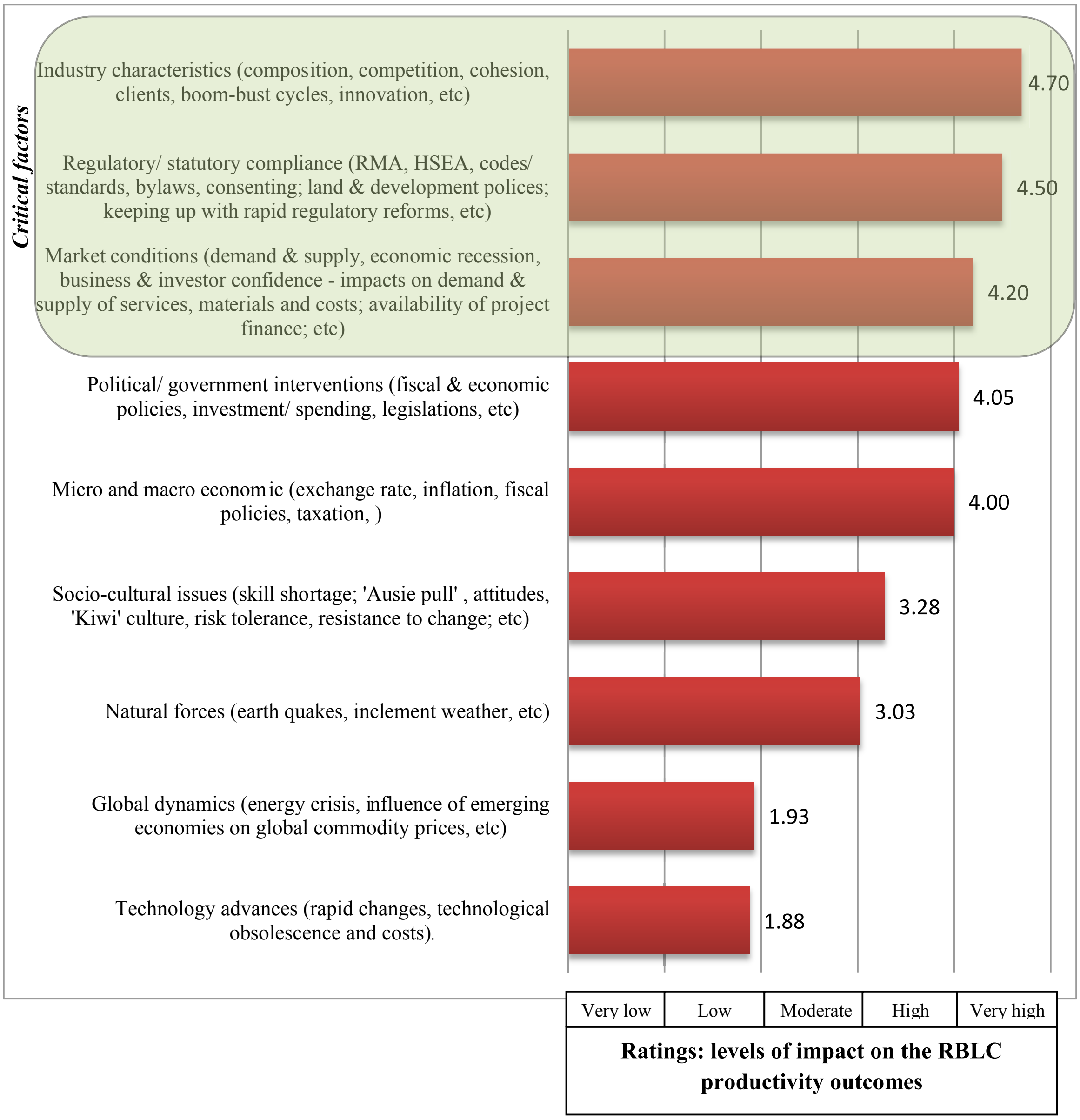


Figure 25: Relative levels of impact of the key external factors on the productivity outcomes in the RBLC

Characteristics of the residential building industry

Issues with the size of the residential building industry and the operators

A number of the interviewees hinted that the very nature of the residential building industry in New Zealand inhibits its ability to grow and leverage the benefits of modern methods of residential development to improve on its practices, productivity and performance. Some indicated that the sole trader business model of most homebuilders is a key inhibitor to their capacity and capability development as well as their potentials to improve productivity and performance. Because the one-man homebuilder is always busy pursuing current jobs, he or she hardly finds time to enrol in training courses to upskill and develop his or her capabilities. Furthermore, most of the house-building businesses do not have the modern technology to drive efficiency. On the contrary, a recent BRANZ-sponsored Value Stream Mapping (VSM) workshop found that many residential builders do engage in training and continuous professional development. Further the LBP scheme requires minimum CPD, which encourages them to involve in CPD activities (Berry, 2013) notes that

The issues raised by the survey participants were also noted in the Productivity Commission's (2012, p. 8) Housing Affordability Report. It was found that the New Zealand residential building industry is essentially "a fragmented cottage industry" dominated by sole traders with no employees, and that most builders have the capacity to build only one house at a time, with each of about 4,604 homebuilders building just one house in 2010.

