

DRIVING INNOVATIVE OFFSITE CONSTRUCTION TECHNIQUES IN NEW ZEALAND

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This paper examines the drivers for developing an innovative offsite culture in the New Zealand construction industry. The paper answers two main questions (1) what encourages, or dissuades, offsite innovation in the New Zealand construction industry? and (2) does innovation lead to better product design and development?. The paper answers these questions by assessing offsite case studies to improve construction product and process development. The cases studied in this paper show how innovation has been used and what new off site building products and designs have been required to meet the needs. Benefits of off-site construction and barriers to uptake of new products and construction processes are discussed.

Keywords: Offsite, Innovation, New Zealand.

INTRODUCTION

Construction industry activity in New Zealand has long been associated with inefficiency and reluctance to take up new technology. The industry operates under tight margins and with expectations from its clients often being high, it is not surprising that the end result is a poorly delivered building designed to minimal performance standards under the building code.

Generally traditional design and construction methods achieve code compliance by means of “acceptable solutions” or predefined examples. These are preferred over developing more innovative, and efficient, “alternative designs” as the immediate benefits are tangible – the consent process is likely to be faster and the project is perceived to be less risky. The requirement for sustainable development is written into the NZ Building Act, there is increasing pressure not only to build in an efficient way, but also to use resources such as water and energy more economically, to send less waste to landfills, to have a smaller “eco footprint” and to enable efficient usage of the structures by the occupants. This paper examines the drivers for developing an innovative offsite culture in the New Zealand construction industry

DRIVERS FOR OFFSITE INNOVATION

Offsite is the term used to embrace the technologies and processes involving various forms of supply chain specifications, prefabrication and off-site assembly. It is widely agreed that offsite methods can make more effective use of materials, speed up delivery, reduce time spent on site, enable high standards of design quality, improve on-site safety and overcome skills shortages in the construction industry. However, the process must be understood and managed correctly to gain such benefits.

Offsite is well established in the UK but the lack of agreement within the industry has led the Housing Corporation to set particular definitions. These have become generally accepted definitions as much of the work in offsite in UK is subject to Housing Corporation grants. In New Zealand, offsite is not a concept that has had much uptake even though the concept could offer a solution to the poor quality of some of the residential building work.

Internationally, off site construction methods are increasingly becoming a popular way of solving many of the industry's problems. Methods include prefabrication of wall panels, steel frames, curtain walling, staircases and beams; modular construction of bathrooms and kitchens for insertion into the building shell on site; and construction off site of volume pods, completed inside and out, for assembly on location.

Designing a building for this form of construction means that the design needs to be finalised early in the programme, although not to such a level of detail that the benefits offered by a particular product are negated because of lack of flexibility of a design. Unlike traditional designer behaviour, this requires an understanding of the nature of prefabrication, and the assembly methods for specific product systems. Likewise, the builder also needs a detailed knowledge of the way a system goes together and the logistics involved in getting the product to site. In order for an off-site culture to develop in New Zealand, an innovative approach is needed by designers, builders, and product manufacturers and retailers.

Innovation, like sustainability, is a popular concept frequently encapsulated in marketing phrases where it is used to persuade customers to make investment decisions. Globally it is held up to be an example of best practice, of leading edge technology, or successful performance enhancement. There is a common view that innovation is crucial to the future of the industry. A CIOB survey in 2007 defined innovation as *"the successful introduction of new technologies or procedures into industry"* by means of Research and Development (R & D). The former Department of Trade and Industry (DTI) in the UK noted that innovation is *"The successful exploitation of new ideas"* and that *"it is the key business process that enables UK businesses to compete effectively in the increasingly competitive global environment."*

Common complaints about the NZ construction industry are that it is slow to take up new ideas, has poorly skilled workers and a high accident rate, is slow to improve its technology and generally prefers traditional construction methods of "acceptable solutions" over "alternative designs" as the consent process is faster. (CIC, 2003)

The research in this paper from the project, "Offsite unplugged" aimed at giving 50 or so students of architecture and construction an insight into the nature of offsite, modern methods construction, the culture of the NZ industry and the industry's readiness to innovate and accept alternative methods of building. The aims were to understand how decisions are made on methods of building and the nature of managing construction products, processes and personnel in order to see the benefits and challenges of using offsite methodology across a range of project conditions.

