THE 15TH ASIACONSTRUCT CONFERENCE

SINGAPORE-COUNTRY REPORT

Prepared by

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BUILDING AND CONSTRUCTION AUTHORITY
SINGAPORE

EXECUTIVE SUMMARY

Due to the impact of global financial crisis which led to the economic slowdown in the second half of 2008, Singapore's economic growth moderated significantly from the 7% to 9% annual growth posted during the period 2004-2007 to 1.1% in 2008. Although there are indications of global economic recovery, the rising unemployment in US and Europe still remain a concern. In view of these uncertain economic conditions and the absence of clear signs of a strong, demand-led recovery, the Ministry of Trade and Industry has projected Singapore's GDP growth forecast for the full year of 2009 at between -6.0% to -4.0%.

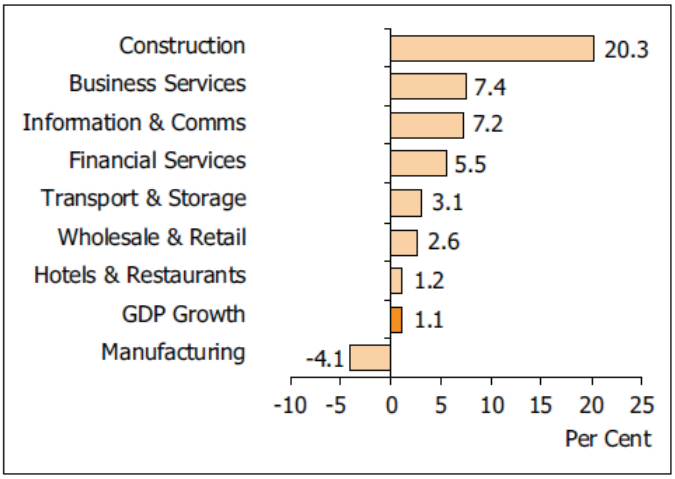
Strong expansion in the first three quarters of 2008 led construction demand for the whole year to reach a record high of $34.6 billion. The exceptionally high level of contracts awarded was largely propelled by continued strong growth in private sector construction demand as well as an upswing in the total value of public housing and infrastructural projects. Given the slowdown of growth momentum in the economy and continued uncertainties in world economic outlook, BCA projected construction demand for 2009 at between $18 billion to $24 billion, and the bulk of this demand will be driven by public sector projects.

2 Macro Economic Review and Outlook

2.1.1 Overview of the Singapore Economy in 2008[1]

In 2008, the economy grew by 1.1% (Chart 2.1.1), down from 7.8% in 2007. The construction sector led the growth with 20%, following an 18% growth in 2007. Growth in the services producing industries moderated to 4.7%, down from 8.1% in 2007, with all major sectors, except the information and communications sector, registering lower growth rates. The manufacturing sector contracted by 4.1%, down from an expansion of 5.9 % in 2007.

Chart 2.1.1: GDP and Sectoral Growth Rates in 2008



2.1.2 Economy in the First Half of 2009[1]

The Singapore economy contracted by 6.5% year-on-year in the first half of 2009, undermined by the 9.5% contraction in GDP in the first quarter of 2009 as economic activity slowed down sharply. Nevertheless, the economic performance in the second quarter of 2009 rebounded and improved by a seasonally adjusted 20.7% compared to the previous quarter. The construction sector remained the star performer and grew by a robust 19% year-on-year, the performances of most other sectors also improved.

Despite the improved performance in the second quarter, the Ministry of Trade and Industry views that without a decisive turnaround in final demand in advanced economies, any economic recovery in the second half of the year will probably be sluggish and modest. Therefore, it is maintaining the 2009 GDP growth forecast at between -6.0% to -4.0%.

[1] Source: Economic Survey of Singapore, 2008 and second quarter 2009, Ministry of Trade and Industry Singapore.

2.2 Main Economic Indicators

Year	2004	2005	2006	2007	2008
GDP and Components					
GDP at real prices (Base Year=2000) (S$Million)	184,257	197,721	214,234	230,871	233,525
GDP at current market prices	185,365	201,313	221,143	251,610	257,418
GDP growth (%)	9.3	7.3	8.4	7.8	1.1
Manufacturing sector (Base Year=2000) (S$Million)	46,205	50,592	56,623	59,987	57,511
% growth	13.9	9.5	11.9	5.9	-4.1
Wholesale & Retail Trade Sector (Base Year=2000) (S$Million)	28,656	31,477	34,719	37,303	38,271
% growth	17.1	9.8	10.3	7.4	2.6
Transport & Storage Sector (Base Year=2000) (S$Million)	17,554	18,567	19,703	20,696	21,334
% growth	11.0	5.8	6.1	5.0	3.1
Financial Services (Base Year=2000) (S$Million)	19,870	21,536	24,054	27,821	29,360
% growth	4.4	8.4	11.7	15.7	5.5
Business Services (Base Year=2000) (S$Million)	21,328	22,598	23,798	25,966	27,877
% growth	3.4	6.0	5.3	9.1	7.4
Construction sector (Base Year=2000) (S$Million)	6,654	6,703	6,943	8,208	9,873
% growth	-5.5	0.7	3.6	18.2	20.3
Demographic Indicators					
Population – Singapore Residents[1] ('000)	3,413.3	3,467.8	3,525.9	3,583.1	3,642.7.
Population growth rate (%)	1.4	1.6	1.7	1.6	1.7
Total labour force ('000)	2,341.9	2,367.3	2,594.1	2,710.3	2,939.9
Labour force growth rate (%)	1.3	1.1	9.6	4.5	8.5
Unemployment rate (%) – Seasonally adjusted as in June	3.6	3.4	2.7	2.3	2.2
Financial Indicators					
Savings deposits (%) (Average quotes from 10 leading banks)	0.23	0.26	0.25	0.25	0.22
Prime lending rates (%) (Average quotes from 10 leading banks)	5.30	5.30	5.33	5.33	5.38
Changes in consumer price index (Base period = 2004, % change over previous year)	1.7	0.5	1.0	2.1	6.5
Annual average exchange rate with $US (Singapore Dollar Per US Dollar)	1.69	1.66	1.59	1.51	1.41

Sources: Singapore Department of Statistics, Ministry of Trade and Industry and Ministry of Manpower Singapore.

