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Theme Paper - Hong Kong

Sustainable Building Practices during Construction

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The RCCREE is the Hong Kong Polytechnic University Centre for solution oriented research and consultancy in construction and real estate economics. It undertakes internationally relevant multi-disciplinary research that supports the advancement of the construction and real estate industries in the following areas: Economic Policy and Institutional Analysis, Real Estate Economics, Construction Economics, Housing, Human Behaviour in Economic Decision making, and Value Management and Facilities Performance. For further information, please contact Professor Francis K.W. Wong, Director of RCCREE (bskwwong@polyu.edu.hk) or Professor Eddie C.M. Hui, Deputy Director (bscmhui@polyu.edu.hk).

Executive Summary

Building and construction work together is the largest user of global resources and emits the most greenhouse gas. In OECD countries, the built environment uses approximately 30% of all raw materials, generates 30% to 40% of all solid wastes, emits 30% to 40% of all greenhouse gas, and uses 25% to 40% of total energy (OECD, 2003). Therefore, the construction industry has strong global incentive to help protect the environment and improve living conditions and well-being.

This paper will focus on sustainable practices during the construction stage in Hong Kong, and share with AsiaConstruct member countries our experience in green technologies, methods, and best practices that builders use to reuse and recycle, save energy, and reduce water in construction sites. The objective of this paper is to provide some insights into the future of developing sustainable building practices and encouraging a wider application of different green technologies and materials in construction projects.

1. Introduction

Construction activities contribute to the adverse impact on the environment via the creation of waste, air pollution, resource depletion, and energy consumption (Ngowi 2001). Energy saving in the operation of buildings and construction work is a critical issue in the construction industry. Issues related to green building have elicited the attention of scholars and professionals in building across the world (Rees, 1999; Ding, 2007). Sustainable building practices such as selection of green materials, designing for recycling, and green technologies are strategic methods in minimizing the detrimental effects of construction work on the natural environment.

2. Green initiatives in the building sector by Hong Kong Government

In order to avoid the significant impact of construction activities on the environment, different restrictions and regulations have been formulated and implemented by the Hong Kong government, as detailed below in chronological order.

2.1 Hong Kong Energy Efficiency Registration Scheme for Buildings (1998)

The registration scheme was launched by Electrical and Mechanical Services Department (EMSD) in 1998. The Building Energy Codes (BECs) are a set of five Codes of Practice. It includes lighting, air-conditioning, lift and escalator installation, and electrical installation.

They are performance-based building energy Codes that stipulate the minimum energy performance standard of these installations.

2.2 Sustainable Development Fund (2003)

The Sustainable Development Fund was established by the HKSAR government. A sum of HK$ 100M was provided as a central financial source of support initiatives, which helped develop public awareness on sustainable development. It also aims to encourage sustainable practices in Hong Kong. A sum of HK$ 10M has been earmarked for disbursement every year (Sustainable Development Fund, 2010).

2.3 Incorporation of elements about environmental concerns in Tender Evaluation of Work Contracts (2004)

According to ETWB (2004), for tenders submitted with the two-envelope approach, the technical proposal of the tender may include the use of environmentally friendly products and processes. Moreover, the reports on contractor performance consider the outcomes of implementation of their waste management plans and the environmental friendliness in their contractors' designs.

2.4 Pay for Safety and Environment Scheme (2005)

The HKSAR government unified the standard and payment methods on specific environmental nuisance abatement measures and incorporated the payable items on environmental management into the Pay for Safety and Environmental Scheme (PFSES) (ETWB, 2005a). Contractors have priced unreasonably low rates for payable items for environmental management due to keen competition. Thus, these items are now pre-priced in the bills of quantities/schedules of rates in public works contracts. Designated deductions of payments will be made to the contractor if the specified actions are not taken (Lam et al., 2011).