RESEARCH METHODOLOGY

The primary objectives for undertaking this research are outlined below:

- To determine the nature of offsite construction (prefab and/or modular) in New Zealand construction industry.

- To determine through interviews and survey the New Zealand construction industry position regarding the exploitation, acceptance and uptake of offsite techniques.
- To determine cultural changes that may need to be made to improve the use of offsite production techniques in New Zealand.

In order to achieve these objectives, the research collected information on offsite production techniques through a semi structured interviews with construction organizations. A total of 96 organisations with operational base in Auckland, New Zealand, participated in the survey and information obtained were analysed using statistical methods.

The interview questions were largely in the form of ordinal and Likert scales, with respondents required to give their opinions about offsite production using scales. The ranks were obtained using weighted average.

ANALYSES & PRESENTATION OF RESULTS

Demography of Participants

The chart in Figure 1 gives a summary of the main categories of respondents that questionnaires were administered to. The chart shows that majority of participants were operating at the national level (53%), followed by local construction organizations (44%) and finally companies with international linkages (22%).

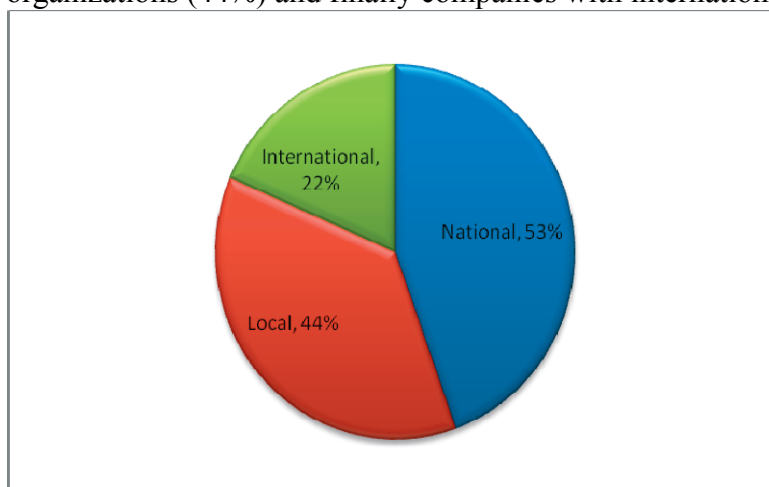


Figure 1 – Types of Organisations

Participants were required to indicate the type of work they were engaged in. The result is presented in chart (Figure 2). The majority of the participants were involved in commercial construction projects. This category had the highest ranking followed by organisations in the industrial sector, residential, education and health sectors in that order. In addition, other organisations (14%) indicated other areas of construction work such as retail property ownership, re-cladding, chapels and fit-outs.