[1] Singapore resident population comprises Singapore citizens and permanent residents.

3.1 Overview of the Construction Industry

3.1.1 Construction Demand Review for 2008

The construction demand[2] in 2008 reached a record high of $34.6 billion. The exceptional high demand was fuelled by continued strong private sector construction demand as well as significant growth in the public sector construction demand on account of increased housing and infrastructure construction contracts last year.

Public Sector

Total public sector construction demand in 2008 expanded remarkably to $14.5 billion, from $5.7 billion in 2007. Of the $4.2 billion worth of public housing construction contracts awarded in 2008, about $3 billion of them were for the construction of new HDB (public housing) flats at various housing estates on the back of the strong take up rates for new HDB flats. Institutional construction demand increased from $1.5 billion to $2.9 billion, contributed by MOE's Programme for Rebuilding and Improving Existing Schools (PRIME), upgrading of Changi Airport Terminal 1, construction of the Khoo Teck Puat Hospital in Yishun and various military-related facilities.

The award of various major contracts for the construction of MRT Downtown Line Stage 1 and Marina Coastal Expressway pushed civil engineering construction demand in 2008 to a new high of $7.2 billion. In additional, major infrastructure contracts at Marina South were also awarded to support the development of the Marina Bay area.

Private Sector

Sustained by continued strong construction demand for committed residential and commercial developments, private sector construction demand remained at a strong level, at $20.1 billion, in 2008.

Residential construction demand reached $6.4 billion in 2008 despite weakening property market in the second half of 2008, buoyed by the construction commencement of various committed projects launched during the bullish property market in 2007. Similarly, fuelled by the award of additional contracts for the development of Marina Bay Sands Integrated Resort and Resorts World at Sentosa, Phase 2 of Marina Bay Financial Centre, Ocean Financial Centre, mixed commercial

[2] Construction demand is measured by total value of construction contracts awarded. All construction demand figures in this paper exclude reclamation projects.

development at Vista Exchange and other hotel developments, private commercial construction demand shot up to a record high of $8.4 billion.

Industrial construction demand moderated from a high base of $6.8 billion in 2007 to about $3.7 billion. Apart from conventional factories, business park developments and warehouses, notable industrial projects awarded were Renewable Energy Corporation's solar panel manufacturing complex and JTC's two PPP (public-private-partnership) projects, Fusionopolis Phase 2B and Biopolis Phase 3.

3.1.2 Construction Demand Forecast for 2009

Based on the recent feedback from developers and public sector agencies on their upcoming development plans, the Building and Construction Authority has revised the construction demand forecast for 2009, from between $22 billion and $28 billion (announced in January 2009), to between $18 billion and $24 billion (see table 3.1.2a). The downward revision was due to the softening of tender prices amidst lower costs of construction resources, re-scheduling of some public sector projects and the prevailing economic recession.

Due to the current global financial crisis, private sector construction demand is likely to soften significantly in 2009. Hence, the public sector will be the key construction demand driver and is anticipated to award between $14.4 billion and $15.6 billion worth of projects in 2009. Strong expansion in institutional and civil engineering construction is anticipated to lead public sector construction demand to a new high in 2009.

Given the slowdown of growth momentum in the economy, the negative sentiments and continued uncertainties in world economic outlook, BCA projects private sector construction demand to soften to between $3.6 billion and $8.4 billion in 2009, which is significantly lower than the annual demand recorded since 2006. Construction demand for all types of building developments is expected to fall in 2009.

Residential Construction Demand

Public Housing

Public residential construction demand is projected to be between $2.8 billion and $3 billion in 2009, with bulk of the demand coming from the construction of new HDB flats to meet the ongoing public housing demand. In additional to new flats to be constructed under the BTO (Build-To-Order) and redevelopment schemes, HDB is also planning to build more rental flats in 2009 in response to their increasing demand. The on-going lift-upgrading programme is also expected to support the construction demand.

Private Housing

Private residential construction demand is projected to drop to between $1.5 billion and $2.5 billion, similar to the level recorded after the Asia Financial Crisis in 1997/98. Nevertheless, on the back of the nascent sign of market recovery, the second quarter saw a strong improvement in private residential construction demand compared to previous two quarters, with about $500 million worth of contracts awarded.

Commercial Construction Demand

In view of the current economic slowdown, falling rental and rising vacancy rate, commercial demand is forecast to fall back nearer to the underlying demand level, at between $1 billion and $1.9 billion, following two years of record high demand at $5-8 billion per annum.

Industrial Construction Demand

Business sentiments in the manufacturing sector remain weak. On the back of weakening outlook, total industrial construction demand is projected to amount to between $0.9 billion and $3.1 billion in 2009. Despite the anticipated reduction in foreign investments, the construction of the first liquefied natural gas (LNG) receiving terminal in Singapore and the various plans to upgrade the facilities of domestic energy sector will provide some support to industrial construction demand in the year ahead. For the public sector, the demand is expected to stay low since most of the industrial buildings are built by the private sector nowadays.

Institutional & Other Building Construction Demand

Total institutional & other building construction demand is forecast to remain strong in 2009, with about $3 billion to $4.1 billion worth of projects to be awarded. This category will continue to be led by the public sector, underpinned by projects to upgrade various educational and healthcare facilities.

Civil Engineering Construction Demand

Civil engineering construction demand is expected to be the bright spot in 2009 and will likely reach an all-time high of between $8.9 billion and $9.4 billion. Several strategic projects have been slated to proceed this year to expand Singapore's road and rail networks. These include MRT contracts for Downtown Line Stage 2, North-South Line Extension and Jurong East Connection, as well as various road contracts.

