

## 1.103 CIVIL ENGINEERING MATERIALS LABORATORY (1-2-3)

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MIT  
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### LABORATORY ASSIGNMENT NUMBER 5

#### CONCRETE I: EARLY AGE BEHAVIOR

**Purpose:** During this laboratory you will learn about:

- (1) The components which make up concrete
- (2) Proportioning concrete mixes
- (3) Mixing procedures
- (4) Consistency properties of fresh (wet) concrete
- (5) Placement and storage of concrete

**Organization:**

- Meeting A     2 hour *Group* meeting
- Data             Will be posted after lab

**Please wear old cloths**

**We will supply gloves, particle masks, and safety glasses**

**Reading:**

- Read this handout and know what will be done in the lab
- Chapter 9 “Proportioning Normal-Weight Concrete Mixtures” *CONCRETE Structure, Properties, and Materials* William Hall, editor
- ASTM C143 Standard Test Method for Slump of Portland Cement Concrete

**Overview:**

Concrete is an essential cost effective construction material that is made from a mixture of nonreactive aggregates, cement powder, water, and sometimes admixtures. The cement is the binder that holds everything together. The strength of the cement paste basically controls the strength of the concrete and is a function of the water to cement ratio. Admixtures are chemicals that are used to change the behavior of the fresh concrete by altering the surface characteristics of the wet cement particle. The aggregate is divided into coarse (gravel) and fine (sand) fractions. Aggregate is basically a filler which is inexpensive, strong, and stiff. The objective of the proportioning exercise is to minimize the cement paste and still achieve the required properties of both the wet and cured concrete.

Concrete mixes are designed (proportioned) to obtain the desired physical properties.

*Workability* is the most important requirement for fresh concrete because it controls the economics of the placement operation and the integrity (surface finish, void distribution, etc.) of the final product. *Strength* is generally the most important design property of hardened concrete but other physical properties such as durability, chemical resistance, and permeability may become important considerations.

The exact properties (both fresh and hardened) of a particular mixture will depend on poorly defined characteristics of the aggregate and hence it is necessary to experiment with every new source of materials. Trial mixes are always used to refine the proportions to obtain the desired properties. General guidelines (see reading material) can be used to get the basic proportions to start the process. During this laboratory you will make five “trial” mixtures of concrete, measure the workability and prepare three compression specimens for testing in laboratory 7. These five mixes have been designed within the guidelines of balanced proportions and should illustrate the range in behavior that is typical of construction mixes.

You must be very careful to measure quantities accurately in order to get the expected results. While most people consider mixing concrete to be an approximate process, the results are quite sensitive to the component ratios.

Workability is used to describe the consistency and cohesiveness of the fresh concrete. Consistency is numerically quantified using the slump test. Cohesiveness is more subjective and attempts to describe the compactibility and finishability of the material. Cohesiveness is evaluated based on a visual judgment of the resistance to segregation of the mix components. (e.g. a mix has poor cohesiveness if the paste does not fill the surface voids). You will measure the slump of each mix and then you should describe the performance of the mix during the operation.

### **Procedure:**

#### *Apparatus Preparation*

1. Zero the scale.
2. Obtain several empty containers.
3. Measure the mass and nominal dimensions of the plastic specimen molds.
4. Get cement, sand, aggregate, and superplasticizer.
5. Get rubber gloves, and safety glasses (cement is very basic and will burn hands and eyes).
6. Get clean particle mask (fine sand, silt and cement are basically inert materials which stay in your lungs!!!! Be very careful to keep the dust under control.)

#### *Make the first mix (water cement ratio equals 0.5)*

1. Fill in the data sheet for the first mix (this should make about  $3/4$  ft<sup>3</sup>).  
11.2 lbs of water  
22.4 lbs of cement  
52.2 lbs of coarse agg (<0.5in)  
45.0 lbs of sand
2. Use a coarse sieve to remove the fine particles from the aggregate.
3. Sieve the required quantity and put this in the mixer.

