THE HONG KONG POLYTECHNIC UNIVERSITY

DEPARTMENT OF CIVIL AND STRUCTURAL ENGINEERING

THE CULTURAL SHIFTOF THECONSTRUCTION INDUSTRY OF HONG KONGUNDERTHE INFLUENCE OF SUSTAINABLE DEVELOPMENT

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A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

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ABSTRACT

Sustainability per se is the outcome of a global change in human culture and embodies entirely new values and consciousness through sustainable development activities. Sustainable development has become a continuous mission for human beings to establish a sustainable society which will be equally prosperous for future generations. A genuinely sustainable society is based upon and run by citizens who initiate developments in sustainable ways according to a recognized code of conduct – the sustainable culture.

Sustainable culture is not static; it changes over time as a dynamic process adapting to external and internal forces that demand for continuous growth and development towards sustainability. The movement of sustainable culture over a certain time interval (cultural shift) records the rate of any positive or negative changes. It reflects the progress on sustainability in a society.

This study focuses on the construction industry and the participants of the construction industry of Hong Kong are categorized into five stakeholder groups according to their functional input viz. Government, Developer, Consultant, Contractor and Non-professional Frontline Participant. A cultural shift within the construction industry is a reflection of the changes in attitudes and practices among participants in project development, design and construction operations. The changes

are embodied in attitudinal and behavioral cultural components comprising awareness, concern, motivation and implementation.

The objectives of this research study are to quantify the changes in these cultural components and to investigate the causes and implications of such changes. The changes are measured by an exclusively designed tool, the T-model, which firstly gathers changes of these cultural components among stakeholders through two comprehensive questionnaire surveys and subsequently converts the surveyed data into cultural scores. Continuous measurement in suitable intervals will capture the trend of movement of sustainable culture and illustrates the culture shift in a simple curve. The curve will be useful reference material for decision-makers in both the Government and private sectors to understand the changes that have occurred or are underway, thus, enabling them to review and adjust policies to align with the trend of cultural changes, or to allow effective modifications that will guide the construction industry of Hong Kong towards being a sustainable society

The questionnaire surveys have been conducted in years 2004 and 2006 among construction participants in managerial and supervisory levels. The data of 446 and 317 valid responses from the two questionnaire surveys have been synthesized by the T-model which illustrated in retrospect a cultural shift from the year 2000 to 2006. To validate the results by a qualitative approach, structured interviews have been conducted with different construction stakeholders to gather their views on cultural shift. The measured results have been further cross-referenced with four detailed case studies.

The results show that positive cultural shift is found within the research time frame of this study. As such, this study elucidates the changes of sustainable culture within the stakeholder groups, the movements of the four cultural components and the eventual cultural shift of the construction industry of Hong Kong.

Key words

Attitude, Behaviour, Culture, Cultural Component, Cultural Shift, Sustainability, Sustainable Construction, Sustainable Culture, Sustainable Society

PUBLICATIONS ARISING FROM THE THESIS

1. Poon, C.S. and Yip, R.C.P. (2005), *Culture Shift of the Construction Industry of Hong Kong under the Influence of Sustainable Development*, Proceedings of the 6th International Conference on Tall Buildings, December 2005, Hong Kong, pp.987-992.

2. Poon, C.S. and Yip, R.C.P. (2005), *Comparison of the Use of Traditional and Low Waste Formwork Systems in Hong Kong*, Proceedings of the 2005 World Sustainable Building Conference in Tokyo, Japan, September 2005, Section 09, Paper 32.

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ABBREVIATIONS

ACQWS – Advisory Committee on the Quality of Water Supplies

ANOVA – One-way Analysis of Variance

ASD – Architectural Services Department

C & D – Construction and Demolition materials

CASET – Computer Aided Sustainability Evaluation Tool

CIB – International Council for Research and Innovation in Building and Construction

CIRC – Construction Industry Review Committee

ERM – Environmental Resources Management

GFA – Gross Floor Area

GHP – Geothermal Heat Pump

GMP – Guaranteed Maximum Price

GRC – Glassfiber Reinforced Cement

HA – The Hong Kong Housing Authority

HKCA – The Hong Kong Construction Association

HKCC – The Hong Kong Community Collage

HKIA – The Hong Kong Institute of Architects

HKICM – Hong Kong Institute of Construction Managers

HKIE – The Hong Kong Institution of Engineers

HKIS – The Hong Kong Institute of Surveyors

HKSAR – Hong Kong Special Administrative Region

ISO – The International Organization for Standardization

IUCN – The World Conservation Union

JPN – Joint Practice Note

NEP – New Environmental Paradigm

NPP – Non-professionally recognized frontline construction participant

OTTV – Overall Thermal Transfer Value

PCICB – Provisional Construction Industry Co-ordination Board

SARS – Severe Acute Respiratory Syndrome

SDS – Sustainable Development System

SPSS – Statistical Package for Social Science

SUSDEV – Sustainable Development in Hong Kong for the 21st Century

TPB – Theory of Planned Behaviour

TRA – Theory of Reasoned Actions

TSW – Tin Shui Wai

TWM – Total Water Management

UNEP – United Nations Environmental Programme

WCED – World Commission on Environment and Development

WSD – Water Supplies Department

WWF – World Wildlife Fund

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CHAPTER 1 INTRODUCTION

1.1 The Study Prologue

The sustainable development concept established in the Brundtland Report (WCED, 1987) attempts to support continuous development of human society for the present and future generations. In the pursuit of sustainable development, all members of society have a role to play. Stakeholders of the construction industry have a decisive role in the built environment and try to explore ways in which they can further contribute. As a guideline, Kibert (1994) has introduced sustainable construction which conceptualized minimizing consumption of basic resources (energy, water, materials and land) throughout the life cycle performance of built facilities. Sustainable construction is indeed a very broad concept, the International Council for Research and Innovation in Building and Construction (CIB) started an international project in 1995 using Kibert's definitions taken as a starting point to compare the visions and perceptions of sustainable development for the future of the construction industry,. The project involved collaboration of experts from 18 countries in Western and Eastern Europe, North America, South Africa and Asia. The study concluded that different countries have different approaches and different priorities in dealing with sustainable construction. Some identified economic, social and cultural factors as part of their framework, others focused on economical and ecological impacts and tolerance of nature and resources (Bourdeau, 1999).

In Hong Kong, the concept of sustainable construction is revealed in a research project commissioned by the Government. A research has been undertaken by the Construction Industry Review Committee (CIRC) to explore improvements in construction output for the betterment of the construction industry of Hong Kong. CIRC refers sustainable construction to construction activities which minimize negative impacts and maximize positive impacts in order to achieve environmental, economic and social performances (CIRC, 2001). Examples of sustainable construction include:

- refurbishment of existing buildings;
- restoration of historical buildings;
- use of non-depletable and recycled construction materials;
- reduction of construction and demolition waste;
- reduction of energy consumption in buildings; and
- provision of healthy, safe and pleasant built facilities.

Brundtland's concept of sustainable development emphasizes balance of growth in social, economic and environmental aspects and this balanced growth is regarded as the key element that supports the development of a **sustainable society**.

A sustainable society as defined by the World Conservation Strategy (1991), developed in partnership by The World Conservation Union (IUCN), United Nations Environmental Programme (UNEP), World Wide Fund for Nature (WWF), is one which features nine principles as listed hereunder:

1. *Respect and care for the community of life.*
2. *Improve the quality of human life.*
3. *Conserve the Earth's vitality and diversity.*
4. *Minimize the depletion of non-renewable resources.*
5. *Keep within the Earth's carrying capacity.*
6. ***Change attitudes and practices.***
7. *Enable communities to care for their own environments.*
8. *Provide a national framework for integrating development and conservation.*
9. *Create a global alliance.*

Among these established principles for a sustainable society, item 1 is the founding principle, while items 2,3,4 and 5 are criteria to be met for the protection of earth resources, items 7, 8 and 9 are directions to be taken for the establishment of a sustainable society. Special attention should be paid to principle item 6 which calls for "**Change of attitudes and practices"**, it is the only principle which demands transformation of mindset and actions of the members of society. The demand for such a change is to alter the established basic assumptions, values, beliefs and behaviour that are presently found as the established culture of a society, which have been well adopted among the members and is collectively a symbolic system of values and beliefs (Wilkinson and Scofield, 2002).

Culture is built upon the development and the lifestyle among members of a society (ibid). To genuinely achieve sustainable development in a society is to nourish a sustainable code of conduct favorable to sustainability requirements. This code of conduct is defined as **Sustainable Culture,** which is the driving force towards a

sustainable society. It is the guiding principle for everyone to think and act within a framework that improves the well being of human life and the integrity of nature (King, 2004). Since the issue of the Brundtland Report in 1987, the call for sustainable development through research activities, promotions and implementations has increased the knowledge on sustainability and subsequently stimulated the growth of sustainable culture in human society. The greater the growth in sustainable culture among members of the society, the higher is the chance in achieving sustainability and the more complete is the achievement of sustainable development.

The status of sustainable culture is never static, but changes with time according to social demands for sustainability and global tendency in sustainable development. The extent of change in sustainable culture within a designated time frame is defined as **Cultural Shift**, which is a phenomenon that represents the essence and magnitude of change in attitudes and behaviours in a designated time frame with respect to basic assumption, guiding principle and moral judgment **(**Schein, 1992**)**. Therefore, the cultural shift within members of a society towards sustainability can genuinely reflect the extent of achievement of sustainability. A measurement that reflects such a social phenomenon will be important reference for decision-makers in the government and in private sectors to formulate policies that couple with universal demands for sustainable development.

For decades, the construction industry of Hong Kong has been one of the key economic sectors which brings both positive and negative effects on sustainable development in Hong Kong. It is true that the construction industry is a major contributor to economic growth and a key provider of employment that maintains

social stability. It is also indisputable that construction industry is a main consumer of earth resources (energy, water, materials and land), a major producer of solid waste (inert and non-inert waste); and a polluter of the atmosphere with gaseous emission (carbon dioxide, sulphurous oxide). In this connection, guidance and action plans specific to the construction industry should be set up to enhance effective use of resources, stringently control solid wastes and the emission of gaseous pollutants.

However, to nourish a sustainable culture which will eventually override the existing mindset and practice is a long process. It requires industry stakeholders to change their attitudes and behaviour in order to replace the existing mode (Trainer, 1995). A rise in general recognition of sustainability, followed by policies to enforce sustainable requirements will stimulate cultural change. When sustainable culture begins to develop among construction practitioners, their thinking and doing will start to restructure thus directing them to behave and perform in a more sustainable-conscious way according to the sustainable principles and requirements.

1.2 The Knowledge Gap in Sustainable Culture and Its Movement

Construction activities are the source of many environmental problems. It is also recognized that built assets consume a considerable amount of energy and natural resources both during the construction process and subsequent operation after completion. Numerous researches have been conducted to enhance sustainability by exploring new materials, equipment and construction management systems aiming at lesser consumption of earth resources, higher production rate, better product quality and lower waste generation (e.g. Lozar, 1994; Wyatt *et al*, 2000; Poon *et al*, 2003; Yip

and Wong, 2004). The results of these research activities, no matter tangible or intangible, are deliverables of new construction technologies and management systems that improve sustainability in economic, social and environmental aspects. The research outcomes are undoubtedly beneficial in certain areas of sustainability within a defined domain. However, there are very limited research activities exploring matters affecting sustainability in a holistic approach, particularly, the fundamental cause of the growth of sustainability in a society - the development and evolution of sustainable culture under the influence of a global demand for sustainable development. Hence, study of the growth and movement of sustainable culture is still a virgin land for researchers to explore, using numerical measurements to address the change of sustainable culture within a designated time frame (cultural shift) is a mission that should be carried out. To study cultural shift towards sustainability would effectively help measuring the cultural status of the chosen field (the construction industry of Hong Kong) and displaying the pace of evolution towards a sustainable society.

Arising from government policy for sustainable development, there has been a series of enactments of laws and regulations, which govern both project design and construction operation that construction stakeholders are obliged to follow. The persistent enforcement of law and regulations steers construction practitioners to discharge their duties in more sustainable ways. When performance in sustainable ways turn into habitual actions among stakeholders, it will be subconsciously acquired and abided as an intrinsic form of performance. A sustainable code of conduct favorable to sustainability is thus gradually developed and shared among construction practitioners. This code of conduct is the guiding principle that directs performance

of daily operational duties in project design and construction operation.

Professional and supervisory practitioners in design and operation are leaders and key players in construction activities. Their performance as a whole on sustainability in various construction projects is the output of their knowledge and recognition of sustainability which is a reflection of their sustainable culture. Measurement of the status of the evolving sustainable culture and the magnitude of evolution in a designated time frame (cultural shift) will provide important information on the current standing of sustainable development in Hong Kong. A genuinely sustainable society is one formed by members who possess sufficient knowledge of sustainability and are willing to perform the same at all times in their careers as well as in their daily life **(**Blank, 1996).

This study does not cover construction workers whose outputs are governed by the criteria of project requirements and specifications. The performance of construction workers and their production output are controlled and monitored by their supervisors in accordance with specifications and codes of practice. In addition, all project designs, specifications and codes of practice are initiated by stakeholders who are predominantly in professional and supervisory positions. According to this reasoning, the output of construction workers is the outcome of the wills and directions of their superiors in professional and supervisory levels. ***Practitioners of the construction industry of Hong Kong are hereinafter referred to as construction participants and stakeholders in professional and supervisory level in various disciplines.***

This study has selected the construction industry of Hong Kong as the research focus

and has developed a means of measurement to effectively assess the magnitude of cultural shift among members of the construction field. The means of measurement so developed may also serve as an applicable reference for other industries. The method of measurement can be used by other industries, though minor modification in data collection may be required according to the nature of the particular industry to be measured.

1.3 The Research Questions

The Government of Hong Kong Special Administrative Region (HKSAR) has promoted sustainable development through its policy making and a series of road shows, public consultations through the mass media since year 2000. Subsequent policies, rules and regulations have been set up to govern activities in the commercial and industrial sectors in their running of business under pre-set sustainable criteria. Government policy and promotion for sustainability have taken place for a number of years, therefore it is valuable, meaningful, timely and necessary to investigate and identify the movement of sustainable culture developed among construction participants of Hong Kong under the global demand for sustainability. In this connection, a number of research questions have been developed as follows:

- Who are the key stakeholders of the construction industry in the professional and supervisory levels?
- Is there any difference in their output that may influence the result of sustainability? And what are the differences in influential power among different stakeholders?

- What are the key components (cultural components) that constitute the sustainable culture of the construction industry of Hong Kong?
- How do the changes of these cultural components transform the attitudes and behaviours of the stakeholders?
- How to measure the change of these cultural components and what is the effect of such change?
- How to present the measurement of the change? And what are the implications of these changes affecting the development of sustainability of the construction industry of Hong Kong?

1.4 Aim and Objectives of the Study

The aim of this study is to investigate cultural shift of the construction industry since HKSAR Government promotion of sustainable development in year 2000. The study introduces a measuring tool which enables measurement of the movement of sustainable culture in the form of a simple tendency curve. Decision-makers in the Government and private sectors may use the curve to review the applicability of their policy. When a policy is aligned with sustainable culture which is oven applicable in habitual practices, construction participants may simply execute their construction duties subconsciously and seamlessly according to their habitual practice and achieve the expected sustainable result smoothly without violating the rules and regulations. With knowledge of the general trend of cultural shift, decision-makers may modify policies from time to time to increase the pace of sustainable development by referring to the current status of sustainable culture of the construction participants. By the same token, conflicts between any industrial practitioners and decision-makers

could be largely avoided and the best result will be achieved. Regularly measuring cultural shift among industrial practitioners is therefore imperative; it may allow policy makers in the Government and private sectors to review responses from time to time in order to elicit best result for sustainable development.

To achieve the stipulated aim, the objectives of the research consist of:

- To identify the key components that constitute the sustainable culture of the construction industry of Hong Kong;
- To categorize stakeholders in groups according to their roles in the construction industry of Hong Kong and identify the respective influential power of each group upon the sustainable output of the built environment;
- To develop a measurement tool which facilitates measurement of sustainable culture developed among the stakeholder groups and the cultural shift of the construction industry;
- To measure the sustainable culture developed and the culture shift by using the measurement tool; and
- To present the measured results in a simple form to decision-makers for reference.

The extent of cultural shift towards sustainability is a reflection on the extent of achievement of sustainable development. The resultant measurement allows decision-makers to identify areas of mismatch between policies and construction practices. This reference will help decision-makers in the Government and private sectors to review and modify policies and objectives in compliance with the general trend of cultural shift so that the expected result in sustainable development can be readily achieved.

1.5 Structure of the Thesis

The structure of the thesis is organized in a way which allows readers to firstly cover previous studies by reviewing relevant literature on similar areas of sustainable development, sustainable construction, relevant government policies and the responses of stakeholders in the construction industry towards sustainability. Then, through a sequential investigation of human behaviour models, major components forming the sustainable culture of the construction industry of Hong Kong are identified and established. The established cultural components and the behavioral pattern of human activities are then used to derive a model which facilitates measurement of cultural shift. Finally, research activities by way of questionnaire surveys together with structured interviews have taken place in Hong Kong in order to derive the empirical research findings on any cultural shift. Case studies are also conducted to triangulate findings from the questionnaire surveys and interviews in order to validate the overall study outcome in a holistic approach.

This thesis is structured as follows:

Chapter 1 is an introduction of the study, providing the background, the research rationale, an overview of the entire research arrangement and an elucidation of how the thesis is structured.

Chapter 2 reviews the concept of sustainable construction, as well as assesses the impact of the promotion of sustainable development by the government of HKSAR which obviously affects the sustainable performance of the construction industry. This chapter also highlights the use of a human behaviour model developed by

Ajzen's theory of planned behaviour (Ajzen, 1991; Ajzen and Fishbein, 2005) to expound how sustainable culture is formed among construction participants and stakeholders.

Chapter 3 details the research methodology, which embraces a comprehensive literature review, two-rounds of questionnaire surveys supplemented by a series of structured interviews. The design of the questionnaire and the marking scheme setup for each question are expounded in detail. The results of these different research approaches are further triangulated with case studies to cross-reference with one another. The development and the application of an exclusively designed measurement tool are unveiled here. This chapter also explains how this tool facilitates the integration of each cultural component to form a cultural shift curve which reflects the trend of sustainable culture among construction participants and stakeholders.

Chapter 4 presents the findings from the analyses of the questionnaire surveys. The respective influential power of each stakeholder group that influences the output of sustainability in construction is identified. Cultural shift towards sustainability that has taken place in the Hong Kong construction industry is revealed by using the measurement tool developed exclusively for this study. The chapter specifically shows statistical analyses of the cultural shift based on Cronbach's Alpha reliability test, T-tests and one-way ANOVA tests.

Chapter 5 focuses on the findings of structured interviews with selected respondents of all stakeholder groups in the two questionnaire surveys. The number of invited

interviewees in each stakeholder group has been determined by the amount of questionnaire survey respondents in that group. Qualitative information obtained from the interviews are analyzed and compared with results generated from the cultural shift measurement tool to validate the research findings.

Chapter 6 examines the current sustainable culture in the construction industry of Hong Kong, based on four in-depth case studies, feathering economic, social and environmental attributes. The findings from these cases are also used to triangulate with the research findings obtained from the measurement tool and interviews.

Chapter 7 is a thorough discussion on the research findings. The discussion focuses on the outcomes of each different approach in comparing the results by triangulation. Findings showing contradicting information are identified via comparisons and were put forward in discussion. Limitations of the study are also revealed in this section.

Chapter 8 is the conclusion together with recommendations. The conclusion of the study and further research direction to improve the situation are drawn.

A flowchart showing the research approach and organization in this thesis is illustrated in Figure 1.1.

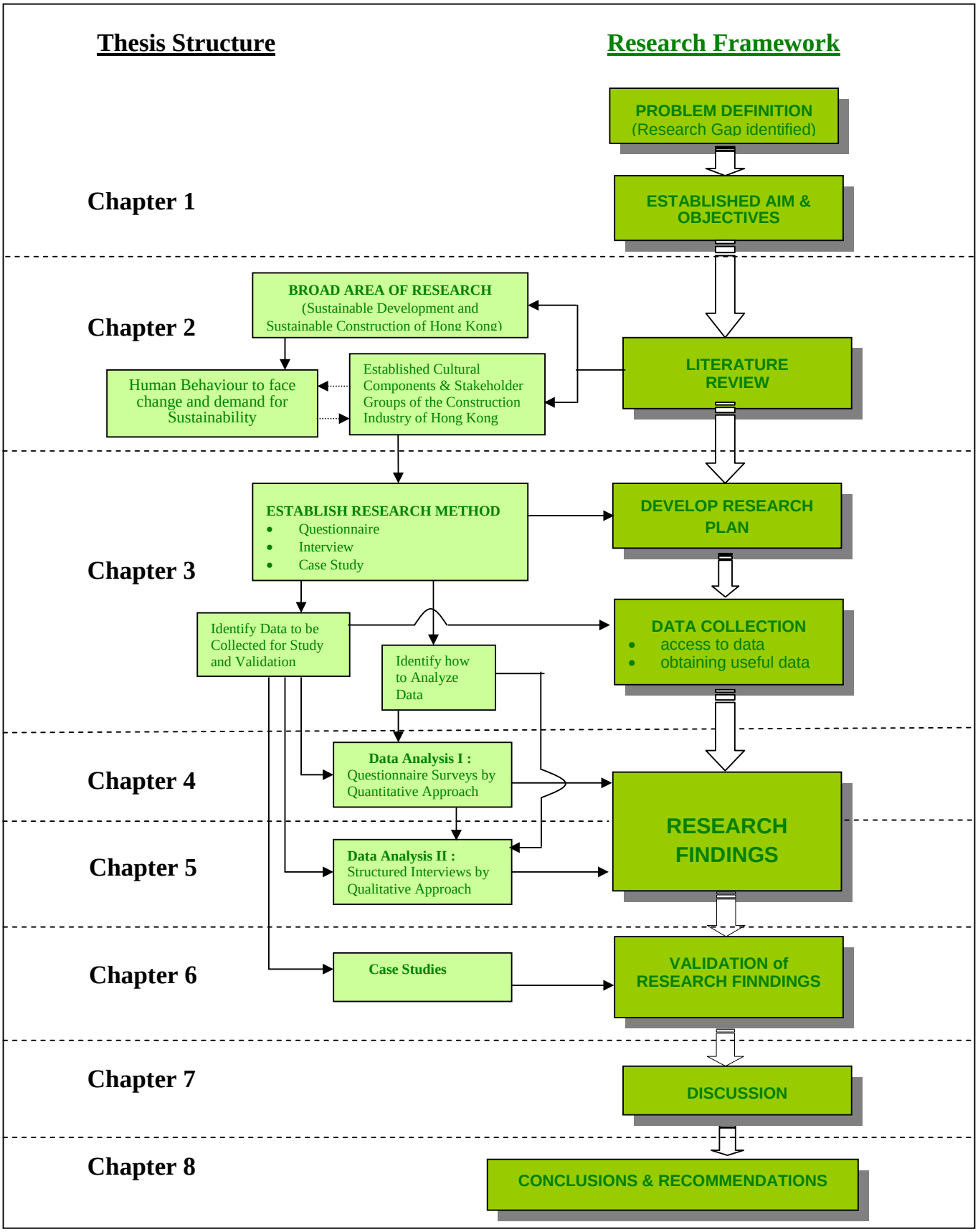


Figure 1.1: Research Framework and the Structure of this Thesis

1.6 Summary

This introductory chapter spelled out the need of the study based on the existence of the research gap in identifying the trend of movement of sustainable culture towards sustainable society. Extensive literature review has revealed that a number of previous researches have been conducted to enhance sustainability by exploring new materials, equipment, technologies and management systems. The research outcomes benefit certain areas of sustainability in a defined domain. However, study of the growth and movement of sustainable culture and their determinants are rare. This research attempts to address the change of sustainable culture in a designated time frame (cultural shift) using an exclusively designed measurement tool. It helps to measure the cultural status and display the pace of evolution towards a sustainable society. The research aim and objectives are clearly identified and a research framework is put forward with a flowchart showing the structure of the thesis.

CHAPTER 2 A REVIEW OF SUSTAINABLE DEVELOPMENT AND SUSTAINABLE CONSTRUCTION

2.1 Introduction

Representatives of the General Assembly of the year 2002 Johannesburg Summit declared *"We commit ourselves to building a humane, equitable and caring global society, cognizant of the need for human dignity for all"* (A/CONF.199/20, and A/CONF.199/20 corr.1, 2002). The declaration resembles the principles of a sustainable society but extended its scale to a global perspective. The Assembly also committed to undertaking concrete actions and measures at all levels and to enhancing international cooperation, including, inter alia, the principle of common but differentiated responsibilities on Environment and Development. The challenge is how to implement sustainable development efficiently and effectively at national level and further pass down to communities in cities, towns and so on. Implementation of sustainable development by enhancing sustainable culture among members of a society is an attainable outlet.

2.1.1 The Background and Evolution of Sustainable Development

The 'earth is like a spaceship' has been known for half a century. Dresner (2002) reported that *"The metaphor of the earth as a spaceship was coined by the American presidential candidate Adlai Stevenson in a campaign speech as far back as 1952. It*

was taken up by the British journalist Barbara Ward in her 1966 book Spaceship Earth. The concept was developed simultaneously by the economist Kenneth Boulding. He put forward the idea that it was no longer possible to put problems somewhere else." The metaphor 'Spaceship Earth' implied two important messages, (a) human activities are confined to a limited space – the Earth, and (b) our living environment depends on how we manage our activities to protect planet Earth.

Few apocalyptic events on Earth have alerted intellectuals and the general public to recognize the urgency in protecting the environment of the earth. These events, for instance, are the destruction of the stratospheric ozone layer above the South Pole and the rapid reduction of rain forest coverage on the Earth's surface. The former disarmed the protective shield of the Earth from excessive ultraviolet radiation, while the later evoked the greenhouse effect leading to global warming (Gore, 2007). These harmful events are responses from the Earth against the impertinent actions of human beings on the ecosystem. Control of carbon dioxide and other pollutant gases emission ensure the reduction rate of ozone layer destruction, prohibition of arbitrary cutting of trees and preserving the obsolescence of rain forest may help to stabilize the gradual rise of temperature on Earth.

These devastating responses from the Earth made people realize that a system which sustains continuous development of mankind and maintains the ecological balance of the Earth is of utmost importance. Reckless industrialization has polluted our planet by uncontrolled emission of greenhouse gases, endless disposal of solid wastes, discharge of untreated wastewater into the sea, all of these have exceeded the natural assimilative capacity and have started to damage the ecological balance. Uncontrolled

seizure of natural resources that exceeds the regeneration power of the Earth will accelerate the pace of exhaustion.

2.1.2 Sustainable Development and its Global Perspectives

In 1984, the World Commission on Environment and Development (WCED) was formed by the United Nations with a view to seeking solutions to the disturbance of the sustainability of the ecosystem. Twenty-three members of WCED from twenty-two countries, in three years time, extensively studied the conflicts among growing global inequalities, environmental problems and the needs of development of all countries in the world. In 1987, WCED produced a report "Our Common Future", commonly referred to as the Brundtland Report (1987), which introduced the concept of sustainable development which is defined as "*development which meets the needs of the present without compromising the ability of future generations to meet their own needs"*. This concept is further extended to include two key concepts (Planning Institute, 2006):

- *The concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given.*
- *The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."*

The concept for sustainability, commonly recognized by intellectuals as well as the general public from both developed and developing countries, brought forth the idea that positive improvement of the present situation will occur only if the principle of

sustainable development is persistently performed methodically and systematically.

The tremendous deterioration of the ecosystem and gradual exhaustion of the Earth's resources has resulted in zealous demands for equality in survival and development being initiated, spread and grew among peoples and governments in developed and developing countries. Actions trying to protect environmental integrity, equitable economic development and upholding human rights became a common issue in a global perspective. The impact induced by the concept of sustainable development to the economic growth of developed and developing countries via globalization at present is nonetheless moderate. However, due to active participation by almost all nations of the world, the study of Byrne and Glover (2002) concluded that *"moderate voices of globalization recognize the need for a measure of environmental regulation, and most proponents of sustainable development accept the essential rationale of the expanding global economy. In this sense, globalization and sustainable development have evolved as two sides of a common vision of our future."*

The ultimate aim of sustainable development is to balance the **social**, **economic** and **environmental** needs for both present and future generations through the efforts of the community and the government (Figure 2.1). Sustainable development tries to achieve a balanced growth in these three dimensions and satisfies the needs locally, nationally and internationally. The concept of sustainability has gained widespread acceptance as a model and a philosophy in guiding communities to improve decision-making pertaining to economic growth, social equity, environmental preservation and quality of life.

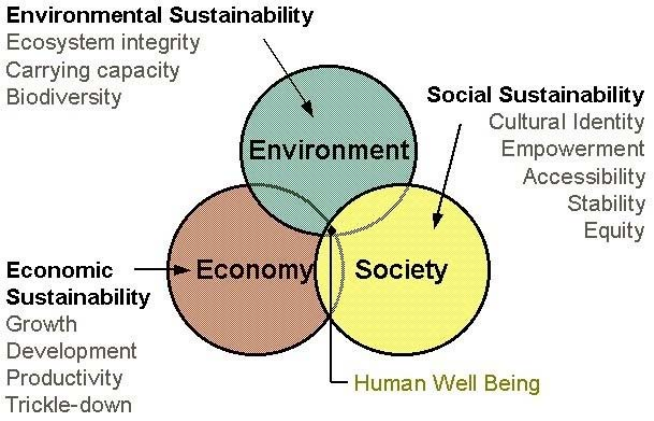


Figure 2.1 Sustainable Development Concept established in Brundtland Report

In 1992, the advocacy of Sustainable Development was deliberately discussed and conferred in the United Nations Conference on Environment and Development in Rio de Janeiro (the Rio Earth Summit). A statement of principles (the Rio Declaration) and an action plan, Agenda 21, was endorsed by the nations of the world. Agenda 21 is a response to further resolve problems by making optimal use of the earth's resources and to protect the environment in the course of development within the 21st century. Serving as an action plan, Agenda 21 established a guidance for the accomplishment of sustainable development involving all levels of government and communities of every country. The Rio Declaration and Agenda 21 were endorsed by the nations of the world in the Rio Earth Summit. All endorsing nations committed to tackle various problems of continuous development and to establish national strategy in attaining sustainable development in the 21st century. The 2002 Johannesburg Earth Summit was the first ten-year anniversary of the 1992 Rio Earth Summit. Commitments made by representatives in Johannesburg as denoted in Section 2.1 above have enriched the Rio Declaration. The coming second ten-year earth summit

will be held in 2012 in Brazil to review what have been achieved since Rio and Johannesburg and setting a new course of action (AFP, 2007).

2.1.3 Sustainable Construction and its Global Influences

Sustainable construction is an approach that coheres with the concept of sustainable development and guides construction activities to minimize consumption of basic resources in energy, water, materials and land. Kibert (1994) focuses on creating sustainable built environment under six principles by limiting resources consumption.

1. Minimize resource consumption (Conserve)

2. Maximize resource reuse (Reuse)

3. Use renewable or recyclable resources (Renew/Recycle)

4. Protect the natural environment (Protect Nature)

5. Create a healthy, non-toxic environment (Non-Toxic)

6. *Pursue quality in creating the built environment (Quality)*

Government, developers, planners and operators within the construction industry have attempted to follow the principles of sustainable construction and properly planned, designed, built, operated, maintained and disposed after the service lives of built assets.

In the energy saving aspect, development of energy efficient buildings is one of the solutions, Doukas et al (2007) developed an intelligent decision support model in Greece to control how building operational data deviate from the setting. The model enables diagnosis of internal conditions to optimize building energy operation. Alnaser and Flanagan (2007) investigated how to remove constraints in the

application of building-integration photo voltaic and building-integration wind energy in Bahrain. Building geometry is a significant issue in energy saving, Ihm et al (2009) evaluated the potential of daylighting to save energy consumption for indoor illumination in the United States. The study illustrated performance of daylighting in various combinations of building geometry, window size and glazing type for reduction of energy in indoor lighting.

On water consumption saving, Jeffrey and Temple (1999) proposed a water management scheme to balance local demands on water as a natural resource against its use by recycling and reuse technologies as a commodity for consumption in Cranfield, UK. Chanan and Woods (2006) demonstrated the attempt by Kogarah Council of Sydney metropolis in water recycling management to reduce per capita water demand.

Recycle, reuse of materials and reduction of construction waste are major focuses of sustainable construction, researches in precast and prefabrication technologies are abundantly active. By using the model of weighted average & minimization and practice index value, Begum et al (2007) identified 12 waste minimization factors in implementing construction waste management Their findings assisted in formulation of policy in addressing construction waste management problems in Malaysia. Esin and Cosgun (2007) focused on minimizing construction waste in interior modifications of residential units in Istanbul, Turkey. Their study identified reasons which caused frequent modification works and suggested waste reduction approaches according to their findings. Lopez-Meas et al (2009) compared the use of precast

concrete slab and cast in-situ concrete slab in residential buildings in Spain and indicated the former has lower impact on the environment than the latter by 12.2%. In a comparison of using recycling concrete waste between Japan and Australia, Tam (2009) recommended the Australian construction industry to establish a unified policy in concrete recycling, seek financial support from government for the development of clear technical specification and standards on the use of recycled aggregate for structural applications.

In land use sustainability, the European Union funded research projects to realize environmentally friendly cities by way of planning and design, construction, operation and maintenance, as well as renewal and reuse. European Commission Community Research (2004) studied the creation of urban environment by decentralizing economic land use on quality of life. The researches produced a simulation model which allows planning strategies to be tested, making land use decision-making more visual, more collaborative, more effective and ultimately offer means to compare alternatives.

2.1.4 Sustainable Construction of Hong Kong and its Influences in Hong Kong

To improve the performance of the construction industry and the built environment of Hong Kong, the Construction Industry Review Committee (CIRC) proposed to achieve a healthier living environment and better quality of life for the community at large through a more sustainable approach to construction. The proposed approaches of sustainable construction in the CIRC report pursue betterment of performance in

the production of quality buildings, the effective use of resources and the reduction of waste in construction management. The report further reveals that *"Efforts to promote sustainable construction in Hong Kong would stand a better chance of success if there was a general appreciation of the need for sustainable development and a firm commitment to this cause"* (CIRC, 2001). However, the suggestions provided by the CIRC Report only served as recommendations for the betterment of the industry and are not mandatory. The environmental section in the CIRC report focuses mainly on reduction of construction waste. Energy saving and greenhouse gas emission are not being addressed. The economic part addressed the quality and value of buildings, but the performance of the built assets has not been covered.

In order to attain sustainable development through the actions of sustainable construction, the existing problems in the construction industry of Hong Kong have to be explored and scrutinized. Nevertheless, the concept and practice of sustainable construction have not been fully developed vis-à-vis Government policy for sustainable development in Hong Kong. On the other hand, the Government and stakeholders of the construction industry have been playing an active role in research and development, aiming at sustainable construction according to Kibert's advocacy on minimal consumption of basic resources.

On energy saving within building energy efficiency of existing buildings, Hui and Cheung (1999) developed a web-based reference for building energy efficiency and solar design, Yik et al (2002) showed that buildings with higher energy performance were associated with operation and maintenance personnel with reasonable remuneration. In implementing policies on sustainable urban development and green

buildings, a progress report made by the Legislative Council of Hong Kong urged the Government of HKSAR to expeditiously formulate and implement policies on energy saving legislation (Progress Report, 2007). Actions proposed by the Council included reviewing of existing legislation, studying formation of a Code of Practice for green building labeling system, the Government and public organizations to take leading steps in applying the relevant policies to both new and existing public buildings, educating the public and offering incentives to actively promote compliance.

On water conservation and saving, the Water Services Department (WSD) of the Government of HKSAR has commissioned a review (ACQWS 2008) for formulating a Total Water Management (TWM) strategy. TWM comprises Water Demand Management and Water Supply Management to serve Hong Kong's needs in the long term. On the water demand side, water conservation initiatives proposed through public education on water conservation, promotion of water saving devices, leakage control, water reclamation and use seawater for flushing, whereas on the supply side, protection of water source and finding new source are addressed.

In the materials aspect of construction use, prefabrication and construction waste reduction are the primary goals. Precast concrete units have been abundantly used in public housing for over two decades and in recent years the private sector started to adopt prefabricated building components, Jaillon and Poon (2008) revealed the extent of both public and private sectors in using prefabricated building components by volume and types, major improvements and innovations over the years. In addition, Jaillon et al (2009) revealed the use of prefabrication in building construction and its impacts on waste reduction, and the major benefit of using precast construction

compared with conventional construction method. The study indicated that the average construction waste reduction level was about 52%. This signals that construction waste could be considerably reduced by using prefabrication techniques in the construction industry of Hong Kong.

Urban land in Hong Kong is scarce. Scarcity makes land use sustainability ultimately critical. A system dynamic model for land use sustainability and urban development has been presented by Shen et al (2009) to test the outcomes of development policy and make forecasts. The model simulates urban density and forecasts over a time frame of 40 years onwards the impacts on the development potential of Hong Kong.

2.2 The Hong Kong Perspective of Sustainable Development and the Impacts on the Construction Industry

Since the endorsement of Agenda 21 in the Rio Earth Summit in 1992 (UN Chroncile, 1993), many nations including the United Kingdom and the People's Republic of China have been actively involved in national and international activities to study and promote sustainable development. Both nations have great political, economical and cultural influences on Hong Kong. Their actions not only initiated the concept of sustainable development in their own national planning and development policy but also have had decisive effects on the progress of sustainable development in Hong Kong. However, the concept of sustainability did not appear in any local government policy documents until 1993. In the White Paper (1993), it proposed a review of the 1989 White Paper on "A Green Challenge for the Community". However, limited

action was taken in Hong Kong during the final portion (1992-1997) of the British regime. Sustainable development in Hong Kong has never been positively put into action before the change over of sovereignty from British to Chinese in 1997.

After Hong Kong became a special administrative region of the People's Republic of China, the Government of HKSAR began to take more active steps in formulating plans and policies of development which incorporate sustainable development principles in her policy making. A more explicit interpretation of sustainable development for Hong Kong was made in the Policy Address (1999) delivered by the Chief Executive of the Government of HKSAR.

"Sustainable development for Hong Kong means,

- *finding ways to increase prosperity and improve the quality of life;*
- *reducing overall pollution and waste;*
- *meeting our own needs and aspirations without doing damage to the prospects of future generations; and*
- *reducing the environmental burden we put on our neighbours and helping to preserve common resources."*

The principles emphasized that during the course of economic development and on striving for progress and advancement, the development opportunity in all areas for future generations must not be sacrificed. The concept was then used as the guiding principle for governance, policymaking and future development of Hong Kong. The government promulgated a number of rules and regulations to steer commercial and industrial operations for the long-term development of a sustainable future for Hong

Kong. The government further emphasized cooperation and commitment of all sectors within the community.

On 1 September 1997, the government of HKSAR further commissioned a study - the Sustainable Development in Hong Kong for the 21st century (SUSDEV 21). The principal objective of the study was to promote sustainable development to the general public and stakeholder organizations of Hong Kong, taking their views and opinions in order to develop a systematic approach and guiding values for the making of policy for future development. A series of activities have been conducted, for example, exhibitions, conferences, public consultations and surveys to promote sustainable development concept. A set of guiding principles were then developed which helped in paraphrasing the definition into a readily understood mode, summarizing issues that represent sustainability in Hong Kong.

The development of the guiding principles was initiated by international, regional and local research expertise, referring to key issues from the socio-economic and environmental criteria in a structured way. The work identified initial parameters and a wide range of key concerns that were scoped out for public consultation and developed as the guiding principles for the sustainable development of Hong Kong:

- *Economy*
- *Health*
- *Natural Resources*
- *Social Infrastructure*
- *Biodiversity*
- *Cultural Vibrancy*

- *Environmental Quality*
- *Mobility*

These guiding principles are categorized by the performance in their distinctive nature of sustainability in the areas of Socio-Economic Sustainability and Environmental sustainability.

Through the SUSDEV 21 study, a systematic process entitled the Sustainable Development System (SDS) was developed. With the implementation of SDS, it enables Hong Kong's decision-makers to gain an understanding of the long-term implications of strategic development decisions. The guiding principles were accepted as a set of indicators to reflect the extent of achievements in sustainability in Hong Kong. A tailor made computer system, the Computer Aided Sustainability Evaluation Tool (CASET) has also been developed as part of the SDS. The indicators were taken as the core of the CASET decision support tool. It is critically important for decision-makers at all levels of the Government to gain a deeper and broader understanding of the sustainable implications to evaluate the goals of sustainability for future strategic policies and development of projects.

Relevant government departments also initiated series of activities in conducting public consultation to obtain views and feedback from the public on the key issues for sustainable development of Hong Kong. For instance, Environmental Resources Management (ERM) was commissioned and led a team of consultants and stakeholders of various sectors to study SUSDEV 21. The final report of ERM (2001) provided long-term strategic development views in economic, social and

environmental dimensions of Hong Kong towards sustainability. Policy makers and stakeholders of various sectors made reference to the recommendations of the EMR final report in order to establish and review their strategies in policy-making and business operation.

2.2.1 Promotion of Sustainable Construction Initiated by the Government of HKSAR

The Hong Kong construction industry is one of the leading industries and is a major pillar that supports both economic and social stability; it is also responsible for fundamental environmental impacts on Hong Kong. Rowlinson and Walker (2003) indicated that *"The construction industry has always played a major role in Hong Kong's economy and if its contribution to gross domestic product is analyzed in detail it can be shown that atits peak property and construction contributed almost 25% of Hong Kong's GDP"*. In 2007 the gross value of construction work undertaken in Hong Kong was over HK$93 billion (approximately US$12 billion), with a roughly 60:40 split between private and public sectors in new capital works (C&SD, 2008a). The construction industry is therefore a major contributor to the economy of Hong Kong. The manpower employed in the construction industry as recorded in the fourth quarter of 2007 was 283,100, or 8.1% of the total employment of labour (C&SD, 2008b). Stable employment rate is a fundamental contributor to social stability. With merits in economic and social attributes, the construction industry, however, generates a considerable amount of pollution to the environment including air, noise, water, solid waste and land contamination (CIRC, 2001). It is also recognized that the built structures consume a considerable amount of energy and natural resources both during their construction and subsequent operation phases. In particular, construction waste

amounted to 2,914 tonnes per day, which represented 21% of the total waste landfilled in Hong Kong in 2007 (EPD, 2008). It can be seen that the construction industry of Hong Kong fundamentally encompasses economic, social and environment attributes, it is one of the most important industries affecting the successful implementation of sustainable development. Improving the sustainable output of the construction industry will undoubtedly uplift the level of sustainable development of Hong Kong. The most effective way to increase the sustainable output of the construction industry is to enhance the knowledge among construction participants on the importance of sustainability which is manifested in the form of sustainable construction. However, there is only very limited organized programmes in Hong Kong to nourish knowledge of sustainability within the construction circle. Promotion and training activities are spasmodic and aimed only at specific issues. These activities are mainly organized by i) the Government based upon policy setting for sustainable development, and ii) various professional bodies of the construction industry offering specific training topics to comply with government policies and regulations.

2.2.2 Promotional Activities Organized by Stakeholders and Professional Bodies

To maintain competitiveness in the market, compliance with requirements for sustainability becomes necessary; stakeholders of industries conform to legislation in order to run their business legally by training their employees to follow sustainable policies and regulations. In the construction industry, sustainability is synonymous to economic use of resources, improvement in construction quality, assurance of site safety and health, reduction of pollution and construction waste (Yip and Wong, 2004).

