Collaboration Among Project Participants Towards Sustainable Construction – A Hong Kong Study

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Abstract: This paper shows that management has dominant influences on sustainable construction practices in Hong Kong. Improving construction business performance along with sustainable development is widely appreciated. Major factors affecting sustainable performance are social, economic and environmental considerations. This has led to the development of various management approaches to advise construction participants on how to improve their performance with a view of bringing satisfactory project sustainable performance across the full construction project life cycle. In particular, methods to improve environmental performance in construction have been extensively investigated. Recent studies have presented methods to mitigate barriers in implementing environmental management in construction. However, these studies are driven by examining the nature of construction activities rather than the management strategies that drive sustainable practice. This paper examines management-related reasons which hinder the implementation of sustainable construction in practice. A construction project participant collaboration framework is developed to improve communication among project participants towards sustainable construction implementation. Future opportunities and challenges are identified for various parties engaging in construction activities to provide effective contributions to sustainable development. This research work also provides useful references in examining sustainable construction practice.

INTRODUCTION

Construction activities refer to a wide range of activities, such as building work, hydraulics, airports, railways, highways, bridges, dredging harbours, dock-work, sewage treatment facilities, tunnelling and demolition activities. Sustainable construction refers to the practice by which construction activities contribute to sustainable development. It is a set of processes by which a profitable and competitive industry delivers built assets [1, 2]: i) to enhance quality of life and to offer customer satisfaction; ii) to offer flexibility and potential to cater for user changes in the future; iii) to provide and to support desirable natural and social environments; and iv) to maximize the efficient use of resources.

Sustainable development is typically defined as to meet basic needs of the public and to extend opportunities to satisfy their aspiration for a better life without compromising abilities of future generations to meet their own needs [3]. It promotes the balance of environmental protection, economic development and social development.

Sustainable assessment is a collective term for measurement and analysis of criteria, which are either having direct or indirect environmental impacts [4, 5]. It is also defined by Kuhre’s study as a continuous monitoring process, which is applied to evaluate companies’ sustainable performance [6]. Sustainable assessment has been broadly used in different business sectors. It can provide reliable, objective and verifiable information on management about achievements of organisations’ environmental objectives and targets, as well as fulfilling legislative regulations regarding environmental protection. Results from sustainable assessment can also help predicting future trends in environment-related development, which assist management in designing suitable environmental strategies for future projects [5, 7-9].

This paper aims to:

• examine various sustainable construction initiatives in Hong Kong;
• investigate different economic periods affecting sustainable construction implementation;
• examine methods improving sustainable construction;
• study opportunities and challenges in practising sustainable construction;
• develop a construction project participant collaboration framework; and
• provide recommendations improving sustainable construction practice in Hong Kong.

Sustainable Construction Initiatives

As construction activities are commonly considered as major contributors to negative environmental impacts, implementation of sustainable construction often focuses on improving environmental performance across a project’s life cycle. Examples of sustainable construction initiatives in Hong Kong are identified as follows [10-20].

Optimum Land and Space Use

At the project planning stage, consideration is given to the optimum use of land and space. For example, there are
The major objective of this study is to examine various sustainable construction initiatives by referring to Hong Kong construction industry. The data used for analysis are mainly from public reports produced by Hong Kong government. The experience by the research team to the construction industry also contributed to the data generation and analysis in the study. In fact, one research member is a senior practitioner in Hong Kong construction industry. The data generation and analysis is largely based on the discussions within the research team. Team-oriented approach has been adopted throughout the study.

**ECONOMIC ISSUES AFFECTING SUSTAINABLE CONSTRUCTION IMPLEMENTATION**

The Hong Kong construction has experienced two different economic periods before and after the handover in 1997: i) a prosperous period in the early and middle 1990s; and ii) a recessive period between the late 1990s and early 2000s. Although the government has introduced sustainable policies and regulations, this study found that insufficient action was taken in implementing sustainable construction across both periods.

