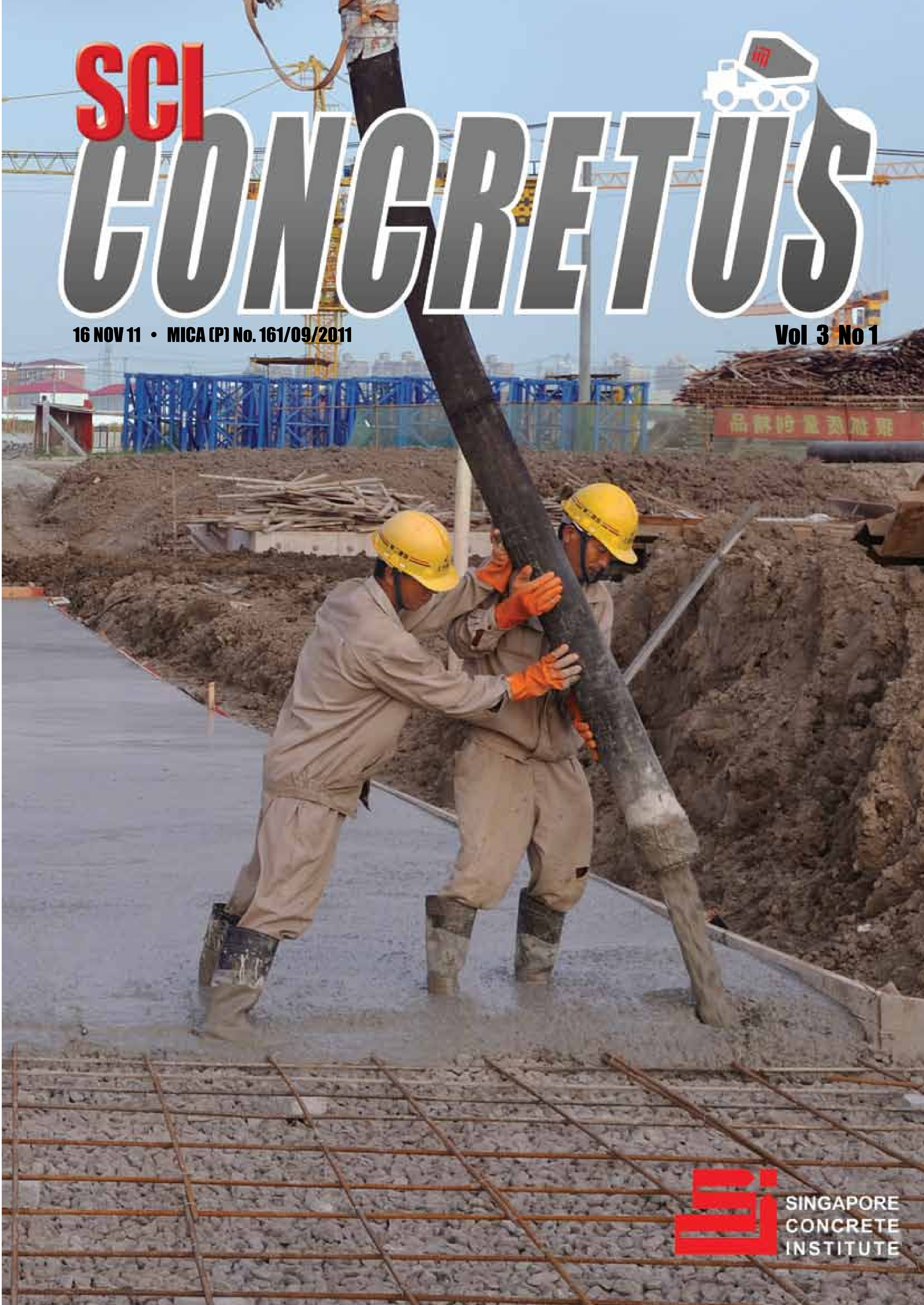
SCI CONCRETUS

16 NOV 11 • MICA (P) No. 161/09/2011

Vol 3 No 1



SINGAPORE CONCRETE INSTITUTE

AN ECO-FRIENDLY APPROACH FOR AIRCRAFT PAVEMENT CONSTRUCTION AT SINGAPORE CHANGI AIRPORT

By
Dr Ho Nyok Yong, Dr Kelvin Lee Yang Pin, Dr Tan Jun Yew, Mr Hon Lip Yung & Mr Lim Wee Fong
Samwoh Corporation Pte Ltd (Contact: wflim@samwoh.com.sg)