Training programmes organized by respective professional bodies of the construction industry may cover areas such as quality improvement, enhanced health & safety, reduced construction waste with less resource, these are mainly designed for professionals and middle to senior level managers. These programmes aimed at upgrading the management system of their organization to meet with government policies and regulations for sustainable construction. It should be pointed out that some reluctant participants in construction field have viewed that product quality, health & safety considerations caused obstacles to construction output and exhibited resistance to changes in their traditional way of working instead of complying with the new requirements in safety and environmental issues. It takes time for managerial and professional staff to accept the necessity and practicality of sustainability before passing the brief to front line subordinates who subsequently transfer to the workers (Teo *et al*, 2005). Through these training activities, professionals and managerial staff gradually changed their mindset and converted the learnt concept and knowledge into management systems, conveying the same to subordinates for implementation in construction sites (Poon and Yip, 2006).

Knowledge obtained by managerial and professional level staff was applied to the modification of the existing management systems of their organizations so as to make the system better suit with the new trend of sustainable requirements. The International Organization for Standardization (ISO) has updated the international quality system ISO 9000 2000 standard and introduced ISO 14000 the environmental management system for the management of environmental issues in business development. Nowadays, all registered general contractors used ISO 9000 2000

standard and a number of well-established contractors are certified with ISO 14000 (EPD, 1999).

To further illustrate the "conveyance mechanism" of sustainable concept and knowledge that now exists in construction practices in Hong Kong, Table 2.1 shows the various interactions between government and stakeholders in the promotion of sustainable construction and the related sustainable policies drawn from the works of professional bodies, private developers and government departments. It indicates that Hong Kong is taking an active role in realizing sustainable construction in various areas.

The Hong Kong Construction Association (HKCA), a professional organization representing general contractors, has developed and set out general guidelines on undertaking environmental protection works in the construction industry. The practice guide (HKCA, 2001) was published as a guidebook to its members for reference and follow when preparing the environmental protection works for project planning and execution. The guidebook was used by managerial and professional staff essentially as guidance to control the environmental performance of the construction site and to relate the requirements to their subordinate frontline staff to follow and implement in construction projects.

Table 2.1: Interactions between Government and Stakeholders in Sustainable Policy

Activity	Nature of the Activity	Year	Initiated Organization	Outcome	Reference
Certification of ISO 14000	Environmental Management System Certification	1999 - present	Various Government Departments/Developers/Consultants/Contractors	Upgrade organization management towards better environmental protection	Zhang *et al* (2000)
The Study on Sustainable Development for the 21st Century in Hong Kong (SUSDEV 21)	Public consultation for sustainable development for Hong Kong	1997 - 1999	Government of HKSAR	Aroused public awareness and concern	ERM (2001)
CIRC Report	Review the performance of the construction industry and recommend improvement measures	2000 - 2001	Construction Industry Review Committee/Government of HKSAR	Motivated stakeholders of the construction industry to improve towards sustainability	CIRC (2001)
Best Practice Guide for Environmental Protection on Construction Sites	Publish Guidebook for Environmental Protection in Construction Site	2001	The Construction Association	Improved performance in construction practice	HKCA (2001)
Guidebooks for Minimizing C&D Waste	Publish Guidebook for Minimizing C&D Waste	2001, 2002	The Hong Kong Polytechnic University	Enhanced adoption of Low-waste construction technologies	Poon *et al* (2001)
Joint Practice Notes (JPN 1 and JPN 2)	Promotion of project sustainability by innovative design and construction by incentive scheme	2001, 2002	Government of HKSAR	Enhanced project sustainability both in design and construction	PCICB (2002)
New Procurement Evaluation Scheme	Introduce score system to evaluate tenders	2002 - now	Various departments of Government of HKSAR	Tender evaluation of government job based on performance in sustainability rather than tender price.	JPN (2001) & JPN (2002)
Environmental Assessment for Building Environment Sustainability	Introduce methods to assess the environmental status of new and existing buildings	2004 and 2005	HK-BEAM	Certifying of buildings in sustainable achievements	HK-BEAM (2004) and HK-BEAM (2005)
Disposal Charge of C&D Waste	Impose of disposal charge of C&D waste at landfill sites	2005 - present	Government of HKSAR	Disposal of C&D waste at landfill sites reduced	Waste Disposal Ordinance, Cap 354 N (2005)

Table 2.2 registers some of the prominent projects which are regarded as examples of achievements of sustainability in project development and construction in Hong Kong under sustainable policies and stakeholder implementation. Practical performance in project sustainability by private developers is seen in the development of The Orchards (Fong *et al*, 2004) and the development of The Charter (Uebergang *et al*, 2004). Both projects are outstanding examples of residential and commercial developments in highly condensed urban areas of Hong Kong with effective performance in sustainable design and construction practices. In addition, the Hong Kong Housing Authority (HA), which is the largest public housing developer, is recognized as an excellent promoter in using pre-cast constructions and applies low waste construction technologies in its housing projects. HA has initiated a series of schemes to enforce sustainability in selecting contractors with good records in site safety, product quality and environmental performance (Chan and Chan, 2002).

A similar evaluation system for past performance has been implemented in government projects. Contractors who failed to comply with sustainable performance have been prohibited from bidding government jobs even if their tender prices are very competitive (PCICB, 2002). Contractors and workers who are reluctant to follow regulations may lose their opportunity of employment and cease from the construction business. In order to maintain competitiveness in the market, contractors of poor performance record had to change their management style into more sustainability conscious while workers manipulated their skills to integrate their trade practices with the sustainable requirements in physical operation. The integrated practice was gradually adopted by tradesmen and became a norm among respective trades.

Table 2.2 Examples of Sustainable Projects under Government Sustainable Policy and Stakeholder Implementation

Project	Year of Completion	Sustainability Driving Organization(s)	Outcome	Reference
The Orchards	2003	Developer and Contractor	Pioneer of Designer sustainability in private residential project	Fong *et al* (2004)
The Charter	2004	Developer and Contractor	Partnering	Uebergang *et al* (2004)
EMSD Headquarter	2004	Architectural Services Department HKSAR	Re-develop old building for new use	Mak (2005)
Wetland Park	2005	Architectural Services Department HKSAR and Contractor	A sustainable design and construction project that aroused public awareness of ecosystem	Li *et al* (2005)
One Peking	2004	Developer and Designer	Green design project using photovoltaic (PV) panel to operate electrical blinds	Tam (2004)
Kadoorie Biological Sciences Building	2000	The University of Hong Kong (HKU)	Green design project with energy saving up to 44,070,000 KWH and CO_2 reduction up to 26,880 tonnes in 50 years life span	http://www.hku.hk/mech/sbe/case_study/case/hk/hku-bsb/bsb-index.html
Hong Kong Community College (HKCC)	2007	Developer and Designer	A pilot building project extensively use pre-cast concrete units in structural elements	Not Available

As a matter of fact, practicing sustainability in construction sites could improve the working environment, enhance construction safety and in most cases increase output in both quality and quantity **(**Glass and Pocklington, 2002). Construction participants in Hong Kong, regardless of their job status, have learned sustainability through training programmes or via physical operations that gradually adopt sustainable construction as standard practice (Chan, 2006). Experiences from discharging their daily duties have allowed participants to realize the merits of sustainable construction, change their attitudes from reluctance to acceptance. The process of transformation

from the traditionally less sustainable working fashion to the more sustainable practice demonstrates a change of culture towards sustainability. The change has in turn enriched their knowledge on sustainable construction and strengthened their willingness to perform. The research findings of Lingard *et al* (2000) have identified a gap between reality and the perceived level of knowledge and involvement in waste management among workers in Australia, and this finding concurred with what was experienced in Hong Kong.

As an echo to Kibert's sustainable construction concept stated in Chapter 1, studies on limiting resources consumption are being carried out in various directions from knowledge development to practical implementation. Researches in low waste construction technologies, reuse and recycle of construction and demolition (C&D) materials etc. are being vigorously carried out. Table 2.3 exhibits research and development activities on low-waste construction technologies, minimization of construction waste, reuse and recycling of C&D materials.

Poon (1997), for instance, conducted a pilot study in using recycled aggregates from C&D materials as road sub-base and coarse aggregate in ready mix concrete. Nowadays, recycled aggregates are increasingly used as structural concrete in various government projects in Hong Kong. Adoption of low waste construction technologies such as the extensive use of precast concrete façade, precast bathroom and precast structural components in the last two decades has become a common practice in public housing projects in Hong Kong. These are regarded prominent sustainable construction achievements. However, sustainability performance in the construction industry of Hong Kong is confined only to certain types of productions and

construction methods (Shen *et al*, 2000). To genuinely achieve sustainable construction, a complete change in the culture, i.e. from mindset to implementation among all participants is imperative.

Table 2.3 Research and Development Activities for Sustainable Construction in Hong Kong

Activity	Nature of Activity	Year	Initiated Organization	Outcome	Reference
Use of recycled aggregate	Pilot test of using recycled aggregate as road subbase and ready mixed concrete	1997	S.C.C.T. of the Govt. of HKSAR and the HK Polytechnic University (HKPU)	Reduced and reuse C&D waste, recycled aggregate is widely used in concrete in government projects	Poon *et al* (1997)
Review on Low-waste construction technologies	Research on various low-waste construction technologies	1999	HKPU	Making low-waste construction technologies to stakeholders	Poon *et al* (1999)
Reuse building stock	Research on reuse of building stock	2001	The Hong Kong Institution of Engineers (HKIE)	Some building stock reused	Koenig and Kwan (2001)
Guidebook for minimizing C&D waste	Published two guidebooks for minimizing C&D waste	2001 and 2002	HKPU	Enhanced adoption of low-waste technologies in the construction industry	Poon *et al* (2001); Poon and Jaillon (2002)
Study modular construction	Research on application of modular construction	2002	HKIE	Enlarge the extent of research on modular construction	Tam (2002)
Reduce construction waste on site	Review on reducing building waste in construction site	2004	HKPU	Promotion of reduction of construction waste	Jaillon and Poon (2004)
Promote adoption of prefabrication	Research on reform construction method	2005	Construction Industry Institute (CII)	Promote application of prefabricated building components	Yeung *et al* (2005)

2.3 Transformation of Construction Practices - Development of Sustainable Culture

Stated by the United Nations Educational, Scientific and Educational Organization (UNESCO, 2002), culture is the *"set of distinctive spiritual, material, intellectual and emotional features of society or a social group, and that it encompasses, in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs"*. For the construction industry, culture is the underlying values, beliefs, and principle that serve as basic assumption that form the common views among members of the construction industry.

As mentioned in section 2.2, Government policy followed by the promotion of sustainable development has uplifted knowledge on sustainability among participants and stakeholders of the construction industry of Hong Kong. Increased recognition of sustainability instigated changes which would inevitably direct its participants and stakeholders, when performing their duties, start to think and act towards a direction favorable to sustainability. Such a process spreading out subconsciously among participants and stakeholders began to form basic assumptions, judgment of work output and sustainable performance in projects that they have been involved in.

The growth of this basic assumption and judgment in the direction of sustainability is the increase of ***cognitive attitude*** among members that determines their value and belief. Thus the concept and knowledge of sustainability inevitably change the attitude and behaviour within the circle of construction community and among its

members from what was part of their inherent culture. Hungerford and Volk (1990) developed in their educational research to reveal changes in learner behaviour through environmental education, *"increasing knowledge could increase awareness or change attitudes, which in turn change behaviour"* and depicted their model of human behaviour in adoption change in Figure 2.2.

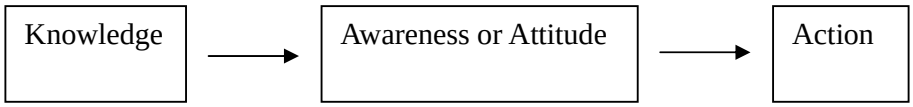


Figure 2.2 Model of Human Behaviour in Adoption to Change

Source: Hungerford and Volk (1990)

Subsequent studies demonstrated that there is moderate to limited relationship between awareness, attitudes and participatory actions. Ajzen (1991) in his behaviour theories, the theory of reasoned actions (TRA) and the theory of planned behaviour (TPB) identified that from acquisition of knowledge to taking an action is not a linear approach but a combination of a number of factors including attitudes, subjective norms and perceived behaviour control (Figure 2.3). Doll and Orth (2006) when applying Ajzen theories in functional operation of the attitudinal and nominative components in an intention to use contraceptive methods in male and female, the study showed that TRA and TPB applied to all test samples without gender barrier.

Using Ajzen's behavioral theories as basis, Teo and Loosemore (2001) studied behaviour of construction participants in handling construction waste. The research illustrated that the behaviour pattern of construction participants follows the positive and negative judgment, evaluation of personal beliefs and cultural values of the construction industry.

Ajzen's model of TRA and TPB shown in Figure 2.3 agrees with the outcome of the study in the practice and implementation of waste management in construction projects.

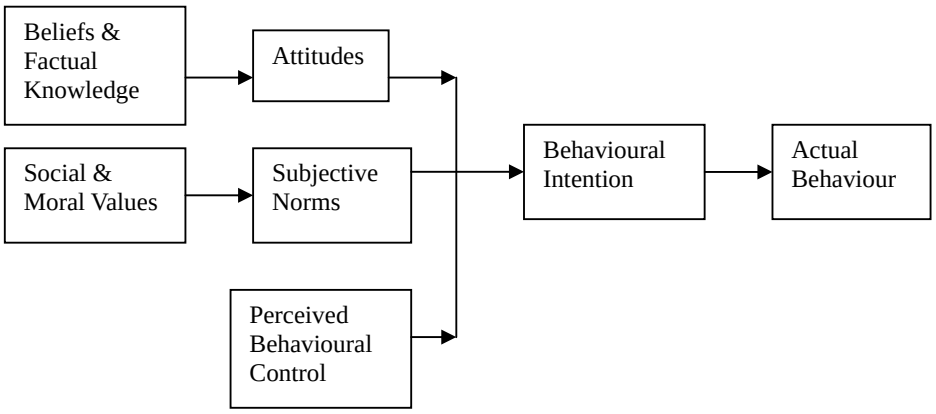


Figure 2.3 The Theory of Planned Behaviour

Source: Ajzen (1991)

The process of judgment and evaluation is a diagnostic process. Fazio (1990) and Fazio and Roskos-Ewoldsen (1992) theorized that "*attitudes themselves may be diagnostic of a variety of judgments and behaviour; they serve as heuristics, saving capacity especially in low-motivation or capacity-limited situations*". Eagly and Chaiken (1993) concurred with their study and defined attitudes are evaluative responses to some object of judgment. Attitudes would be constructed from cognitions, affective responses and behaviour, all may be diagnostic of an evaluative judgment.

Lewin's model of social behaviour (1936) was further expanded by Bordens and Horowitz (2001) as shown in Figure 2.4 the process "evaluation of situation" is the process of diagnostic and judgment that influence the resultant social behaviour.

The change of attitudes among participants of the construction industry of Hong Kong from acceptance to implementation consumed a period of time to accommodate the process of diagnostic. Therefore, it would be proper to place an incubation process in Ajzen's model prior to the process of behavioural intention (Figure 2.4 and Figure 2.5) as a representation of culture movement model in the construction industry of Hong Kong.

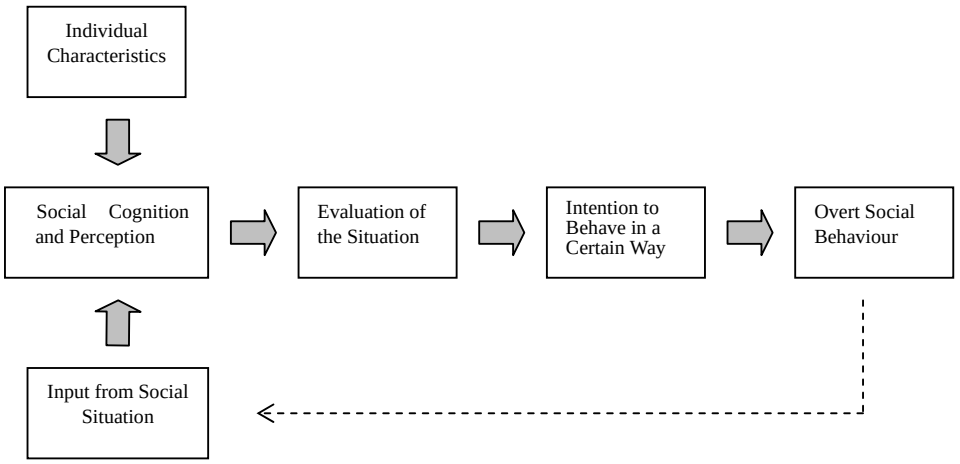


Figure 2.4 An Expanded Model of Social Behaviour
Source: Bordens and Horowitz (2001)

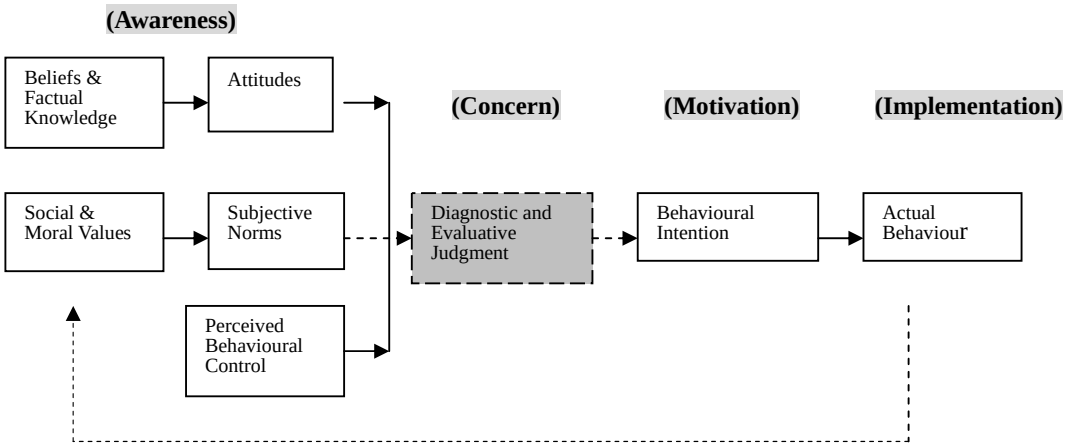


Figure 2.5 The Culture Movement Model of the Construction Industry

Figure 2.6 is a simplified version of the culture movement model derived from Figures 2.4 and 2.5. The culture movement model for sustainability thus formed is based on the processes of ***Awareness***, ***Concern***, ***Motivation*** and ***Implementation*** of sustainability. These key changes drive the movement of attitudes and behaviours of construction participants towards sustainability and are defined as the cultural components of sustainable culture. The sustainable culture of construction starts with cognition of the concept and knowledge (awareness) of sustainability. The increase of awareness results in stronger diagnostic of evaluative judgment (concern) for any change that may cause negative sustainable effect. These are cognitive attitudes that constitute beliefs of sustainability. The theories of TRA and TPB illustrated behavioural intention to respond (motivation) follows a subjective norm in sustainable consciousness and results in performance of corresponding behaviour (Implementation).

Figure 2.6 Culture Shift Model of the Construction Industry (Simplified Version)

Through implementation of sustainability, construction participants and stakeholders realized more merits of sustainable construction and further enhance the sustainable knowledge within themselves. As a result, they further reciprocate their awareness in sustainability by activate diagnosis and judgment. The entire process keeps on recurring and synchronizes with the change of the social atmosphere. Hence, a responsible sustainable-conscious participant in the construction industry is one who possesses basic understanding of sustainable construction issues; has an awareness

and sensitivity to sustainability; feels concern to any change that may cause negative effect; motivated autonomously to initiate improvement; and is actively involved in a certain level of implementation toward sustainable construction. Therefore, sustainable culture is the driving force for sustainability among stakeholders in the construction industry. It constitutes attitudinal and behavioural components and is categorized into awareness, concern, motivation and implementation.

Awareness is defined as the sense of detection about the needs to change an unsatisfied condition or an unease state of mind (Blank, 1996). It is an inner vision in a state of mind to provoke change to rectify the unsatisfied condition according to the knowledge, moral values, briefs, subjective norms as well as input of social situation. When construction industry stakeholders are aware of the negative impacts, e.g. create unnecessary wastage (environmental), neglect construction safety (social), and disregard product quality (economic) that their current practices and performances may have caused impairs to human society, their eagerness to improve grows stronger.

Concern is defined as bringing the anxious feelings of the unsatisfied condition or the unease state of mind into conscious attitudes integrated with judgments (Fazio, 1990; Fazio et al, 1992). Concern arises as a result of awareness on scenarios which arouse desires for improvement (Eagly and Chaiken, 1993). Concern of sustainability is an emotion of care developed on the judgments according to negative impacts and consequences. The attitude of concern would be constructed from cognitions, affective responses and behaviour.

Motivation implies a stimulus impelling to act, to move and to improve. It is the desire to take action to work for the defined objectives in alleviating the undesirable consequences of the un-sustainable acts. Motivation must have direction (Blank, 1996). The eagerness to change is the intention that tries to modify the status quo of the construction industry. The promotion of sustainability in the CIRC Report (2001) is a good example that showed motivation with a defined direction for improvement. The Report suggested a holistic approach that would help to motivate changes to the long existing malpractices of the construction industry of Hong Kong.

Implementation is the result of behavioural intent (Ajzen, 1991). Unlike the attitudinal attributes of awareness and concern, implementation is dynamic rather than static in the construction industry. It is the willingness of construction industry participants to spend time, energy, effort and money to initiate changes in order to achieve sustainable construction.

Change in the attributes and behaviour signifies an increase in the cognition of sustainable construction and a willingness to practice the same within the work environment. The former is represented by the change of cognitive attitudes in ***Awareness*** and ***Concern***, whereas the latter is exhibited through behavioral actions in ***Motivation*** and ***Implementation***. Measuring individually the movement of these attitudinal and behavioral components over a period of time will provide a picture on the change in essence and magnitude within the measured time frame. A synthesis of the changes in these four components within a specific time frame will show the combined effect of culture shift, which is regarded as the result of the enforcement of rules and regulations for sustainable development.

However, it should be noted that different discipline stakeholders exert different influential power due to their distinctive functions in the built assets and this may result in different extent of achievements in sustainable construction. Based on their functions and duties in the construction industry, these different discipline stakeholders can be fundamentally divided into five groups:

(i) Government employees related to development and construction projects (the Government);

(ii) Developers (the Developer);

(iii) Architects, structural engineers, electrical and mechanical engineers, quantity surveyors (collectively the Consultant);

(iv) Main contractors, subcontractors, suppliers (the Contractor);

(v) Site agents, site supervisors, foremen (the non-professionally recognized frontline construction participants, or the NPP).

Stakeholders of different discipline groups discharge different functions and duties. Some functions performed by certain stakeholder groups create more sustainable outcome; while others yield less sustainable results.

The power that influences the extent of sustainable output is referred to as the ***"influential factor"*** of sustainability. Each stakeholder group exerts different influential power according their distinctive roles and functions. The higher the influential factor, the greater is the magnitude in achieving sustainable construction. The government group initiates sustainable rules and regulations which govern the

works of other stakeholder groups. The Developer, who invest on development projects and employ Consultant and Contractor to design and construct according to development schemes that influence the outputs and performances of the Consultant and Contractor as well as the NPP. The hierarchical order of influence is generally established, however, the magnitude of influence of each stakeholder group that affects the sustainable effect of the built assets, however, is to be explored in this study by means of questionnaire surveys and the T-model which will be elucidated in Chapter 3 section 3.3.

2.4 Summary

The Brundtland report (1984) rooted the principles of sustainable development for a balanced growth in economic, social and environmental dimensions. The earth summits of Rio de Janeiro in 1992 and Johannesburg in 2002 brought forward a goal in achieving sustainability within the 21st century around the globe. It is discouraging that governments often set up national and regional policies in the best interest of their own development without any account on the impact of these policies to other nations and ultimately, planet Earth as a whole. Unbalanced growth worldwide is a result of developed countries using finance, technology, political influence, trade conditions and even military actions to snatch earth resources from developing countries in order to fulfill their own needs of development. The snatching actions have sharpened socio-economical conflicts and political contentions between nations of the world. The Rio Summit set out Agenda 21 as guidelines for sustainability in various areas while the Johannesburg Summit intensified the plans of action for implementation.

The Government of HKSAR followed the global trend for sustainability and started to promote the same in Hong Kong. Government commissioned researches for sustainable development and set up a computer aided system to help decision-makers at all levels within the Government to gain more extensive knowledge for evaluating implications of government projects towards sustainable objectives. As one of the leading industries, the construction industry of Hong Kong strives to comply with Government policies for sustainable construction and has provided trainings to construction participants. These trainings are mainly task-oriented, purely educating construction participants and stakeholders in professional and managerial levels to perform their practical duties according to rules and regulations of sustainability. Knowledge obtained could then be applied in practice which in turn enable them to see the merits of sustainable construction. Construction participants and stakeholders have begun to change their attitudes from reluctance to acceptance, thus setting the scene for a cultural change to take effect within the construction circle of Hong Kong.

Culture is the underlying values, beliefs and basic assumptions that form common views of construction participants and stakeholders within the construction industry. The growth of recognition in sustainability results in the transformations of attitude and behaviour. The form of transformation is differentiated into four attitudinal and behavioral cultural components - “Awareness”, “Concern”, “Motivation”, and ‘Implementation” of sustainability. The differentiation of culture into these four cultural components forms the basis of the sustainable culture. Stakeholders of the construction industry exert different influential power which, according to their distinctive discipline in their respective fields of practice, affects the sustainable output within the built environment. Five stakeholder groups are identified in the

construction industry of Hong Kong, they are distinguished by their functional duties as the Government, the Developer, the Consultant, the Contractor and the NPP. Each group possesses different influential power in every construction project. This influential power is a crucial factor representing the sustainable output of the specific stakeholder group.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research approach, strategy and methodology adopted to achieve the research aim and objectives as stated in previous chapters. Based on the established cultural components and the five stakeholder groups of the construction industry of Hong Kong, a measurement tool, the T-model, is introduced. The T-model enables measuring of the movements of cultural components of each stakeholder group within a designated time frame. The effectiveness of the empirical tool is demonstrated, justified and discussed. Methods to validate the research findings from the T-model are also introduced.

3.2 Research Approach

To achieve the research objectives, this research is undertaken in two main phases as presented in Figure 3.1.

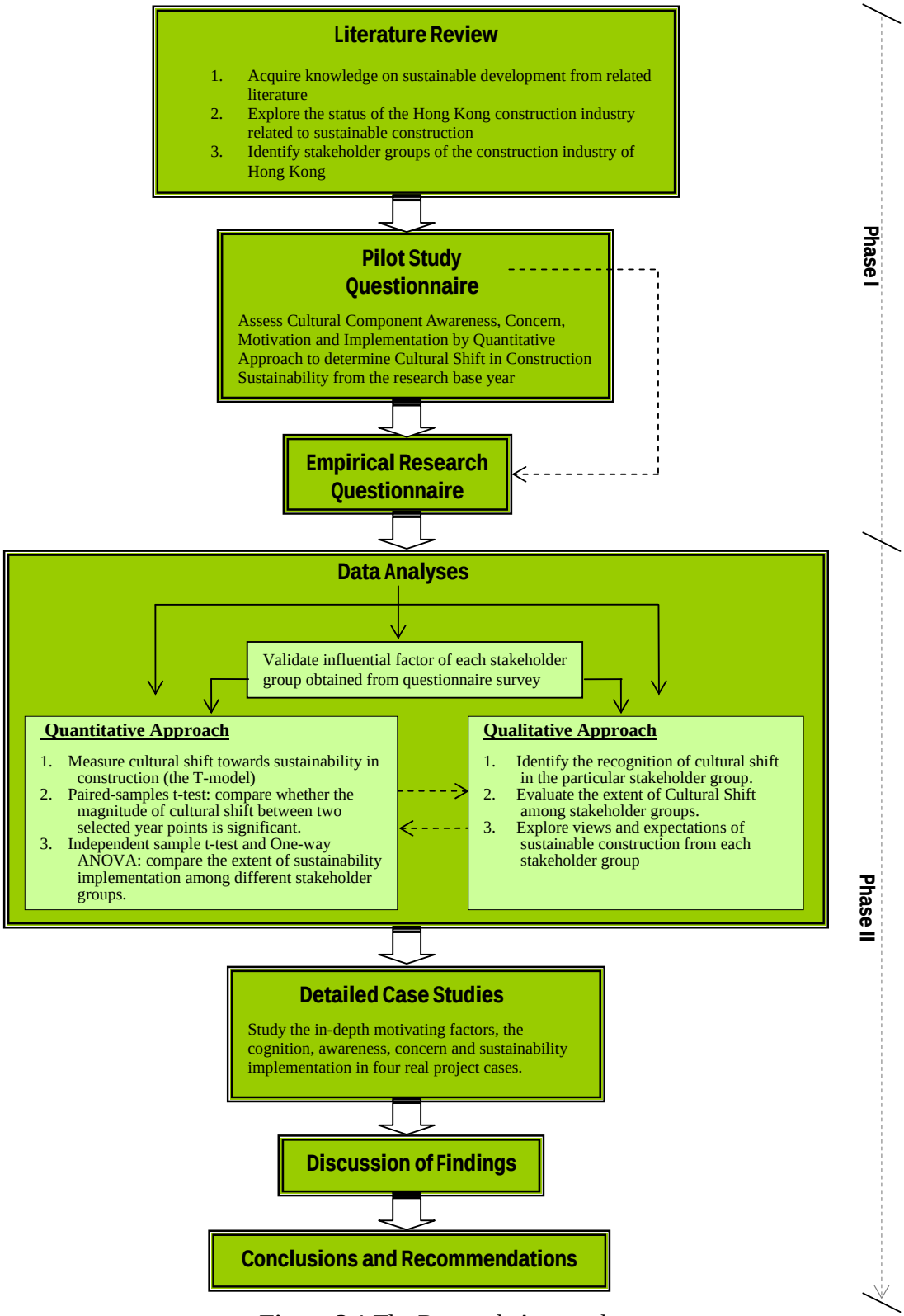


Figure 3.1 The Research Approach

After the research question is identified, the aim and objectives of the study are established. Phase I of the study established the principles of sustainable development as an environment which is a mix of: unbalanced growth and inequitable sharing in consumption of earth resources, and an inequality in the developments between developed and developing countries. Steps taken via Agenda 21 through the Rio and Johannesburg earth summits for improvement on the situation were also reviewed. The approaches that the Government of HKSAR has adopted in response to global demand for sustainable development and influence on the construction industry of Hong Kong have been comprehensively examined. Thorough studies on other research works related to sustainable construction have been done in order to unveil the process of sustainable construction globally and locally. The influence brought about by government promotions on sustainable development is explored. In working through all previous researches in sustainable construction, research work addressing the fundamental issue of a holistic approach towards sustainability, which is the development of sustainable culture among construction participants in the face of the movement of the sustainable culture in response to the global demand of sustainable development, could not be found.

Based on the theories of TRA and TPB developed by Azjen (1991) and other theories dealing with human behaviour, a cultural shift model containing fundamental cultural components comprising Awareness, Concern, Motivation and Implementation is further developed. For an elaboration on the influential power of stakeholders, five stakeholder groups are identified according to different roles and functional duties in the construction industry of Hong Kong. Two questionnaire surveys had been carried out in years 2004 and 2006 for collecting data from construction participants on their

cognition and performance in the area of sustainability of their construction duties within their respective professions. A measurement tool has been developed to handle the data obtained from the questionnaire surveys.

In Phase II, quantitative analyses using the Statistical Package for Social Sciences (SPSS) had been conducted to examine data obtained from the questionnaire surveys on one hand, whilst on the other, a qualitative approach by means of structured interview was adopted to cross-reference results thus generated from the quantitative analysis. Application of both qualitative and quantitative approaches to validate research outcomes concurred with the viewpoint of Fellows and Liu (2003). *"Triangulation – the use of qualitative and quantitative techniques together to study the topic – can be very powerful to gain insights and results, to assist in making inferences and in drawing conclusions"*. All the questions raised in the structured interviews were designed with reference to the research findings of the questionnaire surveys in years 2004 and 2006. Results obtained from structured interviews would therefore be comparable with the questionnaire surveys. The outcomes would help in understanding the unique and applicable features of the research topic of cultural shift in the construction industry.

Case studies had been conducted in order to give examples on the implementation of sustainable construction in projects and as a reflection of the cultural shift which had taken place in project development, design and construction operations by various stakeholder groups:

- Initiation from developer for sustainable construction – the overall precast construction of the Community College of the Hong Kong Polytechnic University
- Sustainability achievements under the incentive policy of the government – The Orchards
- Harmony with the environment with project design and construction management – the development of Wetland Park
- Application of low-waste construction technology – comparison of formwork systems in two identically designed primary school projects

The empirical findings obtained from the questionnaire survey, interviews and case studies are then discussed prior to drawing conclusions of the study.

3.3 Measurement of Cultural Shift

As discussed in the previous Chapters, cultural shift is the combined result of the movements of individual cultural components comprising awareness, concern, motivation and implementation in a designated time frame. Government promotions and enforcement of sustainable policies and regulations brought about significant impacts upon construction participants. To measure cultural shift is to measure the change of these components in every stakeholder group in a certain period of time with respect to a selected point of time as the baseline. All these components are measured and integrated by means of a synthesis mechanism, the **T-model**, which is an empirical measurement tool and is exclusively designed for measuring cultural

shift towards sustainability. However, awareness, concern, motivation and implementation are abstract concepts which are difficult to quantify for measurement. The T-model is therefore exclusively developed by using a specially designed questionnaire to elicit data from the respondents with regards to their changes of mind-set, attitude and behaviour. The questionnaire survey attempts to investigate respondent knowledge, perception, recognition, diagnosis, judgment, intention, drive, and implementation of sustainability towards the ultimate goal of sustainable development.

A scoring system is established by assigning appropriate scores to each question. Data obtained from the questionnaire survey in the research year have been converted into scores according to the established scoring system. The scoring value of each cultural component is then input into a corresponding position of a space diagram as shown in Figure 3.2, which is specially designed to synthesize all cultural components to quantifiable values representing the cultural status of the research year. Comparing the values of the research year with the base year will provide the magnitude of change which is the cultural shift within the designated time frame. Consecutive investigations that take place at suitable intervals will provide a series of data on the tendency of cultural changes towards sustainability. Since cultural shift is a continuous process, measurements should therefore be carried out regularly.

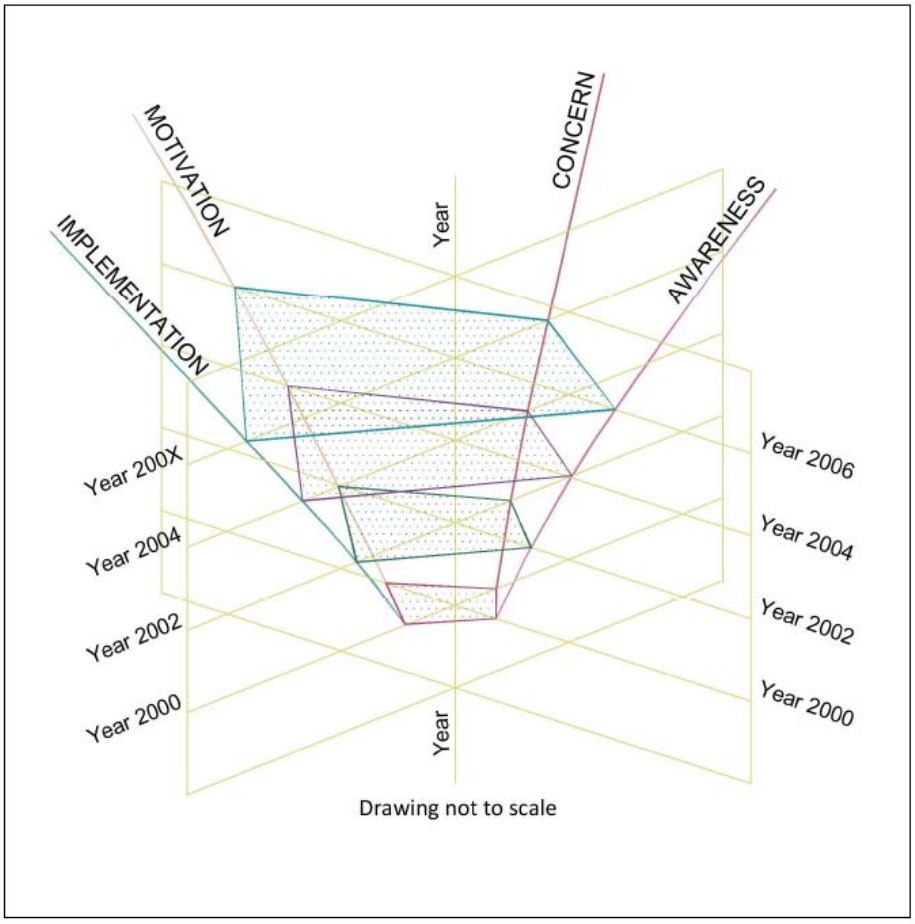


Figure 3.2 Synthesizing Cultural Elements Data by using Space Diagram

3.3.1 Structure of the Questionnaire

The design of the questionnaire is based on studies of about the changes in attitude and behaviour on sustainability and the implementation of sustainable construction within the construction industry of Hong Kong. The theories developed by Allport (1935), Hungerford and Volk (1990), Ajzen (1991) form the basis of understanding attitudinal and behavioral changes. Ideas have also been drawn from the CIB study of Abeysekera (2002) on construction culture. On the other hand, the studies of Poon (1997), Epstein and Roy (2001), Formoso *et al* (2002), Poon *et al* (2003), Poon *et al* (2004), and Yip and Wong (2004) on topics related to planning and design for

sustainability, sustainable construction, waste minimization and recycling of construction and demolition materials have been extensively referenced.

Other than collecting demographic information on the respondents, the questionnaire is separated into five parts, each one trying to tackle individually the changes in attitudes and behaviours of the respondents with respect to influence from current requirements for sustainability. The movement of these cultural components within the research period has been distinctively measured and compared with the selected base year 2000. The selection of year 2000 as the base year of study is to echo with the introduction of sustainable development policy in 1999 by the Chief Executive of the Government of HKSAR (Policy Address, 1999). A pilot test has been conducted in 2004 in Hong Kong with 40 randomly selected construction participants within the five stakeholder groups. Questionnaires were distributed to them and 20 returned questionnaires were analyzed and synthesized by using the T-model. Satisfactory results showing the tendency of cultural shift of sustainability in construction have been obtained in the pilot test (Poon and Yip, 2005).

Part I of the questionnaire aims at collecting information about the level of "awareness" of sustainability in construction. The questions target at understanding the sources of sustainable information to find out the key sustainable indicators established by the Government of HKSAR and how these indicators affect sustainability in Hong Kong. One of the questions in this part of the questionnaire serves an objective weighing of the influential level of each group in their power of influence affecting the sustainable output of the built assets and the construction industry in Hong Kong.

Part II of the questionnaire addresses the "concern" of the respondents to sustainability. The New Environmental Paradigm (NEP) developed by Dunlap and Van Liere (1978) in their ***12-NEP*** scales measuring "paradigmatic" shift has been adopted. The NEP deals with the judgment and diagnosis of changes in the earth environment and the ecosystem, reflects essentially the human concerns about environmental protection, limited industrial growth and population control.

Part III of the questionnaire has been designed on the basis that the concern of sustainability is built up among construction participants and the extent of acquiescence and mentality in acceptance of sustainability is sufficiently mature. Inherent motivation of sustainability will take place when they perform their duties. Their willingness in using sustainable materials and sustainable construction methods, albeit at a higher initial construction cost, is measured as a reflection of their "readiness to change" attitudes and behaviours.

Part IV of the questionnaire assesses the extent of sustainability measures that have been implemented, the physical works which would help to realize sustainability and the additional costs that stakeholders are prepared to bear for the aimed sustainable purpose. These are indispensable indicators of implementation of sustainability.

To measure the cultural shift that may have occurred in the research years with respect to the base year, part V of the questionnaire has provided a selection scale for respondents to review in retrospect their changes in attitudes and behaviours. The respondents are requested to indicate the change they have experienced and performed

in discharging their services throughout the research period. Details of the questionnaire and scoring scheme are attached in Appendix **1**.

3.3.2 Illustration of the T-model Mechanism

The cultural components Awareness (**x**), Concern (**y**), Motivation (**z**) and Implementation (**w**) are abstract. The first two show attitudinal orientation of ideological mind-set whereas the last two cover behavioral actions of physical performance with respect to the culture of the construction industry. The score of each cultural component obtained from the questionnaire survey by any stakeholder group "i" under the influence of sustainable development is represented by $\mathbf{S_i}$.

To evaluate the cultural change within each stakeholder group, the influential factor ($\mathbf{a_i}$) that affects the sustainable output of each group collected from the questionnaire survey has been taken into account. The higher the influential factor, the greater is the power of influence in the achievements of sustainable construction. Therefore, the score of sustainability of a specific stakeholder group in any year is:

$$\mathbf{[S_i] = a_i\ [\ x, y, z, w,\ ]_i} \quad \text{.....(1)}$$

Where **S = Sustainable Score**

i = Discipline Group

a = Influential Power

x = Awareness

y = Concern

z = Motivation

w = Implementation

Summation of scores of all cultural components from the five stakeholder groups

would indicate the total cultural score which represents the status of sustainable culture of the construction participants at professional and supervisory levels.

$$T = \sum_{i=1}^{5} S_i$$

Where T = Total Sustainability Score

$$T = \sum_{i=1}^{5} S_i = \sum_{i=1}^{5} a_i[x, y, z, w] \quad \text{..... (2)}$$

Since a series of survey can be carried out periodically in different research years, data of cultural components (x, y, z, w) obtained from different research years can be converted into scores with respect to the base year.

The scores of each cultural element x, y, z, w, that have been obtained from each research year are plotted at the corresponding spots of the space diagram in Figure 3.2. All the points of the cultural elements have been plotted on the same research year plane and are linked up by straight lines forming a quadrangle on the same plane. The area of each quadrangle can be calculated numerically and represents the synthesized cultural value of that research year. Comparing the value of the research year with the area of quadrangle of the base year plane would numerically provide the cultural shift of the research year with respect to the base year. The pilot test conducted in 2004 (Poon and Yip, 2005) has demonstrated that the T-model is a serviceable mechanism to measure a cultural shift.

Two-rounds of questionnaire survey were conducted separately in years 2004 and 2006. Year 2000 was designated as the base year of the study. Samples in these two separate surveys were randomly selected from construction participants in Hong Kong

at professional and supervisory levels. In the year 2004 study, a two-year interval (2000, 2002, 2004) was selected to measure the cultural shift, whereas in the year 2006 research, a closer interval of one-year (2004, 2005, 2006) was used since more precise results have been aimed at. The questionnaire of both researches were sent by emails, post and personal contacts to government departments related to construction projects development as well as private organizations such as developers, consultant firms, general and specialist contractors. A total of 446 and 317 valid responses have been received in the year 2004 and year 2006 surveys respectively.

3.3.3 Data Analysis Methods

As mentioned earlier, the T-model, as well as formulae 1 and 2 have been established exclusively for handling scores obtained from questionnaire survey that measured the cultural shift of construction participants in Hong Kong over the research years. Several statistical techniques have been utilized to analyze the data obtained from the questionnaire surveys. Descriptive analysis was firstly carried out where means as well as standard derivations of the data were analyzed. As part of the analysis, the Cronbach alpha reliability coefficients were generated to determine the internal consistency or average correlation of items in a survey instrument to gauge its reliability (Norusis, 2002). In particular, the technique was employed to examine the internal consistency among the survey responses for the scale adopted in Part I – Awareness of changes towards sustainable development; Part II – Concerns about sustainable development in construction ; Part III – Motivations towards sustainability; Part IV – Implementation of sustainability; and Part V – Shift of cultural perception of sustainable development. The standardized Cronbach's alpha is defined as:

$$\text{Cronbach's } \alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}} \quad \text{..... (3)}$$

Here N is equal to the number of items, $\bar{c}$ is the average inter-item covariance among the items and $\bar{v}$ equals the average variance (Cronbach, 1951).

Cronbach's alpha coefficients range in value from 0 to 1 and are used to describe the reliability of factors extracted from dichotomous and/or multi-point formatted questionnaires or scales (Santos, 1999). The method is compatible in testing the diverse nature of the cultural components comprising awareness, concern, motivation and implementation. The closer is Cronbach's alpha coefficient to 1, the greater is the internal consistency of the items in the scale and therefore the more reliable is the adopted scale. The F-test devised by Hsu and Feldt (1969) is used to test the significance of this reliability analysis.

