Sustainable Building and Construction in Singapore

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Abstract

This paper presents an overview of the sustainable building and construction strategies envisaged by the Building and Construction Authority (BCA), Singapore. Various policies and initiatives that are currently being pursued are discussed. Two of the latest commercial development projects in Singapore that have successfully adopted sustainability principles are described. The first project involves the use of structural concrete with high dosage of Recycled Concrete Aggregates (RCA) up to 100% replacement for a closed-loop zero-waste construction, while the second project attained carbon neutrality or net zero carbon through a mix of internal and external carbon emission reductions.

Keywords: Singapore, green building, sustainable construction, zero waste, zero carbon

1. Introduction

Singapore is a small city state sited on about 700 km^2 of land, supporting a population of about 5 million people. With one of the highest population densities in the world but practically no natural resources, the development of the city has to be undertaken in a sustainable manner to ensure a first-rate living environment not only for current, but also future generations of Singaporeans.

It is against this backdrop that the Sustainable Singapore Blueprint [1] was announced by the Singapore government in April 2009. The blueprint is the culmination of work undertaken by the Inter-Ministerial Committee on Sustainable Development (IMCSD) to chart the nation's future national sustainability strategies. One of the key thrust of the blueprint is improving resource efficiency and achieving zero landfill. The IMCSD has also set a long-term target for Singapore's built environment that is to have at least 80% of the buildings in Singapore attain the BCA Green Mark Certified rating by 2030.

2. Sustainable Construction Master Plan

The building and construction sector, being one of the key drivers of Singapore's economy (19.8% growth in 2009) [2], will be at forefront of this national effort. It is with this in mind that the Building and Construction Authority (BCA)[1], together with industry associations and major government agencies, formulated the Green Building and Sustainable Construction Master Plans as part of the contribution to Singapore's sustainable development.

In Singapore's context, Sustainable Construction focuses on the adoption of materials and products in buildings and construction that will consume less natural resources and increase the reusability of such materials and products for the same or similar purpose. Two key focus areas of sustainable construction in Singapore are efficient design to optimise use of natural materials, and waste minimization, reuse and recycling.

The Singapore's Sustainable Construction Master Plan was launched in 2008 to reduce the use of natural materials in building projects. Five strategic thrusts shown in Table 1 have been identified to drive the industry towards sustainable construction. Besides reducing the impact of construction activities on the environment through a closed-loop zero-waste construction approach, the Sustainable Construction Master Plan also mitigates impact on limited landfill capacity with a view of working towards zero landfill.

Table 1: Five Strategic Thrusts of Sustainable Construction Master Plan

	Efficient Design to Optimise Use of Natural Materials	**Recycling and Use of Sustainable Materials**
Strategic Thrust 1	Government Taking the Lead in Adopting Sustainable Construction	
Strategic Thrust 2	Promoting Sustainable Construction in Private Sector	
Strategic Thrust 3	Building Industry Capabilities	
Strategic Thrust 4	Strategic Profiling and Raising Awareness to Generate Sustained Demand	
Strategic Thrust 5	Setting Minimum Standards through Legislative Requirements	

[1] The Building and Construction Authority (BCA) is an agency under Singapore's Ministry of National Development to champion the development of a safe, high quality, sustainable and friendly built environment [3].

2.1 STRATEGIC THRUST 1: Government taking the lead in adopting sustainable construction

The Government will continue to lead the way forward in environmental sustainability through adoption of green procurement practices for public sector developments. In general, the public sector projects accounts for about 30-40% of the total construction demand in Singapore. All new public sector buildings and those undergoing major retrofitting works are required to achieve the highest Green Mark accolade, i.e. the Green Mark Platinum Award. Besides new buildings, Government is also committed to have all existing buildings owned by government agencies to attain the Green Mark Gold Plus standard by 2020.

It is also important for government agencies to take the lead in championing sustainable construction practices in their projects and showcase these efforts to the industry. For example, the major public housing developer, the Housing & Development Board (HDB), specifies the use of recycled aggregates for non-structural concrete elements in their projects. The Land Transport Authority (LTA) has also piloted a trial test on the use of Incineration Bottom Ash (IBA) as alternative materials in road construction (Figure 1).