2.5 Construction Waste Disposal Charging Scheme (2005)

Based on the "polluter pays principle," the Construction Waste Disposal Charging Scheme was implemented by the HKSAR Government in December 2005 (Environmental Protection Department, 2011). This scheme aims to charge against violating contractors who dump their construction waste into public landfills, encouraging contractors to recycle and reuse construction and demolition waste instead. An economic disincentive is introduced under this scheme to encourage contractors to reduce, sort, recycle, and reuse construction waste (Legislative Council, 2007).

2.6 Adoption of Renewable Energy Technologies and Energy Efficient Features in Government Projects and Installations (2005)

Another technical circular was issued by the ETWB in 2005 to promote the application of renewable energy technologies and energy efficient features in government projects (ETWB, 2005b). The same circular should be issued so that related departments can strive to identify opportunities to promote existing government buildings or installations to incorporate renewable energy technologies and energy efficient features such as photovoltaic panels and solar water heating systems.

2.7 Building Energy Efficiency Funding Schemes (2009)

In response to the 2008–2009 Policy Address, the Building Energy Efficiency Funding Scheme was set up to subsidize building owners to conduct energy-cum-carbon audit (ECA) and energy efficiency projects (EEP).

The purpose of EPP is to provide incentives to building owners to conduct additional improvement or alteration work to improve the energy efficiency performance of building services installation. The reimbursement for the energy efficiency projects is limited to 50% of the approved total actual expenditure and maximized at HK$ 500,000 per building per application (ECF, 2011). A total of 672 applications were approved up to 30 September 2011.

2.8 Green Government Buildings (2009)

In addition to the issuance of the Technical Circular (Works) 16/2005, the HKSAR Government issued another technical circular, “Green Government Buildings”, in April 2009 to establish a comprehensive target-based green performance framework for existing and new government buildings in view of promoting green buildings in Hong Kong. The targets set in the framework apply to new government buildings and existing government buildings. The framework covers seven areas: 1) Green Building Ratings, 2) Energy Efficiency, 3) Greenhouse Gas Reduction, 4) Renewable Energy, 5) Waste Reduction and Management, 6) Water Management, and 7) Indoor Air Quality. The additional cost involved in items 4 to 7 would be capped at 2% of the total project cost (Development Bureau, 2009).

2.9 Encouraging the Use of Recycled and other Green Materials in Public Works Projects (2011)

A technical circular was issued to establish a framework for the procurement of recycled materials and other green materials to promote their applications in public work projects (Development Bureau, 2011). A three-tier framework for trial use, early phase of implementation, and full implementation of priority use is presented in this document. At the first tier, the technical performance of the new recycled materials (or green material) should be proven satisfactory in the trial run in terms of strength, durability, environmental performance, and the like. At the second tier, if at least two suppliers can be identified, recommendations will be made to work departments for early phase of implementation. At the third tier, if suppliers are identified and the technical performance is reconfirmed, recommendations will then be made to work departments for full implementation of priority use (Development Bureau, 2011).

3. Sustainable Building Practices

The literature reveals various green approaches, technologies, and materials to reduce environmental impact of construction activities. The details of these sustainable building practices will be discussed in this section.

3.1 Green Technologies

Table 1 Application of different green technologies

Green Technologies	Applications	Sustainability
Two level lighting control system	Public area (lobby, corridor and staircase)	Reduce energy consumption
Photocell Sensor Control for Lights in Public Areas	Areas near the windows in public areas	Reduce energy consumption
Electronic Ballast to replace Electromagnetic Ballast	Equipped with fluorescent type lighting fittings	Save about 15% of electrical energy
T5 Fluorescent Tube and LED Lighting Systems	General illumination at housing estates	Reduce energy consumption
Variable speed drive control for the fresh water booster pumping system	Residential housing	Extend the life span of the pumping equipment, achieve higher energy efficiency and occupy lesser plant room space.
Hybrid ventilation system	New shopping centres	Reduce energy consumption and carbon emissions from the air-conditioning system

Two-level lighting control system

In response to the requirements specified in the “Barrier Free Access 2008”, a design manual promulgated by the Building Department, the illumination standard of public areas has been significantly increased to cater to persons with special needs, such as those who have impaired vision. To achieve the new illumination standard for domestic blocks without undue increase on energy consumption, a new two-level lighting control system has been adopted in the new design for public rental housing estates since December 2008. This system enables users to raise the lighting level when necessary. The standby sets of lighting system at different areas can be elevated to 85 lux when switched or triggered on. When occupancy is no longer detected, the lighting system returns to the low stand-by level (ITC, 2011).