Professor Fwa Tien Fang
National University of Singapore (Department of Civil Engineering)

Mr How Choon Onn, Ms Koh Sim Yi & Ms Meryl Lan
Changi Airport Group Pte Ltd (Engineering & Development Group)

Demolition of aircraft stand rigid pavement

Introduction

In recent years, the Singapore government has been actively promoting the use of recycled waste materials in construction applications to alleviate waste disposal problems in land-scarce Singapore, as well as to reduce our strong reliance on the import of natural aggregates from overseas. To support the government's directive towards sustainable development, Samwoh Corporation Pte Ltd, a leading infrastructure construction and material supply conglomerate, has undertaken an ambitious and forward-thinking pilot project by Changi Airport Group Pte Ltd (CAG) to reconstruct the existing aircraft stand rigid pavement at Singapore Changi Airport using concrete made of recycled concrete aggregate (RCA). The existing aircraft stand rigid pavement has been used for over 20 years and is due for rehabilitation. The aim of the project is to recycle the concrete waste derived from the demolition of the existing rigid pavement for the construction of new aircraft stand rigid pavement. The project also involved a pavement consultant from the National University of Singapore (NUS). It is the first of its kind in the region and has opened a new frontier in civil engineering construction and sustainable development in Singapore.

Property	Test Method	Requirements					
Gradation	ASTM C136	Sieve Size (mm)	2.36	5	10	20	25
		% by Weight Passing	0-5	0-10	20-55	90-100	100
Flakiness/Elongation	ASTM D4791	Max 8%					
Los Angeles abrasion	ASTM C131	Max 40%					
Acid-soluble sulfate (SO_3) content	BS EN 1744-1	Max 1.0%					
Chloride content	BS 1881-124	Max 0.01%					

1.Production of Recycled Concrete Aggregate

The existing aircraft stand rigid pavement was broken up using hydraulic breakers and the concrete waste was transported to a nearby recycling facility for processing. The waste contains mainly crushed concrete, ferrous metals and very small amount of other foreign materials. The waste was processed via a few key processes which include crushing, sorting and sieving of the end product (RCA) into the required sizes to meet the CAG requirements as shown in the above table.

2. Mix Design for RCA Concrete

The mix design for the concrete with RCA (hereinafter known as RCA concrete) was determined with respect to CAG specification requirements which specified a minimum flexural strength of 4.2N/mm^2 at 28-day. The workability was designed based on a slump value of 38-65mm in accordance with the requirements for side-form paving method of construction.

The RCA concrete was designed using 20% of RCA (by mass of coarse aggregate). Laboratory tests results have shown that RCA exhibited much higher water absorption (about 5%) as compared to granite aggregate (typically less than 1%) which is normally used for concreting in Singapore. This would drastically reduce the workability of the concrete mix. Many researchers attempt to address this issue by increasing water and cement contents in order to achieve the required workability at a constant water to cement ratio. However, the increase in cement content can affect the properties of the hardened concrete such as shrinkage. To overcome this problem, a rational mix design approach developed by Ho et al. was used without the need to increase the cement and water contents. The method involves adjustments in the coarse aggregate to fine aggregate ratio and addition of some admixtures to achieve the required workability. The findings of the study have been shown that RCA concrete provides comparable strength as compared to normal concrete without RCA using this method of mix design.