Some of the interviewees opined that the low margin in the industry, the high cost of labour and the fact that "you can't hire and fire" under the Employment Relations Act, make these homebuilders to prefer working alone than taking on apprentices. They maintained that, ordinarily, if these homebuilders could take on one or two apprentices each, they could contribute to skill development in the industry. After some years of hands-on experience, these apprentices could help the builders boost their productivity and performance, as well as take care of their work so they could find the time to attend training programmes to develop their capabilities.

In this regard, the interviewees suggested that, to boost productivity in the RBLC, the government should do more to support the apprenticeship programmes run by the industry training organisations so that the cost involved doesn't further reduce the already low margin of the homebuilders.

Issues with the industry clients

Some of the interviewees hinted that, in effect, the attitude of the clients of the residential building industry and wider socio-cultural factors encourage the one-man home building business model and discourage large capacity builders. The interviewees opined that most home owners would prefer customised or bespoke designs to suit their lifestyle living preferences. Group home builders use standardised residential designs and plans to leverage economies of scale in bulk purchases of materials and equipment, as well as minimise consent delays and risks. It is also easier, cheaper and faster to replicate the same design on multiple plots with adaptation being only for the foundations and the façade as dictated by the environment and the district plans. However, most home buyers would still make changes to these plans to suit their unique preferences. This undermines the benefits and productivity increases offered by the use of standardised designs, and in effect, discourage the use of such development strategy. Feedback from the interview participants suggested that the building owners' proclivity to bespoke design is rooted on the fact that the investment in residential development is often the owner's most significant financial investment, especially for the first-timers. Also, a number of the home owners have a long term investment interest on their dwelling and so would like to have a say on the way it is designed and constructed, which may not be attuned to the conventional/standardised designs. However, Berry (2013) observes that some smaller builders are addressing issues such as this by permitting some scope for standardisation of details, methods and processes that still accommodate homeowners' needs for modification of the standard design to suit their lifestyle preferences.

Influence of the regulatory environment

A number of the interviewees acknowledged the profound influence the regulatory environment has on productivity and performance of the role players in the RBLC.

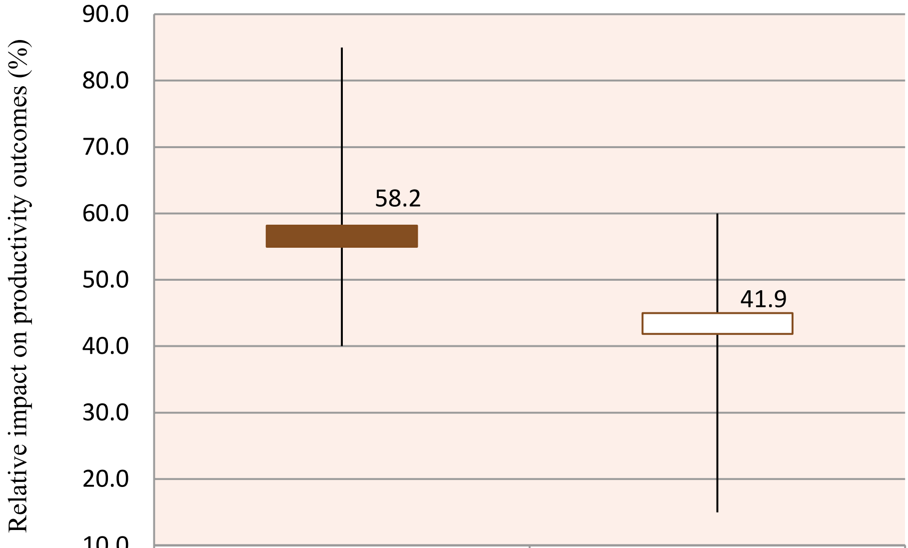
On a different note, some interviewees saw, as a key issue, the rapid rate of change of the legislations and the time and costs involved in taking steps to keep abreast with the changes. Compliance with the current codes, especially on weathertightness and seismic strengthening, requires a more rigorous and costly process that results in longer completion time and higher outturn costs.

Further opinions suggested that the current regulatory environment has contributed to poor productivity performance. Notable among these include the following:

- RMA, HSEA, Local Government Act; Building Act; Council bylaws;
- Building codes, building standards; LBP;
- Resource and building consent issues;
- Land supply and development policies.

5.10 Relative levels of impact of the role players and the external factors on the RBLC productivity outcomes

The survey participants were also asked to rate the relative levels of impact of the two main sources of productivity/efficiency constraints in the RBLC as identified in the study: the external factors in the operating environment and the role of the key stakeholders in the various phases of the cycle. This information is crucial to understanding where the critical impact lies, with a view to formulating the appropriate risk response strategies. Each participant's ratings add to 100%. The outcome of the analysis using the descriptive statistics is shown in Figure 25. The figure provides the graphical representations of the outcome in the box plot and the pie chart formats. The box plots show the range of values as rated by the participants, including the minimum, maximum, mode, mean and the standard deviation values for each set of constraints.



