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INVESTIGATION OF THE WORKABILITY AND MECHANICAL QUALITIES OF HIGH-STRENGTH LWSCC

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Abstract

Nan-Su has developed a new type of self-compacting concrete that is both lightweight and highly durable (HLSCC). This study examines the mechanical properties of HLSCC in both its fresh and hardened states. The JSCE second-class grading standard was used to test and assess HLSCC's flowability, segregation resistance, and fresh concrete filling ability. After 28 days of curing, researchers examined HLSCC's compressive strength, splitting tensile strength, elastic moduli, and density. Second-class standard of the JSCE states that the lightweight aggregate mix ratio of the HLSCC must not exceed 75% for LC and 50% for new. Compressive strength of HLSCC after 28 days was more than 40 MPa in all but one mix, whereas structural efficiency increased in direct proportion to mix density.

Keywords: *HLSCC;New concrete; Compressive strength*

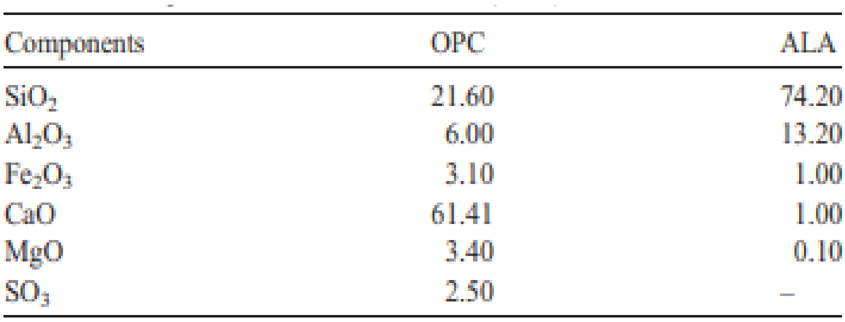
1 Introduction

In the near future, there will be further research into these topics [3–6]. This type of concrete doesn't need to be further compacted because it's self-compacting and can support the weight of an entire structure. Professor Okamura of Tokyo University devised a more advanced mix design approach in 1993 [7,8]. Mix design must take into account the concrete's flowability and resistance to segregation in order to ensure its ability to compress, and this requires a new mixing process, grading standards, and testing procedures. Professor Okamura outlines the most widely used mixture technique for SCC in this research. Cement and mortar are initially tested for quality, then superplasticizer and fine aggregate and pozzolanic material characteristics are investigated. It is, however, a challenge for ready-mixed concrete companies to use this technology because of the long procedure. Taiwan's Nan-Su company came up with a new way of mixing that is easier to utilise. An crucial component of the PF's shifting range [9,10] has severe problems in this new method. The Nan Su self-compacting concrete mix design approach, which has been PF-modified and enhanced [11,12], may now be used to build HLSCC.

2. Methodology

2.1. Materials

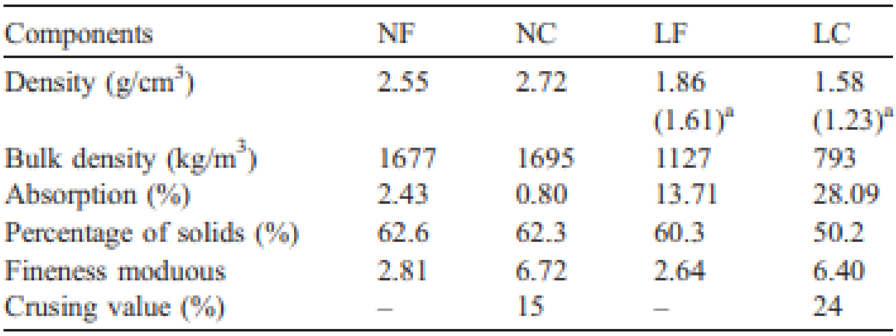
The ALA (artificial lightweight aggregate) utilised in the study had a blaine fineness of 3539 cm2/g and was mostly composed of rhyolite powder, the organicconfigurationsdepicts inTable-1 of OPC and ALA. Natural coarse (NC) and lightweight coarse (LC) aggregates were mixed together at 20 mm Gmax...



