SELF-COMPACTING CONCRETE IN DEVELOPING COUNTRIES: A CASE IN CAMBODIA

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ABSTRACT

Normally in developing countries, the design of some concrete structures using high strength concrete has been limited because the lack of the appropriate level of technology for producing high strength concrete. Self-compacting concrete (SCC), which can flow under its own weight and completely fill a formwork even in the presence of dense reinforcement without requiring any vibration, can be used to produce high strength concrete in stable condition. The technology required for high strength concrete should be innovated with local materials in the developing countries environment in order to draw more benefit from the construction and to ensure durability of structures.

This paper presents the investigation of materials and apparatus for producing SCC in Cambodia by applying the Japanese SCC-designing method. Fresh performance of SCC was determined by: i) a slump flow test, which measures the filling ability and flowability, ii) a V-funnel test, which shows the stability and ability to maintain homogeneity and iii) a Box-shaped container test, which measures the ability to pass freely around reinforcements.

KEYWORDS: High strength concrete, Self-compacting concrete, local materials, developing countries.

1. INTRODUCTION

Because self-compacting concrete (SCC) requires no vibration, many advantages of using it are provided such as faster construction, less manpower, easier placing, better surface finishes, thinner concrete section, highly effective in reducing noise especially in precast product plants, and safer working environment. Especially SCC gives high strength in the stable condition.

SCC was developed in Japan starting in the mid 1980s. Until now it has been developed

and used for almost two decades. Kochi University of Technology where the author made this study is one of the key centers of this new technology. In Japan, it has become a standard concrete but in Cambodia it is a new and special concrete. In June of 2004 the first experiment of how to produce the SCC with available materials on the market was conducted at the Institute of Technology of Cambodia (ITC).

The special rheological requirements of SCC are high deformability with high segregation resistance. The additions of powder are commonly used to improve and maintain the workability, as well as to regulate the cement content and so reduce the heat of hydration, and special concrete admixture are necessary to be able to achieve fluid concrete with controlled workability, very high water reduction, and stable and cohesive concrete. This paper presents the use of limestone powder in Cambodia and high rang water reducing admixture to demonstrate the possibility of producing SC

2. ADVANCE INVESTIGATION

Local materials and apparatus for producing SCC and for checking the fresh performance of SCC are the two important factors to be investigated. The investigation was made with the consideration of economical and environmental conditions.

2.1 Material investigation

Each component for producing SCC was investigated. Table 1 shows the cost of materials used for producing the concrete.

Table 1: cost of materials

Materials	Sand	Coarse aggregate	Portland cement	Limestone powder	Fly ash	Silica fume	Viscocrete HE-10
Unit	ton	m^3	ton	ton	ton	ton	liter
Unit cost (USD)	4.5	12.5	68	26	100	990	3

2.1.1 Cement (C)

In Japan and in Europe, the moderate heat or low heat cement types have been used for SCC because SCC need high content of cement that can cause the temperature rise in concrete. In Cambodia, only ordinary Portland cement is available at the present time. It was decided to be used for the experiment. There is no local production of cement in Cambodia. Varoius types of cement are imported from abroad. Table 2 shows the chemical composition and physical properties of cement used for the experiment.

Table 2: Chemical composition and physical properties of cement

SiO2	Al2O3	Fe2O3	CaO	MgO	SO3	Na2O	K2O	Sp. gravity	Sp. Surface area
%	%	%	%	%	%	%	%		cm2/g
21.1	5.2	3.3	65.3	1.0	2.71	0.08	0.54	3.15	3358

2.1.2 Additions

The authors studied three main resources to select the appropriate powder beside cement for producing SCC. Firstly the industrial by-products such as granulated blast furnace slag powder, fly ash, and silica fume, were considered. Some of them could be found on the market in Cambodia, but the price was very high (Table 1). Then the agricultural by-products such as rice husk ash and rice straw ash was considered and discussed. These materials were very suitable, but many factors needed to be investigated before using for producing SCC. It required the future research. Finally stone powder such as finely crushed granite, dolomite and limestone was considered.