Paired-samples t-test was applied to compare whether the magnitude of cultural shift in awareness, concern, motivation and implementation between two selected year points is significant. Independent sample t-test and One-way Analysis of Variance (ANOVA) have also been performed to compare the results among different groups of stakeholders in determining which stakeholder groups had achieved more significant sustainable outcome than the other. Using Statistical Package for Social Sciences (SPSS), the significance of difference between the group means can be measured by expressing the ratio of the difference of means between groups to the variability within the groups. If the test result was significant at the 0.05 level, then the null hypothesis that there is no significant difference in the mean values between the respondent groups can be rejected (Norusis, 2002).

3.4 Structured Interviews

In order to confirm the reliability of the research outcome of the above-mentioned questionnaire surveys, two major issues on the cultural shift within the research time frame have been assessed and verified:

- The research outcome of cultural shift revealed from the questionnaire surveys has truly reflected the situation of the construction industry of Hong Kong.
- The variation in cognition among stakeholders in awareness, concern, motivation and implementation.

Questions for the interview were subdivided into three sections, the closed-end questions, the open-end questions and the questions about cultural attributes (Appendix 2). Details of the structured interview are spelt out in Chapter 5, section 5.1. To ensure the effectiveness of the structured interviews, some fundamental requirements for the structured interviews must be noted. Naoum (2002) recommended that the interviewer controls the course of the structured interview throughout the entire process. Avoidance of bias is always an issue to the researcher, as Bell (2005) pointed out *"many factors can result in bias and there are always dangers in research carried out by individual researchers, particularly those who have strong views about the topic they are researching"*. The interviewer must always be alert to these bias traps. Selection of views favorable to sustainability and adoption of inappropriate language may indicate strong feeling on the interviewer's part and these in turn may influence the interviewees and induce biased results.

Since the interviews have been conducted in a face-to-face discussion fashion, the interviewer could read the expressions and body language of the respondents. When doubts and uncertainties arose in the course of interview, immediate actions have been taken to clarify misconceptions and misunderstandings between the interviewer and the interviewees. Therefore, the answers obtained through all the interviews were accurate and objective.

3.4.1 Selection of Interviewees

Interviewees were selected from the respondents who have provided contact details in the questionnaire surveys conducted in years 2004 and 2006. To enhance the result of verification, interviewees covering the five stakeholder groups have been chosen. Due to the comparatively large number of valid feedbacks from (763 in total) the two surveys, one extra interviewee would be added when the number of responses exceeded 100. The number of responses from the Government group (228) and the Contractor group (385) justified the selection of three and four interviewees respectively. Unfortunately, two interviewees, one from each side, declined the interview appointments at the last minute and no substituent accepted the second round invitation. Therefore, three interviewees from the Contractor group and two from the Government group were eventually interviewed. Since the number of respondents from the Developer group (69), Consultant group (48) and the NPP group (32) were comparatively small, one interviewee for each group was chosen.

In order to elicit comprehensive perception, selection of interviewees was based on different sources. For the Government group, two government officers were chosen

from different government departments which are responsible for projects of a different nature. To represent the Contractor group, three targeted interviewees were selected from two contractor firms of different sizes. Two of them belonged to a Group C contractor firm (Group C contractors in Hong Kong are statutory qualified to tender Government construction works of unlimited contract amount); one was the project manager and the other was head of the department for safety, health and environmental protection. The third interviewee was the owner of a subcontractor firm, the core business of which was subcontracting of construction work for reinforced concrete superstructure of high-rise buildings. Interviewees representing the other stakeholder groups were an architect for the Consultant group, a general manager of a leading developer representing the Developer group. As for the non-professionally recognized construction participant group, a site agent from a Group C contractor firm was invited for interview. The detail of interviewees is listed in Table 3.1 below:

Table 3.1 Details of Interviewees

ID	Sector	Stakeholder	Position of Interviewee	Type of Organization
1	Private	Developer	General Manager	Leading private property developer
2	Private	Contractor	Senior Manager (Safety and Environmental Management)	Leading Contractor firm in Hong Kong
3	Private	Contractor	Project Manager	Leading Contractor firm in Hong Kong
4	Private	Contractor	Director	Sub-contractor firm for formwork erection
5	Public	Government	Project Architect	Architectural Services Department HKSAR
6	Public	Government	Deputy Director	Environmental Protection Department HKSAR
7	Private	Consultant	Director	Leading Architect and Structural Engineer in Hong Kong
8	Private	NPP	Site Agent	Major construction company

All of the selected interviewees have practiced in the construction industry in Hong Kong for at least 15 years, some of them have over 25 years post qualification experiences, although some of the experiences were gained abroad, most of them have at least 10 years of Hong Kong experience. The views and opinions on the research topic are therefore reliable and of a profound depth.

3.4.2 Mode of the Interviews

Throughout the interviews with all selected respondents, the *cognitive interview* approach as introduced by Dillman (2000) was applied. Cognitive interview is a technique to determine whether respondents comprehend the interview questions. It is to ensure the true meaning of the intended question is understood so that accurate answers could be obtained to fulfill the study purpose. In cognitive interview, respondents are requested to inform the interviewer everything they think about the questionnaire. The interviewer probes the respondents on how each question is being interpreted and whether the intent of each question is delivered.

All interviews of the study were carefully organized. To achieve an unprejudiced outcome from the structured interview, the questions asked and the sequence of questioning were identical to all respondents in face-to-face discussion fashion. Except for the NPP group respondents, the questions to be raised during the interviews were given to the interviewees prior to the meeting, the respondents have had ample time to think about the questions which enabled them to provide their views accurately.

All the interviews were conducted with cognitive interview criteria. The interviewees were first requested to spell out their interpretation of the questions so as to allow the interviewer to assure that their understanding of the questions was accurate. Closed-end questions were raised first and followed by the open-end questions. When all the questions had been answered, interviewees were encouraged to provide their subjective views on the appropriateness of the questions and their personal opinion on what they believe should be done to uplift sustainability in the construction industry. The purpose was to probe their forward-looking styles and their enthusiasm in sustainable construction.

3.5 Summary

This chapter has introduced and justified the research design and strategy to achieve the research objectives. This research comprises two key phases embracing both qualitative and quantitative analyses. A T-model is exclusively established which contained two formulae to calculate data obtained from the questionnaire surveys tailor-made for this research. Questionnaire surveys conducted in years 2004 and 2006 provided data on cognition of sustainability among construction participants and their performance in sustainability in their construction output. The survey data have been analyzed quantitatively with SPSS software and the result triangulated with qualitative research approach in structural interviews. Case studies on different type of projects have also been adopted to cross-reference with cultural shift in sustainability in real life experiences as shown in Chapter 5.

CHAPTER 4 MEASURING CUTURAL SHIFT TOWARDS SUSTAINABILITY: QUESTIONNAIRE SURVEY

4.1 Introduction

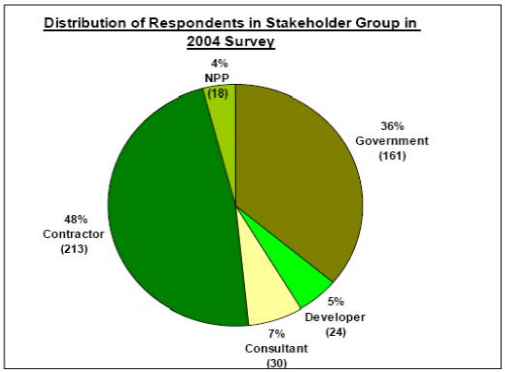
The change in sustainable culture is reflected by the change in attitude and practice among construction participants, this can be found in their performance in project development, design and construction operations. Through two extensive surveys among participants of the construction industry of Hong Kong, the T-model which was designed to synthesize survey data has revealed a change of sustainable culture between years 2000 and 2006. This Chapter presents the empirical findings from the T-model.

4.2 Respondents' Profile

Respondents to the questionnaire surveys conducted in years 2004 and 2006 were random samples. Demographic information of these random respondents displayed in Table 4.1 showed that the majority of the respondents were affiliated to professional bodies of Hong Kong including the Hong Kong Institute of Architects (HKIA), the Hong Kong Institution of Engineers (HKIE), the Hong Kong Institute of Surveyors (HKIS) and the Hong Kong Institute of Construction Managers (HKICM). Most of the respondents had over 15 years of prior practical working experience in the

construction industry in Hong Kong, and some of them had over 20 years of experience. This showed that the respondents were very experienced in the local construction industry and their views and opinions were therefore representative.

Demographic Information of Respondents	Survey Result of Year 2004	Survey Result of Year 2006
Number of Qualified Professionals / Total Number of Respondents	323/446 (72%)	192/317 (61%)
Number of Respondents over 20 Years Experience / Total Number of Respondents	151/446 (34%)	74/317 (23%)
Number of Respondents over 10 Years Experience / Total Number of Respondents	326/446 (73%)	183/317 (58%)
Number of Respondents over 5 Years Experience / Total Number of Respondents	410/446 (95%)	385/317 (90%)



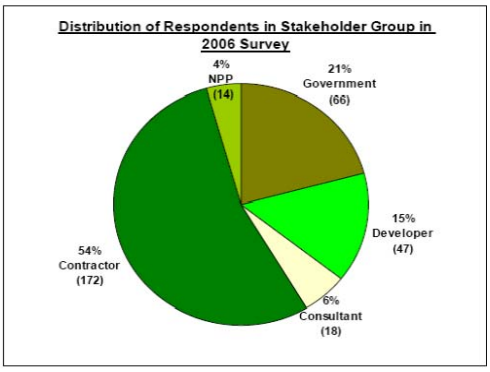


Table 4.1 Demographic Information of Respondents in 2004 and 2006 Surveys

4.3 Reliability Test: Cronbach's Alpha

Cronbach alpha reliability (the scale of coefficient) measures were first examined to independently verify the internal consistency of the responses on the cultural components comprising awareness, concern, motivation and implementation. Table 4.2 is a summary of the Cronbach's alpha reliability test for the questionnaire surveys in the years 2004 and 2006. Although alpha obtained from Awareness might not be satisfactory ($\alpha < 0.5$), the results of F-tests indicated that all the scales used for

measuring the sustainability in construction are reliable at the 5% significance level (sig. < 0.05).

Table 4.2 Results of Cronbach's Alpha Tests

	2004					**2006**				
	N of Cases	N of Items	Alpha	*F*	Sig.	N of Cases	N of Items	Alpha	*F*	Sig.
Part I - Awareness	446	7	0.3433	363.55	0.000	317	7	0.3528	410.38	0.000
Part II - Concern	431	12	0.4933	96.89	0.000	317	12	0.5289	70.97	0.000
Part III - Motivation	437	7	0.8147	117.71	0.000	317	7	0.7678	13.74	0.000
Part IV - Implementation	434	7	0.7897	191.39	0.000	317	7	0.8499	41.88	0.000
Part V - Shift	391	36	0.9166	87.7408	0.000	317	36	0.9531	56.90	0.000

4.4 The Influential Factors

As defined earlier, different stakeholder groups bear different influences in both the course of construction and the final built asset. The power that influences the result of sustainable output is referred to as the influential factor ($\mathbf{a_i}$). It is of interest to note that although the years 2004 and 2006 surveys were conducted at different time frames with different sample respondents, the outcome of $\mathbf{a_i}$ revealed little variance. The small variation displayed in the influential factors shown in Table 4.3 demonstrates that the respondents from each stakeholder group shared equal perception about their influential power. The values of $\mathbf{a_i}$ for various stakeholder group obtained from both surveys are suitable for use as multipliers for the respective cultural scores for each questionnaire survey.

Table 4.3 Influential Factor (a_i) of Each Stakeholder Group

Stakeholder Groups	Influential Factor (a_i)	
	Year 2004 Survey	Year 2006 Survey
Government	37.3%	39.5%
Developer	28.4%	28.0%
Consultant	13.1%	12.7%
Contractor	12.5%	12.5%
Non-professionally recognized frontline construction participant (NPP)	8.7%	7.4%
SUM	100%	100%

4.5 The Cultural Value

Based on the cultural values obtained from the surveys in years 2004 and 2006, the extent of cultural shift for each group is identified and shown in Table 4.4, and Figure 4.7. All stakeholder groups indicated certain shifts in sustainable culture within the study period. Positive shifts were found in most of the stakeholders groups and these shifts are the evidences representing improvement on sustainable culture among stakeholders. There were a few negative shifts appeared among the overwhelming amount of positive shifts, and the presence of these negative shifts is an evidence to demonstrate that cultural shifts among stakeholders are not synonymous.

Table 4.4 Shift of Cultural Components of Each Stakeholder Group between 2000 and 2004

Groups	Cultural Components	Shift			Cultural Score			a_i	Cultural Value = (a_i) x (Cultural Score)		
		2000	2002	2004	2000	2002	2004		2000	2002	2004
Government	Awareness (x)	7.30	9.08	10.86	14.29	14.85	17.76	37.3%	5.33	5.54	6.63
	Concern (y)	7.76	8.92	9.93	5.61	5.79	6.45	37.3%	2.09	2.16	2.40
	Motivation (z)	7.43	8.42	9.56	18.17	18.15	20.60	37.3%	6.78	6.77	7.68
	Implementation (w)	7.15	7.69	8.93	18.69	17.30	20.10	37.3%	6.97	6.45	7.50
Developer	Awareness (x)	8.50	9.25	10.75	17.23	16.13	18.75	28.4%	4.89	4.58	5.33
	Concern (y)	8.63	9.00	9.75	7.91	7.62	8.25	28.4%	2.25	2.16	2.34
	Motivation (z)	8.38	7.88	9.38	22.73	17.96	21.38	28.4%	6.46	5.10	6.07
	Implementation (w)	6.75	7.88	8.75	17.36	18.23	20.25	28.4%	4.93	5.18	5.75
Consultant	Awareness (x)	7.60	9.00	10.10	14.02	14.79	16.60	13.1%	1.84	1.94	2.17
	Concern (y)	7.10	8.10	8.60	9.20	9.89	10.50	13.1%	1.21	1.30	1.38
	Motivation (z)	5.70	8.00	8.80	13.32	17.00	18.70	13.1%	1.75	2.23	2.45
	Implementation (w)	5.70	7.00	7.40	13.44	15.61	16.50	13.1%	1.76	2.04	2.16
Contractor	Awareness (x)	7.28	8.75	10.31	14.08	14.35	16.92	12.5%	1.76	1.79	2.11
	Concern (y)	7.79	8.75	9.46	7.10	7.37	7.97	12.5%	0.89	0.92	1.00
	Motivation(z)	7.59	8.38	9.27	18.32	18.29	20.23	12.5%	2.29	2.29	2.53
	Implementation (w)	6.51	7.73	9.06	15.35	15.57	18.24	12.5%	1.92	1.95	2.28
NPP	Awareness (x)	6.33	9.00	11.00	12.78	14.86	18.17	8.7%	1.11	1.29	1.58
	Concern (y)	8.83	9.50	9.83	10.69	11.11	11.50	8.7%	0.93	0.97	1.00
	Motivation (z)	6.17	7.83	9.33	14.96	15.95	19.00	8.7%	1.30	1.39	1.65
	Implementation (w)	6.83	9.17	10.00	14.41	17.72	19.33	8.7%	1.25	1.54	1.68

Note: The total score of each cultural component has no direct reference to one another

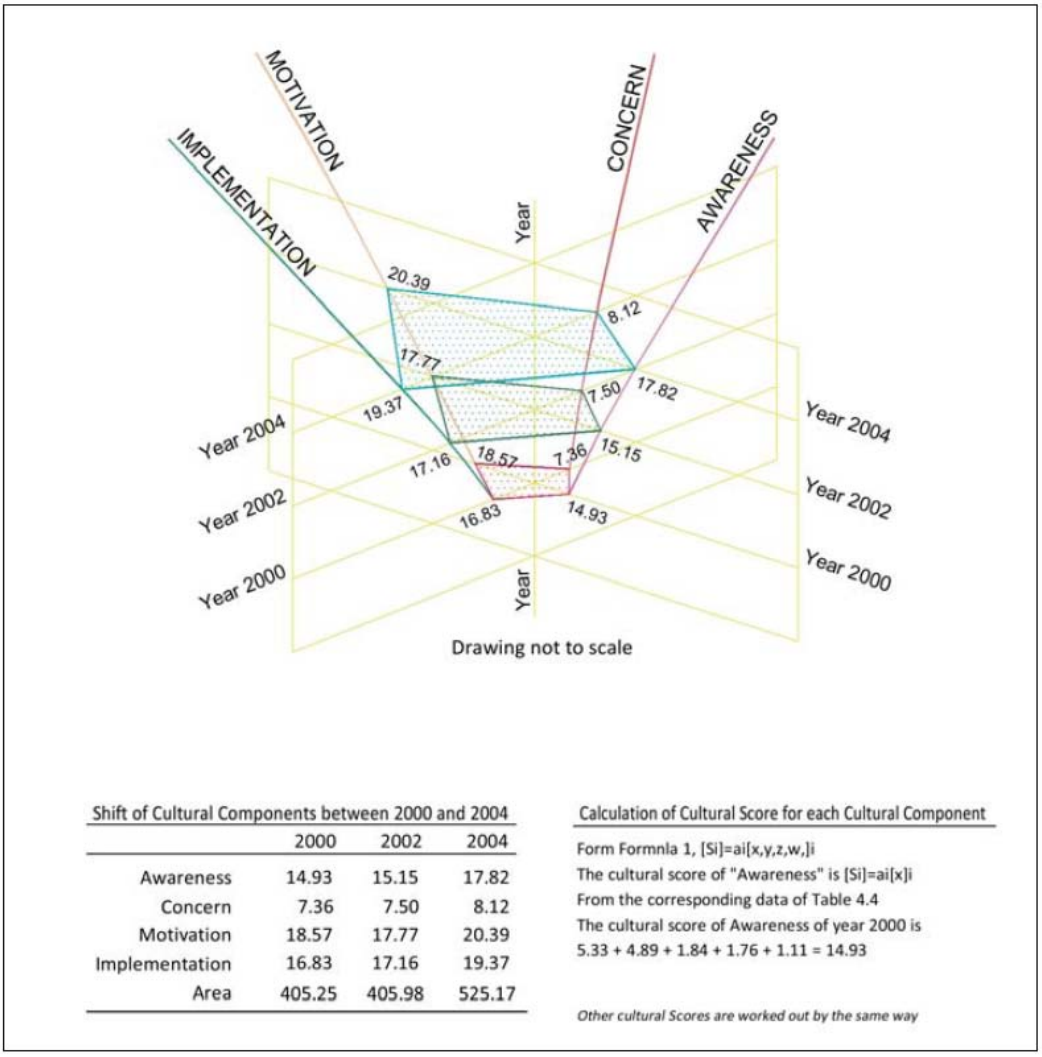
Table 4.5 Shift of Cultural Components of each Stakeholder Group between 2004 and 2006

Groups	Cultural Elements	Shift			Cultural Score			a_i	Cultural Value = (a_i) x Cultural Score		
		2004	2005	2006	2004	2005	2006		2004	2005	2006
Government	Awareness (x)	11.01	11.83	12.76	17.13	18.40	19.85	39.5%	6.76	7.27	7.84
	Concern (y)	9.64	10.47	10.64	8.79	9.55	9.70	39.5%	3.47	3.77	3.83
	Motivation (z)	10.16	10.83	11.36	21.82	23.27	24.39	39.5%	8.62	9.19	9.63
	Implementation (w)	9.80	10.29	10.54	21.24	22.31	22.84	39.5%	8.39	8.81	9.02
Developer	Awareness (x)	10.13	11.74	12.39	17.82	20.64	21.77	28.0%	4.99	5.78	6.10
	Concern (y)	9.77	10.52	11.19	8.33	8.98	9.55	28.0%	2.33	2.51	2.67
	Motivation (z)	8.71	9.47	9.95	20.40	22.18	23.31	28.0%	5.71	6.21	6.53
	Implementation (w)	7.97	9.01	10.16	14.96	16.90	19.05	28.0%	4.19	4.73	5.33
Consultant	Awareness (x)	8.64	10.56	12.90	13.82	16.89	20.63	12.7%	1.76	2.15	2.62
	Concern (y)	9.90	10.32	10.68	8.25	8.60	8.90	12.7%	1.05	1.09	1.13
	Motivation (z)	9.36	11.10	11.52	20.60	24.43	25.36	12.7%	2.62	3.11	3.23
	Implementation (w)	9.36	10.68	11.52	17.63	20.11	21.69	12.7%	2.24	2.56	2.76
Contractor	Awareness (x)	9.02	10.27	11.72	14.23	16.20	18.49	12.5%	1.77	2.02	2.30
	Concern (y)	9.04	10.10	10.79	9.57	10.69	11.43	12.5%	1.19	1.33	1.42
	Motivation (z)	8.80	9.80	10.97	18.36	20.45	22.90	12.5%	2.29	2.55	2.85
	Implementation (w)	8.45	9.64	10.62	16.18	18.46	20.34	12.5%	2.01	2.30	2.53
NPP	Awareness (x)	9.64	10.80	12.42	13.98	15.66	18.01	7.4%	1.04	1.17	1.34
	Concern (y)	10.26	11.34	12.03	9.97	11.02	11.69	7.4%	0.74	0.82	0.87
	Motivation (z)	10.03	11.26	12.11	25.77	28.94	31.12	7.4%	1.92	2.16	2.32
	Implementation (w)	9.72	11.65	11.96	19.13	22.92	23.53	7.4%	1.42	1.71	1.75

Note: The total score of each cultural component has no direct reference to one another

4.6 Synthesis of Cultural Shift by Space Diagram

The scores of each cultural component that are tabulated in Table 4.4 summarized the survey results of year 2004. They were integrated in the space diagram in a two-year interval. Figure 4.1 synthesized all the cultural components in years 2002 and 2004 with respect to the base year 2000.



Shift of Cultural Components between 2000 and 2004

	2000	2002	2004
Awareness	14.93	15.15	17.82
Concern	7.36	7.50	8.12
Motivation	18.57	17.77	20.39
Implementation	16.83	17.16	19.37
Area	405.25	405.98	525.17

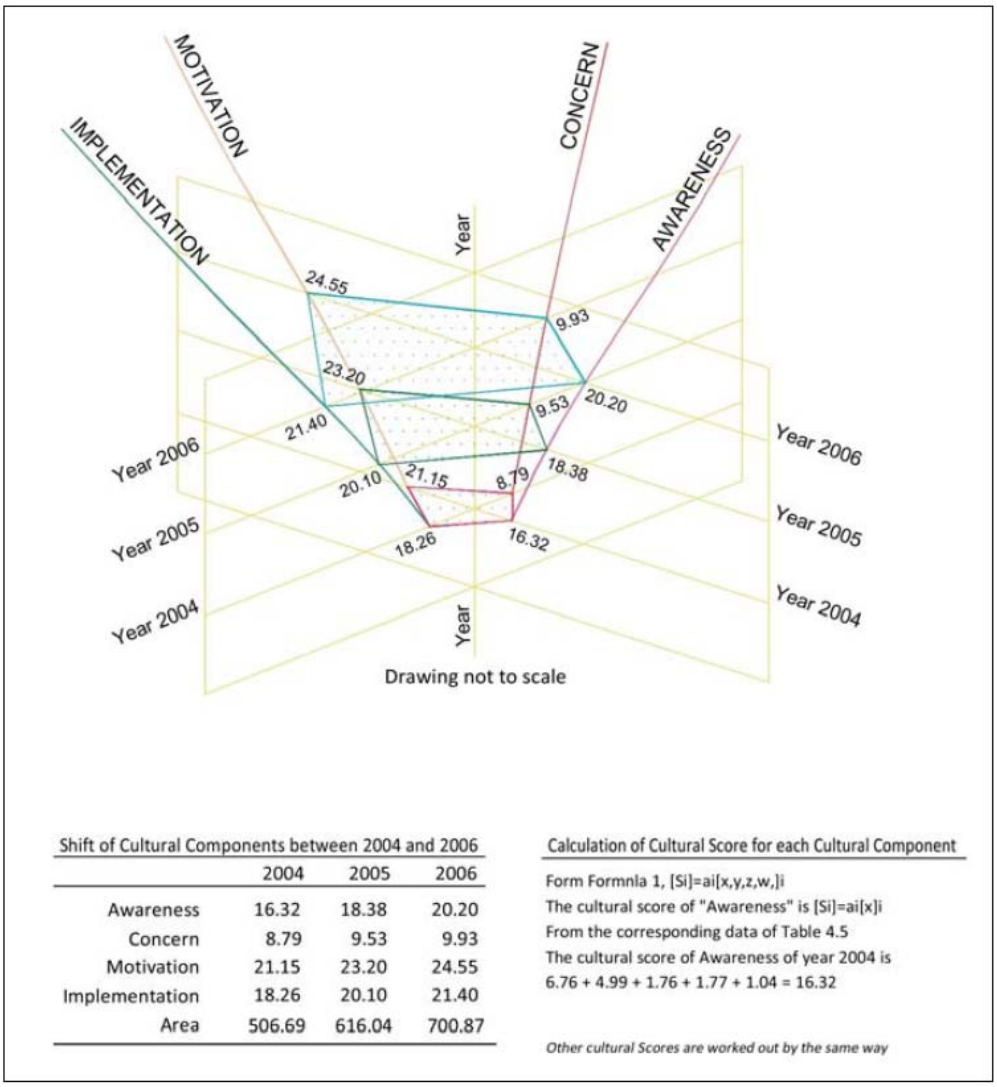
Calculation of Cultural Score for each Cultural Component

Form Formnla 1, [Si]=ai[x,y,z,w,]i
The cultural score of "Awareness" is [Si]=ai[x]i
From the corresponding data of Table 4.4
The cultural score of Awareness of year 2000 is
5.33 + 4.89 + 1.84 + 1.76 + 1.11 = 14.93

Other cultural Scores are worked out by the same way

Figure 4.1 Integrating Cultural Components in the Space Diagram of the T-model for Year 2004 Survey

Furthermore, the scores of cultural components of the year 2006 survey are handled in the same way. The scores of each cultural component were placed in space diagram Figure 4.2 showing the shift between the years 2004 and 2006**.**



Shift of Cultural Components between 2004 and 2006

	2004	2005	2006
Awareness	16.32	18.38	20.20
Concern	8.79	9.53	9.93
Motivation	21.15	23.20	24.55
Implementation	18.26	20.10	21.40
Area	506.69	616.04	700.87

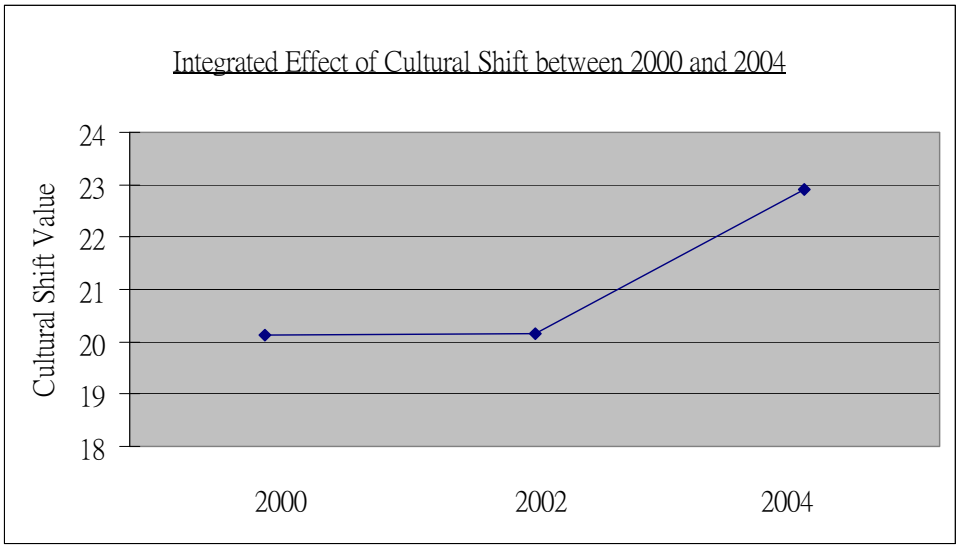
Calculation of Cultural Score for each Cultural Component

Form Formnla 1, [Si]=ai[x,y,z,w,]i
The cultural score of "Awareness" is [Si]=ai[x]i
From the corresponding data of Table 4.5
The cultural score of Awareness of year 2004 is
6.76 + 4.99 + 1.76 + 1.77 + 1.04 = 16.32

Other cultural Scores are worked out by the same way

Figure 4.2 Integrating Cultural Components in the Space Diagram of the T-model for Year 2006 Survey

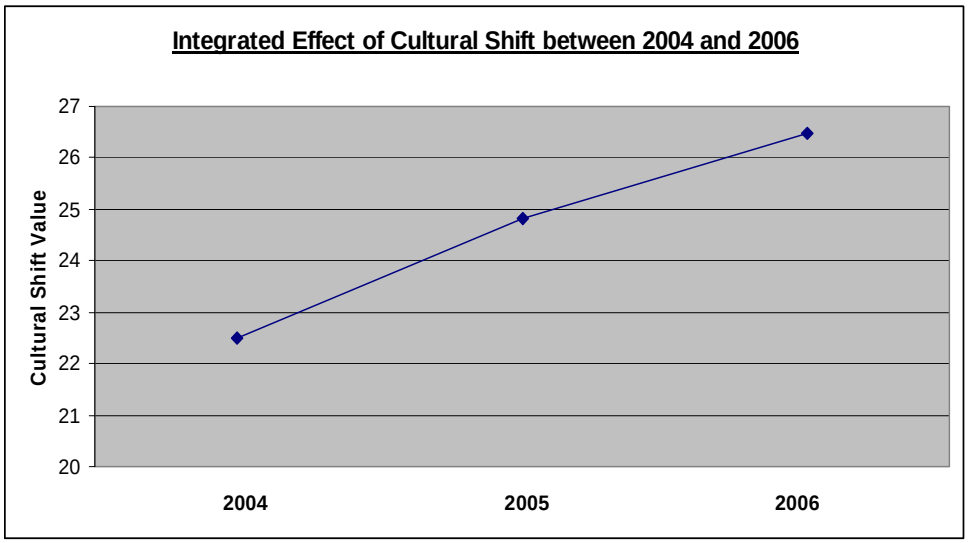
The areas of the quadrangles developed in Figure 4.1 and Figure 4.2 of the space diagrams displaying areas formed by the four cultural components with respect to the corresponding year planes. To derive the cultural shift curve of the two surveys, square root the area of each quadrangle will provide a linear representation of the research results. Figure 4.3 and Figure 4.4 reveal the cultural shift results of the construction industry of Hong Kong from years 2000 to 2004 and 2004 to 2006 respectively.



Integrated Effect of Culture Change between 2000 and 2004

	2000	2002	2004
Awarenes	14.93	15.15	17.82
Concern	7.36	7.50	8.12
Motivation	18.57	17.77	20.39
Implementation	16.38	17.16	19.37
Areas formed in Space Diagram	405.25	405.98	525.17
Square Root of the Area	**20.13**	**20.15**	**22.92**

Figure 4.3 Cultural Shift between 2000 and 2004



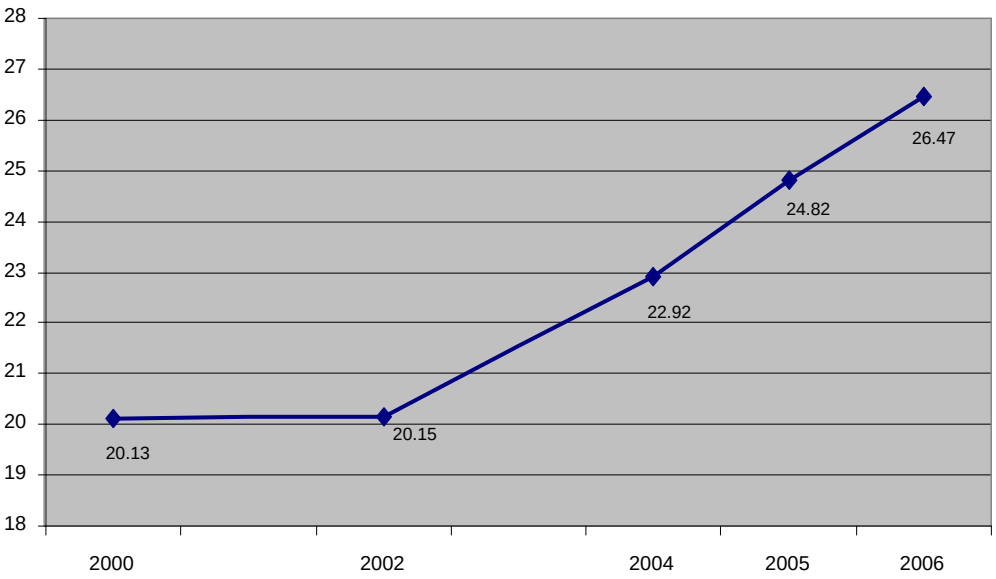
Integrated Effect of Culture Change between 2004 and 2006

	2004	2005	2006
Awareness	16.32	18.38	20.20
Concern	8.79	9.53	9.93
Motivation	21.15	23.20	24.55
Implementation	18.26	20.10	21.84
Areas formed in Space Diagram	506.69	616.04	700.87
Square Root of the Areas	**22.51**	**24.82**	**26.47**

Figure 4.4 Cultural Shift between 2004 and 2006

The results shown in Figure 4.3 and Figure 4.4 represent the outcome of two different surveys in different time frames with different random sample respondents. It is important to note that the studies generated two sets of results for year 2004. The result of cultural shift value derived from the year 2004 survey was 22.92, while the result of cultural shift value from the year 2006 survey was 22.51. The differences were sufficiently close to each other with variance less than 1.8%. It would be safe to judge that the study outcomes obtained from both survey activities are reliable.

According to the research methodology, the former 2004 cultural shift value was the actual surveyed result of the 2004 survey, while the latter 2004 cultural shift value was the calculated result of the 2006 survey. The actual surveyed results of year 2004 are considered more appropriate to be adopted in reflecting the research finding. Therefore the integrated cultural shift value of 22.92 is adopted as the connection point to combine the outcomes of both surveys in years 2004 and 2006. The cultural shift curve shown in Figure 4.5 is a combination of the curves of Figure 4.3 and 4.4 with the connection point at 22.92.



Integrated Effect of Culture Change between 2000 to 2006

	2000	2002	2004	2005	2006
Awareness	14.93	15.15	17.82	18.38	20.20
Concern	7.36	7.50	8.12	9.53	9.93
Motivation	18.57	17.77	20.39	23.20	24.55
Implementation	16.83	17.16	19.37	20.10	21.84
Areas formed in Space Diagram	405.25	405.98	525.17	616.04	700.87
Square Root of the Areas	**20.13**	**20.15**	**22.92**	**24.82**	**26.47**

Figure 4.5 Integrated Cultural Shift between 2000 and 2006

The cultural curve shown in Figure 4.5 represents the trend of cultural shift of the construction industry of Hong Kong between the years 2000 and 2006 under the influence of sustainable development as introduced by Government.

Cultural shift of individual stakeholder group can be reflected by using the space diagram approach with the cultural values of respective stakeholder groups shown in Table 4.4 and 4.5. The curves shown in Figure 4.6 below represent the shift of each stakeholder groups individually within the research period. The calculation worksheets for each curve are displayed in Appendix 4.

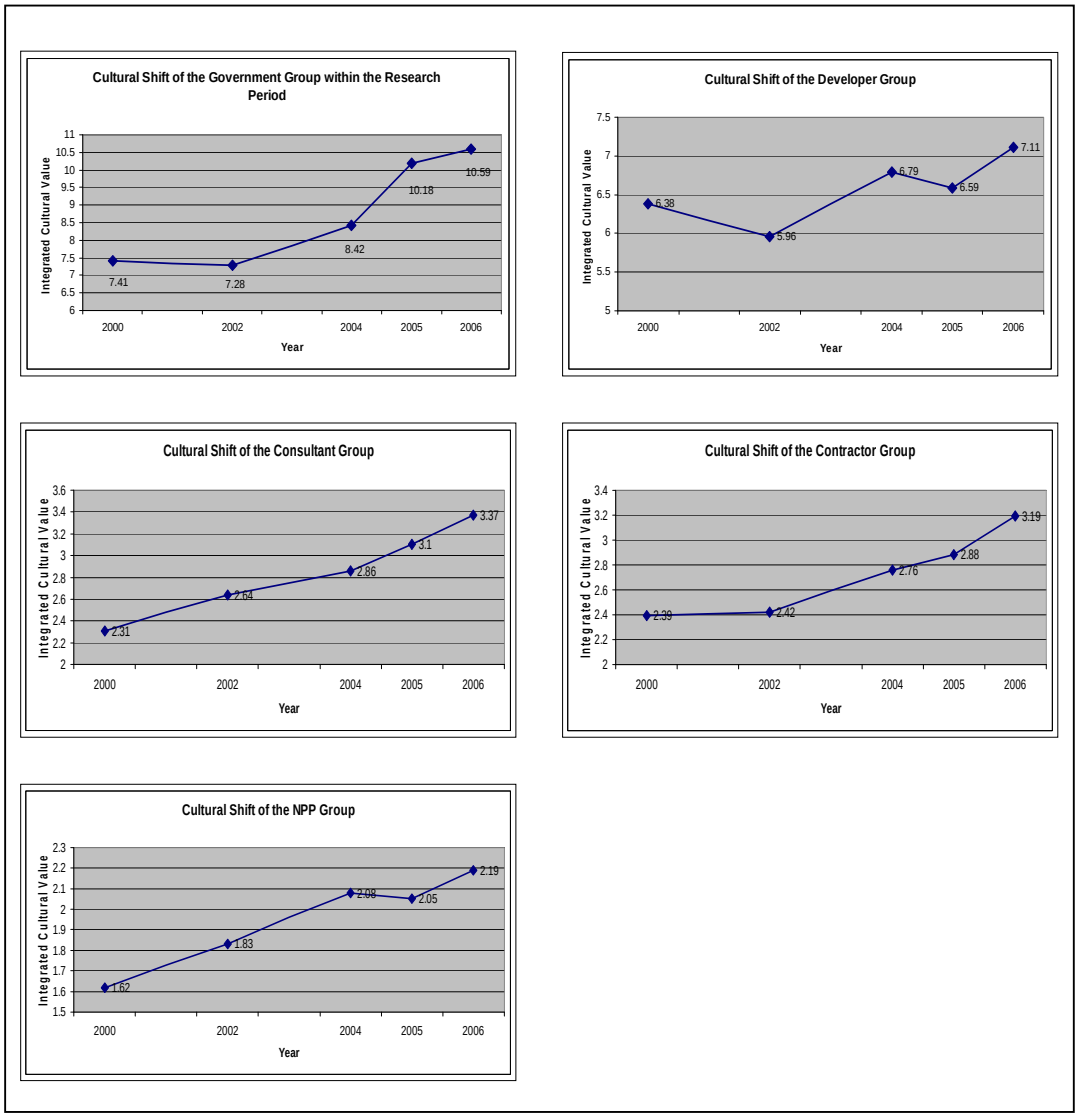


Figure 4.6 Cultural Shift of Individual Stakeholder Group

Similarly, using cultural values of Table 4.4 and 4.5, the shift of cultural components of each stakeholder group can be presented by curves as shown in Figure 4.7.

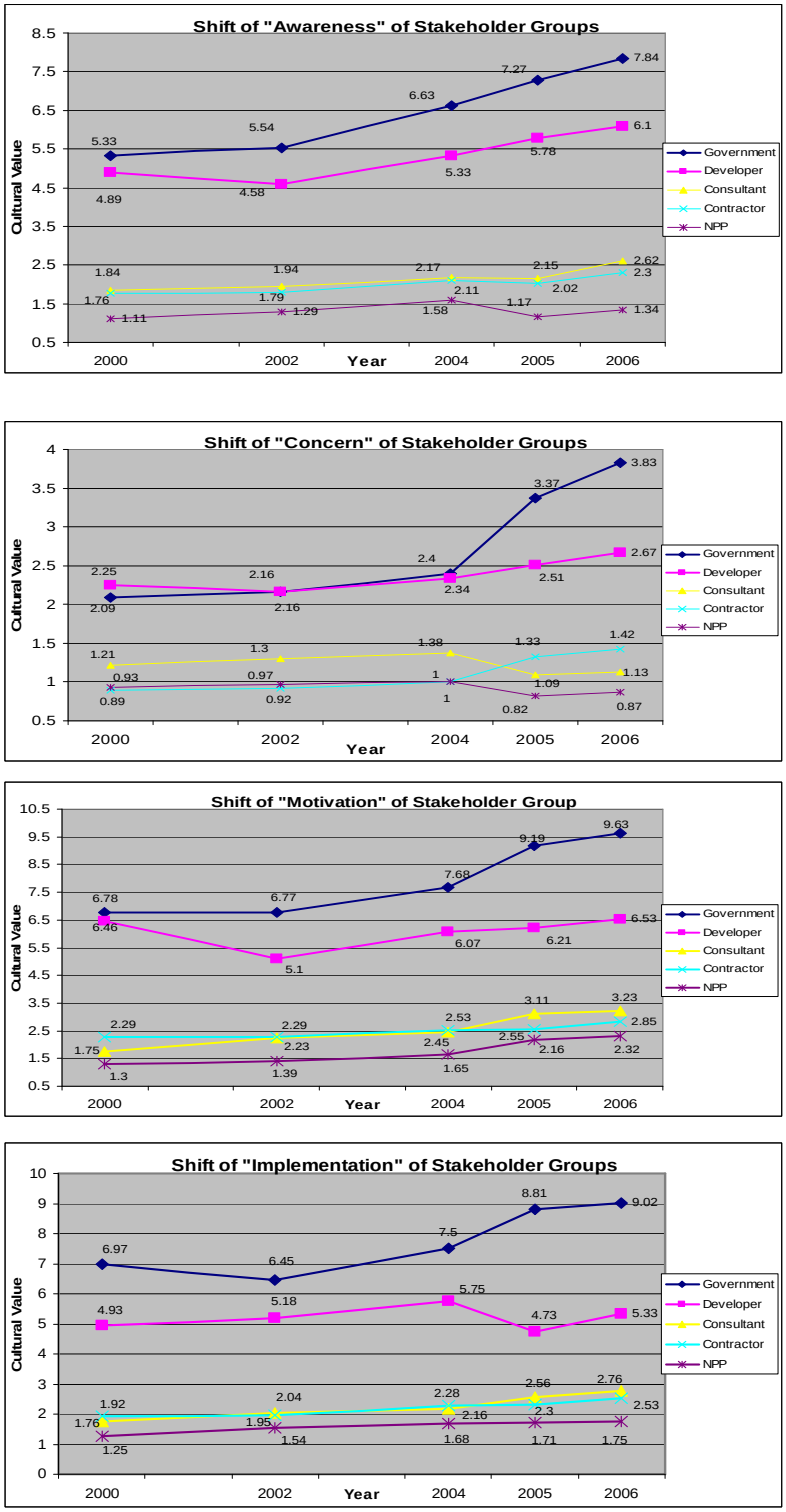


Figure 4.7 Shifts of Cultural Components of each Stakeholder Group

Figure 4.7 indicated the shifts of cultural components of each stakeholder group, the curves illustrate only the trend of the shift within each stakeholder group. The magnitude on the curve of each figure is the cultural value which is the result of multiplying the cultural score with the influential factor (a_i). Therefore, it does not represent the significance of the shift within each stakeholder group and is not to be used for comparison. The effects of cultural shift within each stakeholder group will be discussed in Chapter 7.

4.7 Paired-Samples T-test: Identifying Cultural Shift on Sustainability

Paired-samples t-tests were used to compare and determine whether the magnitude of the cultural shift of various cultural components (Awareness, Concern, Motivation and Implementation) between the two selected year points is significant. A comparison by pairs of two year points covering the entire research period would show the significance of cultural shift within the research period of years 2000 to 2006. If the test result was significant at 0.05 level, then the null hypothesis of no significant mean difference between the two designated research years can be rejected, in order words, the shift of the cultural component in the two year points is significant.