Table 3.1.2a: Breakdown of Construction Demand

Contracts Awarded by Sector and Type of Work (2002 to 2009*)
(Excluding Reclamation Works)

Billion Singapore Dollars

	2002	2003	2004	2005	2006	2007	2008	2009 Forecast (mid-Year Review) (in $b)	
Both Sectors	**14.5**	**10.0**	**10.3**	**11.5**	**16.8**	**24.5**	**34.6**	**18**	**- 24**
Building Work	11.1	8.7	7.5	9.8	14.9	21.5	26.7	9.1	- 14.6
Residential	3.6	3.0	3.9	3.7	5.3	7.4	10.6	4.3	- 5.5
Commercial	1.2	0.5	1.1	1.0	2.4	5.2	8.5	1	- 1.9
Industrial	2.4	2.0	1.0	3.1	5.5	7.0	3.7	0.9	- 3.1
Institutional & Others	3.8	3.1	1.5	1.9	1.7	1.9	3.9	3	- 4.1
Civil Engineering Work	3.4	1.3	2.8	1.7	1.9	3.0	7.9	8.9	- 9.4
Private	**4.8**	**4.6**	**5.7**	**7.5**	**13.1**	**18.8**	**20.1**	**3.6**	**- 8.4**
Building Work	4.7	4.5	4.9	6.8	12.3	17.9	19.3	3.4	- 7.9
Residential	2.5	1.9	2.6	2.6	4.1	5.6	6.4	1.5	- 2.5
Commercial	1.0	0.4	1.0	0.9	2.3	5.1	8.4	0.9	- 1.7
Industrial	0.7	1.4	1.0	2.7	5.4	6.8	3.7	0.8	- 3
Institutional & Others	0.4	0.7	0.3	0.5	0.5	0.4	0.9	0.2	- 0.6
Civil Engineering Work	0.2	0.2	0.8	0.7	0.8	0.9	0.7	0.2	- 0.5
Public	**9.6**	**5.4**	**4.6**	**4.0**	**3.7**	**5.7**	**14.5**	**14.4**	**- 15.6**
Building Work	6.4	4.2	2.6	3.0	2.6	3.6	7.3	5.7	- 6.7
Residential	1.1	1.1	1.3	1.1	1.2	1.8	4.2	2.8	- 3
Commercial	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	- 0.2
Industrial	1.7	0.6	0.1	0.4	0.1	0.2	0.0	0.1	- 0.1
Institutional & Others	3.4	2.4	1.1	1.4	1.2	1.5	3.0	2.8	- 3.4
Civil Engineering Work	3.2	1.2	2.0	1.0	1.1	2.1	7.2	8.7	- 8.9

Source: BCA as at 1 July 2009
**Forecast*

Table 3.1.2b: Number of Major Projects in the Pipeline

Number of Construction Tenders To Be Called By Public Sector Agencies
(Tentative schedules subject to changes)

Construction Cost Category	Development Type	3Q09	4Q09	1Q10	2Q10
Up to $15m (3Q09 - 4Q09)	**Residential Upgrading** (e.g Neighbourhood Renewal Programme)	4	2	1	3
	Education (e.g Retrofitting of teaching facilities including Institutes of Higher Learning (IHL))	16	3	0	0
	Other Buildings (e.g. Retrofitting of government amenities)	42	26	13	12
Up to $13m (1Q10 - 2Q10)	**Sub-Total (Building)**	**62**	**31**	**14**	**15**
	Road & Bridge (e.g. Pedestrian walkways, road widening)	18	10	4	4
	Sewerage & Drainage (e.g. Drainage improvement)	6	6	1	1
	Other Civil Engineering (e.g Parks, waterway and utilities projects)	8	11	10	5
	Sub-Total (Civil Engineering)	**32**	**27**	**15**	**10**
	Total	**94**	**58**	**29**	**25**
$15m to $50m (3Q09 - 4Q09)	**Residential & Upgrading** (Lift Upgrading Programme, Home Improvement Programme, student/staff hostels)	3	6	8	6
	Education (e.g Retrofitting of teaching facilities including IHL)	5	6	3	0
	Other Buildings (e.g. Retrofitting or building of government amenities)	3	4	2	1
$13m - $40m (1Q10 - 2Q10)	**Sub-Total (Building)**	**11**	**16**	**13**	**7**
	Road & Bridge (e.g. Widening of expressways or roads)	4	5	2	2
	Sewerage & Drainage (e.g. Canal and drainage improvement)	4	4	1	0
	Other Civil Engineering (e.g. Waterworks and utilities projects)	4	1	5	1
	Sub-Total (Civil Engineering)	**12**	**10**	**8**	**3**
	Total	**23**	**26**	**21**	**10**
Above $50m (3Q09 - 4Q09)	**Residential** (e.g Public housing, student hostels for IHL)	2	2	3	9
	Education (Campus expansion for IHL)	3	1	2	0
	Other Buildings (e.g. Building of business park, new hospital facilities, recreational facilities)	3	5	4	3
Above $40m (1Q10 - 2Q10)	**Sub-Total (Building)**	**8**	**8**	**9**	**12**
	Road & Bridge (e.g. Widening of expressways, construction of flyover)	2	2	0	3
	Sewerage & Drainage (e.g. Drainage improvement)	0	0	0	1
	Rail & Related (e.g. New MRT lines, trackworks)	0	2	11	7
	M&E - Rails and Roads (e.g. M&E for MRT or expressways)	9	0	0	0
	Other Civil Engineering (e.g. Water pipeline works, infrastructure upgrading)	0	1	1	3
	Sub-Total (Civil Engineering)	**11**	**5**	**12**	**14**
	Total	**19**	**13**	**21**	**26**

Source : BCA as at 14 August 2009

3.2 Construction Companies

The total number of companies registered under BCA Contractors Registry has been on an uptrend and reached 7,396 firms by end June 2009. Of these, 60 firms are A1 contractors with unlimited tendering limit for public sector projects.

