Spring 1-1-2020

# CIMT 205-102: Concrete Properties and Testing

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# Concrete Properties and Testing
## CIMT 205-102 Spring 2020



| | Date | Topics | Concrete Primer | Laboratory | Assignment Due |
|---|---|---|---|---|---|
| 1 | 1/25 | Introduction to Concrete Design:<br>Materials, Properties, Procedures & Testing ACI Field Level I Certification Sampling, Temp, Slump, Density, Yield, Gravimetric Air %, Pressure Air %, Volumetric Air %, Cylinders, Curing<br>**Bulk Density and Voids** | 1-22, 177 | Bulk Density, ASTM **C29** | |
| 2 | 2/ 1 | ACI FL1 Certification<br>Technician Workbook Chapter assignment | 69-84, | Mix, Test, Cast & Cure, C31<br>C143, C173, C192,C231,C1064 | **Dry-Rodded Density& Voids** |
| 3 | 2/ 8 | Strength Testing, 7-day, fc', cement efficiency<br>**Specific Gravity**, Moisture Characteristics<br>**Sieve Analysis**, Max Size, Fineness, Gradation | 114, 185<br>ACI 214, 318 | ASTM C39, C617, C1231, C78, C469, C496<br>ASTM **C127, C128, C566 C136** | **Fresh Concrete Testing #1**<br><br>**Workbook Chapter** |
| 4 | 2/15 | Concrete Admixtures, Water reducers, air entraining agents, Pozzolans, Fibers<br>ACI 211 Concrete Mix Design | 16-21, 49-65 85-105, 112-131, 191<br>**ACI 211 Chapter 6** | ACI 212**,** 214, 318<br>ACI **211**<br>**ASTM** C127, C128, C566 C136 | **Spec Grav, Moisture, Sieve Analysis, Fineness Modulus, Max Size,** |
| 5 | 2/22 | Mix design drafts & questions, Concrete Chemistry<br>**Exam I: ACI FL1,Agg Properties and Mix Design** | 146, 168-169, 177-190, 198-199, | ACI 211, ASTM C31, C138, | **Spec Grav, Moisture, Sieve Analysis, Fineness Modulus, Max Size,** |
| 6 | 3/ 1 | **Volumetirc Air ASTM C 173, the hardest test** | 154-158, 166-171 | Major Mixing: **C173, C143, C138, C231, C1064, C31** | **Detailed Mix Design** |
| 7 | 3/ 8 | Non-Destructive Testing, Schmidt, Windsor Probe, Maturity Method, (k-slump)<br>Advanced Testing & Beyond: ICP, NRD, XRF & XDD, Electron Scanning, | 204, 209 | ACI 228, ASTMs C597, C803, C805, C873, C 900, C1074, C215, C78<br>7-Day, Effects of Admixtures<br>**C 39, C1231, C31, C138, C143, C231, C1064** | **Aggregate Properties**<br>**Fresh Properties** |
| 8 | 3/15 | Spring Break, 3/16 6:00 NJACI Dinner @ Stagehouse (call Dianne Johnston, 732 940 1820 to confirm) | No Classes | No Classes | No Classes |
| | 3/22 | **Exam 2: Detailed Concrete mix design, ACI FL1** | | ACI 318,<br>ASTMs **C39, C1231, C78** | |
| 9 | 3/29 | ACI 214, & 318 Concrete Building Code,<br>Step 9 revisited, cement efficiency & mix adjustments<br>Admixtures 7-day Strengths<br>**28-day Strength Testing, Admix 14-day** | 98 | ASTMs **C39, C1231, C469, C496, C215, C805** | **Admixture Fresh Tests**<br>**NDT Admixture Strength Tests**<br>**Group Project Topic**<br>**Exam 2** |
| 10 | 4/ 5 | High Strength, Lightweight, Pervious, Precast/Prestressed, Autoclaved Cellular,<br>**28-day Admixture testing** | | ACI 211 reports | **Concrete Mix Design and Testing with Rebatch calcs** |
| 11 | 4/12 | Statistical Control of Concrete Mixes, Concrete Pipe, Block, and Pavers | | ACI 214<br>Block Testing ASTM C140 | **Effects of Admixtures on Concrete Properties** |
| 12 | 4/19 | | | ASTM C31, C138, C143, C173, C192, C231,C1064 | **Block Testing**<br>**ACI FL1 Quiz** |
| 13 | 4/26 | | | | |
| 14 | 5/3 | Group Project Presentations | | | **Group Progress report** |
| | 5/ ? | Comprehensive Final Exam | | | **Group Project Report**<br>**Final Exam** |
| | 5/13 | NJACI Annual Awards Dinner (Major Networking Event) | | | |

By the end of the semester the student will demonstrate understanding and command of the following topics:

Know how to assemble, write, and present laboratory reports.

- ACI Field Level 1 Certification
  - 7 ASTM tests
  - $108 for NJIT Concrete Students through NJACI
- Concrete components and properties
  - Aggregate testing, 5 ASTM tests
  - Cement
  - Common cement replacements
  - Admixtures and Additives
  - Special properties – high-strength, permeability, weather, decorative, ect.
- ACI 211 Absolute Volume Mix Design
  - Mass-Volume Relationships, Relative Density (specific gravity)
  - The unit volume
  - Trial batching and the first trial batch
  - Design by iterative trial batching and testing
  - The nine steps
  - The critical nature of step 9
  - Mock-ups
- Concrete testing
  - Fresh concrete testing
    - ACI Field Level 1 Certification, 7 ASTM tests, $108 to NJIT Students
  - Hardened concrete testing
    - Strength testing 2 ASTM Tests
    - Testing for other properties, 2 ASTM tests
    - Non-destructive concrete testing, 2 ASTM tests
  - ACI 214: Evaluation of Concrete Strength tests, Statistical Methods, Mix Control
  - Concrete Building Code ACI 318 and Required Overdesign
- Other concrete applications
  - Precast, Pipe, Block, Pavers, Autoclave, Pervious, Decorative

By the end of the semester the students will produce 5 major reports and 11 minor sub-reports. The sub-reports are written individually, the major reports result from the collaboration of the group.

A report on **Concrete Aggregate Properties**, comprised of 3 sub-reports with a summary introduction and conclusion,

A Report on **Concrete Mix Design and Testing, with Rebatching Calculations**, comprised of 4 sub-reports, with a summary introduction and conclusion,

A Report on the **Effects of Admixtures on Concrete**, comprised 3 of sub-reports, with a summary introduction and conclusion,

A **Block Testing** Report with a proper summary introduction and conclusion,

A well organized, complete **Report on a Topic of Interest**, with 1 progress report.

Over the semester there will be Weekly quizzes two exams and a comprehensive final.