	Role players influence in the RBLC phases	External factors in the operating environ
Mean	58.2	41.9
Highest	85.0	60.0
Lowest	40.0	15.0
Mode	55.0	45.0
Std	12.9	12.9

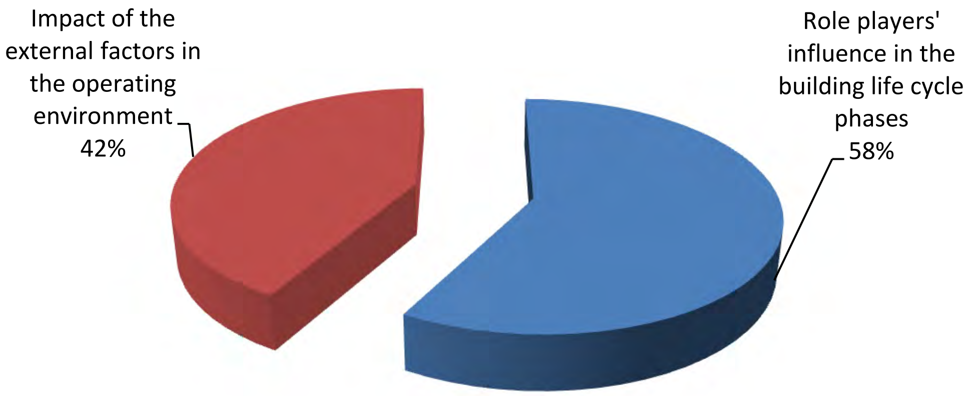


Figure 26: Relative impact of the external factors and the stakeholder roles on productivity outcomes in the residential building life cycle

Figure 25 shows that based on the mean values, the external factors could account for 42 percent of the productivity outcomes in the RBLC, while the influence of the stakeholder roles accounts for 58 percent. The influence of the stakeholder roles is therefore more critical than influence of the external factors. With the latter constraint sources not being within the control of the stakeholders in the RBLC phases, the appropriate risk response strategy to these constraints is to have adequate contingency plans to deal with them as they arise. This result also shows that the controllable constraints – i.e. the stakeholder roles – offer greater opportunities for productivity increase leverage in the RBLC.

5.11 Productivity increase leverage points: Where the greatest opportunities lie

Based on the investigations and the analysed results, it could be deduced that the greatest opportunities for productivity increase leverage in the RBLC lie with the stakeholder roles in the critical phases of the cycle, namely, the design, inception and construction phases. Decisions made at these three phases account for about 80% of the overall productivity outcomes attributed to controllable influences. The key role players involved in the decision making at these phases comprise the architect, the owner, the project manager and the contractor. The roles and responsibilities of these stakeholders where these decisions are made are shown in Figure 26. Overall, the figure presents a summary of the critical stakeholder influences and those of the external factors in the operating environment having the most profound impact on the productivity outcomes in the RBLC. The stakeholders have control over their own influences and can do something about these influences by addressing the issues highlighted in their roles and responsibilities. However, they cannot control the impact of the external factors. All the same, being mindful of, and by formulating adequate contingency plans for, these critical external factors, the stakeholders would be better positioned to significantly redress the prohibiting factors and lift productivity gains in the RBLC.