**Sustainable Construction Practice During the Economic Prosperous Period**

In the prosperous period, it could be more effective to promote sustainable construction measures than in the recessive time. However, it seems that the local government did not pay sufficient attention during the economy boom in the early 1990s. Increasing gross domestic products (GDP) and
contributions of construction work to GDP during the main period of 1990s are shown in Table 2.

Table 2. Statistics of GDP and construction contribution in Hong Kong during 1992-1997 (in HK$million) [22]

<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>1993</th>
<th>1994</th>
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</thead>
<tbody>
<tr>
<td>GDP</td>
<td>805,082</td>
<td>927,996</td>
<td>1,047,470</td>
</tr>
<tr>
<td>Construction</td>
<td>62,232</td>
<td>56,226</td>
<td>59,710</td>
</tr>
<tr>
<td>GDP</td>
<td>1,115,739</td>
<td>1,229,481</td>
<td>1,365,024</td>
</tr>
<tr>
<td>Construction</td>
<td>65,611</td>
<td>74,901</td>
<td>81,629</td>
</tr>
</tbody>
</table>

It appears to the research team that insufficient effort was contributed by both project clients and contractors in implementing sustainable construction measures during the construction boom. The discussions from the survey have revealed typical reasons for not implementing sustainable construction in the local industry.

1. There is an opportunistic culture in the construction industry, in particular in the private property sector, to make “quick” revenue when there is a good economic environment and market, and thus insufficient attention to environmental performance.

2. During the economic boom, there was high labour cost and low material cost. Therefore, there was a strong reluctance for business to invest management and labour resources to improve environmental performance.

3. Programmes promoted by the government are always late due to one reason or another which shows a growing culture of “decision but no action”. This has sent a message to both construction professionals and the public that environmental considerations are not on the government agenda.

4. Comprehensive applications of multi-layered subcontracting arrangements present difficulties in effectively supervising on-site activities. Usually, there are three to four non-value-adding multi-layered subcontracting tiers in construction work. On site bottom-tier contractors cannot be provided with clear guidance and close supervision by main contractors, and is considered one of the major reasons resulting in poor environmental performance on site.

5. Environmental awareness issues among construction workers in the industry are low, worsened by the reluctance of senior management to commit resources to tackle environmental issues.

6. Despite numerous land reclamation programmes in the local industry, potential demand for a great amount of material, construction and demolition waste for this purpose has not been realized. The ever increasing amount of construction waste still presents the largest pollution component in the local region.

7. Principles of sustainable construction have not been sufficiently incorporated in feasibility study and design. Design parameters usually include building types, shapes, directions and materials, which often ignore environmental performance.

8. The government has no specific measures to encourage construction professionals in implementing sustainable construction practice. Although various regulations have been introduced, construction professionals find limited effectiveness without encouragement or incentives. It is suggested that incentive schemes should be implemented to achieve environmental improvement.

Sustainable Construction Practice During the Recessive Period

Having realized that Hong Kong is behind other countries in practising sustainable construction, the former Chief Executive of the Hong Kong Special Administrative Region (HKSAR) in 1999 brought sustainable development issues into the Policy Address. He requested that every citizen, every business, every government department and bureau starts partnering to achieve sustainable development for Hong Kong. However, his address was not optimum because Hong Kong was in a recessive period, beginning with the Asian financial turmoil in late 1997. This economic recession also caused the downturn of construction businesses, which is evidenced by the statistics shown in Table 3.

