Sustainable Architecture

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Going more green and sustainable

When the inaugural edition of PREFAB Architecture was issued in 2003, its aim was to promote and upgrade the design and construction techniques of prefabricated architectures in Singapore. The intention was to feature outstanding prefabricated solutions used in various local and overseas buildings.

Over the years, the team has highlighted various prefabricated systems successfully adopted by local designers and builders. PREFAB Architecture has been well-received locally and overseas.

Green Mark Scheme

In January 2005 BCA launched the Green Mark Scheme to promote environmental awareness and the development of green buildings in Singapore. Since then, close to 80 buildings have achieved Green Mark certification. Building designs are increasingly focused on being ***green*** and ***sustainable***. More developers and designers are incorporating best practices in environmental design and construction, and adopting green building technologies. These measures will reap many long term benefits for the building owners, such as reduced energy and utility bills, and improved indoor environmental quality for healthy living and reduced environmental impact.

It is therefore time for PREFAB architecture to be revamped and re-named Sustainable Architecture. Besides buildable buildings, Sustainable Architecture will showcase green buildings, green building technologies and products, and sustainable construction.

This inaugural issue of Sustainable Architecture features the Xilinx Asia Pacific headquarters, a BCA Green Mark Platinum Award winner and the Parc Emily Condominium, one of the pioneer projects that was awarded the BCA Green Mark Gold Award in 2005. In addition, construction waste recycling technologies and the application of such recycled products are highlighted in another article.

I would like to thank SIA for its strong support and making this newsletter a successful private-public collaboration. I am confident that Sustainable Architecture will inspire designers to deliver more innovative, buildable and green designs in the future.

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Constructive application of waste materials in construction

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Singapore is a highly urbanised country with a small land area of about 700 sq km. The amount of solid waste generated has increased six times over the past 30 years. At this rate, the National Environment Agency (NEA) has estimated that a new incineration plant has to be built every 5-7 years and a landfill every 25-30 years. The recycling of the waste materials for construction applications has become one of the key interests of the Singapore government. Not only does it help to reduce the amount of waste disposed in landfill, it also provides a substitute for natural aggregate which is largely imported from overseas. The recent incidents of sand ban and disruption of granite aggregate supply have further reinforced the importance of recycling waste materials.

There are three major types of waste materials that can be or has been used for construction applications in Singapore in recent years, namely, construction and demolition waste, asphalt pavement waste and incinerator bottom ash generated from the incineration of refuse waste.

Construction and Demolition Waste

Construction and demolition (C&D) waste is generated from construction activities such as demolition works, concreting, renovation and road works. The waste contains mainly crushed concrete, metals, bricks, ceramic tiles, wood, plastics etc. A significant amount of C&D waste is generated every year. In 2007 Singapore's property market rocketed, generating a high number of property and commercial developments. The buoyant property sector has led to many collective sales of old condominiums and other properties, whose rebuilding activities have created substantial C&D waste.

Over the years, C&D waste has been used mainly for temporary access roads at construction sites and in the subbase course (see Figure 1) for road construction. With the increasing demand and cost of natural aggregate, there is a need to recycle the C&D waste for more beneficial applications.

In 2005, BCA awarded Samwoh Corporation Pte Ltd (Samwoh) a research grant to conduct a study on the effective use of C&D waste for construction applications. The C&D waste can be processed into recycled concrete aggregate (RCA) which contains mainly aggregate and cementitious material. The recycling processes include removal of ferrous metals, removal of foreign materials, crushing and screening of RCA into various sizes as shown in Figure 2.

The findings of the study showed that RCA can be used as an alternative to natural granite in the base course for road construction and non-structural precast concrete components such as road kerbs and drains. The RCA also provides cost savings of about 30 percent compared to natural granite, depending on the quantity and cost of natural aggregate. Further tests are being carried out on the use of RCA in semi-structural and even structural concrete. It is envisaged that the RCA can be incorporated in the specifications for various construction applications.

Asphalt Pavement Waste

Asphalt pavement waste is generated mainly from the milling of asphalt pavement and full-depth removal of asphalt pavement during pavement maintenance and rehabilitation. The waste can be processed into reclaimed asphalt pavement (RAP) which is the removed and/or reprocessed pavement materials comprising mainly aggregate and asphalt (a by-product of petroleum-refineries). At present, the waste is largely used in subbase course for road construction and temporary access roads in construction sites. However, these applications are of low economical value as the asphalt in the RAP can be more beneficially used in the production of asphalt mixtures for the wearing and binder courses (see Figure 1), thereby reducing the demand for new asphalt (which cost about 20 times more than aggregate). The use of RAP in asphalt mixture has been practiced worldwide for many years.

Currently, a study is being carried out by Samwoh to evaluate the use of RAP in the asphalt mixture for the wearing and binder courses under a research grant from NEA. The study involves laboratory evaluation, processing of the asphalt pavement waste and setting up an asphalt batching plant with recycling facilities as shown in Figure 3. The project is scheduled to be completed by early 2008.

