TRANSFERENCE OF SELF COMPACTING CONCRETE TECHNOLOGY TO DEVELOPING COUNTRY

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***ABSTRACT*:** Self compacting concrete technology had been developed in the 1990's in Japan. This new technology was introduced to other developed countries positively. However there have been and still will be some difficulties for the acceptance of this new technology to the developing country. The purpose of this paper is to discuss these difficulties which are caused by the differences of standards, materials and costs.

KEYWORDS: technology transference, standard, unit cost

1. INTRODUCTION

Self-Compacting Concrete (SCC) is now a well-known concrete technology in some developed countries. Some of these countries have established well maintained Standards and/or recommendations for production and placing of SCC. On the other hand in some other countries, SCC is not popular due to several reasons such as differences of Standards, differences of material, and differences of cost efficiency. Therefore some negativity emerges when SCC is introduced.

Through case studies, difficulties and their reasons were identified and with this paper some suggestions are made for a more positive introduction of SCC.

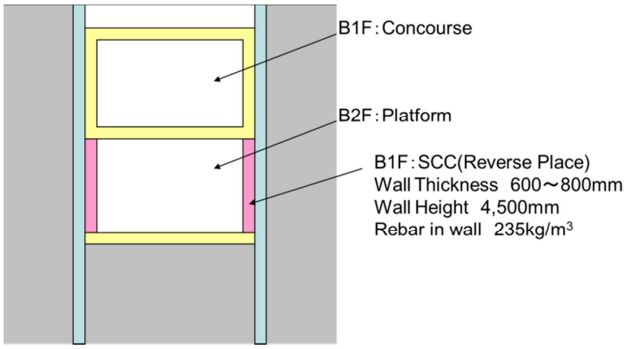

Figure-1 Location of SCC placing

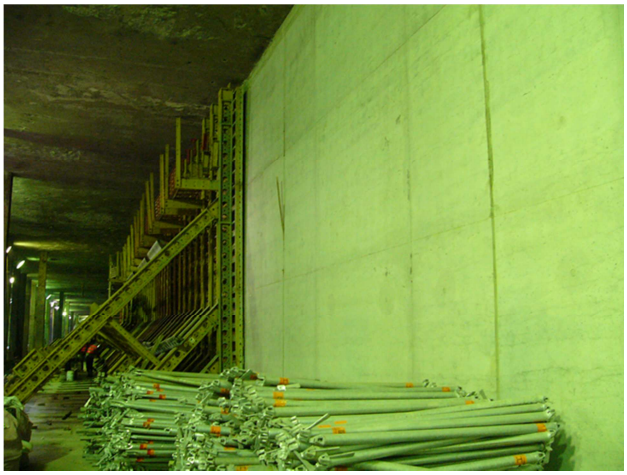

Photo-1 SCC concrete in B2F wall

2. CASE STUDIES

2.1 SCC used in a subway station (Taiwan)

SCC was placed in the wall of an underground subway station as shown in the figure-1 and photo-1. SCC was introduced in the original design of this project, and the Standard for SCC was prepared which was almost the same as the Japanese SCC Standard. All specified testings were done with trial mixes and trial mock-up demonstrations. Seminars and meetings, prior to the placing of concrete, was carried out by the initiating of the Client, and participating of the Engineer, the Contractor, the

Subcontractors, and Universities.

SCC mix proportioning, trial mixes, production and placing were planned and supervised by the authors of this paper. Originally ready-mixed concrete plant was proposed to be used for the mixing of the SCC, but it was observed that the mix did not have enough viscosity for SCC due to the use of sea sand and the lower cement content, even if the test result of the U-shape box and the V-Funnel passed the specified requirements. This conflict between test results and visual observation occurred due to the property of the materials, especially the sea sand and coarse aggregate. The lower fine content of the sea sand caused segregation but the small (maximum) size of coarse aggregate has produced acceptable test value in the U-shape box test and V-Funnel tests. The mix proportion was therefore revised and modified to satisfy the true requirement of SCC, which is smooth flowing without segregation.