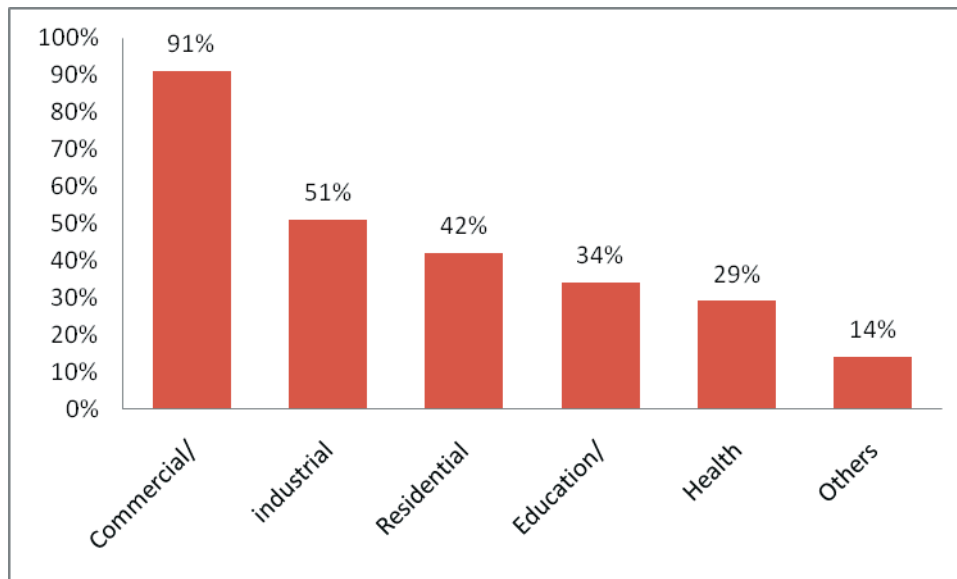


Figure 2 – Type of work done by organisations

74% of the organizations investigated employ more than 20 permanent operating staff, 12 % with 13 – 20 operational staff and 14 % with less than 12 staff members. This gives an indication of the caliber of organisations used for this research study. It is anticipated that the organizations would be in a position to offer valuable opinion about the use of offsite production in New Zealand.

Perceptive Views of Respondents

In this question participants were required to indicate the type of project they were currently involved in. The response indicate that the greatest percentage of building type considered were apartments with 37%; followed by car parking facilities with 34%; multiple tenanted buildings (31%) in that order respectively.

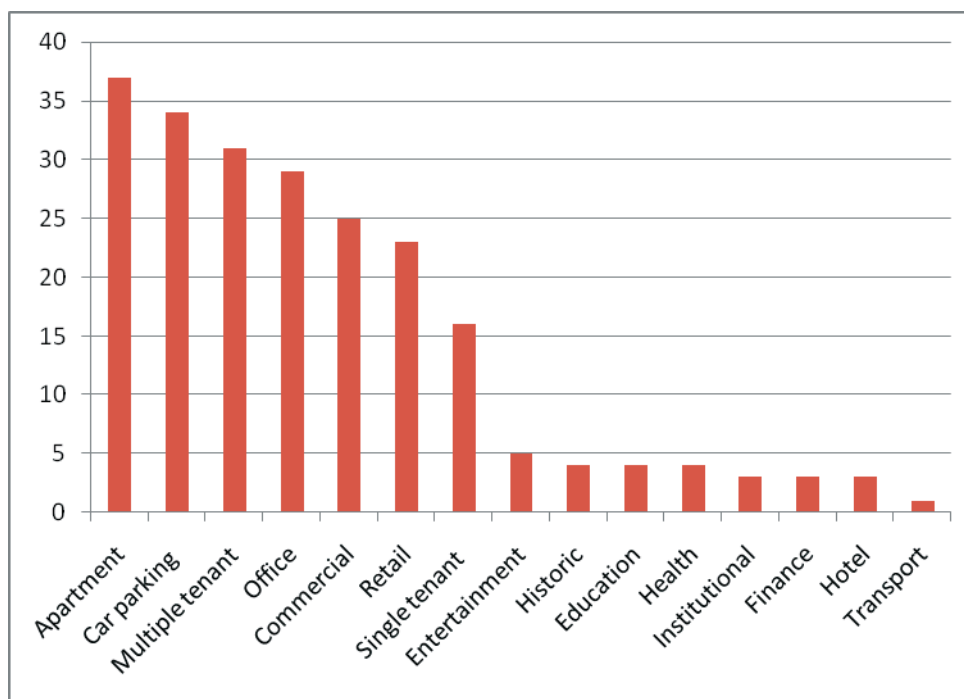


Figure 3 – Types of projects

Decision to Use Offsite Production

The question required participants to indicate the stage on a building project at which decisions were made to use Offsite production on their ongoing projects. The participants were given several project stages and required to indicate a Yes or No to when offsite decisions were made. Further analysis of the responses permitted a ranking of the responses from the highest to the lowest of the stages selected. The results indicate that majority of decisions on offsite production were made before actual construction work commenced and especially at the building design stage. Decisions made at the basic building design stage had the highest percentage of 38, followed by initial planning stage 30%, down to the construction stage. The majority response on basic building design stage seems consistent with the fact that key decisions are on methods and technology at this stage of any building project. For example the decision to use steel, concrete or hybrid construction systems are often reached before actual construction begins. Such early decisions can save time and money. One could suggest that the participants who decided on offsite methods during construction had done so as an afterthought or probably after a re-evaluation of alternative approaches.