The summary of test results shown in Table 4.6 reveals that the shift of cultural components in all stakeholder groups is evident in the research period between years 2000 and 2006. There are a few occasions in the analysis that had exceeded the 5% significance level and therefore the null hypothesis of no significant change in the tested sustainable components cannot be rejected. Among all stakeholder groups, the

developer group was the least aggressive in cultural change. Insignificant shift was found in “awareness”, “motivation” and “implementation” especially between year points of 2000, 2002 and 2004. Similar results are obtained from the Government group in “concern” and “implementation” between years 2000 and 2002, reflecting the fact that the Government and the Developer groups in Hong Kong have made limited improvement in the early years in the promotion on sustainable construction. In contrast, the Consultant, the Contractor and the NPP groups exhibited significant cultural shift throughout the research period.

Table 4.6 Summary of Paired-sample t-tests Result

		Government			Developer			Consultant			Contractor			NPP		
	year	Mean Difference	*t*	Sig.	Mean Difference	*t*	Sig.	Mean Difference	*t*	Sig.	Mean Difference	*t*	Sig.	Mean Difference	*t*	Sig.
Awareness	2000 vs. 2002	1.17	-16.21	0.000**	0.14	-0.49	0.629	0.15	-4.16	0.000**	0.32	-13.10	0.000**	0.32	-8.57	0.000**
	2002 vs. 2004	1.11	-18.82	0.000**	0.60	-1.72	0.099	0.17	-2.32	0.030*	0.33	-15.13	0.000**	0.36	-4.59	0.000**
	2004 vs. 2006	0.89	-6.47	0.000**	0.79	-7.54	0.000**	0.79	-7.98	0.000**	0.42	-12.58	0.000**	0.25	-4.26	0.001**
Concern	2000 vs. 2002	0.05	-0.39	0.695	0.10	-2.12	0.045*	0.02	-0.89	0.383	0.09	-8.30	0.000**	0.06	-1.82	0.086
	2002 vs. 2004	0.23	-10.00	0.000**	0.20	-4.33	0.000**	0.10	-3.44	0.002**	0.09	-8.52	0.000**	0.05	-2.92	0.010*
	2004 vs. 2006	0.29	-5.30	0.000**	0.21	-2.41	0.020*	0.06	-4.58	0.000**	0.19	-9.46	0.000**	0.15	-3.16	0.008**
Motivation	2000 vs. 2002	0.79	-12.24	0.000**	-0.44	1.31	0.203	0.36	-3.56	0.002**	0.22	-6.17	0.000**	0.28	-4.85	0.000**
	2002 vs. 2004	0.93	-12.66	0.000**	1.12	-2.91	0.008**	0.30	-4.95	0.000**	0.27	-8.96	0.000**	0.24	-3.74	0.002**
	2004 vs. 2006	0.78	-5.28	0.000**	0.62	-4.78	0.000**	0.64	-5.79	0.000**	0.48	-11.03	0.000**	0.33	-4.18	0.001**
Implementation	2000 vs. 2002	0.23	-1.73	0.085	0.76	-2.63	0.016*	0.17	-2.57	0.017*	0.30	-12.03	0.000**	0.42	-5.86	0.000**
	2002 vs. 2004	0.99	-14.07	0.000**	0.57	-1.77	0.093	0.08	-2.09	0.048*	0.35	-12.72	0.000**	0.13	-5.45	0.000**
	2004 vs. 2006	0.59	-3.48	0.001**	1.13	-4.98	0.000**	0.53	-6.07	0.000**	0.44	-11.86	0.000**	0.26	-4.80	0.000**
Total	2000 vs. 2002	2.25	-8.31	0.000**	0.49	-0.73	0.475	0.62	-3.81	0.001**	1.00	-15.92	0.000**	1.10	-8.02	0.000**
	2002 vs. 2004	3.23	-20.53	0.000**	2.27	-2.49	0.020*	0.91	-2.92	0.007**	1.02	-16.00	0.000**	0.70	-5.60	0.000**
	2004 vs. 2006	2.76	-6.50	0.000**	2.82	-6.95	0.000**	1.95	-7.24	0.000**	1.59	-15.63	0.000**	1.05	-6.24	0.000**

Note:
** *t*-statistic significant at .01 level
* *t*-statistic significant at .05 level
N (2006 survey) = 161; N (2004 survey) = 66

4.8 Independent T-test: Identifying Difference among Industry Stakeholders

Independent sample t-test is a statistical test for comparing the means between two construction stakeholder groups in order to determine whether the means on the four sustainable components are significantly different from one another in a specific point in time. If the test result was significant at the 0.05 level, then the null hypothesis that there is no significant difference in the mean values between the respondent groups can be rejected. Table 4.7 and Table 4.8 reveal the results of the independent-sample t-tests based on the surveys conducted in years 2004 and 2006, respectively (the mean values can be found in Appendix 5). Discussions of the findings are presented in Chapter 7, section 7.1.4.

Table 4.7 Summary of Independent-sample t-tests Result in 2004

Government	Developer	Contractor	Consultant	NPP
Government compares with →	A: 0.166 (1.391)	A: 0.017* (2.410)	A: 0.114 (1.587)	A: 0.733 (0.342)
	C: 0.247 (1.185)	C: 0.001** (3.489)	C: 0.000** (4.741)	C: 0.000** (6.634)
	M: 0.582 (0.632)	M: 0.883 (0.148)	M: 0.084 (1.736)	M: 0.235 (1.191)
	I: 0.899 (0.127)	I: 0.014* (2.466)	I: 0.001** (3.266)	I: 0.403 (0.849)
	T: 0.147 (1.455)	T: 0.163 (1.398)	T: 0.251 (1.151)	T: 0.321 (0.996)
	Developer compares with →	A: 0.002** (3.113)	A: 0.010* (2.658)	A: 0.499 (0.685)
		C: 0.855 (0.185)	C: 0.149 (1.471)	C: 0.041* (2.125)
		M: 0.507 (0.665)	M: 0.105 (1.652)	M: 0.183 (1.354)
		I: 0.148 (1.452)	I: 0.008** (2.769)	I: 0.462 (0.743)
		T: 0.052 (1.950)	T: 0.050* (2.009)	T: 0.795 (0.261)
		Contractor compares with →	A: 0.609 (0.512)	A: 0.255 (1.176)
			C: 0.004** (2.918)	C: 0.001** (3.290)
			M: 0.119 (1.565)	M: 0.212 (1.286)
			I: 0.017* (2.394)	I: 0.515 (0.661)
			T: 0.749 (0.320)	T: 0.148 (1.452)
			Consultant compares with →	A: 0.179 (1.365)
				C: 0.397 (0.855)
				M: 0.850 (0.190)
				I: 0.050 (2.013)
				T: 0.104 (1.657)

Note: A – Awareness; C: Concern; M: Motivation; I: Implementation; T: Total

** *t*-statistic significant at .01 level

* *t*-statistic significant at .05 level

Values in parentheses are absolute *t*-statistics

Table 4.8 Summary of Independent-sample t-tests Result in 2006

Government	Developer	Contractor	Consultant	NPP
Government compares with →	A: 0.002** (3.125)	A: 0.005** (2.876)	A: 0.595 (0.540)	A: 0.289 (1.100)
	C: 0.890 (0.139)	C: 0.021* (2.324)	C: 0.528 (0.633)	C: 0.147 (1.464)
	M: 0.328 (0.240)	M: 0.084 (1.733)	M: 0.568 (0.573)	M: 0.000** (3.711)
	I: 0.003** (0.244)	I: 0.004** (2.903)	I: 0.489 (0.695)	I: 0.785 (0.278)
	T: 0.217 (0.358)	T: 0.063 1.881	T: 0.945 (0.069)	T: 0.075 (1.807)
	Developer compares with →	A: 0.000** (5.195)	A: 0.449 (0.771)	A: 0.043* (2.198)
		C: 0.064 (1.862)	C: 0.653 (0.453)	C: 0.147 (1.487)
		M: 0.660 (0.441)	M: 0.257 (1.162)	M: 0.000** (4.939)
		I: 0.188 (1.320)	I: 0.126 (1.53)	I: 0.041* (2.093)
		T: 0.929 (0.090)	T: 0.484 (0.704)	T: 0.021* (2.376)
		Contractor compares with →	A: 0.149 (1.507)	A: 0.799 (0.287)
			C: 0.092 (1.692)	C: 0.874 (0.158)
			M: 0.155 (1.477)	M: 0.000** (5.074)
			I: 0.339 (0.958)	I: 0.203 (1.335)
			T: 0.456 (0.762)	T: 0.001** (3.434)
			Consultant compares with →	A: 0.229 (1.227)
				C: 0.092 (1.740)
				M: 0.017* (2.534)
				I: 0.498 (0.691)
				T: 0.207 (1.290)

Note: A – Awareness; C: Concern; M: Motivation; I: Implementation; T: Total

** *t*-statistic significant at .01 level

* *t*-statistic significant at .05 level

Values in parentheses are absolute *t*-statistics

4.9 Summary

This Chapter has presented the findings from the quantitative analyses of the questionnaire surveys. The influential power of each stakeholder group towards the outcome of sustainability in construction is identified. Based on the measurement tool developed i.e. the T-model, the cultural shift towards sustainability took place in the Hong Kong construction industry between years 2000 and 2006 is revealed. Significant cultural shift has occurred in the construction industry and the reasons behind the shift are validated, discussed and will be elucidated in following Chapters.

CHAPTER 5 MEASURING CULTURAL SHIFT TOWARDS SUSTAINABILITY: STRUCTURED INTERVEIW

5.1 Introduction

The results of the data analyses on the cultural shift of the construction industry of Hong Kong between years 2000 and 2006 have been presented in the previous chapter and were based on Kibert's theory on sustainable construction and Azjen's theories of TPB and TRA. Positive cultural shift has been identified in the questionnaire survey researches, it is a reflection on the accomplishment in sustainable construction by stakeholder groups within the entire construction industry of Hong Kong. To investigate cultural shift through the perspectives of various industry stakeholders, a series of interviews have been conducted to cross-reference with the measured result. The details on how the interviews were planned, structured, and executed have been elucidated in Chapter 3, section 3.4.

The questions that formed the basis of the interviews are grouped into three parts. Part 1 comprised the closed-end questions which were designed to re-examine the findings obtained from the two questionnaire surveys after the analytical processes of the T-model. Part 2 comprised open-end questions which encouraged interviewees to freely express their opinion on perception of cultural shift not only within the stakeholder group that they personally belong to but also the cultural shift of the other groups. Part 3 featured three schedules which listed out questions on how cultural attributes are related to activities, whereby interviewees were requested to identify the

cultural components that have taken effect to accomplish the sustainable results listed in these three schedules. Their identifications were not limited to the prescribed cultural components in awareness, concern, motivation and implementation, as interviewees were invited to provide additional component(s) in accordance with their own view and judgment. In addition, interviewees were encouraged to express freely their perception on the sustainable culture of the construction industry of Hong Kong and their observations on the shift of sustainable culture among their colleagues and co-workers.

5.2 Views of Interview Respondents on Groupings of Stakeholders and their Influential Power

With respect to the categorization of stakeholder groups, all interviewees agreed with the categorization of the first four stakeholder groups (i.e. government, developer, consultant, and contractor). However, 5 out of a total of 8 interviewees (62.5%) did not recognize NPP as a stakeholder group. Some of them even expressed doubts on the existence of such a group, in fact, the NPP group does not belong to any of the distinguished social settings such as unions or professional associations within the construction industry. Nevertheless, all rejecters agreed that even though NPP may not be recognized as a stakeholder group, the non-professionally recognized managers and supervisors who worked on the construction sites have played an important role in various construction projects and their existence in the construction industry of Hong Kong cannot be denied. In this connection, deletion of the research data on cultural shift perception from the NPP group is therefore inappropriate.

One interviewee suggested putting the end-users of built facilities such as owners of residential units into the NPP group. This idea has not been accepted because most residential unit end-users are not participants in the construction industry and do not play a significant role in driving any change in sustainability in construction. From a business strategy point of view, end-users expectations on quality building asset may influence the business setting for developers which may affect the output of contractors, but then again influence of this nature would be very diversified, e.g. selling price of residential units, facilities provisions within the residential development, which are clearly beyond the core of this study.

In the identification of influential power of each stakeholder group that affect the sustainable output of construction project, the result of the interviews matched closely with the results obtained from questionnaire surveys conducted in years 2004 and 2006. Table 5.1 listed out the results of each stakeholder group in the two surveys and the outcome of structured interviews on influential power of each stakeholder group.

Table 5.1 Comparison of Influential Factor of Each Stakeholder Group

Stakeholder Groups	**Weighing of Influential Power**			
	2004 Survey Result	**2006 Survey Result**	**Respondents' View from Questionnaire Surveys**	**Interviewees' View from Structured Interviews**
Government	37.3%	39.5%	Highest	Highest
Developer	28.4%	28.0%	High	High
Consultant	13.1%	12.7%	Moderate	Moderate
Contractor	12.5%	12.5%	Low	Low
Non-Professional Participants (NPP)	8.7%	7.4%	Lowest	Lowest

The survey results in years 2004 and 2006 are close to each other which signaled a consistency of the influential power weighing of each stakeholder group. The same hierarchy of influential power has been obtained from the structured interview exercise which confirmed the validity of the influential factor (a_i). Thus, the cultural values of this study are reliable because they are generated from multiplying (a_i) with the cultural scores from the two questionnaire surveys.

5.3 Views of Interview Respondents on the Closed-end Questions

The closed-end questions in Part 1 guided interviewees to provide firm answers to each question so as to allow them to build up a solid impression on sustainable culture before entering the open-end question section which required interviewees to express views on cultural shift and provide suggestions for enhancement of sustainable construction in Hong Kong. The results of structured interviews obtained from the interviewees of each stakeholder group on the closed-end questions were very consistent. Their responses are summarized and tabulated in Table 5.2.

Table 5.2 Research Results of Closed-end Questions in Structured Interviews

Interview Questions Answers to the Closed-end Questions		Interview Results (Categories of Interviewees)								Survey Results	Remarks
		Government (Govt.)		Developer (Devp.)	Consultant (Consu.)	Contractor (Contr.)			NPP (Npp)		
1. Interviewee is aware of Sustainable Indicators established by the Government of Hong Kong.		N	N	N	Y	N	Y	N	N	Partially Aware	Note 1
2. The construction industry of Hong Kong is generally subdivided into the following 5 stakeholder groups.	Govt. group	Y	Y	Y	Y	Y	Y	Y	Y	Y	Note 2
	Devp. group	Y	Y	Y	Y	Y	Y	Y	Y		
	Cons. group	Y	Y	Y	Y	Y	Y	Y	Y		
	Cont.. group	Y	Y	Y	Y	Y	Y	Y	Y		
	NPP group	Y	Not exist	Not exist	Not exist	Not exist	Not exist	Y	Y		
3. Interviewees expressed their opinion on the hierarchy of Influential Power of Stakeholders that aligned with the results from the year 2004 and 2006 questionnaire survey.		Y	Y	Y	Y	Y	Y	Y	Y	Y	Note 3
4. Interviewee expressed their opinion on Sustainable Construction will improve the well being of the construction industry as well as the society as a whole		Y	Y	Y	Y	Y	Y	Y	Y	Y	
5. Interviewees expressed their opinion on the changes in attitude and behaviour among their colleagues and co-workers that is favorable to sustainable construction.		Y	Y	Y	Y	Y	Y	Y	Y	Y	
6. Interviewees expressed their opinion that their colleagues and co-workers are aware of the necessity to implement sustainable construction.		Y	Y	Y	Y	Y	Y	Y	Y	Y	
7. Interviewees expressed their opinion that their colleagues and co-workers are concern about the construction industry has causing damages to the environment		Y	Y	Y	Y	Y	Y	Y	Y	Y	
8. Interviewees expressed their opinion that their colleagues and co-workers are willing to motivate changes to improve the damage.		Y	Y	Y	Y	Y	Y	Y	Y	Y	
9. Interviewees expressed their opinion that their colleagues and co-workers are taking actions to implement sustainable construction		Y	Y	Y	Y	Y	Y	Y	Y	Y	
10. Interviewees expressed their opinion that their colleagues and co-workers are prepared to increase budget to uplift sustainable construction		Y	Y	Y	Y	Y	Y	Y	Y	Y	

Legend: N = No, Y = Yes,
Govt. = Government
Devp. = Developer
Cons. = Consultant
Cont. = Contractor
NPP = Non-professionally Recognized Frontline Construction Participant

Note 1 : 6 out of 8 interviewees (75%) are not aware of the Sustainable Indicators established by the Government which is higher than the surveyed results of 62% in year 2004 and 68% in year 2006

Note 2 : 5 out of 8 interviewees (63%) disagree that NPP is regarded as a stakeholder group, but all of them recognized their importance in ensuring sustainable output in construction project.

Note 3: All the stakeholder groups come out with the same hierarchy in Influential Power and the result of the interviews closely matched with the outcomes of the year 2004 and 2006 questionnaire surveys.

The responses of interviewees to the closed-end questions are firm answers to each questions and this may signify that the respondents have sufficient knowledge on the interview topic, thus their answers provided in the entire structured interview are dependable. Except a single difference on the groupings of stakeholders in NPP category, the answers to the closed-end questions from all interviewees are identical and the outcome is close to the findings obtained from the two questionnaire surveys.

5.4 Views of Interview Respondents on Open-end Questions

In answering the open-end questions which attempted to identify the existence of cultural shift, all interviewees agreed that they have certainly seen positive changes in sustainable culture among stakeholders. They confirmed that some stakeholders initiated changes autonomously and aggressively, while others changed reluctantly and tried to cling to their habitual practices without taking into account of the new sustainable requirements. However, all the interviewees concurred that more and more stakeholders are willing to use more environmentally friendly materials, employ low-waste construction methods and reduce generation of construction waste if these options do not increase considerably both cost and time, and if these materials and construction methods are convenient to apply without too much diversion from habitual practices. The interviewees also agreed that some stakeholders have even considered spending more to reduce negative environmental impacts arising from project development and construction. They have seen extra resources that aimed at improving sustainability being provided in some government projects. The situation was most obvious after the Severe Acute Respiratory Syndrome (SARS) incident in

year 2003. In general, the changes in resources allocation were brought about by demands for betterment in economic, social and environmental conditions.

In exploring their views on the cultural components that constituted the sustainable culture, all the interviewees were positive and agreed that the cultural components of awareness, concern, motivation and implementation covered the attitudes and behaviours of stakeholders in recognition and execution of sustainable construction requirements. Most importantly, all of them agreed that their co-workers and counterparts showed changes in attitudes and behaviours to a certain extent favorable to sustainability which indicated a positive change towards sustainable culture. It is concurrent within all stakeholder groups that the universal values of sustainable construction and sustainable development have started to be commonly recognized by the construction industry of Hong Kong.

In replying to the question on rating of changes in sustainable culture among stakeholder groups, all acknowledged that the Consultant group and the Government group ranked higher in the hierarchical order, the Developer group was the lowest rated group.

All interviewees showed enthusiasm in uplifting sustainability if they are given authority to spend more in their projects. Interviewees of the government group were prepared to spend 5 to 10% more in contract sums for sustainability; the interviewee of the developer group would allow only 1 to 2% extra in the construction budget; the consultant group suggested to add 5% to enhance sustainable construction; the contractor group dangled between 2% to 3% additional in their cost of construction,

and the NPP group envisaged an increase of 10% to cover the tidying up of the construction site and improve construction safety. The percentage of increase suggested by the interviewees of each stakeholder group, however, is not a gauge to assess the devotion of each group to sustainability. The variance in percentages suggested cannot be viewed as a scale of measurement, instead, it is a result of their professions and the job nature they performed in their different job duties. The most important fact is that all of them are eager to spend more on sustainability which is a solid reflection that a cultural shift is underway among all stakeholder groups.

In view of practicality in promoting sustainable construction, the interviewees have been asked what they would propose to their superiors on enhancing sustainability. Except the NPP interviewee who suggested improvement on safety and environmental protection on construction sites, the interviewees of all other stakeholder groups suggested partnering approach in construction management to their superiors as a tool to enhance sustainability. The overwhelming recognition of partnering approach as an effective tool to enhance sustainability is a therefore a new topic for further study.

It is interesting to note that despite promotional work undertaken by the government, the sustainable indicators established by the Government of HKSAR were not familiar to stakeholders to such an extent that even interviewees belonging to the government group had not been aware of the existence of such sustainable indicators. In view of this situation, it would be safe to conclude that Government efforts in the early years of promotion activities for sustainable development have not been effective.

An important message was given by one of the interviewees from the contractor group. It was suggested that when sustainable construction is fully implemented as a basic requirement for all construction projects and stakeholders are performing the same autonomously, a moral sentiment can be built up among them as an obligation, all construction participants at this stage are "committed to perform sustainability" as a voluntary action. It was opined that "committed to perform sustainability" should be added after implementation as one of the cultural components.

5.5 Attributes of Cultural Components that were Realized in Sustainable Construction Activities

Subsequent to Government promotion on sustainable development in 1999, examples of sustainable construction activities and events that were carried out in Hong Kong that helped to realize sustainability could mainly be represented by three different types of attributes:

- Activities carried out by academia and stakeholders in the area of research and development of new products, construction methods and management systems favorable to sustainable construction;
- Interactive activities between by government and stakeholders to realize sustainable construction through policy making and regulatory action; and
- Sustainable construction project cases that have been carried out under Government policy and/or stakeholders implementation.

Part 3 of the interview questions were given to the interviewees in advance, these questions listed out the abovementioned activities as well as some commonly recognized sustainable project cases. Interviewees were allowed the opportunity to

thoroughly appreciate the cultural components attributable to these selected events before they were interviewed. They were guided to differentiate their judgments in various cultural components in order to identify which of the cultural components have been better covered within the research time frame. They were guided to provide answers at the beginning according to the pre-set definitions of cultural components and were encouraged to freely express their views on whether new cultural components are embodied in these activities and sustainable project cases**.** Their answers were differentiated into cultural components of awareness, concern, motivation and implementation and are listed in Tables 5.3, 5.4 and 5.5 which identify the attributes of sustainability towards sustainable construction.

Table 5.3 Research and Development Activities for Sustainable Construction

Survey Results						Interview Results
Activity	Nature of Activity	Year	Initiated Organization	Outcome	Reference	Cultural Attribute
Use of recycled aggregate	Pilot test of using recycled aggregate as road subbase and ready mixed concrete	1997	S.C.C.T. of Govt. of HKSAR and the HK Polytechnic University (HKPU)	Reduced and reuse C&D waste, recycled aggregate is widely used in concrete in government projects	Poon *et al* (1997)	Motivation and Implementation
Review on Low-waste construction technologies	Research on various low-waste construction technologies	1999	HKPU	Making low-waste construction technologies to stakeholders	Poon *et al* (1999)	Awareness, Concern and Motivation
Reuse building stock	Research on reuse of building stock	2001	The Hong Kong Institution of Engineers (HKIE)	Some building stock reused	Koenig *et al* (2001)	Awareness, Concern and Motivation
Guidebook for minimizing C&D waste	Published two guidebooks for minimizing C&D waste	2001 and 2002	HKPU	Enhanced adoption of low-waste technologies in the construction industry	Poon *et al* (2001); Poon and Jaillon (2002)	Awareness, Concern, Motivation and Implementation
Study modular construction	Research on application of modular construction	2002	HKIE	Enlarge the extent of research on modular construction	Tam (2002)	Motivation and Implementation
Reduce construction waste on site	Review on reducing building waste in construction site	2004	HKPU	Promotion of reduction of construction waste	Jaillon and Poon (2004)	Concern, Motivation and Implementation
Promote adoption of prefabrication	Research on reform construction method	2005	Construction Industry Institute	Promote application of prefabricated building components	Yeung *et al* (2005)	Motivation and Implementation

Table 5.4 Interactions between Government and Stakeholders in Sustainable Policy

Survey Results						Interview Results
Activity	Nature of the Activity	Year	Initiated Organization	Outcome	Reference	Cultural Attribute
Certification of ISO 14000	Environmental Management System Certification	1999 - now	Various Government Departments/ Developers/ Consultants/ Contractors	Upgrade organization management towards better environmental protection	Zhang *et al* (2000)	Implementation
The Study on Sustainable Development for the 21st Century in Hong Kong (SUSDEV 21)	Public consultation for sustainable development for Hong Kong	1997 - 1999	Government of HKSAR	Aroused public awareness and concern	ERM (2001)	Awareness and Concern
CIRC Report	Review the performance of the construction industry and recommend improvement measures	2000 - 2001	Construction Industry Review Committee/Government of HKSAR	Motivated stakeholders of the construction industry to improve towards sustainability	CIRC (2001)	Awareness, Concern and Motivation
Best Practice Guide for Environmental Protection on Construction Sites	Publish Guidebook for Environmental Protection in Construction Site	2001	The Construction Association	Improved performance in construction practice	HKCA (2001)	Motivation and Implementation
Guidebooks for Minimizing C&D Waste	Publish Guidebook for Minimizing C&D Waste	2001, 2002	The Hong Kong Polytechnic University	Enhanced adoption of Low-waste construction technologies	Poon *et al* (2001)	Awareness, Concern, Motivation and Implementation
Joint Practice Notes (JPN 1 and JPN 2)	Promotion of project sustainability by innovative design and construction by incentive scheme	2001, 2002	Government of HKSAR	Enhanced project sustainability both in design and construction	JPN (2001) & JPN (2002)	Implementation
New Procurement Evaluation Scheme	Introduce score system to evaluate tenders	2002 - now	Various departments of Government of HKSAR	Tender evaluation of government job based on performance in sustainability than tender price	PCICB (2002)	Implementation
Disposal Charge of C&D Waste	Impose of disposal charge of C&D waste at landfill sites	2005 - now	Government of HKSAR	Disposal of C&D waste at landfill sites reduced	Waste Disposal Ordinance, Cap 354N (2005)	Implementation

Table 5.5 Sustainable Projects under Government Sustainable Policy and Stakeholder Implementation

Survey Results					Interview Results
Project	Year of Completion	Sustainability Driving Organization(s)	Outcome	Research Reference	Cultural Attribute
The Orchards	2003	Developer and Contractor	Pioneering sustainability in project design in private residential project	Fong *et al* (2004)	Motivation and Implementation
The Charter	2004	Developer and Contractor	Partnering approach in construction management	Uebergang *et al* (2004)	Awareness, Concern and Implementation
One Peking Road	2004	Glorious Sun Group Ltd	Green design project using photovoltaic (PV) panel to operate electrical blinds	Tam (2004)	Implementation
Kadoorie Biological Sciences Building	2000	The University of Hong Kong (HKU)	Green design project with energy saving up to 44,070,000 KWH and CO2 reduction 26,880 tonnes in 50 years life span	http://www.hku.hk/mech/sbe/case_study/case/hk/hku-bsb/bsb-index.html	Awareness and Implementation
EMSD Headquarter	2004	Architectural Services Department HKSAR	Re-develop old building for new use	Mak (2005)	Motivation and Implementation
Wetland Park	2005	Architectural Services Department HKSAR and Contractor	A sustainable design and construction project that aroused public awareness of ecosystem	Li *et al* (2005)	Awareness, Concern and Implementation
Hong Kong Community College (HKCC)	2007	Developer and Designer	A pilot building project extensively use pre-cast units in structural elements	Not Available	Implementation

The interviewees' views provided in these three Tables show that activities carried out by academia in Table 5.3 in the area of research and development as a component of motivation far exceeded other components. It is a sign that the academia's effort has contributed to motivateing the change in sustainable culture. The views on activities undertaken by the Government and stakeholders as listed in Table 5.4 demonstrate a considerable excess in the component of implementation. The opinions obtained from the interviewees on the sustainable projects as tabulated in Table 5.5 show that the cultural component of implementation has overwhelmingly outweighed other components. This part of the structured interview revealed a twofold phenomenon: the academia's action motivated sustainability; the Government and other stakeholders

helped to implement sustainable construction.

5.6 Summary

The study by way of structured interviews outlined in this chapter was based on a qualitative approach, which in itself is a means of triangulation to cross-reference with the results obtained from the quantitative approach in questionnaire survey as presented in Chapter 4. The research outcomes from both qualitative and quantitative approaches are generally comparable.

The opinion from a significant number of interviewees on whether the NPP group should be genuinely regarded as a stakeholder group is an important piece of information on the grouping of the stakeholders. It is obvious that the stakeholders easily recognized the grouping system based on existing categorization by professions and practices. The categorization of the NPP stakeholder group as frontline supervisory participants should be further reviewed in future studies. Partnering approach in project management was introduced by the interviewees of the government group, the developer group, the consultant group and the contractor group as an effective means to enhance sustainable construction. The effectiveness of the partnering approach in enhancing project sustainability should be another topic for future study.

CHAPTER 6 MEASURING CULTURAL SHIFT TOWARDS SUSTAINABILITY: CASE STUDY

6.1 Introduction

Case study is a particular method of qualitative research, it involves an in-depth, longitudinal examination of a single instance or event rather than using large number of samples to examine a limited number of variables (Naoum, 2002). The process included observing phenomena, collecting data and analyzing information of a complex nature through extensive description and contextual analysis to generate a research result.

Support for the use of case study as appropriate research approach can be found in many sources, one of which is Babbie (1995) who stressed the comprehensiveness and perspective that field research can achieve. He contended that by going directly to the social phenomenon under study and observing it as completely as possible, a deeper and fuller understanding can be developed; the researcher *"may recognize several nuances of attitude and behaviour that might escape researchers using other methods"*.

Case study is particularly useful when it is important to understand some particular problems or situations in great depth (Patton, 1990). Indeed, seeking the extent of

cultural shift of the construction industry of Hong Kong is specifically the type of research for which the case study approach may apply.

Further support for using case study as the most suitable form of inquiry for this research is provided by Yin (2003). He asserted that as a research endeavour, a case study contributes uniquely knowledge of individual, organizational, social and political phenomena – one of the purposes of this research is to contribute to knowledge on fundamental elements leading to achievement of sustainability – the development and growth of sustainable culture among members of an identified social group. The cases selected allow investigations to retain the holistic and meaningful characteristics of real life phenomenon under the prevailing demand for sustainable construction and upgrading the practice in project development and construction operation. The four different projects below present various sustainability achievements and reflected the extents of cultural shift that have occurred in each case, retaining respective focuses on sustainability:

- ***The Hong Kong Community College Complex*** focused on application of precast construction in the superstructure of the development. As a result of cultural change among construction participants and stakeholders, an application of innovative construction method in project design and construction management was realized.

- ***Development of The Orchards*** (a residential development) focused on achievements in sustainability according to Government policy in promoting sustainable construction via the promulgation of Joint Practice Note 1 and Joint

Practice Note 2 (JPN 1 and JPN 2) in year 2001,

- ***Development of the Wetland Park*** focused on project design for sustainability and has resulted in promoting sustainability in project management within areas of project partnering and 5-S practice.

- ***Comparison of Formwork Systems for Identically Designed School Projects*** focused on the measurement of effectiveness in construction cost and time by using different construction methods. Although the attempt was initially driven by economic reasons, change of sustainable culture is revealed in the implementation of the new formwork system.

These case studies enabled assessments on implementation of sustainability in real life projects to reflect changes that took place among construction participants of "the developer stream" and "the contractor stream" in terms of their attitudes and behaviours towards sustainable construction. Members in the developer stream (Developer) included designers such as architects, engineers and surveyors and other related disciplines, whereas members of the contractor stream (Contractor) included main contractors and subcontractors of various trades and specialties.

The principle of assessment for the achievement of sustainability is based on sustainable indicators established by the Government of HKSAR in the Study on Sustainable Development for the 21st Century (SUSDEV, 1998) and the Environmental Resources Management Report (ERM, 2001). These sustainable indicators formed part of the questionnaire surveys which measured respondents'

awareness and concern for sustainability which resulted in motivation and implementation of sustainable construction. As originated by the Government, these indicators included economy; health and hygiene; natural resources; society and social infrastructure; bio-diversity; leisure and cultural vibrancy; and mobility. The selected cases for this research showed attempts to change design and construction methods towards sustainability and these sustainable indicators in turn reflected the shift of sustainable culture among construction participants.

To standardize the measurement and follow the attributes of sustainable development, these indicators are respectively classified as:

- Economic indicators,
- Social indicators, and
- Environmental indicators.

To deepen the analyses, indicators of these three attributes were used to calculate the impacts of different natures which are further divided into Direct Impact and Indirect Impact (Uebergang et al 2004).

On economic indicators, the monetary measurement for achievements as a result of stakeholders' (the Developer and the Contractor) value of money in terms of costs spent and profits realized were classified as direct impact. Indirect impact referred always to non-monetary measurements, such as innovations in project design, product quality, process effectiveness/efficiency, public image, enhancement of construction technology in improvement of construction method, enrichment in production of

materials and components, formation of new procurement system in supply chain management and development of partnership between contracting parties.

On social indicators, the direct impact pertains to safety and health of workers on the construction sites, shift of job skill from one trade to another, effects on the employment security of construction participants, quality of the product they produced and the change of employment opportunity. The most obvious example was the shift of traditional carpentry formwork fixing to installation of precast concrete unit in superstructure construction. The indirect impact related to shifting of job skills from one trade to another and was perceived as the creation of a new trade, uplifting the image of performing sustainable construction and impressing other construction participants to re-model their performances.

On environmental indicators, the direct impact represented the quantity of pollution and nuisance generated during construction stage in terms of emission of dust, discharge of waste-water, release of excessive noise and disposal of construction waste that harmed the environment. The measurement focused on environmental merits elicited from both project design and construction operations. The indirect impact signified the long-term results of the above pollutants which could have induced biodiversity effects to the atmosphere, hydrosphere and lithosphere.

6.2 Case Study I: The Development of the Hong Kong Community College – An Attempt for Betterment in Precast Construction

The Hong Kong Community College (HKCC) is a complex development for education purpose and is part of the Campus Development Plan of the Hong Kong

Polytechnic University. According to the sustainable criteria set up for campus development, the design and construction of HKCC must satisfy the functional requirements of a community college and to fulfill the standards of sustainable building in terms of development, construction and long-term operation.

The finalized development scheme was a 19-storey tertiary education building (Main Building) standing on top of a 4-storey podium (Podium). The complex comprises classrooms, lecture theatres, multi-purpose hall, laboratories, workshops, studios, and sport facilities. The superstructure of the development could be built by either traditional construction method or precast construction method with extra input from the developer, the design consultants and the contractor.

Precast construction is generally accepted as one of the improvements in the construction industry towards sustainability (Anson et al, 2003). The design of the superstructure has indicated an extensive use of precast units for most of the structural elements including column, beam and semi pre-cast concrete slab. Topping up concrete is used to monolithically bind all pre-cast units into an integral structural frame. The building is enveloped with Glassfibre Reinforced Cement (GRC) precast panel cladding.

The appealing surface of the precast concrete discarded the use of false ceiling in most portions of the building and facilitated easy access to building services in long term maintenance.

6.2.1 Design and Installation of Precast Concrete Units

Construction site is always regarded as a source of nuisance and a creator of large amount of waste. The precast concrete structure eliminates the use of timber formwork and reduces a significant amount of wet trade. Hampering noise in timber formwork erection and vibration noise in in-situ concrete pouring were greatly alleviated. The precast concrete units used in the superstructure of the Main Building were composed of precast columns, main beams, secondary beams, semi-slabs, façade and staircases. These precast units were manufactured off site in a specialist plant. The process is fully controlled to maintain product quality and reduce construction waste. Assembly and installation of such a large quantity of sizable precast concrete units required careful planning to ensure well-organized installation in proper sequential order. Figure 6.1 illustrates the arrangement and combination of these precast elements in a typical bay of the Main Building.

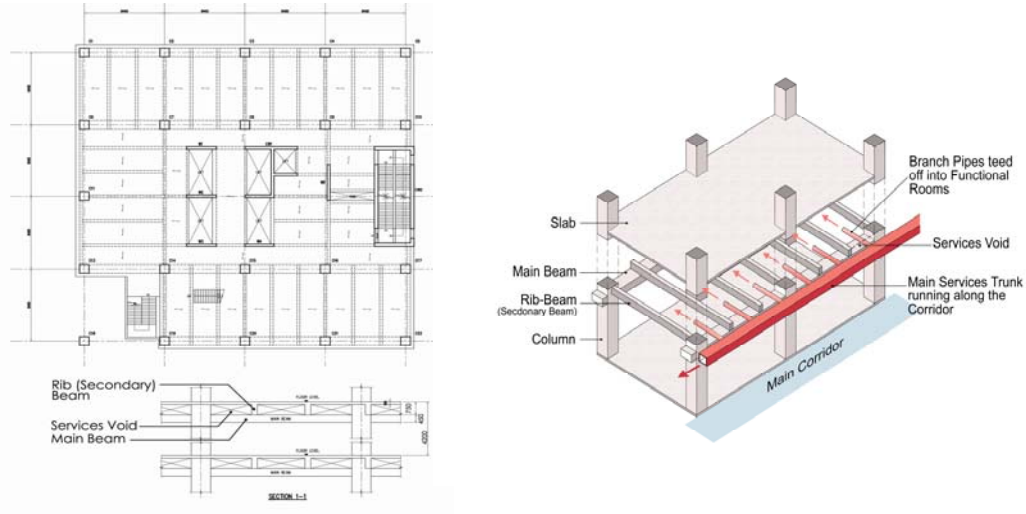


Figure 6.1 Arrangement and Integration of Precast Concrete Members and Main Services Trucking

Figure 6.2 shows the design and installation on a typical bay of the 19-story tower where precast columns in the upper and lower positions of the intermediate floor slab were fixed and stabilized by temporary raking shores to their final installation position with beams and other structural members. The precast columns and beams were interconnected with reinforcement bars and monolithically grouted with high strength concrete. Precast secondary beams were then placed on the top of the main beams where precast semi-slab panels were laid side by side on the precast secondary beam and followed by pouring in-situ concrete topping to complete the floor slab.

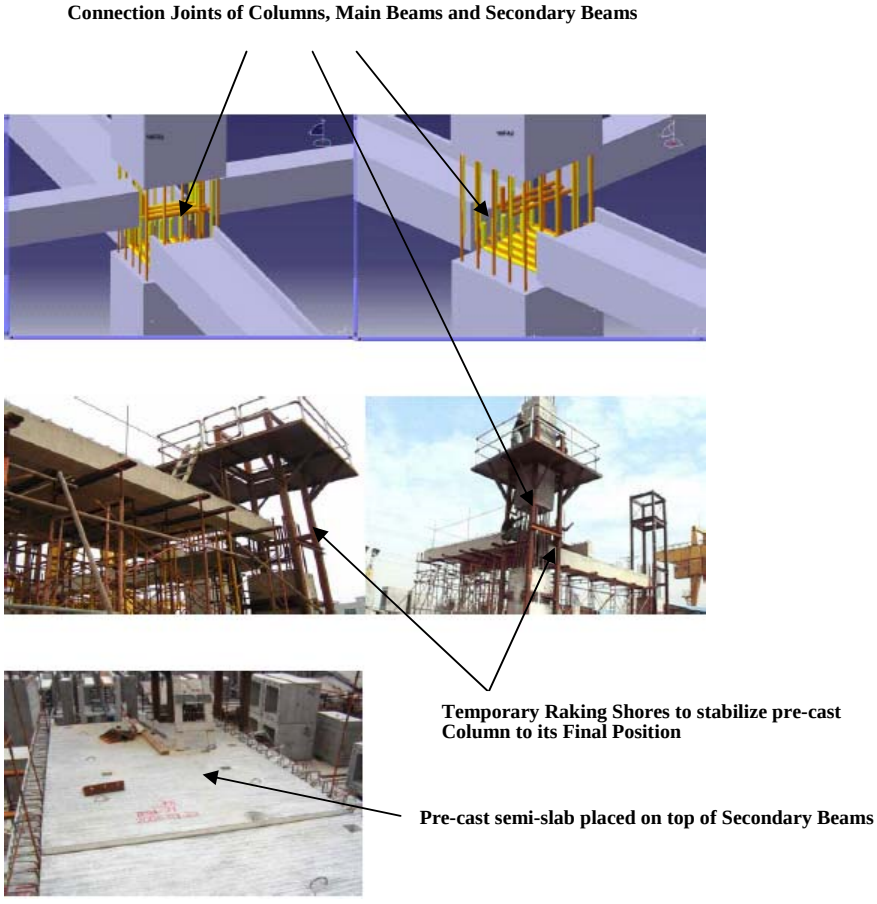


Figure 6.2 Design and Installation of Precast Elements of the Main Building

One way to maximize the advantages of precast construction for sustainability is to integrate the design of the precast superstructure and the method of installation. By so

doing, the size of the structural members of the superstructure are standardized into various types of precast units enabling sufficient repetition in the manufacturing process. The shape of precast units must be kept in simple geometrical forms to facilitate transportation and installation.

Previous studies revealed that construction costs can be reduced by using precast construction in large residential developments where similar or identical structural frame were chosen in a cluster of high-rise towers (Chiang et al 2004). Since the HKCC project is a single development of one 19-story tower on top of a 4-story podium, the development is not favorable for precast construction when compared to a multi-tower development. Other than cost effectiveness, converting major structural members of the 19-story building into precast units is considered adding value to the project in a sustainability perspective.

6.2.2 Assessment of Performance in Sustainability

According to section 6.1, evaluations within the case studies are standardized and followed the attributes of sustainable development, with data obtained through research activities being interpreted as performance indicators in economic, social and environmental attributes. These indicators were literally separated, and yet substantially interrelated with one another, e.g. investment in training to improve safety and environmental practices seemed to be financially unfavorable, but the return would be a reduction in accident rate and increased production under safer and cleaner site conditions, both of which signified contributions to the social and environmental attributes. In addition, an evaluation between the construction costs of precast superstructure and in-situ concrete superstructure shown in Table 6.1 showed

the former is slightly more expensive by HK$1,350,000 than the latter which represents 3% of the overall construction cost of the superstructure. However, the extent of reduction in construction waste (environmental) and the improvement of project quality (social) have not been evaluated, therefore, assessments must be made in a wider perspective on values of sustainability.

Table 6.1 Cost Comparison for In-situ Construction and Precast Construction

Particulars	**Estimated in-situ concrete structure for the whole development (HK$) ***	**In-situ concrete structure for Podium + pre-cast concrete structure for the 19-story tower (HK$) ***
The Podium		
Entirely in-situ concrete structure	21,030,000	21,030,000
The 19-story tower		
Lift core and Lift lobby areas (in-situ concrete portion)	12,690,000	12,050,000
In-situ concrete frame and slabs	11,440,000	--
Precast columns	--	3,485,000
Precast main beams	--	3,865,000
Precast secondary beams	--	3,090,000
Precast slabs	--	2,350,000
Concrete topping to precast slab surface	--	640,000
	45,160,000	46,510,000
Cost Difference	46,510,000 – 45,160,000 = **HK$1,350,000**	

* Allowances for preliminaries and contingencies are excluded

6.2.3 Assessment of Sustainability Performance in Economic Perspective

For the purpose of deepening the analysis and as spelt out in previous sections, the assessment of economic issues is separated into Direct Impacts and Indirect Impacts.

(i) Economic Issues

Direct Impacts

The economic issues are related to budgets of procurement in terms of the value for money spent against goods/services received. The assessments were based on the estimated budgets against the awarded contract sum. When the Developer decided to adopt precast construction, he is committed to expend more in enhancing project sustainability. The estimated cost of the project, as provided by the project quantity surveyor, was HK$305.64 million and the Contractor's tender amount was HK$307 million. The excess contract amount of HK$1.36 million is less than 0.5% of the estimated budget and has been included for the application of precast construction.