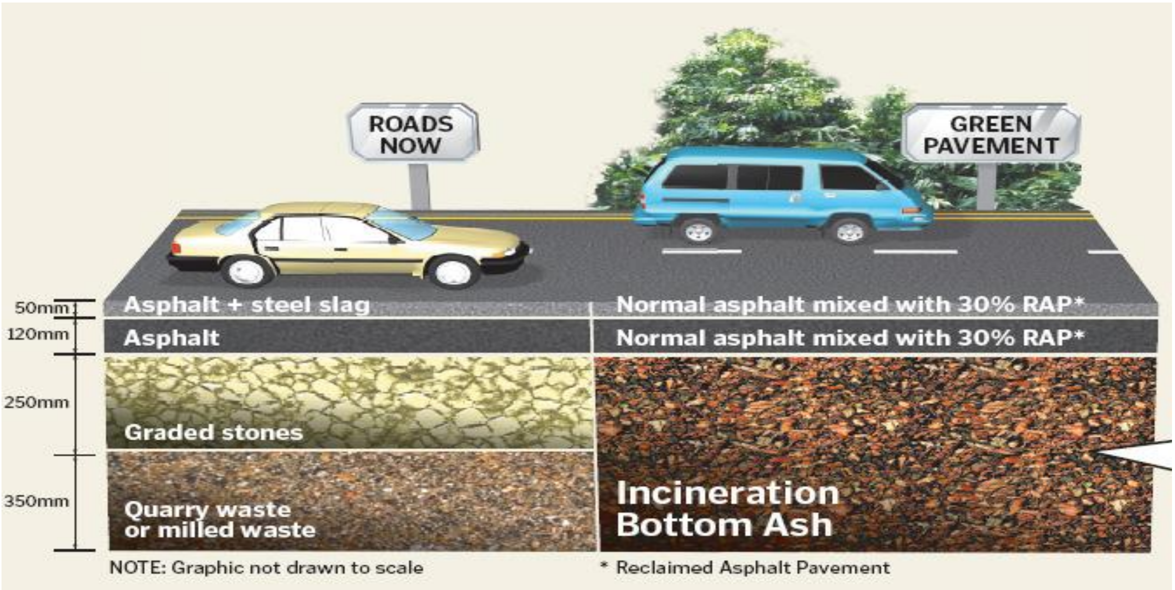

Figure 1: Use of Incineration Bottom Ash in road construction (*from Straits' Times, 19 Mar 2009*)

2.2 STRATEGIC THRUST 2: Promoting sustainable construction in the private sector

Promotion of sustainable construction in the private sector is mainly being done through BCA's Green Mark Scheme [4] via adoption of the Code for Environmental Sustainability of Buildings [5]. The Green Mark Scheme is a locally-developed green building rating system to evaluate a building for its environmental impact and performance. Since April 2008, the Green Mark Certified rating has been legislated as the minimum mandatory standard for all building works with a gross floor area of 2,000 m^2 or more. In 2009, the government has also set higher Green Mark standards, such as the Green Mark Platinum or Green Mark Gold Plus Award as land sales conditions for selected new growth areas.

To further encourage private developers to achieve outstanding design, quality and sustainability objectives in their projects, BCA and the Urban Redevelopment Authority (URA) has introduced the Green Mark Gross Floor Area (GM GFA) Incentive Scheme in 2009. The scheme will grant developments that achieve either the Green Mark Platinum or Green Mark Gold Plus Award with additional gross floor area over and above the Master Plan Gross Plot Ratio control. For instance, developments that obtained the Green Mark Platinum rating will earn an additional gross floor area up to 2% of the individual development's total gross floor area, subject to a cap of 5,000 square metres.

2.3 STRATEGIC THRUST 3: Building industry capabilities

The government recognises the need to build up industry competencies and capabilities as a basis for the industry stakeholders to integrate such practices into their design and construction processes. In 2006, the government established a S$20 million Green Mark Incentive Scheme For New Buildings (GMIS-NB). The scheme offers cash incentives to private developers, building owners and project consultants whose new developments with a gross floor area of at least 2,000 square metres achieves a Green Mark Gold rating or higher. In 2009, BCA unveiled a S$100 million Green Mark Incentive Schemes For Existing Buildings (GMIS-EB) to jump-start the 'greening' of existing buildings in the private sector.