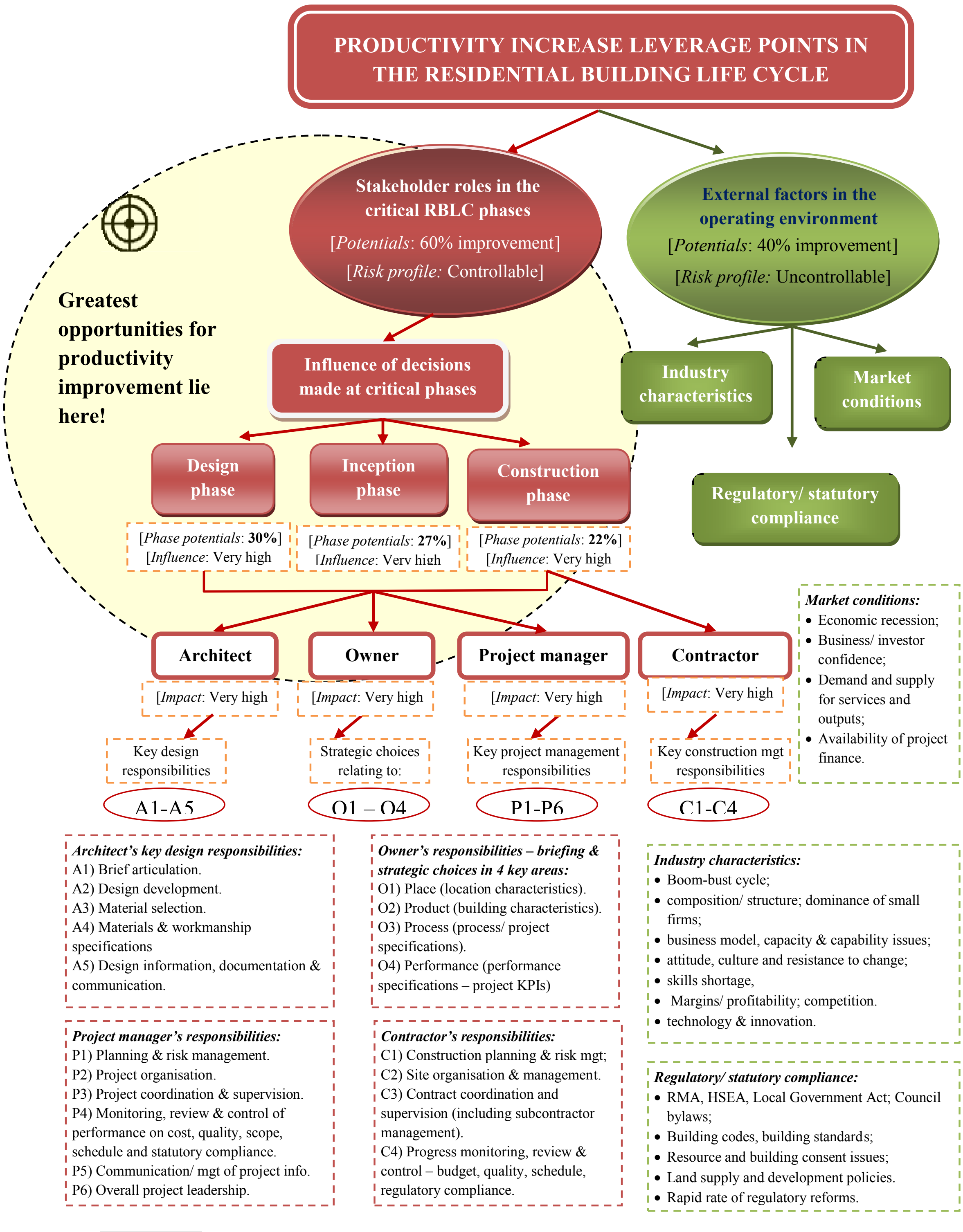


Figure 27: Productivity increase leverage points in the residential building life cycle

6 Conclusions And Recommendations

6.1 Conclusions

An exploratory study has been completed, which aimed at identifying where the potentials for productivity increase leverage exist in the RBLC. 24 case study residential buildings were investigated. These comprised buildings at the development, operation and maintenance, renovation and decommissioning phases. One-on-one interviews were held with 38 stakeholders working on the case study buildings. The stakeholders' feedback provided the empirical data, which were analysed using the multi-attribute analytical method.

To qualify the survey participants' feedback to the questions asked, their understanding of the concept of productivity was first established. Thematic analysis of their definitions of the concept suggests that an ideal definition of productivity at the project level must include effectiveness (i.e. achievement of set targets or objectives), efficiency (i.e. optimal use of the available resources in achieving the set targets), and sundry issues such as client satisfaction, safety and statutory/regulatory compliance.

Results of the analysis of the interviewees' feedback on the key questions showed that the greatest opportunities for productivity increase leverage in the RBLC lie with the stakeholder roles in the critical phases of the cycle, namely, the design, inception and construction phases. Decisions made at these three phases account for about 80% of the overall productivity outcomes attributed to controllable influences. The key role players involved in the decision making at these phases comprise the architect, the owner, the project manager and the contractor. The roles and responsibilities of these stakeholders where these decisions are made are highlighted. Also the critical stakeholder influences and those of the external factors in the operating environment having the most profound impact on the productivity outcomes in the RBLC were summarised.

It was found that the design phase offers the biggest opportunity for productivity increase leverage in the RBLC. The critical role and responsibilities of the architect having the most profound influence in the cycle include brief articulation, design development, materials selection, specifications, and design information documentation and communication. Through these responsibilities, the architect firms up, as performance standards, the building owner's brief within the scope permitted by the town planning and consenting requirements. The architect's outputs in this regard are the designs, the drawings and the specifications, which are used to direct/inform the contractors' performance. Buildability issues, lack of details, detailing errors, design errors, and a myriad of other issues further compound the contractor's productivity in terms of costs, time and quality by creating complexity, communication gasp and uncertainties which may engender rework, delays, wastages, and variation claims.

The second biggest opportunity for productivity increase leverage in the RBLC lie in the conception phase through the building owners' needs and preferences as documented in the brief. The owner's key influences hinge on the strategic choices he or she makes in four key areas: place/location characteristics, product/building characteristics, process/project specifications, and performance/project KPIs. Through these strategic choices, the owner sets the boundaries or parameters within which other role players in the development process must operate. The key influence here is the crystallisation effect on the building form and characteristics and the limiting influence on the efforts of the downstream role players to increase productivity in their respective phases and for the RBLC overall. The crystallised building form and characteristics in turn have a profound effect on the productivity metrics at any stage and for the whole cycle, namely in the nature of impact on the numerator side of the productivity index measure (i.e. the value of the output or completed building) and on the denominator (i.e. the total resource input costs for procuring and maintaining the completed building).

At the operations and maintenance phase, the building parameters, as designed and built, have profound impact on maintenance frequencies, downtimes, heating and cooling performance and overall running costs. However, the key aspects that impact on the productivity of the building and construction crew relate to the planned and restorative maintenance value and costs at this stage. Again, the dynamics of the development phase also play out at these two phases resulting in profound impact on productivity outcomes.