Through these preparative works, SCC was placed very smoothly and finished off without any trouble. The cost of the SCC was also feasible to all parties.

2.2 SCC used in concrete dam (China)

SCC was used with a combination of pre-packed rock, called “rock filled concrete (RFC)” This technique was developed by Prof. Jin and Prof. An of the Tsinghua University.

Rock filled concrete is composed of pre-packed rocks with sizes larger than 300mm and the SCC was filled into the gaps of the pre-packed rock as shown in the Figure-2. Construction circumstance is shown in the Photo-2.

RFC was used for dam constructions by the initiating of Tsinghua University, and technically consulted by Tsinghua-Maeda-Okamura Advanced Construction Technology Research Center (TMOACTRC). The Standard codes for RFC was prepared by this center prior to the placing of the concrete, seminars and meetings were carried out by the initiating of the

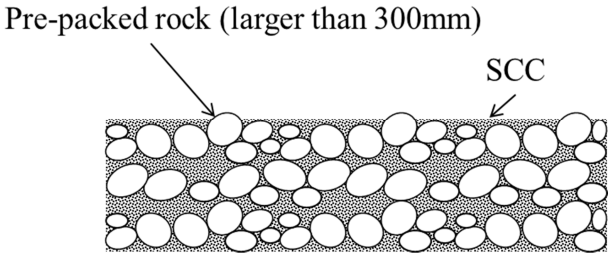

Figure-2 Concept of RFC

Photo-2 RFC construction

Tsinghua University, with the participation of the Client, the Contractor and the Subcontractors. The Technical specification for RFC was prepared by TMOACTRC. Quality management for SCC was done by the technical staff team of Tsinghua University, which included students under consulting of TMOACTRC.

Some problems were faced such as the deforming of the formwork during the placing of the concrete owing to the inexperience of workers in the early stage of construction, however, it has improved gradually.

The University and the Client cooperated closely together on this case, and consequently the introduction of this new technology has started smoothly, and has spread China.

2.3 SCC used in concrete dam (Sri Lanka)

SCC was placed in the space under the sand flashing way of the concrete gravity dam as shown in the

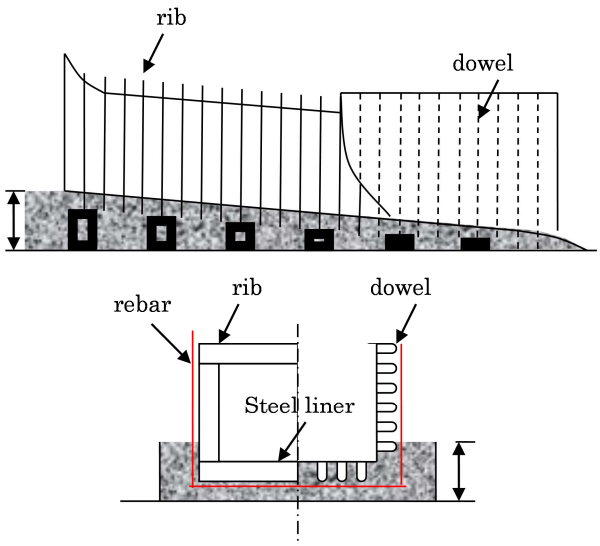

Figure-3 Location of SCC filling

Photo-3 SCC placing under Sand Flashing Way

figure-3 and photo-3. A Japanese Joint Venture constructed this dam. SCC application was proposed by the Contractor with supporting documentation reports on the mix design including the Japanese SCC Standard and method statement. Comparable mock-up trials between conventional concrete and SCC were carried out to establish the most feasible mix for the filling capacity. It was time consuming to obtain the approval because the Contractor was requested to prove the performance of SCC. The Japanese SCC Standard was rejected and ACI 237 standard was used instead. Cost and quantity were surveyed as SCC by the variation order.