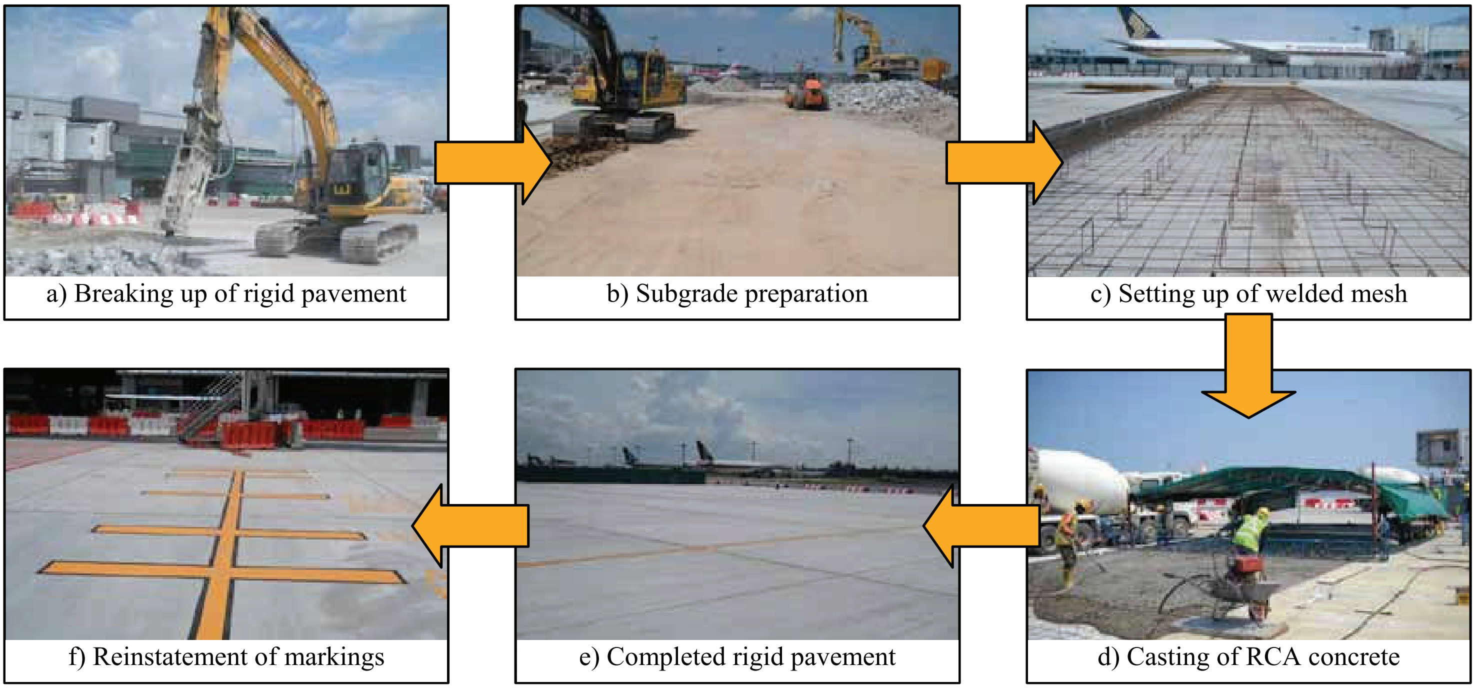
3. Construction

The aircraft stand rigid pavement comprises 435mm thick of the RCA concrete and 75mm thick of lean concrete. A key challenge in the construction of the rigid pavement is that RCA concrete tends to exhibit higher shrinkage than normal concrete which may lead to shrinkage cracks. Special curing measures were undertaken during the casting of RCA concrete. Immediately after casting, the concrete surface was applied with a concrete curing compound and then covered with a curing shelter and polyethylene sheets. Based on site observations, the method was found to be effective even when the construction was conducted in the afternoon. With this curing method, it allows casting in the day which eases casting work, improves visibility and increases productivity.