At the decommissioning stage, the influence of the design phase productivity is felt through the ease or lack of it with which the decommissioned facility could be deconstructed or decoupled without much waste going to the landfill and how easy it is to recycle or reuse the building components.

Activities at the decommissioning stage do not pose serious problems to the life cycle productivity outcomes due to rare occurrence of these activities and the increasing emphasis on re-use and recycling which mitigate the resource inputs at this phase.

Implications for industry and practice

The stakeholders in the RBLC have control over their own influences and can do something about them by addressing the issues highlighted in their roles and responsibilities. However, they cannot control the impact of the external factors, which account for about 40% of the overall productivity outcomes in the cycle. All the same, being mindful of these critical external factors and by formulating adequate contingency plans for them in line with their risk profiles as established in this study, the stakeholders would be better positioned to significantly redress the prohibiting factors and lift productivity gains in the RBLC.

Limitations

This is a discussion document. As an exploratory study, the scope was limited to the nature of the buildings selected for the case study, namely bungalows and duplexes. Other forms of residential buildings such as multi-unit apartments were not covered in the investigations. Also all investigations were limited to the Auckland region.

The research by and large was exploratory in nature; the scope of the investigations was narrow and the data points were limited in size. As a result, the findings, and the conclusions and recommendations flowing them, may be used with caution, as they may not be generalised beyond the study scope. The main intent of the report is to stimulate wider debate on the issues.

6.2 Specific recommendations

Based on the investigations that were carried out and the findings, the following recommendations are put forward for improving productivity at the key stages of the RBLC. The recommendations relate to the new build procurement route involving designing from the scratch. This was identified as the area offering the greatest challenges as well as opportunities for greatest efficiency gains and productivity improvement in the residential development process.

6.2.1 Briefing stage

1. The homeowner should carefully consider his or her wish lists or requirements for the building and clearly communicate these to the designer at the briefing stage. This will help to ensure that the homeowner does not change his or her mind frequently and/or include extra requirements at late stages. This way, design time and costs, as well as resource wastage would be minimised to ensure efficiency gains and more productivity outcomes.
2. The designer should use experience, hindsight and exercise of good professional judgement in ensuring proper and comprehensive brief articulation, being mindful of the homeowner's level of knowledge of the building process (or lack of it), likelihood of changes in some key areas.

6.2.2 Concept design stage

1. The designer should carry out proper investigation of the proposed building site and ensure that the design proposals presented to the homeowner have maximised value in terms of meeting the owner's requirements, the site characteristics and the development requirements of the local council.
2. Before the concept design is frozen to commence full design, the owner should seek the advice of the prospective builder on the suitability of the design to the section and wider issues.

6.2.3 Full design and documentation stage

1. Prior to finalising the design and documentation stage, it is strongly advised that a preconstruction design review meeting be held between the owner, the designer, the builder and the specialist tradespeople who will be involved in the implementation of the project. The purpose is to give the designer the opportunity to convey the design intent and objectives to the builder and the tradespeople. It will also give the builder and the tradespeople the opportunity to review the contract documents and seek clarifications on issues that may affect their work and progress on site such as conflicting information, design/detailing details, errors or omissions, constructability issues, contractual deficiencies, etc. This will help to sort out early issues that could give rise to disputes, delays, misinterpretation of the design documents and defective work and hence unblock likely clogs to progress and value delivery at the construction phase.
2. Overall, the designer should ensure the selection and specification of appropriate materials and components based on whole-of-life performance outcomes. Though accessing the design information for life cycle performance may be a challenge, gathering and documenting feedback from end-users would help to provide the in-use performance characteristics of a range of building materials and components to inform whole-of-life economic and sustainable design and specifications
3. Overall, the designer should ensure good quality of design documentation from the perspectives of the builder and the BCA.

6.2.4 Consenting stage

The design team should be able to properly manage the information requirements of the BCA through effective use of pre-application meetings and quality of documentation. This way, the information clarification and documentations required for the issuance of the CCC would have been provided at the time of application to avoid unnecessary delays and back-and-forth iterations.

6.2.5 Building contract stage

1. Whether for simple or complex residential building projects, verbal contracts should be avoided. Written contracts should be used to clearly document the terms and conditions that will govern the implementation of the contract. This will help to minimise disputes about the rights and obligations of the parties to the contract.
2. As much as possible, standard forms of contract that are widely accepted as being fair to all parties and not biased towards any one trade or professional organisation should be used such as the Standards New Zealand's (NZS 3902:2004) Housing, Alterations and Small Building Contract. The standard clauses should not be overly modified as to introduce risk into the contract or serve the interest of one party to the detriment of the other.

