

MaSTEC 2015 Learning Journey
24th June 2015



Singapore Strategies on Sustainable Construction

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Topics

- Main Goals of Sustainable Construction
- Adoption of the 3Rs principles
 - Reduce, Reuse, Recycle
- Reduce
 - Manpower, Materials, Labour at Site, Processes
 - Enablers – Design Codes & Guides, Buildability Score
- Reuse
 - Formwork System, Steel Struts
- Recycle
 - Enablers - Design Code, Accreditation scheme, Code of practice for Demolition Works
 - GreenMark Scheme, Bonus GFA, SC Fund, CCPF
- Building Industry Capabilities
- Concluding Remarks



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Key Functions Championed By BCA

- 
1. Leading and Transforming the Industry
- 
2. Ensuring a SAFE Built Environment
- 
3. Championing a high QUALITY Built Environment
- 
4. Enhancing Environmental SUSTAINABILITY
- 
5. Championing a FRIENDLY Built Environment

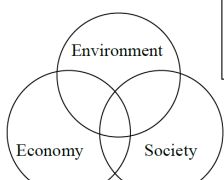
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What is Sustainable Construction?

Development which meets the needs of the present without compromising the ability of future generations to meet their own needs.

The need to find a balance between **economic**, **environmental** and **social factors** in the design, construction and use of buildings.


Economy
Whole Life Cost
Value engineering
Capital v revenue



Environment
Minimise depletion of natural resources
Prevent pollution
Reduce-Reuse-Recycle

Social
Fit for purpose
Meeting place
Supports local economy
Minimise disturbance to local residents

Source: Paper on "Sustainable Construction" by Dr. Neil Smith Environment Manager, The University of Southampton @2008

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Objectives of Sustainable Construction



- Reduce Carbon Emissions
- Ensure Resource Resilience
- Reduce Social Disamenities
- Achieve Cost Competitiveness



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Reduce Carbon Emissions

- Effects of global warming has led to
 - Rise in sea-level and occurrence of extreme weather conditions affects every nations



The aftermath of a bushfire in the area near One Tree Hill in the Adelaide Hills, Australia
(Straits Times, 7 Jan 2015)



Malaysia's flood crisis worsens
(Straits Times, 28 Dec 2014)



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Ensure Resource Resilience

... Sand Crisis in 2007...




- ▶ Reduce reliance on import of concreting resources
- ▶ Improve resilience against supply disruption



Ensure Resource Resilience

“The disruption in the supply of concreting sand and granite from Indonesia is a wake-up call for the industry to switch to sustainable construction as much as possible and as soon as we can.”

- Minister of State for National Development Grace Fu
24 April 2007

...industry actively urged to look at alternatives ..

Use alternative materials, industry urged

THE one dark speck on the horizon for the industry is rising construction cost – a challenge which can be met by using alternative materials and technology.

With a surge in construction activity fanning a demand for basic construction materials

the commercial buildings and a quarter of residential ones do so.

Here, concrete is the mainstay, said Mr Lim Yew Soon, executive director of construction group Evan Lim & Co.

The use of ready-mixed concrete is still going up. This



Reduce Social Disamenities

- 300,000 foreign workers in Singapore
- Loss of amenities causing unhappiness among the citizens
- To reduce reliance on foreign workers



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Achieve Cost Competitiveness

- Initial assistance from government needed to implement sustainable practices
- To be cost neutral in the long run

Funding Support




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Sustainable Construction (SC)

3 Key Principles


- Reduce
- Reuse
- Recycle



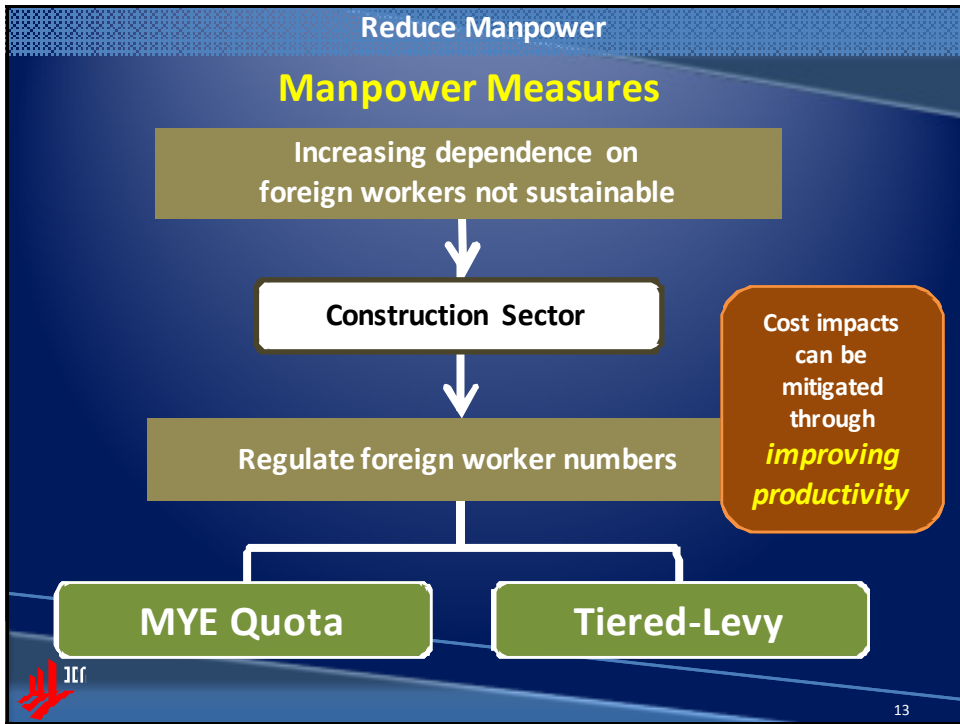
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Reduce

- **Reduce Resources** e.g. minimise use of materials, minimise wastage, minimise labour
- **Reduce On-site Labour** e.g. precast, steel
- **Reduce Processes** e.g. getting it right the first time, use of BIM



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Enablers for SC – Changes to Regulations

Manpower measures

- Regulate Foreign Workers numbers**

MYE cuts	Jul 2010	5%	45% cut since 2010
	Jul 2011	10%	
	Jul 2012	15%	
	Jul 2013	15%	

MYE: Man Year Entitlement

- Incentivise Upgrading of Workers**

	Upgrading Workers from R2 to R1
R1 (Higher Skilled)	Higher-Skilled (R1) workers enjoy: <ul style="list-style-type: none"> • Lower levy • Longer Period of Employment
R2 (Basic Skilled)	