In the Contractor's perspective, precast construction is not an economic issue because precast construction has been technically specified and the Contractor tendered the specified requirement accordingly. The economic impact on the Contractor's perspective is the additional budget to be allowed for procurement of sustainability in enhanced site safety, site cleaning and other environmental friendliness issues. The additional costs in equipment, material and manpower to improve site safety and environmental protection issues provided by the Contractor during research activities are summarized in Table 6.2.

Table 6.2 Contractor's Budget for Site Cleaning and Environmental Protection

Item	**Original Budget (HK$)**	**Actual Running Cost (HK$)**	**Additional Cost spent on Site Improvements (HK$)**
Waste water control Plant	100,000	100,000	50,000
Temporary drainage for de-watering	30,000	50,000	30,000
Temporary latrines	60,000	40,000	40,000
Removal of rubbish I (by general cleaning contractor)	2,200,000	-	-
Removal of rubbish II (rubbish sorting cost)	-	-	500,000
Removal of rubbish (Payment for landfill charge)	-	-	420,000
Car washing pool	-	15,000	-
Total	**2,390,000**	**205,000**	**1,040,000**

The Contractor's budget for site cleaning and environmental protection was HK$2,390,000 + HK$205,000 = HK$2,595,000. On top of the original budget and the actual running cost, the Contractor spent additional expenses for site improvement were HK$1,040,000. Hence, the Contractor has spent 40% extra (1,040,000/2,595,000 = 0.4) on improvement of sustainability.

Indirect Impacts

The CIRC report (2001) suggested the selection of contractor by means of the value of performance. The tendering arrangement of the HKCC project was divided into two stages: prequalification stage and tendering stage. The purpose of prequalification was to shortlist qualified contractors to tender for the project. The selection emphasized sustainability and competence. In the prequalification stage, all interested contractors were asked to show their competence in handling substantial quantity of precast concrete units in high-rise superstructure, and to provide sustainable construction proposals in safety management and environmental

protection. The construction cost was not stressed as a priority. Ten reputed local and overseas contractors with proven performance records passed the prequalification and were eligible to tender for the project. The prequalification exercise has disqualified incompetent contractors with less sustainability consciousness from entering the tendering process even though they have historically low price records. The tendering arrangement indicated the Developer, the Hong Kong Polytechnic University, emphasized on sustainability rather than the cost of construction.

Each Contractor submitted a project management plan together with his tender submission. The plan integrated site safety supervision plan and waste management plan as part of the method statement for precast construction. The superstructure of the 19-story tower is a precast concrete superstructure. All precast components were manufactured by a specialist precast concrete supplier and installed by an experienced installation subcontractor under the management of the Contractor. The entire process formed a chain of supply with installation being handled by a group of professional companies with performance competency. The quality of precast concrete units and the installation works on site were kept to a high standard demonstrating effective progress along a competent supply chain. This supply chain has formed a strategic business alliance for projects of precast construction nature in Hong Kong. Such a strategic business alliance, when reviewed in a wider spectrum, instituted strategic partnering among stakeholders in the supply chain and may initiate a total reform of traditional business style of the construction industry of Hong Kong.

(ii) Social Issues

Direct Impacts

The superstructure of HKCC was composed mainly of precast concrete columns, beams, slabs and facades, with the method of construction entirely different from the traditional practice. To manage a project that contained large number of precast units, site tidiness and material supply logistics were the decisive factors for smooth running of construction activities. It was found that site tidiness and material supply were spontaneously performed by both the front line staff and construction workers. The site improvement and effective performance are obvious direct indicators in a social perspective.

Indirect Impacts

The adoption of the precast construction method in the HKCC project was not a common practice in Hong Kong, since most local contractors were not familiar with the operation. Traditional timber formwork erection was no longer a major construction activity and was replaced by precast unit installation. The indirect social indicators of the HKCC project were the increase in employment opportunities for precast concrete installers and the shrinkage of job vacancies for traditional formwork carpenters. The intensive use of precast concrete units as structural members in the superstructure of HKCC was regarded as substantial improvement in sustainable construction as it created a new image of pioneering sustainability by HKCC site staff. Their performance may have impressed other construction participants who would re-

model their mentality in adopting new construction technologies and perform more sustainable construction in other respective construction disciplines.

(iii) Environmental Issues

Direct Impacts

The structural members of the 19-story building were designed into a limited number of standard sized precast concrete units. The types of formwork moulds required to manufacture the precast units were reduced and thus increased the repetitive usage. The precast concrete units were manufactured in specialized plants for precast concrete production. Generation of construction waste was better controlled when compared to traditional timber formwork and in-situ concrete placing practice. Installation of pre-cast concrete units reduced a considerable amount of hands-on site activities thus minimized the chance of other forms of pollution in the construction site and its vicinity. The reduction of pollution included absence of hammering noise due to timber formwork, dust dispersion in concrete and mortar mixing, waste-water discharge, and last but not the least disposal of abandoned timber formwork materials to landfill sites.

Indirect Impacts

The reduced amount of pollution in terms of dispersion of dust, discharge of wastewater, release of excessive noise and disposal of construction waste were readily achieved when in-situ concrete construction was substantially replaced by precast construction, which in turn influenced the ecological impact on biodiversity in the terrestrial, freshwater and marine environments indirectly.

6.2.4 The Sustainable Culture of Stakeholders in HKCC Project

Direct impacts and indirect impacts regarding the sustainable indicators have reflected the input of the HKCC project in realizing sustainability. These inputs were the efforts of construction participants in the Developer and the Contractor streams, which represented a shift of sustainable culture among them. Research activities in this case study have attempted to explore the thinking of the key personnel of the Developer and the Contractor who have provided their views from various perspectives.

The Views of the Developer Project Team

Information obtained through discussions with the Developer project leader and subordinates revealed that the Developer project team intended to develop the HKCC into a sustainable building complex. The idea was supported by the top management of the campus development office of the Hong Kong Polytechnic University. The team initiated a development brief and instructed the design architect to propose both a sustainable building scheme and a traditional building scheme. A higher budget of not exceeding 15% in total construction cost would be allowed for the purpose of turning the development into a sustainable project. The designer in turn proposed three schemes for the building complex:

- Scheme A: a traditional cast in-situ superstructure
- Scheme B: a partial precast superstructure with pre-cast façade and semi pre-cast slab
- Scheme C: an intensive precast concrete superstructure with precast columns, main beams, secondary beams, staircases and slabs

Scheme C was finally adopted by the Developer project team and the extra cost spent on the superstructure was controlled within the predetermined 15% budget limit. The project leader of the Developer team has conveyed a very important message, that all members of the project team were aroused by the sustainability requirements and extended remarkable care to reduce construction waste, they autonomously attempted extra efforts to investigate more sustainable alternatives. Other than the precast construction of the superstructure, some other sustainable initiatives were also added into the project. These sustainable initiatives were not addressed here because they were beyond the focus of this case study on precast superstructure.

The Views of the Contractor Project Team

Information obtained from the project manager of the Contractor and his key subordinates during various site visits can be divided into three stages, namely the tender stage, the construction planning stage and the construction operation stage.

The Contractor is a well-established construction firm with abundant experience in handling a large quantity of precast concrete units in sizable projects for many years, the database of construction cost and management experience for precast construction is rich. The comparison of volume of concrete to be used in precast concrete units and cast in-situ concrete is summarized in Table 6.3

Table 6.3 Cost Data for Precast Units and Cast in-situ Concrete

Pre-cast Units	Unit rate of precast concrete component in m^3 (round up)	Unit rate of cast in-situ concrete of the same component in m^3 (round up)	Quantity of pre-cast unit against total quantity of precast concrete (by volume)	Cost spent on surface finishes
Semi-slab	HK$3,900	HK$2,700	22%	Minimal
Main and secondary beams	HK$2,800	HK$2,400	20%	Minimal
Façade (tile finishes excluded)	HK$5,700	HK$3,300	37%	None
Column	HK$3,500	HK$2,400	21%	Minimal

The Contractor generalized a 35% higher overall cost of precast construction than that of cast in-situ concrete in tendering the project. By using precast construction in the HKCC project, erection of scaffold for external finishes and ceiling finishes for most of the construction floor area have been eliminated. These represented substantial savings in the tender price. The Contractor eventually won the contract because of the following reasons:

(a) Performance record as a quality contractor in previous campus development projects.

(b) A good site safety and tidiness record.

(c) Experience in handling precast construction with large amount of precast concrete units.

(d) A reasonable tender price within the "15% extended budget" for sustainable building (information provided by the Developer project team).

(e) A preliminary Safety Management Plan and Waste Management Plan were incorporated into the tender submission to show that the Contractor has seriously put sustainability requirements into consideration.

After the award of contract, the Contractor upgraded their sustainability proposals into practice in the construction site. Site sorting facility for construction waste was set up, all construction wastes were sorted out and useful construction wastes were sent to respective dump sites or recycling facilities. In the selection of subcontractors, other than the tender price, performance of sustainability became an important issue to the Contractor. Site cleaning and tidiness requirements were deliberately added as an obstinate condition into subcontract documents and were stringently required for all subcontractors to comply. All subcontractors employed in this project were adequately alerted to the strict requirements and transmitted the same to their workers. Under the instruction of their employers, the workers reluctantly performed sorting construction wastes at the beginning of the project, however, they became increasingly more willing to sort once they became accustomed to the sorting activities with the support of their employers.

The research activities revealed that the planned sustainable operations were fully implemented with the support of the Contractor's top management. The project manager had once expressed that his greatest challenge was the logistic arrangements in handling the large quantity of precast units and the maintaining of a smooth and safe working environment without compromising site tidiness. He further expressed that the site was just like a training school for the subcontractors' workers who did not have experience with precast construction and the requirements for sustainability. The most difficult part was to change their "habitual malpractice" that contrasted markedly with the safety and environmental regulations. Some workers changed swiftly with attentive performance and others needed close supervision. There were incidents that a few very experienced workers with good traditional skills persistently

followed their usual practices and ignored the safety and the sustainability requirements, they were all removed from site. In the waste reduction perspective, the Safety, Health & Environmental (SHE) Manager of the Contractor added that the quantity of construction waste disposed in landfill sites was 70% less compared to other concurrent projects undertaken by the Contractor with traditional construction methods. He believed that the reduction of waste generation has been a result of both replacing timber formwork by precast construction and sorting construction wastes for recycling. In general, the overall performance of the site team achieved sustainable construction gradually and autonomously.

6.2.5 Summary of the Research Findings of the HKCC Project

The direct impacts and indirect impacts that affected the culture of construction participants of the HKCC project are summarized in Table 6.4 in terms of sustainable indicators according to economic, social and environmental attributes.

Table 6.4 Summary of Research Findings in terms of Sustainable Indicators - HKCC

Attributes of Sustainability	Direct Impact Indicators	Indirect Impact Indicators	Shift of Sustainable Culture
Economic Impacts			
1. Extra cost allowed by the Developer to procure sustainability.	*Up to 15% of the estimated cost for traditional construction method.*	*Use precast construction eliminated cost of handling timber formwork waste.*	***The willingness of stakeholders to spend extra cost to procure sustainability***
2. Extra cost allowed by the Contractor to procure site safety, cleaning and tidiness.	*Up to 40% of the estimated site cleaning and tidiness expenses at tender stage.*	*Improved site cleanliness and safety*	***ditto***
3. Innovative in Design towards sustainability.	*Encouraged the designer to pursue sustainability in project design*	*The supply chain of precast construction may result in the formation of Strategic Business Alliance between main contractor, pr-cast unit supplier and installation subcontractor in the form of strategic partnering*	***Motivated stakeholders to partnering approach in project management among stakeholders***
Social Impacts			
1. Using new construction technologies and management skill in precast construction.	*Reduced the use of traditional timber formwork and cut down the employment of carpenter and increase of precast concrete installation labour* *Creation of new trades in the construction industry*	*Gradually change of trade practices, occupations and employment opportunities.*	***Adoption of change and readiness to shift from one trade to another to meeting with the global trend for sustainable construction***
2. *Building up team spirit between project participants of client, designer and contractor.*	*Enhancement of cooperation and foster problem solving among front line staff*	*Removal of confrontational style of working attitude between project streams*	***Foster partnering culture among stakeholders in the construction industry***
3. Creation of a safer and cleaner working environment	*Increase of site safety and improvement of tidiness. Created safety and environmental culture among workers.*	*Improved image in construction safety and environmental protection in personal and organizational level.*	***Stakeholders have subconsciously accepted sustainability in construction management.***
Environmental Impacts			
1. Increase the use of precast construction for structural members.	*Standardizing pre-cast concrete members in structural frame, reduced the number of moulds thus reduced generation of construction waste of formwork, concrete, and other pollution like noise, dust waste- water etc.*	*Reduced biodiversity in terrestrial and freshwater pollution.* *Reduction of emission of dust and greenhouse gases into the atmosphere*	***NA***
2. Reduction of generation of construction waste and enhance recycling of construction waste by on site and off-site sorting.	*Construction waste is reduced 70% due to large elimination of timber formwork by pre-cast concrete elements.*	*Biodiversity effects would be reduced when construction waste in various forms is reduced.*	***Implementation of construction waste sorting have changed the attitude and behaviour in creation and handling of construction waste***

The project development, building design, construction management and operation of the HKCC project which all operated under the umbrella of precast construction have achieved the requirements of sustainable construction objectives. It is undoubted that the Developer team initiated sustainability in project development and their readiness to prepare to spend 15% more has inspired other stakeholders to perform sustainable

construction accordingly. The Contractor has set up management systems to maintain site safety and tidiness, sorting out construction waste and reduced pollution in noise, dust and wastewater etc. All these actions have in turn impacted upon the performance of subcontractors and affected their workers to work in a more sustainable way. A sustainable construction culture was thus built up in the HKCC project and has influenced the others in the construction industry of Hong Kong. The initiation for sustainability by the Developer project team has evidently influenced the attitudes and behaviours of other project participants in the implementation of sustainable construction. Such a change has propelled other project teams to focus on achieving sustainability in project design and construction. As such, the designer project team which was categorized as part of the Developer team has flexibly rendered extra efforts in producing three design schemes of non-sustainable, medium-sustainable and highly sustainable solutions and the Contractor project team adopted a number of environmentally friendly construction methods to achieve sustainability.

Sustainable indicators in an economic dimension have shown that the Developer invested an extra of HK$1,360,000 more for precast construction. The Contractor spent HK$1,040,000 more to procure site tidiness and cleanliness. Their actions resulted in motivating front line staff to implement sustainable construction and subcontractors to rectify their malpractice in safety and construction waste generation. The business alliance between stakeholders for future long-term cooperation was the indirect economic indicator which modified subconsciously the business culture among them. The social indicators for sustainability embraced building up team spirit among project participants of different discipline streams. The emerging of new occupations and the exit of the out-of-date skills has created an awareness because

these occupations were generally linked to sustainable construction. A new image may have emerged in the construction industry which in turn impresses other construction participants to re-model their performance. Reduction of construction waste by 70% is a significant indicator as an environmental issue. The reduced pollution in terms of dispersion of dust, discharge of wastewater, release of excessive noise is also significant and apparent.

6.3 Case Study II: The Development of The Orchards – Synergy of Government and Private Sector Pursuing for Sustainability

6.3.1 Background Information of The Orchards

The Orchards is a private sector residential development project in Hong Kong. It stands on a 5,740m^2 site allowing the development to erect two 48-storey residential towers of identical design on top of a 3-storey car-park podium (Figure 6.3). The development comprises 442 residential units, 144 parking spaces, podium garden, a swimming pool, a clubhouse on the 5th floor and sky gardens on the 17/F and 32/F of each tower. The gross floor area (GFA) of the project is 56,576 m^2, almost 10 times of the site area out of which 36,720 m^2 of the GFA is for domestic use.

Figure 6.3 The Design Concept of The Orchards – Two Residential Towers and a 3-storey Podium Car Park

The developer is one of the leading property developers and is commonly accredited as an environmentally conscious firm in Hong Kong. The Orchards was an urban residential development practically completed in 2004 and was given an "Excellent" rating by the HK-BEAM (Fong *et al*, 2004). The development was purposely designed to respond to Government policy in meeting newly introduced sustainable construction objectives under Joint Practice Note No. 1 (JPN 1, 2001) and Joint Practice Note No.2 (JPN 2, 2002). Joint Practice Notes No. 1 and 2 were jointly issued by the Buildings Department, Lands Department and Planning Department of the HKSAR Government in February 2001 and 2002 respectively. These Joint Practice Notes encourage the construction industry to explore ways to improve environmental performance in design and construction throughout the life cycle of new buildings. According to these two JPNs, additional GFA will be granted by virtue of the Building Ordinance for balconies, communal sky gardens, communal

podium gardens and wider common corridors and lift lobbies, etc. The additional GFA is a strong incentive to developers because this is equivalent to increasing the saleable area of the development.

The Orchards contained a number of green initiatives, innovations in design and construction including precast façade, lost form system, semi precast balcony and energy saving devices in illumination and ventilation. In the course of the development process from project inception stage to project completion stage, stakeholders of the developer project team, the designer project team and the contractor project team have worked together and put together a number of sustainable elements in the project. The achievements in sustainability in project design and construction management exemplify the cultural development and cultural changes in sustainability among stakeholders involved in the project. This case study focuses on measuring both achievements in sustainability:

- Project development in project design and construction management, and
- Sustainable culture development among stakeholders.

The former addresses performance of sustainability in project development, design, and construction operation, while the latter tackles the development of sustainable culture among stakeholders at every stage of the project.

6.3.2 Project Performance in Sustainability

Sustainability in Project Development

The measurement of project development sustainability focuses on achievements of a proposed project with respect to design, construction management and post occupancy operation according to values of sustainability. Assessment is made on introduction of new techniques to improve project quality, reduce pollution and construction waste, preserve earth resources, enhance living quality and, in parallel, create incentives by additional return on investment. In view of these merits, erecting of sustainable buildings would create a win-win situation for everyone involved including the end users and individual property owners.

The developer of The Orchards invited key stakeholders, including the design consultants and the main contractor of the project at the early design stage to make a number of innovative designs and construction means viable, including semi-precast balcony, lost form façade and energy saving devices. The adoption of all these new construction technologies in a single private residential development project has rarely been implemented in Hong Kong (Figure 6.4). CIOB (2002) appraised that *"new construction technologies were introduced with three different kinds of system in use at residential floors. Semi precast balconies cantilever out from floor slabs, joined to structural elements by rebars and beams, precast facades were placed at bedrooms and lost form panels were used at end walls"*. As a result, these green elements in The Orchards enabled the Developer to achieve additional GFA amounting to one additional floor in each Tower. The success of The Orchards was so attractive that to use precast construction in private residential development

became subsequently a trend in the construction industry of Hong Kong. The Orchards contained a number of environmentally friendly design and construction approaches covering architectural, structural and building services as well as construction management and site operation:

These environmentally friendly elements included:

- *Optimization of the Site Potentials:*

  The two residential towers were methodically positioned within the site area to optimize open spaces, energy efficient airflow as natural ventilation and desirable views to all residential units. All typical floors were located centrally and laterally symmetrical, thus allowing a full repetition of large panel formwork and pre-cast concrete elements.

- *Enlargement of Lift Lobbies in typical floors*

  Lift lobbies in all typical floors are 2.5 meters, which is 0.85 meter wider than the conventional lift lobby design for residential towers.

- *Adoption of Pre-cast Façades integrated with sun-shading fins*

  Pre-cast Façades integrated with sun-shading fins and cast-in window frames were pre-finished with either spray print or mosaic tiles in the manufacturing yard and transported to the site for installation.

- *Maximization of communal green spaces*

  The design maximized green spaces with hard and soft landscape provisions in

the podium area and the sky gardens on the 17/F and 32/F of each Tower.

- *Integration of Semi Pre-cast Balcony, precast façade with sun-shading fins into the superstructure*

  The structural design integrated semi precast balcony, precast facade and sun-shading fins into the superstructure monolithically as the building starts to envelope externally with in-situ concrete placing on every floor (Figure 6.4).

Figure 6.4 External Envelope of The Orchards containing Lost Form, Semi pre-cast Balcony and Pre-cast Facade

- *Application of Pre-finished Permanent Formwork (lost form) in the Building Envelope*

  The lost form system is a pre-cast concrete panel of 75 mm thick pre-finished with external wall tile. During construction of the superstructure, the lost form was installed as the exterior side of superstructure formwork system. The interior side of the formwork system was a large aluminum panel. Concrete was placed between the lost form panels and the aluminum formwork panels forming

the external wall of the building. By applying lost form in the superstructure formwork scraps and construction wastes have been reduced. Every typical floor of the residential tower used 12 pre-cast façade panels, 20 lost form wall panels, 10 lost form columns and 6 semi pre-cast balconies (building.com.hk, 2003).

Figure 6.5 indicates the installation of lost form and the aluminum formwork panel in each concreting cycle.

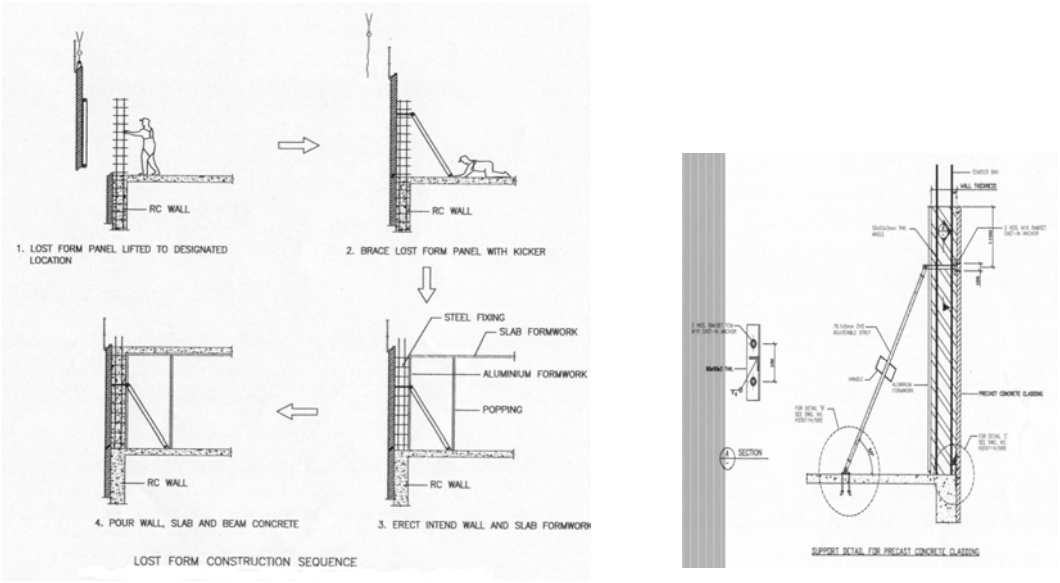


Figure 6.5 Construction of External Wall with Lost Form and Large Aluminium Formwork Panel

source: http://www.cse.polyu.edu.hk/~cecspoon/lwbt/Frame_Page/Frame_casest.html

- *Adoption of Environmentally Friendly Building Services Installations*

  Energy saving and environmental conservation were some of the prime design principles and equipment selection guidelines for building services installations.

In energy saving, solar power lighting systems were installed in the podium garden as landscape lighting. Natural lighting and ventilation were used in the podium car park and lift lobbies whenever possible. Cross ventilation was encouraged by opposite window installations in residential flats. For water saving, dual flush toilets were selected to save flushing water; rainwater-recycling tanks were equipped to collect rainwater for irrigation use. Ecologically, non-ozone depleting air conditioning systems were adopted throughout the entire development.

- *Construction Management and Site Operation to enhance sustainability*

  Apart from the use of low waste construction technologies and energy saving installations, the site management has implemented a comprehensive plan on pollution control with a list of objectives set up for monitoring the environmental conditions. Standard environmental control facilities such as wheel washing system at the site entrance, dust and noise barriers, and wastewater pollution control by checking the daily pH value of wastewater prior to discharging to public sewage system have all been implemented on site.

  A highly effective means to efficiently manage the development and construction progress of the project was the "e-Project Management System" (e-Project). This was a construction management extranet system pioneered in Hong Kong for handling contractual documentation, correspondence and drawing registration. A network was established and used by all contractual parties including the developer, designers, main contractor, nominated subcontractors and some major domestic subcontractors. They shared latest

construction information, variation orders, site condition changes as well as the exchange of documentation on a computer platform exclusively built up for the project and accessible only by the involved parties. Controlled access was provided to individual users to acquire sufficiently controlled information from the platform to perform their respective project duties. The instantaneous transmission of information facilitated rapid communication among all involved parties, thus prevented project delays and double handling. It was proven that the use of paper was largely reduced by 60% (Fong *et al*, 2004). The result was not only environmental friendliness but also relieved project staff from burying themselves into contract documentation hurdles.

6.3.3 Assessment of Performance in Sustainability

Sustainability performance of The Orchards project is also evaluated based on the attributes of sustainable development in economic, social and environmental dimensions.

(i) Economic Issues

Direct Impacts

One direct economic indicator of The Orchards was the Guarantee Maximum Pricing (GMP) contract value against the actual cost of the contract. The awarded contract value under GMP procurement is HK$497 million and the final contract sum is HK$468 million which is 5.8% less than the awarded contract amount (Swire, 2004). Construction cost is one of the major considerations in project finance, however,

achieving sustainability to gain extra GFA under JPN 1 and 2 has now become a key element for development finance. The developer used a two-stage tendering method to select the most ideal contractor who is capable of meeting both the competitive edge in construction cost as well as sustainability requirements.

Three lowest bidders were selected in the first round tendering process. These three selected contractors were required to demonstrate their technical capacity in handling the pre-cast construction requirements and other sustainable construction issues of the project. Cost assessment showed that precast construction demanded 1% higher cost than conventional cast-in-situ method, however, the developer decided to absorb higher costs to pursue sustainability and awarded the contract to the capable contractor (Fong *et al*, 2004).

Indirect Impacts

The use of GMP procurement has become a new trend in the construction industry in Hong Kong; the traditional procurement system has been replaced by GMP procurement in some construction contracts. Adoption of GMP procurement by a number of casino hotel projects in Macau (a neighboring city and a special administrative region under Chinese regime) has taken place by Hong Kong contractors working in Macau (Las Vegas Sands Inc. Quarterly Report, 2003). Eventually, intention of developers of new casino hotel projects in Macau to use GMP procurement has influenced Hong Kong contractors in return to modify their bidding strategy for Macau projects. Nowadays, the use of GMP procurement is growing in Hong Kong.

(ii) Social Issues

Direct Impacts

Social Indicators are measurements on how the project has affected social issues which encompass participants' working habit and attitude in safety and health, team spirit, trust and respect towards others. It is apparent that adoption of new construction methods and new technologies may have changed the working tradition of workers. For The Orchards, skills in erection of timber formwork have been largely replaced by installation of precast facades, lost form and aluminum formwork system. The change in employment opportunities for timber formwork carpenters has major impacts on social sustainability.

The direct social indicators of the project also included the safety performance in the construction site after introducing new technologies and construction methods. Front-line workers and site supervisors have adopted changes in construction methods and new technologies, and eventually changed their working habits and their trade practice. As advised by the project manager and the site agent of the contractor during a site visit, the number of timber formwork carpenters and the in-situ mixing plasterers had dropped drastically in the construction site. It is evidenced that changes in the social attribute of sustainable development have taken place. The annual accident rate in The Orchards (30 per 1,000) was below the average annual accident rate (85.2 per 1,000) of the construction industry of Hong Kong in 2002. Adoption of the e-project system has changed the mode of communication among the project team members. Productivity has improved because less time was spent on documentation retrieval and filing (HK-BEAM, 2005). The wider use of a paperless documentation

system reduced the consumption of paper which is also considered as one of the environmental indicators.

Indirect Impacts

The indirect social indicators embraced the change in employment opportunities as well as the emergency of new occupations and practices in the construction industry. Introduction of the lost form system, semi pre-cast balcony and the pre-cast façade in private residential development, when widely adopted, have significantly reduced the employment opportunity of conventional timber formwork carpenters which resulted in the reduction of carpentry occupation in the construction industry in Hong Kong. Certain construction skills such as application of spray-on-plaster and pre-finished wall partitions have replaced a large amount of traditional in-situ mixing and plastering works in The Orchards. These new construction skills are regarded as innovative working methods in sustainable construction. The views and opinions of front-line workers and site supervisors on the changes to traditional construction trades are particularly important; the recognition of sustainable construction that has been built up among them became a guiding principle and a concept that would impress other construction participants to re-model their traditional way of reviewing performance of sustainability.

(iii) Environmental Issues

Direct Impacts

The lost form and precast concrete units were manufactured under fully controlled conditions in a specialist precast concrete plant off-site. The chance that there might

be a large amount of construction waste generated was slim when compared to in-situ method of pouring concrete into traditional timber formwork. Installation of precast concrete units and lost form system reduced a considerable amount of hands-on site activities and thus minimized the chance of pollution in terms of noise and dust. In addition, the introduction of the e-project system has successfully reduced paper usage by 60%. The use of recycled rainwater irrigation system and dual flush toilet have cut down water consumption by 33%, energy-saving equipment such as solar lights have reduced electricity consumption by HK$500,000 per year (Fong *et al*, 2004).

Indirect Impacts

The major indirect impacts on the environments are biodiversity in terrestrial, freshwater, marine environment and the greenhouse effect with regards to the reduced quantum of pollution in terms of dispersion of dust, discharge of waste water, release of excessive noise. Adoption of non-ozone depleting air conditioning system have also reduced harmful emissions and therefore reduced harmful effects on biodiversity in the long run.

6.3.4 Development of Sustainable Culture among Stakeholders

To investigate cultural development in sustainability among stakeholders, the study has focused on the change of behaviour within those construction participants who have been involved in the project. The developer and the designers have initiated green features in the project according to the Government sustainable construction principles in JPN 1 and 2. Contractors who have been selected to tender were invited

to provide suggestions on improving the buildability of these green schemes. The process has brought together the project teams of the developer, designer and contractor to focus on building the development in compliance with sustainable construction criteria and become one sustainability conscious project team. The mutual recognition in project development sustainability was therefore consolidated among them before any construction work physically took place. Such cognition continued to strengthen and was implemented throughout the entire construction period.

Sustainable Culture Development in the Contractor Team

After the completion of The Orchards, key site management staffs were transferred to other construction sites. Unstructured interviews were conducted separately with them in a relaxed manner in their new assignment areas. The interviewees' replies to cultural changes were quite similar. They recalled that at the early stage of construction, subcontractor front line site staffs and workers did not concern themselves too much on sustainability and merely carried out their duties according to respective contractual obligations despite the fact that they noted the obligations contained requirements to enhance sustainable construction issues; in most case, they performed these obligations in an involuntary manner. When the project progress became stable and proceeded steadily, these site staffs started to realize the advantages of performing sustainability and became faithful performers through physical practices. Sustainable behaviour was gradually developed among them through practical works. It is unfortunate that the sustainable behaviour developed among members of the project team in the project could not be sustained when work conditions changed. After The Orchards was completed in 2003, some members of

the project team were transferred to other works where sustainability was not a priority, their sustainable performance in The Orchards diminished. The situation was particularly obvious when they were transferred outside of Hong Kong; their willingness to implement sustainability faded when, in their new assignment for a casino hotel project in Macau, sustainability was overridden by pressing completion schedule in meeting commercial objectives.

Sustainable Culture Development in the Developer Team

In an unstructured interview with the developer's senior project staff, he revealed that sustainable culture in the developer project team and the designer project team sustained after The Orchards was practically completed. Practice of sustainability continuously persisted among them in other projects of various natures. For the case of The Orchards, achievements in architectural and structural sustainability were obvious. During the project design stage, designers have found ways to extend their innovative power to new sustainable issues. The ideas were first discussed and shared among team members, inputs from contractors were then invited to refine buildability. The final design of The Orchards contained green features that were practical to build and proved that the incentives from JPN 1 and JPN2 were achievable. Both the developer and designer project teams tried to achieve sustainability in every aspect and persisted their efforts throughout the entire project life. The developed sustainable culture remained very active among the developer project team members as well as the designer project team members since fulfilling similar sustainable requirements become consensus. Ideas for sustainability became guiding principles for other new developments and were largely used in some other projects.

6.3.5 Summary of the Research Findings from The Orchards

To signify the accomplishment of sustainability in the development of The Orchards, Table 6.5 summarizes the indicators of sustainability in project development and construction operation.

Table 6.5 Summary of Research Findings in Sustainable Indicators – The Orchards

Attributes of Sustainable Development	Direct Impact Indicators	Indirect Impact Indicators
Economic Impacts		
1. Reduced Total cost of construction by GMP procurement system	*The awarded GMP contract sum reduced from HK$497 million to HK$468 million. A 5.8% reduction is realized.*	*GMP procurement method was increasingly adopted thereafter by developers in a number of projects in Hong Kong.*
2. Extra cost allowed in using precast façade, lost form and semi pre-cast balcony	*1% of increased in construction cost was estimated and expected for but end up with 5.8% saving*	*Quality of building envelope was increased by using precast façade and lost form system.*
3. Aiming in green concession from the Buildings Department with additional GFA	*Area exempted in gaining one additional floor of residential area for each building.*	*N.A.*
Social Impacts		
1. Using new construction technologies in pre-cast construction, spray on plaster and pre-finished wall partition	*Reduced application of traditional construction system in private residential projects. Cut down the employment opportunity for traditional carpentry and masonry works.* *Improved site safety and tidiness and hygiene.*	*Gradual change of trade practices, new occupations with new employment opportunities emerge. Some traditional trades and skills diminish.*
2. Adoption of e-project management system for construction management	*Changed the pattern of documentation flow and traditional way to deal with contractual matters. Increased overall efficiency by 20%*	*Gradually change the traditional way of contractual documentation flow and record keeping. Speed up the process of e-tendering and payment assessment process.*
Environmental Impacts		
1. Encouraged using low waste construction technologies in private residential development	*Reduced generation of construction waste and other construction nuisance and pollution like noise, dust and waste-water etc.*	*Reduce less overall bio-diversity in terrestrial and freshwater pollution.*
2. Adoption of e-project management system for construction management	*Reduced by 60% of paper use.*	*Reduced damage to the earth's ecology*
3. Used recycled rain-water irrigation system, dual flush toilet	*Reduced consumption of water by 33%*	
4. Used energy efficient lightings, and non-ozone depleting air conditioning system.	*Save HK$500,000 or HK$4/m2 running cost per year.*	

To summarize, the process of project development, building design and construction management of The Orchards achieved both functional requirements and sustainability objectives. It is undoubted the Developer's intention to meet requirements of JPN1 and 2 to obtain incentives by implementing sustainability in residential development has been achieved. The willingness of the Developer to spend more on construction cost for sustainability is a clear indicator reflecting enforcement of sustainable policy enables sustainable achievement. It is obvious that the Government is the enabling party for sustainability. The Developer project team and the Designer project team have demonstrated continuous performance after the completion of The Orchards. This reflected that sustainable culture has been built into their project development philosophies and was extended subsequently to other new projects. The Contractor project team followed contractual requirements in performing sustainability. It is clear that their performance was involuntary initially until they realized that implementing sustainability is beneficial to all and their performance changed from rather reactive to proactive from that time onward. It was a clear sign of behavioral change. Their cognitive attitude grew as they continued to perform, and eventually, became willing performers.

Unfortunately, their sense of sustainability and performance diminished when joining other projects where sustainable construction is not a priority. Sustainable behaviour is therefore a volatile habitual action that is subject to a favorable external operating environment. The behaviour could be reversed if it does not become part of the culture. The sustainable culture developed in the developer project team and the designer project team has sustained where similar working atmosphere prevailed. It is obvious that to maintain a positive cultural shift towards sustainability, all

stakeholders of the construction industry including the Government have a role to play.

6.4 Case Study III: The Development of the Hong Kong Wetland Park Phase 2 – Preservation of Ecological Balance

6.4.1 Background information of the Hong Kong Wetland Park Phase 2

The Hong Kong Wetland Park which is developed on a 64 hectare site at the north-eastern edge of Tin Shui Wai (TSW), a new town located at the northwest out-skirt of the New Territories of the Hong Kong Special Administrative Region, is regarded as one of the New Millennium projects of Hong Kong and was initiated as part of the TSW new town development as early as 1995. The development is a government project under the Architectural Services Department (ASD) as the project manager who would integrate artificial edifices harmoniously into the natural setting of the existing wetland at the northwest edge of the new town.

The feasibility study of the Wetland Park as an infrastructure project commissioned by the Hong Kong Tourist Association was completed in 1999. The project comprised two phases including the construction of a Visitor Centre, a Satellite Building, 3 Bird Hides, and a numbers of facilities such as Boardwalks and Outdoor Classrooms. To meet with the Millennium opening of the Phase 1 development, a 5,000-m^2 wetland area including a 240 m^2 exhibition hall was completed and opened to the public in December 2000. Other than serving as an exhibition hall, the Phase 1 development

has provisions for researches and steering project development for Phase 2 development to realize a number of sustainable construction objectives. The most innovative research attribute that took place in Phase 1 site was the pilot study in using geothermal air-conditioning heat pump system. The study has successfully proved that geothermal resource can be applied as heat exchanger medium for the Visitor Centre in Phase 2 development. Other sustainable construction tests included energy saving scheme by double-layered vent louvers and vented skylights at External Washrooms and low capacity water cistern toilets. The results of these successful pilot studies have been applied in Phase 2 development.

The design brief of Phase 2 development was completed in 2001 and represented a hybrid facility satisfying ecological conservation, education and tourism output which is capable of attracting over 500,000 visitors per year (ETWB 2003). Figure 6.6 shows the site layout of the entire development.

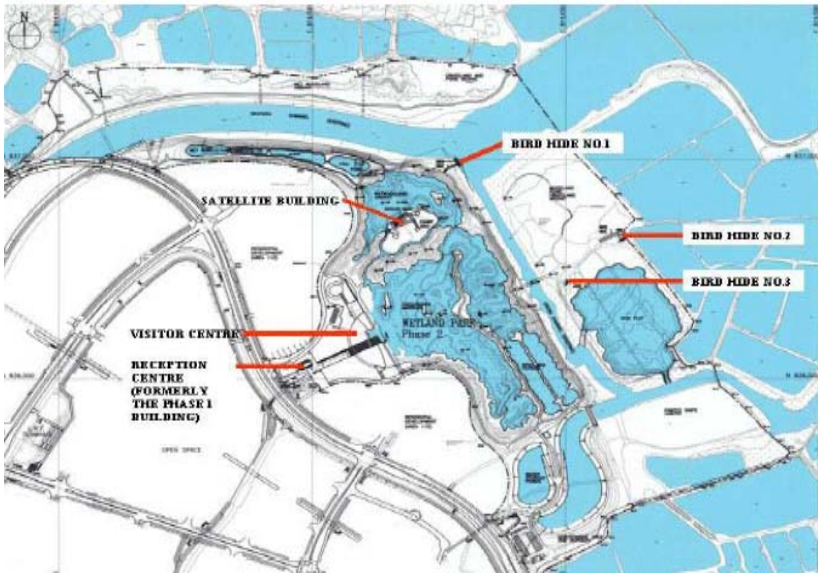


Figure 6.6 Master Layout Plan of the Wetland Park Phase 2 Development

Source: Works Digest (2003), the Government of HKSAR, Issue No. 52

6.4.2 Assessment of Project Performance in Sustainability

The assessment is focused on measuring the project design and execution in the following directions:

- Architectural design – focus on harmony with natural setting
- Structural design – extend the use of recycled aggregate in structural concrete
- Building Services design – introduce geothermal heat pump system in air-conditioning
- Construction management – apply 5-S Practice in site management and construction activities

Project Design Sustainability – Architectural Design

The architectural design of the Wetland Park Phase 2 comprises the Visitor Centre, the Satellite Building, the Bird Hides and conversion of the Phase 1 building into the Ticket Office. The achievements of sustainable principles and innovative ideas are shown as follow:

- Optimize site potential and functional advantages
- Synthesize the development into harmony with the natural setting
- Intensify indoor environmental quality
- Use environmentally friendly and recycled materials

In optimizing site potential and functional advantages, the 64-hectare wetland site has

originally been envisaged purely as a conservation and ecological mitigation initiative, it was believed that any land development would disturb the ecological balance of this highly recognized ecological area for the migrating birds and wetland habitats. The development of a tourist attraction theme park in the wetland area and maintain it as an ecological reserve zone for habitat creation and study would have been two conflicting tasks. The design team resolved this by prioritizing the hierarchy of intent of land use, landscape/habitat creation and conservation, site layout, building form, geothermal air cooling system and selection of materials from sustainable sources. (Works Digest, 2003)

The Visitor Centre is the main building of the development and is located close to the park main entrance at the edge of the urban area of TSW new town in order to maximize transportation facilities and logistic supply. Opposite to the main entrance water feature is the Ticket Office. This is converted from the exhibition hall of the Phase 1 development which served as a pilot study site for a geothermal air-conditioning heat exchanger system and other sustainable construction proposals for the phase 2 development.

To synthesize the development in harmony with the natural setting required minimizing disturbance of the existing wild life habitat and the ecosystem. Hiding the superstructure of the Visitor Centre under a gently lawned sloping roof became an added attraction for visitors to stroll uphill to embrace the spectacular vision of the entire wetland. It is a spectacular architectural achievement since the vegetation on the roof reduces the Overall Thermal Transfer Value (OTTV) of the building to only 16W per square metre. The Visitor Centre is carefully oriented to maximize the energy

efficiency and minimize solar gain.

The northeast facade of the Visitor Centre overlooking the water frontage of the wetland is a continuous unitized curtain wall system which is capable of providing visitors inside the building with a view of the wetland and invites them to walk outside to enjoy the outdoor environment. A seamless transition from the interior gallery space to exterior wetland landscape is obviously achieved. Figure 6.7 shows the views of the sloping roof and the window walling façade of the Visitor Centre.

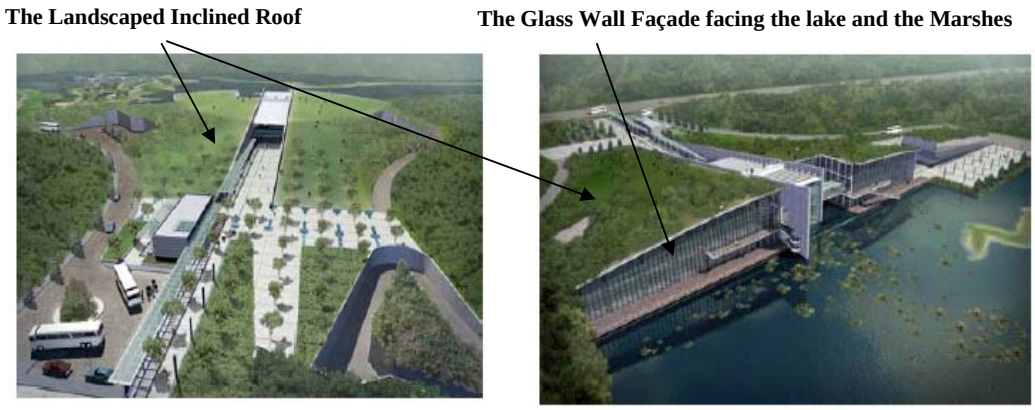


Figure 6.7 Birds Eye-view of the Visitor Centre

Source: Works Digest (2003) Issue No. 52, the Government of HKSAR

To intensify indoor environmental quality, skylights are extensively used in the Central Atrium of the Visitor Centre and are all integrated with carefully placed timber louvres, the arrangement optimizes natural lighting by blocking direct sunshine from entering the indoor environment. Timber louvres installed at the glass curtain wall façade overlooking the main lake serve the same function as a sunlight barrier apart from acting as sound and visual barriers to minimize disturbance to the water-birds which occupy the water horizons. Figure 6.8 illustrates the use of natural lighting as the major indoor luminous source of the Visitor Centre.