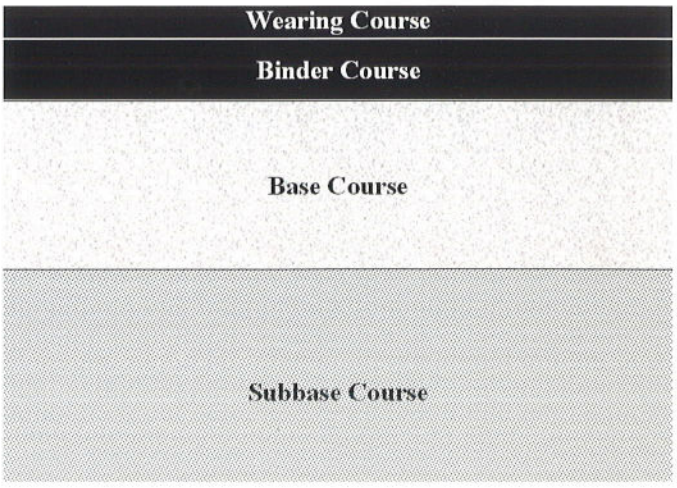


Fig 1 - Pavement section

C & D waste

Preliminary crushing and removal of ferrous metals

Removal of foreign materials such as bricks, plastics and asphalt

Further crushing and screening of RCA into various sizes

Stockpile of RCA for usage

Applications of RCA

Fig 2 - C&D processing

Loading of asphalt pavement waste for crushing

Crushing and screening of asphalt pavement waste

RAP is ready to be used

An asphalt batching plant with recycling facilities

Fig 3 - Asphalt processing

Incinerator Bottom Ash

Incinerator bottom ash (IBA) is derived from the incineration of refuse waste. Presently, IBA is disposed in Pulau Semakau, which is an offshore landfill in Singapore. Studies have been carried out worldwide on recycling IBA to see if it is possible to extend existing landfill capacity and to create a value-added product that conforms to regulatory requirements for management and to use IBA as a substitute for natural aggregate. A major concern is the possible leaching of heavy metals such as cadmium and lead. Most regulatory agencies require the ash to be assessed for composition and potential leaching of hazardous compounds before it can be used.

Recently, Samwoh is carrying out a project on the use of IBA for construction applications. The project involves setting up a proper commercial facility to process IBA into an engineered aggregate. The proper processes include weathering (or ageing) for stabilisation reactions to occur, removal of ferrous and non-ferrous metals, crushing, separation of over-sized particles, screening, and chemical treatment using a patented system which is well-proven for treating incinerator ash as shown in Figure 4. The treatment allows the treated IBA to meet regulatory leaching limits and be safely used for construction applications such as base and subbase courses, asphalt mixture, concrete, land reclamation and backfill for trenching works.

Conclusion

The recycling of waste materials for construction applications has offered a means to alleviate waste disposal problem in land scarce Singapore and to provide a substitute for natural aggregate. There are three types of waste materials that can be beneficially used for various construction applications:

1) RCA, which can be used in base course for road construction and partial replacement of natural aggregate for producing concrete;

2) RAP, which can be used in asphalt pavement mixtures for the wearing and binder courses; and

3) Treated IBA, which can be used for road construction including base and subbase courses, sea shore protection and other applications such as land reclamation.

Such applications have been practiced worldwide for many years. The recycling of these waste materials will provide economical and environmental benefits as well as contribute towards Singapore's goal to achieve environmental sustainability.

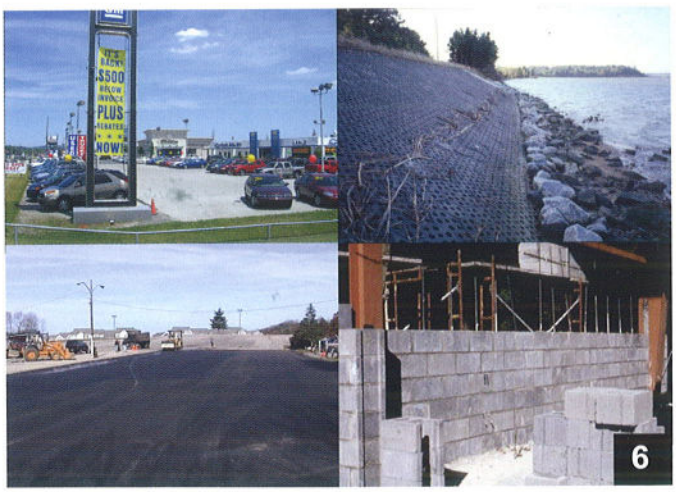
IBA is produced after the incineration process

Aging of IBA

Crushing and screening of IBA

Removal of ferrous and non-ferrous metals from IBA

Chemical treatment of IBA using a patented system



Applications of treated IBA

Fig 4 - IBA processing