- Co-Fund Upgrading through Workforce Training And Upgrading (WTU) Scheme**

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Enablers for SC – Changes to Regulations

Manpower measures


Incentivise Upgrading of Workers

- Widen Levy Differential

	Present July 2014		July 2015		July 2016		July 2017	
	R1	R2	R1	R2	R1	R2	R1	R2
MYE Quota	\$300	\$550	\$300	\$550	\$300	\$650	\$300	\$700
MYE Waiver	\$700	\$950	\$600	\$950	\$600	\$950	\$600	\$950

Implemented Levy rates adjustment.
Widened R1/R2 to \$250

Adjusting levy rates till 2017
Widening R1/R2 to \$400



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Reduce Resources

- Reduce Concrete Usage**
 - BCA worked with the industry and other stakeholders to formulate an index unique to Singapore, known as the Concrete Usage Index (CUI)
 - CUI calculation takes into consideration the concrete volume over constructed floor area for superstructures

Concrete Usage Index (CUI)

$$\text{Concrete Usage Index (CUI)} = \frac{\text{Concrete Volume in m}^3}{\text{Constructed Floor Area in m}^2}$$

- Typical beam-slab RC structures: CUI ≈ 0.6 - 0.8


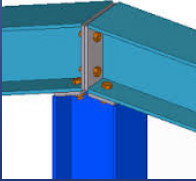
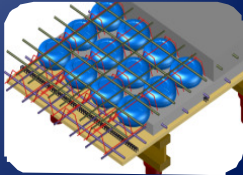


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Enablers for SC – Changes to Regulations

- The industry is encouraged to design buildings with **low Concrete Usage Index (CUI)**

Pro-CUI Systems & Technologies

		
High Strength Concrete Conc reduction* ≈ 20% CUI* ≈ 0.45 to 0.55	Steel Structures Conc reduction* ≈ 50 to 75% CUI* ≈ 0.2 to 0.35	Void Formers Conc reduction* ≈ 25 to 30% CUI* ≈ 0.4 to 0.5

Note: Typical beam-slab RC structures, CUI ≈ 0.60-0.80
**Values are indicative only; depending on extent of usage, size of project, development type etc*


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Enablers for SC – Design Guides

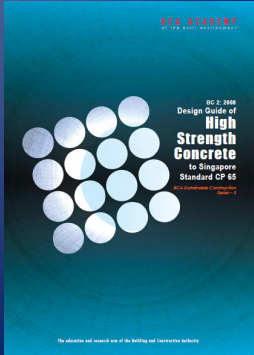
Use of High Strength Concrete


Before: BS8110, CP65 only allow up to Grade 60 concrete.

Now:

- BC2 – provision for use of high strength concrete of up to Grade 105 concrete

This is to provide a transition, pending the introduction of Eurocode where High Strength Concrete is allowed

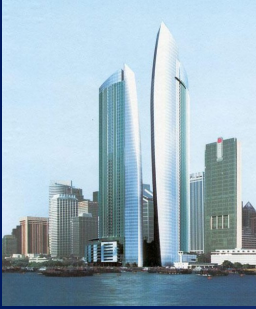



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Projects using High Strength Concrete

The Sail @ Marina Bay

70-sty & 63-sty Residential Tower &
7-sty Carpark




High Grade Concrete Specification – Grade 80 Mpa

(perimeter columns on the 2 residential towers up to 45th storey)


South Beach

45-sty & 42-sty Mixed Development



High Grade Concrete Specification – Grade 80 Mpa

(perimeter columns from level B3 to 10th storey)



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Projects using High Strength Concrete

CapitaGreen

40-Sty Commercial Development



High Grade Concrete Specification – Grade G100/G80/G60 Mpa

Core walls:
Grade 60 (fr basement to roof)

Perimeter Columns:
Grade 80 (fr 18th sty to roof)
Grade 100 (fr 12th to 17th sty)
Grade 60 (fr basement to 11th sty)
(Precast columns fr 12th to 36th sty)

Transfer beams:
Grade 80 (basement & 1st sty)

DUO

50-Sty Mixed Development at Rochor Rd / Beach Rd / Ophir Rd



High Grade Concrete Specification – Grade 80 Mpa

(Commercial tower – perimeter columns from B3 to 25th storey; residential tower – columns from B3 to 1st storey, transfer floor at 3rd storey and walls at 3rd & 4th storey)



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Projects using High Strength Concrete

Interlace Development
31 blocks of 6-sty Residential Dev
(Highest floor at Level 24)



High Grade Concrete Specification – Grade 80 Mpa
(All columns from basement level)

Tanjong Pagar Mixed Development
64-sty Residential and Office Tower



High Grade Concrete Specification – Grade 80 Mpa
(perimeter columns & corewalls from B3 to 18th storey)



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Enablers for SC – Design Guides

Use of Alternative Steel Materials

Singapore’s Code of Practice: BS 5950



Before- only British Standards steel

Now – **BC1:2012** version
5 major international standards

1. European/ British
2. American
3. Chinese
4. Australian /New Zealand
5. Japanese



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Enablers for SC – Design Guides

Use of Alternative Steel Materials

Assessment criteria:

A. Certification
Based on 5 major international standards


- BS/EN
- ASTM/API/AWS
- JIS
- AS/NZS
- Chinese GB

B. Reliability

- a) Factory Production Control Certificate (FPC)
- b) Manufacturer test certificate

- ✓ **Class 1:** Satisfy all criteria – 100% design strength
- ✓ **Class 2:** No Factory Production Control certificate - 90% design strength
- ✗ **Class 3:** All other steel materials – not suitable for structural use

- FPC issued by an independent third-party international **certification body (CB)*** on the basis of **audit/inspection**
- The CB must be **acceptable to BCA**, e.g. Bureau Veritas, TUV Rheinland, Lloyd’s Register, Germanischer Lloyd (GL) & American Bureau of Shipping (ABS)


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Projects using Structural Steel

Green Mark Platinum Award

- Less labour intensive
- Shorter construction time



One Raffles Place



CapitaGreen



**Marina One
– Office Tower**



Yishun Hospital

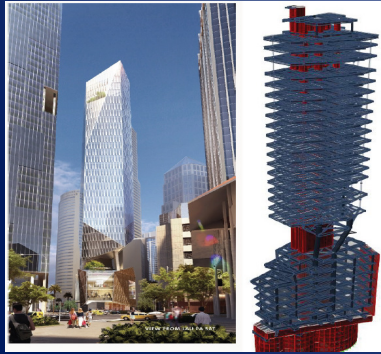




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Projects using Structural Steel

