# High Volume High Performance Fly Ash for LEED Concrete

Emrah Demircan, C. Vipulanandan, Ph.D., P.E.
Center for Innovative Grouting Material and Technology (CIGMAT)
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
Phone: (713) 743-4278
Email: emrahdemircan@gmail.com, cvipulanandan@uh.edu

**Abstract:** In this study, high volume fly ash concrete with 70% fly ash as replacement for cement with appropriate chemical admixtures, was investigated. Both the 4 ksi strength in 7 days and 4 in. slump requirements were satisfied.

## 1. Introduction

Fly ash, one of the most commonly used pozzolanic material for cement replacement, gained popularity because of its contribution to durability, strength and eco-system. It is known that approximately one ton of $CO_2$ is released into the atmosphere as a result of producing each ton of Portland cement [1]. Any concrete containing a fly ash content greater than 50% by mass of the total cementitious material is considered as high volume fly ash concrete (HVFA) [2].

## 2. Objectives

The overall objective of this research was to determine the proportion of fly ash in concrete that can satisfy both slump and strength requirements and meet or exceed the LEED concrete requirements.

## 3. Materials and methods

Type 1 Portland cement in accordance with ASTM C 150 and Class C fly in accordance with ASTM C 618 were used as cementitious material. Tap water was used for all mixtures. According to ASTM C 494 Type A, Type E and Type F admixtures were used. Locally available crushed stone with maximum 1 inch size and locally available sand were used as aggregates.

The slump for each batch was measured according to ASTM C 143 and unit weight was measured according to ASTM C 138. For each batch, twelve 4x8, one 6x12 and five 3x6 were cast in accordance with ASTM C 192. The 6x12 cylinder specimen was used to monitor internal temperature change of the mixture with a commercially available thermocouple which was sensitive to response time less than 0.15 seconds. The 3x6 cylinder specimens were used to determine the time of setting for each mixture as per ASTM C 403. The 4x8 cylinder specimens were used for compression test as per ASTM C 39 at 3, 7 and 28 days. Specimens were air-cured until the day of testing and 3 specimens were tested each time. The pulse velocity was measured for each specimen, before compression test, in accordance with ASTM C 597-02.

## 4. Analysis and Discussions

In this research, 70% cement replacement (by mass) with fly ash was investigated. In order to increase the performance of high volume fly ash concrete mixtures, 40% water to total cementitious material (cement + fly ash) ratio was chosen. All the mixes were required to satisfy at least 4 in. slump, therefore a combination of commercially available concrete admixtures were used.

In accordance with ASTM C 39/C 39M-01 (Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens), compressive strength for 70% fly ash mixture was determined at 3, 7 and 28 days by testing three specimens at each age and taking the average property. The compression test results are shown in Fig. 1. The concrete mixture with 70% fly ash had 5.6 ksi strength in 28 days and exceeded the 4 ksi strength requirement in 7 days.

In accordance with ASTM C 597-02 (Standard Test Method for Pulse Velocity Through Concrete), pulse velocity through concrete was determined at 3, 7 and 28 days. The pulse velocity through concrete results are shown in Fig. 2. The 7 day to 28 day strength ratio was 76%; pulse velocities at 7 and 28 days were 4717 m/s and 4820 m/s respectively.

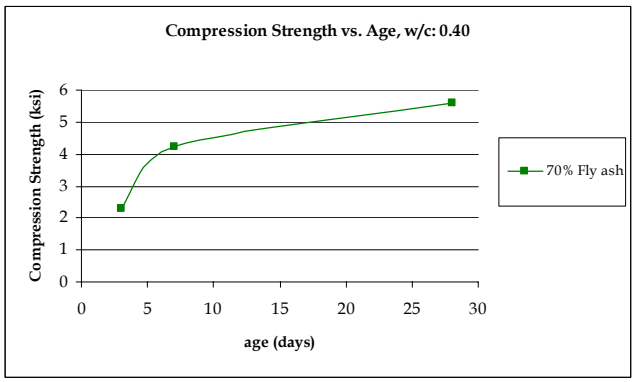


**Fig 1: Compressive Strength vs. age**

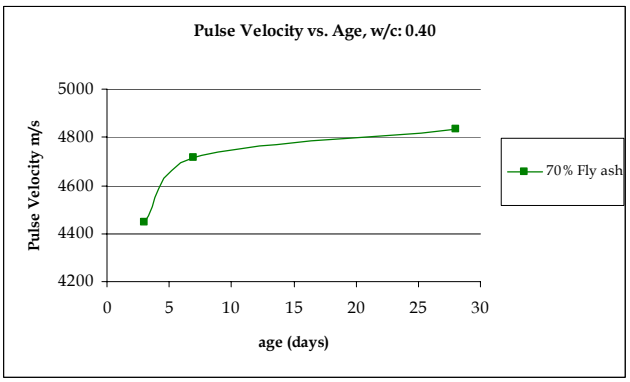


**Fig 2: Pulse Velocity vs. age**

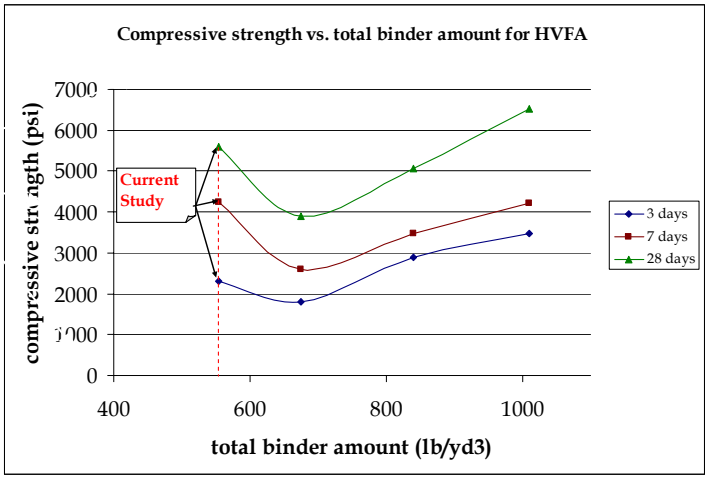


**Fig 3: Variation of strength per total binder amount**

The 70% fly ash mixture was compared with other mixtures from literature to indicate the effectiveness of the mixture. As shown in Figure 3, the 70% fly ash mixture achieved higher strength values at each age in spite of its less binder amount.

## 5. Conclusions

By using appropriate chemical admixtures in the concrete; slump, setting time and strength for mixtures were controlled. Concrete with 70% fly ash replacement and a slump of 4 in. had 5.6 ksi compressive strength and 4820 m/s pulse velocity in 28 days.

## 6 Acknowledgements

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## 7 References

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