Table 3.2: Trend of Registered Contractor

Year (calendar)	2003	2004	2005	2006	2007	2008	2009*
No. of registered contractors	4739	5167	5621	5942	6346	7021	7396

Note: Firm with multiple workheads registered is considered as a single registered entity.
*No. of registered contractors as at 30 June 2009

3.3 Construction Manpower

Underpinned by the high level of construction activities, construction employment has continued to grow though at slower rate compared to previous quarter. According to the latest employment statistics released by MOM, construction employment grew by 8,300 in the first quarter of 2009 to 368,300 as at March 2009. This brings total employment gains in the construction sector since January 2006 to a significant 133,200 jobs.

3.4 Productivity

Due to surge of construction demand in 2008 and influx of less experienced foreign workers, the labour productivity of the construction sector (in terms of value-added per employee) dropped by 0.6% in 2008.

Table 3.4.1: % Change in Value-Added Per Employee

	2004	2005	2006	2007	2008
Construction Sector	-0.6	-0.1	-2.6	7.6	-0.6

Source: Singapore Department of Statistics

3.5 Construction Cost

3.5.1 Tender Price Index

BCA Building Works Tender Price Index (TPI)[3] increased by about 12% year-on-year in 2008, lower than the 19% increase in 2007. The increase was largely contributed by the steep surge in construction costs in the first half of 2008 due to strong global demand and inflation. With the softening of global construction materials and oil prices, BCA Building Works TPI has, since 4th quarter of 2008, dropped by a cumulative 14% by mid-2009.

3.5.2 Average Construction Material Prices

Concrete

In tandem with the rising volume of construction activities, the demand for ready-mixed concrete increased by a significant 32.3% in 2008 compared to 2007 (Table 3.5.2a). On the other hand, the demand for cement in 2008 rose by a lower 18.2%, which could be due to the higher stock level carried over from 2007. The key import sources for cement in 2008 were Japan (44%), Taiwan (26%), Malaysia (19%) and Thailand (11%).

The market price for ready-mixed concrete[4] reduced by about 4% year-on-year to $122 per cubic metre by end Dec 2008, and dropped by a further 16% by Jul 2009. In contrast, cement[5] (bulk) price was at $120 per tonne as at end Dec 2008, up by 4.3% compared to Dec 2007, but it has since softened by 16% by Jul 2009.

[3] BCA TPI excludes piling works, sub-structure works and mechanical & electrical works as these cost items are either project specific or not feasible to compile due to lack of data.
[4] The price (inclusive of both delivery & GST) refers to Grade 35 pump ready-mixed concrete.
[5] The price (inclusive of both delivery & GST) refers to Ordinary Portland cement.

Riding on the projected heightened construction activities in 2009, the estimated demands for cement and ready-mixed concrete are expected to increase by 16% and 15% respectively this year. With anticipated lower construction raw materials costs arising from the easing of global freight and fuel costs, ready-mixed concrete prices are likely to remain competitive in the second half of the year.

Reinforcement Bars (Rebars)

On the back of rising local construction activities, demand for rebars in 2008 rose by 62.2% to 1.3 million tones (Table 3.5.2a). The key import sources of rebars were China (about 52%), Turkey (about 23%), Malaysia (about 11%) and other countries like Taiwan, Vietnam, Japan and Korea etc. For 2009, the demand for rebars is expected to increase by about 15% in anticipation of higher volume of construction activities.

Influenced by strong global demand in China, India and the Middle East, coupled with high raw material costs up till July 2008, the average market price for rebar[6] had surged by close to 60% since beginning of 2008 to reach about $1,700 per tonne in Jul 2008. A slackened market demand impacted by the credit crunch since September 2008 had seen the average market price for rebar dropped to about $1,000 per tonne in Dec 2008, and subsequently to $742 per tonne in Jul 2009. .

3.5.3 Construction Industry Salaries and Wages

With the higher demand for construction manpower, construction professionals such as engineers and associate professionals and technicians enjoyed higher wage increases in 2008 (Table 3.5.3b). Compared to most other economic sectors, the average monthly earnings per employee in the construction industry was still relatively lower (Table 3.5.3c).

[6] The price (inclusive of both delivery & GST) refers to 20mm High Tensile rebar.

Table 3.5.2a: Basic Construction Materials

Demand						
Year	**Cement (Mil tonnes)**	**% Change**	**Ready-Mixed Concrete (Mil m³)**	**% Change**	**Steel Bars (Mil tonnes)**	**% Change**
2007	3.85	-	7.53	-	0.82	-
2008	4.55	18.2%	9.96	32.3%	1.33	62.2%
Current Market Prices						
Year	**Cement ($ per tonne)**	**% Change**	**Ready-Mixed Concrete (Grade 35 Pump) ($ per m³)**	**% Change**	**Steel Bars ($ per tonne)**	**% Change**
Dec 2007	$115	-	$127	-	$1,055	-
Dec 2008	$120	4.3%	$122	-3.9%	$913	-13.5%
Jul 2009	$101	-15.9%	$103	-15.6%	$742	-18.8%

Table 3.5.3b: Mean Monthly Gross Wages in Construction

Category	2005	2006	2007	2008
Professionals ($/month)	3,155	3,237	3,400	3,737
Associate Professionals and Technicians ($/month)	2,565	2,646	2,736	2,808

Source: Report on Wages in Singapore, various years, Ministry of Manpower

Table 3.5.3c: Average Monthly Earnings Per Employee ($ per month)

Industry	2005	2006	2007	2008
Average	3,444	3,554	3,773	3,977
Manufacturing	3,495	3,618	3,764	3,955
Construction	**2,513**	**2,517**	**2,646**	**2,861**
Wholesale and Retail Trade	3,017	3,101	3,262	3,441
Transport and Storage	3,507	3,525	3,797	3,989
Hotels & Restaurants	1,360	1,381	1,442	1,504
Information & Communications	4,553	4,745	5,018	5,304
Financial Services	5,949	6,291	6,768	7,153
Retail Estate and Leasing Services	2,732	3,053	3,355	3,513
Community, Social & Personal Services	3,704	3,831	4,074	4,168

Source: Yearbook of Statistics Singapore, 2009.