Figure 6.8 Skylight and Curtain Wall System provide the Visitor Centre with Natural Lighting
Source: Works Digest (2003) Issue No. 52, the Government of HKSAR

Intensive use of environmentally friendly, re-used and recycled materials is one of the sustainability architectural designs in the Phase 2 development. As the existing Phase 1 exhibition hall is converted into the Ticket Office, materials used are largely re-used in the Visitor Centre. Many re-used materials are used here in the Visitors Centre, for instance, recycled Chinese bricks from the demolition of old Chinese village houses are used in the processional route; oyster shells from nearby Lo Fo Shan oyster farm are reused as fence decoration; aluminum wetland habitat sculptures displayed at the Phase 1 building are now on display in the Visitor Center. Demolished materials from other government projects are also used here. Granite materials from the fence wall of the Hong Kong Police Headquarter are used as paving stone; fenders collected from the Victoria Harbour piers are used in the freshwater marshes and serve as resting posts for wildlife. Some 15,300 tonnes of recycled aggregates have been used as sub-

bases, hardcore and fill materials and 5,600 tonnes recycled coarse aggregates have been placed in the sub and superstructure of the Visitor Centre as structural concrete. Only sustainable timber from identified renewable sources has been allowed for use in the project and the timber is mainly applied in the horizontal and vertical louvres throughout the project façade.

Project Design Sustainability – Structural Design

The design of the Visitor Centre, Satellite Building and the Bird Hides are unique for their specific purposes. The possibility to create a repetitive construction cycle for a similar project of this kind is very slim. Employment of low waste construction technologies such as system formwork or precast construction is impractical. Traditional timber formwork to construct the concrete structure of all the buildings within the Wetland Park project would be the most sensible selection. Although employing a low waste construction method is hindered by the non-standard design, the use of recycled aggregate in structural concrete is very extensive. 20mm recycled aggregates obtained from a recycling plant at Tuen Mun Area 38 amounted to 5,600 tonnes. The highest grade of structural concrete mixed with recycled aggregates is 35D/20. 20% of recycled aggregate is used to replace the same amount of virgin aggregate material, some technical difficulties have been encountered in the mixing process at concrete batching plant. The high water absorption rate of recycled aggregates has caused low workability in the ready mixed concrete one hour after mixing. The difficulty was overcome after a number of trial and error tests conducted at site during concrete placing operation. The solution is obtained by careful control of water cement ratio by mist spraying the recycled aggregates before entering the

batching plant, coupled with the use of water reduction admixture. The water reduction agent formulated with lignosulphonates and modified polymer at a dosage rate of 0.2 to 0.7 ml per 100kg of cement resulted in increasing the workability of the ready mixed concrete similar to virgin aggregates. The 28 days cube strength stays between 35 to 60.5 Mpa with an average of 49.2 Mpa and the standard deviation is maintained at 5.2. The quality of concrete with recycled aggregates in terms of strength, workability, Young's modulus, creep, shrinkage and durability characteristic such as carbonation are very comparable with concrete containing ordinary crush rock aggregates (Li et al, 2005). Detail of Concrete mix and quantity of recycled aggregate used is shown in Appendix 3.

Project Design Sustainability – Building Services Design

The focus of sustainability in building services design is energy saving in the long-term operation of the development. It encompasses

- Supply natural lighting as primary indoor illumination
- Use geothermal energy resource as heat exchanger for air-conditioning installation in the Visitor Centre
- Reduce water consumption in toilets, water feature and irrigation system

Usage of natural lighting as Primary Indoor Illumination is the fundamental concept of the development. It is achieved by careful orientation of the building to enhance the illumination of the north light through skylights at Atrium and external toilets. Artificial lighting employed in the project is kept to minimum.

The use of geothermal heat pump (GHP) for air-conditioning system is an outstanding achievement in building services design for the Wetland Park. GHP is an A/C system which extracts the rather constant underground temperature (cooler in summer and warmer in winter) to exchange surplus heat or cool with the ambient atmosphere of the serviced area. The ground therefore serves as a source of heat energy. Bose et al (2002) stated that the ground is a better heat source or heat sink than the ambient air as ground temperature swing is more moderate than the ambient air. The GHP A/C system used in the Visitor Centre consists of heat pumps with reverse cycle function, water-cooled condensing units and ground source heat exchangers. The ground source of heat exchangers are 468 numbers of 32 mm diameter pipes inserted into bored holes underground to approximately 50m deep and surrounded by cement grouting for better conductivity. The bored holes are placed at 4 metres centre to centre in order to ensure sufficient space for heat dissipation effect. These heat exchanger pipes are grouped into 12 headers containing 39 or 40 pipes each. They minimized the excavation of trenches and facilitate maintenance work by only shutting down one group at a time which affected only 8% of the total air-conditioning capacity. By splitting the total A/C load into smaller zoning A/C units so as to avoid constant running of a large central chiller plant at all times, the actual flow rate of condensing water can be varied according to the actual requirement. The system achieved a 25% energy saving over conventional cooling tower and eliminated visible and noisy heat dissipation air-conditioning equipment which may disperse direct heat to the atmosphere.

Water consumption reduction considerations in the Wetland Park are separated into two schemes. A rain water collection system is installed in the Satellite Building and

the rain water is used as flushing water in toilets. Recycling lake water is provided in the water feature at the entrance of the Visitor Centre, which reduces the consumption of fresh water in the water supplying system. Irrigation is provided only at night time to reduce evaporation and water consumption.

Project Execution Sustainability – Implementation of 5-S Practice in Construction Management.

To cope with the regime to uplift sustainability in the Wetland Park project, the contractor attempted to enhance sustainable construction via site management to echo with the stringent requirements in environmental issues. Skills in achieving effectiveness, safety, environmental control including the introduction of 5-S management practice technique have been applied during the construction processes.

The 5-S Practice is a technique pioneered in Japan and is used to establish and maintain quality environment in an organization or workplace (Ho, 1998). Most Japanese 5-S industrial practitioners consider 5-S practice is useful not only in the betterment of their physical environment, but is also in improvement of the thinking processes (Gapp et al 2008). The Japanese established this management framework which enabled them to successfully convey messages across employees within the organization in achieving total participation and systematically implementation of the organization objectives. 5-S practice tackles the root problem of management. Ho (2002) further stressed that a 5-S workplace increases benefits to organization in higher quality and productivity with lower cost, ensuring delivery. It is a safe place for people to work and keeps high morale.

5-S Practice was first introduced to the construction industry in Hong Kong in 1990s and was adopted by some construction projects. The most obvious achievement of implementation of 5-S practice is the improvement on housekeeping. As simplified in Table 6.6, each "S" specified a Japanese word and being translated as "Structurize, Systematize, Sanitize, Standardize, and Self-discipline" to achieving betterment of any working environment in uplifting safety, enhancing efficiency, improving quality and reducing breakdowns.

Table 6.6 5-S Management Practice for Construction Site

Japanese	English Translation	Meaning	Typical Establishments in Construction Site
Seiri	Structurize	Organization	Well planned site allocation
Seiton	Systematize	Neatness	Retrievable of documents & drawings
Seiso	Sanitize	Cleaning	Cleaning responsibility of all individual
Seiketsu	Standardize	Standardization	Building up acceptable standard
Shitsuke	Self-discipline	Discipline	Performing 5-S as accountability in daily activity

Continuous 5-S practice in a construction project enhances product quality, site safety and environmental protection. The benefits of applying 5-S Practice in construction site are as follows:

- Better document control through systematic handling and filing
- Better communication through internal audits, non-conformance reporting and regular reviews of the quality assurance system
- More disciplined staff
- Improved site environment (housekeeping)
- Reduce material wastage and provide a safer workplace to all parties.

The Contractor of the Wetland Park project introduced 5-S Practice in site management. Achievements in housekeeping, waste reduction and uplifting site safety were obviously realized.

To identify changes in sustainable culture among site staff, a questionnaire survey was carried out immediately after the completion of the Wetland Park project aiming to explore the effects of the implementation of 5-S practice. It was thought that 5-S practice may have changed the perception of the participants on the merits of sustainable construction. The questionnaire used in the survey was adopted from a similar study used by the Hong Kong Housing Society for its maintenance projects. All the staffs of the Contractor who have been involved in project management ranging from site foremen to project manager were encouraged to respond to the questionnaire and a 100% response (36 numbers) was obtained. The sample of the questionnaire, marking scheme and data analysis exercise are appended in Appendix 3.

As all site management staff of the Contractor responded to the questionnaire survey, the result obtained represented fully the perception of the site management staff on implementation of 5-S practice in the Wetland Park project. The findings reflected the attitude and behaviour of contractors in Hong Kong.

From the demographic information, site management staff is masculine dominant, mature, with sufficient site experience, highly educated of whom over 70% are post secondary and 50% university graduated. All of them hold various responsible positions in the site management.

The Contractor of the study is not a certified contractor of ISO 14000 and ISO 18000 certification. Uncertified in ISO 14000 and ISO 18000 is very common among contractors in Hong Kong. It would be fair to assume that staffs of the Contractor are not fully trained with environmental management knowledge. However, the respondents of the questionnaire survey acknowledged the importance of environmental control for the Wetland Land Park project. Factors about safety (126 score) are placed in the highest hierarchical order followed by environment (118), quality (106), time (108) and cost (87) issues. All respondents ranked the significance of problems in the construction industry in a descending order. These are poor housekeeping, lack of environmental awareness, lack of planning, lack of training, poor safety record, material waste, progress delay, overloaded with paper work and poor workmanship.

The factors that affected construction progress are poor housekeeping followed by unclear instructions given by supervisor, poor safety control, limited authority and poor document control.

Based on the scoring system assigned to each question, the respondents' perception on management systems commonly used in Hong Kong leading to the success of a construction project is evaluated. The highest score is assigned to material and equipment management (14 point), followed by quality management (11.7 point), safety and environmental management (8.7 point), and finally production management (6 point). The incremental variations of each construction management system are comparatively stable, the scores varied within the range of 2.3 points to 3 points.

It is interesting to note that contrasting results have been obtained from the implementation of 5-S practice. Significant improvement in communication and information flow between the head office and the site office is obtained (18 point), and a negative improvement in reducing paper work is discovered (-1 point). The reason explaining this controversial result is 5-S practice has a stringent requirement in documentation control, in that all communication and information exchanges must be documented and filed; hence, additional paperwork was generated from heavy recording and filing requirements. Finally, most of the respondents agreed that 5-S Practice improved the overall performance of the Wetland Park construction management and improvement of safety culture among workers representing an important shift in social attribute of sustainable development.

6.4.3 Perceptions of Stakeholders on the Overall Performance of Sustainability in Wetland Park Phase 2

Investigations on the roles of stakeholders involved in the Wetland Park project have been based on the results of their performance in project design and construction management. The attitude and behaviour of project staff in different disciplines were obtained through unstructured interviews with the team leaders of the Developer/designer stream and the Contractor stream. The interview with the project architect was arranged right after practical completion of the project, while the interview with the Contractor team was with the contractor's project manager, the site agent and the safety officer 6 months afterwards. Perceptions about changes in attitude and behaviour towards sustainability were discussed and explored in these interviews. Assessments of cultural shift among the project participants of the developer group and the contractor group are separately expressed below.

The project architect of ASD performed dual functional roles in the Wetland Park project as the design team leader and project manager of the Developer. Although the Wetland Park is a government project, the project development process had to rush out resembling most private sector development projects in Hong Kong. The project team took over the design duty in March 2000 and the development was earmarked as a Millennium project for the opening requirement of the Phase 1 by December 2000. Time allowed for the project design team to maneuver a well-considered sustainable project in Phase 1 was critical and extremely slim. Most of the project development sustainability issues were therefore left to the Phase 2 design.

The design team was composed of various disciplinary professionals in ASD and most of them had not worked together before. At the commencement of the project, all members of the design team were made aware of the stringent requirements in achieving the establishment to harmonize with the natural setting of the 64 hectares of wetland with minimum disturbance to the habitats. The designers worked together, built up a sense of cognition as the design work deepened to the core issue of the project – *minimize the building area and let nature take over the built environment*. An environmental sensitivity developed within the designer team as the work continued. A sharing of knowledge base among themselves stimulated a number of ideas to improve the sustainable outcome. Changes in attitudes and behaviour towards sustainability led to a higher scale of achievement. To better express the perception on the shift of sustainable culture of the designers, the concluding words from the team leader and project manager that ended the interview is quoted: '*A "relationship" aiming to consummate sustainability is built up among the team*

members of the project, and I wish I could have a chance to work with them in a similar or more challenging project in the future'.

The perceptions of the Contractor project team were obtained through an unstructured interview with the project manager and his key subordinates which was held 6 months after project completion. A retrospective reflection shone on the faces of the interviewees as they mentioned the implementation of 5-S practice. The Contractor made his bid on the Wetland Park project in early 2003 when the economy of Hong Kong sank to its bottom and this was perceived as the only presentable new project to sustain the image of the contractor firm as a Group C contractor in Hong Kong. The Contractor team was well aware of the importance of the project to their firm and therefore committed to deliver a successful project. In compliance with the stringent environmental requirements, the Contractor project team decided to uplift sustainable construction in site management and attempted to implement the 5-S practice system. It was the first time that the Contractor applied 5-S practice. Only a few senior managers had attended training sessions of the 5-S practice, but front line staff knew very little about it.

Upholding construction safety and environmental protection has been the policy of the Contractor, however, implementing 5-S practice in the project remained a challenge. Team spirit is a traditional culture of the Contractor and cohesion amongst site staff is not a problem. Knowledge of 5-S practice was delivered top-down to front line staff through encouragement and practice. Implementation extended to all subcontractors who were employed in various trades under subcontract arrangements. The site management enforced the 5-S practice as a contractual requirement and executed the

penalty clause when a subcontractor violated the requirements. Objections arose initially from some reluctant subcontractors until they started to enjoy benefits from the practice and started to change. The 5-S practice was not completely successful in changing the entrenched practice of some subcontractors. However, the 5-S practice has successfully improved housekeeping throughout the working areas, improved document control and communication. Efforts to enhance site safety, environmental management and reduction of construction waste have been achieved with satisfactory results.

The culture of 5-S practice has not been practiced by this Group C Contractor after completion of the Wetland Park project when site staff carried out duties elsewhere and workers were transferred to other construction sites where 5-S practice was not implemented, lax practice prevailed habitually.

6.4.4 Summary of the Research Findings of the Wetland Park Phase 2

Design sustainability has been achieved significantly in the Wetland Park project by the project design team of the Government. They should upkeep their innovative power and maintain the sustainable culture that has developed among members of the design team. They can extend the influence to others via interchange of experience and knowledge within the government system.

Although the Contractor project team has successfully implemented 5-S practice and upkeep the site safety and tidiness in the Wetland Park project, the practice developed could not be sustained when staff were transferred to other workplaces. This bounce

back shows a strong resistance to improvement and habitual lax practice adopted commonly among construction sites in Hong Kong still prevails. The findings of cultural shift in the case of the Wetland Park project resembled very much the case of The Orchards. Positive changes in the designer stream sustained within the sustainable-conscious environment, while changes in the contractor stream failed to continue when the working atmosphere emphasized other objectives. The practice of sustainability within the construction industry can only be sustained by continuous implementation until a sustainable culture is thoroughly established among all construction participants.

6.5 Case Study IV: Comparison between Timber Formwork System and Composite Formwork System – A Reflection on Contractors' Undertakings in Sustainable Construction

Formwork is one of the most important temporary works for reinforced concrete superstructures in building projects. The use of traditional timber formwork has dominated the construction market in Hong Kong for many years. Nowadays, low waste construction technologies for superstructure construction are becoming more common and selection of a suitable formwork system for superstructure construction is also considered as an important approach in sustainable construction. For many years, stakeholders have been consistently exploring improvements in formwork technologies in terms of cost, time, quality and construction waste generation. This case study compares the use of two different formwork systems in superstructure construction of two identically designed low-rise school buildings showing

stakeholders' attempts in exploring new solutions for formwork systems. Through the data obtained from a comparison exercise on the merits and demerits of the two different formwork systems, a cultural shift towards sustainability among stakeholders of the construction industry is revealed.

The two different formwork systems being studied are:

- Large panel steel formwork system integrated with precast concrete semi-slab (composite formwork system)
- Traditional timber formwork system

Similar comparisons have been made in previous studies for standardized high-rise residential buildings (Wong and Yau, 1999; Yeung et al, 2002), however, there were very few cases of composite formwork system used in low-rise buildings. This case study is particularly interesting because the driving force behind the stakeholder's attempts in low-rise buildings is a sign showing their eagerness for change.

The two selected school projects were identically designed, one used composite formwork system and the other traditional timber system to complete the superstructure. Both projects commenced in 2001 and were completed almost simultaneously in 2003 by different contractors of similar capacity in Group C category. Quantitative data on the cost, working schedule and construction waste generation were used as comparison criteria. Therefore, this is a "like-with-like" comparison and no adjustment was needed for the entire exercise.

The selected school projects were of a standard design called the Millennium Design School, where the design must satisfy both the education reform policy and the sustainable development policy of the HKSAR Government. Over 100 numbers of

standard schools of an identical layout were constructed to expand the number of schools in the existing school portfolio. The design solutions that complied with both requirements were separated into three different sizes (30-classrooms, 24-classrooms to 18-classrooms) standard schools which would satisfy land use economy but also cater for the pre-requisite population threshold of the local community. Each school comprised two low-rise buildings, the Classroom Block and the Assembly Hall/Special Room Block interconnected by a Common Area on each floor which serves as a space for lift and staircase lobby (Figure 6.9).

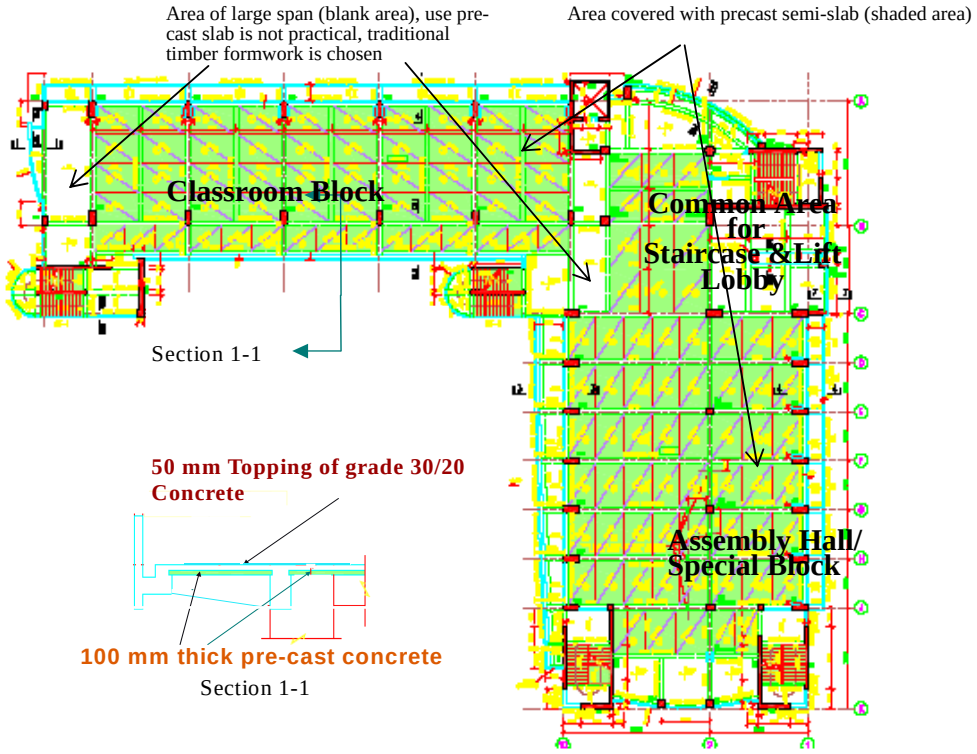


Figure 6.9 Typical Floor Plan of Millennium School Project and the Installation Arrangement of Semi-slab panels

Due to the low-rise nature of the Millennium School buildings, the advantages which may be gained from repetitive construction cycle by using large panel system

formwork are very slim, whereas precast concrete semi-slab integrated with large panel formwork (composite formwork system) may be a possible solution.

6.5.1 Previous Studies of Formwork Systems in terms of Constructability and Sustainability

Project designs and selection of construction methods are key issues in achieving sustainable construction objectives. In the 1980s, explorations to improve constructability (Tatum et al, 1986) and study on industrialized building systems for repetitive constructions (Commandante, 1988) were common research topics which led to the development of precast construction. The study on modular systematic systems for industrialized building began in the 1990's (Sarja and Hannus, 1995). Since then, researches exploring various types of new prefabrication and assembly technologies for industrialized building systems have been actively undertaken (Gibb, 2000; Glass, 2000; Howes, 2002).

To follow the pace of international research systems, Hong Kong researchers conducted investigations in prefabrication and industrialized building in a wider spectrum covering technologies development (Sparrow and Chu, 2001; Chan and Chan, 2002; Code of Practice, 2003), construction management (Wong, 2000; Tam, 2002; Wong et al, 2003) and waste reduction issues (Jaillon et al, 2006) . A more comprehensive study on low-waste building technologies was carried out in Hong Kong (Poon et al, 2003) which reported that large panel steel formwork, pre-cast facades and pre-cast staircases were better options for superstructure construction.

All these researches identified that large panel formwork system and precast construction are beneficial in terms of cost, quality and sustainability.

In contrast, it was also revealed that, despite its low initial investment cost and high flexibility in use, the less durable nature and demand for a large amount of manpower with skilled craftsmanship which are always costly and sometimes unavailable, timber formwork is not an ideal formwork system. Furthermore, it is a major contributor to construction waste accounting for 30% of all identified construction waste generation from typical building projects (Poon *et al*, 2004). Construction and demolition (C&D) waste is one of the most significant sources of waste in Hong Kong. The Environmental Protection Department (EPD) indicated that in the year 2004, the average daily construction waste disposed of at landfills was 2,914 tonnes representing approximately 21% by quantity of the total amount of total waste landfilled in Hong Kong (EPD, 2008).

6.5.2 Measured Data of Two Different Formwork Systems Applied in the Millennium School Buildings

The measured data of the application of different formwork systems are based on materials use, cost of construction, construction schedule, quality of product; the two Millennium Projects selected for comparison are:

- Traditional timber formwork system for a 30-classroom standard Millennium School in Lam Tin District of Kowloon, Hong Kong (Lam Tin School)

- Composite formwork system for two standard (30-classroom and 24-classroom) Millennium Schools in Kowloon Bay District of Kowloon, Hong Kong (Kowloon Bay School)

Traditional Timber Formwork System Used in Lam Tin School

The Lam Tin School comprised two reinforced concrete buildings forming an L-shape building complex, where the Classroom Block and the Assembly Hall Block/Special Room Block were interconnected by a Common Area (lift lobby) on each floor (Figure 6.9). Traditional timber formwork was used in the superstructure of this project.

Material Used and Working-cycle of Timber Formwork

The timber formwork systems for columns and walls composed of 18mm thick 6-ply plywood and served as the vertical shutter formface. The shutters were vertically stiffened with 50mm x 75mm softwood sawn timber studs at an average of 180mm centre to centre and horizontally withstanding four layers of proprietary steel walers. Ready-mixed concrete was delivered to the site by concrete trucks and placed between the shutters. The wall and column formwork was removed the next day after completion of concrete placing for the entire floor. The removed wall and column formwork was lifted to the upper floor level to repeat the working-cycle.

The beam and slab formwork system was composed of 18mm thick 6-ply plywood for beam and slab soffit. The soffits and side shutters were strengthened by timber runners of 50mm x 100mm softwood-sawn timber and propped by a propriety steel falsework system. According to the amount of work on each floor, the planned

working cycle of the superstructure was 11 days per floor.

All the soffits of slab, beam and cantilever elements must be propped for at least 7 days, 16 days and 28 days respectively to allow concrete strength development according to the specifications (CIRIA, 1995). In order to achieve early removal of the beam and slab formwork, individual dead propping supports must be installed at suitable positions to support the dead and live loads until the full development of the 28 days concrete strength. The beam and slab timber formwork system could only be removed earlier and reused in the upper floors to maintain the planned 11-day per floor working cycle by adopting this technique.

The breakdown of the 11-day per floor working cycle for the whole timber formwork system was as follow:

- Fix wall and column reinforcement and formwork 3 days
- Erect scaffolding system and fix beam and slab formwork 3 days
- Place concrete to wall and column 1 day
- Fix beam and slab reinforcement and E/M conduit 3 days
- Place beam and slab concrete 1 day

(Total: 11 days)

Quantity of Timber Material Used

All timber formwork system used in the superstructure of the Lam Tin School was quantified according to the Standard Method of Measurement (2001).

Timber for miscellaneous uses such as strut, side bracing and cutting wastage were estimated by experience. The estimated quantity was sufficiently close to the actual

timber consumption which was later verified by material delivery record provided by the main contractor.

The construction work for ground beam was carried out in phases according to the excavation progress. Whenever the excavation work and concreting of the blinding layer for a particular section was ready, erection of formwork for ground beam followed immediately. The site record showed that a total of 6 concreting cycles had been undertaken. Ground slabs were cast on grade, whilst the use of timber material was negligible.

To maintain the 11-day working cycle, the contractor determined that one set of wall and column formwork for the entire floor area was necessary. For the entire building, two sets of beam and slab formworks and three sets of formwork for cantilever beam and slab portion were required. Table 6.7 shows the quantity of timber formwork used in various portion of the entire superstructure.

Summarizing the figures shown in Table 6.7, timber material used in the Lam Tin School comprised two types: the 18 mm thick 6-ply plywood and the softwood sawn timber. The total quantity of timber material used was 8,808 square metres of plywood and 80,512 metre-run softwood sawn timber. As a common trade practice in Hong Kong, the use of softwood sawn timber material was measured in volume, the total softwood sawn timber used was 367 cubic metres.

Table 6.7 Quantities of Timber Used in Lam Tin School

Items	Area of Formwork for One Complete Floor (m^2)	Set(s) of Formwork Provided	Area of Formwork Provided (m^2)
1 Column	450	1	450
2 Wall	3,009	1	3,009
3 Miscellaneous walls for roof stair house, hose reel cabinets, dropper wall etc	140	1	140
4 Water tanks	123	1	123
5 Beam	502	2	1,004
6 Slab	1,168	2	2,336
7 Ground beam	296	0.5	148
8 Ground slab (suspension portion only)	42	Measured as required	42
9 Cantilever beam	129	3	387
10 Cantilever slab	154	3	462

Cost of Applying Traditional Timber Formwork for Lam Tin School

It is a common practice in the construction industry of Hong Kong to sublet all major trades to subcontractors. The formwork fixing trade for the superstructure of Lam Tin School was subcontracted to a carpentry-subcontracting firm as a supply and fix subcontract. The rates for each type of carpentry works were different in the bill of quantities. For simplicity, the costs are categorized into three major groups – wall and column, beams, slabs (including ground beams, beams and slabs of cantilever portion). The cost is rounded up to the nearest one thousand Hong Kong dollars as shown in Table 6.8.

Table 6.8 Total Cost (Supply and Fix) of Traditional Timber Formwork System in Lam Tin School

Category	Contract Arrangement	Material and Labour Cost
Wall and Column	Supply labour and material	HK$3,277,000
Beam	Supply labour and material	HK$1,061,000
Slab	Supply labour and material	HK$1,002,000
Variation Orders	Changes in column,beam and slab	(HK$71,000)
	Total Amount	**HK$5,269,000**

US$ 1 = HK$7.8

Composite Formwork System used in Kowloon Bay School

The composite formwork system used in the school buildings comprised large panel steel formwork and precast concrete semi-slab. The semi-slab served as a temporary shuttering in the composite formwork system to receive cast in-situ topping concrete to form a permanent slab structure which bonded the other structural elements monolithically together. Large panel steel formwork has been used in Hong Kong for over two decades. It is a steel frame panel surfaced with metal sheathing. Comparing steel and timber in terms of material durability and stiffness, we find that the large panel steel formwork can easily be used in over 100 erection and stripping cycles of concrete placing operations, while timber formwork can last for not more than 10 cycles in normal conditions. The result of a site waste audit indicated that in the concreting operation of large panel steel formwork, an effective reduction of concrete loss of about 30% can be achieved when compared with the traditional cast in-situ method due to broken formwork (Poon et al, 1999). The concrete surface produced

by the large panel steel formwork is much neater and smoother than that of the timber formwork. The concrete surface essentially needs no trimming and additional applied finishes.

The design of the school project in Kowloon Bay was the result of a new educational concept called “school village”. The school village composed of three schools built on a common site forming a school compound to share a larger open space and common facilities. The three school buildings consisted of one 30-classrooms secondary school, one 30-classrooms primary school and one 24-classrooms primary school. The two primary school buildings were based on the standard design of Millennium Design School as shown in Figure 6.9. Due to different functional requirements for secondary education, the building layout and the detailed design of the secondary school was different from that of the two primary schools. The formwork system applied in the two primary school buildings was not compatible with that used in the secondary school building. Since all the three schools were located adjacent to one another forming a school compound, the construction contract was awarded as a package to one general contractor.

Selection of Formwork System for the School Village Project

Since the two primary schools were both of column and beam framed structure of identical design, the formwork system could be interchangeably used. The contractor decided to use large panel steel formwork for walls, columns and beams. Slab construction was done by installing semi-slabs between the recessed edges of the beams, columns and walls. Topping concrete was placed in-situ connecting the beams, columns, shear walls and semi-slabs together. With proper curing, both the topping

concrete and the pre-cast components formed a monolithic structure (Elliott, 1996) As shown in Figure 6.9, semi-slab panels (shaded area) were extensively used covering most of the floor area. The remaining slab areas, such as all the staircases, A/C platforms, and lift lobbies, where the slabs were of longer span and the use of pre-cast concrete elements were unsuitable, traditional timber formwork and in-situ concrete placing were used in these long span areas.

Working Cycle of Large Panel Steel Formwork integrated with Precast Semi-slabs

Due to the magnitude of the work and time constraints, a "one formwork two schools system" was adopted (i.e. one full set of large panel steel formwork for a 30-classrooms school was provided for alternative uses by the 30-classrooms and the 24-classrooms school buildings). The site condition of the Kowloon Bay school allowed a full range operation of tower cranes and crawler cranes and this made lifting and shifting of the large panel steel formwork from one school building to another possible. The formwork erection was sequenced into four consecutive working phases, operating in an alternative manner between the two school buildings in a 12-day working cycle. Figure 6.10 shows the formwork zoning layout and the working cycle schedule.

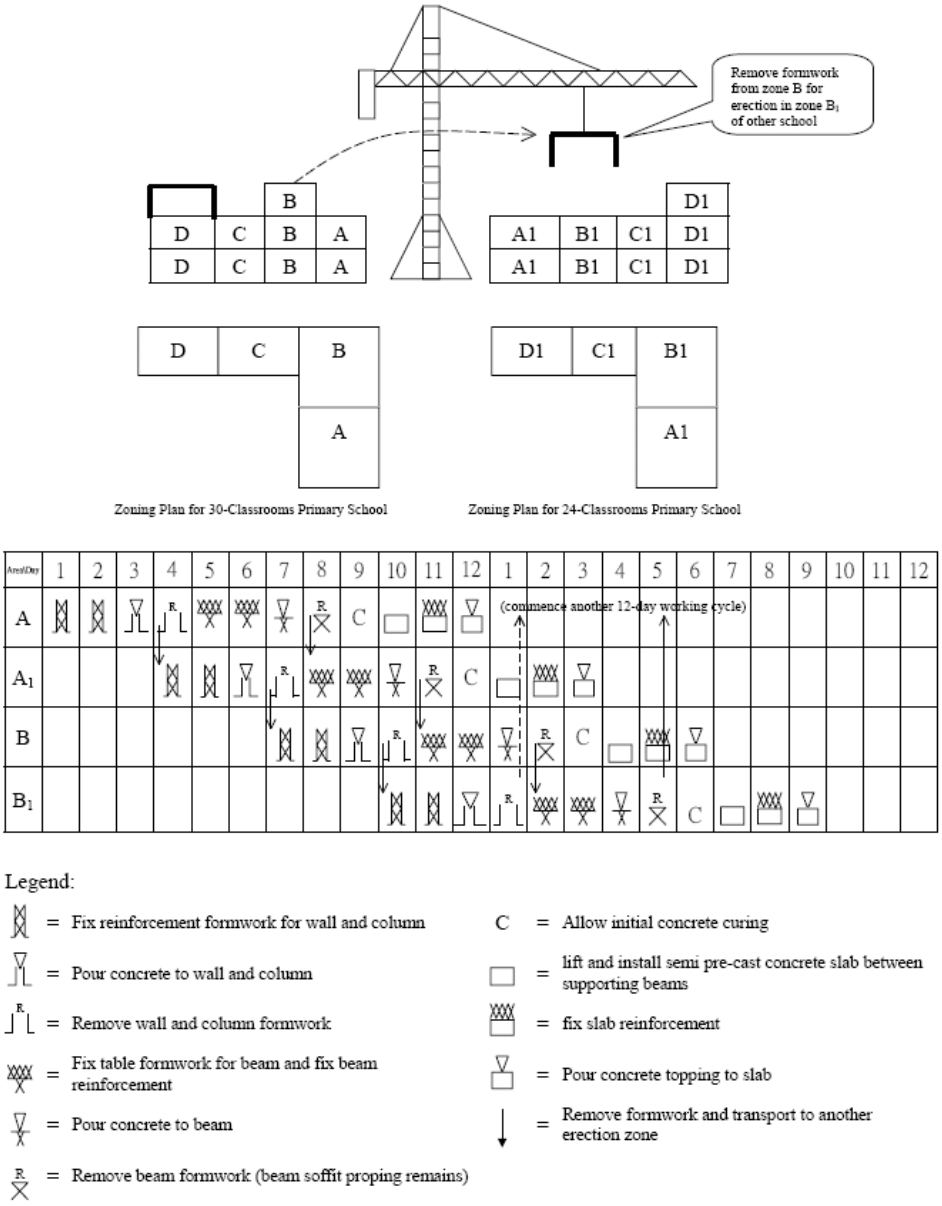


Figure 6.10 12-day working cycle for 2 schools with one full set large panel formwork in Kowloon Bay School

The merit of using one full set of system formwork for two buildings was economics. However, the demerit was the progress of one building would be dependent on the progress of the other because the formwork components were used interchangeably between the two buildings, dismantling and lifting of the formwork component from one building to the other had to maintain a "dismantle-remove-transport-receive and install" synchronized operation.

Quantity of Material Used

Materials used in the large panel steel formwork system were mainly steel frame panel and 4 mm thick mild steel sheathing. The material quantity and the associated cost are listed in Table 6.9:

Table 6.9 Quantity and Cost of Steel Formwork Material Used in Kowloon Bay School

Large Panel Steel Form Steel Material	**Quantity of Steel used by weight (in tonne)**	**Rate/Tonne (in HK$)***	**Total Cost (in HK$)**
Total area of column = 450 m^2	45 tonne	5,520	240,000
Total area of wall = 3,150 m^2	275 tonne	5,350	1,470,000
Total area of beam = 1,004 m^2	195 tonne	5,650	1,100,000
Total area of cantilever beam = 129 m^2	75 tonne	5,750	430,000
Total weight of mild steel used	**590 tonne**	Total cost of material	**3,240,000**

* Unit rates given by the contractor of the Kowloon Bay School were rounded up due to commercial reasons

Other than large panel steel formwork, some traditional timber formwork was also used for staircases and other longer span areas. To maintain the planned 12-day working cycle for each typical floor, two sets of tradition formwork covering the longer span areas and staircases with dead prop devices were utilized.

The quantity of timber used in the traditional formwork portion of the superstructure was measured according to the same method of measurement used in the Lam Tin School. The total timber material consumption was 940 m^2 of 18mm 6-ply plywood and 40 m^3 of softwood sawn timber.

Cost of Applying Composite Formwork System in Kowloon Bay School

Similar to the traditional timber formwork subcontracting system, the main contractor of the Kowloon Bay School project had sublet the formwork subcontract to a system formwork subcontractor. The cost information provided by the main contractor, as shown in Table 6.10, had been rounded up to HK$100,000 due to commercial reasons.

Table 6.10 Cost of Large Panel Steel Formwork and Semi-slab for Two Primary Schools in Kowloon Bay

Description	**24-Classroom Primary School (GFA=4,038 m^2)***	**30-Classroom Primary School (GFA=4,440 m^2)***	**Total**
Cost of material for system formwork (one set of formwork for two schools)	HK$1,530,000	HK$1,710,000	HK$3,240,000
Cost of pre-cast unit semi-slab	HK$1,777,000	HK$2,638,000	HK$4,460,000
Cost of conventional timber formwork portion	HK$ 340,000	HK$ 400,000	HK$740,000
Cost of installation of system formwork	HK$4,590,000	HK$5,130,000	HK$9,720,000
Cost of installation of pre-cast unit	HK$1,600,000	HK$2,020,000	HK$3,620,000
Total Cost	HK$9,837,000	**HK$11,943,000**	HK$21,780,000

*source: Information Paper CB(2)1693/99-00(03) www.legco.gov.hk/yr99-00/english/panels/ed/papers/e1693-03.pdf

6.5.3 Assessment of The Merits and Demerits of Lam Tin School and Kowloon Bay School through Comparison Exercise

Assessment of the merits and demerits of both schools using different formwork systems for the construction of superstructure focused on the time required, cost of application, construction waste generation and the consumption of labour resource.

Time Required for Construction

The working cycle per floor for the Lam Tin School was 11 days while for the Kowloon Bay School was 12 days. There were 8 typical floors in both of these two standard schools and the total time spent for the construction of the superstructure of the Kowloon Bay School was 8 days more than the Lam Tin School. Taking into account the time required for site cleaning and tidiness, which was a pre-requisite prior to commencement of the finishing works, the composite formwork system used in the Kowloon Bay school project was more favorable than the traditional timber formwork system used in the Lam Tin school project.

The Costs of Application of these two formwork systems

In accordance with the normal practice in Hong Kong, main contractors of both school projects used trade subcontractors to supply labour and materials for the superstructure works. Due to the difference in methods of construction, the subcontract costs of the two school projects varied considerably. Taking all incurred costs into consideration, the Lam Tin School subcontract value was HK$5,269,000 and the Kowloon Bay School subcontract value for the share of the 30-classroom school building was HK$11,943,000. The cost of the Composite Formwork System

used in the Kowloon Bay School was 126.7% higher than the cost of the Traditional Timber Formwork System used in the Lam Tin School.

Use of Materials and Generation of Construction Waste

The use of formwork materials for the Lam Tin school and Kowloon Bay school is tabulated in Table 6.11 for comparison.

Table 6.11 Comparison of Construction Costs and Waste Produced

Particulars		**Cost**	**Material Use**			**Waste Produced and Disposed at Landfill**		
			Plywood	**Softwood Sawn Timber**	**Steel Material**	**Plywood**	**Softwood Sawn Timber**	**Steel Material**
Items	**Lam Tin School**	**HK$5,269,000**	yes	yes	no	8,803m^2	367m^3	Nil
	Kowloon Bay School	**HK$11,943,000**	yes	yes	yes	940m^2	40m^3	590 tonne
Comparison	**Timber Formwork System** (100% as base)	100%	8,803m^2	367m^3	Nil	100%	100%	**Nil**
	Composite Formwork System	**226.7%**	940m^2	40m^3	590 tonne (100% recycled)	**10.6%**	**10.8%**	**Nil**

It should be noticed that a recycling channel for used timber formwork was not available in Hong Kong but the recycling of scrap steel was very common. A past study on C&D waste management revealed that the used timber boards generated from timber formwork was the most significant waste type in building projects requiring disposal (50%), and steel from metal formwork had the highest recovery level (100%) in Hong Kong (Poon et al, 2004). As reflected from the site cleaning

records of both school projects, the used timber materials were disposed of at landfill sites. From Table 6.11, the amount of timber requiring disposal at landfill sites from the Lam Tin School was about 10 times more than that of the Kowloon Bay School project. Moreover, the large panel formwork used in the Kowloon Bay School could be reused in other similar projects if further works had been available until the end of its service life, and the scrap metal was 100% recyclable. From the perspective of construction waste reduction, the composite formwork system is more favorable when compared with the timber formwork system. (It must be noted that the higher embodied energy of steel in its manufacturing and subsequent recycling should be taken into account in carrying out a life cycle environmental assessment of the formwork systems).

Labour Requirement

Skilled carpentry workers were employed in the Lam Tin School project throughout the superstructure construction period (an average of 16 skilled carpenters and 10 semi-skilled carpentry work helpers and 5 unskilled workers). For the Kowloon Bay project about 20 steel panel installers and 10 general labourers were required for the installation tasks of the large panel formwork and semi-slabs. It is obvious that there was a shift of requirement of tradesman skills from the more complex carpentry works in the timber formwork system to the less skilled installation tasks in the large steel panel formwork and semi-slabs system. The employment opportunity for skillful carpenters would therefore diminish as low-waste construction technologies become more common.

6.5.4 Indications of Cultural Shift from Research Findings of The Two Formwork Systems

Based on the comparisons in Section 6.5.3, using traditional timber formwork system for the low-rise superstructure school building was more economical. However, the consumption of timber material in the traditional timber formwork system was huge. The massive quantity of construction waste generated by the used timber formwork increased the pressure on the limited availability of landfill capacity in Hong Kong. Although using composite formwork system in the school project of identical design was financially not favorable, it is noted that the potential use of the large panel steel formwork had not been fully utilized by the time the Kowloon Bay School was completed. According to the number of concrete placing activities carried out in the Kowloon Bay School, the steel formwork had only been used 35 times, which represented only one-third of its service life of 100 erection-stripping cycles in normal practice. If the same set of large panel steel formwork can be re-used in two or more standard Millennium Design School projects, the economic advantage could indeed be realized. The 100% recyclable nature of scrap steel also can reduce the quantity of construction waste generation (Yip and Poon, 2008).

It is interested to note that under the current tendering system of bidding Government project, the opportunity for the Kowloon Bay School contractor to use the “residual value” the steel formwork and re-apply the same in other identical Millennium Design School project is not promising. The driving force for the Kowloon Bay School contractor to apply composite formwork system was obviously not to merely pursue economic advantages. During data collection process, discussions with the site

management staffs of the Kowloon School contractor, they realized that it will be a financial handicap to apply composite formwork system only in the Kowloon Bay School project, however, their considerations were aimed at improvement of construction works by enhancing environmental protection and construction management. The attempt is to uplift the construction performance and company image in order that the chance of bidding Government project opportunity will be increased accordingly. As mentioned in Section 2.2.2, past performance record of sustainability (PCICB, 2002) is one of the important evaluations for the award of Government contract. It is obvious that Government policy is a critical issue in promotion of sustainability. Moreover, site management staff claimed that through the application of composite formwork systems, they have experienced successes and failures in handling composite system in low-rise building, furthermore, they were very satisfied with the substantial improvements on site tidiness, reduction of construction waste and site safety. They have firmly expressed that with the experiences learnt from applying composite formwork system in low-rise building, they will do better in other projects; a cultural shift faithful to implement sustainable construction is built up among site staff of the Kowloon Bay School project through implementation of low-waste construction method.

6.6 Summary of the Case Studies

The preceding sections featured case studies of four selected projects, viz. the Hong Kong Community College, The Orchards, the Wetland Park and the Millennium Design Schools, all of which investigated sustainability of the construction industry of

Hong Kong from the economic, social and environmental points of view and hinged upon impacts of sustainability.

The four selected projects had different focuses as early as their development and planning stage as explained, the research also exemplified their respective rationale in selecting a particular type of construction method. Ultimately, it was found that they all shared a common ground in sustainable construction and have succeeded one way or the other.

The HKCC project has emphasized precast construction as a direct means of construction according to the basic development concept for sustainability with the economic costs well considered at tender stage. Precast construction has been implemented willingly by both the Developer's project team and the Contractor's project team and has achieved sustainable construction as initially envisaged by the Developer.

The Orchards has adopted a variety of design and construction methods apart from incorporating green features in residential flat designs as a direct means to maximize GFA as promulgated in Government Joint Practice Notes 1 and 2. These innovative construction methods and green features are perceived as a step forward in sustainability as encouraged by Government and implemented by an environment-conscious Developer.

The Wetland Park has been conceived with sustainability in mind at the planning stage, and tried to merge the project into the environmental setting and minimize

adverse effects on the ecosystem of the area caused by tourism and educational functions. All as envisaged by the Government and implemented by the contractor who also introduced 5S practice in construction management and activities as a complement.

