CEE 351: Lab 4

Self Compacting Concrete and Fresh Concrete Properties

1.0 INTRODUCTION

The goal of this lab was to acquaint ourselves with self compacting concrete (SCC), its properties, and testing methods used in the design and mixing of SCC. Given a given design mix we made our own SCC. Moreover, we became familiar with a number of tests designed specifically for use with fresh SCC. We also became familiar with the method of testing to find the compressive strength of cylindrical hardened concrete specimens.

2.0 PROCEDURE

2.1 Proportioning of SCC Mixtures

Mix proportions were provided by the instructor, thus no design procedure was required.

2.2 Making and Curing SCC Test Specimens

There are no American standards for self compacting concrete, so we mixed our concrete per instructor's directions. First all coarse aggregate was placed in the mixer with about 1/3 of the water. Then sand was added to the mix and all was allowed to become saturated. Next we added the concrete and fly ash to the mix slowly, and allowed that to combine. A small portion of the superplasticizer was then added to the remaining water, and the majority of water was added to the mixer. Finally, the remaining superplasticizer was added to the water, and the water added to the concrete mix. This was allowed to mix for a few minutes. Then we let it set for 5 minutes, and mixed for a little longer. Once the concrete mix was uniformly blended, fresh concrete tests were performed and samples of SCC were placed into molds.

2.3 Standard Property Tests on Fresh SCC

2.3.1 Unit Weight:

The unit weight of the fresh concrete can be determined following ASTM C-138. First, the weight and volume of a chosen cylinder must be recorded. The cylinder is then filled with fresh SCC, however it is *not* rodded due to its self compacting nature. Once the container is full, the excess concrete must be struck off with the rod. The filled cylinder is then weighed, and the unit weight of the concrete can thus be calculated.

2.3.2 Air Content by Pressure Method

The air content test can be performed following the ASTM C-231 procedure. This process requires a special apparatus made up of a measuring bowl, top section, pressure gage, and air pump. First the bowl is wetted and filled completely with SCC, which does *not* need to be rodded due to its self compacting nature. Excess concrete should be struck off, and the seal of the bowl should be cleaned. The top section is then attached to the bowl and locked in place. The petcocks must be in the open position on each side of the top section, and water must be slowly added to one side until it begins to spill out the other. The petcocks must both then be closed. Begin pumping air into the chamber until the reading is 3 tick marks past the 0 mark. Next hit the pressure release tab on top, allowing all air to escape. The final reading on the pressure gage represents the air content in the SCC. Repeat all steps by releasing the petcocks on the base once again and filling with water. Once a consistent reading can be taken, that is recorded as the percent air content in the SCC

2.3.3 Slump Flow and T_{50cm} Test

This test requires a standard cone from the ASTM C-143 slump test. Also required is a strong nonabsorbent base at least 700mm square with a 500mm diameter circle drawn on the center. A stopwatch and ruler will also be needed. Begin by placing the cone small opening down on the center of the board. Then fill the cone completely with SCC in a timely fashion. Simultaneously start the stop watch and lift the cone up from the board at a constant speed. Stop the clock when the SCC reaches the drawn circle on the board. The recorded time is generally acceptable between 3-7 seconds. Finally, measure the diameter of the SCC circle in two places and take the average. Acceptable values range from 650-800mm.

2.3.4 V-Funnel Test

This test requires an apparatus developed in Japan known as a V-shaped funnel. The funnel shaped like a V consists of a trap door on the bottom, which is locked closed and is then filled with about 12 liters of SCC to the top. Place a container underneath the funnel. Be prepared with a stopwatch and begin timing from when the trap door is released, then stop time when light can be seen through the bottom of the funnel. Immediately fill the funnel back up with the same SCC, after closing the trap door once again. Allow the SCC to set in the funnel for 5 minutes and repeat the same timing procedure. Record both times, and compare. A large segregation of materials will result in a much greater time for the 5 minute test. An acceptable time for the first flow test is about 10 seconds.

2.3.5 L-Box Test

This test also requires a special apparatus, developed in Japan to be used for underwater concrete. This L-shaped box assesses the flow of concrete, especially when subjected to blocking by reinforcement bars. The box consists of a vertical and horizontal section, separated by a moveable gate. With the gate closed, the vertical portion is filled with SCC and allowed to set for one minute. The gate is then lifted allowing the SCC to flow through the horizontal section past the reinforcement bars. Once flow has stopped, two readings are taken: the height of the concrete at both ends of the horizontal section. These heights are then used to calculate the slope of the SCC; the height closest to the vertical end divided by the height furthest from that end. It is suggested that the maximum value of this ratio be 0.8.