3.6 Import and Export of Construction Services

3.6.1 Import of Construction Services

Singapore has one of the most open construction markets in the world, with no special restrictions applied to foreign construction firms, for instance, the BCA's Contractors' Registry applies to all contractors, regardless of local or foreign firms. Foreign construction firms from countries such as Japan, South Korea and China have been undertaking many significant projects in Singapore.

3.6.2 Export of Construction Services

Construction Consultancy Services

Following a 13% year-on-year increase in the number of consultancy projects clinched in 2007, Singapore consultants remained active overseas by securing a total of 423 projects in 39 countries in 2008 (Chart 3.6.2a). The moderated 4% year-on-year increase in the number of overseas projects secured in 2008 could be due to the exceptionally high domestic construction volume and also, to a certain extent, affected by the start of global financial crisis in the later part of 2008 which caused a slowdown of growth momentum in the global economy.

Chart 3.6.2a: Number of Consultancy Firms and Projects, 2004 - 2008

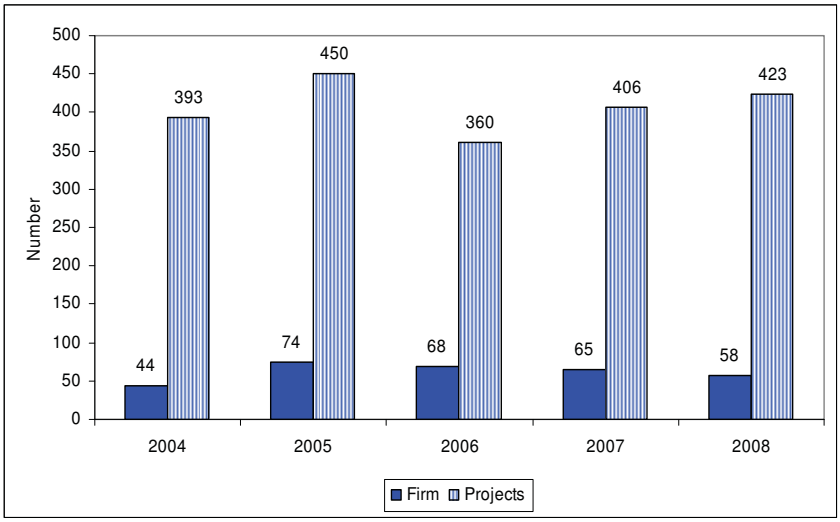
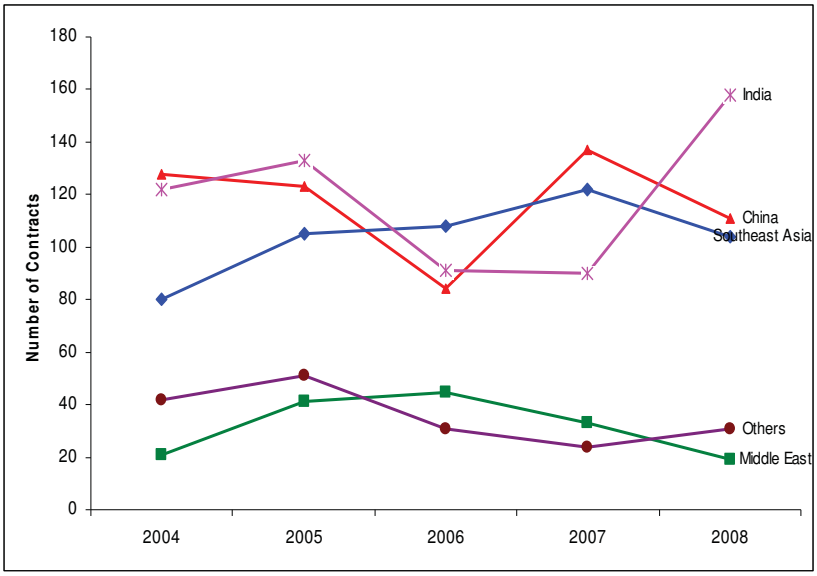


Chart 3.6.2b: Trend of Overseas Consultancy Projects, 2004 - 2008



Construction Services

Singapore construction and engineering firms clinched $1.6 billion worth of overseas contracts in 2008 (Chart 3.6.2c). Except for petrochemical and power plant projects, the volume of all types of overseas contract had dropped significantly. The exceptionally high volume of construction activities in the domestic market coupled with the onset of global financial crisis were the likely causes to lower construction export level in 2008 as Singapore firms were constrained by the available contracting resources as well as higher risks in undertaking overseas projects.

In tandem with the drop in export volume, the number of firms that had clinched projects overseas recorded a sharp fall by about 17% in 2008 after staying relatively stable over the years (Chart 3.6.2d).