Components	OPC	ALA
SiO_2	21.60	74.20
Al_2O_3	6.00	13.20
Fe_2O_3	3.10	1.00
CaO	61.41	1.00
MgO	3.40	0.10
SO_3	2.50	–

Table 1 Organic configuration of OPC and ALA

Gravel of lake side was cast-off as a natural fine aggregate (NFA). Table 2 depicts the aggregates' physical qualities in accordance with the Korean industry standard (KS). BS 812 was used to gauge the aggregate's crushing ratio. To manufacture high-strength, lightweight self-compacting concrete, an air entrainment agent (AEA) and polycarbonate acid water reduction (HRWR) were utilised (HLSCC). HRWR and adenosine triphosphate (AEA) have specific gravities of 1.100.02 and 1.400.01, respectively..



Components	NF	NC	LF	LC
Density (g/cm^3)	2.55	2.72	1.86 (1.61)[a]	1.58 (1.23)[a]
Bulk density (kg/m^3)	1677	1695	1127	793
Absorption (%)	2.43	0.80	13.71	28.09
Percentage of solids (%)	62.6	62.3	60.3	50.2
Fineness moduous	2.81	6.72	2.64	6.40
Crusing value (%)	–	15	–	24

Table 2 Physical properties of aggregate

BS 812 was used to gauge the aggregate's crushing ratio. To manufacture high-strength, lightweight self-compacting concrete, an air entrainment agent (AEA) and polycarbonate acid water reduction (HRWR) were utilised (HLSCC). HRWR and adenosine triphosphate (AEA) each have a specific gravity of 1.100.02 for HRWR and 1.400.0 for AEA...

2.2. Combinationprocess of concrete

The concrete mix design for this experiment was refined and modified using the Nan-Su method. Also known as clearing out the PF value assumption ambiguity, the pretest was utilised to arrive at an accurate estimate of the PF value. There are two ways to determine the mass of fine and coarse aggregates, shown in Figs. 1 and 2. After that, it may be incorporated into the SCC design mix. After obtaining the PF value using this mix design approach, the concrete was mixed with the fine proportionof aggregateand the appropriate volume of SP to test for flowability. If the flowability appears to be off, more precise PF values will be obtained from the testing in order to improve the mix. According to KS, the weight of coarse aggregate in the compressedperiod is 1461 kg/m^3, whereas the weight of fine aggregate in the loose stage is 1376 kg/m^3 and the weight of coarse aggregate in the compacted stage is 1666 kg/m^3. An estimated value of 1.18 was determined by utilising a fine aggregate ratio of 53 percent, as given in Eq. (1).

$$\text{"PF} = \frac{\text{Unit weight of coarse aggregate (compacted stage)}}{\text{Unit weight of coarse aggregate (loosely filled stage)}} \times \left(1 - \frac{\mathrm{S}}{\mathrm{a}}\right) + \frac{\text{Unit weight of fine aggregate (compacted stage)}}{\text{Unit weight of fine aggregate (loosely filled stage)}} \times \frac{S}{\mathrm{a}} \ldots\ldots\ldots (1)$$

$$\frac{S}{\mathrm{a}} = volume\ ratio\ of\ fine\ aggregates\ to\ total\ aggregates\text{"}$$