4. Measure out the required amount of sand and add to mixer.
5. Measure out the required water and add about 1/2 to the mixer.
6. Mix these components for about one minute to blend and hydrate the particles.
7. Measure out the required amount of cement.
8. Add the cement and the rest of the water to the mixer.
9. Mix for five minutes making sure to get good blending action.
10. Stop mixer and wait for 2 minutes.
11. Mix for another 2 minutes.
12. Measure slump and make three test specimens as describe below.
13. Return the material from the slump test to the mixer and mix for 30 seconds.
14. Measure the mass of two empty containers.
15. Empty the mixer equally into the two containers.

Make the second mix (water cement ratio equals 0.6)

1. This mix will be made by adjusting the proportions of the first mix.
2. Determine the mass of one container and concrete from the first mix.
3. Clean the mixer as thoroughly as possible with a small trowel.
4. Empty the container of concrete into the mixer.
5. Determine the following masses (% based on mass of concrete added to mixer from the first mix).
  - 5.89% aggregate
  - 2.52% cement
  - 3.22% water
6. Add these components to the mixer in the specified order.
7. Mix for 5 minutes.
8. Measure slump and make three test specimens as describe below.
9. Empty the mixer into a waste container with a **plastic liner**.

Make the third mix (first mix with superplasticizer)

1. This mix will be made by adding superplasticizer to the first mix.
2. Determine the mass of the second container and concrete from the first mix.
3. Determine the required superplasticizer corresponding to 0.18% of the concrete mass.
4. Add the superplasticizer to the concrete in the container.
5. Mix with a shovel until uniform.
6. Measure slump and make three test specimens as describe below.
7. Empty the container into a waste container with a **plastic liner**.
8. Clean the container with water to remove the superplasticizer. This is very important because small quantities will influence the next mix.

Make the fourth mix (water cement ratio equals 0.42)

1. Fill in the data sheet for the fourth mix.
  - 9.3 lbs of water

- 22.1 lbs of cement
- 43.5 lbs of coarse agg (<0.5in)
- 33.5 lbs of sand
- 2. Use the same procedures as for the first mix.
- 3. Measure slump and make three test specimens as describe below.
- 4. Measure the mass of one empty container.
- 5. Empty the mixer into the container and add the extra material from the slump test.

*Make the fifth mix (fourth mix with superplasticizer)*

- 1. Determine the mass of the container and concrete from the fourth mix.
- 2. Determine the required superplasticizer corresponding to 0.20% of the mass.
- 3. Add this to the container.
- 4. Mix with a shovel until uniform.
- 5. Measure slump and make three test specimens as describe below.
- 6. Empty the container into a waste container with a **plastic liner**.

*General Procedures for the Slump Test and Making Test Specimens*

- 1. Fill the slump mold with a scoop being careful to fill the cone evenly.
- 2. Fill the cone in three layers.
- 3. Compact each layer with 25 blows of the ½ inch diameter rod.
- 4. Finish top surface with a trowel.
- 5. Tap mold and twist to remove.
- 6. Stand cone next to concrete pile.
- 7. Place the rod on top of cone and extending over the concrete pile.
- 8. Measure and record the slump as the distance from the bottom of the rod to the top of the pile.
- 9. Fill two of the 3 inch diameter specimen molds one third at a time and rod to compact.
- 10. Vibrate the specimens for about two minutes to remove the air.
- 11. Finish top with trowel.
- 12. Measure and record the mass of each filled mold.
- 13. Seal with plastic cap.
- 14. Mark the mold with batch, group #, date, and specimen number.
- 15. Be sure these numbers are recorded on the data sheets.

*Final Clean Up of the Laboratory*

- 1. Concrete sets hard and adheres to essentially any surface. It is therefore absolutely essential that you thoroughly clean every tool, container, the mixer, slump cone, and the floor.
- 2. Put all the fresh concrete in the plastic lined containers. Remember this will harden into a solid block that someone must carry out of the laboratory so please do not over fill containers.
- 3. The two blue baskets contain wash water. Use this water to wash the mixer, the

slump cone, and tools. Do not under any circumstances wash concrete into the sink. This will clog the drain pipe forever!!