Chart 3.6.2c: Value of Construction Exports by Singapore Firms, 2008

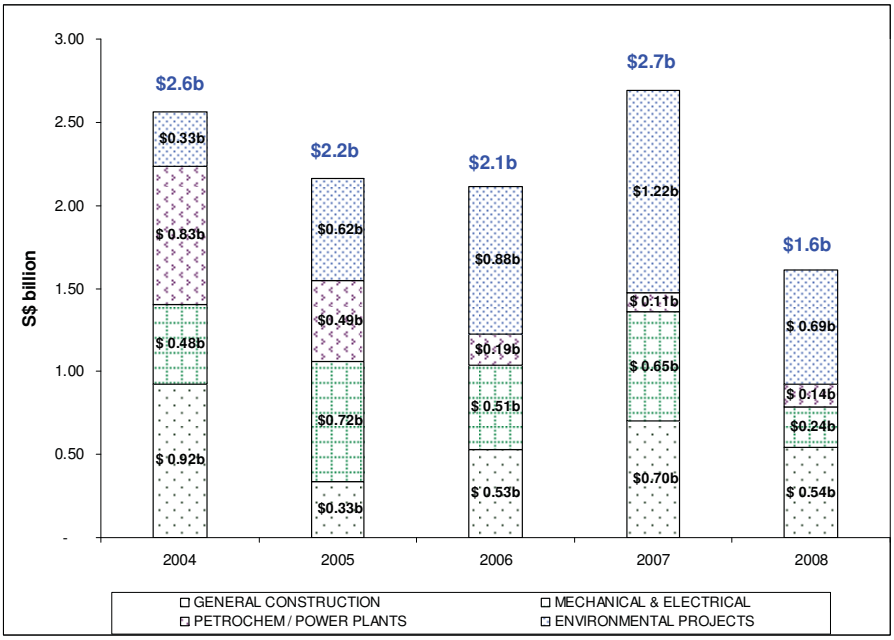
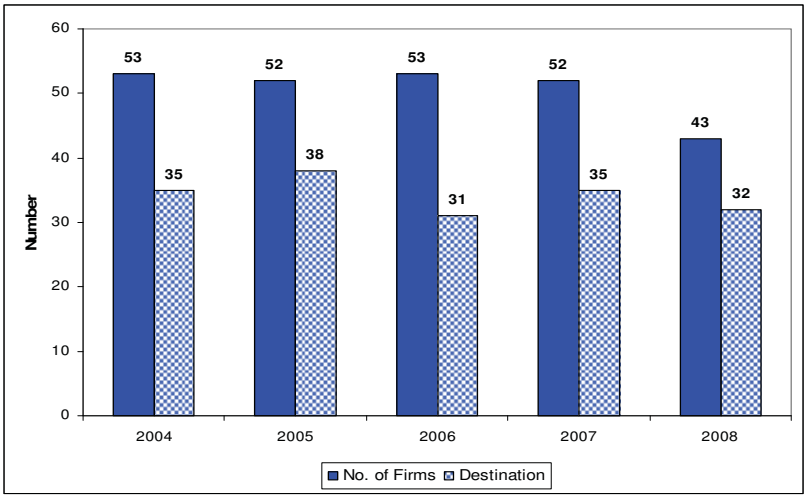


Chart 3.6.2d: Number of Construction Exporting Firms and Markets Assessed, 2004 - 2008



AN INTEGRATED APPROACH TO SUSTAINABILITY FOR THE CONSTRUCTION SUPPLY CHAIN- A WASTE-TO-RESOURCE STRATEGY

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EXECUTIVE SUMMARY

For the construction industry, an industry which is often perceived as fragmented, a coordinated and integrated approach similar to the supply chain management concept could bring about synergy among key industry players; develop their capabilities and potential, thus making it possible to implement initiatives for the benefit and development of the whole industry.

The Building and Construction Authority of Singapore (BCA) developed a strategy on recycling and reuse of concrete aggregates and adopted integration among key players in the construction supply chain- namely the demolition contractors, construction and demolition (C&D) waste recyclers, ready mixed concrete (RMC) suppliers, building contractors and developers, for the benefit of the whole construction industry.

This paper shows that an integrated waste-to-resource approach to recycle potential building materials for the industry could result in a sustained supply and demand of sustainable construction materials, thus contributing to Singapore's goal of achieving environmental sustainability.

Key words: integration, waste-to-resource *approach, recycled concrete aggregates, sustainable, construction/ materials supply chain, systems approach*

CURRENT SITUATION

The construction industry in Singapore is characterised and composed of numerous small to medium sized enterprises. It is fragmented by nature of its operation and the mechanism of the market forces- each enterprise is often 'disconnected' from one another, operates independently with little or no synergy among them; and because competition is intense, the players are skeptical of sharing information or resources and therefore supply chain integration or management practices are difficult to be realised in this industry.

For Singapore the construction materials supply chain is heavily reliant on imported raw materials. As such it is subjected to influence from global market forces. Uncertainty in the supply of materials is a reality and material prices fluctuate according to global demand and supply, which in turn affects project costs. Therefore to enhance the resilience in the supply of essential construction materials, which is of strategic importance to Singapore's economic development, the adoption of sustainable construction becomes crucial as it looks at the efficient usage of raw materials in construction, reduction of waste, and waste recycling.

As natural resources deplete and more technological means are available to convert waste into useful materials for various construction applications, it is timely and worthwhile to explore the use of sustainable materials in construction works. These include novel building and construction materials reclaimed from waste generated from building and construction related activities and other 'fit for purpose' materials. However for such materials, the challenges are daunting. There are no building or design codes governing their usage nor are there schemes or quality standards to ensure consistency in the quality of products produced from the upstream waste generators all the way to the downstream end users in the construction supply chain. Furthermore there are limited research studies on the use of alternative materials for building projects, or project references as a basis for engineers to specify these materials for use in projects. In the area of research and development not only are the players in the supply chain limited in resources, they have neither the incentive to

fund research and explore other sources of materials nor the impetus for using alternative materials or trying out new technologies [1].

The other challenge for these 'specialised' materials supply chains is the lack of collaboration among these players. Due to broken links within the supply chain, industry players have little or no knowledge of the suppliers of these materials, the potential demand for them and how such materials could be applied. There is also no proper system or channel where materials usage could be optimised. This results in low efficiency in the use of resources, low recycling rates and lots of wastage. Waste generated upstream, which could be potential raw materials for the players downstream, are regrettably disposed off. This lack of integration or coordination between players often resulted in insufficient raw materials for recycling, uncertainty in supply and production, thereby causing delays to projects. These factors ultimately drive up material and project costs, making sustainable construction materials even less attractive to potential customers.