Because limestone powder could be found in Cambodia, limestone exists in Kompot and Battembang provinces, so limestone powder was decided to be used in the experiment. An application example in Japan about using limestone powder is its use in the anchorage of the Akashi Kaikyo Bridge. Limestone powder could inhibit the temperature rise of concrete.

2.1.3 Aggregates

Many types of sand can be used for construction such as crushed sand, sea sand or river sand. In Cambodia, river sand is usually used for construction. In this experiment, river sand was decided to be used.

And coarse aggregate (G) used for construction is gravel or crushed stone made from basalt, granites, limestone or rhyolite. In this experiment crushed rhyolite was decided to be used because it could be found near to Phnom Penh.

2.1.4 High rang water reducing admixture

At this moment only high rang water reducing admixture (superplasticizers: SP) for conventional concrete was available on the market in Cambodia. The SP suitable for SCC was still not available. Because it is useful for producing SCC, the authors considered the possible way to find this material. The first consideration was to take this type of SP from Japan to Cambodia. Another way is to communicate with Sika (Cambodia) Ltd. Fortunately, SP suitable for SCC (Viscocrete HE-10) could be ordered from Vietnam. General Manager of Sika (Cambodia) said that this type of SP would be available in Cambodia when the requirement increases. The authors accepted the Viscocrete HE-10 for the experiment.

2.2 Apparatus investigation

For producing SCC and checking the fresh properties of SCC, some apparatus are necessarily required. The required apparatus were made according to JSCE recommendation such as V-funnel (Figure 1) and box-shape container (Figure 2) and steel plate for slump flow test.

The tilting drum mixer is the popular mixer type in Cambodia. This type of mixer with effective capacity of 50 liters is available in the laboratory of Civil Engineering Department of ITC. It was decided to be used in this experiment.

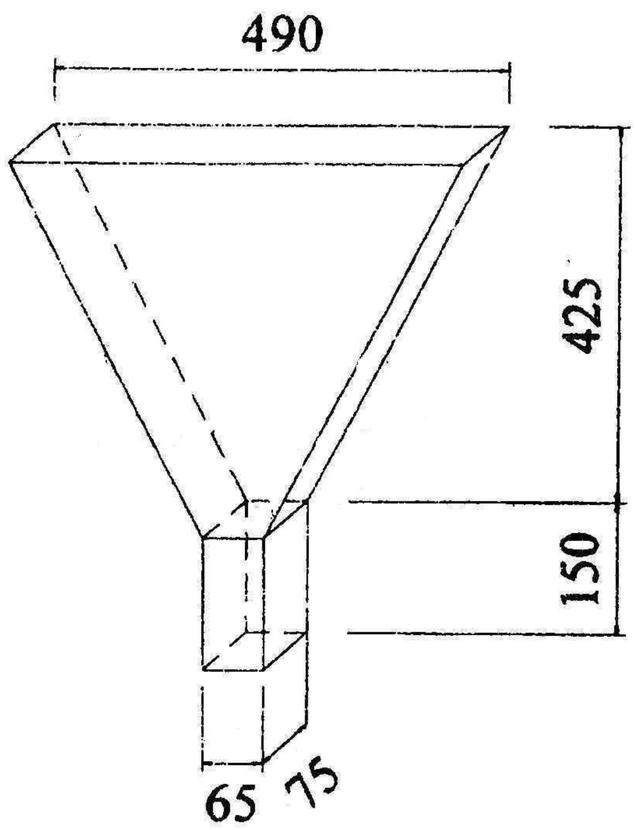

Figure 1: V-funnel (Unit: mm)

