A STUDY ON USING SAM SON SEA SAND AND FLY ASH TO PRODUCE FINE-GRAINED CONCRETE

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Abstract: *This paper presents an experimental study on production of fine-grained concrete using sea sand and fly ash. Workability, compressive strength and effect of curing conditions on compressive strength of concrete were investigated. The experimental results show that it is possible to produce high strength fine-grained concrete using sea sand and fly ash. Compressive strength of concrete could reach over 50MPa at 28 days. For cement replacement by fly ash 0-30 %, workability of concrete was improved, however, compressive strength tends to slightly decrease. The compressive strength of concrete under standard conditions was significantly higher (14% at 28 days) than that of concrete under natural air conditions.*

Keywords: *Sea sand, fly ash, compressive strength, curing conditions, fine grained concrete.*

I. INTRODUCTION

Coarse aggregates are considered to be the major component of ordinary concrete. The fine and coarse aggregates generally occupy 60% to 75% of concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy. However, the source of coarse aggregates is gradually depleted and in some coastal areas the natural rock used for the production of coarse aggregates is very rare. Furthermore, the production of thin-walled structures, in particular, the use of textile reinforcement requires concrete having fine grained-aggregates. The results of empirical and theoretical studies show that it is possible to refine the coarse aggregates by using small aggregates to produce concrete to meet the technical requirements. The production of fine-grained concrete also requires a large amount of micro-aggregates. Industrial wastes, such as fly ash, ground slag, rice husk ash, etc. can be used as micro-aggregates to produce fine-grained concrete [1-3]. The fine-grained concrete technology extends the knowledge of concrete in general and cement concrete in particular. The application of fine-grained concrete will take advantage of locally available sand materials which bring economic efficiency.

In recent years, the demand for sand in construction has been increasing. Natural sand (river sand) used for construction is scarce. According to the plan for development of construction materials of the Prime Minister [4], the demand for construction sand of our country in 2015 is 92 million m^3 per year and in 2020 increased to 130 million m^3 per year. In actual construction, the demand for sand is even higher, at present it is about 140-150 million m^3 per year and by 2020 it will increase to 200 million m^3 per year. With the increasing demand for such materials, it is unsuitable to use only river sand because the sand is gradually depleted. Therefore, the search for suitable alternative sources of sand for river sand needs to be studied and put into use. Sea sand can be used for construction after treatment of salt or combination of solutions.

This paper presents some preliminary results of the study on using sea sand for production of fine-grained concrete. Workability, compressive strength and influence of curing conditions on the properties of sea sand concrete (SSC) were investigated. In addition, the effect of fly ash on the properties of SSC was also carried out.

II. MATERIALS AND EXPERIMENTAL METHODS

2.1. Materials

Materials used in this study include: But Son Cement PC40 (CEM), Uong Bi thermoelectric fly ash (FA), Thanh Hoa sea sand with particle size <0.63 mm, and superplasticizer (SP) - polycarboxylic ether (PCE) MasterGlenium ACE by BASF.

Chemical composition of cement, FA and sea sand are presented in Table 1. Particle size distributions of FA and cement were analyzed by Lazer. The particle size distributions of cement, FA and sea sand are shown in **Error! Reference source not found.**. The morphology of FA was photographed by scanning electron microscope - SEM (**Error! Reference source not found.**).

Table 1. *Chemical composition (%) of cement, FA and sea sand*

Oxide	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	K_2O	Cl	Na_2O	LOI
Cement	21.29	3.30	5.72	63.18	1.10	1.50	0.30	-	0.12	0.20
Fly ash	53.88	6.70	21.82	4.27	1.45	0.20	3.40	0.001	0.67	6.27
Sea sand	83.10	-	-	1.30	0.60	-	1.42	0.15	0.50	-