The Millennium Design Schools did not have the composite formwork system specified in the design stage, nor was this in Government sustainable policy. It was a trial to achieve the impossible by the contractor despite the fact that this portion of the budget was 126.7% higher and the slender chance in applying the residual value of the steel formwork in any identical project bids in the future. The shift was caused by the initiatives of improvement in sustainable construction and the sustainability policy that the Government insistence on the past performance record of bidders which have largely motivated the contractor to work out a better track record in order to bid for future jobs.

All of them had different goals to achieve, however, during the course of development and construction of these projects, all changed the stakeholders' perceptions of sustainability in a different way. As a common result, a cultural shift towards sustainability among participants of these four projects is evident. Some of the participants' sustainable culture sustained and others diminished. The participants who can continuously practice sustainability were those who worked in an environment where sustainable culture is prevalent. Those who failed to continue were those who were transferred to work elsewhere where sustainability w not encouraged.

CHAPTER 7 DISCUSSION OF RESEARCH FINDINGS

7.1 Introduction

To elaborate a discussion of the research findings, it is necessary to revisit the research approaches in preceding chapters which have worked out both quantitatively and qualitatively on the cultural shift of the construction industry of Hong Kong between years 2000 and 2006. The research objectives as spelt out in Chapter 1 are addressed in this chapter as follows.

7.1.1 Identification of the Key Components of Sustainable Culture

This study highlighted the use of a specific human behaviour model, Taking Ajzen's (1991) theory of reasoned actions and theory of planned behaviour as basis, supplemented by the Borden and Horowitz (2001) expanded model of social behaviour, in order to elucidate how sustainable culture is formed. The study further identified four cultural components viz. awareness, concern, motivation and implementation as key components that constitute the sustainable culture of the construction industry. These components span over the cognitive attitudes and behavioral actions which covered spiritual, material, intellectual and emotional features of an identified circle of the society (the construction industry) and cover the basic assumptions, intrinsic core values, beliefs and principles found within that circle.

This study also identified external factors viz. an acknowledged global trend of sustainable development and consequently government policy on sustainability, which formed a platform for members of the construction industry of Hong Kong to rationalize, judge and act in a direction proved favorable to sustainability. Government sustainability policy in response to global trend is a prime driver in changing attitudes and behaviour of construction participants, albeit in the absence of any obvious financial reward for stakeholders, it is clear that there existed a process of evaluation within specific stakeholder groups when certain actions were taken as a conscious step of merits. When this change is measured within a certain time frame, the change over that span of time is named as the 'cultural shift'.

7.1.2 Stakeholder Groups and the Influential Power of each Group

Stakeholders of the construction industry of Hong Kong comprised various discipline participants. Stakeholders in managerial and supervisory levels are the subject personnel of this study. They are categorized into different groups according to the roles they played and functions executed in the construction industry of Hong Kong. These groups included the Government, Developer, Consultant, Contractor and Non-professionally recognized Frontline Construction Participant. Each of the groups exerts different influential power due to its hierarchy of functions and has a unique fundamental impact on the built assets. To evaluate the cultural shift in each stakeholder group, the influential factor (a_i) which affects the sustainable output of each group was studied via questionnaire surveys. It is stipulated that different stakeholder groups bear different influences during project development and with the final built asset. It was found that the influences which affected the output of the built

facilities showed little variance between the years 2004 and 2006 surveys. The results of both investigations prove that the respondents shared equal perception about their influential power despite the surveys were conducted in varied timeframes and with different individuals.

7.1.3 Development of T-model as a Measurement Tool of Cultural Shift

The T-model, an exclusively serviceable mechanism developed for the measurement of cultural shift, proved to be capable of providing integrated research results. Changes in attitude and practice among construction participants and stakeholders within the research period of years 2000 and 2006 were examined in the preceding chapters by means of measuring the changes in stakeholders' performance from project design to construction operations covering awareness, concern, motivation and implementation. Since these four cultural components are abstract elements, handling them must be done by rationalizing research data into a scoring system. All surveyed data related to cultural components must be handled by scoring, sorting and grouping in accordance with their respective nature. For instance, the scores for the cultural component "awareness" of the government group was worked out based on the marking scheme setup in the questionnaire survey. The sorted scores of awareness were then multiplied by the influential factor (a_i) of the government group, which is the cultural value of awareness of the government group. This cultural value of awareness of the government group can be added up with the cultural value of awareness of other groups being worked in the same way to form the total cultural value of awareness of construction participants and stakeholders.

Similar summations have been applied to other cultural values to obtain the total concern, total motivation and total implementation of construction participants and stakeholders. By using the space diagram to integrate all cultural values, of the extent of change which represented the status of sustainable culture of all the construction participants and stakeholders in professional and supervisory levels within a particular time frame is revealed. The application of such in handling data obtained from questionnaire surveys has been unveiled in Chapter 3 section 3.3. The mechanism that handled the surveyed data has been displayed in Chapter 4 section 4.6. With a certain time frame being specified for measurement, cultural shift of the entire construction industry with respect to the specified period of time is thus obtained.

7.1.4 The Extent of Sustainable Culture Developed among Stakeholder Groups

Data obtained from questionnaire surveys conducted in years 2004 and 2006 on cognition and performance of sustainability among members of the construction industry of Hong Kong were converted to cultural scores which, in turn, provided numerical information on the extent of cultural shift within the research period between years 2000 and 2006. The surveyed data were analyzed by using Statistical Package for Social Science (SPSS). Cronbach's Alpha reliability tests supported by F-tests revealed that all the scales used for measuring the sustainability in construction are reliable at the 95% confidence level.

The measured results tabulated in Table 4.4 and Table 4.5 covered the research period from year 2000 to year 2006, the figures shown in these two tables have been

integrated in Figure 4.7 which showed individually the extent of shift of cultural components of all stakeholder groups in the form of cultural shift curves. Significant changes were found in awareness, concern, motivation and implementation by stakeholders' performance from project design to construction operations in the research time frame between years 2000 and 2006. A few negative shifts that stretched over the research period were found among the overwhelming amount of positive shifts. These negative shifts were considered as important findings in the questionnaire surveys. Between years 2000 and 2002, negative shifts occurred in the government group and the developer group in implementation and motivation respectively. Between years 2004 and 2006, negative shifts also appeared in the consultant group in concern, the developer group in implementation and the NPP group in awareness and concern. All these negative shifts, although insignificant in number when compared with the amount of positive shifts, were crucial findings representing deteriorations within the groups throughout the research period. Proper corrective actions by decision-makers may transform attitudes and behaviours of the respective stakeholder groups and that could yield significant and persistent improvements to sustainability in the construction industry. All in all, the test result at 95% confidence level as shown in Table 4.6 ruled out the null hypothesis of no significant mean difference on the tested sustainable cultural components in construction between the test year points. Hence, a generalized positive shift of the cultural components within the research time frame is justified.

Attention must be drawn to a few occasions in the analysis when the null hypothesis of no significant change in the four sustainable components cannot be rejected. Figure 4.7 unfolded few contradicting movements where the consultant group exhibited

negative shift in concern between years 2004 and 2005, but very positive shifts were revealed in motivation and implementation. The same contradiction appeared between years 2004 and 2005 in the NPP group, in which negative shifts were observed in awareness and concern, while positive shifts in motivation and implementation were found. These contradicting movements can be explained by the shift of job opportunities from Hong Kong to Macau, a neighbour city 61 kilometers south west of Hong Kong, where the Government of Macau released two additional gaming licences to international gaming operators in 2002 attracted investments to Macau to build casinos, hotels and tourism facilities. The economy boom in Macau has absorbed a large amount of Hong Kong construction work force, workers and professionals working in Macau which have alleviated the contemporary high unemployment rate in the construction industry of Hong Kong. According to the studies of Leung et al (2007) and Chou (2007), the number of Hong Kong residents working in Macau in year 2006 was approximately 12,000 in which 90% of them were employed in construction projects. This number represented only legally imported workers, if illegal working population from the Hong Kong construction industry was also put into account, the number of Hong Kong construction workers in Macau would be largely increased. Sustainable construction was not a priority in the Macau construction industry at that time, and it became apparent that the shift of job opportunity from Hong Kong to Macau has reduced the cognitive attitudes of concern in sustainability within both the consultant groups and the NPP groups. Nevertheless, these Hong Kong construction participants were accustomed to performing sustainability in discharging their construction duties, therefore, they still embraced motivation and implementation behaviours.

In order to compare the results of significance between different stakeholder groups on the outcome of sustainability, Table 4.7 and Table 4.8 summarized results of the independent sample t-test and one-way ANOVA. The Government had a consistently higher apprehension on sustainability in construction than other groups. The Government had a remarkably higher score on concern of sustainability than all the other groups in 2004. The cultural component concern seems to have shifted to sustainability implementation in 2006, when Government was rated significantly higher than the Developer (sig. = 0.003) and the Contractor (sig. = 0.004) in implementation. It is interesting to note that although the developer group has a significantly higher score in awareness than the other groups, the score in implementation is lower than the others especially when compared with scores of the Government (sig. = 0.003) and the NPP group (sig. = 0.041). This may reflect that genuine execution of sustainable construction is limited to local developers, although they are key players in sustainability. The results may have indicated that the NPP group, the frontline runners in executing sustainable construction, demonstrated superior performance in sustainability particularly in motivation and implementation than other groups.

The T-model has synthesized the scores and revealed a significant change in sustainable culture. The cultural values obtained from the surveys identified the extent of a positive cultural shift among all stakeholder groups, in particular the Government and Contractor groups which were instrumental in promoting and executing statutory requirements and regulation. These ruled out the negative variances found within the developer group in implementation, the consultant group in concern and the NPP group in awareness and concern. A gereralized growth of

sustainable culture is thus revealed in Figure 4.5. When individual stakeholder group is taken out for review, Figure 4.6 reflected that the developer group was the least aggressive in cultural change especially in the earlier year points of 2000, 2002 and 2004. Profitability was still the sole concern for most developer groups, it is primarily due to insufficient incentive to provoke concerns and motivations on sustainable construction during recession. Similar result is obtained in the government group between years 2000 and 2002 when the Government strived hard to improve the economic and the unemployment conditions of Hong Kong, sustainability was comparatively less important at that point, however, the situation changed swiftly upon the outbreak of SARS in year 2003. The government group showed a significant rebound from years 2002 to 2006 and became the driving force of sustainable development in the construction industry of Hong Kong. In contrast, the Consultant, the Contractor and the NPP exhibited a rather steady improvement in sustainable culture throughout the research period. This improvement can be explained by the fact that their performance was largely governed by Government rules and regulations. Readiness in compliance by the consultant group, the contractor group and the NPP group as well as willingness of these three groups to adopt new practices resulted in a new operating environment which was favorable to sustainable construction, it would be true to say that these three groups pioneered the cultural shift towards sustainability in practice under the direction of the Government.

7.1.5 Presenting the Trend of Cultural Shift to Decision-makers as Reference

Presentation of the trend of cultural shift collectively within the research period between 2000 and 2006 for the construction industry is shown in Figure 4.5, the shift

of individual stakeholder group is shown in Figure 4.6 and the shift of each cultural component is shown in Figure 4.7. These three figures would give decision-makers a simple and clear picture on the trend of change of every stakeholder group, the movement of each cultural component and the outcome of the entire construction industry as a whole. Decision-makers can use these curves to review and monitor the trend of growth of every stakeholder group in order to identify any mismatches and regulate policies in parallel with the trend of change. Any acute rise or fall in the curves and any contradictions appeared in the movements between cultural components, such as the contradictions found in the Consultant group and the NPP group in years 2004 and 2005 as specified in Section 7.1.4 above, are reflections of impact on the healthy growth of sustainable culture. Decision-makers can initiate investigations into reasons behind and take appropriate action.

7.2 The Research Findings from Questionnaire Surveys

The results obtained from the questionnaire surveys as shown in the integrated cultural curve illustrated a generalized positive growth in sustainable culture of the construction industry of Hong Kong. The influential factor (a_i) plays an important role in the research outcome as it served as a multiplier to each cultural score forming cultural value of each research year. The magnitudes of (a_i) of both questionnaire surveys that were obtained from different survey samples at different research years, were very close to one another; this is evidence showing the reliability of the survey results. It is understandable that the government group possesses the highest influential power, it not only pioneered the sustainable development of Hong Kong

through policy making actions but also took a leading role enabling sustainable construction. The Developers were the investors of built assets and occupied the second highest influential power among all stakeholders. The developer group employed consultants to design and contractors to build, the requirements and the functional objectives of the built assets dominated the performances of the consultants and the contractors. The consultant group had less influential power than the developer group due to the nature and the roles of their services, however, they are important players influencing the sustainable output of the development by applying considerable sustainable elements in their designs and using substantial amounts of environmentally friendly materials. The Contractor's role was to build according to the design and specifications; the method of construction selected by the Contractor was a crucial factor that would heavily affect the sustainable construction result. Although the influential power of the contractor group was not being placed in a high ranking, the output of the contractor group in sustainable construction in terms of consumption of resources and the generation of construction waste was crucial. The NPP group is formed by individuals who were employees within the other groups and played supervisory functions in construction sites as front line managers. Even if they had a very high recognition of sustainable construction and performed diligently in their respective job duties, their output in sustainable construction remained at the level of an individual. Their influential power being placed at the lowest ranking is self-explanatory.

Since the design of the questionnaires covered economic, social, and environmental aspects generally in equal weighing, the integrated curve in Figure 4.5 represented a

balanced growth in economic, social and environmental attributes between years 2000 and 2006 under the influence of sustainable development within the research period.

It is interesting to note from Table 7.1 that the economic conditions of Hong Kong in terms of gross domestic product per capita between the years 2000 and 2003 was unfavorable due to the prolonged Asian economic recession which began in early 1998. The economy of Hong Kong started to pick up by the third quarter of 2004 and the economic condition continued to improve till year 2007.

Year	Taiwan	Korea	Singapore	China	Hong Kong	USA	Japan
2007	17252	20045	33919	N.A.	**31066**	46029	35424
2006	16494	18401	28852	2026	**28222**	43774	35169
2005	16613	16413	25533	1729	**26124**	41737	36452
2004	15156	14206	24247	1488	**24898**	39624	36740
2003	14012	12717	21996	1268	**24102**	37495	33705
2002	13604	11497	20593	1124	**24392**	36104	31269
2001	13348	10159	20662	1027	**25356**	35338	32717
2000	14519	10938	23079	847	**25426**	34548	36602

Table 7.1 GDP per Capita in US dollar of Selected Countries and Hong Kong between 2000 and 2007
Source: Department of Finance, Republic of China, Taiwan, 10/10/2008

The curve in Figure 4.5 revealed that the cultural shift value moved from 20.13 to 20.15, indicating a negligible movement between years 2000 and 2002. An acute improvement was recorded between years 2002 and 2004 when there was no significant improvement in the economy, yet the cultural shift value actually moved from 20.15 in year 2002 to 22.92 in year 2004. It is believed that the outbreak of Severe Acute Respiratory Syndrome (SARS) which claimed 299 lives in Hong Kong in 2003 was the main cause that led to this eventual outcome. The spread of this fatal epidemic and the attempts to subdue and prevent further outbreaks resulted in

substantial demands on improvements for better hygienic conditions and living environment; a remarkable change among Hong Kong citizens in recognition of sustainability started to prevail. After the SARS incident, a steady growth in positive cultural shift was recorded for the rest of the research time frame between years 2004 and 2006. In this period of time, the economic condition of Hong Kong improved and an increase in GDP was recorded and is reflected in Table 7.1. Comparison can be made between the continuous growth of Hong Kong economy and the growth of sustainable culture for the same period of time. A relationship between cultural shift towards sustainability and the trend of movement of economy can be established. Figure 7.1 is a comparison of the curves showing the growth of Hong Kong GDP within year 2000 to 2007 and the shift of sustainable culture between years 2000 and 2006.

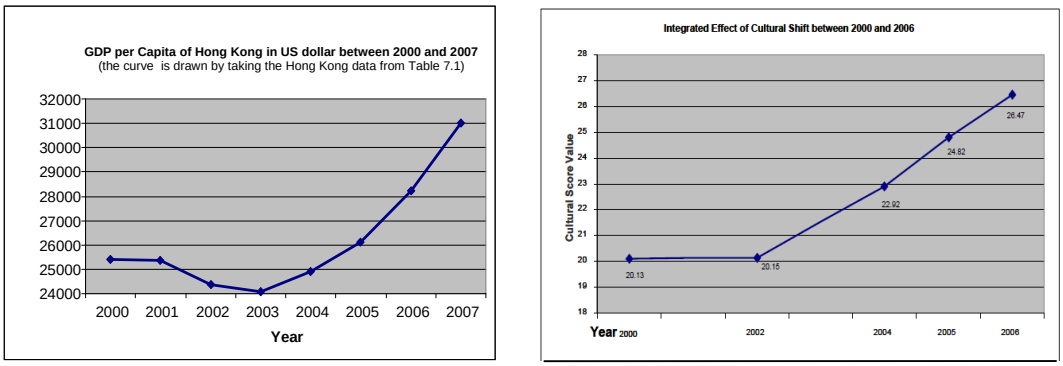


Figure 7.1 Comparison of GDP Movement and Cultural Shift

The shape of both curves resembled each other and might imply that tendency of change of GDP per capita and cultural shift are interrelated.

The finance tsunami outbreak in the autumn of 2008 has swept the global economy in that year onwards, the Hong Kong economy was seriously affected and the effects of

such economy downturn had not improved up to the writing of this thesis in the middle of year 2009. If a future investigation on cultural shift between years 2008 and 2009 would have been turned out to be negative and resembled the downturn of the economy, the concordant relationship between the movement of economy and the cultural shift towards sustainability could be further validated.

It is interesting to note that another noticeable drive of the growth in sustainable culture in the construction industry was the introduction of landfill charges for C&D waste disposed in the landfill sites. The charge was a vigorous subject for debate for over six years in the Legislative Council until it was finally promulgated in year 2005. The Ordinance affected all construction participants from project planning to construction operation. Stakeholders started to try strenuously to reduce construction waste which was applicable not only to construction operations but became an important part of contractual arrangements and commercial interests. All stakeholders tried to reduce contractual liabilities in the generation of C&D wastes starting from project design activities to construction operations. Such attempts in cutting down construction waste have resulted in apparent changes in the habitual practices of all construction participants in their daily duties. The new waste minimizing activities induced changes in sustainable culture among stakeholders. Cultural shift took place subconsciously among them in their performance from project inception stage to project design and from construction planning to construction operation. Investigation conducted in this period as shown in the year 2006 questionnaire survey elicited important information that showed continuous growth of sustainable culture up to the cultural shift value of 26.47 which is an obvious result of Government

legislation actions that brought about the change of sustainable culture among construction participants.

The study also revealed that some construction participants were albeit initially weak in awareness of sustainability, their recognition grew stronger via the implementation process. The implementation of sustainable construction improved the overall conditions of their work environment and made them realize the merits of sustainability. Their understanding helped to enhance thier awareness of the necessity of sustainable construction and exercised feedback to the precedent cultural component. The sense of development in awareness of sustainability as a result of implementation process echoed with the human behaviour theory developed by Allport (1935), Ajzen and Fishbein (1975) and Ajzen (1991).

7.3 Interpretation of Findings from Qualitative Approach through Interview

The questionnaire surveys identified a positive cultural shift within the research period and this shift is a reflection on the accomplishments of sustainable construction among all stakeholder groups. To investigate cultural shift through the perspectives of various industry stakeholders, a series of interviews with all stakeholder groups were conducted to cross-reference with the measured result from questionnaire surveys on the change of sustainable culture within each group and the construction industry of Hong Kong as a whole.

The results of interviews in identifying the influential factors of each stakeholder groups matched perfectly with the hierarchical results obtained from the year 2004 and 2006 questionnaire surveys. From the answers to the closed-end questions summarized in Table 5.2, all the interviewees unambiguously agreed that positive changes in attitudes and behaviours among their colleagues and co-workers towards sustainability were underway. These changes propelled actions to perform sustainability with willingness to increasing construction budget to acquire sustainable result. They further admitted that they have seen a positive movement in sustainable culture and indeed witnessed stakeholder groups initiating changes autonomously whilst others followed due to contractual or trade obligations.

The research outcome of the open-end questions revealed similar results of the closed-end questions which agreed with the results obtained from questionnaire surveys. Interviewees also agreed that adoption of sustainable construction methods did not cause much diversion from general requirements to produce quality product, however, conversion of habitual practices to environmentally favorable practices were effected due to global demands for betterment in sustainability. This concurrence within all stakeholder groups is clearly a positive recognition of the universal values aiming for sustainability in construction.

Interviewees have signaled an interaction among different groups, where research activities carried out by academia and professional bodies motivated the change in sustainable culture by the output of their research works, Government initiatives in policy making and legislation for sustainable development enabled the process of sustainability. Based on the promulgated ordinances and regulations, stakeholder

groups played their respective roles implemented sustainability in accordance with their professional functions. It is therefore logical to conclude that research results facilitated Government policy-making which in turn had a direct impact on practice irrespective of stakeholder grouping. Government is therefore taking an enabling role towards sustainability while sustainable culture among stakeholders is nurtured and developed through the process of implementation. It was found that sustainable culture of stakeholders and their intention to implement could be sustained when the working environment and atmosphere were conducive to sustainability. On the contrary, sustainable culture and intention to implement diminished where the working environment did not put sustainability as a priority.

In addition to validating the research outcomes from questionnaire surveys, the interviewees' reply to the open-end questions yielded two important issues. The first one is "**partnering**" which would help to improve sustainability in project management, and the second one is "**commit to perform sustainability**" when sustainable practice would become a culture.

"Partnering" in project basis is a legally non-binding agreement between parties of a construction project. Partnering seeks cooperation, trust, common goals, mutual benefits, commitment and respect between contracting parties (Bennett et al 1996, Li et al 2000). Experiences of interviewees on projects that were run with partnering approach achieved conflict resolution that eliminated unnecessary waste of resources and time, giving more sustainable results in project achievements. Applications of partnering approach have been recorded in projects in Hong Kong and were proven with very successful outcomes. One of the most successful partnering projects is the

Tseung Kwan O Extension of the Mass Transit Railway in Hong Kong which achieved cost and time savings, quality enhancement and environmental effectiveness (Bayliss, 2002). The study of Hunt and Yeung (2002) expounded partnering process in a case study by using a partnering project case in Hong Kong. A number of construction projects in Hong Kong have applied partnering approach with recorded success in various aspects. These projects included government development projects, quasi-government projects and private development projects.

Another important finding in the open-end question session was "commit to perform sustainability". One of the interviewees opined that when practice of sustainable construction became a habitual practice among stakeholders, reluctance to perform sustainability would be unethical and resisted by professional bodies and trade unions. When attitudes and behaviours towards sustainability ripen into social settings and sustainable construction became a culture of all stakeholders, it becomes a pattern of life style and is adopted by all. Such an adoption is a commitment on performance for sustainability.

The shifts of cultural components are interacting with one another in a progressive manner. The movement from one stage to the other is a continuous process rather than simply jumping from one step to another. The changes from awareness to concern and from concern to motivation then to implementation is not a one way process but reflecting feedback to the precedent cultural component as a response along the course of cultural shift. For instance, when motivation increases and reaching to the succeeding step implementation, knowledge gained from implementation will then provide feedback and remodel motivation. Likewise,

increase in concern will direct the concern component into motivation activities. When barriers are encountered in motivation actions will re-shape the concern component with feedback actions. Similar feedback actions can be applied to all cultural components from the successors back to the predecessors. To better illustrate the movements and feedback actions of cultural components, the simplified version of the cultural shift model (Figure 2.6) shall be modified accordingly and the moral sentiment Commitment is added in the Modified Cultural Shift Model as shown in Figure 7.2.

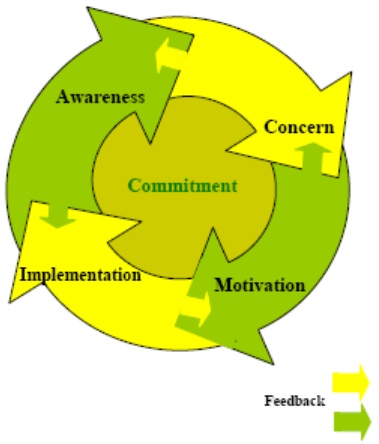


Figure 7.2 Modified Cultural Shift Model

It was opined that when all stakeholders become sympathetic to sustainability and embrace sustainable culture, they will commit themselves in performing the same in discharging their job duties. Commitment is a responsible charge, it can only be recognized among members of society when sustainable culture is commonly established and mature. When performance of sustainability becomes a commitment and all stakeholders of the construction industry autonomously perform the same, a sustainable society within the construction industry will be readily realized as shown in Figure 7.3 Cultural Shift Leading to a Sustainable Society.

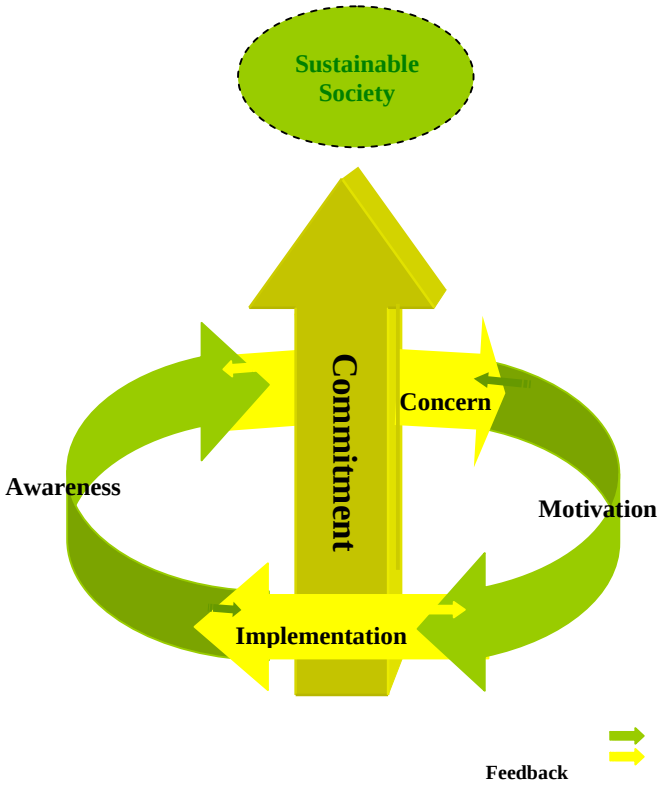


Figure 7.3 Cultural Shift Leading to a Sustainable Society

7.4 Triangulation of the Research Findings by Case Study

The four case studies shown in Chapter 6 focused on four different perspectives in achievement of sustainable construction, namely:

- Extensive use of precast concrete units initiated by developer – The Hong Kong Community College
- Government incentive schemes for green construction – The Orchards

- Harmonious design integrated with environmental setting achieved in project design and project management by using 5-S Practice – The Wetland Park
- Applying composite formwork and precast construction in low-rise school project pioneered by contractor as a trial to intensify precast construction – The Millennium School Project

Despite the end results of these four cases, it is evidenced that inputs by all stakeholder groups in these projects reflected a definite change in attitudes and behaviours towards sustainability. The changes in attitudes behaviours modified both the mind set and habitual practices of stakeholders. As governed by the nature of each project, the information obtained from these four cases are hardly comparable in achieving a perfect match with the questionnaire surveys and structured interviews, however, all these four cases have clearly signaled that a cultural shift is underway in the construction industry of Hong Kong and this is an acceptable result of triangulation in supporting the research outcome. Table 7.2 summarized the major outcomes of these case studies and tabulated the affirmative results attributable to each cultural component.

Table 7.2 Identification of Selected Cases Attributable to each Cultural Component

Identification of the Selected Cases Attributable to each Cultural Component

Cultural Components *Defined in Chapter 2 section 2.3* / Nature of the Selected Case	CCHK	The Orchards	Wetland Park	Formwork Comparison
	Extensive use of precast unit in superstructure construction	**Design in meeting sustainability requirements to capture incentives**	**Integration of built assets into nature setting and implementation of 5-S practice in construction management**	**An attempt to apply composite formwork system in low-rise buildings of identical design**
Awareness: *Awareness is an inner vision in a state of mind to provoke change to rectify the unsatisfied condition according to knowledge, moral values, briefs, subjective norms as well as input of social situation. Construction industry stakeholders are aware of the negative impacts, e.g. create unnecessary wastage (environmental), neglect construction safety (social), and disregard product quality (economic) that their current practices and performances may have caused impairs to human society, their eagerness to improve grows stronger.*	**YES** Developer, Consultant, Contractor and NPP were aware that precast construction is higher in construction cost and environmentally friendly.	**YES** Government was aware that sustainability in construction could be acquired by incentive scheme and promulgated JPN 1 and 2 for stakeholders to achieve.	**YES** Government (played dual roles as Developer and Consultant) and Contractor were aware the importance of the nature setting with strong intention to protect the environment and the wetland ecology.	**YES** Contractor was aware that there is a need to attempt for an innovative construction method for low-rise building with repetitive construction cycle.
Concern: *Concern is defined as bringing the anxious feelings of the unsatisfied condition or the unease state of mind into conscious attitudes integrated with judgments. Concern arises as a result of awareness on scenarios which arouse desires for improvement.*	**YES** Contractor and NPP concerned the social impact on shifting of employment from high skill carpentry to low skill precast unit installation.	**YES** Developer evaluated and judged (regarded as part of concern component) that followed JPN1 and 2 would be beneficial by increasing salable area.	**YES** Government (played dual roles as Developer and Consultant) concerned the adverse effects of the development and construction process that may endanger the habitat of the wetland.	**YES** Contractor evaluated and judged (regarded as part of concern component) that using composite formwork and precast semi-slab in low-rise building could be risky in construction cost and time.
Motivation: *Motivation implies a stimulus impelling to act, to move and to improve. It is the desire to take action to work for the defined objectives in alleviating the undesirable consequences of the un-sustainable acts. Motivation must have direction. The eagerness to change is the intention that tries to modify the status quo of the construction industry*	**YES** Consultant, Contractor and NPP motivated cultural changes by impressing other construction participants with the intensive use of precast units in building structure.	**YES** Government initiated sustainable policy and Developer motivated sustainable construction to elicit incentives.	**YES** Design in harmony with the nature setting motivated stakeholders to remodel thinking on sustainable construction. Extensive use of recycled aggregate in concrete motivated other government projects to follow.	**YES** Contractor motivated an attempt to change the traditional practice by using system formwork and precast semi-slab in low-rise building.
Implementation: *Implementation is the result of behavioural intent. Unlike the attitudinal attributes of awareness and concern, implementation is dynamic rather than static in the construction industry. It is the willingness of construction stakeholders to spend time, energy, effort and money to initiate changes in order to achieve sustainable construction.*	**YES** Developer, Consultant, Contractor and NPP implemented sustainable construction by extensively use of precast unit and waste management in construction.	**YES** Consultant/Contractor /NPP implemented design and construction of various green elements.	**YES** Government implemented sustainability in green designs, e.g. geothermal heat exchange for air conditioning and extensive use of recycled aggregate in concrete. Contractor and NPP implemented 5-S practice in construction management.	**YES** Contractor implemented sustainable construction by using system formwork and precast semi-slab in low-rise building.

7.5 Limitation of the Study

The study focused on cultural shift among managerial and supervisory construction participants, construction workers who carry out various physical works and handle construction materials on construction sites have not been included in this study. Construction workers form a massive group in the construction industry, they take orders from their supervisors in performing their daily job duties; their performances are dependent upon instructions and requirements of the design criteria, specifications as well as the wills of their supervisors. It remains unknown whether the construction workers have been influenced by their supervisors and subsequently changed their attitudes and behaviours which might have been favorable to sustainability or, indeed, enhanced sustainable construction output.

The design of the questionnaire cannot on one hand investigate the cultural shift of the professionals and, on the other, be fit for use in probing changes in inclination of construction workers. Cultural shift of construction workers can only be investigated as a separate activity with an exclusively designed survey instrument.

The Government of the HKSAR set out to implement sustainable development as early as year 1999. The influence of Government action upon the construction industry should have commenced in year 2000; that is the reason for setting the baseline of cultural shift at year 2000. The research started in year 2003 and the first questionnaire survey was conducted in the last quarter of year 2004. Sustainable culture of construction stakeholders of the baseline year was established by virtue of retrospective information given by the respondents in the first questionnaire survey. The starting point of the cultural shift curve comprised responses which were based

on recollections of the respondents. Moreover, developers and contractors normally do not retain complete sets of information and data of finished projects. Shortage of real life project information between years 2000 and 2004 handicapped the validation of the research findings that were based on retrospective information obtained from the first questionnaire survey. Nevertheless, the accuracy of the research remained reliable, because most of the respondents are experienced in the construction industry of Hong Kong and most of them hold responsible posts in their own disciplines for a number of years, retrospective information provided by them is trustworthy.

7.6 Summary

This chapter revisited the setting of research approaches and evaluated the research findings. The research approaches established in the questionnaire surveys, structured interviews and case studies cross-referenced with one another. Justifications of the research findings were discussed with reference to the economic, social and environmental conditions of Hong Kong within the research period. Cultural Shift Model was modified according to the findings to better represent the real life situation of the construction industry of Hong Kong.

All the objectives as set out in Chapter 1 guiding the research activities were responded to with research findings, so much so that a conclusion of the study as stipulated in the succeeding chapter could be drawn from them.

CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

The construction industry of Hong Kong contributes an important portion of the local GPD and is a major employer of different professions and trades. It generates construction waste which amounts to over 20% of total landfill disposal. Over the years, the industry has established its own ways and means of getting jobs done; the practices became habitual and are accepted by all participants as a culture despite changes that have taken place over time due to improvements in construction technology, method and management. The demand for sustainable development rings the bell for improvement. Stakeholders of the construction industry of Hong Kong realized that there are areas where progress is behind the global trend and local demands. Under the governance of the Government of HKSAR, changes towards the direction of sustainable construction from mind set to implementation have taken place.

This study hypothesized that a cultural shift towards sustainability has taken place among construction participants ever since the HKSAR Government initiated sustainable development in year 1999 as a policy for the future development of Hong Kong. As the prime driver for sustainability, the Government has promulgated rules and regulations that changed the sustainable mode in all construction activities. The study attempted to identify a cultural shift towards sustainability which took place among construction participants in Hong Kong within the research period between the

years 2000 and 2006. This hypothesis proved and the findings showed that a cultural shift towards sustainability has indeed occurred, identified and validated by using surveys, interviews and case studies.

8.2 Conclusion

The study concluded that:

- The sustainable development policy of the Government of HKSAR has significant effect on the essential output of construction projects,
- Stakeholders of the construction industry of Hong Kong have undergone attitudinal and behavioral changes based on the sustainable construction principles (Kibert 1994). Such a change is the migration of code of conduct favorable to sustainability and is referred to as sustainable culture; the change of sustainable culture within a certain timeframe is defined as Cultural Shift,
- Cultural Shift can be measured numerically by means of an exclusively designed model, the T-model,
- Cultural Shift has occurred within the construction industry of Hong Kong and positive cultural shift is identified in the research period between years 2000 and 2006 by means of a simple tendency curve (Figure 4.5), with the findings being cross-referenced with interviews and case studies,
- The T-model is a useful tool to investigate cultural shift which filled in the knowledge gap in exploring the trend of movement of sustainable culture. It is an important reference for decision-makers in the Government and private sectors to formulate and modify policies that align with social tendency.
-

The study identified:

- Sustainable culture of the construction industry comprises basically four cultural components viz. awareness, concern, motivation and implementation,
- The existence of an influential power which affects the sustainable construction output of stakeholder groups (Table 4.3),
- The trend and extent of cultural shift of each stakeholder group within the research period by making use of a simple tendency curve (Figure 4.6),
- The trend and extent of the change of cultural components of each stakeholder group within the research period and presented by using a simple tendency curve (Figure 4.7).

This study has categorized five stakeholder groups that formed the construction industry of Hong Kong as a whole. Each of them owned influential power in accordance with their functional hierarchy with financial weighing in the construction industry. Cultural components such as awareness and concern are attitudinal orientations which interact with behavioral actions in motivation and implementation, hence, may inadvertently have attributes in financial weighing, social consideration and environmental significance. A positive interaction between Government and the construction industry has taken place and if the construction industry of Hong Kong continues to perceive these attributes as real benefits to the enterprise and society as a whole, the change will sustain growth in the direction of sustainable development. If the ultimate aim of sustainable development is to balance the social, economic and environmental needs for both present and future generations through the efforts of the community and the government, then this study has shown that all parties listed have

a role to play and their concerted efforts hinge upon one core value: how society and future generations may benefit from present day activities.

8.3 Recommendations

It is recommended that the study should be carried out continuously in a defined timeframe such as once a year, so that the trend of movement is well recorded and closely monitored. The more yearly surveys are done, the better the cultural shift curve is revealed, providing reference for decision-makers to formulate policy for sustainable development.

Cultural shift recorded in this study is unable to demonstrate whether there is a co-relation between economy growth and the change of sustainable culture. A sluggish growth in sustainable culture was recorded between years 2000 and 2002 during the Asian economic recession period but the trend of growth escalated by the sudden SARS raid in year 2003. A steady economical growth started in year 2004 which paralleled with the positive growth of sustainable culture between years 2004 and 2006. Continuous investigation may illustrate the influence of the year 2008 financial tsunami on the shift of sustainable culture, because the predicted prolongation of recession after the financial tsunami may provide certain impact to the movement of sustainable culture. When the measured results of cultural shift between years 2000 and 2006 are compared with the economic cycle, which included the retarded growth of sustainable culture in the Asian economic recession, the sudden outburst in the SARS incident, and the positive growth between years 2004 and 2006, together with

the results yet to be measured in the period of the expected prolonged recession after the financial tsunami, the relationship between the financial trend and the cultural shift tendency could be revealed.

As mentioned in Section 7.5, construction workers form a massive group within the construction industry of Hong Kong, their mind-set towards sustainable construction and the tendency of their cultural inclination should be investigated by using an exclusively design instrument.

Seven out of eight interviewees in the structured interviews have suggested that a Partnering approach in construction management will enhance sustainability. Partnering rouses trust and cooperation between contracting parties, removal of dispute, etc. This overwhelming suggestion represents substantial ground as to how this project management approach may improve project output in sustainable construction remains a topic to be explored in future study.

8.4 Postscript

Hong Kong as a society has made its demands on sustainability for more than a decade and this can be seen in the presence of concerned groups and numerous civic actions on Government or developer construction plans. The tolerance threshold has changed, now that society is well aware of sustainability and its implications for its present and the future generations.

By the end of year 2008 when the conclusion of this study is written, Hong Kong witnessed a substantial change in a development proposal plan. The significant reduction in development intensity of Hopewell Centre 2 to match with existing conditions, substantial changes made to this prospective urban development within the old urban district of Hong Kong are reflections on how a sustainable society functions. The gross floor area of the new plan is reduced from its originally approved 172,731 square meter by 31%, the plot ratio is reduced from a permissible 15 to 10.3 which means the building height is being lowered by 105 meters cutting its original 93 stories to the present 55 (The Standard, 2008). It is an answer responding to society demand for a mega-size building development project but one that is more in line with the local environmental setting; it is an obvious balance between the owner's development right on the one hand and addressing public concern on the other.

The HKSAR Government has a plan to re-develop the Tamar site into the new Government Headquarters and other civic facilities. The joint venture contractor who won the bid has commenced site activities and it is interesting to note the content of site banners have undergone a change in context. Previously, one would find most construction sites carry slogans and display boards emphasizing site safety. In the Tamar site, the contractor has put very prominently a display board facing a trunk road reading: ***"Building in an Environmentally Sustainable Manner"***. This is clear indication on a shift of construction culture and the contractor's commitment towards sustainability.

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APPENDICES

Appendix 1

Sample of Year 2004 ***Questionnaire Survey and Marking Scheme***

Questionnaire Survey (Marking Scheme)

Sustainable Development of the Construction Industry of Hong Kong

The government of HKSAR continuously promoted sustainable development through media, exhibitions and public consultation between years1998-2000**.** This survey seeks to collect your perception and the extent of your involvement in sustainable development of the construction industry of Hong Kong.

Please tick/click on the box ☐ for each question and type your answers in the space provided _____ according to directions given.

General Information

A. What is the nature of your Company?

- ☐ Government department, public developer or quasi-government organization
- ☐ Private developer
- ☐ Contractor
- ☐ Consultant
- ☐ Other. Please specify: _____

B. What is the size of your Company?

- ☐ Less than 50 employees
- ☐ 51 – 250 employees
- ☐ 251 – 500 employees
- ☐ More than 500 employees

C. Are you affiliating to the following professional institutions?

Yes ☐ Please check ☐ HKIA
☐ HKIE
☐ HKIS
☐ HKICM
☐ Other. Please specify: _____

No ☐ Please go to item E

D. What is your class of membership in the above professional institutions?

☐ Fellow
☐ Corporate member
☐ Associate member
☐ Graduate member
☐ Other. Please specify: _____

E. How many years have you practised in the construction field?

☐ Less than 5 years
☐ 5 – 10 years
☐ 10 – 15 years
☐ 15 – 20 years
☐ Over 20 years

F. How old are you

☐ 20 to 29
☐ 30 to 39
☐ 40 to 49
☐ 50 to 59
☐ 60 or older

Part I: The following is about your *Awareness* of the sustainable development movement. (ONE mark for each selected answer except otherwise specified)

1. By what means you have acquired knowledge of sustainable development? You may select **more than one** answer.

- ☐ Attending seminars arranged by the government
- ☐ Attending CPD events arranged by professional institutes
- ☐ Through working experience / on-job training
- ☐ Through self-study
- ☐ Other channels _____

2. The three attributes of sustainable development are 'economic', 'social' and 'environmental'. In your opinion, which one is more important? You may select **more than one** answer.

- ☐ Economic (1 mark)
- ☐ Social (1 mark)
- ☐ Environmental (1 mark)
- ☐ They are equally important (3 marks)

(The maximum score for this question is 3 marks)

3. Subsequent to the government consultation about sustainable development for Hong Kong between 1998 to 2000, the followings are the proposed ***'key concerns'*** and ***'indicators'*** of sustainable development for Hong Kong. Show your acknowledgement to the proposed key concerns by ticking/clicking on the box ☐ provided. You can select **more than one answer** whenever appropriate.

   ☐ Economy
   ☐ Health and Hygiene
   ☐ Natural Resources
   ☐ Society and Social Infrastructure
   ☐ Biodiversity
   ☐ Leisure and Cultural Vibrancy
   ☐ Environmental Quality
   ☐ Mobility

   (One mark for each selection, the total score for this question is 8 marks)

4. Do you agree that the 'key concerns' and 'indicators' of question 3 above are the only elements that constitute the sustainability of Hong Kong?

   ☐ Yes,

   ☐ No,

   If 'no', what other element(s) you wish to add _____.

5. Are your aware that there is a growing recognition of the concept of sustainable development among the people around you? You may select **more than one** answer from the following boxes.

   ☐ Your Colleague
   ☐ Your Counterpart
   ☐ Your Competitor
   ☐ Your Client
   ☐ Government Official
   ☐ Others

6. The followings are principal stakeholder groups that constitute the construction industry of Hong Kong. Each group possesses substantial power to influence sustainability output in their belonging disciplines.

Base on your opinion, please provide the weighting of influential power of each group. Your weighting of your opinion must sum up to 100%.

Stakeholder Groups	***Weighting of Influential Power***
Government	_____%
Developer	_____%
Consultant (including architect & engineer)	_____%
Contractor (including subcontractor & supplier)	_____%
Individual Non-professional Participants	_____%

Total: 100 %

Part II: The following is about your *Concerns* about sustainable development.
(Marking provisions are as indicated to each respective answer)

Please tick/click the appropriate answers indicating the degree of your agreement on the following statements

.