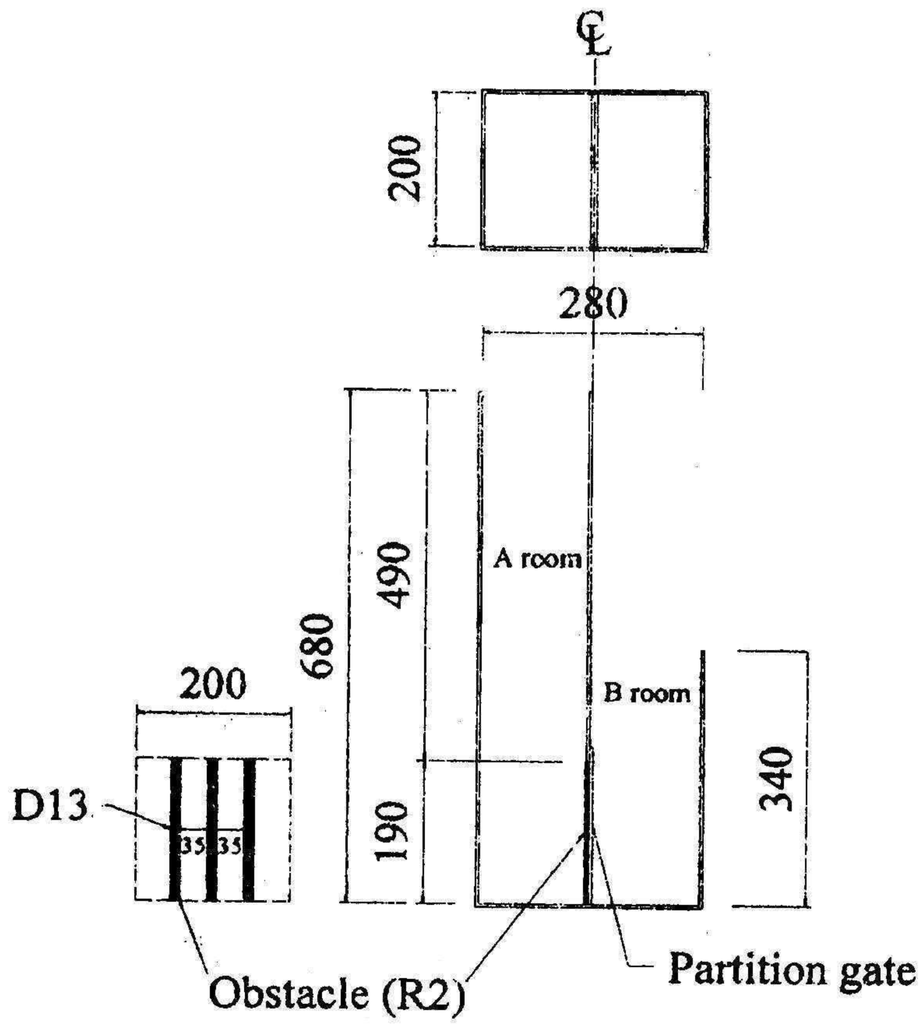

Figure 2: Box-shaped container (Unit: mm)

3. EXPERIMENT

The preparation is very important before starting trial mixes. It can ensure the accuracy of test results. Sand and coarse aggregate were prepared to be in saturated surface dry state. The absorptions of sand and coarse aggregate were tested as shown in Table 3.

Table 3: Physical properties of aggregates

Type	Specific gravity	Absorption (%)
Sand	2.57	1.38
Crushed stone	2.73	0.42

Generally mixing times for SCC need to be longer than for conventional mixes. In this experiment, mixing was made through the procedure as shown in Figure 3.