Table 3. Statistics of GDP and Construction Contribution in Hong Kong During 1997-2005 (in HK$ Million) [22]

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>1,365,024</td>
<td>1,292,764</td>
<td>1,266,702</td>
</tr>
<tr>
<td>Construction</td>
<td>81,629</td>
<td>79,007</td>
<td>70,941</td>
</tr>
<tr>
<td>GDP</td>
<td>1,314,789</td>
<td>1,298,813</td>
<td>1,276,757</td>
</tr>
<tr>
<td>Construction</td>
<td>79,599</td>
<td>80,702</td>
<td>73,223</td>
</tr>
<tr>
<td>GDP</td>
<td>1,273,893</td>
<td>1,291,568</td>
<td>1,382,052</td>
</tr>
<tr>
<td>Construction</td>
<td>70,295</td>
<td>66,280</td>
<td>59,266</td>
</tr>
</tbody>
</table>

Although the HKSAR economy began to prosper in 2000, good trends could not be continued as the world suffered adverse impacts from the Y2K network bubble in late 2000 and the “911” terrorist attack in 2001. Severe acute respiratory syndrome (SARS) caused the Hong Kong property market to collapse to its lowest point in 2003, although from 2004 onwards the economy has been recovering. But there is no improvement in construction activities, evidenced by decreasing figures seen in Table 3. A major reason for this is that there is the lack of major infrastructure projects since the beginning of year 2000.

Over the fourteen years (1992-2005) reported, GDP of Hong Kong has increased by about 71.67%, whereas construction has declined by about 42.68% from its peak in 1997. Yet construction has contributed between 4.29% and 7.73% of GDP, with an average of about 5.86% over the period. This mismatch is the results of an overheated construction market in the early 1990s.
During the interview discussions, the interviewees highlighted their difficulties in implementing sustainable construction during the recessive period:

1. There was a lack of resources including facilities and equipment available to implement sustainable construction on site due to very tight budget.

2. The local government and clients were not concerned with sustainable construction; rather lowering construction cost was their main project objective.

3. Project developers provided insufficient support for designers and contractors to implement sustainable construction to their projects, including financial and technical assistance.

4. As sustainable construction was still new in the local industry during this time, construction practitioners were using a “wait-and-see” attitude.

5. There were insufficient standards, specifications or guidelines provided by the government or private organizations to assist with sustainable construction implementation.

6. There was a lack of sustainable awareness by project stakeholders. The main goals for them were to lower project costs and shorten project duration, while sustainable construction involved high initial cost and potentially longer construction periods.

METHODS TO IMPROVE SUSTAINABLE CONSTRUCTION

The analysis in Section 0 suggests that there is still a pressing need to improve sustainable construction performance in the Hong Kong construction industry. From that, effective methods can be adopted. Various methods have been suggested by the previous research to effectively implement sustainable construction practice [1, 2, 4-9, 23-29]. In line with these developments, the HKSAR government has introduced certain measures for implementing sustainable construction over the years. In chronological order, these are:

- In 1980, major environmental ordinances and regulations, shown in Table 1, were enacted, to control environmental performance and to improve sustainable construction.

- In 1989, the government addressed environmental protection issues with the establishment of a framework for a comprehensive 10-year plan to reduce construction waste and other pollution problems, including a commitment to review its progress every two years.

- In 1995, the government launched a green manager scheme, requiring every government department appoints a green manager to manage environmental performance of individual organizations.

- In November 1998, the government launched its waste reduction framework plan, which aims to change waste treatment habits of the public.

- In February 2001 and 2002, the Building Department, Lands Department and Planning Department issued two Joint Practice Notes entitled “Green and Innovative Buildings”. The objective is to encourage the design and construction of buildings to adopt a holistic life cycle approach, to maximize the use of green building materials, to minimize the consumption of energy and to reduce construction and demolition waste.

- In February 2003, the Buildings Department issued a practice note for authorized persons and registered structural engineers entitled “use of recycled aggregate in concrete.” This technical guideline can be applied to prescribed mix concrete (20P) and designed mix concrete (25D to 35D) to adopt 100% and 20% recycled aggregate respectively.

- In May 2003, the Environment Transport and Works Bureau produced a circular (Ref: 15/2003) on “waste management on construction sites” that explained the implementation of the government’s “waste management plan” and “pay for safety and environment scheme” for public construction projects.

- In 2004, the Civil Engineering Department commissioned a pilot recycling plant at Tuen Mun Area 38 to supply recycled aggregate to a number of public projects from 2004 to 2006.