- 30% Reports
  - 20% Major
  - 10% Minor
- 20% Exams
- 20% Quizzes
- 20% Final
- 10% Class Participation and Laboratory Demeanor

## ASTM Tests to Master for Various ACI Technician Certifications

The complete set of ASTM Standards is available behind the reference desk in the library. ***Concrete and Aggregates*** is Volume 04.02.

**ASTM Tests and ACI Documents to Be Covered in CIMT 205 are Bold**

## Concrete Field Testing Technician - Grade I

A Concrete Field Testing Technician - Grade I is an individual who has demonstrated the knowledge and ability to properly perform and record the results of seven basic field tests on freshly mixed concrete.

A Concrete Field Testing Technician requires a working knowledge of the following ASTM Standards:

C ***1064*** Temperature of Freshly Mixed Portland-Cement Concrete
C ***172*** Sampling Freshly Mixed Concrete
C ***143*** Slump of Hydraulic Cement Concrete
C ***138*** Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
C ***231*** Air Content of Freshly Mixed Concrete by the Pressure Method
C ***173*** Air Content of Freshly Mixed Concrete by the Volumetric Method
C ***31*** Making and Curing Concrete Test Specimens in the Field

## Concrete Laboratory Testing Technician - Grade I

A Concrete Laboratory Testing Technician - Grade I is an individual who has demonstrated the knowledge and ability to properly perform, record, and report the results of basic laboratory procedures for aggregates and concrete.

A Concrete Laboratory Testing Technician - Grade I requires a working knowledge of the following ASTM Standards:

C 617 - Capping Cylindrical Concrete Specimens
C ***1231***- Unbonded Caps for Concrete Cylinders
C ***39*** - Compressive Strength of Cylindrical Concrete Specimens
D ***75****** - Sampling Aggregates
C ***702*** - Reducing Field Samples of Aggregate to Testing Size
C 117 - Materials finer than 75- m (No. 200) Sieve for Mineral Aggregates by Washing
C ***136*** - Sieve Analysis of Fine and Coarse Aggregate
C ***29*** - Unit Weight and Voids in Aggregate
C ***127*** - Specific Gravity and Absorption of Coarse Aggregate
C ***128*** - Specific Gravity and Absorption of Fine Aggregate
C ***566*** - Total Moisture Content of Aggregate by Drying
C 40 - Organic Impurities in Fine Aggregates for Concrete
*Written exam only

# Concrete Laboratory Testing Technician - Grade II

A Concrete Laboratory Testing Technician - Grade II is an individual who has demonstrated the knowledge and ability to properly perform, record, report, and evaluate the results of advanced laboratory procedures for aggregates and concrete.

Concrete Laboratory Testing Technician - Grade II ***partially*** requires a working knowledge of the following ACI and ASTM Standards:

*ACI* ***214*** Evaluation of Strength Test Results of Concrete
*ACI* ***211.1*** Selecting Proportions for Concrete

# Instructions for accessing ACI Online Manual of Concrete Practice

1. Go to www.concrete.org
2. (While you're on the site join ACI as a Student Member, it's free.)
3. Logon as nj-ch.
4. Password is acinj
5. Select Bookstore & Publications menu.
6. Select MCP online.
7. Select MCP online for registered users.
8. Select document needed from list, or type in key word for search.
9. Since only one user at a time is allowed, as quickly as possible do your research or download your documents, and logoff so someone else can access the MCP.

**CIM 205 will need ACI 116R, ACI 211.1, ACI 214R, ACI 228.1R**

# Aggregate and Concrete Properties Data Sheet

### ACI 211 Absolute Volume Design Requirements and Values

| | |
|---|---|
| Maximum aggregate size | 3/4-inch |
| Required Slump | 3-4 inches |
| Air Entrained or Non-entrained | Non air-entrained |
| Required 28-day strength | *as assigned* |
| Fine aggregate fineness modulus | 2.5 |
| Coarse aggregate dry-rodded density | 101 lb/bulk $ft^3$ |
| Cement assumed relative density | 3.15 |
| Coarse aggregate relative density | 2.69 |
| Fine aggregate relative density | 2.67 |
| Coarse aggregate % moisture | 0.2 % |
| Coarse aggregate % absorbance | 0.5 % |
| Fine aggregate % moisture | 0.3 % |
| Fine aggregate % absorbance | 0.4 % |
| Mix volume | 5 6"x12" test cylinders + 5 % |

***Read ACI 211.1 Section 6.3. List the step and section number where each of these values is used***.

# NJIT Undergraduate Laboratory Safety Rules

1. Keep yourself safe, Think Safety - Be aware of your own and other's safety
2. Know emergency procedures (fire escapes routes, emergency phone locations and telephone numbers)
3. Report any perceived safety hazards
4. No working alone
5. No eating or drinking in the lab
6. Wear appropriate safety equipment
7. No loose cloths or long hair around machinery
8. Do not work with electrical appliances in the presence of water
9. Do not put obstructions in walkways (keep fire escape routes completely clear)
10. Immediately clean-up spills
11. Know the hazards of any materials or machinery you are working with
12. No horseplay

## Safety Glasses Must be worn at all times when work is being done in the laboratory

**Safety awareness training is part of our educational mission. Safety is considered in all engineering design, therefore, students must learn how to keep themselves and others safe in the laboratory, the workplace, everywhere and always. You must adopt an attitude of safety when working. As a final reminder to keep yourself and others safe, safety glasses must be worn at all times when work is ongoing in the lab. In doing so you are both literally and figuratively putting on safety. Never become so involved in your work that you forget the dangers around you, constantly check your surroundings for safety.**

# Laboratory Exercise 1

# Introduction to Laboratory work

**Scope of Laboratory Work**:

To give the student an understanding of the physical properties of concrete its components, and to teach methods of testing these properties

To provide practice in the art of making concrete by handling of the materials

To provide familiarity with Concrete Testing equipment and procedures

To provide a platform for improving communication skills through report writing and presentation

To provide experience in leadership and teamwork

**Procedures Used In Laboratory Tests**

The test methods and procedures used during lab sessions are adapted from, and are in accordance with, the standards devised by the American Society for Testing and Materials.

**Student Responsibilities**

**Attendance**
Prompt and regular Classroom and Laboratory attendance is required. Much of the laboratory work is group oriented so the loss of one person affects the entire team.

**Preliminary Preparation**
Each laboratory exercise and appropriate class notes should be studied and reviewed prior to each session. Procedures should be reviewed so that work in the laboratory will progress smoothly.

**Class Organization**
The instructor will divide the class into groups of three or four students to maintain active participation by each member. These groups will remain the same for the entire semester.