Robinson Tower Re-development



Industrial building @ Sungei Kadut



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Reduce Resources

Advantages of using Void Former

- **Lower CUI** of **0.4 to 0.5**
- Uses **recycle plastic void formers** to reduce self-weight of slab thus saving 25% to 30% of concrete
- Replaces **100 Kg** of concrete with every Kg of recycle plastics

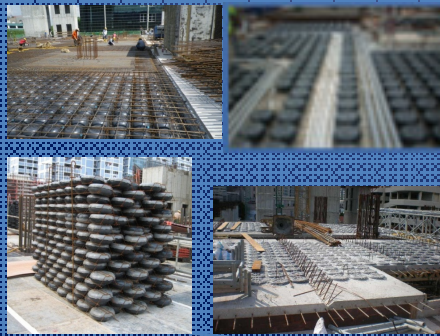


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Types of Void Formers used in Singapore

- Cobiax – 9 projects
- AlveoDeck – 1 project
- BubbleDeck – proposed for 1 project

Cobiax



AlveoDeck



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Projects using Cobiax

The Wharf Residence

4 Residential Blocks of 10 to 15 storey



Cast in-situ Cobiax flat plate and slab system

Park Royal Hotel Upper Pickering Street

15-sty Hotel & 14-sty Office Block



Cast in-situ and Precast Cobiax slab used for the 15-sty hotel and 14-sty office block

Volari at Balmoral Road

12-sty Residential Flats



Cast in-situ Cobiax for residential typical floors

Hundred Trees

6 Blks of 12-sty & 2 Blks 11-sty Condominium



Cobiax slabs for residential floors





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Projects using Cobiax

<p>The Glyndebourne 8 Blocks of 5-sty Residential Flats</p>  <p>Cobiax slabs was used in the floors slabs of the low-rise residential flats</p>	<p>Tiong Seng Prefab Hub 5-sty Industrial Building</p>  <p>Cobiax floor slabs</p>
<p>The Luxurie (Sengkang Square) 10 Blocks of 15-sty Condominium</p>  <p>Cobiax floor slabs</p>	<p>Equinix Singapore Data Center 7-sty Industrial Building</p>  <p>360mm thick Cobiax flat plate for span up to 10.8m</p>



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<h3 style="text-align: center;">Projects using Cobiax</h3> <p>NTUC Warehouse at Joo Koon 16-sty and 7-sty Industrial Blocks</p>  <p>250 mm thick Cobiax flat plate spanning 9m for carparks (5th - 8th storey)</p>	<h3 style="text-align: center;">Projects using AlveoDeck</h3> <p>The Crest 3 blk of 23-sty & 4 blk of 5-sty Residential Bldgs</p>  <p>230 mm thick AlveoDeck used for typical floor slabs</p>
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Reduce Resources

- Encourage **higher usage of Prefabricated Reinforcement Cages**
- Reduce on site labour
- Minimise wastage
- Shorter construction time on site
- Minimise errors on site



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Reduce Resources

- Encourage **higher usage of Prefabricated Reinforcement Cages**
- About 8 companies supplying cages
- Adoption rate of prefab cages approximately 70 to 80%



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Reduce On-site Labour

What is Buildable Design?

- Extent to which the design of a building results in less labour to construct

What is Buildable Design Score (B-scores)?

- The score for buildable design computed in accordance with the Buildable Design Appraisal System (BDAS) as set out in the Code of Practice






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Enablers for SC – Changes to Regulations

Raising Minimum B-scores *

	Private projects			Private projects			Govt Projects		
Year	1 st Sep 2013			1 st Nov 2014			1 st Nov 2014		
Category	GFA > 2000m ²	GFA > 5000m ²	GFA > 25000m ²	GFA > 2000m ²	GFA > 5000m ²	GFA > 25000m ²	GFA > 2000m ²	GFA > 5000m ²	GFA > 25000m ²
Residential (Landed)	63	68	71	70	75	78	73	78	81
Residential (non-landed)	70	75	78	77	82	85	80	85	88
Commercial	72	77	80	79	84	87	82	87	90
Industrial	72	77	80	79	84	87	82	87	90
Schools	67	72	75	74	79	82	77	82	85
Institutional & others	63	69	72	70	76	79	73	79	82

Minimum B-scores * - The lowest Buildable Design Score allowed under a particular category of development




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Reduce On-site Labour

Buildable Design Score (B-scores)

- Higher B-scores awarded for Precast and Structural Steel systems

	Labour Saving Index
In-situ System	
Flat plate with perimeter beams	0.7 to 0.85
Cast in-situ one-directional beam	0.7
Cast in-situ two-directional beam	0.45
Precast Concrete System	
Full Precast	1.0
Precast Column/Wall System with flat plate and perimeter beams	0.75 to 0.9
Precast Beam & Slab System	0.9
Structural Steel System	
Steel Beam & Column	1.0



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Reduce On-site Labour

- Encourage **Precast Components, Steel Structures**

How can projects achieve a high Buildable Design Score?

- Less wet trades, more dry construction such as drywall and precast
- Regular floor layouts and ceiling heights
- Use of standard components and sizes



Precast



Structural Steel





Drywall




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Enablers for SC – Changes to Regulations

Examples of Buildable Design

Non-buildable Structural Systems	Buildable Structural Systems
 <p>Labour-intensive Cast on-site Beam-Slab System</p>	 <p>Labour-saving Precast System</p>

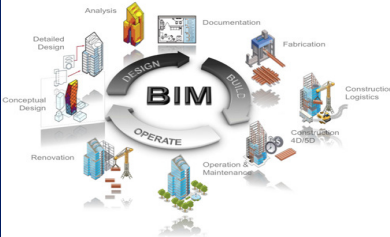
Manpower savings
From 30 workers to 20 workers

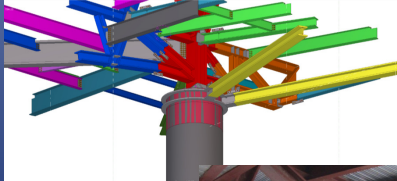



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Reduce Processes

- **Use of BIM** – getting it right the first time, detect clashes and avoid rework