- In December 2005, the government implemented a land-fill charging scheme that charges those who dump their waste into public landfills, thereby encouraging contractors to recycle and to reuse construction waste.

In addition to the relevant ordinances, regulations and practice notes driving sustainable practice, private sectors should also be encouraged to implement an environmental management system (EMS) at an organizational level. This ensures that a company is continuously improving its environmental performance through identifying, minimizing, preventing and managing environmental impacts which may come from its business activities [30-32]. Therefore, risks of environmental violation are reduced by implementing an EMS. A typical EMS consists of four major areas, namely, environmental policy, organisational structure, environmental management programme, and audit of environmental performance. The EMS can be classified into a generic EMS and a corporate EMS. The generic EMS is designed to be adopted by any industry sector and generally developed as a commercial-available system. The corporate EMS is developed in-house to suit specific requirements of a company or a government organization. To guide establishing EMS, ISO 14000 provides a standard or sample that organizations can follow.

Principles of the ISO 14000 provide frameworks for the EMS. In construction practice, the ISO 14000 standard provides a benchmark of proper environmental management practice, so different organizations can have different specifications under the framework. The EMS defined in ISO 14001 emphasizes on more effective environmental ethics to project design, material selection, and transportation logistics throughout a product’s life cycle. This standard provides a framework to achieve and to demonstrate a desirable level of environmental performance. The framework defines a management system to track environmental performance, to set pragmatic objectives, to develop consistent procedures and
program initiatives, and to review progress for continuous improvement [33].

A typical advantage of implementing ISO 14001 is that the system provides a benchmark to implement an EMS. Management is required to demonstrate commitment to environmental management, which includes clearly setting environmental objectives and targets, provides adequate measures for responding environmental events and achieves the defined objectives and targets. Management should emphasize on pollution prevention rather than corrective action, and get all employees throughout the organization involved and communicated. An environmental culture should be cultivated within the organization, thus all staff can participate and help identify environmental problems, which in return increases efficiency in utilizing resources and energy to correct them. This leads to continuous improvement in the organization’s environmental performance.

The ISO 14001 standard does not define any particular acceptable level of performance. Different organizations can define their own level of environmental performance by applying the ISO 14001 framework. But with the structured approach that the system provides, senior management can have clear procedures and specific actions in committing environmental liabilities. Well-planned strategies can enhance an organization to respond quickly to environmental events instead of hastily reacting to crises and surprises. Furthermore, construction waste and energy consumption during project processes can be reduced through a continuous process to improve environmental performance. Consequently, an organization’s long-term profitability can be enhanced as its environmental competitiveness increases.

OPPORTUNITIES AND CHALLENGES IN PRACTICING SUSTAINABLE CONSTRUCTION

The Hong Kong government is going to implement ambitious construction plans involving huge amounts of public infrastructure construction work in the coming years. The government has recognized the importance of infrastructure investment, and accordingly the importance of implementing sustainable construction practice. This is evidenced by a large number of initiatives. The finance secretary of the HKSAR indicated that the government wants to spend about HK$29,000 million per year on construction over the next five years [34]. In 2004, the government launched strategies and procedures to promote sustainable development in the local territory by publishing a document called “the first sustainable development strategy for Hong Kong” [35]. In a policy address from the Chief Executive in 2006, it was stated that currently “Hong Kong development is hampered by insufficient investment and slow pace of public investment. I believe that in the days ahead, it will be important for the government to enhance communication with the business community, councils and environmental groups on development goals. Only in this way we can smoothly take forward our public investment programmes” [36].

In line with these initiatives, a substantial number of construction initiatives for Hong Kong have been specified in the booklet “Policy Agenda” attached to the 2006-2007 Chief Executive’s Policy Address. These projects are in different categories according to their progression status although it is difficult to give detailed demarcation lines among them as infrastructure work often lasts for many years. Some of these works have been constructed, some are planned and ready for construction, and some are still in design or feasibility stage. Typical work among these categories is listed as follows.