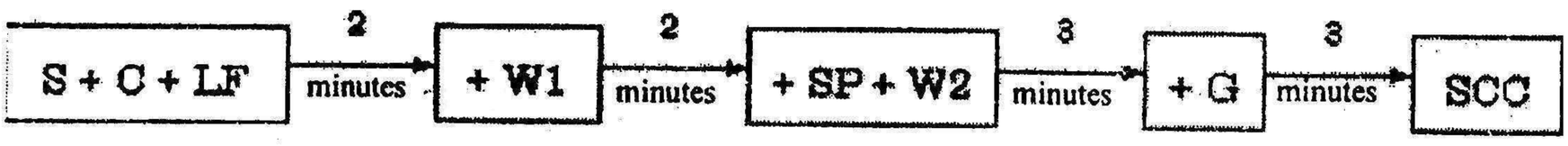

Figure 3: Mixing procedure

Note: W1 = 70% of total water
W2 = 30% of total water

Mix design was followed the method proposed by Okamura et al. in 1993. The method of Japanese Society of Civil Engineers (JSCE) was considered. The procedure of doing this test was made according to recommendation of JSCE for SCC. Trial mixes were carried out. Slump flow, V-funnel and box-shape container were tested. The test results [3] showed that one mix proportion gave a good SCC as can be seen in Figure 4.

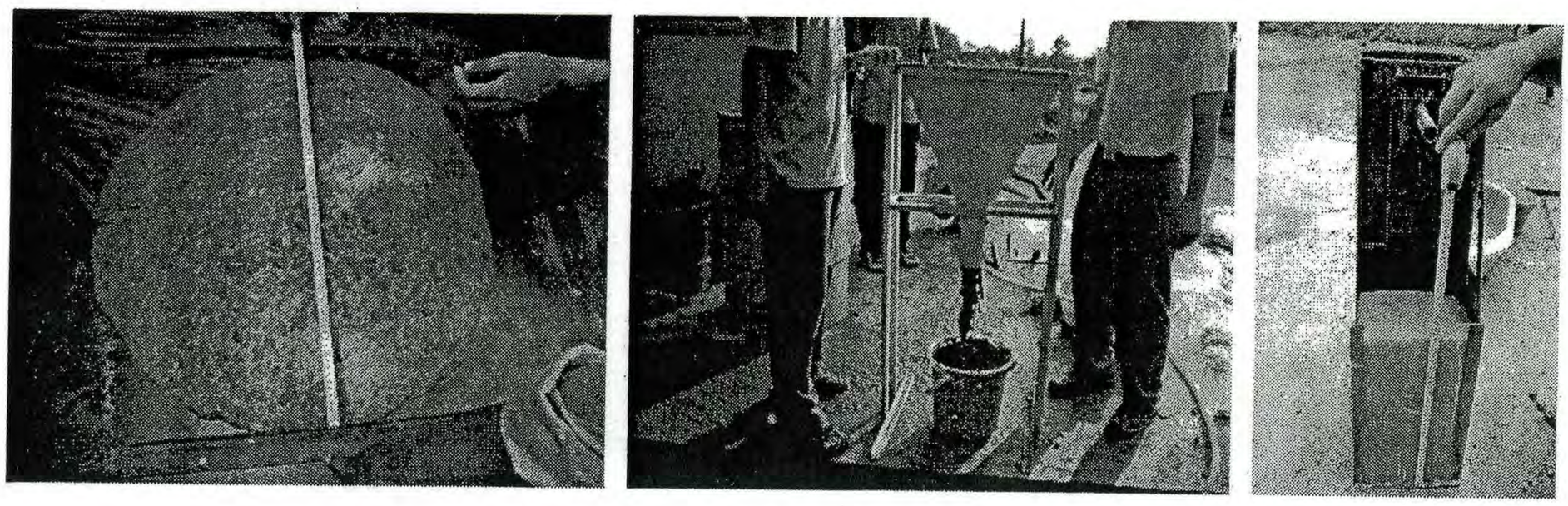

Figure 4: fresh performance of SCC

4. CONCLUSIONS

The conclusions of this study were made as:

(1) It is possible to produce SCC using the available raw materials in Cambodia.

(2) Limestone powder produced in Cambodia is one of powder materials used for SCC.

(3) Ordinary Portland cement using in Cambodia can be used for producing SCC

(4) High rang water reducing admixture (newly developed SP) such as Viscocrete HE-10 will be available on the market in Cambodia.

(5) Slump flow decreased significantly in short time in hot weather.

5. REFERENCES

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