BIM model



Actual connection


- It facilitates **integration of value chain** involving **multi-disciplinary players**


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Reduce Processes

BIM Submission Requirements

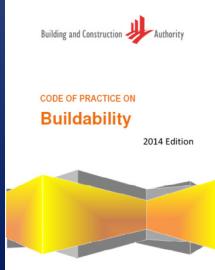
July 2013*	Architecture Submissions for all new building projects > 20,000 m ²
* 100% of QP working on 49 projects > 20k m ² since July 2013 could meet the architectural BIM e-submission requirements	
July 2014	Engineering Submissions for all new building projects > 20,000 m ²
July 2015	All submissions for all new building projects > 5,000 m ²




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Reduce Resources


- Through **Buildable Design** and **BIM Implementation**



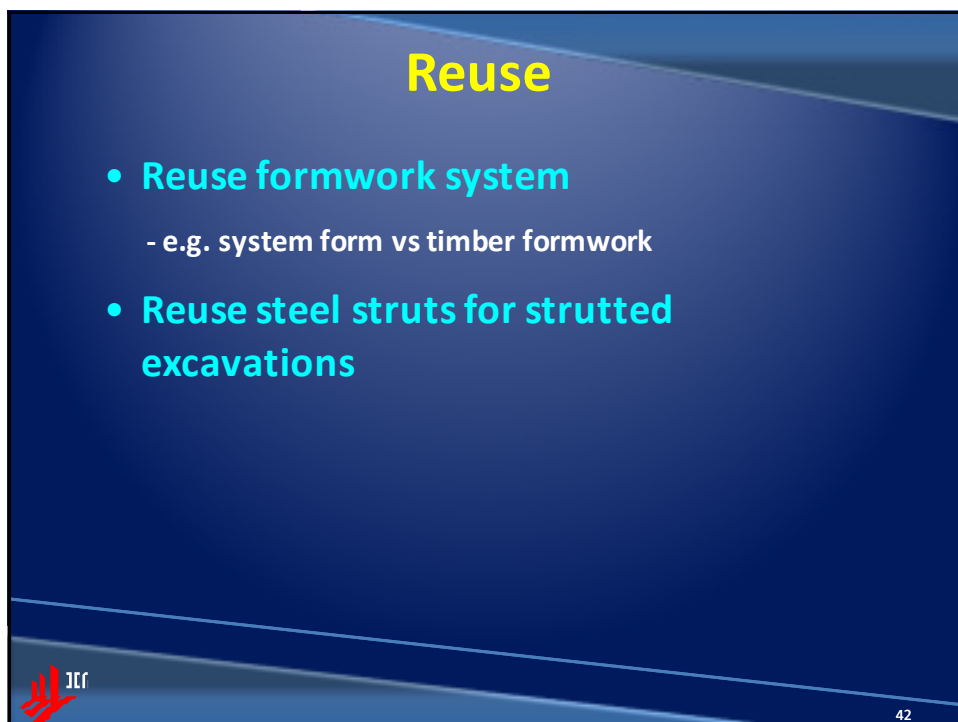
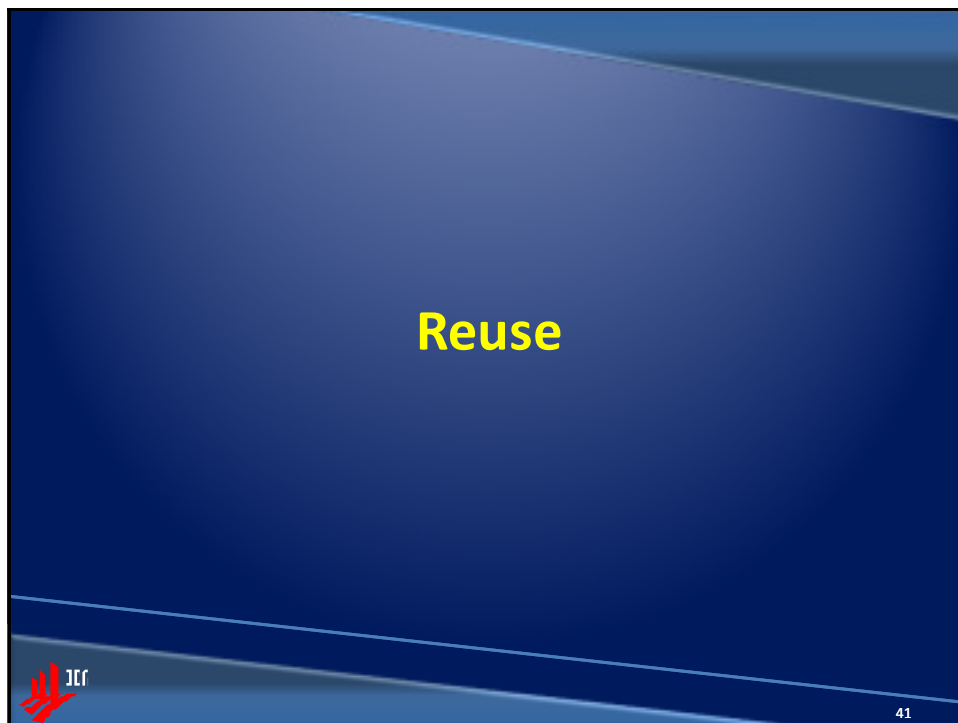
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➔ **Reduce the demand for on-site labour !!!**




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Reuse

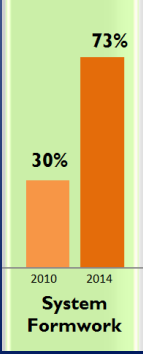
- **Reuse formwork** e.g. system formwork vs timber formwork



Timber Formwork




System Formwork



Year	Adoption rate
2010	30%
2014	73%


- **Benefit of System Formwork:**
 - Reduce on-site labour
 - Speed up erection of formwork
 - Reusable (*say up to 50 times*)
- **Funding available to defray the cost of purchase**



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Reuse

- **Reuse steel struts**



For steel struts to be reusable
- Need to ensure traceability and quality



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Enablers for SC – Design Codes
Design Code for Concrete

SS 31 - Specification for Aggregates from natural sources for concrete

A new code **SS EN 12620** was introduced since 2009 to allow the use of manufactured and recycled aggregates e.g. copper slag, RCA

SINGAPORE STANDARD
SS 31 : 1998
(CS 91-000-30)