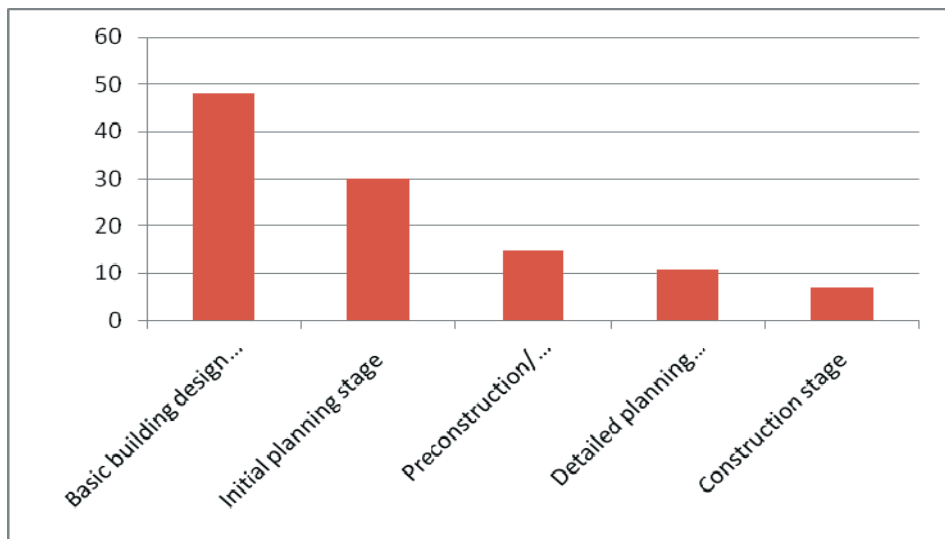


Figure 4 – Stages at which decisions are made

Factors Involved In the Decision to Use Offsite Methods

This question required participant to indicate which factors was involved in their decision to use offsite methods. Participants were to give their opinions on scale of 1 to 5 with 1 being ‘Not important’ and 5 being ‘Very important’. Further analysis using a Weighted Sum Average method generated a ranking of the responses, so that the given factors can be ranked according to their level of importance in offsite decisions. Table 1 below presents the result in percentages and associated ranking scores.

Table 1 – Factors influencing offsite methods

	Not Important		Neutral		Very Important	No Response	RANKING
	%	%	%	%	%	%	
Ensuring time certainty	4	3	7	22	64	0	1

Achieving higher quality	2	6	13	21	58	0	2
Ensuring cost certainty	5	6	12	18	59	0	3
Minimizing on-site duration	5	5	9	28	53	0	4
Restricted site access	13	20	14	22	30	1	5
Reducing health and safety risks	15	15	20	24	25	1	6
Addressing skills shortages	14	21	26	25	14	0	7
Client's influence	26	18	15	14	27	1	8
Reducing environmental impacts during construction	17	19	28	27	8	1	9
Maximizing lifecycle environmental performance	18	11	38	23	8	2	10
As part of an energy strategy	35	13	18	22	11	1	11
Revisions to Building regulations	42	12	27	9	9	1	12
Government promotion	59	12	18	7	3	1	13

It can be observed from the results that the need to ensure time certainty ranked the highest among given factors for decisions on offsite methods. This is followed by achieving high quality; ensuring cost certainty; minimizing on-site duration etc respectively in that order. The three highly ranked factors are consistent with the importance that is attached to time, costs and quality in project implementation. They are therefore key drivers for the use of offsite methods in building production in New Zealand.