4. Return all tools and materials to the storage areas.

### **Report:**

Your report should include the following information:

- All the hand recorded data sheets.
- For each of the five mixes, a table containing the mass of each component, the water to cement ratio, and the aggregate to sand ratio, the total unit weight of the specimens, the slump, and your cohesiveness observations. You can assume the Saturated Surface Dry (SSD) water content is zero for your calculations.
- Assuming the cement has a specific gravity of 3.15 and 2.65 for both the sand and aggregate, compute the theoretical total unit weight of the wet mix if the air content is 2%. Compare these theoretical values to your measured numbers.
- Based on the water mass determine the expected slump (Table 9-2) and compare this to the measured value for each mix.
- What is the effective water to cement ratio based on the slump test for the mixes with the superplastizer (use Table 9-2 to get an approximate water mass and then convert to the water to cement ratio).
- Based on the water to cement ratio, determine the expected compressive strength from Table 9-3. Remember that the superplastizer does not increase the actual water content and hence should not alter the hardened properties. Add these strength predictions to your summary table.

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CONCRETE I: EARLY AGE BEHAVIOR

DATA SHEET (1 of 2)

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All dimensions in \_\_\_\_\_ Group No. \_\_\_\_\_ Date \_\_\_\_\_  
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**MIX NO. 1** Target Water to Cement ratio \_\_\_\_\_  
Target Mass Water \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Water \_\_\_\_\_  
Target Mass Cement \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Cement \_\_\_\_\_  
Target Coarse Agg \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Agg \_\_\_\_\_  
Target Mass Sand \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Sand \_\_\_\_\_  
Slump \_\_\_\_\_ Description of cohesiveness \_\_\_\_\_  
=====

Specimen1: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen2: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen3: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
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**MIX NO. 2** Target Water to Cement ratio \_\_\_\_\_ Tare & Parent Mix Mass \_\_\_\_\_ Tare Mass \_\_\_\_\_  
Target % Incr. \_\_\_\_\_ Mass Water \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Water \_\_\_\_\_  
Target % Incr. \_\_\_\_\_ Mass Cement \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Cement \_\_\_\_\_  
Target % Incr. \_\_\_\_\_ Mass Agg \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Agg \_\_\_\_\_  
Target % Incr. \_\_\_\_\_ Mass Sand \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Sand \_\_\_\_\_  
Slump \_\_\_\_\_ Description of cohesiveness \_\_\_\_\_  
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Specimen1: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen2: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen3: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
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DATA SHEET (2 of 2)

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**MIX NO. 3** Target Water to Cement ratio \_\_\_\_\_ Tare & Parent Mix Mass \_\_\_\_\_ Tare Mass \_\_\_\_\_  
Target % Superplast. \_\_\_\_\_  
Target Mass Superplast. \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Superplast. \_\_\_\_\_  
Slump \_\_\_\_\_ Description of cohesiveness \_\_\_\_\_

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Specimen1: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen2: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen3: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_

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**MIX NO. 4** Target Water cement ratio \_\_\_\_\_

Target Mass Water	_____	Tare Mass	_____	Tare plus Water	_____
Target Mass Cement	_____	Tare Mass	_____	Tare plus Cement	_____
Target Coarse Agg	_____	Tare Mass	_____	Tare plus Agg	_____
Target Mass Sand	_____	Tare Mass	_____	Tare plus Sand	_____

Slump \_\_\_\_\_ Description of cohesiveness \_\_\_\_\_

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Specimen1: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen2: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen3: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_

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**MIX NO. 5** Target Water to Cement ratio \_\_\_\_\_ Tare & Parent Mix Mass \_\_\_\_\_ Tare Mass \_\_\_\_\_  
Target % Superplast. \_\_\_\_\_  
Target Mass Superplast. \_\_\_\_\_ Tare Mass \_\_\_\_\_ Tare plus Superplast. \_\_\_\_\_  
Slump \_\_\_\_\_ Description of cohesiveness \_\_\_\_\_

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Specimen1: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen2: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_  
Specimen3: Ident # \_\_\_\_\_ Ht \_\_\_\_\_ Dia. \_\_\_\_\_ Mass Mold \_\_\_\_\_ Mass Mold plus Spec. \_\_\_\_\_

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