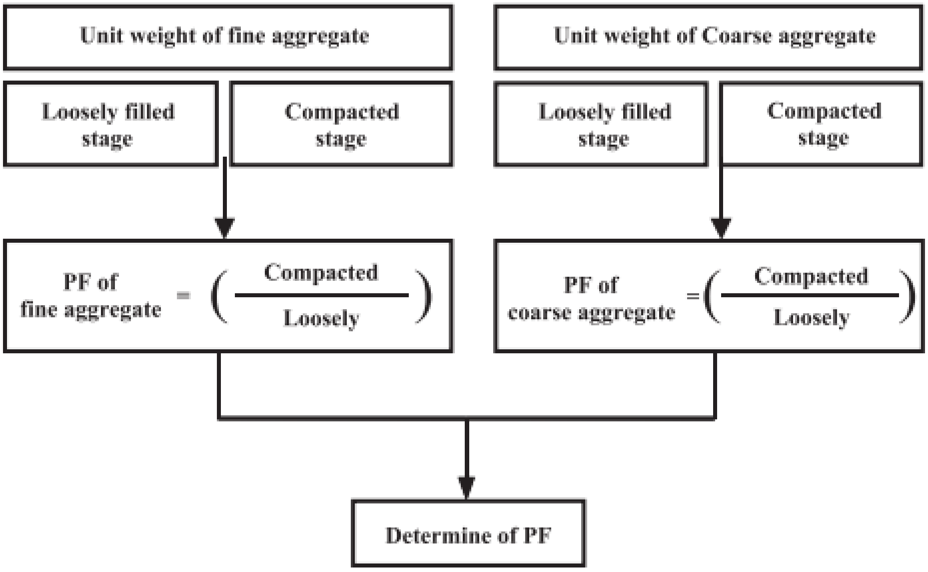


Fig. 1Flow-Chart of identifying the PF value

2.3. Procedure

Slump flow, time to 500 mm of slump flow (s), time to flow through the Vfunnel (mm), and U-box test filling height were all measured immediately after mixing using JSCE's self-compact concrete testing methods. It was from these guidelines that HLSCC deviated. JSCE Without compacting, 100x200 mm () samples of concrete were made. After a 24-hour period, the mould was removed and the product was allowed to cure as normal until the next test. These tests were conducted on the third, seventh and 28th days of curing to find compressive strength ofcement. A statistical tool known as SPSS was used to examine the properties of various combinations of lightweight particles in cured concrete. LC (group B) and LF (group A) mix ratios influenced hardened concrete mechanical properties, its 28-day compressive strength, and its structural efficiency in the long run (group C). Comparing and contrasting the suggested formula with the LC/LF combination was done using this study's findings (group D).

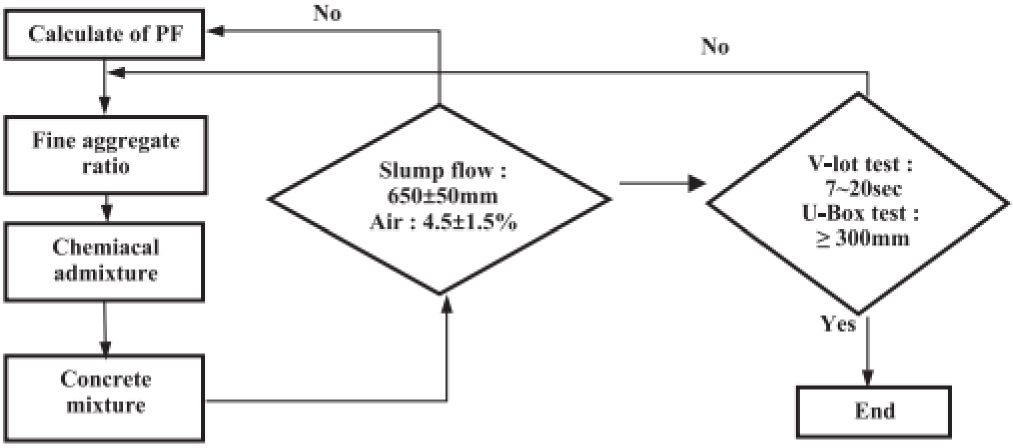
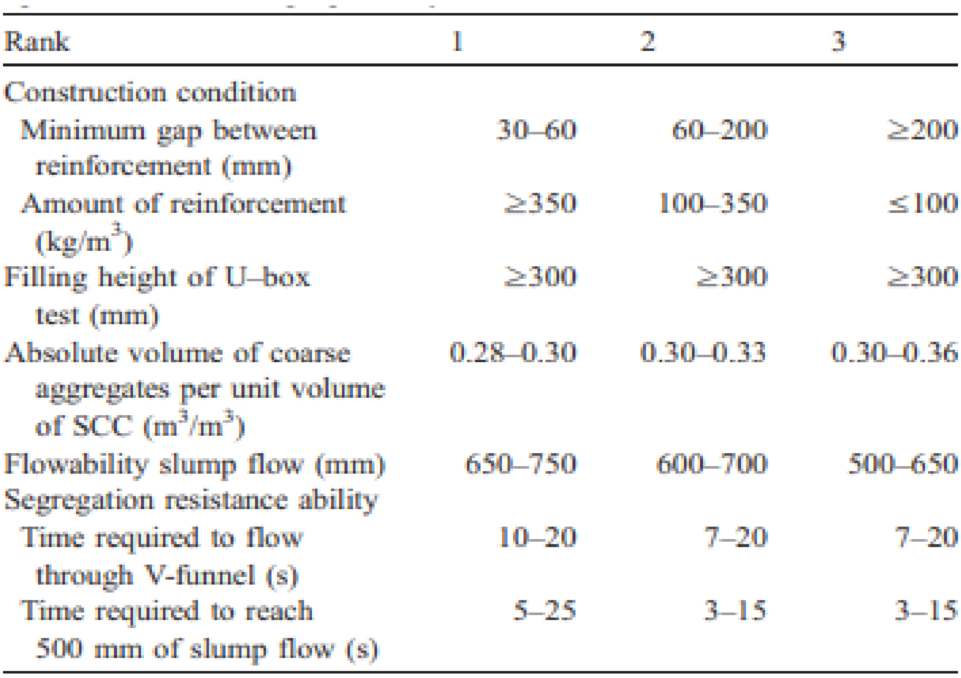