Other factors that had relatively lower responses, but equally important, were site access restrictions; reduction in health and safety risks; skill shortages; clients' decisions etc. In general all the given factors were important in offsite production decisions but with variable level of importance. It is interesting to know that a particular organization decided on offsite production because it felt it would enable the achievement of a green star rating of 4 through the reduction of environmental impacts during construction. Environmental impacts are able to be reduced as work takes place under controlled conditions where the systems are already in place to minimise waste and deal with possible pollutants. Revisions to building regulations and government promotion are not as important to some participants as a factor to consider for the use of offsite methods.

Most participants also mentioned that the benefit to this type of construction method are the reduction of the general costs and increase in productivity through better working environment. Although few of the firms considered other factors as being important, the study believes that these factors will become significant in the future across all sectors of the construction industry because awareness in sustainable building is on the increase.

Barriers To Increasing Offsite Production

As a follow on to the question above, participants who selected either of the two options: 'A lot more needed' and 'More needed' were given a list of factors that could explain the reason for their choice. The given factors were a list of barriers to offsite production which they could rank on a scale 1 to 5 (1 being 'Not a barrier' and 5 being 'Definitely a barrier'). Table 2 gives a summary of their responses.

Few participants (n=20) indicated that the greatest barrier to offsite production is New Zealand's manufacturing capacity. This is followed by site specifics and constraints; inability to freeze design early on; complex interfacing between systems; difficulty of achieving economies of scale; and higher capital in that order.

It is important to note that Client skepticism, Attitudinal barriers due to historic failures, Risk averse culture; Lack of previous experience with offsite; and Skills shortage were not considered as barriers to offsite production as these have the lowest ranking.

Table 2 – Barriers to offsite production

	Not a Barrier		Not Sure		Definitely Barrier	RANKING
	%	%	%	%	%	%
Manufacturing capacity	15	12	3	35	35	1
Site specifics and constraints and transportation	8	15	19	31	27	2
Difficulty of achieving economies of scale	8	8	42	12	31	3
Inability to freeze the design early on	15	15	19	31	19	4
Complex interfacing between systems	23	4	23	35	15	5
Higher Capital cost	23	12	30	12	23	6
Reluctance to innovate	31	15	31	12	15	7
Organisational mechanism unfavourable with offsite	31	15	23	12	19	8
Nature of the planning system	32	15	23	15	15	9
Fragmented industry structure	21	15	23	23	8	10
Lack of long term co-operation between project team	35	15	27	0	23	11
Legal issues	38	12	23	19	8	12
Skills shortage	46	0	35	4	15	13
Lack of previous experience with offsite	31	19	38	4	8	14
Risk averse culture	31	31	30	4	4	15
Attitudinal barriers due to historic failures	42	38	8	4	8	16
Client scepticism	54	23	11	8	4	17

Constraints Posed By Projects to Offsite Production

The participants were given several project constraints and were required to indicate whether the given constraints posed any impediment to the use of offsite production. The responses have also been ranked according to the level of effect on offsite production.

The analysis show that 71% of the respondent indicated difficult access to construction sites as major constraints to the use offsite production as it might be difficult to deliveries and assemblage on site. This is followed by speed of enclosure, budget constraints, extreme climate etc. New Zealand’s climatic extremes require adequate speed for building enclosure. Its unpredictable nature requires building envelopes to be erected quickly as there is never any guarantee of fine weather.

Labour shortage, services difficulty, remoteness of site and lack of equipments were not considered as major constraint to the use of offsite production. These given factors had the lowest ranking as indicated on the table.

Participants specified other project constraints to include: crane time, site storage, neighbouring properties, sea level, contractors’ contract, and speed of overall completion.