3. An owner-managed process should be avoided. No matter how simple or standard a residential building project may be perceived to be at the start, it could take on increasing levels of complexity as the implementation process gains traction, largely on account of the unknowns such as the unforeseeable ground conditions, market dynamics and wider environmental and operation conditions. The building owner, except if an LBP, may not be experienced or skilled enough to manage such uncertainties and /or complexities.
4. For complex residential building projects, bridging the communication gap between design and construction could help to significantly address the bottlenecks around the supply of vital design information to support progress at the construction stage. This could be accomplished by having an experienced project manager or project coordinator with full authority over all aspects of the residential building project development – from the briefing, right through to the design, consenting and construction phases. It would be most productive to have an experienced builder perform this role. The builder is able to effectively leverage in-depth construction knowledge and experience to ensure quality outputs of the design, planning, procurement and field operations and to optimise the achievement of the overall project objectives and value-for-money. Alternatively, the designer could be engaged to do this; this way, the designer is able to ensure a good fit between the design assumptions and the work execution. It would be most unproductive for the owner to perform this role, given the depth of experience and technical expertise required to effectively discharge the responsibility.
5. Where it is not possible to integrate the design and construction function through a project manager or coordinator, it is strongly advised that a preconstruction design review meeting be held between the owner, the designer, the builder and the specialist tradespeople who will be involved in the downstream implementation of the project. The purpose is to give the designer the opportunity to convey the design intent and objectives to the builder and the tradespeople. It will also give the builder and the tradespeople the opportunity to review the contract documents and seek clarifications on issues that may affect their work and progress on site such as conflicting information, design/detailing details, errors or omissions, constructability issues, contractual deficiencies, etc. This will help to sort out early issues that could give rise to disputes, delays, misinterpretation of the design documents and defective work and hence unblock clogs to progress and value delivery at the construction phase.

6.2.6 Construction stage

Irrespective of the scale or complexity of the residential project, the builder should prepare a plan for effectively integrating and coordinating his own work and those of the specialist tradespeople and to monitor progress. This should also include a safety plan for monitoring health and safety compliance, as well as a quality assurance plan for monitoring quality. Such best practice approach, even for a simple standard residential project has huge productivity benefits in terms of ensuring a safe and defects-free work completed on time and within budget.

As much as possible, the designer should be involved in the construction monitoring and building inspections. This would be more productive in the sense that the designer is able to verify and confirm the alignment of the works with the design assumptions much quicker than an independent inspector or certifier who, on account of not being privileged to the design assumptions, may go overboard in scrutinising the works resulting in delays to progress on site.

6.3 General recommendations

6.3.1 Procurement route

1. The procurement route for new house involving the bespoke design (i.e. designing from scratch by an independent architect) presents the greatest challenge to efficiency gains and productivity. This should be avoided when seeking productivity improvements.
2. The turnkey approach (i.e. land and house package – fully designed and built house) offers the opportunity for greatest productivity improvement and optimum value delivery in the residential building sector. As much as possible, this route should be utilised when seeking productivity improvements.
3. Engagement of the builder on labour only or managed labour contract should be avoided when seeking productivity improvements. The builder should be engaged to have full control of the construction process, including the recruitment and contractual agreements with the subcontractors/specialist tradespeope. This helps to minimise disputes and gaps in the project management needs of the implementation process.
4. Overall, the design and build procurement approach where the builder has the capacity for in-house design and construction is the most productive alternative to the turnkey approach, where the owner wishes to make significant input into the design of the building.

6.3.2 Project management

1. For complex residential projects, there is a need for a tool that could enable simultaneous monitoring and benchmarking of the cost, scope and schedule performance of the project execution, if productivity is to be properly monitored and controlled. The Earned Value Management (EVM) is a more robust approach for effectively tracking the schedule, scope and budget performance using one performance index. Though the use of EVM is not popular in the New Zealand construction industry, it has been proven overseas to be a more effective tool for monitoring progress and achieving improved productivity outcomes in the construction phase.
2. Also lean construction and partnering have also been found to improve efficiency and productivity in the overseas construction industry, irrespective of the type of project involved.
3. Use of BIM and greater uptake of prefabrication, standardisation and innovation will also generally improve productivity in the residential and the New Zealand building and construction industry. In addition to skill development and culture change, these measures would help to achieve the 20 by 202 productivity agenda for the nation.

6.3.3 Sundry issues

1. Key role players should take steps to rethink the identified key areas in which they negatively impact on productivity outcomes in the RBLC.
2. Adequate contingency plans should be put in place to cushion the negative impact of the external limiting factors.
3. The government and the industry should work together to address the key industry characteristics, market conditions and the regulatory/statutory compliance issues which limit the ability of the stakeholders to innovate and improve productivity.
4. The building owner's proclivity to design customisation and frequent change orders should be discouraged through professional advice on the negative impact on costs, scope, completion time and value of the finished property.
5. The building consent processes should be made cheaper and fast-tracked through initiatives such as online consenting, streamlined BCA operations and greater use of the standard, multi-proof building designs.
6. The owner-builder exemption to the restricted building work regime should be re-considered given its tendency to result in low productivity and a return to the era of leaky building in the near future.
7. Greater use of the CodeMark product certification scheme to provide a wider range of materials and components for use by designers to deliver more economic, flexible, innovative, productive and environmentally friendly design solutions to satisfy a variety of end-user requirements.
8. Encourage the involvement of home-builders who have in-house design, management and construction capacity to provide one-stop design and build service to the owner. This contrasts with the current domination by volume builders who do not have the technical expertise of home-building to effectively coordinate and manage the quality of work and performance of the specialist tradespeople engaged to deliver the job.
9. Greater use of off-site manufacturing system to improve quality, speed, life cycle costs, productivity and sustainability in the home building sector.