Photocell Sensor Control for Lights in Public Areas of Domestic Blocks

Photocell sensor controls for lights are installed in areas with natural light, such as areas near the windows in communal areas, to switch off certain lights to save energy when the illumination level is adequate. In the area of energy savings, the Hong Kong Housing Authority (HKHA) adopted the Code of Practice for energy efficiency of EMSD. Trial applications of Photocell sensor control system have been conducted at selected housing estates. In the case of Ching Yi Estate, a public housing estate comprising 4 multi-storey residential blocks housing altogether 2,000 residents in 800 households, electricity consumption in the public areas was reduced by 30.9% after setting up indoor lighting control devices in the corridors. With reference to the assessment results of pilot projects, wider application of such control system may be considered for adoption in other new estates (HKHA, 2012a).

Use of Electronic Ballast to replace Electromagnetic Ballast

Control gear is an essential element for the operation of fluorescent lamps, which is used to regulate the amount of electricity that flows to the lamp. The control gear used is known as ballast. Ballast can be divided into two major kinds: electronic ballast and magnetic ballast (EMSD, 2011a). Magnetic ballast has been developed and adopted for over two decades, whereas electronic ballast is a modern energy-saving option. For fluorescent-type lighting fittings, approximately 15% of electrical energy could be saved if electronic ballast is used instead of electromagnetic ballast. Thus, the HKHA has widely adopted the use of electronic ballast. At present, all new buildings being constructed are equipped with fluorescent-type lighting fittings driven by electronic ballasts.

Wider Use of T5 Fluorescent Tube and LED Lighting Systems

T5 fluorescent tubes of higher efficacy have been used for all exit and directional signs of public rental housing to replace the T8 counterparts. Coupled with the use of electronic ballast, the overall efficacy of the fixture can be raised by approximately 20% to 30% (Cheung and Fan, 2012). In one renovation project were the replacement of the existing 320 sets of T8 fluorescent luminaries in the office areas with T5 fluorescent luminaries, complete with electronic ballasts. The average daily lighting energy consumption measured onsite before retrofit was 470 kWh, whereas the energy consumption measured after retrofit was 270 kWh. Thus, energy savings of 55,000 kWh per floor is anticipated annually (EMSD, 2011b).

Variable speed drive control for the fresh water booster pumping system

The HKHA has adopted variable speed drive controls for the fresh water booster pumping system in all new public rental housing estates (HKHA, 2012a). In a variable speed drive control system, the water pump output is adjusted and varied to meet the system requirements. The pump will deliver the exact amount of water that is required by the system. The system has been used together with smaller stainless steel pneumatic pressure vessels and stamped stainless steel multi-stage pumps to extend the life span of the pumping equipment, achieve higher energy efficiency, and occupy less plant room space.

Hybrid ventilation system

The hybrid ventilation system is a combination two-mode system. An energy efficient way to provide a comfortable indoor environment is to use both natural and mechanical forces at different periods of the day or season of the year. In order to maintain a satisfactory indoor environment, the hybrid ventilation systems can be controlled automatically and changed between natural and mechanical modes to minimize energy consumption (Heinonen and Kosonen, 2000). This system has been introduced at some new shopping centers. Combining the use of natural ventilation and mechanical air conditioning, as well as switching between two operation modes to suit user needs, the new system greatly reduces energy consumption and carbon emissions from the air-conditioning system.