**Care of Facilities and Equipment**
The laboratory facilities and equipment are provided to augment the learning of all the students. Facilities must be properly cared for to ensure their continued availability. Recycling is the rule, place bottles and cans in proper receptacle, place other trash, especially food waste, in proper trash can.

**Cleanup Procedures**
Concrete equipment must be kept clean and organized. After a laboratory session, cleanup is required and necessary to maintain the equipment in working order. If

concrete is allowed to set up in the equipment, then the purchase of new equipment may become necessary.

Excess or waste concrete should be dumped into shallow containers to which hardened concrete will not stick for disposal. Wheelbarrows lined with plastic are ideal containers.

Items coated in concrete **should not be washed out in a conventional sink**. Concrete can cause severe pipe damage. **Use the wash down pit** to clean all fresh concrete off small and large equipment. Large equipment should be hosed down and brushed thoroughly after each use.

All equipment and apparatus should be left clean and organized before departure from the session. Waste materials should be placed into the appropriate receptacle.

**Materials and Apparatus**
Materials must not be moved until students are sure of their instructions. Machines must not be operated until students have been "checked-out", that is properly instructed Any breakage of equipment should be reported immediately.

**Scales and Balances**
Check scale for capacity and never overload. Use weighing devices with care and do not shock load. Check for balanced condition and recent calibration to ensure accuracy.

**Testing Machines**
Do not use testing machine until instructions have been given and permission obtained from instructor.
Know the machine's capacity and never overload. Be familiar with proper load range of the machine.
Apply loads at specified rates.
Observe all safety precautions.
Leave the machine clean and with all controls in the "off" position when session is completed.

**Miscellaneous Equipment**
Fine sieve trays are ruined with coarse bristle brushes.
Hot aggregate can damage fine sieve trays
Be careful when working with an oven. Be mindful of loose clothing, hair, etc.
Use thermometers with suitable temperature range.

**Safety Precautions**

1. Report all accidents to lab instructor immediately.
2. Know where the first aid kit is located.
3. Approved safety goggles are to be worn.
4. Heavy gloves are to be worn when working with material above 140 degrees F.
5. Filter masks are to be worn when working with fine particulates.
6. Lab coats are available in the lab for usage.
7. Wear appropriate clothing for the lab.

8. Work efficiently and do not rush. Many accidents are caused by carelessness.
9. Know how to work/operate the equipment before you use it.
10. Be careful in proximity to others.
11. Use of any personal equipment is forbidden without prior approval of the instructor.
12. Lift heavy objects properly and obtain help with objects greater than 50 lbs.
13. Never climb on anything except an approved ladder.
14. Know where the fire escapes and fire extinguisher is located.

**Laboratory Exercises**

Each laboratory session will start with an overview and description of the required assignment. All equipment and materials to be used will be specified so there is no confusion. When in doubt, ask the instructor!

**Reports**

***Requirements.*** Each student is responsible for submitting a separate report for each test performed. The reports should be computer generated and bound with a staple, paper clip or folder. The instructor will indicate due dates for the reports.

***Format.***

<u>Cover Page</u>

- Title of the test
- Laboratory session number
- Students name
- Group number and member names
- Date due

<u>body of report</u>

Title

Objective of test (what property are you measuring?)

Scope of test (why are you measuring)

- A description of materials and equipment used (range of scale)

Procedure

- Procedural References ASTM standards
- Procedural summary (past tense, sequential order, ASTM reference).
- Enumerate deviations (there are some),the effect and significance of each.

Data

- The data should be tabulated in a systematic format.
- All equations and formulas used should match ASTM and be stated with clear definitions and symbol descriptions. Sample neat handwritten computations are acceptable and must be provided in proper ASTM form.

Results

- Test results should be clearly summarized in tabular and/or graphical form.

Discussion/Conclusion

- Clearly state all the required results. Give a brief discussion of the test results drawing conclusions based on lectures and reference reading.
- Respond in narrative form to questions posed in the handouts or by the instructor.
- Briefly explain any problems encountered and what the effect such a problem has on the test results.

Appendix

# Laboratory Session 2
# Dry-Rodded Bulk Density and Voids

**Reference ASTM C 127**

**Scope of Work**
To determine the Dry-Rodded Bulk Density and Voids for both coarse and fine aggregates proposed for use in concrete. These properties are needed for the application of the ACI 211 Absolute Volume Method of concrete design.

**Apparatus**
**Balance** accurate within 0.1% of test load, graduated to at least 0.1 lb.
**Tamping Rod** 5/8 inch in diameter, approximately 24 inches long, rounded to hemispherical tip.
**Cylindrical measure** with height no less than 80% or more than 150% of the diameter.

**Materials**
Available oven-dried sample should be at least125% the capacity of measure

**Procedure**
1. Determine the volume of the measure.
2. Determine the tare mass of the measure.
3. Fill the measure about 1/3 full with oven-dried aggregate, level the surface with fingers. Rod the layer 25 strokes of the tamping rod evenly distributed over the surface, approaching the bottom without hitting it.
4. Fill the measure to about 2/3 full, level the surface with fingers. Rod the layer 25 strokes of the tamping rod evenly distributed over the surface, where the rod will penetrate about 1 inch into the lower layer.
5. Fill the measure to over the rim. Rod the layer 25 strokes of the tamping rod evenly distributed over the surface, where the rod will penetrate about 1 inch into the lower layer. If the level falls below the layer of the rim add more material.
6. Strike-off the surface such that the bits peaking over the rim are evened out by the depressions under it.
7. Measure the gross weight of the measure and aggregate
8. Subtract the tare weight to determine the mass of the aggregate
9. Divide the mass of aggregate by the volume of the container to determine the bulk density.
10. If the relative density (specific gravity) is known the void % can be determined.

## Worksheet for Dry-Rodded Bulk Density, M

| | |
|---|---|
| Material | |
| Date | |
| Diameter of Measure (in) | |
| Area or Measure ($in^2$) | |
| Height of Measure (in) | |
| Volume of Measure ($in^3$) | |
| Volume of Measure, **V**, ($ft^3$) | |
| Dry Mass of Measure **T** (lb) | |
| Mass of OD Sample and Measure, **G** (lb) | |
| Oven Dry Mass, ODM (lb) ODM=**G-T** | |
| Dry-Rodded Bulk Density, **M** ($lb/ft^3$)<br>M=ODM/V | |

# Laboratory Session 3

# Specific Gravity of Coarse and Fine

## Saturated Surface Dry, % Moisture, % Absorbance

## Specific Gravity of Coarse by Immersion Method

**Reference Astm C 127**
**scope of work**

To determine the bulk, oven dry (OD), saturated surface dry (SSD), and apparent specific gravities, and % absorption of coarse aggregate proposed for use applying appropriate standards. These properties are needed for volume when applying the absolute volume method of aci 211.