2.4 SCC used in Powerhouse (Sri Lanka)

SCC was placed in the space under the spiral casing of the underground powerhouse as shown in the figure-4 and photo-4. A Japanese Joint Venture constructed this powerhouse. SCC application was proposed by the Contractor, as the same as in Case-3.

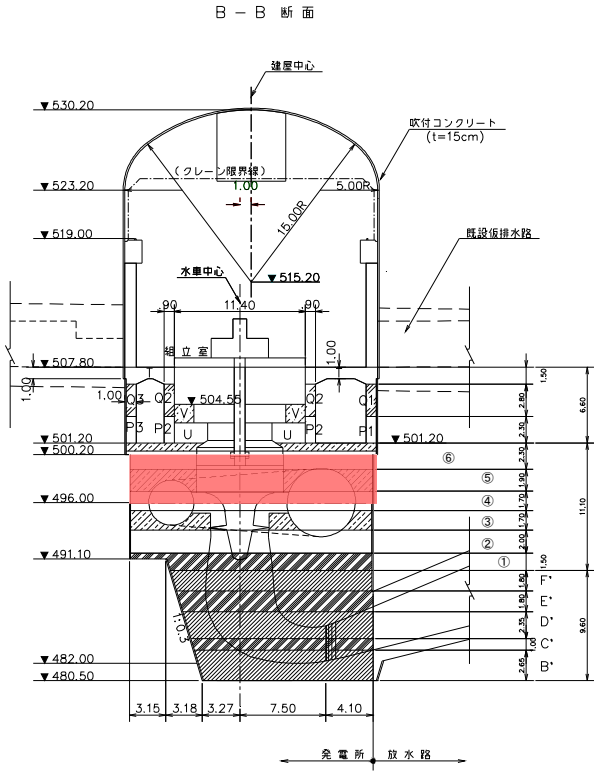

Figure-4 Location of SCC filling

Photo-4 SCC placing under spiral casing

Conventionally mortar grouting was applied to fill the space under the spiral casing. In this case SCC application was approved without a Variation Order since it was regarded as a convenience matter for the Contractor. Cost and quantity were surveyed as conventional concrete in the original design.

3. DIFFICULTIES OF APPLYING SCC

3.1 Standard and Specification for SCC

It is more convenient to apply SCC when the Standard and Specification for SCC is already prepared by the National Public Institution of the country with the consideration of the characteristics of the local materials and the construction situation. On the contrary, there are difficulties to use SCC when the Standard or Specifications for SCC of other countries are used. For example, ACI 237 specified to employ an ACI Level 1 Field Testing Technician for quality control of SCC, however this is very difficult to find in some countries.

The differences of specified aggregate gradation between standards are also causing difficulties for the mix proportioning of the SCC when the standard for aggregate and the Standard for SCC differs.

In the Case-1, Standard for SCC is almost the same as the Japanese Standards, but the actual aggregate conditions are different in Japan. There are very few domestic sources of sand in Taiwan, therefore imported sea sand is popularly used. The fine parts smaller than 0.3mm of the sea sand is less than usual and this creates a sharp gradation curve. Therefore SCC, which is proportioned by the Japanese SCC Standard doesn't have enough viscosity and this will cause segregation.

Such mismatches of standard may frequently occur in the developing countries if all the parties of the project, i.e. the Client, the Engineer, and the Contractor don't share the knowledge of the SCC application.

3.2 Materials and equipment for SCC

Cement, mineral and chemical admixtures are the essentials for SCC. These materials are available in some of the developed countries but in other countries they are sometimes not available. In some cases the batching plant equipment such as silos, admixture tanks, measuring and mixing tools are not available, therefore the SCC cannot be produced. These additional materials and equipment are also very costly and the costs feasibility disturbs the application of SCC.