Stringent quality control was carried out to monitor the workability of the fresh concrete and the flexural strength. The workability of fresh concrete was monitored for every batch of concrete delivered to the site to ensure it meets the slump requirement of 38-65mm. Samples of the RCA concrete were also obtained and tested for 7- and 28-day flexural strength for every concrete mix produced per day or per pavement construction operation. The following observations can be drawn from the test results.

a) 7-day flexural strength – All the test results meet the required strength of 4.2N/mm^2. This implied that the completed aircraft stand can be opened to traffic earlier

Samples of RCA



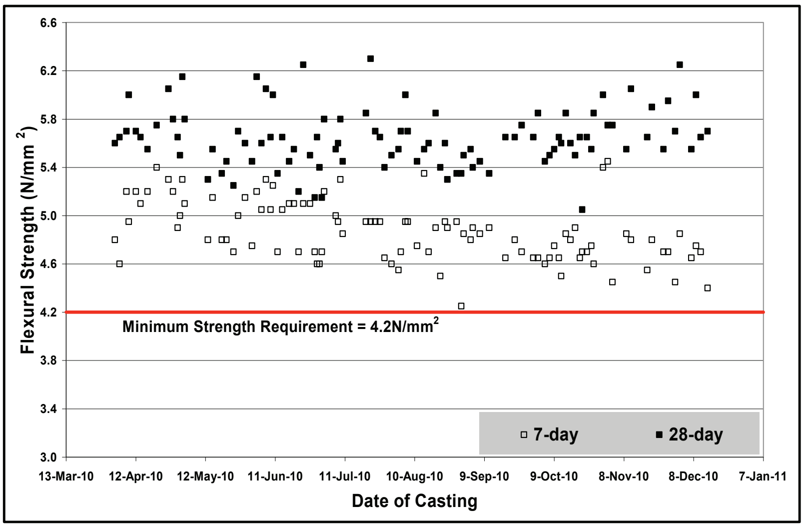
Construction process of aircraft stand rigid pavement using RCA concrete

than the stipulated period of 14 days after placement of concrete as specified according to CAG specification.

b) 28-day flexural strength – The average flexural strength is in the range of 5.1-6.3N/mm². This implied that that RCA concrete can be designed to achieve or perform even better than the required flexural strength.

4. Conclusions and Further Study

This project has demonstrated the feasibility of using RCA derived from the demolition of the existing aircraft stand rigid pavement for the reconstruction of the aircraft stand rigid pavement at Singapore Changi Airport. To date, the project has been carried out successfully since March 2010 and the first phase, comprising 8 aircraft stands, will be completed in December 2011. The remaining aircraft stands will be progressively rehabilitated using the RCA concrete over the next few years. To further optimize the use of RCA, Samwoh has carried out extensive research to evaluate the feasibility of using higher dosage of RCA. The laboratory tests have shown that it is possible to use up to 40% of RCA in concrete for the aircraft stand rigid pavement and field trials are being carried out to validate the performance. In addition, carbon footprint analysis was also carried out to evaluate the carbon footprint of RCA versus natural granite aggregate. The study showed the RCA produces less carbon emissions than natural granite aggregate. In other words, the use of RCA not only provides a substitute for natural aggregate, it is also a greener alternative to granite aggregate. It is envisaged that the project will put Singapore in the forefront of sustainable development in the region.



Quality control test results of RCA concrete

REFERENCES

Ho, N.Y., Lee, Y. P. K., Lim, W. F., Ting, S. K., Soh, Y. and Low, G. L. (2009). Efficient utilization of recycled concrete aggregate for structural concrete applications. 27th Conference of the ASEAN Federation of Engineering Organizations, Singapore. 30 November to 2 December.

Your One Stop Solution

for the Construction Industry

SAMWOH

* Supply & lay of asphalt premix
* Supply of ready-mixed concrete
* Supply of green building materials
* Quarrying and supply of building materials
* Civil engineering and infrastructure
* Logistics and machineries rental
* Precast concrete components
* Geo-technical & micro-piling services
* Explosives & controlled blasting systems
* Tunneling & deep excavations
* Specialised pavement products
* Research and development
* Pavement evaluation & consultancy services
* Recycling of industrial wastes
* Shipping services
* Supply of sea sand for land reclamation projects

三和私人有限公司

SAMWOH CORPORATION PTE LTD

25E Sungei Kadut St 1, Singapore 729333
Tel: 6269 7288 (10 Lines) Fax: 6368 2886
Email: info@samwoh.com.sg
Website: www.samwoh.com

TÜV SÜD TÜV SÜD ENTERPRISE 50 SAC bizSAFE Partner