One such material in particular is concrete waste, which is generated from the demolition of concrete structures. Concrete recycling is gaining recognition as a green practice worldwide. It protects the environment by eliminating the need for disposal and the readily available concrete waste could be broken down relatively easily and processed into recycled concrete aggregates (RCA). Nevertheless within the supply chain, they are not directly passed down to the construction and demolition (C&D) waste recyclers or utilised in the most efficient way.

It was observed that although the C&D waste recycling in Singapore had been established for the last few years, few members of the industry were aware of it. In addition, RCA were viewed as inferior to natural aggregates and were only used for non-structural and low value applications- as backfill or hardcore material or as sub-base material for roadworks and construction of drains and road kerbs. The rest of the concrete waste that is not utilised will be disposed off at the landfill.

The reasons for the above are due to the following:

- Waste recycling is a very small segment in the construction industry; it is often neglected and disconnected from the rest of the mainstream industry players

- Lack of awareness in the industry
- Absence of proper quality control system in the production of RCA
- Absence of relevant design codes or user specifications with respect to RCA
- Absence of established and verifiable procedures
- Uncertainty in the supply of RCA

To address these issues and for the well-being of the built environment and the development of the sustainable construction materials supply chain, BCA adopted an integrated waste-to-resource approach to recycle concrete aggregates for use in new building developments.

INITIATIVES & MEASURES

The concept of the supply chain management is "integration" for the mutual benefit of enterprises, from the industry players extracting the basic raw materials to the final customers using the materials in the supply chain [2]. This systems approach to construction management involves upstream and downstream linkages in the various processes and activities that generate value in the form of products and services [3].

With this in mind, BCA coordinated with the various key industry players in the construction supply chain (shown in Figure 1) - namely the demolition contractors, C&D waste recyclers (RCA suppliers), ready mixed concrete (RMC) suppliers, building contractors and developers- to increase the supply of building materials by maximising resource recovery of concrete waste and to drive demand by increasing the usage of RCA.

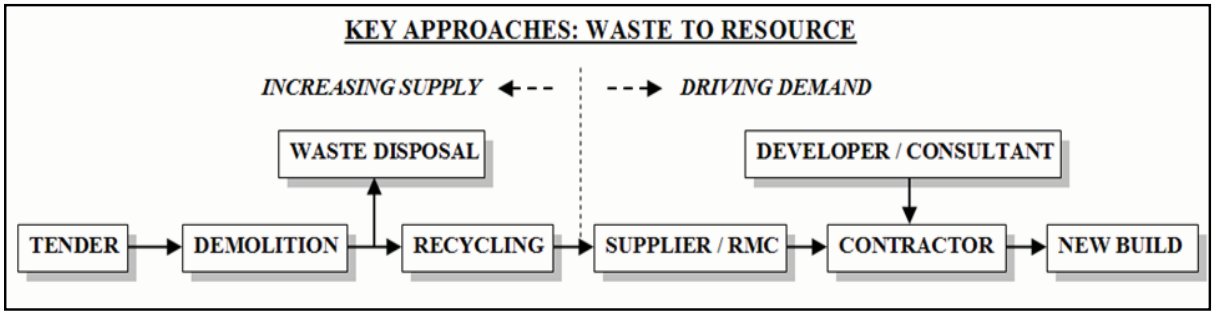

Figure 1. Waste-to-Resource Approach to maximise recycling and use of RCA

Increasing Supply and Addressing Quality Issues

The key to increasing the supply of recycled concrete aggregates (RCA) is to maximise recovery rates of concrete waste. Therefore the strategy is to formulate controls upstream so that the amount and quality of material passed downstream would improve. For this reason, BCA partnered with the relevant industry players in the supply chain to develop the demolition protocol and quality protocol.

The demolition protocol was targeted at the demolition contractors and it comprises three components- pre-demolition audit, sequential demolition and site waste management. The protocol helps demolition contractors to better plan their demolition procedures so as to maximise recovery of concrete waste for beneficial reuse/recycling. Whereas in most cases a building structure is taken down in the fastest, most economical and convenient way, resulting in difficulty of sorting out the various demolition wastes later on, this protocol facilitates the recovery and segregation of concrete from the rest of the building materials by identifying the concrete elements to be taken down very early during the demolition process. This minimises the level of 'contamination' of the concrete debris during sorting and significantly improves the quality of recovered concrete waste when they are delivered off-site to the C&D waste recyclers for RCA processing.

The quality protocol was targeted at the receivers' end- the RCA suppliers and the RMC suppliers that produce concrete incorporating RCA. BCA worked with the Waste Management and Recycling Association of Singapore (WMRAS) to develop the Accreditation Scheme for Recycled Aggregates Suppliers [4], and the Singapore Accreditation Council (SAC) to accredit RMC plants meeting certain performance criteria. Both schemes are part of BCA's efforts to promote greater self-regulation by the industry. The schemes aim to improve the quality and consistency of RCA and concrete produced, by establishing an assessment framework for the materials supply chain and by adopting relevant testing standards. The newly developed European Standards (EN), which are performance-based codes, were thus adopted for the schemes. They paved the way for the use of RCA and concrete incorporating RCA or other industrial by-products (such concrete is also termed 'green concrete').

The other benefit of these schemes is that they provide recognition to the plants committed to quality, consistency and safety of the production plant and products, thereby enhancing their image and marketability.

Driving Demand and Championing Usage

To drive the adoption and increase the demand of RCA and green concrete, BCA adopted a multi-pronged approach targeted at the major building contractors, consultants and developers.

These initiatives include a reward scheme to recognise the efforts of developers who specify the use of these materials in their building projects for environmental reasons. Points are awarded for the use of such materials in BCA's green-building rating system, the Green Mark scheme. At the same time to further drive sustainable construction initiatives and increase the take-up rates of these materials, BCA is working on a capability development fund to expand, strengthen and develop the capabilities of these players in the supply chain. The funding can be used to support technology and plant upgrading, education and training to build up knowledge and competencies, development of quality management systems and pilot trials etc.