**apparatus**

5 kg Balance, 0.5 grams precision, or better.
Submerged weighing apparatus
Wire mesh sample basket, 8 inch diameter and 8 inches deep
Large absorbent cloth or towel
Drying oven

**materials**

Minimum Weight of Sample varies depending upon nominal maximum size of aggregate. Choose minimum sample size according to Table 3-1, derived from sec. 7.3 of ASTM C 127. Reject all material that is finer than the #4. Use the Quartering method of C 702 to obtain a representative sample.

Table 3-1

| Nominal Maximum Size, in. | Minimum Size of Test Sample, lb. |
|---|---|
| ½ or less | 4.4 |
| ¾ | 6.6 |
| 1 | 8.8 |
| 1 ½ | 11 |
| 2 | 18 |

**procedure**

1. Immerse oven-dry sample in water for 24 +/- 4 hours
2. Weigh the dry sample basket, and the sample basket immersed in water
3. In a large absorbent cloth roll the sample until all visible water film is removed. The aggregate should have a dull, dry appearance. Take care to avoid evaporation of water from the aggregate pores if heat is used to accelerate drying.
4. Weigh the sample in this saturated surface dry (SSD) condition, and record to the nearest 0.1 gram.
5. Immediately place the sample into the wire mesh basket and submerge in water. Shake the container while submerged to release entrapped air.
6. Suspend basket from hook and adjust height to weighing level
7. Once the scale stabilizes, record the total immersed weight, TI.
8. Place the sample from basket into a drying container, taking great care to not lose any small particles, and dry to a constant weight at 230 +/- 9 degrees F.

   where:
   A = Mass in grams of oven dry (OD) sample
   B = Mass in grams of saturated surface dry (SSD) sample
   C = Mass in grams of immersed SSD sample

9. Cool, then weigh and determine oven dry (OD) mass, A.
10. Calculate Bulk Specific Gravity (OD) = A/(B-C)
11. Calculate Bulk Specific Gravity (SSD) = B/(B-C)
12. Calculate Apparent Specific Gravity = A/(A-C)
13. Calculate Absorption = [(B-A)/A] 100

**report**

1. Record all Observations and calculations on table 3-2
2. Turn in a completed report according to the requirements listed in Lab Session 1

Table 3-2

# Coarse Aggregate Relative Density (Specific Gravity) and Absorption Determination

| | |
|---|---|
| Material | |
| Date | |
| Dry Mass of Basket, bskt (g) | |
| Mass of SSD Sample and Basket ,T (g) | |
| Oven Dry Mass, **A** (g) | |
| SSD mass in air, **B** (g)<br>B = T – bskt | |
| Mass of immersed Basket, Ibskt | |
| Mass of immersed sample and basket, TI (g) | |
| Mass of immersed Sample, **C** (g)<br>C= TI - Ibskt | |
| Mass or drying container (g) | |
| Bulk Rel Den (od)= A/(B-C) | |
| Bulk Rel Den (ssd) B/(B-C) | |
| Apparent Rel Den SG = A/(A-C) | |
| Absorption, %<br>= [(B-A)/A] 100 | |

# Specific Gravity of Fine Aggregate Using Pycnometer

**Reference:** ASTM C 128

**SCOPE OF WORK**

To determine the bulk, Oven Dried (OD), saturated surface dry (SSD), and apparent specific gravities, and absorption, % of fine aggregate using appropriate standards. These properties are needed for of the volume calculations when applying the absolute volume method of ACI 211.

## Apparatus

1 kg Balance precise to at least 0.1 grams
Pycnometer (volumetric flask of 500 cc capacity or fruit jar fitted with pycnometer top)
Metal sand cone mold
Metal tamper for sand cone mold
Heat gun or hot plate
Drying Oven

## Materials

Approximately 1000g of fine aggregate obtained through the sample splitter.

## Procedure

1. Decant excess water from sample that has soaked 24 +/- 4 hours. Spread the sample on a flat surface exposed to a gentle current of warm air. For faster drying action place on a hot plate. Take care to avoid over drying. Stir the test sample frequently so that it will dry uniformly and continue until the sample approaches a free flowing condition.
2. Fill the metal sand cone with the large end down to overflowing with dried fine aggregate on a smooth, nonabsorbent surface. Lightly tamp the surface of the sand 25 times with the tamper while continuing to fill. Strike-off level with the top and smoothly lift mold vertically. If surface moisture is still present, the aggregate will retain the molded shape. Continue drying and test at frequent intervals until the aggregate slumps slightly upon removal of mold.
3. If the SSD condition is passed, thoroughly mix a few milliliters of water into the aggregate and cover for 30 minutes before starting procedure again.
4. Immediately split the sample. Take a 500 +/- 10 grams) of the fine aggregate for determination of the SSD specific gravity. Place the remaining sample, or fill, a drying container for a second measure of the % absorbance (the value should agree closely with the % absorbance determined through the pycnometer.)
5. Determine the mass of the pycnometer filled to its capacity with water.
6. Measure and record the SSD mass of the Sample. Place it into the pycnometer, taking care not to loose the very fines, and fill with water to approximately 90% capacity. Gently roll and agitate pycnometer for a few minutes to remove air bubbles. This process could take as long as 15 minutes

7. Fill pycnometer to capacity and determine the total mass of the pycnometer, the sample, and water to the nearest 0.1 gram and record.
8. Remove the fine aggregate sample from the pycnometer, take great care not to leave behind any of the sample. Utilizing a plastic wash bottle helps in this process. Dry sample to a constant mass at a temperature of 230 +/- 9 degrees F. until there is no further change in the mass. record the mass of oven dry sample.
9. Calculate Bulk Specific Gravity (OD) = A/(B +S-C)
   where:
   A = weight in grams of oven dry (OD) sample
   B = weight in grams of pycnometer filled with water
   C = weight in grams of pycnometer with sample and water filled to calibration mark
   S = weight in grams of saturated surface-dry sample
10. Calculate Bulk Specific Gravity (SSD) = S/( B +S-C))
11. Calculate Apparent Specific Gravity = A/(B + A- C))
12. Calculate Absorption, % = [(S-A)/A] x 100
13. Calculate the % total evaporable moisture (TEM) of the back-up sample, p. (p should agree closely with Absorption, %.)
    TEM = (SSD-OD)/OD 100

## Report

1. Report table 3-3
2. Turn in a completed report according to the requirements listed in Lab Session 1 and the appropriate ASTM Standards.