Work undertaken and / or in construction includes:

- To provide a variety of infrastructure, resources and support services to the digital entertainment industry in Cyberport;
- To operate new job centres in Yuen Long and northern district areas;
- To assist the airport authority to expand intermodal connections between the airport and pearl river delta region;
- To implement measures enhancing the competitiveness of Hong Kong ports as recommended by a port master plan 2020;
- To expedite development of new cruise terminal facilities;
- To monitor and to develop marine police headquarters in Tsim Sha Tsui into a heritage tourism attraction in 2008;
- To monitor progress of the Lok Ma Chau Spur line to be commissioned in the first half of 2007;
- To develop the Kowloon southern link;
- To prepare commissioning of the Hong Kong western corridor to the Shekon boundary crossing in the middle of 2007; and
- To ensure the disposal of a surplus home ownership scheme beginning in 2007.

Work planned and for implementation includes:

- To replace a civil aviation department with an air traffic control system;
- To develop new civil aviation department headquarters on the airport island;
- To map out long-term developments of the electricity market;
- To coordinate various major tourism infrastructure projects including Disneyland, Wetland Park and Ngong Ping 360;
- To plan a Aberdeen tourism project to complement the Ocean Park redevelopment;
- To enhance the Lei Yue Mun waterfront;
- To develop a piazza in Tsim Sha Tsui;
- To implement a design-and-build Tamar project; and
- To pursue preparatory work for the Hong Kong-Zhuhai-Macao bridge.

Work in design includes:

- To reduce coverage of frontier closed areas for development;
- To plan widening of town centre sections;
To improve an expressway section of Tuen Mun road;
To evaluate the eastern corridor at Liantang/Heung Yuen Wai control point and new crossing;
To determine optimal timing for the container terminal 10 construction in port cargo forecast;
To assess ecology on northwest Lantau for development of the container terminal 10;
To implement a Lantau logistics park project for subsequent zoning and reclamation;
To proceed a combined project of the Hong Kong section of a Guangzhou-Shenzhen-Hong Kong express rail link;
To plan Shatin to central link and the western island line;
To assess the viability of the southern island line;
To update a Lantau concept plan providing fresh impetus for Hong Kong economic development; and
To coordinate the timetable for railway property developments.

According to the plan described in the 2005-06 Budget of the Hong Kong, there would be HK$29 billion investment from the Government for the period 2006-2010. From Table 4, entitled Major Capital Projects to Begin in 2007-08, the government has commenced 14 projects for infrastructure and support with annual budget of HK$22,425 million, 5 projects for education (HK$3,138 million), 2 projects for health (HK$3,063 million), 3 projects for security (HK$1,824 million), 3 projects for community and external affairs (HK$1,682 million) and 2 projects for environmental and food (HK$1,037 million). It is envisaged that the government will spend HK$33.1 billion in 2007-08, even more than HK$29 billion as planned.

The implementation of the above public construction work can certainly revitalize the Hong Kong construction industry, which can stimulate those in the private sector in return. Thus the time to implement sustainable construction practice in the local construction industry is ripe.

**DEVELOPMENT OF A CONSTRUCTION PROJECT PARTICIPANT COLLABORATION FRAMEWORK**

Various methods and policies identified in the previous sections are important and should be encouraged for their application. However, from the interview discussions, the interviewees argued that there is a major gap in promoting these measures. Existing methodologies focus on solutions to solve particular technical issues, such as waste, air pollution, and ecological impacts. Solutions are also available for implementing management activities, such as establishing EMS using ISO standard procedures. However, one of the interviewees noted that neither the establishment and operation of an EMS nor the introduction of policies and regulations would necessarily result in the improvement of environmental performance. Another interviewee explained that collaboration among various project participants provides insufficient attention. In fact, implementing construction activities normally involves multiple organizations, including government departments, project owners, contrac-