2.3.6 Sampling Fresh Concrete

Preparing specimens can be done according to ASTM C-192. In this lab we were asked to produce three sizes of specimens: 8 small cylinders (4"x8"), 2 large cylinders (6"x12"), and 4 beams (3"x4"x12"). Each mold was first greased so as to make concrete removal go smoother at a later time. All cylinders and beams were filled completely with SCC to the top of the mold. The large advantage of SCC is that it requires no pouring of layers, rodding, or tapping of the molds. It consolidates on its own, and only the excess concrete must be struck off the top to create a surface with a clean look.

2.4 Compressive Strength of Cylindrical Specimens

All concrete specimens were capped by placing them in a pool of hot wax, allowing the wax to harden on the ends of the concrete, creating a smooth and consistent surface. This preparation allows the compression machine to get a flat even surface on the specimen so the load can evenly be distributed throughout the cylinder. Once capped and dry, a specimen can be placed in the machine, and its dimensions entered in accordingly. The machine then begins its test, using algorithms to determine the maximum load the specimen is able of handling. This force can then be recorded as the maximum compressive stress for that specimen, keeping in mind the number of curing days the concrete has had. Multiple cylinders' tests can be averaged for a more accurate result of f_c'.

3.0 DATA RESULTS

3.1 Mix Proportioning

Generally following all procedures as stated above, we performed our design and mixing. Our design is based off data provided by the instructor. Table 3.1 provides all the values of mix proportioning for our SCC.

TABLE 3.1: SCC Mix Proportions (Superplasticizer III)

Component	SI Units (kg)
Cement	17.28
Fly Ash	9.60
Water	7.68
Sand	39.84
Gravel	40.80
Superplasticizer ALLEGRO X-122	230.4 mL
w/c (ratio)	0.44
w/p (ratio)	0.29
TOTAL	**48 L**

3.2 Fresh Concrete Test Results

The following Table 3.2 gives results from all the tests that we performed on our fresh SCC. All test procedures were followed generally. *Shown in parentheses are the acceptance criteria.*

TABLE 3.2: SCC Test Results

TEST	RESULT
Unit Weight	2465 kg/m^3
Slump Flow	Time: 4.19 s *(3-7)*
	Radius: 683 mm *(650-800)*

V-Funnel	Time 1: 10.34 s
(T_2-T_1 < 3)	Time 2: 11.24 s
L-Box (H_2/H_1)	0.9559 *(>0.8)*
Air Content	1.25%

3.3 Compressive Strength Results

The following Table 3.3 gives results from the compressive strength tests that we performed on two of our previous concrete specimens.

TABLE 3.3: Compressive Strength Results

Cylinder	**f_c'**
4" x 8"	2653 psi
6" x 12"	2469 psi

4.0 DISCUSSION

Comparing our test results to the standards set forth by their procedures, our mix of concrete is adequate and meets all criteria.

The addition of fly ash and superplasticizer to our mix of concrete had large influences on the fresh concrete as well as it will on our hardened specimens of concrete. Superplasticizer mainly acts as an additive that significantly increases the workability of fresh concrete. Moreover, it allows higher strength concrete with lower amounts of water, and the same strength concrete with less cement content. It has been shown that an addition of a superplasticizer will not hurt the overall durability of concrete or increase its shrinkage and creep.
Fly ash's main effect is increasing the concrete's strength over time. It can also decrease concrete's permeability keeping harmful aggressive compounds on the surface. Shrinkage can also be reduced indirectly by reducing the amount of water required in the concrete.
SCC has many advantages as well as disadvantages. Advantages include: early stripping strengths, increased productivity, design flexibility, and pumpability. Other benefits are a decrease in noise levels, time required during placement, overall production costs, and wear and tare on equipment. Disadvantages consist of: sensitive mixing, possible segregation, long setting time, touchy quality control, no ASTM standards for mix design or testing, and changing location of ingredients can alter a whole mix of SCC.

5.0 CONCLUSIONS

Throughout this lab we gained experience in mix proportioning self compacting concrete. Using given data we were able to design concrete to meet specifications, and take these values into the lab. We then were capable of creating the design mix and forming our own batch of SCC mix. Furthermore we were able to properly sample the concrete, as well as perform V-funnel test, slump flow test, L-box test, unit weight test, and air content test. We gained practice in preparing molds of concrete to be later used in testing. Finally, our group gained familiarity with testing cylindrical concrete specimens for their compressive strength. The results of our lab were given in this report.