SPECIFICATION FOR
Aggregates from natural
sources for concrete
(incorporating Enquiry No. 1, October 1998)

SINGAPORE STANDARD
SS EN 12620 : 2008
(CS 91-100-15, 91-100-30)

Complies with

SPECIFICATION FOR
Aggregates for concrete

Published by
SINGAPORE ENGINEERING COUNCIL
11 South Bridge Road
Singapore 059311
SINGAPORE ENQUIRY NUMBER: www.singapore-engineering-council.com.sg
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Recycle - Use of Recycled Materials

Eco-concrete & Green Concrete

Green Concrete

- Used for structural applications
- Replacing of sand by up to 10% Washed Copper Slag (WCS)
- Replacement of total aggregates by up to 20% RCA
- Replacement of cement for superstructure by up to 20% Ground-Granulated Blast Furnace Slag (GGBS) / Fly Ash

Eco-concrete

- Use for non-structural applications
- At least 50% by mass of total aggregates replaced by recycled materials such as WCS or RA or both



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Recycle - Use of Recycled Materials

Accreditation Scheme for Recycled Aggregates

Jointly launched by BCA and Waste Management & Recycling Association of Singapore (WMRAS)



Objectives of accreditation:

- Provide assurance in quality and consistency of end products (**comply with SS EN 12620*** & other relevant Codes/Guidelines)
- Greater product acceptance & marketability

Now 4 Recyclers (3 accredited & 1 pending) certified to supply aggregates for structural applications.




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Enablers for SC – Design Codes

Amend the Code of Practice for Demolition

A key inclusion is the provision of Demolition Protocol

- To maximize resource recovery of demolition & waste materials for reuse and recycling, a demolition checklist is provided in **SS 557 Code of Practice for Demolition** (former CP11):
 - a) **Pre-demolition audit**
 - b) **Sequential demolition**
 - c) **On-site sorting**



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Enablers for SC – Code of Practice for Demolition


(1) Pre-Demolition Audit

- a) To identify suitable materials to be recycled;
- b) To put in place steps and measures for sequential demolition and waste segregation

On-Site Waste Management Plan

Types of wastes	(A) Estimated Quantity (tons)	B. Recovery Rate (%)	Target Quantity Recovered (A x B tons)	(C) Actual Quantity Recovered (tons/truckloads)	(D) Proposed Usage/ Course of Action
Concrete Components	16000	70	11200		
Beams	4400	70	3080		
Columns	2900	70	2030		
Ground Slabs	600	70	420		
Pile Caps	800	70	560		
Walls	300	70	210		
Floor Slabs	8000	70	5600		
Others, pls specify (e.g. roof slabs)	-	-	-		
Masonry Components	8000	30	2400		
Bricks	4500	30	1350		
Tiles	3500	30	1050		

An early estimate and recovery rate of the wastes should be planned as shown



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Enablers for SC – Code of Practice for Demolition

(2) Sequential Demolition

- Systemic removal of Structural & Non-structural building elements


i) Soft-stripping of building

- Fixtures and furniture, e.g. electric socket outlets, door frames, windows, etc **removed systematically** in order not to contaminate the concrete waste



Before **After**


ii) Demolition of Concrete Structures



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Enablers for SC – Code of Practice for Demolition

(3) On-Site Sorting




Concrete wastes to be sorted

Concrete wastes fed through crusher for RCA

RCA fed through sieve for segregating RCA and fines


Stockpile of RCA




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Demolition of HDB Flats

On-site Recycling




Example of good quality RCA from demolition of HDB flats



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Demolition of UIC Building

Recycled Materials




Before Demolition

Sequential Demolition




On-site Recycling



Processing of concrete waste into smaller aggregates

Type	Actual Recovered	Usage
Concrete Components	24,500t	37% for use off site, 63% sent to recycling facility.
Masonry	10,050t (5,500m ³)	100% sold as hardcore.
Metal includes Structural Steel, Re-bar	1,560t	Sold for scrap
Timber	60t	




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Demolition of National Stadium

Recycled Materials


Sequential Demolition




Demolition of Grand Stand

Type	Actual Recovered	Usage
Concrete Components	76,800t	RCA was sold to main contractor, Dragages Singapore PL, who used it for road works and stadium pitch.
Masonry	64,800t (36,000m ³)	50% disposed off-site and 50% used by main contractor
Metal includes Structural Steel, Re-bar	7,000t	Sold for scrap
Timber	50t	


On-site Recycling



RA stockpiled on site for main contractor's use


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Examples on use of Eco-concrete (non-structural) and Green-concrete (structural)


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Recycle - Use of Recycled Materials

Eco-Concrete for Park Connector Network

Length constructed: 240 km
Estimated length for the next 5 years = 60km

Use of eco-concrete for walkway slabs, park connectors, pedestrian footpaths and cycling tracks