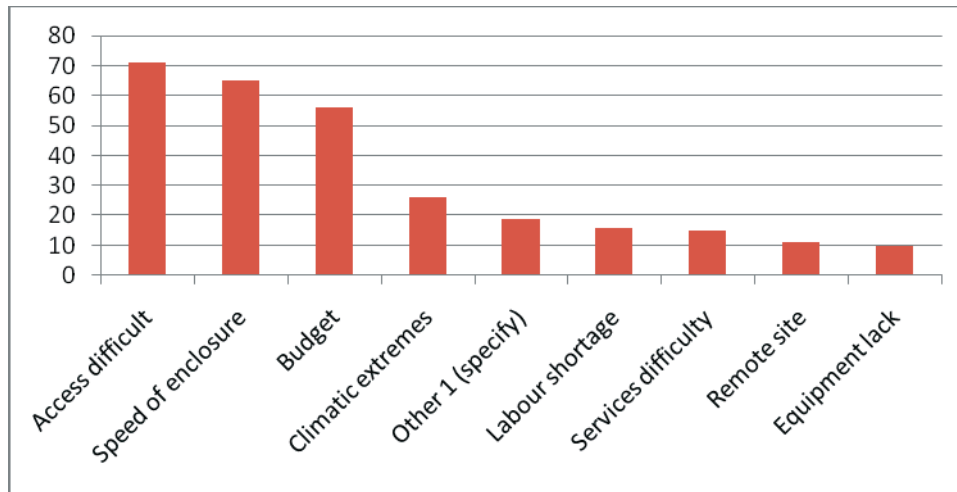


Figure 5 – Project constraints

Prospects for use of offsite methods in the next 1-3 years?

This question requires participant to indicate if their organizations would consider the use of offsite production in the next 1-3 year. The majority (55%) of the participants believe that the current level of use of offsite methods will remain the same. This is consistent with their opinions that offsite usage is ‘about right’ at an instance level. Without change there can be no innovation. On the other hand, 28% believe the level of use will increase somewhat. This suggests that the New Zealand building industry may be willing to use offsite production techniques in the near future.

Fewer participants indicate higher increase in use beyond those suggested by the majority of participants, while even fewer (7%) indicated that they do not feel for what will happen to the use of offsite production in the next 1-3 years. This may be indicative of low awareness in the use of offsite production.

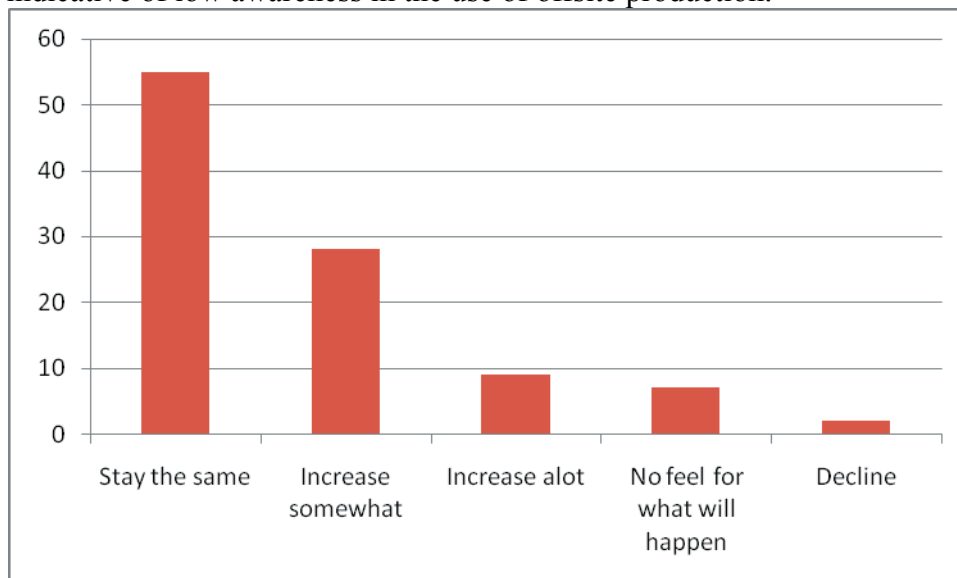


Figure 6 – Opinion on the use of offsite methods

Building Element with The Most Potential For Offsite Production

In this question participants were required to indicate their opinions on which elements of the building process has the most potential for Offsite production in New

Zealand. Participants' responses was to be given on a scale of 1 to 5 with 1 = No potential; 3 = Neither / Nor; and 5 = Great Potential.

A summary of the results is presented in percentages in the table below. In order to gain an understanding of the building process that has the most potential of being produced off site; further computation was made to determine the weighted average from the frequency of the responses.