Table 3-3

# Fine Aggregate Specific Gravity and Absorption Determination

| | |
|---|---|
| Material | |
| Date | |
| Weight of SSD sample, **S** (grams) | |
| Weight of oven dry sample, **A** (grams) | |
| Weight of pycnometer with sample filled to calibration mark, **C** (grams) | |
| Weight of pycnometer filled with water, **B** (grams) | |
| Bulk Specific Gravity, OD | |
| Bulk Specific Gravity, SSD | |
| Apparent Specific Gravity | |
| Absorption, % | |
| SSD Mass of back-up sample, (g) | |
| OD Mass of back-up sample, (g) | |
| Total Evaporable Moisture, p, %<br>TEM = (ssd-od)/0d 100 | |

# Laboratory Session 4

# Fine and Coarse Sieve Analysis

**Scope of work**

To perform sieve analysis of the coarse and fine aggregates to determine 1) The maximum nominal size of the coarse aggregate, and 2) the fineness moduli of both coarse and fine aggregates using the appropriate standards. The maximum size of the coarse aggregate, and the Fineness modulus of the fine aggregate are required by the ACI 211 design method for estimating the mixing water, and the bulk volume of the coarse aggregate, respectively.

**Apparatus**

Balances accurate to 0.5 gram
Set of standard mesh sieves
Shovel
Scoop
Sample splitter
Mechanical shaker (optional)
Oven

**Procedure**

**Reference:** ASTM C702, ASTM C 136

*Use of Sample Splitter (Figure 2-1)*. Samples of fine aggregate should be reduced by means of a sample splitter. When splitting the aggregate, one half is set aside, and the other half is split again until the proper sample size is obtained. The sample should be free flowing for reduction with the sample splitter. Do not reduce the samples to an exact predetermined weight.

Figure 2-1 Sample Splitter

*Quartering Method of Reducing Sample..* Samples of coarse aggregate should be placed on a hard, clean surface or canvas blanket. Mix sample thoroughly by shoveling three times, then shovel the entire sample into a conical pile, one shovelful on top of the other. Flatten the pile by pressing down on the pile with the shovel. Mark the flattened mass into quarters by two intersecting lines at the center of the pile. Remove the aggregate from two diagonally opposite quarters and brush the cleared spaces. Mix and quarter the remaining sample until the sample is reduced to the desired size.

*Test Sample Weight.* Obtain a sample of fine aggregate that will weighs approximately 500 grams after drying. Coarse aggregate weights vary depending upon maximum coarse aggregate size. It is recommended to use larger than 16 in. Diameter sieves for coarse aggregate. Table 4-1 lists Minimum weights to be used.

Table 4-1

| Nominal Maximum Size , inches | Minimum Sample Weight, lbs. |
|---|---|
| 3/8 | 2 |
| 1/2 | 4 |
| 3/4 | 11 |
| 1 | 22 |
| 1 1/2 | 33 |
| 2 | 44 |

*Test Procedure.* Perform the test once for fine aggregate and once for coarse aggregate*.

1. Use oven dried sample prepared previously by instructor. Weigh the sample and record weight above Table 2-2. Fill out technician, date of test, and sample description.
2. Stack sieves in descending order
   Fine Aggregate: 3/8",No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, and Pan;
   Coarse Aggregate: 1 ½", 1", ¾", ½", 3/8", No. 4, no 8 and Pan.
3. Record sieve sizes and openings in Column 1 and 2 of Table 4-2.
4. Place the sample in the top sieve and cover. Agitate the sieves by hand or by means of mechanical agitation for 5 minutes.
5. Transfer particles retained on top sieve tray to a tared dish or pan. Work out the particles wedged in the mesh with a brush or thumbnail and push them back toward the direction they came. Do not use hard objects or bang on the screen. Use fine bristle brushes for sizes #100 to #30, and coarse bristle brushes for #16 and higher.
6. Weigh the aggregate to the nearest 0.1 gram and record this weight in Column 3 of Table 4-2 as having been retained on the sieve size from which it was removed.
7. Follow steps 4 and 5 for each sieve. When completed, the sum of all the weights should equal the initial total weight within 0.3% for acceptance testing.
8. Calculate the percent retained as indicated and enter in Column 4 of Table 4.2.
9. Calculate cumulative percent retained and percent passing and enter in Columns 5 and 6, respectively.

* ***use of spreadsheet greatly facilitates and speeds this analysis***

**Report**

1. Plot on semi-log paper: percent passing versus opening size (Column 6 over. Column 2) for both fine and coarse.
2. Determine the nominal maximum size, calculate the coefficient of uniformity, coefficient of curvature, and fineness modulus for both the fine and course aggregate. Precision for the coefficients should be to the nearest 0.1 and 0.01 for fineness modulus.
3. Turn in a completed report according to the requirements listed in Lab Session 1

**Requirements**

1. For use in concrete Fineness modulus must be no less than 2.35 and no more than 3.04
2. Not more than 45% of the sand may be retained between two consecutive sieves
3. Cumulative sample weight after testing must be within 0.3% of original sample weight for acceptance.

Note: Each lab group will perform a sieve analysis on fine aggregate. A sample of coarse aggregate will be tested using larger sieve sizes and data will be shared for each group. The report should cover both fine and coarse aggregate.

Table 4-2

# Fine Aggregate Sieve Analysis
# Particle Size Distribution

**Technician________________** **Date of Test______________**
**Sample Description____________________________________________**
**Initial Sample Weight, ISW_____________grams**

| Sieve # | Opening (mm) | Mass before P (g) | Mass after Q (g) | Weight Retained W = Q-P (g) | Percent Retained %Ret = W/isw x 100 | Cumulative Percent Retained | Percent Passing |
|---|---|---|---|---|---|---|---|
| 4 | | | | | | | |
| 8 | | | | | | | |
| 16 | | | | | | | |
| 30 | | | | | | | |
| 50 | | | | | | | |
| 100 | | | | | | | |
| pan | | | | | | | |
| TOTALS | | | | | | | |

Table 4-3

# Coarse Aggregate Sieve Analysis
# Particle Size Distribution

**Technician**_______________

**Date of Test**_____________

**Sample Description**_____________________________________________

**Initial Sample Weight**____________

| Sieve # | Opening (mm) | Mass before P (g) | Mass after Q (g) | Weight Retained W = Q-P (g) | Percent Retained %Ret = W/isw x 100 | Cumulative Percent Retained | Percent Passing |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| # 4 | | | | | | | |
| # 8 | | | | | | | |
| pan | | | | | | | |
| TOTALS | | | | | | | |

# Testing of Aggregates for Use in Concrete

## Motivation: Aggregate Properties Needed for ACI 211 AVM Design

The results of the aggregate testing are summarized in Table 1

**Table 1: Values Chosen for Design**

| | Selected Value |
|---|---|
| Max Size | |
| Fine Modulus | |
| CA DRBD | |
| CA RD | |
| FA RD | |
| CA Moist % | |
| CA Abs % | |
| FA Moist % | |
| FA Abs % | |

## Details of your Testing

Write the procedural sections in the past tense, in sequential order, for a more authoritative tone, mix with references to particular sections of ASTM standard.