Fig. 2Flow diagram of the procedureof SCC mixture

To determine the HLSCC fluidity in a U-box test, the data in Table 4 indicates the slump flow (mm), the time (s) required to reach 500 mm of slump flow, the time (s) required to flow through a V-funnel, and the filling height (mm) after mixing. 100200 mm (b) specimens have been manufactured without compacting for concrete testing. After a 24-hour period, the mould was removed and the product was allowed to cure as normal until the next test. These tests were conducted on the third, seventh and 28th days of curing to determine the compressive strength and splitting tensile strength of the concrete. A statistical tool known as SPSS was used to examine the properties of various combinations of lightweight particles in cured concrete. LC (group B) and LF (group A) mix ratios influenced hardened concrete mechanical properties, its 28-day compressive strength, and its structural efficiency in the long run (group C). Comparing and contrasting the suggested formula with the LC/LF combination was done using this study's findings (group D).



Rank	1	2	3
Construction condition			
Minimum gap between reinforcement (mm)	30–60	60–200	≥200
Amount of reinforcement (kg/m^3)	≥350	100–350	≤100
Filling height of U–box test (mm)	≥300	≥300	≥300
Absolute volume of coarse aggregates per unit volume of SCC (m^3/m^3)	0.28–0.30	0.30–0.33	0.30–0.36
Flowability slump flow (mm)	650–750	600–700	500–650
Segregation resistance ability			
Time required to flow through V-funnel (s)	10–20	7–20	7–20
Time required to reach 500 mm of slump flow (s)	5–25	3–15	3–15