<table>
<thead>
<tr>
<th>Table 4. Major Capital Projects to Begin in 2007-08 [37]</th>
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<tbody>
<tr>
<td><strong>Infrastructure and Support (HK$22,425 million)</strong></td>
</tr>
<tr>
<td>- Construction, improvement and widening of Pol Oi Interchange/Shaa Tin Trunk Road T4/Tuen Mun Road Tsing Tin Interchanges/Tuen Mun Road L18A/Ha Tsuen Section of Ping Ha Road</td>
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<tr>
<td>- Customs Headquarters Building</td>
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<tr>
<td>- Demolition of buildings and structures in Kwai Chung, Kennedy Town and Cheung Sha Wan</td>
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<tr>
<td>- Development at Anderson Road (site formation and associated infrastructure works)</td>
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<tr>
<td>- Drainage improvement works on Northern Hong Kong Island, in East and West Kowloon and in New Territories</td>
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<tr>
<td>- Engineering infrastructure works for Pak Shek Kok development</td>
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<tr>
<td>- Improvement and extension of pedestrian subway system and footbridge in Kwai Chung and Tsuen Wan</td>
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<tr>
<td>- Improvement to Hong Kong Central mid-level and high level areas water supply</td>
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<tr>
<td>- Provision and replacement of traffic control, surveillance and information dissemination facilities</td>
</tr>
<tr>
<td>- Provision and uprating of salt water supply for Northwest New Territories/Northwest Kowloon</td>
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<td>- Replacement and rehabilitation of water mains, stage 2</td>
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<tr>
<td>- Retrofitting of noise barriers on Tseung Kwan O Road and Yuen Shin Road</td>
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<tr>
<td>- Site formation for school development at Aberdeen Reservoir Road, Aberdeen</td>
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<td>- Tamar Development</td>
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<td><strong>Education (HK$3,138 million)</strong></td>
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<tr>
<td>- Construction, extension, redevelopment and repositioning of primary, secondary and special schools</td>
</tr>
<tr>
<td>- Headquarters and onscreen marking centres of the Hong Kong Examinations and Assessment Authority</td>
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<tr>
<td>- Multi-media Building – stage 2, The City University of Hong Kong</td>
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<tr>
<td>- New campus at Tiu Keng Leng for the Vocational Training Council</td>
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<td>- 1 500-place student hostel, The Chinese University of Hong Kong</td>
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<tr>
<td><strong>Health (HK$3,063 million)</strong></td>
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<tr>
<td>- Prince of Wales Hospital – extension block</td>
</tr>
<tr>
<td>- Redevelopment of Caritas Medical Centre, phase 2</td>
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<td><strong>Security (HK$1,824 million)</strong></td>
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<tr>
<td>- Government Complex at Mei Lai Road</td>
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<tr>
<td>- Junior Police Officers’ married quarters in Area 44, Tuen Mun</td>
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<tr>
<td>- Redevelopment of Lo Wu Correctional Institution</td>
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<tr>
<td><strong>Community and External Affairs (HK$1,682 million)</strong></td>
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<tr>
<td>- Improvement works to the sports venues for the 2009 East Asian Games</td>
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<tr>
<td>- Provision of open space and recreation grounds in Ma On Shan, Kwai Chung, Tsing Yi, Sheung Shui, Tsuen Wan, Wong Tai Sin and Ap Lei Chau</td>
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<tr>
<td>- Renovation of libraries – phase 2 works</td>
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<tr>
<td><strong>Environment and food (HK$1,037 million)</strong></td>
</tr>
<tr>
<td>- Conversion of aqua privies into flushing toilets</td>
</tr>
<tr>
<td>- Northern District, Port Shelter and outlying islands sewerage</td>
</tr>
</tbody>
</table>
tors, architects, consultants, material and equipment suppliers, and various specialist tradesmen. The effectiveness of applying various methods and regulations for sustainable construction practice is determined by the effectiveness of the level of collaboration among project participants. From that, by examining roles of individual project participants, the research team developed a collaboration framework enabling better application of sustainable construction practice.