The Author of this paper has tried to produce high strength SCC by mixing with truck mixer in Hong Kong. This has failed as it took 10 minutes to mix the SCC. This is due to the high content of cement and fly ash, and the low water cement ratio. The mixing of SCC will becomes very difficult if the mixing plant has lower power or less efficiency rate .

3.3 Unit cost of SCC

Unit cost of SCC is the main disadvantage and discourages the Client, the Engineer, and the Contractor in using it. In the Case-1, the Client was positive to apply SCC from the design stage, therefore the unit cost for SCC was also properly calculated and estimated at the tender stage. The actual unit cost of SCC was approximately 1.2 times more than the conventional concrete.

In the Case-2, since SCC was used together with pre-packed rock, the unit cost of the structure was almost the same as if conventional concrete was used. The volume percentage of SCC in the unit mass of structure was only approximately 45-50%. The easiness of the construction method advances the progress, which has reduced the labour cost. Therefore the total cost of concrete placing can be reduced compared with the conventional method. This case is the successful example, which was guided by the University.

In the Case-3, the high content of fly ash was used

with OPC to reduce hydration heat. Fly ash was not available on the local market in Sri Lanka at that time, therefore all fly ash was imported from India with a higher price than OPC. This also increased the unit cost of SCC, therefore the total unit cost of SCC was approximately 1.2 times than of the original designed concrete including the construction cost. The approval of a Variation Order for such cased a long negotiation period and eventually additional claims.

In the Case-4, the Contractor decided to use SCC even if the existing unit price was not enough to cover the actual cost of the SCC. It was clear to the Contractor that the demerit of using conventional concrete such as the time factor and technical difficulty for the placing of the concrete was bigger than the additional cost for SCC. In other words, SCC has a big merit when the location and/or shape of the structure are not ordinary, i.e. complicated shape, narrow space, dense reinforcement etc.. In other cases SCC application will causes a loss of cost which is then normally carried by the Contractor.

4. KEY ROLE OF EACH PARTY

The important thing to transfer such new concrete technology to developing country successfully is to clarify the roles of each party, i.e. the Client, the Engineer, the Contractor and the University.

4.1 Key roles of the Client

The Client is the authority of the project, thus final decision of applying new concrete technology should be made by him. Therefore the Client has to decide which the SCC is surely necessary or not. The cost impact of the new technology to the project shall be evaluated carefully. Not only the construction cost but the life cycle cost includes maintenance cost in the future shall be considered.

4.2 Key roles of the Engineer

The Engineer has to evaluate the SCC in the view point of cost impact, technical suitability, feasibility, material availability in the market, and design optimization. If the SCC is applied without design change from conventional concrete, it will cause not only the cost loss but also a lot of demerits.

The technical specifications and standard codes for the SCC shall be prepared by the Engineer after his evaluation mentioned above.

Supervising of SCC application shall be carried out by the well trained inspector of the Engineer.

4.3 Key roles of the Contractor

The Contractor has to prepare the relevant documents, materials, equipment, and human resources for the SCC. The education and training programs are also important for the contractor to ensure the smooth application of the SCC and quality control of it. Method statement shall be carefully prepared by the contractor includes organization for the application. The material manufacturer such as cement manufacturer and/or admixture manufacturer are usually useful because they usually have the knowledge and experience of SCC by using their products and these knowledge and experience are the key for the SCC.

4.4 Key roles of the University

The University (or the independent institution) can be the good connecter between the Client, the Engineer and the Contractor as the third party. The University can organize a kind of committee for SCC. He can also organize an independent consulting team for the SCC. These committee or consulting team will lead the smooth application of SCC. University can also supply good staffs such as the inspector, technician, etc. for the quality controlling of SCC.

5. CONCLUSION

Four cases of SCC application in the deferent conditions were introduced, and the difficulties of applying SCC were discovered through these case studies. Finally, the key roles of each relevant party were suggested to lead the SCC application smoothly. These suggestions are not limited to the SCC but also recent new concrete technologies such as the Fiber Reinforced Concrete, High Performance Concrete and so on.

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