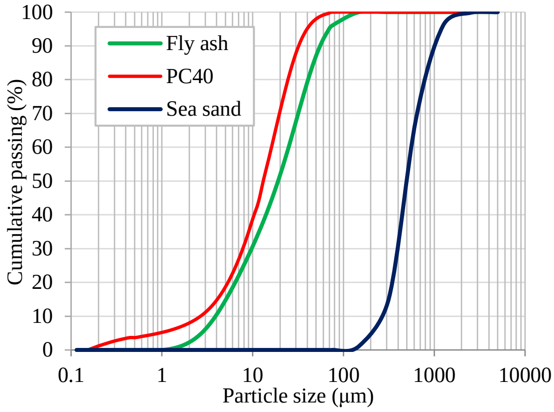

Figure 1. *Particle size distribution of FA, PC40 and sea sand*

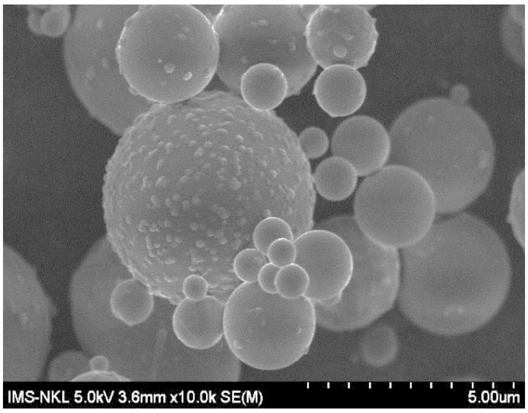

Figure 2. *Morphology of FA particles by SEM*

2.2. Experimental methods

The main experimental methods used in this study include:

- Workability of SSC was measured by flow table test according to standard ASTM C230.
- Compressive strength of SSC were tested according to TCVN 6016: 2011. The strengths of SSC were determined at ages of 3, 7 and 28 days.
- SSC were cured under two conditions, standard conditions (in water) according to TCVN 6016: 2011 and under natural conditions (in the air) as shown in Figure 3.

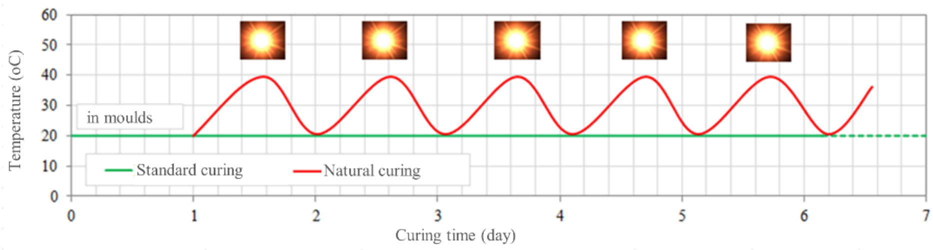

Figure 3. *Standard curing conditions and natural curing conditions*

2.3. Mixture proportions of SSC

The mixture proportions of SSC were determined by the theory of absolute volume. The w/c (w/b) ratio was determined on the basis of compressive strength. FA was used to replace cement with 0, 10, 20, and 30% by weight, as shown in Table 2.

Table 2. *Mixture proportions of SSC*

Mixtures	w/b	FA (%)	SP (%)	CEM (kg)	Water (kg)	Seasand (kg)
100% CEM	0.32/0.36/0.40	0	2.0	620/616/581	199/221/233	1573/1547/1547
10% FA	0.32/0.36/0.40	10	2.0	550/547/515	196/218/230	1573/1547/1547
20% FA	0.32/0.36/0.40	20	2.0	482/479/452	194/215/228	1573/1547/1547
30% FA	0.32/0.36/0.40	30	2.0	415/413/390	191/213/225	1573/1547/1547

III. RESULTS AND DISCUSSION

3.1. Workability of sea sand concrete

The workability (evaluated by slump flow) of the SSC mixtures is shown in Figure 4. Similar to ordinary concrete, increasing w/b ratio improved workability of concrete, e.g. for the 100% CEM mixture, increasing the w/b ratio from 0.32 to 0.40 resulted in a higher slump flow, from 120 to 150 mm. For FA concrete mixtures, the workability increased with a high FA content. The effect of FA on workability of concrete is more pronounced with a high w/b ratio, as for w/b = 0.40. FA has a spherical morphology (see **Error! Reference source not found.**) that can yield a "ball bearing" effect, along with its lower water demand than cement. As a result, the cement replacement by FA could give higher workability of SSC mixture.