1	We are approaching the limit of the number of people the earth can support.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion
2	The balance of nature is very delicate and easily upset.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion
3	Humans have the right to modify the natural environment to suit their needs.	-2☐ Strongly Agree	-1☐ Agree	1☐ Disagree	2☐ Strongly Disagree	0☐ No Opinion
4	Humankind was created to rule over the rest of nature.	-2☐ Strongly Agree	-1☐ Agree	1☐ Disagree	2☐ Strongly Disagree	0☐ No Opinion
5	When humans interfere with nature it often produces disastrous consequences.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion
6	Plants and animals exist primarily to be used by humans.	-2☐ Strongly Agree	-1☐ Agree	1☐ Disagree	2☐ Strongly Disagree	0☐ No Opinion
7	To maintain a healthy economy we have to develop a “steady-state” economy where industrial growth is controlled.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion
8	Humans must live in harmony with nature in order to survive.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion
9	The earth is like a spaceship, with only limited room and resources.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion
10	Humans need not adapt to the natural environment because they can remake it to suit their needs.	-2☐ Strongly Agree	-1☐ Agree	1☐ Disagree	2☐ Strongly Disagree	0☐ No Opinion
11	There are limits to growth beyond which our industrialized society cannot expand.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion
12	Humankind is severely abusing the environment.	2☐ Strongly Agree	1☐ Agree	-1☐ Disagree	-2☐ Strongly Disagree	0☐ No Opinion

Part III: This section of the questionnaire wishes to explore whether you have actually *motivated* changes towards sustainability since 2000 within you daily duties.

(Marking provisions are as indicated to each respective answer)

Please tick/click the appropriate answers indicating your have motivated changes since 2000 (e.g. use of environmentally friendly materials and methods in construction works, caring more about safety and health issues in discharging construction duties, and the increased emphasis on the quality of products).

1	What is the extent of changes in using environmentally friendly material/green construction methods?	1☐ Nil -10%	2☐ 10 -20%	3☐ 20 – 30%	4☐ 30 -40%	5☐ >50%
2	What extra cost would you consider paying for adopting changes to using environmentally friendly materials /green construction methods?	1☐ 1%-3%	2☐ 3%-5%	3☐ 5%-7%	4☐ 7%-10%	5☐ >10%
3	What is the extent of changes in caring of safety and health issues in project design and construction process?	1☐ Nil -10%	2☐ 10 -20%	3☐ 20 – 30%	4☐ 30 -40%	5☐ >50%
4	What extra cost would you consider paying for adopting changes to increase safety and health in project design and construction process?	1☐ 1%-3%	2☐ 3%-5%	3☐ 5%-7%	4☐ 7%-10%	5☐ >10%
5	What is the extent of changes in emphasis of product quality?	1☐ Nil -10%	2☐ 10 -20%	3☐ 20 – 30%	4☐ 30 -40%	5☐ >50%
6	What extra cost would you consider paying for adopting changes to enhance product quality?	1☐ 1%-3%	2☐ 3%-5%	3☐ 5%-7%	4☐ 7%-10%	5☐ >10%
7	If you try to promote environmental issues, safety and health issues, and enhance quality in your project, what is the percentage of cost increase you would propose to your boss or your client?	1☐ <1%	2☐ 2%-3%	3☐ 3%-4%	4☐ 4%-5%	5☐ over 5%
8	If you are not aware of the mentioned changes are underway, what is the main reason for that? (this question should be categorized and assessed in Section II –Awareness)	1☐ I don't know the reason	2☐ it is useless	3☐ nobody cares about it	4☐ impossible to change	5☐ incur additional cost

Part IV: This section of the questionnaire wishes to explore whether you have actually *implemented* changes towards sustainability since 2000 within you daily duties.

Please tick/click the appropriate answers that indicate your implemented changes since 2000 (e.g. use of environmentally friendly materials and methods in construction works, caring more about safety and health issues, and increase emphasis upon the quality of products).

1	Extent of changes in using environmentally friendly material/green construction method you would consider?	1☐ Nil -10%	2☐ 10 -20%	3☐ 20 – 30%	4☐ 30 -40%	5☐ >50%
5	What is the percentage of extra cost you would recommend to your boss or your client to pay for using environmentally friendly materials/ green construction methods	1☐ <1%	2☐ 2%-3%	3☐ 3%-4%	4☐ 4%-5%	5☐ over 5%
2	Extent of changes in applying care for safety and health issues in project design and construction process you would consider?	1☐ Nil -10%	2☐ 10 -20%	3☐ 20 – 30%	4☐ 30 -40%	5☐ >50%
4	What is the percentage of extra cost you would recommend to your boss or your client to pay for increasing safety and health in project design and construction process?	1☐ <1%	2☐ 2%-3%	3☐ 3%-4%	4☐ 4%-5%	5☐ over 5%
3	Extent of changes achieved in the area of enhancing product quality?	1☐ Nil -10%	2☐ 10 -20%	3☐ 20 – 30%	4☐ 30 – 40%	5☐ >50%
6	What is the percentage of extra cost you would recommend to your boss or your client to pay for enhancing product quality?	1☐ <1%	2☐ 2%-3%	3☐ 3%-4%	4☐ 4%-5%	5☐ over 5%
7	If your boss or your client is reluctant to accept your change proposal in sustainable construction, what will you do?	1☐ leave it as it is	2☐ leave it for other project	3☐ try again when condition is allowed	4☐ try to convince them	5☐ insist your change proposal
8	In what way have you encouraged your boss or your client to gradually adopt such changes? (this question should be categorized and assessed in Section II – Awareness)	1☐ leave it as it is	2☐ one step at a time	3☐ follow statutory requirements	4☐ step by step beyond statutory requirements	5☐ whenever I think fit

Part V: Change in Perception

This question tries to obtain the ***shift*** of cultural perception of sustainable development since 2000 and compare that with the current year.

On a scale of 5, circle/click the number of the following conditions that best represents your perception of the role of a construction professional in the following sustainable development issues (1 represents negligible significance and 5 represents extremely significant. Please ***circle the scale in both columns*** to indicate whether you have changed your perception.) : -

1 = 1 mark, 2 = 2 marks and so on.

*Questions 1, 2, 3 are used to measure the shift of **Awareness** from year 2000 to 2004 in Part II of this questionnaire survey. Questions 4, 5, 6 are for **Concern** in Part III. Questions 7, 8, 9 are for **Motivation** in Part IV and questions 10, 11, 12 are for **Implementation** in Part V.*

Changes of your Perception	**2000**	**2002**	**2004**
1. I believe sustainable development is important to the world.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
2. Use of environmentally friendly materials and green construction methods will eventually help to preserve natural resources.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
3. I am aware that sustainable development is getting more recognition among my colleagues and co-workers.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
4. Caring about safety and health in the project design & construction process, and an emphasis of quality of products is a sign of recognizing the importance of the socio-economic equity of sustainable development.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
5. I believe that using environmentally friendly materials and green construction methods, caring for safety & health, and emphasizing product quality will **increase** construction cost and time.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
6. On the contrary, the use of environmentally friendly materials and green construction methods, caring of safety &health, and enhancing product quality would **reduce** construction cost and time.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□

7. Even if there is an **increase** in the construction cost and time, I intended to apply sustainable construction methods in Hong Kong.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
8. Even if there is an **increase** in the construction cost and time, I have noticed that my colleagues and co-workers intended to apply sustainable construction methods in Hong Kong.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
9. Even if there is an **increase** in the construction cost and time, I have noticed that my clients intended to apply sustainable construction methods in Hong Kong.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
10. I have implemented sustainable development principles in my work and will practice the same continuously.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
11. I have found that my colleagues and co-workers have implemented green ideas and added socio-economic equity elements in their work.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□
12. I have found that my clients have implemented green ideas and added socio-economic equity elements in their proposed projects.	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□	1 2 3 4 5 □□□□□

Appendix 2

Questions for Structured Interview

Notes to Interviewee

Thank you for your kind acceptance to accept the invitation for a 45 minutes interview. It is organized as a follow-up investigation of your earlier response of the questionnaire survey for cultural shift of the construction industry towards sustainability. The following questions are identically designed for interviewees representing the Government*, Developer*, Consultant*, Contractor* and Non-professional Participant* stakeholder group. (*delete as appropriate). No matter which stakeholder group you are belonging to, your opinion to the questions carries equal weighing.

Thank you very much for your kind acceptance to our request for interview. In order to save your valuable time and making the interview most effective, please take a few minutes to read the questions set out below which will be raised during the interview. The questions designed are separated into three sections. Please provide your answer to all of them according to your best understanding of sustainable development, sustainable construction and policy that the Government is taking towards sustainable development. Please contact the researchers with the contact details provided hereunder for anything you wish to clarify before the interview. Your query is most welcome.

Contact Person: Robin Yip - research student of the Department of Civil and Structural Engineering, the Hong Kong Polytechnic University

Telephone Number: 9196

Email Address: robin.yip@

Part 1: Closed-end Questions

1. Do you know that the government has set up 7 sustainable development indicators *(Economy, Health and Hygiene, Natural Resources, Society and Social Infrastructure, Biodiversity, Leisure and Cultural Vibrancy, Environmental Quality, Mobility)* to reflect the conditions of sustainability in Hong Kong? Y/N

2. The construction industry of Hong Kong is generally sub-divided into five stakeholder groups – the Government, the Developer, the Consultant, the Contractor and the Non-professional Participant? Y/N

3. Do you agree that there are differences in power between stakeholder groups to influence sustainable construction? Y/N (for the knowledge of awareness)

4. Do you believe that sustainable construction would improve the well being of the construction industry as well as the society as a whole? Y/N
5. Did you observe that your colleagues, co-workers and other construction participants have change in attitude and/or behaviour that is favorable to sustainable construction? Y/N

6. Did you observe that your colleagues, co-workers and other construction participants were aware that sustainable construction is a necessity in Hong Kong? Y/N

7. Did you observe that your colleagues, co-workers and other construction participants concern about the construction industry are causing damages to the environment? Y/N

8. Did you observe that your colleagues, co-workers and other construction participants are motivating changes to improve the damages? Y/N

9. Did you observe that your colleagues, co-workers and other construction participants are taking position actions to implement sustainable construction in their job duties? Y/N

10. Did you observe that your colleagues, co-workers and other construction participants are intended to increase budget to uplift sustainable construction to their project? Y/N

Part 2: Opened-end Questions

1. The construction industry of Hong Kong is generally grouped into five stakeholder groups as identified above, please provide your opinion if you do not agree with and suggest what should be the grouping.

2. According to your own opinion, provide the weighting influential power of each stakeholder group in percentage? The sum of all five stakeholder groups must be 100%.

3. The researchers have established the four cultural components that constitute the culture of the construction industry of Hong Kong. What other component(s) you may suggest as supplement to consummate sustainable culture?

4. What kinds of change(s) in sustainable culture have been undergone in among your colleagues, co-workers and other construction participants in Hong Kong?

5. Please provide your hierarchical rating of changes in sustainable culture in each of the stakeholder groups (suggested rating scale: highest, high, moderate, low and lowest).

6. If you are given the authority, will you spend more to uplift sustainability in your construction project, please state the proposed amount in percentage of the budget.

7. What kind of suggestion you will give the authority (the government or your boss) to enhance sustainable construction?

8. In your opinion what is the role of construction stakeholders in Hong Kong to enhance sustainable construction?

Part 3: Identification of Cultural Components that have taken effects on accomplishments of sustainability

Identify the attributes in the category of the specified cultural components (awareness, concern, motivation and implementation) as tabulated in the following three schedules for the physical works being accomplished by stakeholders in various domains.

You are encouraged to provide your views not only limited to the specified cultural components. Please indicate your opinions if new component(s) is/are suggested.

Schedule 1 - Works accomplished in Research and Development						Interviewee's Perception
Activity	**Nature of Activity**	**Year**	**Initiated Organization**	**Outcome**	**Reference**	**Cultural Component Attributes**
Use of recycled aggregate	Pilot test of using recycled aggregate as road subbase and ready mixed concrete	1997	HK Polytechnic University (HKPU)	Reduced and reuse C&D waste, recycled aggregate is widely used in concrete in government projects	Poon et al (1997)	
Review on Low-waste construction technologies	Research on various low-waste construction technologies	1999	HKPU	Making low-waste construction technologies to stakeholders	Poon et al (1999)	
Reuse building stock	Research on reuse of building stock	2000	The Hong Kong Institution of Engineers (HKIE)	Some building stock reused	Koenig and Kwan (2000)	
Guidebook for minimizing C&D waste	Published two guidebooks for minimizing C&D waste	2001 and 2002	HKPU	Enhanced adoption of low-waste technologies in the construction industry	Poon et al (2001) and Poon and Jaillon (2002)	
Study modular construction	Research on application of modular construction	2002	HKIE	Enlarge the extent of research on modular construction	Tam, A. (2002)	
Reduce construction waste on site	Review on reducing building waste in construction site	2004	HKPU	Promotion of reduction of construction waste	Jaillon and Poon (2004)	
Promote adoption of prefabrication	Research on reform construction method	2005	Construction Industry Institute	Promote application of prefabricated building components	Yeung et al (2005)	

Schedule 2 - Works accomplished by Organizations						Interviewee's Perception
Activity	**Nature of the Activity**	**Year**	**Initiated Organization**	**Outcome**	**Reference**	
Certification of ISO 14000	Environmental Management System Certification	1999 - now	Various Government Departments/Developers/Consultants/Contractors	Upgrade organization management towards better environmental protection	Zhang et al (2000)	
The Study on Sustainable Development for the 21st Century in Hong Kong (SUSDEV 21)	Public consultation for sustainable development for Hong Kong	1997 - 1999	The Government of HKSAR	Aroused public awareness and concern	ERM (2001)	
CIRC Report	Review the performance of the construction industry and recommend improvement measures	2000 - 2001	Construction Industry Review Committee/Government of HKSAR	Motivated stakeholders of the construction industry to improve towards sustainability	CIRC (2001)	
Best Practice Guide for Environmental Protection on Construction Sites	Publish Guidebook for Environmental Protection in Construction Site	2001	The Construction Association	Improved performance in construction practice	HKCA (2001)	
Guidebooks for Minimizing C&D Waste	Publish Guidebook for Minimizing C&D Waste	2001, 2002	The Hong Kong Polytechnic University	Enhanced adoption of Low-waste construction technologies	JPN (2001) & JPN (2002)	
Joint Practice Notes (JPN 1 and JPN 2)	Promotion of project sustainability by innovative design and construction by incentive scheme	2001, 2002	Government of HKSAR	Enhanced project sustainability both in design and construction	PCICB 2002	
New Procurement Evaluation Scheme	Introduce score system to evaluate tenders	2002 - now	Various government department of HKSAR	Tender evaluation of government job based on performance in sustainability than tender price.	JPN (2001) & JPN (2002)	
Disposal Charge of C&D Waste	Impose of disposal charge of C&D waste at landfill sites	2005 - now	The government of HKSAR	Disposal of C&D waste at landfill sites reduced	Integer (2000)	

Schedule 3 - Recognized Sustainable Projects in Hong Kong between 2003 and 2005					Interviewee's Perception
Project	**Year of Completion**	**Sustainability Driving Organization(s)**	**Outcome**	**Research Reference**	
The Orchards	2003	Developer and Contractor	Pioneer of Designer sustainability in private residential project	Fong et al (2004)	
The Charter	2004	Developer and Contractor	Partnering	Uebergang et al (2004)	
One Peking Road	2004	Glorious Sun Group Ltd	Green design project using photovoltaic (PV) panel to operate electrical blinds	Tam, A. (2004)	
Kadoorie Biological Sciences Building	2000	The University of Hong Kong (HKU)	Green design project with energy saving up to 44,070,000 KWH and CO_2 reduction 26,880 tonnes in 50 years life span	http://www.hku.hk/mech/sbe/case_study/case/hk/hku-bsb/bsb-index.html	
EMSD Headquarter	2004	Architectural Service Department HKSAR	Re-develop old building for new use	Mak, M.S.C. (2005)	
Wetland Park	2005	Architectural Service Department HKSAR and Contractor	A sustainable design and construction project that aroused public awareness of ecosystem	Li et al (2005)	
Hong Kong Community College (HKCC)	2005	Developer and Designer	A pilot building project used to increase	Not Available	

Appendix 3

Research Information and Analysis of the Wetland Park Project

Questionnaire Survey – Implementation of 5-S Practice in the Wetland Park project [Sample, Marking Scheme and Data Analysis]

Part 1 (第一部份) [Demographic Information of Respondent]

Personal Particulars (受訪者資料)

Q.1 **Age (年齡)**

(a) Under 20 (二十以下)
(b) 20-29 (二十至二十九)
(c) 30-39 (三十至三十九)
(d) 40-49 (四十至四十九)
(e) 50-59 (五十至五十九)
(f) 60 or above (六十或以上)

Q.2 **Gender (性別)**

(a) Male (男)
(b) Female (女)

Q.3 **Academic Qualification (學歷)**

(a) Primary (小學)
(b) Secondary (中學)
(c) Post Secondary (大專)
(d) University or above (大學或以上)

Q.4 **Nature of the Organization (工作機構性質)**

(a) Developer (發展商)
(b) Consultant (顧問公司)
(c) Main Contractor (總承建商)
(d) Specialist Contractor (專家承建商)
(e) Domestic Sub-Contractor (內判承建商)
(f) Nominated Sub-Contractors (業主指定承建商)
(g) Others (其他) _____ (Please specify 請註明)

Q.5 **Current rank / position (現時職級/職位)**

(a) Director / Project Manager (董事/項目經理)
(b) Architect (建築師)
(c) Engineer (工程師)
(d) Inspector / Clerk of Works / Safety Officer (監工/安全主任)
(e) Surveyor / Technician (測量員/技術員)
(f) Site Agent / Sub-Agent / Foreman (承建商駐地盤代表/副代表/管工)
(g) Labour (工人)
(h) Clerical Staff (地盤文職人員)

Q6 **How many years have you been working in construction industry? (地盤工作年資)**

(a) under 5 years (五年以下)
(b) 5-10 years (五至十年)
(c) 11-20 years (十一至二十年)
(d) above 20 years (二十年以上)

Q7 **Have you ever heard of 5-S system? (你之前有否聽聞有關五常法?)**

(a) Yes (有)
(b) No (否)

Part 2 (第二部份) [Respondent's View on Project Management]

Q.8 **Please rank the following factors that you would consider important for your project.**
[Please provide your answers in hierarchical order in which "5" represents the most important factor, and "1" represents the least important factor]
(請依據你的意見排列下列要素對你參予的計劃的重要性.)
(5 代表最重要, 1 代表最不重要)

(a) Quality (品質) ( )
(b) Cost (成本) ( )
(c) Time (時間) ( )
(d) Safety (安全) ( )
(e) Environmental (環境) ( )

Q.9 **Please rank the significance of the following problems that you observe in HK construction industry. (請依據你對香港建造業的觀察排列下列問題的嚴重性.)**
[Please provide your answers in hierarchical order in which "10" represents the most important factor, and "1" represents the least important factor]

(10 代表最重要, 1 代表最不重要)

(a) Material Waste (材料浪費) ( )
(b) Poor Housekeeping (不良工地整理) ( )
(c) Lack of Planning (缺乏施工計劃) ( )
(d) Progress Delay (工程延誤) ( )
(e) Poor Safety Record (安全記錄欠佳) ( )
(f) Lack of Training (缺乏訓練) ( )
(g) Poor Workmanship (手工不良) ( )
(h) Overload of Paperwork (文件工作過量) ( )
(i) Lack of Environmental Awareness (環保意識不足) ( )
(j) Others (其他) _____ ( )

Q. 10 **Please rank the problems that you think will affect the project schedule.**
[Please provide your answers in hierarchical order in which "5" represents the most significant problem, and "1" represents the least significant problem]

(請依據你的意見排列以下問題對工期的影響.)
(5 代表最重要, 1 代表最不重要)

(a) Poor Safety Control (不良安全管制) ( )
(b) Poor Housekeeping (不良工地管理) ( )
(c) Poor Document Control (不良文件管理) ( )
(d) Limited Authority by Supervisor (監工授權不足) ( )
(e) Unclear Instruction by Supervisor (監工指令不明確) ( )

Q.11 **What kind of quality system does your organization apply?**
(你服務的機構採用那種品質管理系統?)

(a) ISO9001
(b) 5S (五常法)
(c) Both (a) & (b) (a 及 b 兩項同時使用)
(d) Others (其他) _____ (Please specify 請註明)
(e) None of the above (以上均沒有採用)
(f) No idea (不知道)

Q.12 What kind of environmental management system does your organization apply?
(你服務的機構正採用那個環境管理系統?)

(a) ISO 14001
(b) 5S system
(c) Two of the above (以上其中兩項同時採用) (Please indicate 請指示)
(d) None of the above (以上均沒有採用)
(e) Others (其他) _____ (Please specify 請註明)
(f) No idea (不知道)

Q.13 What kind of Safety Implementation(s) does your company applied?
(你服務的機構採用那種品質安全系統?)

(a) OHSAS 18001
(b) 5S system
(c) Both of (a) and (b) (a 及 b 兩項同時採用)
(d) None of the above (以上均沒有採用)
(e) Others (其他) _____ (Please specify 請註明)
(f) No idea (不知道)

Part 3 (第三部份)

Using the scale provided, please indicate whether you agree or disagree with each of the following statements. Circle your response: (閱讀句子後，請把選擇的答案圈起：)

Q.14 5-S practices are aimed at the major achievement in Total Quality Management (TQM).
(五常法的主要目的是要實行全面品質管理)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.15 Quality assurance (QA) system is *not* the most advanced management tool for quality management.
(品質確定系統不是最好的品質管理系統)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.16 All staffs should be involved in the quality system.
(所有員工都應該參予品質管理)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.17 **The adoption of effective and efficient management system(s) will lead to cost saving for the project / company.**
(採用高效率的管理體系是會降低工程/公司的成本)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.18 **Project time management is *not* important to the whole project schedule.**
(時間管理對整體工期並非最重要的)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.19 **The implementation of effective and efficient management system(s) will result in a good time control of the project.**
(採用高效率的管理體系是會帶來較好的時間管理)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.20 **The average site accident rate has *not* been significantly minimized after the 5-S or other management systems have been implemented.**
(五常法或其他管理系統實行之後, 工地意外率並沒有大大地降低)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.21 **Environmental protection and awareness have become necessities in nowadays construction industry.**
(環境保護及環保意識已成爲今日建造業必要的原素)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.22 **A comprehensive monitoring and checking mechanism is important to monitor the compliance of the relevant environmental legislation requirement .**
(一個完善的監察系統對監察遵守環保法例是重要的)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.23 **Proper selection of tools & study how to use the selected tools effectively to suit with each particular work are beneficial to construction project especially in time, quality, cost, environment and safety issues.**
(選用合適的工具及有效地運用所選用的工具對工程時間、品質、成本、環保及安全是有益處)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.24 **Regular examination / maintenance of machines or plants is *not* important to maintain effective construction activities.**
(定期檢查/維修建築機械對建造工作並非最重要的)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.25 **Preparation of suitable & proper stocks of materials to match with the construction programme is beneficial to construction project in time and cost issues.**
(物料的安排配合工程的進度是對工程時間及成本是重要的)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.26 **The document and drawing filing system in site and head office has *not* been improved after the 5-S or other management systems have been implemented.**
(五常法或其他管理系統實行之後, 公地及總辦公室內的檔案及圖紙儲存系統並沒有得以改善)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.27 **The efficiency for the flow of information in site and head office has been improved after the 5-S or other management systems have been implemented.**
(五常法或其他管理系統實行之後, 公地及總辦公室內資料流通的效率可以得以改善)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.28 The workload of general paperwork has been decreased after the 5-S or other management systems have been implemented.
(五常法或其他管理系統實行之後, 一般紙上作業的工作量得以減輕)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.29 The safety culture amongst workers has been improved after the 5-S or other management systems are implemented?
(五常法或其他管理系統實行之後, 工人的安全文化是可以得以改善)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Q.30 Good safety environment could eliminate workplace hazards.
(良好安全環境是可以減少工作危機)

Assigned Score	-2	-1	0	+1	+2
	Strongly disagree	disagree	Neutral	agree	Strongly agree
	非常不同意	不同意	中立	同意	非常同意

Analysis of Questionnaire Survey after Implementing 5-S Practice in the Wetland Park Project

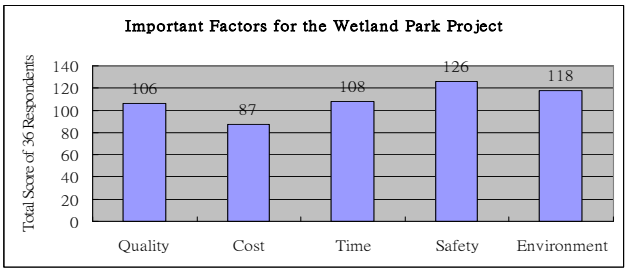
Part 1 – Demographic Information of Respondents:
(Question 1 to 7)
\

Age	20 - 29	30 - 39	40 - 49	50 - 59
	28%	28%	39%	5%
Education	Primary	Secondary	Post-secondary	University and Above
	0%	28%	22%	50%
Position	Clerical	Front Line Supervisor	Technical	Managerial and Directorate
	16%	23%	28%	33%
Site Experience	Below 5 Years	6 –10 Years	11 –20 Years	Over 20 Years
	17%	10%	45%	28%
Sex	Male = 95%	Female = 5%	--	--

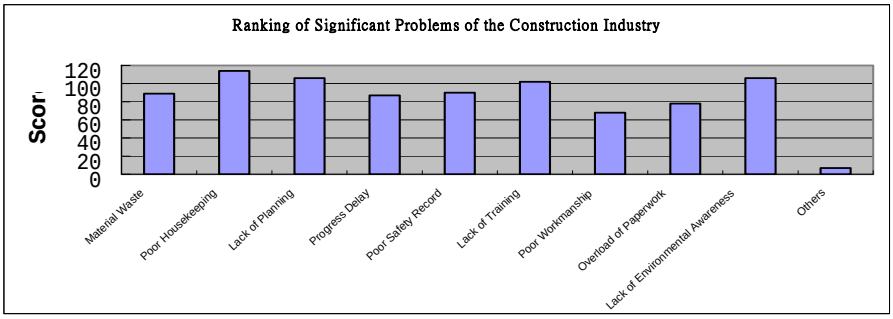
Part 2 – Respondents' Perception of the Importance of Construction Management Systems in the Construction Industry of Hong Kong:

(Question 8 to 13)

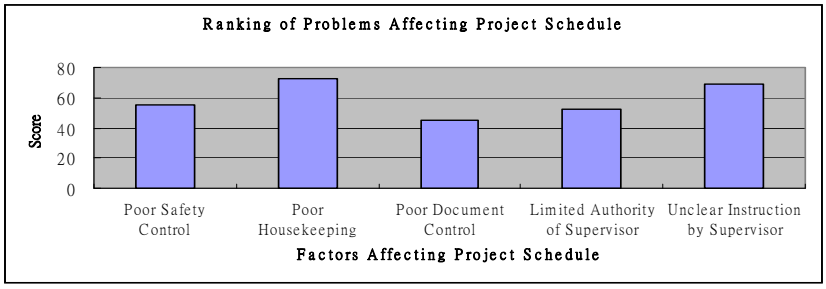
Question 8: Respondents' perception about the important factors of the Wetland Land Park project



Question 9: Respondents' perception about the ranking of Significant Problem of the construction industry



Question 10: Respondents' perception about the ranking of problems affecting Construction Schedule



Question 11 to 13: International Management Standards used by the contractor of the Wetland Park project

ISO 9000 = 100%

ISO 14000 = 0%

ISO 18000 = 0%

Part 3 –Respondents' Perceptions in specific management systems applied in construction projects (Question 14 to 30)

Question 14 to Question 25: Weighting Score of Construction Management Systems

Questions	**Construction Management Systems**	**Weighting Scores**	**Average Weighting Score (for each Question)**
Question 14 -16	Quality Management	35	11.7
Question 17-19	Production Management	18	6
Question 20 -22	Safety and Environmental Management	26	8.7
Question 23 -25	Material and Equipment Management	42	14

Question 26 to Question 30: Respondents' perception about the Improvements in adopting 5-S Practice

Questions	**Improvements in adopting 5-S Practice**	**Weighting Score**
Question 26	Improvements in Filing System for documents and drawings in head office and site office	1
Question 27	Improvements in Information Flow and Communication between head office and site office	18
Question 28	Improvements in Reducing Work Loads in General Paper Works	- 1
Question 29	Overall Performance in Safety Culture after Implementation 5-S Practice	12
Question 30	Overall Performance of the Wetland Park Construction Management in Safety Management	24

Demonstration of Data Analysis

Worksheet of Question 8

Q.8 Please rank the following factors that you would consider important for your project.

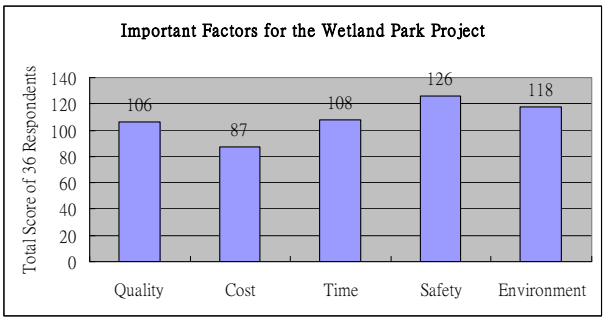
[Please provide your answers in hierarchical order in which "5" represents the most important factor, and "1" represents the least important factor]

(請依據你的意見排列下列要素對你參予的計劃的重要性.)

(5 代表最重要, 1 代表最不重要)

(a) Quality (品質) ( )
(b) Cost (成本) ( )
(c) Time (時間) ( )
(d) Safety (安全) ( )
(e) Environmental (環境) ( )

Respondent	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*Total Score*
Quality	4	2	2	2	3	3	3	3	2	3	3	2	4	4	4	4	3	4	3	3	2	4	5	2	5	2	1	2	3	3	5	2	3	1	3	2	106
Cost	2	4	1	3	4	4	1	1	3	4	4	1	1	2	1	3	4	1	1	1	4	5	4	3	1	4	4	1	4	1	1	4	1	2	1	1	87
Time	5	3	3	5	1	1	5	2	1	2	5	3	5	1	3	5	5	3	2	4	1	1	1	1	4	1	3	5	1	2	4	1	2	3	4	5	103
Safety	3	5	4	4	2	5	2	4	4	1	2	5	3	3	2	2	2	5	4	2	3	2	3	5	2	5	5	4	2	4	3	5	5	5	5	4	126
Environment	1	1	5	1	5	2	4	5	5	5	1	4	2	5	5	1	1	2	5	5	5	3	2	4	3	3	2	3	5	5	2	3	4	4	2	3	118



Similar data analysis approach is applied to Part 2: Question 8, 9,10,

Worksheet of Question 14 to 16

Question 14 to 16 are grouped as Questions for Quality Management Category

Q.14 5-S practices are aimed at the major achievement in Total Quality Management (TQM).

(五常法的主要目的是要實行全面品質管理)

Assigned Score	**-2**	**-1**	**0**	**+1**	**+2**	
	Strongly disagree 非常不同意	disagree 不同意	Neutral 中立	,agree 同意	Strongly agree 非常同意	
Score obtained from 36 respondents	**0**	**-3**	**0**	**+9**	**+2**	**Sub total = +8**

Q.15 Quality assurance (QA) system is *not* the most advanced management tool for quality management.

(品質確定系統不是最好的品質管理系統)

Assigned Score	**-2**	**-1**	**0**	**+1**	**+2**	
	Strongly disagree 非常不同意	disagree 不同意	Neutral 中立	agree 同意	Strongly agree 非常同意	
Score obtained from 36 respondents	**0**	**-6**	**0**	**+6**	**+4**	**Sub total = +4**

Q.16 All staffs should be involved in the quality system.

(所有員工都應該參予品質管理)

Assigned Score	**-2**	**-1**	**0**	**+1**	**+2**	
	Strongly disagree 非常不同意	disagree 不同意	Neutral 中立	agree 同意	Strongly agree 非常同意	
Score obtained from 36 respondents	**0**	**0**	**0**	**+11**	**+12**	**Sub total = +23**

For Quality Management Questions the Total Score is +35

Similar data analysis approach is applied to Question 14 to 30

Concrete Mixed Data and Test Result

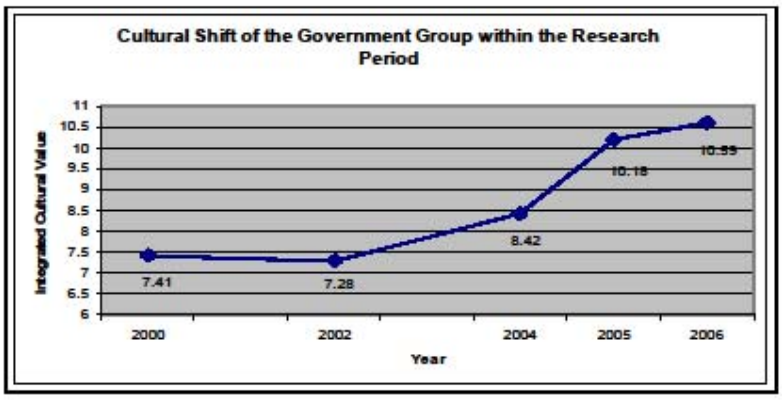
Contract Title	Construction of International Wetland Park and Visitor Centre, at Tin Shui Wai, New Territories, - Phase 2			
Planned amount of recycled aggregate concrete	4570M^3	6751M^3	1355M^3	1421M^3
Concrete Grade	Grade 35D/20	Grade 35D/20	Grade 20D/20	Grade 10D/20
Area of Usage	Ground slabs and beams and perimeter wall	External works including retaining walls	Mass concrete and minor concrete works	Concrete blinding
RMC Supplier	Multi-Way Industries Ltd. – Yick Yuen Plant, Lot 1825 in DD130 Yick Yuen, Tuen Mun, Yuen Long, N.T.			
Travelling distance	~10 km from ready mix concrete depot to site			
Time between cement added and arrival on site	Average 30 minutes			
Supply Date	May 2003 – June 2004			
Concrete mix data Natural aggregates 20mm Recycled aggregates 20mm Fine aggregates 10mm Fines Cement Free water W/C ratio A/C ratio Admixture	For Grade 35D/20 568 kg **217** kg 300 kg 683 kg 380 kg 178 litres 0.47 4.65 2.89 l/m^3 KFDN-100	 560 kg **214** kg 296 kg 675 kg 395kg 184 litres 0.47 4.42 2.97 l/m^3 KFDN-100	Grade 20D/20 000 kg **798** kg 320 kg 753 kg 300 kg 182 litres 0.61 6.24 2.24 l/m^3 KFDN-100	Grade 10D/20 000 kg **810** kg 315 kg 735 kg 275 kg 185 litres 0.67 6.76 2.20 l/m^3 KFDN-100
Design Concrete Slump	75mm	100mm	75mm	75mm
Measured slump during trial mix	80 – 95mm	90 – 115mm	70 – 90mm	N/A
Mean 7-day cube strength (Trial Mix)	35.8 N/mm^2	39.5 N/mm^2	23.8 N/mm^2	N/A
Mean 28-day cube strength (Trial Mix)	47.0 N/mm^2	48.6 N/mm^2	31.5 N/mm^2	N/A
Measured slump	75-95mm	100-125mm	75-80mm	70-90mm
Measured average slump	85mm	105mm	75mm	80mm
Design 28-day cube strength	49 N/mm^2	49 N/mm^2	32 N/mm^2	N/A
Designed standard deviation	7 N/mm^2	7 N/mm^2	6 N/mm^2	N/A
Works 28-day cube strength (06/03-02/04)	49.2 N/mm^2	52.6 N/mm^2	33.8 N/mm^2	23.9 N/mm^2
Standard deviation from cube test (06/03-02/04)	5.2 N/mm^2	2.6 N/mm^2	5.3 N/mm^2	5.1 N/mm^2
Difficulties encountered	1. Ready mix supplier has no spare silo for storage of 10mm recycled aggregates 2. Occasionally, the recycled aggregates contain excessive fines that cause extra water demand and faster slump loss. 3. When recycled aggregates are wetted for use, there is not too much problem in controlling the slump ex-plant. However, when the surplus wetted recycled aggregates are stored in bins for over one day, they dry out again quickly and re-spray is required to restore a saturated condition. 4. As a conclusion, handling care is of paramount importance to maintain the stability of the quality of concrete using recycled aggregates.			

Appendix 4

Worksheets of Cultural Shift Curve of Stakeholder Groups

Work Shett for Cultural Shift of the Government Group

Year:				Σ Area	√(Σ area)
2000	2.09				
	6.78	7.09 / 5.57 / 23.63 / 18.58	5.33	= 54.86	7.41
		6.97			
2002	2.16				
	6.77	7.31 / 5.98 / 21.83 / 17.87	5.54	= 52.99	7.28
		6.45			
2004	2.40				
	7.68	9.22 / 7.96 / 28.80 / 24.86	6.63	= 70.83	8.42
		7.50			
2005	3.77				
	9.19	17.32 / 13.70 / 40.48 / 32.02	7.27	= 103.53	10.18
		8.81			
2006	3.83				
	9.63	18.44 / 15.01 / 43.43 / 35.36	7.84	= 112.24	10.59
		9.02			



Worksheets of Cultural Shift Curve of Stakeholder Groups

Work Shett for Cultural Shift of the Developer Group

Year:				
			Σ Area	√(Σ area)
2000	2.25 / 7.27 / 5.50 / 6.46 / 4.89 / 15.92 / 12.05 / 4.93	=	40.75	6.38
2002	2.16 / 5.51 / 4.95 / 5.10 / 4.58 / 13.21 / 11.86 / 5.18	=	35.53	5.96
2004	2.34 / 7.10 / 6.24 / 6.07 / 5.33 / 17.45 / 15.32 / 5.75	=	46.11	6.79
2005	2.51 / 7.79 / 7.25 / 6.21 / 5.78 / 14.69 / 13.67 / 4.73	=	43.40	6.59
2006	2.67 / 8.72 / 8.14 / 6.53 / 6.10 / 17.40 / 16.26 / 5.33	=	50.52	7.11

Worksheets of Cultural Shift Curve of Stakeholder Groups

Work Shett for Cultural Shift of the Consultant Group

Year:				Σ Area	√(Σ area)
2000	1.21 / 1.06 / 1.11 / 1.75 / 1.84 / 1.54 / 1.62 / 1.76			5.33	2.31
2002	1.30 / 1.45 / 1.26 / 2.23 / 1.94 / 2.27 / 1.98 / 2.04			6.96	2.64
2004	1.38 / 1.69 / 1.50 / 2.45 / 2.17 / 2.65 / 2.34 / 2.16			8.18	2.86
2005	1.09 / 1.69 / 1.17 / 3.11 / 2.15 / 3.98 / 2.75 / 2.56			9.60	3.10
2006	1.13 / 1.82 / 1.48 / 3.23 / 2.62 / 4.46 / 3.62 / 2.76			11.38	3.37

Worksheets of Cultural Shift Curve of Stakeholder Groups

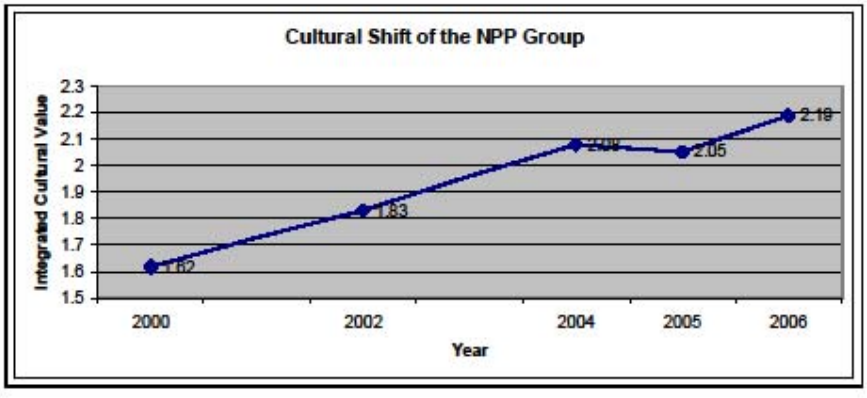
Work Shett for Cultural Shift of the Contractor Group

Year:				Σ Area	√(Σ area)
2000	0.89 / 1.02 / 0.78 / 2.29 / 1.76 / 2.20 / 1.69 / 1.92	=		5.69	2.39
2002	0.92 / 1.05 / 0.82 / 2.29 / 1.79 / 2.23 / 1.75 / 1.95	=		5.85	2.42
2004	1.00 / 1.27 / 1.06 / 2.53 / 2.11 / 2.88 / 2.41 / 2.28	=		7.61	2.76
2005	1.33 / 1.70 / 1.34 / 2.55 / 2.02 / 2.93 / 2.32 / 2.30	=		8.29	2.88
2006	1.42 / 2.02 / 1.63 / 2.85 / 2.30 / 3.61 / 2.91 / 2.53	=		10.17	3.19

Worksheets of Cultural Shift Curve of Stakeholder Groups

Work Shett for Cultural Shift of the NPP Group

Year:				Σ Area	√(Σ area)
2000	0.93 / 0.60 / 0.52 / 1.30 / 1.11 / 0.81 / 0.69 / 1.25			2.63	1.62
2002	0.97 / 0.67 / 0.63 / 1.39 / 1.29 / 1.07 / 0.99 / 1.54			3.36	1.83
2004	1.00 / 0.83 / 0.79 / 1.65 / 1.58 / 1.39 / 1.33 / 1.68			4.33	2.08
2005	0.82 / 0.89 / 0.48 / 2.16 / 1.17 / 1.85 / 1.00 / 1.71			4.21	2.05
2006	0.87 / 1.01 / 0.58 / 2.32 / 1.34 / 2.03 / 1.17 / 1.75			4.79	2.19



Appendix 5

Summary Tables of Year 2004 and Year 2006 Survey

Summary Table – Year 2004 Survey

		N	Mean	Std. Deviation
Awareness	Government	161	17.83	3.96
	Developer	24	19.00	3.06
	Contractor	213	16.92	3.11
	Consultant	30	16.60	3.47
	NPP	18	18.17	4.42
Concern	Government	161	17.39	3.56
	Developer	24	6.66	2.89
	Contractor	213	8.25	6.46
	Consultant	30	8.00	4.40
	NPP	18	10.50	4.25
Motivation	Government	161	11.50	3.29
	Developer	24	7.85	4.19
	Contractor	213	20.60	5.49
	Consultant	30	21.38	6.23
	NPP	18	20.51	5.98
Implement ation	Government	161	18.70	5.65
	Developer	24	19.00	4.68
	Contractor	213	20.41	5.75
	Consultant	30	20.10	5.57
	NPP	18	20.25	4.36
Total	Government	161	18.77	4.77
	Developer	24	16.50	5.37
	Contractor	213	19.33	3.34
	Consultant	30	19.20	5.13
	NPP	18	65.07	12.04
	Total	446	68.88	11.35

Summary Table – Year 2006 Survey

		N	Mean	Std. Deviation
Awareness	Government	66	15.98	2.41
	Developer	47	17.53	2.83
	Contractor	172	14.88	3.17
	Consultant	18	16.61	4.75
	NPP	14	14.50	4.93
Concern	Government	66	8.47	4.11
	Developer	47	8.34	5.35
	Contractor	172	9.98	5.36
	Consultant	18	7.78	4.10
	NPP	14	10.21	3.70
Motivation	Government	66	21.11	5.40
	Developer	47	20.17	4.35
	Contractor	172	19.81	5.05
	Consultant	18	21.94	5.90
	NPP	14	26.93	4.98
Implement ation	Government	66	20.94	5.89
	Developer	47	17.47	5.90
	Contractor	172	18.65	5.28
	Consultant	18	19.89	4.81
	NPP	14	21.57	8.06
Total	Government	66	66.50	12.24
	Developer	47	63.51	13.12
	Contractor	172	63.33	9.99
	Consultant	18	66.22	15.80
	NPP	14	73.21	14.41
	Total	317	64.62	11.71