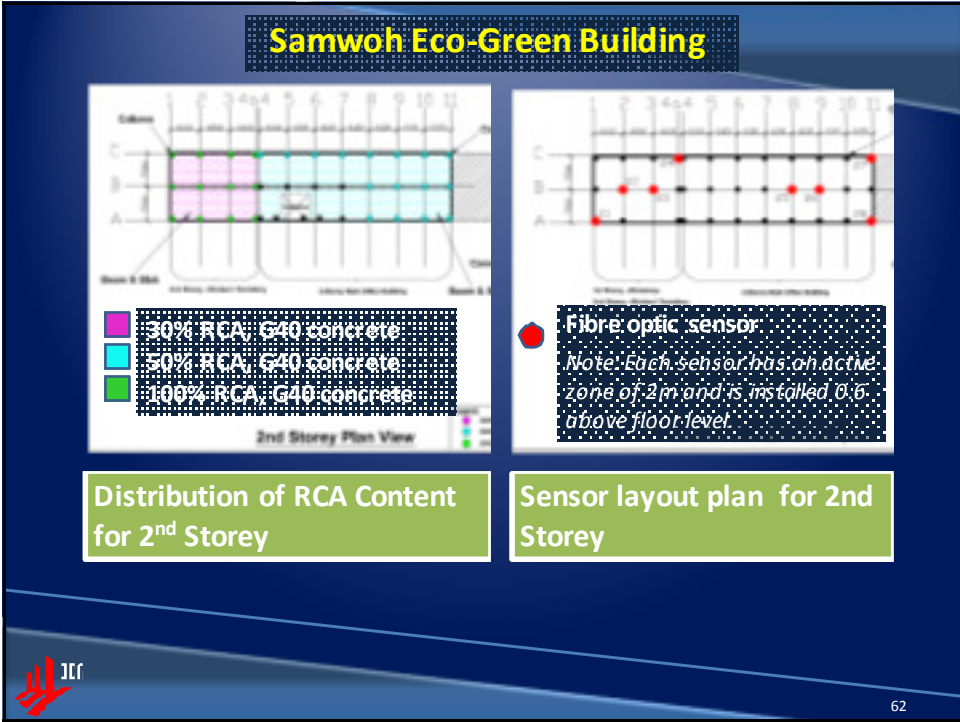
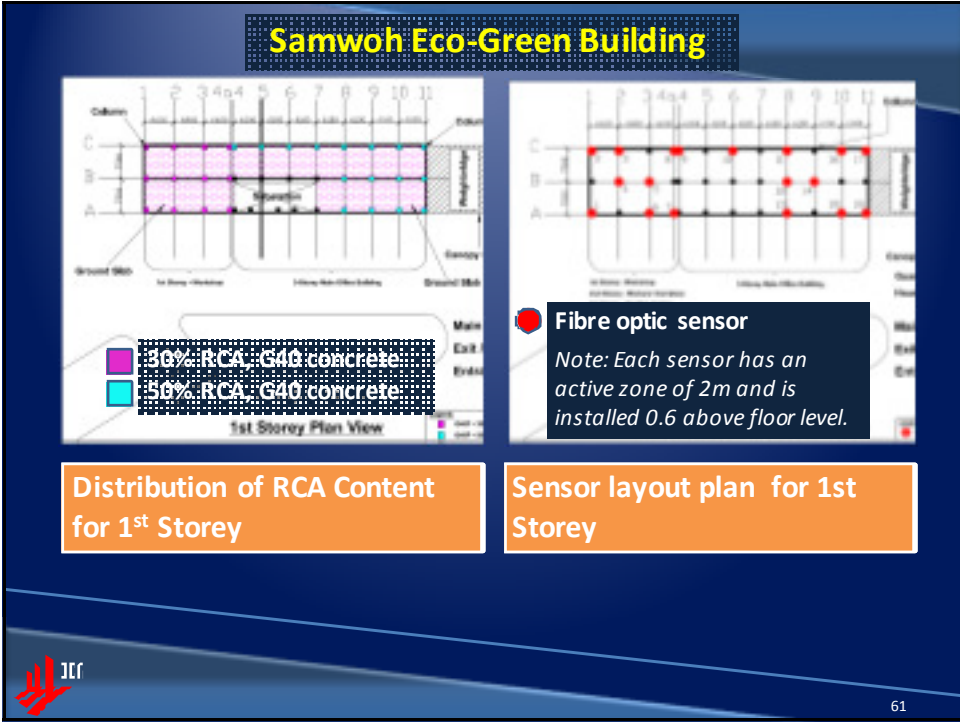
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Recycle - Use of Recycled Materials

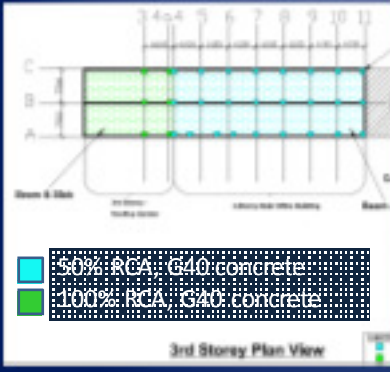
Samwoh Eco-Green Building
3-sty Office Building
Green Mark Platinum Award

- **Full scale evaluation study** by Samwoh Corporation, Nanyang Technological University and BCA
- 1st in Asia Pacific region to use up to **100% RCA** for its structural concrete
- **Instrumented and monitored for its performance** compared to regular concrete
- Testify that RCA and green concrete are just as sound as conventional building materials

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Samwoh Eco-Green Building



Mechanical properties

- Compressive strength
- Tensile strength
- Flexural strength
- Elastic modulus
- Creep
- Drying & wetting shrinkage
- Shrinkage

Durability properties


- Depth of Water Penetration under Pressure
- Water Absorption
- Initial Surface Absorption Test (ISAT)
- Chloride Ingress
- Sulphate Attack

Distribution of RCA Content for 3rd Storey

50% RCA, G40 concrete

100% RCA, G40 concrete

Reference from paper on "Efficient Utilization of Recycled Concrete Aggregate in Structural Concrete", Journal of Materials in Civil Engineering (March 2013), by ASCE


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Samwoh Eco-Green Building

Reference from paper on
"Efficient Utilization of Recycled Concrete Aggregate in Structural Concrete"

By Ho Nyok Yong, Lee Yang Pin Kelvin, Lim Wee Fong, Tarek Zayed, Chew Keat Chuan, Low Giau Leong and Ting Seng Kiong

Journal of Materials in Civil Engineering (March 2013), by American Society of Civil Engineers (ASCE)


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Enablers for SC – Changes to Regulations

Green Mark Requirements**Launched in 2005**

(Certified, Gold, GoldPlus and Platinum)

Main Objective: to drive Singapore's construction industry towards more environment-friendly buildings



Targets: **80% of buildings** in Singapore to achieve **Green Mark by 2030** (up from about 27% today)



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Enablers for SC – Changes to Regulations