6.4 Recommendations for further research

Given the highlighted limitations of the study, it is recommended that large scale investigations be carried out at the national level to cover other residential building types.

Further research is also recommended to gain understanding of what drives the building owners' risk-averse dispositions and preference for bespoke designs.

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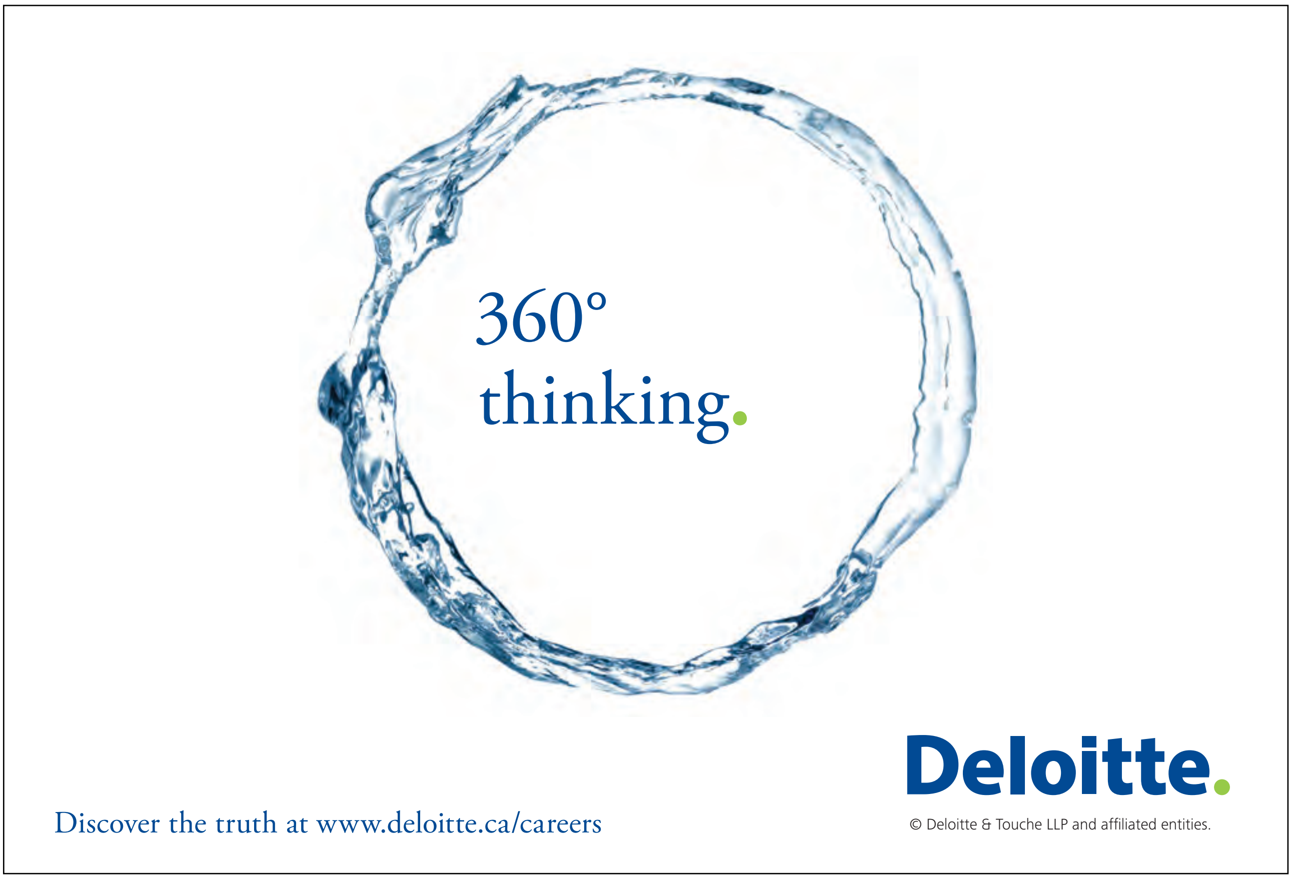

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8 Appendix: Interview Schedule

PRODUCTIVITY INCREASE LEVERAGE POINTS IN THE BUILDING LIFE CYCLE PHASES: CASE STUDY OF RESIDENTIAL BUILDINGS

Jasper Mbachu
School of Engineering and Advanced Technology
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Research aim, questions and objectives

The overarching aim of this study is to explore the productivity increase leverage points in the residential building life cycle (RBLC) (see the figure overleaf). The key objective of the study is to find answers to the research questions relating to the research aim, drawing upon the feedback from industry stakeholders during an interview. The interview is envisaged to take about 20 minutes of your time, with 15–25 minutes being an ideal range.

Interview Questions

1. What is your role in the residential building sector?
2. In the context of your role what does productivity mean to you?
3. How do decisions made at the various phases of the residential building life cycle (RBLC) influence the overall productivity outcomes in the cycle? How would you rate the relative levels of influence of the decisions made at each phase to the overall productivity outcomes in the RBLC?
4. Who are the key decision makers or role-players in the RBLC? In what ways do they influence productivity outcomes? How would you rate the relative levels of influence of the role-players to the overall productivity outcomes in the RBLC?
5. What are the productivity/efficiency limiting factors in the operating environment of the residential building? In what ways do they influence the RBLC productivity outcomes?
6. Overall, how could productivity be improved in the RBLC?