For research and development, a S$50 million "Research Fund for the Built Environment" was launched in 2007 to kick-start R&D efforts in sustainable development. To further accelerate adoption of sustainable construction practices and technologies, a S$15 million Sustainable Construction Capability Development Fund was established to build up the capabilities of the industry. A comprehensive training framework has also been put in place to nurture a core group of green building professionals. Some 20,000 green specialists at the PMET (Professional, Manager, Executive and Technician) level are expected to be trained over the next 10 years in the development, design, construction, operation and maintenance of green buildings.

2.4 STRATEGIC THRUST 4: Strategic profiling and raising awareness to generate sustained demand

In October 2009, BCA launched the inaugural Singapore Green Building Week to profile Singapore as a hub for green building development in the region. The event featured the International Green Building Conference (IGBC) that showcased Singapore's achievement in shaping a sustainable built environment and engaged foreign experts to share their experiences in green building with the industry. The Singapore's first Zero Energy Building was also launched and much international awareness was generated through Singapore's iconic Green Mark projects.

In the area of sustainable construction, BCA has also been proactive in raising awareness through the inaugural Conference on Recycling for Sustainable Construction in Nov 2007. This was followed by the International Solid Waste Association (ISWA) World Congress in Nov 2008. To review and enhance our sustainable construction efforts, BCA has formed an International Panel of Experts (IPE) on Sustainable Construction in April 2009. The IPE comprised 4 renowned experts from UK, USA and Austria, with the participation of 2 local experts from the academia. The panel serves as a platform for industry stakeholders, academia and public sector agencies to discuss and recommend ways to advance the adoption of sustainable construction further.

2.5 STRATEGIC THRUST 5: Setting minimum standards through legislative requirements

Legislative requirements remain fundamental in determining the advancement of new methods and materials. In 2008, BCA required all demolition contractors to declare the estimated quantity of demolition waste, as part of the conditions of the permit to commence demolition work. Further in 2008, BCA adopted the local equivalent of BS EN 12620: Specification for Aggregates for Concrete [6], which has provisions for the use of manufactured and recycled concrete aggregates. The recognition of the new Standard is crucial for providing guidelines to the industry on the performance of new construction materials from non-natural sources.

To encourage recovery of higher quality recycled materials, a Demolition Protocol for Resource Recovery was incorporated into the local Code of Practice for Demolition or CP11. The Demolition Protocol is a set of procedures on how demolition wastes should be managed on-site to maximise resource recovery for beneficial reuse and recycling. It aims to produce cleaner demolition waste to a quality acceptable for waste recyclers to produce high quality Recycled Concrete Aggregates (RCA). The protocol consists of the following:

2.5.1 Pre-Demolition Audit

Pre-Demolition Audit enables the quantity of recyclable and non-recyclable materials such as concrete and bricks respectively to be identified on different parts of a building. The level of material segregation and the required demolition sequence are pre-determined before the actual demolition for better planning and on-site management. Resource recovery target is also established.

2.5.2 Sequential Demolition

The demolition process is separated into phases in which individual materials are carefully dismantled one step at a time and salvaged for reuse and recycling. The wastes generated in each dismantling stage should be of similar type and nature such that contamination by non-recyclable items can be significantly reduced. The sequence of demolition is principally carried out in reverse order to the construction process.

2.5.3 On-site Sorting

For demolition wastes to have meaningful applications, it is vital that the wastes are properly managed and stored separately on site to avoid cross-contamination of wastes. Once the demolition wastes have been properly separated, they can be channeled to appropriate recycling facilities for further processing into useable products.

3. Latest developments of Sustainable Building and Construction in Singapore

The following sections highlight two of the latest development projects in Singapore that have successfully adopted sustainability principles.

3.1 Case Study – Samwoh Eco-Green Building

The Samwoh Eco-Green Building (Figure 2) is the first 3-storey office building in South East Asia to be constructed using concrete with RCA beyond code limits for structural concrete. It was a joint project between Samwoh Corporation, BCA and Nanyang Technological University, and funded by the MND Research Fund for the Built Environment, to conduct a full-scale evaluation on the use of various percentages of recycled concrete aggregates in structural concrete for building structures.