**BCA Green Mark scheme**

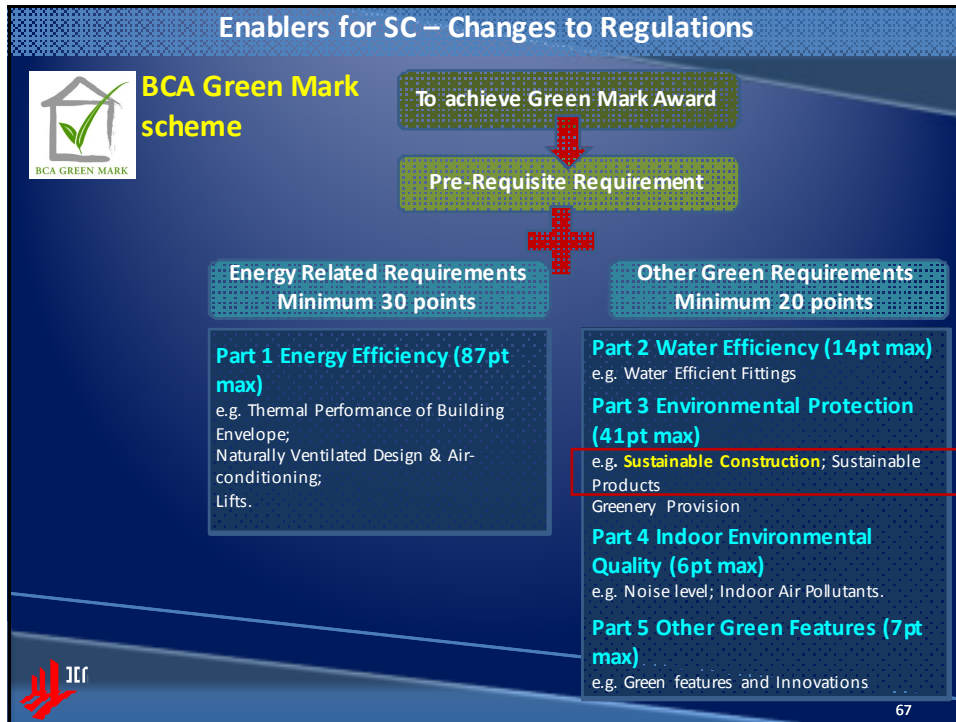
Legislation on Environmental Sustainability for Buildings

Since 2008, the minimum **Green Mark score** for a building is **50 points**

Green Mark Score	Green Mark Rating
90 and above	Green Mark Platinum
85 to < 90	Green Mark Gold ^{Plus}
75 to < 85	Green Mark Gold
50 to < 75	Green Mark Certified



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Enablers for SC – Changes to Regulations

BCA Green Mark scheme

Part 3 : Environmental Protection		
RB 3-1	Sustainable Construction	10
RB 3-2	Sustainable Products	8
RB 3-3	Greenery Provision	8
RB 3-4	Environmental Management Practice	8
RB 3-5	Green Transport	4
RB 3-6	Stormwater Management	3
Category Score for Part 3 – Environmental Protection		41

Sustainable Construction – 10 points max


10 points under Sustainable Construction

- Can be achieved by having:
 - Use of **Green Cement** and **RCA** or **WCS** (5 points max)
 - High CUI** index (5 points max)
- Pre-requisite for **Gold+ and Platinum projects** to score **3 and 5 points** respectively

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Green Mark Platinum Award


Tampines Concourse




- All columns, walls and beams - **10% WCS and 20% GGBS**
- Non-structural components (apron drain, footpath) - **30% WCS, 20% GGBS and 20% recycled aggregates**

Woh Hup HQ Building


SC Fund- Study of WCS+RCA Concrete performance



- Internal walls replaced by **Precast Compac Green Wall**
- Superstructure - **30% RCA & 30% WCS**
- Drains & pavements - **50% RCA & 50% WCS**




GAIA @ Jalan Dusun
16-sty residential building



Structural Elements using Green Concrete:

- 1st to 2nd sty (column & wall) - G55
- 2nd sty (beam & slab) - G55
- 3rd to roof (beam, slab, column/wall) - G35
- 20% RCA, 10% WCS, 10% GGBS**

10-storey BCA Academy Building




Structural elements from 2nd sty except transfer structures

- 20% RCA, 10% WCS, 20% GGBS**

Non-structural elements:

- 20% RCA, 10% WCS, 75% GGBS**



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Green Mark Platinum Award

Ngee Ann Polytechnic Campus Expansion (Phase 7-1)
9-sty Classrooms/Lecture Theatres



Structural elements (beams, columns, walls and slabs):

- 10% RCA, 7% WCS, 20% GGBS**

Ngee Ann Polytechnic Campus Expansion (Phase 7-3)
6-sty Classrooms With Basement



Structural elements (beams and slabs):

- 10% RCA, 10% WCS, 20% GGBS**

Mixed-used Devt At Fusionopolis
17-sty Business Park, A 2-sty Retail Blk, A 5-sty Office Blk & 2 Basement Carpark



Structural elements (columns, beams and slabs):

- 10% WCS**
- 30% GGBS**

Eco Sanctuary Condo Devt
3 Blocks Of 24-sty With Basement



Structural elements (beams and slabs):

- 10% RCA**
- 10% WCS**



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Green Mark Platinum Award

12 Storey Media Complex At Mediapolis@One-north
3 Basements, Theatre, Studios, Retails



Structural elements (columns, beams and slabs):
- 10% RCA, 10% WCS,
20% GGBS

Tanjon Pagar Centre
19/64-sty Commercial, 13-sty Hotel, 32-sty Office And 26-sty Resi Flats, 3 Basement



Structural elements (walls, beams and slabs):
- 10% RCA
- 30% GGBS

Mixed Development At JEM
17-sty blk (shopping complex & office tower) with 3 Basement



Structural elements (columns, beams and slabs):
- 10% RCA
- 30% GGBS

Mapletree Business City II At Pasir Panjang
30-sty Business Park Development



Structural elements (columns, beams and slabs):
- 10% RCA, 10% WCS

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Why developers go for Green Mark ?!

Benefits

- Savings in energy cost and more importantly
- ...Bonus GFA !!!

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Enablers for SC – Incentives

Bonus GFA**Green Mark Gross Floor Area (GM GFA) Incentive Scheme**
(Launched In Apr 2009)**Objectives**

- To encourage private sector to develop higher tiered Green Mark buildings of Platinum or Gold^{PLUS}
- To encourage industry stakeholders to consider going green as early as possible



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Enablers for SC – Incentives

Bonus GFA

Joint scheme with the Urban Redevelopment Authority (URA)

For *eligible developments that targets to achieve Green Mark **Platinum or Gold^{PLUS}**, URA will grant additional floor area over and above the Master Plan Gross Plot Ratio (GPR) control.