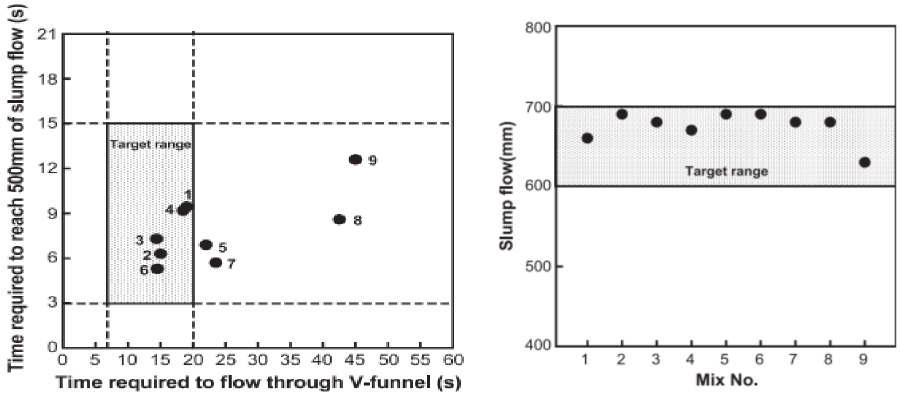
Table 4 Description of projected SCC

3. Results

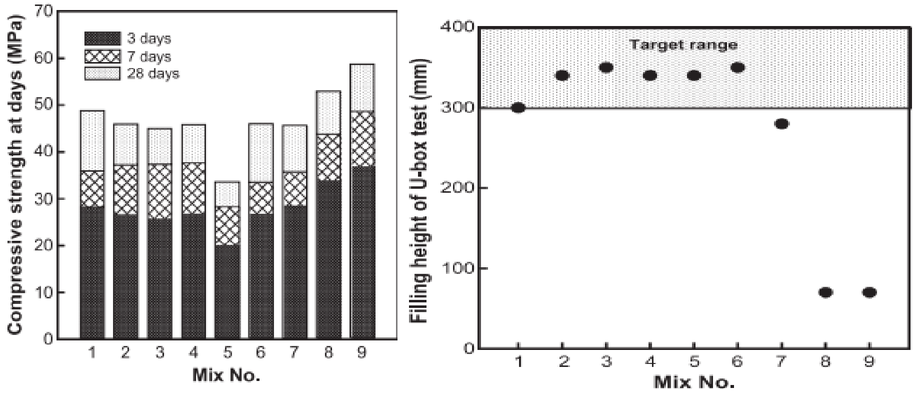
3.1. Characteristics of fresh cement concrete

Flowability, resist segregation, and fill of HLSCC shown in the fig 3,4 and 5 respectively. Flowability ranges from 600 to 700 mm, which falls within the second-class capability of self-SCC, according to results of slump flow tests on all combinations. Using prewetting and lightweight aggregates to reduce the concrete's self-weight resulted in this conclusion being drawn. Figure 4 shows how long it takes to extent 500 mm slump flow and go through a V-funnel while testing HLSCC's fresh material segregation resistance. (s). It is shown in Fig. 4 that for all combinations, the time need to attain 500 mm of slump flow (s) was within projected capacity range. Only normal (Mix #1), LC (Mix #2–4), and LF (Mix #5) mixtures are suitable for flow via a V-funnel (s). (Mix No.6). Despite the fact that Mix Nos. 7–9 contained a higher percentage of LF, they failed to get the intended results. Slump flow (s) and V-funnel flow via a V-funnel were slower for mixing with LF at higher proportions (Mix Nos. 6–9) than for mixing with LF at lower proportions. In the past, this pattern has been attributed to a rise in powder proportional to an increase in viscosity. As shown in Fig. 5, HLSCC has the ability to fill the U-box test (mm). Standard (Mix No. 1) and LC (Mixes 2–5) showed no significant differences, as seen in the figure below. As can be seen in Figs. 3 and

4, a fall in flexibility and anrise in thickness were associated with the comparative rise in LF in Mix No. 6 (which included 25% of LF) [16].



Figures 3 and 4 Slump flow and relationship of time required to flow through V-funnel and to reach 500 mm of slump flow



Figures 5 and 6 Mechanical properties

3.2. Mechanical properties

In a specific period of time how the compressive strength of HLSCC varies shown in figure 6. It descript the LC combinations up to 75% (Mixes 2–4) declined by 6%, whereas the compressive strength of LC mixtures of 100% (Mix No. 5) dropped by 31% when compared to Mix No. 1. Over 50% (Mix No. 8–9) showed an 8–20 percent gain in strength compared to the 50% (Mix No. 6–7) that had a comparable 6 percent loss in comparison to the LF-mixed concrete for LF-mixed concrete on the other hand (Mix No. 1). The light aggregate's physical qualities appear to have led to this outcome: Rewetting results in an increase in total mix volume because to the lowered compressive strength caused by a lower crushing rate, which is approximately 63% higher than NC [17]. With the addition of additional micro particles, the compressive strength of LF mix ratios is increased. Standard lightweight aggregate concrete mixes' strength-to-density relationship may be evaluated using the structural efficiency ratio, which is the product of concrete strength and density. As a result, structural effectiveness was improved.

4. Conclusion

Over 50% (Mix No. 8–9) showed an 8–20 percent gain in strength compared to the 50% (Mix No. 6–7) that had a comparable 6 percent loss in comparison to the LF-mixed concrete for LF-mixed concrete on the other hand (Mix No. 1). The light aggregate's physical qualities appear to have led to this outcome: Due to a decrease in compressive strength, the volume of the mix rises each rewetting because of the lower crushing rate, which is approximately 63 percent more than NC. With the addition of additional micro particles, the compressive strength of LF mix ratios is increased. Standard lightweight aggregate concrete mixes' strength-to-density relationship may be evaluated using the structural efficiency ratio, which is the product of concrete strength and density. As a result, structural effectiveness was improved.

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