Figure 2: Samwoh Eco-Green Building

Currently the use of RCA from construction and demolition wastes in structural concrete at low percentages (10-20%) is already allowed in Singapore. It is also important to highlight that construction and demolition wastes in Singapore generally comes from relatively clean concrete structures with practically no variability in aggregate type since granite is the main type of coarse aggregate used. Figure 3 illustrates the processes involved in the production of RCA from construction and demolition wastes. In this building project, the first, second and third levels were constructed with concrete using 30%, 50% and 100% RCA respectively, with concrete strengths ranging from Grade 20 to Grade 60.

Another unique feature of the building was the use of fibre-optic sensors embedded in the columns to monitor the long-term structural performance of the concrete. The long term monitoring data obtained from the building will be useful for in-depth structural analysis and the formulation of future specifications on the use of RCA for structural concrete. Finally, the results can be used to build confidence of industry stakeholders on the use of RCA and for policymakers to consider increasing the limit of percentage replacement of RCA for structural concrete going forward. The Samwoh Eco-Green Building has also achieved the highest green building rating, the BCA Green Mark Platinum, due to extensive use of other green and sustainable features [7].

Figure 3: Processing of C&D Waste into RCA

3.2 Case Study – Tampines Concourse

The Tampines Concourse Building shown in Figure 4, held the distinction as being the first carbon-neutral building in Singapore and it has also achieved the BCA Green Mark GoldPlus Award in 2009. Designed and built with environmental sustainability in mind, the 15 years leasehold building offers a total of 105,000 square feet of eco-friendly office space across 3 storeys.

The carbon neutrality of the development or net zero carbon emission was achieved through a mix of internal and external reductions. Internal reductions were the carbon emission savings from actions within the organization including construction materials and processes, and building operations. External reduction known as 'carbon offsets' was achieved by purchasing an amount of CO_2 equivalent saved from an accredited project overseas. In the first phase, the developer had off-set the construction and estimated first year of tenancy carbon emissions which totaled about 6,750 tonnes of CO_2 emissions[2]. The sustainable features used in the project are highlighted below.

3.2.1 Designed for Energy Efficiency

It is the first building in Asia that utilizes a pre-cooled mechanical ventilation system for indoor cooling. Coupled with facade greening area of 2,504m^2 and green roof system of 1,921m^2, these vertical and horizontal greenery helps to mitigate solar heat gain in the building. The building also optimized the daylight penetration at atrium and lift lobbies with natural day-lighting system via specially-designed light shaft and sun pipes. Lastly, the installation of photocell sensors at every floor automatically regulates use of artificial lighting on overcast days. The energy savings for entire building is estimated to be over 620,000 kWh per year.

3.2.2 Designed for Water Efficiency

The project is the first office building in Singapore to be fully fitted with waterless urinals and water-efficient fittings in all toilets to reduce potable water usage and operational costs. Nano-coating was applied on waterless urinals for deodorisation and sterilisation and ease of maintenance. The water savings from these environmentally friendly features is approximately 280m^3 per year

3.2.3 Designed for Sustainable Construction

The building was designed to promote conservation of natural resources. Green concrete was used for both structural and non-structural building components, through a mix combination of washed spent copper slag, recycled concrete aggregates and ground granulated blast furnace slag (GGBS). Zero potable water usage was also achieved during construction due to the use of rainwater recycling and waste water treatment system.

3.2.4 Designed for High Indoor Environmental Quality

To achieve a high indoor environmental quality, non-chemical anti-termite treatment was used to prevent subterranean termite attack together with low VOC paints for all internal walls and ceilings to improve occupational health and comfort of building's users.

Figure 4: Tampines Concourse

[2] The estimated emissions have been measured in compliance with the internationally recognized Green house Gas Protocol criteria as defined by the World Business Council for Sustainable Development and the World Resource Institute (WBCSD/WRI Protocol). By complimenting internal reductions with external ones, the building is able to reach net zero carbon today.

4. Summary

A concerted and holistic approach on sustainable buildings and construction that covers the whole value chain is currently taking shape in Singapore towards improving resource efficiency and achieving zero landfill. BCA has been working closely with the industry to shift from conventional construction methods to adoption of sustainable construction materials and practices. Through tackling design and regulatory issues related to sustainable buildings and construction, the industry has increased its awareness and receptiveness to alternative building and construction materials and methods. Besides closing the loop for construction and demolition wastes to achieve zero waste, sustainable construction strategies will also enhance environmental sustainability and preserve natural resources for use by future generations.

5. References

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