Aggregate Sampling Methods,
- Procedures ASTM D75, C702
- Significance of methods
- Detail equipment and procedure

Dry-Rodded Bulk Density, Void %,
- Procedure**:** C 29
- Where used in concrete design (serves like small intro)
- Detail equipment and procedure
- Values Measured G, T, V
- Computation M, Void %
- Results of interest, reported to appropriate level of precision

Coarse aggregate SG, Moist %, Abs % Coarse
- Procedure: C 127, C566
- Where used in concrete design
- Detail equipment and procedure
- Values Measured A, B, S
- Relative Density and Moisture Computations
- Report to appropriate level of precision

SG Fine, Moist % Fine, Abs % Fine
- Procedure: C 128, C566
- Where used in concrete design
- Detail equipment and procedure
- Values Measured A, B, C
- Relative Density and Moisture Computations
- Report to appropriate level of precision

CA Max Aggregate Size, Fineness Modulus
- Procedure: C 136
- Where used in concrete design
- Detail equipment and procedure
- Values Measured for Coarse and Fine Aggregates: weights on each sieve
- Computations % Recovery, % Retained, Cumulative % Retained, % Passing, Fineness Modulus
- Report to appropriate level of precision

## Other Results

Other Groups Results for values of interest
Reference Values
Table 2 Values for Evaluation

**Table 2**

| | Group 1 | Group 2 | Group 3 | Reference: | Selected Value |
|---|---|---|---|---|---|
| Max Size | | | | | |
| Fine Modulus | | | | | |
| CA DRBD | | | | | |
| CA RD | | | | | |
| FA RD | | | | | |
| CA Moist % | | | | | |
| CA Abs % | | | | | |
| FA Moist % | | | | | |
| FA Abs % | | | | | |

(Selected Values taken from Table 2 form Table 1)

## Conclusions

Discussion of Table 1
Reasons for selecting each selected value
Suitability of the selected values for ACI 211 design purposes
General observations on ASTM testing

## Appendix

raw data
worksheets

# Laboratory Session 5

---

# Concrete Mixing

## Fresh Concrete Properties

**Scope of work**

1. To gain hands-on experience mixing. casting, and curing concrete following your designs, and ASTM C 192 Standard for laboratory mixing.
2. To determine the Temperature, slump, unit density, Gravametric air %, Pressure air %, of your concrete mixes using appropriate standards
3. To then compare the class values with the ACI 211 design expectations for a general evaluation of the method.
4. To gain verbally expressive hands-on experience with the ASTM standards in preparation for the ACI Level I Field Technician practical examination.

    (The samples will be tested for their hardened properties in a subsequent laboratory exercise.)

## MIX DESIGNS

| | UNIT | PER CUBIC YARD | PER CUBIC FOOT | PER MIX VOLUME |
|---|---|---|---|---|
| WATER | lb | | | |
| CEMENT | lb | | | |
| FINE AGG | lb | | | |
| COARSE AGG | lb | | | |
| ADMIXTURE | ml | | | |
| SUM OF WEIGHTS | | | | |

| | UNIT | PER CUBIC YARD | PER CUBIC FOOT | PER MIX VOLUME |
|---|---|---|---|---|
| WATER | lb | | | |
| CEMENT | lb | | | |
| FINE AGG | lb | | | |
| COARSE AGG | lb | | | |
| ADMIXTURE | ml | | | |
| SUM OF WEIGHTS | | | | |

| | UNIT | PER CUBIC YARD | PER CUBIC FOOT | PER MIX VOLUME |
|---|---|---|---|---|
| WATER | lb | | | |
| CEMENT | lb | | | |
| FINE AGG | lb | | | |
| COARSE AGG | lb | | | |
| ADMIXTURE | ml | | | |
| SUM OF WEIGHTS | | | | |

## MIXING AND CURING PROCEDURES

# 1) Mixing Procedures

**Apparatus:**
Mixing Pan
Shovels
Hoes

**Materials**:
Cement
Fine Aggregate
Coarse Aggregate
Water

**Reference:** ASTM C 192

1. Mix cement and fine aggregate without water
2. Add coarse aggregate and mix thoroughly
3. Add water and mix until homogeneous

# 2) Temperature Measurement

**SCOPE OF WORK**

To determine the temperature of freshly mixed Portland cement concrete

**APPARATUS**

Nonabsorptive container
Temperature Measuring Device

**MATERIALS**
Freshly mixed PCC

**PROCEDURE**

**Reference:** ASTM C 1064

1. The temperature of the freshly mixed concrete may be measured in the transporting equipment used during sampling procedures.
2. Ensure 3 inches of concrete cover in all directions surrounding the temperature measuring device.
3. Place the temperature measuring device in the concrete a minimum of 3 inches and gently press the concrete around the device so that ambient air temperature does not affect the reading.
4. Leave the temperature measuring device in the freshly mixed concrete for a minimum of 2 minutes or until temperature reading stabilizes.

5. Read and record the temperature.
6. Complete the temperature measurement within 5 minutes of obtaining the sample.

**REPORT**

1. Complete the ACI Workbook Sample Questions pertaining to this test method.

# 3) SLUMP DETERMINATION

**SCOPE OF WORK**

To determine the slump of hydraulic-cement concrete both in the laboratory and in the field and provide experience in performing the method.

**APPARATUS**

Slump cone mold
Tamping rod
Mold base
Ruler

**MATERIALS**

Minimum of 0.25 $ft^3$ of freshly mixed PCC

**PROCEDURE**

**REFERENCE:** ASTM C 143

1. Premoisten the cone mold and place it base down on the mold base. Secure it with the side clamps to allow free hand operation.
2. Fill the mold with freshly mixed concrete in three separate layers, each approximately 1/3 of the volume of the mold.
3. Rod each layer 25 times uniformly over the surfaces using the hemispherical tipped tamping rod. The second and third layers should be rodded so that the strokes just penetrate the underlying layer.
4. Once rodding is completed, strike off any excess concrete with a sawing motion of the tamping rod in forward motion.
5. Clear any excess concrete around the base of the mold taking care not to touch the cone mold.
6. Remove the side clamps and slowly lift the mold (5 +/- 2 secs).
7. Raise the base mold handle to the upright position over the slumped concrete.
8. Measure the slump by taking a ruler from the bottom of the handle to the original displaced center.
9. Read and record the slump to the nearest ¼”

# 4) DENSITY AND YIELD

**SCOPE OF WORK**

To determine the density in pounds per cubic foot of concrete, and the yield in cubic feet converted to cubic yards.