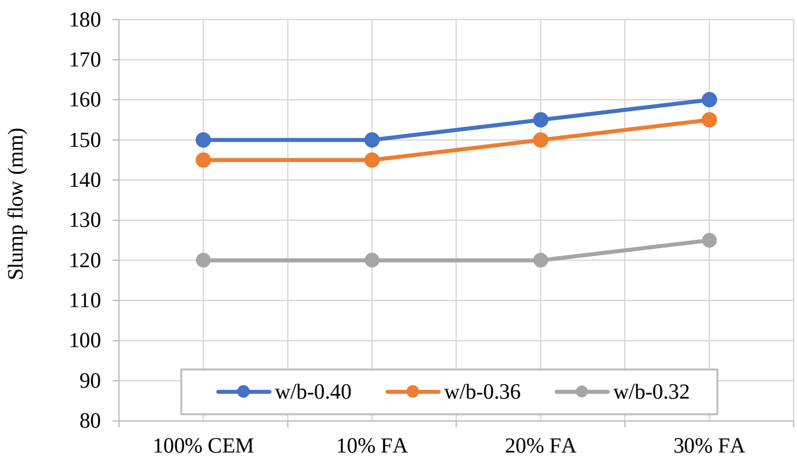

Figure 4. *Workability of SSC containing various fly ash contents*

3.2. Effect of w/b ratio on compressive strength of SSC

In this study, SSC was produced with three w/b ratios, i.e. 0.40; 0.36 and 0.32. Compressive strength at 3 days (Figure 5) and 28 days (Figure 6) were determined. Similar to ordinary mortar and concrete, the strength of SSC increased when the w/b ratio decreased. Increasing FA content from 0 to 30% also reduced compressive strength of SSC at 3 days and 28 days.

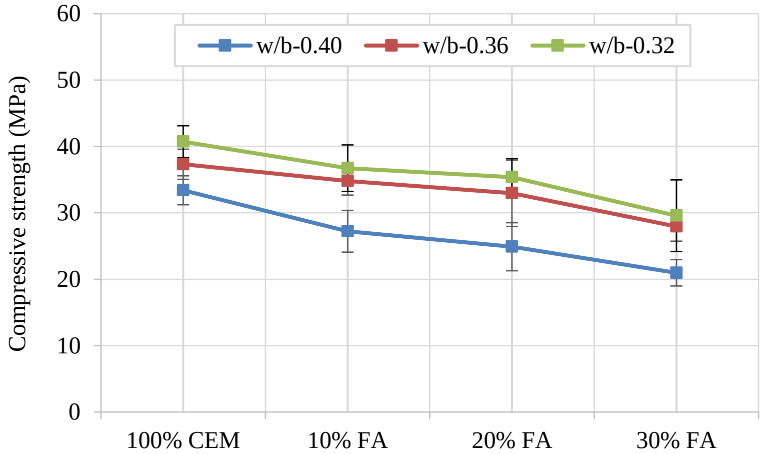

Figure 5. *Effect of w/b ratio on 3 - day compressive strength of SSC*

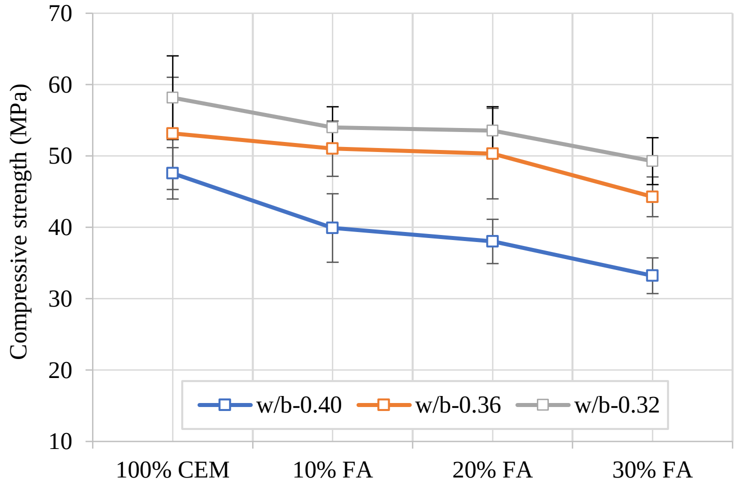

Figure 6. *Effect of w/b ratio on 28 - day compressive strength of SSC*

3.3. Effect of fly ash content on compressive strength of SSC

In this study, FA is used as a substitute for cement, and contributes to the improvement of particle size distribution, and together with sea sand to create granular structure of fine-grained concrete. According to some studies [5, 6], the use of FA combined with cement also contributes to the durability of concrete in the marine environment. Figure 7 shows the development of the compressive strength of the SSC over time. The 28-day compressive strength of SSC with or without FA was about 50 MPa. Similar to ordinary concrete, compressive strength of SSC develops rapidly from 0 to 3, 7 days, and then slows down. The use of FA reduces the compressive strength of SSC, the reduction depended on its content. However, it can be seen that SSC using 10-20% FA reached compressive strength of 50 MPa at 28 days.