3.2 Green Materials

Table 2 Application of different green materials

Green materials	Applications	Sustainability
Concrete paving with recycle glass	◆ Production of paving blocks	◆ Recycle waste glass
Air pollutant removal paving block	◆ Paving blocks	◆ Remove air pollutants such as nitrous oxides (NOx) by at least 20 %
Recycling and reuse of marine mud	◆ Paving tiles ◆ Backfill materials	◆ Reduce construction and demolition wastes
Recycled concrete and aggregates	◆ Pavement sub-base; ◆ Production of concrete ◆ Production of recycled concrete paving blocks ◆ Parapet wall and planters ◆ Partial replacement of virgin aggregates for concrete works in retaining walls, beams ground slabs and pile caps etc.	◆ Reduce the impact on the landscape due to the exploitation and quarrying of natural aggregates. ◆ Slow the consumption of natural resources used in concrete ◆ Reduce construction and demolition wastes
Recycled brick	◆ Reuse as bricks ◆ Recycle into new bricks ◆ Brick wall	◆ Reduce construction and demolition wastes ◆ Save energy to manufacture new bricks
Recycled boards and partition	◆ Partition walls for office and toilets use	◆ Reduce construction and demolition wastes
Recycled flooring	◆ Floors of residential and commercial buildings	◆ Reduce construction and demolition wastes
Energy efficient windows glazing	◆ Windows of residential and commercial buildings	◆ Reduce solar heat transfer and cooling load ◆ Reduce noise and internal condensation

Concrete paving with recycle glass (Eco-Glass-Block)

In 2004, the Environment Protection Department (EPD) funded research on developing local recycling outlets for waste glass by a local university. In the recycling process, the waste glass such as glass containers were crushed into smaller particles to replace natural river sand for the production of paving blocks. Since 2004, two concrete paving blocks manufacturers have used recycled glass containers collected in Hong Kong. EPD (2012) reported that the Highways Department (HD) introduced new requirements in its road maintenance contracts in October 2010 to prioritize the use of concrete paving with recycled glass at paving areas. The Housing Department also started using such environmentally friendly concrete pavers in their projects in late 2010.

Air pollutant removal paving block

The air pollutant removal paving blocks can effectively help improve the environment. They are also manufactured from environmentally friendly materials. The paving block is a thin surface layer made of cement, recycled aggregates, a small amount of titanium dioxide, and other industrial wastes, with a concrete base layer. When the surface layer of the block is irradiated by natural sunlight, active oxygen molecules will be created on the paving block surface. Thus, NOx in the air will be oxidized into nitrate. The nitric acid, as a resultant, will be washed away by rain. Approximately 20% of air pollutants such as nitrous oxides (NOx) can be removed (HKNG, 2011).

Recycling and reuse of marine mud

The construction site for the Kai Tak public rental housing development involved substantial amounts of marine mud excavation. Approximately 12,000 m^3 were excavated, which is equivalent to five standard Olympic-sized swimming pools. Traditionally, the excavated mud would be treated as waste and dumped in landfills or out at sea. However, an innovative and practical method was developed by the project team to help minimize construction costs as well as environmental impact. More than HK$ 8 million was eventually saved on waste disposal (HKIE, 2010).

The excavated marine mud mixed with cement and sand is processed at the treatment plant on-site. The green-treated marine mud was then backfilled and compacted in layers of approximately 300 mm for sufficient reinforcement to support the building foundation. This treatment of marine mud was turned into other products such as paving tiles and used at other construction sites of new public rental housing projects of HKHA in Tseung Kwan O (HKHA, 2012b).

Recycled concrete and aggregates

Many environmental, economical, and energy benefits can result from recycling and reusing concrete. The use of recycled concrete and aggregates can greatly reduce the natural disturbance on the landscape due to the exploitation and quarrying of natural aggregates, preserve our landfill space, and regain the embodied energies. The demand for natural resources can also be reduced. In the disintegration process of the concrete matrix, recycled aggregates can be obtained. Moreover, constituents of the concrete matrix tend to return to their most stable form during the crushing process. This means that only strong particles can survive, whereas weaker particles will be reduced to more stable, yet smaller particles that can still be reused. Recycled aggregates have been commonly applied in construction work such as the replacement of virgin aggregates for concrete works in retaining walls, beams, and ground slabs, among others (EMSD, 2012).