Green Mark Rating	GM GFA Incentive Scheme
Platinum	Up to 2% additional GFA beyond Master Plan GPR (subject to cap of 5,000 sqm)
Gold ^{PLUS}	Up to 1% additional GFA beyond Master Plan GPR (subject to cap of 2,500 sqm)

**new private developments, redevelopments, reconstruction developments and existing building undergoing substantial EE enhancements (excludes landed developments)*




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Enablers for SC – Incentives

...other incentives to promote sustainable construction

1. Sustainable Construction Capability Development Fund (**S\$ 15mils**)
2. Construction Productivity and Capability Fund (**S\$ 250mils**)




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Enablers for SC – Incentives

Sustainable Construction Capability Development Fund

Launched April 2010 - \$15 Mil fund

<p>Develop capabilities of the industry in</p> <ul style="list-style-type: none"> • <i>Delivering SC materials</i> • <i>Adopting SC methods</i> • <i>Recycling</i> • <i>Use of recycled materials</i> • <i>Demolition</i> • <i>Other SC-related aspects</i> <p>Prepare industry to support future SC initiatives & possible legislation</p>	<p>Target Groups</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"><i>Demolition Contractors</i></div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"><i>Waste Recyclers</i></div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"><i>RMC Suppliers</i></div> <div style="border: 1px solid black; padding: 5px;"><i>QPs & Contractors</i></div>	<p>Areas of Focus</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"><i>Waste mgmt & recovery</i></div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"><i>SC practices & technologies</i></div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"><i>Env-friendly products & innovation</i></div> <div style="border: 1px solid black; padding: 5px;"><i>SC Materials & Efficient design</i></div>
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Enablers for SC – Incentives

Enhanced SC Fund Framework


Assessment of CUI performance:


1. Design (70%)	2. Innovation (30%)
<p>1.1) Able to achieve the pre-requisite criteria of min. CUI value <u>0.5</u> or below. (50%)</p> <p>1.2) Use of recycled / alternative materials (20%)</p>	<p>To encourage global technology scanning & approaches undertaken in the areas of adoption of new materials/technologies, capable of reducing/replacing overall concrete usage</p>





Projects with low CUI can now apply for funding





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Enablers for SC – Incentives

Construction Productivity and Capability Fund

- Encourage process improvement through
 - technologies adoption; or
 - simplification of work procedures

Progress under 1st Construction Productivity Roadmap

Improvement in site productivity:	Achievement (per year from 2010 – 2014) 1.4 % 
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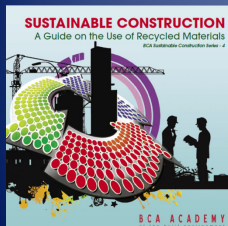
Targets
Annual **average of 2-3%** productivity improvement by 2020


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Building Industry Capabilities on Sustainable Construction



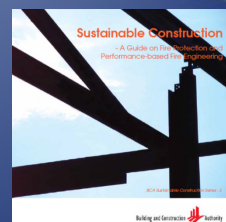
Series of Guidebooks on Sustainable Construction



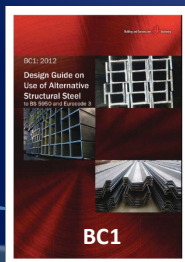
A Guide on the Use of Recycled Materials



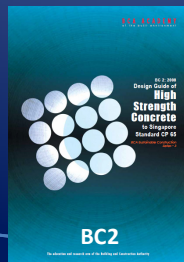
Sustainable Construction - Materials for Building



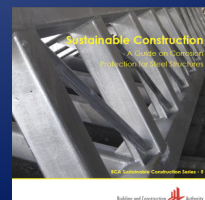
A Guide on Fire Protection & Performance-based Fire Engineering



BC1



BC2



A Guide on Corrosion Protection for Steel Structures



Seminars

- **Achieving Sustainable Construction** through the Use of Recycled & Waste Materials in Concrete (2008)
- Parallel Session on Sustainable Construction at **ISWA/WMRAS World Congress 08**
- **BCA-WMRAS Sustainable Construction Seminar** in 2011
- **Singapore Green Building Week (SGBW) 2012**
- Parallel Session on Sustainable Construction at **International Green Building Conference (IGBC) 2012**
- **BCA-SCI 1½-day Workshop on Recycled and Secondary Aggregates and their Use in Construction** in 2014
- **BCA-RMCAS Sustainable Concrete Seminar** in Jan 2015



Moving Forward



Moving Forward 1

- Promoting the use of **game-changing technology** such as Prefabricated Prefinished Volumetric Construction (PPVC)



- Manpower savings of up to **40%** at the project level



Moving Forward 2

- Encourage **higher usage of low-carbon concrete**
 - Develop National Specifications for Low Carbon Concrete



Moving Forward

3

- Develop material specification for **Grade 600 reinforcement bars**



- BCA is working with SPRING to **enhance SS560 to cover Grade 600 rebar**
- Grade 600 steel is now allowed in EC2: lesser material used
 - **15% saving** in rebar weight
 - **more productive** (smaller and lighter rebar → easier to handle at site)

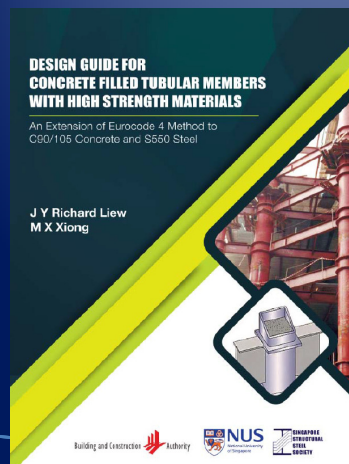


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Moving Forward

4

- Develop **Design Guide for Concrete Filled Tubular Members**



- **Introduce Design Guide** jointly published by BCA/NUS/SSSS in Jan 2015
- Extending the scope of EC4 to cover
 - Concrete cube strength of **105 MPa**
 - Steel yield strength of **550 MPa**



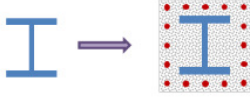
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Moving Forward

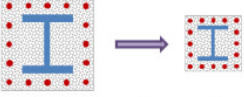
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- Develop **Design Guide for Encased Composite Column**

DESIGN GUIDE FOR ENCASED COMPOSITE COLUMN WITH HIGH STRENGTH MATERIALS



Make use of king-post at excavation stage and become composite column at final stage



Make use of high strength concrete and high strength steel to reduce section sizes. Improve site productivity by 30% reduce materials by upto 30%

Building and Construction Authority NUS SINGAPORE STRUCTURAL STEEL SOCIETY

- EC4 currently covers **Encased Composite Column** of **normal strength materials**:
 - Concrete cube strength of **60 MPa**
 - Steel yield strength of **460 MPa**
- **BCA** working with **NUS** on Research project for **enhancing EC4** to cover **high strength materials** for **Encased Composite Column**



Concluding Remarks

Sustainable Concrete Construction is a long journey !!!



- Baby steps have to be taken
- BCA will continue to work with the industry to implement **Sustainable Construction** practices in all projects