**APPARATUS**

Balance accurate to 0.10 lb
¼ $ft^3$ measure
Tamping Rod
Strike off plate made of glass, metal or plastic
Mallet

**MATERIALS**

Minimum of 0.50 $ft^3$ of freshly mixed PCC

**PROCEDURE**

**REFERENCE:** ASTM C 138

1. Weigh and record the weight of the empty measure onto Table 6-1.
2. Dampen the inside of the measure and fill it with concrete in three layers. Compact each layer with 25 strokes of the tamping rod. The second and third layers should be rodded as to penetrate the previous layer slightly. The third layer should slightly overfill the measure.
3. After each layer, the measure should be tamped smartly with a mallet 10-15 times.
4. Strike off the excess concrete and finish it smooth with the flat strike off plate. The best practice is to place the plate so that it covers about 2/3 of the surface withdraw the plate in a sawing motion. Then place the plate back at the two-thirds mark and apply pressure in a forward direction and apply a sawing motion. Several final strokes with the inclined edge of the plate will produce a smooth surface.
5. Clean off any excess concrete from the measure and weigh
6. Calculate Unit Weight, $lbs/ft^3$ = Net Weight of Concrete, **W**/ Volume of Measure
7. Calculate Yield, $ft^3 = W_1/W$; Yield, $yd^3 = W_1/(27*W)$
   Where: $W_1$ = sum of batch weights for design
8. Calculate Gravametric Air Content A=[(T-W)/T] x 100

TABLE 5-1

# UNIT WEIGHT AND YIELD DETERMINATION RESULTS

| Procedure | Rodding |
|---|---|
| Total Weight, lb | |
| Tare Weight, lb | |
| Sample Weight, lb | |
| Volume of Container, $ft^3$ | |
| Unit Weight, $lb/ft^3$ **W** | |
| Σ of Batch Weights, lbs **WI** | |
| Theoretical Weight (from design) lbs | |
| Yield, $ft^3$ Yf = WI / W | |
| Yield, $yd^3$ | |
| Grava. Air Content A = [(T-W) / T] x 100 | |

# 5: Air Content Determination: Pressure Method

**SCOPE OF WORK**

To perform the test method for determining air content using the pressure air meter

**APPARATUS**

Type A or Type B Pressure Air Meter
Rod
Scoop
Strike Off Bar/Plate
Balance accurate to 0.5 grams

**MATERIALS**

Utilize measure + concrete from Laboratory 6A
Water at room temperature

**PROCEDURE**

**Reference:** ASTM C 231

**Type B Meter:**

1. Fill the measure with three layers, 25 rods per layer, mallet between each layer for consolidation. Screed off top layer and clean the edge of bowl for a tight seal.
2. Dampen the cover assembly and ensure that the pressure tight seal is clean.
3. Assemble the apparatus.
4. Close the air valve between the air chamber and measure.
5. Open both petcocks.
6. Inject water using rubber syringe through one petcock until water emerges from the opposite petcock. Jar the meter gently until all air is expelled from this same petcock.
7. Close the airbleeder valve on the air chamber and pump air into the air chamber until gage hand is on initial pressure line.
8. Stabilize the gage hand at the initial pressure line by pumping or bleeding off air as necessary while tapping the gage lightly.
9. Close both petcocks.
10. Open the air valve between the air chamber by pressing your thumb on the tab.
11. While pressing the air valve, tap the sides of the measure with the mallet and tap the pressure gage lightly with your hand to stabilize.
12. Read the percentage of air on the dial gage.

13. Calculate Air Content, % = (Reading from Dial Gage – Aggregate Correction Factor)
    a. Aggregate Correction Factor will be given or assumed in class
14. Release the pressure by opening both petcocks before removing the cover

**REPORT**

1. Complete the ACI Workbook Sample Questions pertaining to this test method.

# 6) AIR CONTENT DETERMINATION: VOLUMETRIC METHOD

**SCOPE OF WORK**

To perform the test method for determining air content using the volumetric air meter

**APPARATUS**

Volumetric Air Meter (Roll-A-Meter)
Metal Funnel
Tamping Rod
Strike Off Bar
Metal measuring cup
Rubber syringe
Scoop

**MATERIALS**

Freshly mixed PCC
Isopropyl Alcohol
Water at room temperature

**PROCEDURE**

**REFERENCE:** ASTM C 173

1. Fill the bottom measure of the air meter with three layers of concrete. Rod each layer 25 times equal depth. Tap the sides of the bowl 10-15 times with a mallet between each layer.
2. Strike off excess concrete with strike off bar until surface is flush with edge of bowl
3. Wipe the sides and top of flange on the measure
4. Clamp the top of air meter to the measure. Insert the metal funnel into the top and add atleast 1 pint of water and a selected amount of alcohol (See note 2 in astm C173) until it is visible in the neck of the top. Remove funnel and add water with syringe until reaches calibration mark.

5. Attach and tighten screw cap
6. Quickly invert the meter, shake the base and return meter to upright position.
7. Invert and agitate until concrete is mixed thoroughly (minimum 45 seconds)
8. Tilt air meter 45 degrees and rock and roll on a hard surface for approximately 1 minute. Set the air meter upright and allow it to stand while air rises to the top and stabilizes.
9. Repeat the rocking and rolling procedure until two consecutive readings do not change by more than 0.25% after stabilizing.
10. Make a reading of the liquid at the bottom of the meniscus to the nearest 0.25%.
11. Calculate Air Content according to section 8.
    a. when less than 2.5 pt of alcohol is used, the final air meter reading is the air content of the sample tested.
    b. when 2.5 pt or more alcohol is used, subtract the correction from table 1 from the final meter reading to obtain the air content.
    c. if it was necessary to add calibrated cups of water to obtain a reading, add the number of cups recorded to the air content.

**REPORT**

# 7) CONCRETE CYLINDERS

**SCOPE OF WORK**

This practice covers the procedures for making and curing cylinder specimens from representative samples of fresh concrete for a construction project.

**APPARATUS**

Plastic 6 x 12 Molds
Tamping Rod
Sampling Receptacle
Scoop
Trowel

**MATERIALS**

Minimum 1 cubic foot of freshly mixed PCC

**PROCEDURE**

**REFERENCE:** ASTM C 31

1. Fill the cylinder mold with three equal layers of concrete. Rod each layer 25 times with the rounded end of the tamping rod before adding the next layer. The rod should penetrate about 1 in. into the underlying layer. with an open hand, Lightly tap the sides of the cylinder mold to close voids left by rodding.

2. Strike off the top surface of the concrete with the tamping rod or trowel, and finish the concrete surface by troweling.
3. Mark the side of the cylinder mold with group number and number identifying the concrete batch.
4. Cover the cylinders with plastic caps or wet burlap overlaid with polyethylene film.
5. Due to the short lab session, allow the students to practice with the other test methods for their ACI certification and ask questions of the students to test their knowledge.