The result show that external walls have the greatest potential for offsite production followed by metal frames; modular; timber frames up to ground elements in that order. The highest ranked elements are consistent with New Zealand's level of technology. For example it is common for external walls, metal frames and timber frames to be produced offsite and assembled on site.

Participants have also indicated some other building elements apart from those presented to them as capable of being produced offsite. The elements are: Drainage elements, super structure, and drainage systems.

It is important to note that participants ranked Ground Elements, Dormers and Chimneys, and Services and Distribution as the lowest building elements with potential for offsite production. Though ranked low the study believes that all building element have the potential of being produced offsite.

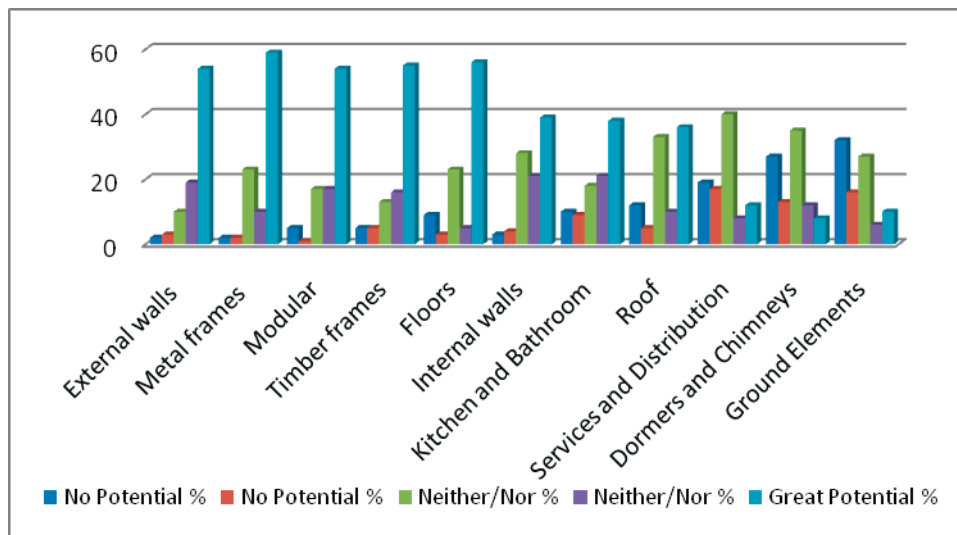


Figure 7 – Building element with potential for offsite production

Conclusions: Future Directions for The New Zealand Industry

The major offsite opportunities at present were offered by timber and steel framing, kitchen and bathroom pods, and modular buildings. Architects do not appear to be taking a leading role in designing for Offsite methods of construction, even though the decision to use offsite is usually made in the concept stage. This might imply that most of the projects using offsite were not designed by Architects, but were more design and build.

High quality is becoming much more sought after and gives a competitive advantage – more achievable using prefabricated components. It is felt that in New Zealand there is need for a much wider range of products for offsite solutions. Although offsite is seen by some as a way to use innovative techniques to build on difficult sites, shorten the construction time on site, and to achieve a much higher quality of finish, most companies are still not expecting to progress their use of this technique much in the

near future. A clear majority of people interviewed feel that Offsite is being used sufficiently at present.

Inability to freeze the design early on is seen as a major problem. The reason for this is unclear but may be due to the fact that the drawings were not properly completed in the early stages and leave the contract in an insecure state. Freedom to continue modifying a design as it is being built often adds cost and time uncertainty and can be a cause of major budget blow outs. This is a common occurrence and possibly freezing the design and having more discipline in the process would assist the budget.

The main barriers to taking a more proactive approach are perceived to include a lack of production capability and knowhow, insufficient marketing to builders of the benefits of using offsite manufacturing, inability to be flexible in making changes later in the construction programme, overly complex interfacing between trades

As far as the future is concerned, a significant number of respondents said they had no feel for how much their use would increase over the next 3 -5 years. Acceptance was indicated, but a lack of confidence in the ability to deliver, and a need for more training and improvement of techniques to assist offsite development.

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