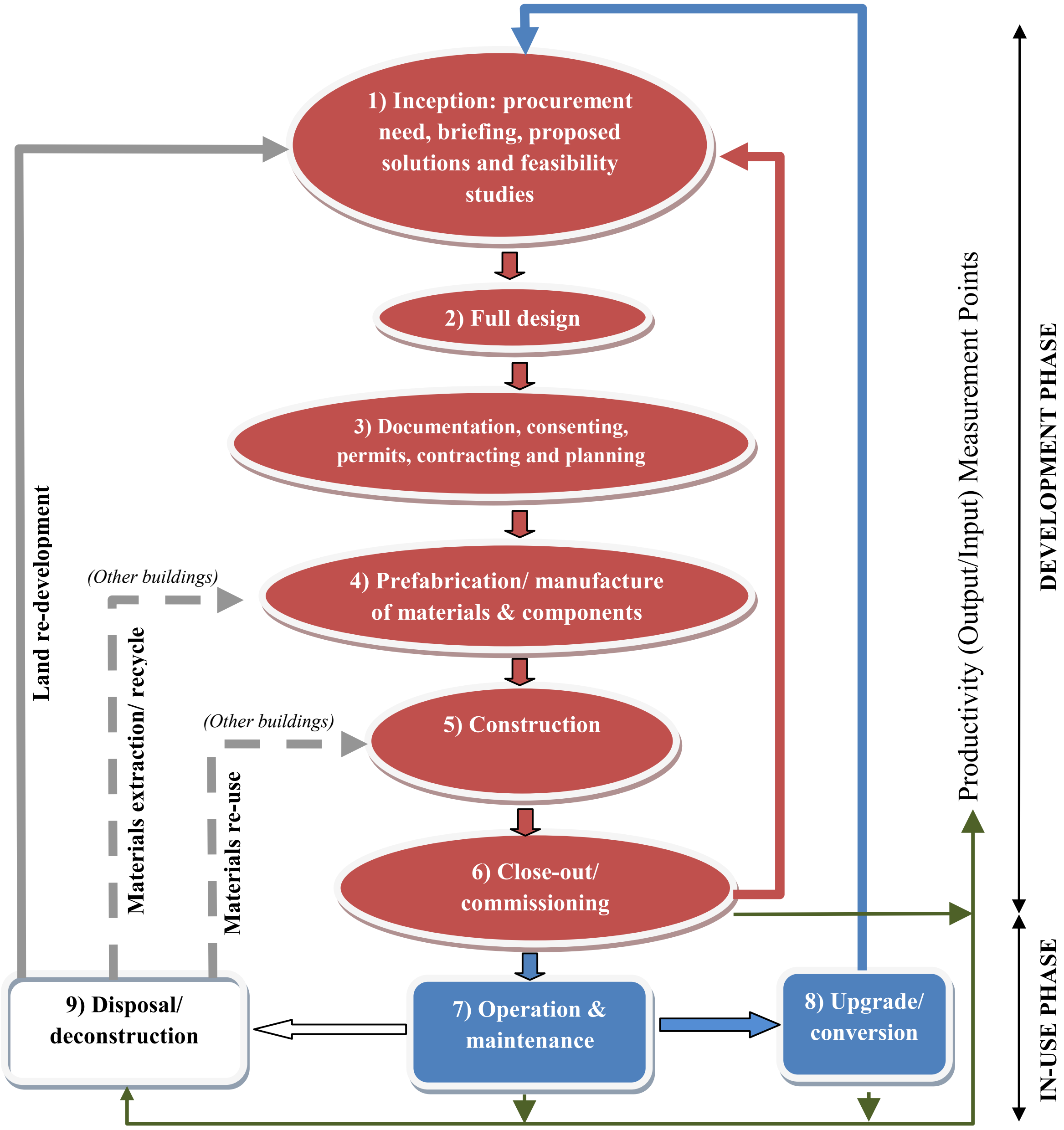
Appreciation

Thank you for your time and useful contribution to this study. As has been promised, your feedback will be treated in strict confidence and used solely for the purpose of this research without revealing your details or those of your organisation. If you would you like to receive the key findings of the research following its completion, you may wish to advise ANY ONE of the following mediums for receiving the research findings.

Fax: ____________________ Attention: ____________________

Email: ____

Postal address: ____



***Project life cycle*: 1) - 2) - 3) - 4) - 5) -6) - 1). *Continuous building life cycle*: 1) - 2) - 3) - 4) - 5) - 6) – 7) –8) - 1)**

***Terminal building life cycle*: 1) - 2) - 3) - 4) - 5) - 6) – 7) –9) -1).**

Figure 28: Relating project and building life cycles

9 Endnotes

1. Item 3, page 2 of http://www.dbh.govt.nz/UserFiles/File/Building/Building%20law%20and%20compliance/Paper-3-Stepped-consenting.pdf.