In addition BCA collaborates with various government agencies, tertiary institutes and players in the construction supply chain to champion the use of RCA and green concrete in buildings to demonstrate the feasibility and performance of using sustainable construction materials. An excellent example is a recently completed 3-storey commercial building (Tampines Concourse), which innovatively made use of various mixes of industrial by-products in concrete such as washed copper slag, ground granulated blastfurnace slag and RCA for structural and non-structural applications. Another commercial building (Samwoh Building), slated as a showcase at the upcoming International Green Building Conference to be held in October 2009 Singapore, uses percentages of RCA beyond code limits for structural concrete. This building will be instrumented and monitored for its performance compared to regular concrete. These pilot projects testify that as long as appropriate measures and

technical considerations are in place, RCA and green concrete are just as sound as conventional building materials. To further build up the industry, knowledge gained in the process will be shared with the industry players through platforms such as conferences and seminars organised by BCA.

Due to the coordinated and integrated efforts of all the stakeholders in the construction supply chain, it was observed that more and more building contractors, consultants and developers are beginning to specify and adopt the use of such sustainable construction materials for their building projects. With the increased demand and supply of these materials, the reduction of material and production costs would ultimately translate into lower and competitive project costs.

From the systems approach perspective, what was noteworthy was that an integrated effort to recycle potential building materials resulted in a higher quantity of concrete waste being contained and used back for building works within the supply chain (refer to Figure 2). Material wastage due to poor resource allocation and low efficient usage of resources also decreased significantly.

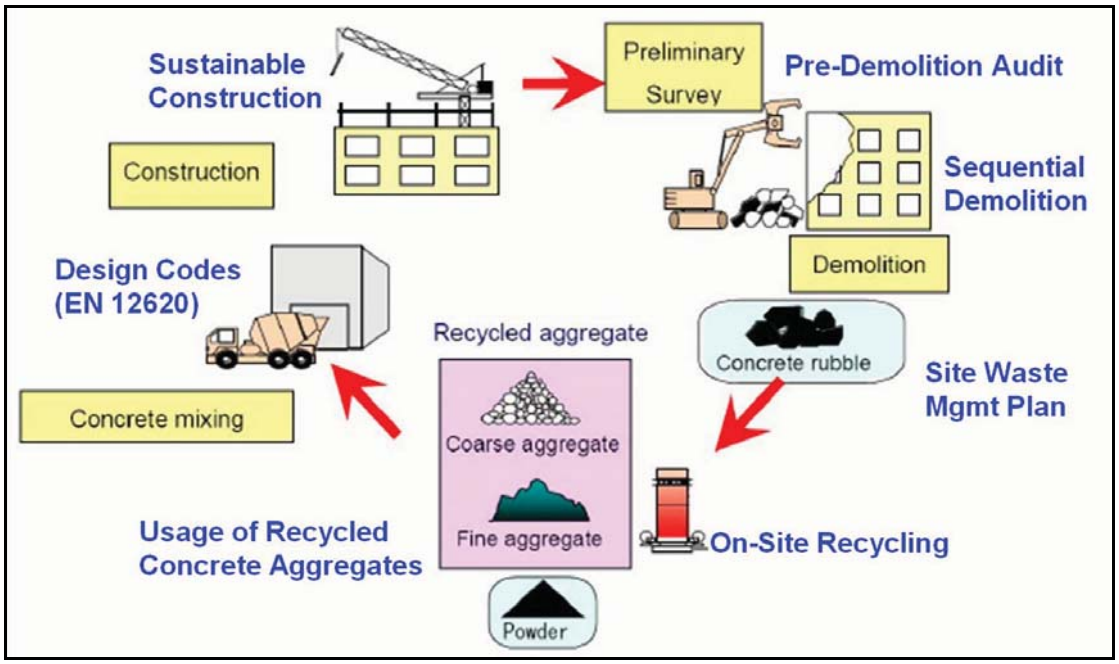

Figure 2. Closed Loop Concrete Recycling System

FUTURE DEVELOPMENTS

In literature, many supply chain methods have been proposed but successful cases are few and far between for the construction industry. While a systems approach to sustainable construction resolves fragmentation and brings the best out of the players within the construction supply chain, more studies are still needed before Singapore can successfully develop a feasible supply chain management system for the local industry. This is due to the complex nature of the construction industry, which makes a truly integrated supply chain system problematic and difficult to achieve. Many factors such as the number of supply chain partners to be involved, environmental and procurement related factors, logistics, use of sustainable materials etc, have to be carefully studied before BCA recommends for industry-wide implementation.

BCA will also continue to research into other novel waste materials generated from industrial activities and find applications for their usage by adopting a similar integrated waste-to-resource approach. Other construction technologies in the process of R&D include the "design for deconstruction" approach to building construction. Accordingly, such systems could maximise materials conservation by adopting a lifecycle management approach and by creating adaptable buildings to optimise the use of building materials.

CONCLUSION

It can be shown that the supply chain management system, when applied appropriately to sustainable construction materials, benefits the whole construction industry. With continuous improvements made within the construction supply chain and more collaboration between the industry players, resource allocation and efficiency can improve significantly, thereby optimising the use of natural materials and minimising waste through the use of recycled materials. This is indeed something worth exploring especially for a small country like Singapore with no natural resources.

In the case of novel materials recycled from waste streams that still require much research and pilot trials, an integrated systems approach to convert waste to resource is useful to address issues like quality, material applications, user confidence, costs, demand and supply, and capability development of the whole supply chain. Once such issues are resolved, these materials would gradually find their niche in the mainstream construction materials supply chain and become acceptable substitutes to natural resources.

Lastly, with sustained and increased supply and demand of usable recycled materials for building and construction applications, material costs and consequently project costs would also lower. The use of alternative materials as substitutes to natural resources then becomes a viable and environmental-friendly option for the construction industry.

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