Fig. (1) shows the proposing construction project participant collaboration framework (CPPCF). The essence of the CPPCF is a data exchange hub (DEH), where all project participants share and communicate information embodied in their organizational EMS. Communication and information sharing through the DEH can ensure all project participants act in concert in achieving better environmental performance. Whilst individual organizations have their own EMS, they consistently comply with the EMS principles. Different parties should be motivated to use the DEH to review their performance and to modify wherever necessary their management methodologies. Previous studies suggested four essential components in an EMS [4,17,26,38-44]:

i) Formation of comprehensive environmental policy: environmental policy is to establish a desirable level of environment performance. This established level is used to judge the actual environmental performance of all activities.

ii) Reforming the existing organizational structure for implementing environmental policies: organization structure requires to be established to implement all measures of environmental management. The establishment of such organizational structures give the means to determine responsibilities, authority, lines of communication and resources to implement an EMS. For example, within such organizations, one group or division is responsible to study alternative methods in using tropical wood boards for concrete formwork, and to search for waste disposal methods. A line of communication within organizations should be designed to connect with all concerned parties working on the project.

iii) Laying down specific environmental programmes: an environmental management programme is a detailed plan that specifies specific targets to be met and work instructions and controls to be applied to achieve compliance with environmental policy established within an organization, for example, to reduce construction waste by about 50%.

iv) Reviewing environmental performance and auditing the implementation of the EMS: it is important to undertake periodic audits of environmental performance of construction firms. To audit the environmental performance of construction firms is to measure the progress of a firm’s environmental performance. To audit the effectiveness of the EMS is to identify its weaknesses and to provide an essential information feedback to management who can take corrective action.

The CPPCF highlights that all project participants can share the DEH. Individual parties have specific roles and functions. These roles and functions among participants, including government departments, project owners or clients, architects, consultants, contractors, suppliers, specialists, tradesmen, and occupiers, must be clearly specified. From the interview discussions, the interviewees noted that without a specific role, a party cannot provide useful contributions. They also suggested the following roles for different parties.

**Roles of Government**

To apply sustainable development strategies in a project implementation process, it is expected that the government has to take a leading role. This is consistent with the government’s objectives ‘to secure sustainable development for our future generations and to take the lead in addressing regional environmental issues’ as promised in its policy address [36].

The most important action plan should be to incorporate the EMS to all public projects, and to let legislative councils and the public know its importance and implementation. The public and the legislative councils need to take on the role of monitoring whether the government has done its best for the future of Hong Kong.

The discussions within the research team also suggested that the government should also issue technical guidelines including but not limited to: i) efficient use of space and land; ii) efficient use of energy, reuse and recycling; iii) development of procurement systems allowing for environmental protection costs; iv) reduction of energy demand (embodied energy and operational energy); v) cleaner production rather than ‘end-of-pipe’ practice; vi) reuse of building materials/components; vii) recycling of materials which cannot be reused directly; viii) proper choice and specification of environment-friendly building materials, and the control of toxic chemicals and dangerous waste; ix) environmental education during study and training; and x) collaboration with co-ordinated regulators.

Furthermore, there are various government bureaux and departments involved in massive infrastructure projects. It is highlighted that the Chief Executive should assign a principal official at a secretary or deputy secretary level to lead construction practitioners and be responsible to oversee co-
ordination and adjustment work in the implementation of
government sustainable development strategies. The gov-
ernment departments should also provide assistance and en-
courage private sector clients to implement the EMS.

Roles of Clients

Public sector clients have liability to set an example to
implement sustainable construction practice. Clients should
participate in the whole project process. In the early planning
and design stages, clients should provide project briefs and
guidelines aiming to improve project sustainability perform-
ance. For example, environment-friendly materials and con-
struction methods should be encouraged, lower energy con-
sumption construction structures should be chosen, and cer-
tain budget allowances should be made for adopting envi-
nmental protection measures across the whole project life
cycle.