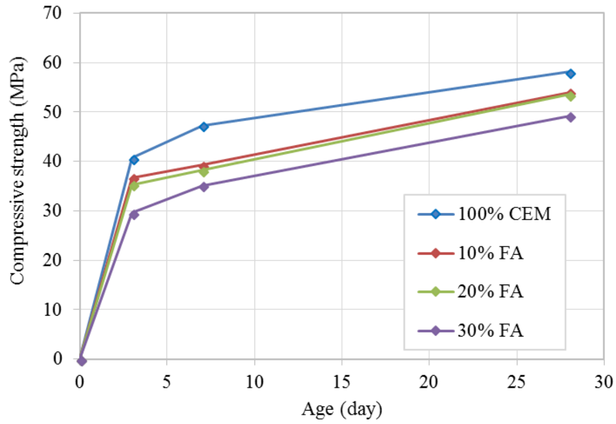

Figure 7. *Effect of fly ash content on compressive strength of SSC at w/b = 0.32*

3.4. Effect of curing conditions on compressive strength of SSC

In this study, SSC containing 20% FA was cured in two different conditions: under standard conditions (in water) and under natural conditions (in the air). Figure 8 shows 7 and 28-day compressive strengths of SSC cured in the two conditions. It can be seen that the 7-day compressive strength of SSC in water was similar to that in the air. Over time, changing relative humidity and temperatures (Figure 3) resulted in evaporation of water and shrinkage, then the lower 28-day compressive strength compared to that of SSC cured under standard conditions (20^{o}C and 100% relative humidity).

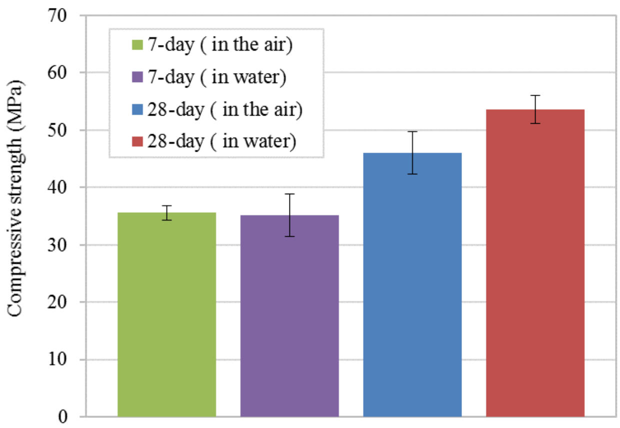

Figure 8. *Effect of curing conditions on compressive strength of SSC at w/b = 0.32*

Influence of curing conditions on the strength of concrete is expressed through Curing Sensitivity Index (CSI) [7]. The CSI is the percentage difference between the compressive strength of the concrete in the water and the compressive strength of the concrete in the air, as shown in the formula below. The higher this coefficient, the more sensitive the concrete to the curing conditions, or the natural curing condition has a greater effect on the compressive strength of concrete.

$$CSI = \frac{f'_c(WC) - f'_c(AC)}{f'_c(WC)}.100\ (\%)$$

Where, $f'_c(WC)$ - the compressive strength of water-cured concrete (MPa); $f'_c(AC)$ - the compressive strength of air-cured concrete (MPa).

According to this formula, the CSI of the SSC containing 20% FA is 14.0%. This demonstrates the natural curing conditions have a great influence on the compressive strength of SSC. Sea sand contains a large amount of salt (see Table 1) which may dissolute and crystallize in the concrete under changing temperature and humidity in the air [8-10]. The dissolution and crystallization may lead to internal microstructure cracking, and then reduces the strength of concrete.

IV. CONCLUSIONS

It is possible to use sea sand and fly ash to produce fine-grained concrete having 28-day compressive strength: 50-60; 40-50 and 30-40 MPa corresponding to w/b ratios = 0.32; 0.36; 0.40.

Similar to ordinary concrete, increasing the fly ash content as partial cement replacement (0-30%) could improve the workability of sea sand concrete.

The increase in fly ash content in the range of 0-30% reduced the compressive strength of concrete at the ages of 3, 7 and 28 days.

Concrete using sea sand and 20% fly ash is significantly affected by natural curing conditions. The 28-day compression strength of the sea sand concrete under natural conditions reduces by 14% compared to that under standard conditions.

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