Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

MASSEY UNIVERSITY
COLLEGE OF SCIENCES

OFF-SITE MANUFACTURING AS A MEANS OF IMPROVING PRODUCTIVITY IN NEW ZEALAND CONSTRUCTION INDUSTRY: KEY BARRIERS TO ADOPTION AND IMPROVEMENT MEASURES

Wajiha Mohsin Shahzad

June 2011

OFFSITE MANUFACTURING AS A MEANS OF IMPROVING PRODUCTIVITY IN NEW ZEALAND CONSTRUCTION INDUSTRY: KEY BARRIERS TO ADOPTION AND IMPROVEMENT MEASURES

A research thesis submitted in fulfilment of the requirements for the

Degree of

Masters of Construction Management

School of Engineering and Advanced Technology

Massey University

Albany

New Zealand

Wajiha Mohsin Shahzad

June 2011

STATEMENT OF ORIGINALITY

I declare that this thesis is my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for degree or any other qualification.

_____

Wajiha Mohsin Shahzad

ABSTRACT

Off-site manufacturing (OSM) of building components could be leveraged to improve the reported low productivity trend in the New Zealand (NZ) construction industry. Despite the numerous known benefits of OSM, the uptake of the technology in the industry has been discouragingly low. Previous studies offer little help in terms of prioritising identified barriers to the uptake of OSM. As a result, improvement efforts have been daunted by numerous barriers in the face of limited resources. This study aims to contribute to bridging the gap in the extant literature by identifying and prioritising the key constraints to the industry-wide uptake of prefabrication and the improvement measures. Through a nation-wide survey of consultants, contractors, employers and manufacturers, feedback was received and analysed using the multi-attribute analytical technique. Results show that the broad categories of constraints to the adoption of prefabrication in NZ are (in order of decreasing impact and relative contributions): industry and market culture (16.2%), skills and knowledge (15.5%), logistics and site operations (14.8%), cost/value/productivity (14%), supply chain and procurement (13.7%), process and programme (13.6%), and regulatory (12.2%). The subcomponents of the broad constraint categories and their relative levels of impact on the uptake of the technology were reported. In addition to addressing the key barriers identified in the study, further measures for improving the uptake of the technology in New Zealand include promotion by client through specifying OSM in the design briefs, improved education and training on the use of OSM, more marketing/ awareness campaign on the benefits of the technology and better supply chain management and transportation logistics.

To enable a methodical evaluation of the marginal value achievable by the use of a variant of OSM over and above that of the traditional stick-built system at the design and life-cycle phases of the procurement process, a decision support model was developed. The model incorporates the key performance indicators (KP1s) underlying clients' value system at the development and operational phases and compares the extent to which each variant of OSM delivers each value criterion relative to the conventional system. The sum of the marginal values at each phase of the procurement

system provides the rationale basis for choosing either the OSM variant or the conventional system based on the approach that delivers the highest marginal value.

The model application to real life project was demonstrated using the modular variant of the OSM compared to the conventional stick-built system. Results of the model application at the development phase shows that the OSM was more beneficial to the client than the conventional system with an overall marginal value of 34% relative to the conventional construction approach. Individual results showed 22% improvement in the completion time for the project, 9% improvement in quality and 3% reduction in the carbon footprint at the development phase. However, the technology was found to be 2.4% more expensive than the traditional stick-built system.

Results of the model application at the operation and life-cycle phases also show that the technology achieved superior value compared to the conventional stick-built system. The overall marginal value achieved by the modular OSM application at the operation phase was 49% compared to the traditional stick-built system; this comprised 23% reduction in the running and maintenance costs, 18% reduction in the maintenance frequency of the structure and fabric, and an annual 8% reduction in the carbon footprint.

Overall, the use of modular variant of the OSM was found to deliver superior value to clients compared to the conventional system at the development, operational and life-cycle phases of the procurement process.

Keywords: Modularization, New Zealand construction industry, Off-site manufacture, Prefabrication, Productivity improvement.

ACKNOWLEDGMENT

First of all, I would like to express my deep gratitude for my supervisor, Dr. Jasper Mbachu, for his expert advice, outstanding support and unfailing patience. This thesis would not have been possible without his enthusiasm and guidance. Dr. Mbachu remained a source of support and encouragement for me during a crucial time when I had to bear the loss of my beloved father, for which I am greatly indebted.

I would like to thank my co-supervisor, Dr. Robyn Phipps and the Academic Director, Prof. Ian Maddox, for their guidance and encouragement.

I am grateful to the Building Research Association of New Zealand (BRANZ) for providing funding for this research. I feel extremely grateful to Dr. John Duncan, for showing confidence in my research and providing continuous support.

I also wish to express thanks to Massey University Human Ethics Committee (MUHEC) for granting approval to undertake the stakeholder consultations.

I am grateful to the organizations and individuals who participated in this research. I would like to thank Dr. Wayne Sharman, John Granville, Martin Fahey, Gregory Chawynski, Rosemary Scofield, Pamela Bell and many others who extended their support, dedicated their time and shared with me their valuable experiences. Their support and knowledge greatly contributed to the quality of this research.

I would like to acknowledge the support of my entire family including my four year old son, Muhriz, who cooperated with me and allowed me to complete the research without minding the reduced motherly attention he was receiving. In the end, my fondest thanks for my husband, Mohsin for his never ending love, support, encouragement and for much needed cups of coffee.

DEDICATION

I dedicate this thesis to my father, Gulzar Ahmed (Rest in Peace), who departed for the eternal world on 20th August 2010.

I wish to tell him that he will always be in my heart and I can never stop missing him.

Daddy, you are truly missed!

Table of Contents

List of Figures

List of Tables

List of Appendices