Recycled brick

Bricks and masonry units are similar to concrete, involving extensive primary embodied energy. Considerable amounts of energy, natural resources, and valuable landfill space can be preserved by recycling and reusing these units. Several types of bricks are reusable. Reused brick can be collected from other construction sites and recycled, crushed, and manufactured into new bricks. Some by-products of recycling, such as fly-ash, can be integrated into mixtures of brick or masonry (EMSD, 2012). Crushed brick rumble can be utilized as an aggregate for lightweight concrete. Crushed masonry aggregate from different types of demolition waste can be used for the production of pavement bases and in the precast concrete industry. Moreover, they are applied as landscaping rocks in some regions in the US.

Recycled boards and partition

Previously used partitions and boards can be refurbished and reused to reduce the amount of new resources used. This process also minimizes diverting material from entering the waste stream, which ultimately enters landfills. Recycled boards can be applied as partition walls for office and restroom use. In the construction project of the Jockey Club Environmental Building, located in Kowloon Tong in the Kowloon Peninsula of Hong Kong, the amount of waste that could be generated was reduced with the application of recyclable hoarding instead of traditional plywood hoarding. When the building structure was finished and the boundary fence was erected, the entire recyclable hoarding can be removed and reused as internal permanent partitions inside the building. Recycled boards and partitions have been applied successfully in many places throughout the world. For example, gypsum boards with recycled content were adopted at the City of White Rock Operations Building in New York. The walls of Sonoma County Waste Management Agency in California were made of gypsum board with approximately 20% recycled gypsum (EMSD, 2012).

Recycled flooring

Many types of environmentally-friendly floor finishing materials are available in the market, including bamboo, concrete, wood, ceramic tile, and terrazzo. It is recommended to avoid using the traditionally-used synthetic materials, because they contain chemicals that are harmful to our health, such as petroleum. Green carpet options comprise natural and inert fibers that are primarily made from sustainable materials that are biodegradable, recyclable, or renewable. Cork is another sustainable flooring choice. With proper care, cork is an economical, resilient, and durable floor finishing option. Linoleum that is made from renewable and natural materials is also a naturally durable flooring material that is simple to maintain and fix. Ceramic tile is entirely recyclable because it comes from natural sources. Asian bamboo strips laminated onto durable flooring boards are innovative technology from a renewable resource (EMSD, 2012).

Energy efficient window glazing

Window technology has undergone a significant revolution in the past few years. The application of energy-efficient window and glazing systems can significantly reduce building energy consumption. These energy-efficient windows feature improved frame, insulating gas in between glass panes, multiple glazing, and are specialized with transparent coatings. All these features minimize heat transfer; they are thus able to cut energy costs. Low-emissivity glass is coated with a special layer of metal, which is able to reflect much of the infrared portion of the solar spectrum while transmitting most of the visible spectrum. Thus, the amount of solar heat transmitted to the building can be reduced (EMSD, 2012). Double glazing windows comprise two glass panes that are separated by an air gap. Double glazing offers greater insulation from convective and conductive heat transfer when compared with single glazing. In addition to thermal advantages, double glazing can provide a notable reduction in internal condensation and outside noise. The thermal insulation performance of double glazing can be further enhanced by filling inert gas such as krypton or argon, instead of air, between the two glass panes.

4. Conclusions

The construction industry, as one of the major users of environmental resources, is consequently a major polluter of the natural environment. This paper has attempted to demonstrate how environmental impact could be reduced using sustainable building practices. A series of green technologies and sustainable building materials during construction stages of a building are introduced and recommended. If these approaches could be effectively applied in the construction process of all building, the adverse effects of construction activities on the environment would be largely reduced.

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