Roles of Architects and Consultants

Architects and consultants should incorporate into their
work with attributes affecting environmental performance of
the project during its construction phase and post-commis-
sioning process throughout design. It is well appreciated that
the design has fundamental effects on project performance
throughout its life cycle [4,6,38,45-47]. Thus applications of
sustainable construction principles into the design process
can improve total project sustainability performance. Never-
theless, designers often only focus on technical design pa-
rameters such as building types, shapes and directions. This
tradition can be improved by encouraging designers to con-
sult specialists or manufacturers on specific aspects with
reference to project environmental performance, including
energy consumption, life cycle cost, material features, and
characteristics and functions of plants and equipment. The
interview discussions in this study suggested that project
sustainability performance can be improved to a larger extent
if designers can collectively consider the following parame-
ters into their designs: i) buildability; ii) life cycle costs; iii)
maintainability; iv) repairability; v) upgradeability; vi) choice
of materials and their recyclability; vii) construction
methods (e.g., adoption of prefabrication, standardization of
design); viii) energy efficiency; and ix) users’ health and
comfort (air, light and view).

Roles of Contractors

Contractors are key players in contributing to sustainable
performance. Contractors should be encouraged to take al-
ternative designs, or supplies, or construction methods if
better environmental benefits can be gained [4,6,33,38,46,
49], for example, adopting metal-formwork instead of timber
formwork. Contractors should employ well-trained manage-
rial staff to oversee on site environmental aspects, to identify
events arising from construction activities and to mitigate
their adverse environmental impacts. Pollution and waste
control are among the major environmental commitments to
contractors. Proper methods must be planned to reduce and
to recycle construction waste.

Roles of Suppliers

Suppliers for construction materials and equipment can
also make contributions to attain sustainability performance
by supplying environmentally-friendly products. When there
is a culture of sustainable construction practice, suppliers are
driven by the market to provide products that meet specifica-
tions in line with sustainable development principles. New
products must have less impact on the environment over the
project’s life cycle, or otherwise they become obsolete in an
environmentally-aware marketplace.

Roles of Users

Users or owners of construction projects have effects on
project sustainability. Project sustainable performance can be
improved if the users can efficiently use facilities and main-
tain them properly.

RECOMMENDATIONS

To effectively improve sustainable construction, the fol-
lowing are suggested based on the interview discussions:

• To consider sustainable construction implementation at
  an early project stage;
• To receive initial support from government and clients;
• To mandate sustainable construction practice by gov-
  ernment or clients on projects;
• To provide incentive schemes from government and
  clients in enhancing the implementation of sustainable
  construction;
• To develop an efficient communication framework
  among project participants;
• To provide sufficient on site supervision in ensuring
  optimal sustainable construction practice; and
• To attend training programs to enhance sustainability
  knowledge.

CONCLUSION

The implementation of environmental management in
construction presents both challenges and opportunities or
benefits. This paper suggests that management-related fac-
tors are more influential than other factors to the implemen-
tation of sustainable construction. The practice in the Hong
Kong construction industry shows that the major manage-
ment-related causes include: (i) the opportunistic culture in
the local private property sector to make quick gains; (ii)
high labour costs compared with low material cost; (iii) ex-
cessively accelerated delivery programmes, leading to inade-
quate attention being given to environmental considerations;
(iv) non-value-adding multi-layered subcontracting and lax
site supervision, resulting in ineffective site environmental
management; (v) low awareness of environmental issues
within construction workers, and reluctance of senior man-
agement to commit resources to tackle environmental issues;
(vi) failure to efficiently use construction and demolition
waste for land reclamation; (vii) insufficient design inputs
respecting sustainable development; and (viii) ineffective
government encouragement and monitoring for sustainable
development. A construction project participant collabora-
tion framework was developed in this study to improve
communication among project participants by using a data
exchange hub. The study has found that there is good poten-
tial for construction participants to make contributions to
sustainable development as there are ambitious plans of con-
Collaboration Among Project Participants

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