Table 5-

# Summary of Results

| **Property** | **Unit** | **Expectation** | | | | |
|---|---|---|---|---|---|---|
| Temperature | ° F | | | | | |
| Slump | inches | 3-4 inch | | | | |
| Unit Weight, $W_l$ | lb/ft$^3$ | | | | | |
| % Air | % | | | | | |
| Compressive Strength 28-day $f_c$’ | psi | | | | | |
| Splitting Strength, $f_t$ | psi | | | | | |
| Modulus of Elasticity, E | psi | | | | | |
| 7-day strength $f_7$’ | psi | | | | | |
| lb cement cubic yard, pccy | lb | | | | | |
| Cement efficiency $f_c$’/pccy | psi/lb | | | | | |

3.

4. How can the lack of workability be corrected in a concrete mix?

5. give three instances in which the workability of concrete is a consideration in mix design?

6. Give a definition of air content percentage?

7. do all the air content methods require aggregate correction factors? why or why not?

8. what would be the advantage of using smaller size cylinders for testing?

9. which air method – volumetric, pressure method, or gravimetric would you assume to be the most accurate? why?

# Laboratory 6
# Testing of Hardened Concrete

**Scope of Work**:

1. To qualify cylinders for testing
2. To observe the various ways the ends can be treated
3. To understand how to measure the compressive strength of concrete
4. To evaluate the ACI 211 design procedures
5. To understand how to measure the splitting tensile strength of concrete
6. To compare the splitting tensile to the compressive strength
7. To understand how to measure the Modulus of Elasticity, E, of concrete
8. To compare measured E with standard equation from Building Code

**Apparatus**:

1. Square and feeler gages (C 39)
2. Unbonded Caps (C 1231)
3. Concrete Cylinder Compression Testing Machine (C 39)
4. Splitting Tension Fixtures (C 496)
5. Compressometer (C 469)

**Procedure**: Cylinder Compressive StrengthTesting

Test three cylinders, one after completing C 469.

**Reference: ASTM C 39, C1231, C617**

1. Measure the diameter, D, of your specimens to assure they meet the standards of Section 6 of ASTM C 39. From D, compute A, the area, needed to compute the compressive strength, $f_c$.
2. Measure the surface irregularities, perpendicularity and squareness of the samples to assure they meet the standards of Section 6 of ASTM C 1231
3. For your size specimen, compute the loading rate range (thousands of pounds per minute) needed to keep within the 20-50 psi/sec required in Sec. 7 of C39.
4. Review instructions for QC-50 and TA-1248
5. With no cylinder in the machine, practice makeing the piston move up and down. Reset the display to zero.
6. Set-up, reading live load. Center the lower unbonded cap onto the testing machine platen, rubber up. Place the test cylinder into that cap, then place the other cap rubber down onto the top of the cylinder.
7. Keeping the top and bottom centered in the machine, close the gap and apply a small load of several thousand pounds.
8. Continuously and smoothly apply additional load, within the prescribed range, until failure.
9. Read and record Max load, and type of failure.
10. Compute compressive strength P/A.
11. Record the design goal, and actual strength of all groups

| | | Table 6-1 Compression Testing Data | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | D | A | P | $f_c$ | Design f | Difference | % Diff | Failure Type |
| 1a | | | | | | | | |
| 1b | | | | | | | | |
| 1c | | | | | | | | |
| **1avg** | | | | | | | | |
| 2a | | | | | | | | |
| 2b | | | | | | | | |
| 2c | | | | | | | | |
| **2avg** | | | | | | | | |
| 3a | | | | | | | | |
| 3b | | | | | | | | |
| 3c | | | | | | | | |
| **3avg** | | | | | | | | |
| 4a | | | | | | | | |
| 4b | | | | | | | | |
| 4c | | | | | | | | |
| **4avg** | | | | | | | | |

## Instructions for Forney QC-50 Hydraulic Cylinder Testing Frame

Lever 1, small knob, swings horizontally, regulates the loading rate from zero at A to max at B
Lever 3, the big knob, swings vertically, controls loading or unloading

For Loading: Turn pump motor switch on. Set lever 3 to load position, move lever 1 towards position B until the desired loading rate is achieved, feather lever 1 to keep within loading rate range until failure.

**<u>Do not operate the pump above the platen limit line!</u>**

To Unload: Turn off pump motor, move lever 3 to unload position, move lever 1 to midrange

## Instructions for Forney TA-1248 Electronic Load Display:

**The following buttons are used when testing concrete cylinders:**

**DSP** Switches display between Live Load, Max ($_{max}$), and Loading Rate ($_{TOT}$) ($1.00_0$ = 1000 lb/min)

**F1** **Resets Max** Load Memory

**RST** **Zeros the live load** display. (reset with no sample)

The other buttons are not used for testing.

To test usually: **Check live load zero** with no specimen
Reading live load, **Apply** seating load of between 1000-2000 lbs**,**

Reading the loading rate, **Smoothly apply test load**, keeping between 20 and 50 psi/sec (display is in thousands of pounds per minute), until failure, then
Reading Max, **Record** maximum load.
**Remove** the broken specimen
**Compute** the compressive strength

**Procedure**: Split Tension Testing

**Reference: ASTM C 496**

1. Measure the diameter, D, and the length, L, of the specimen.
2. Place specimen in marking frame and scribe alignment lines on the top and bottom of the cylinder.
3. With the alignment lines up&down, place and center, front-to-back and side-to side, the cylinder into the splitting-tension testing in the machine.
4. Roll the cylinder to the side enough to slip the 1x12 inch plywood strip under the cylinder so that the alignment lines center on the wooden strip, both front and back.
5. Turn-on the machine, move the lever on the left to the loading position and using the rate-control lever, advance the piston until load is applied.
6. Apply the load at the specified rate until failure.
7. Record the maximum load, P, on Table 6-2.
8. Compute $f_t = 2P/\Pi LD$, Enter on Table 6-2
9. Record also the splitting tensile, and compressive strength of the other groups.

| | | **Table 6-2** | **Splitting-Tension** | | **Testing Data** | |
|---|---|---|---|---|---|---|
| | **P** | **L** | **D** | **$f_t$** | **$f'_c$** | **ft/f'c %** |
| 1a | | | | | | |
| 1b | | | | | | |
| **1avg** | | | | | | |
| 2a | | | | | | |
| 2b | | | | | | |
| **2avg** | | | | | | |
| 3a | | | | | | |
| 3b | | | | | | |
| **3avg** | | | | | | |
| 4a | | | | | | |
| 4b | | | | | | |
| **4avg** | | | | | | |

**Instructions for SoilTest Dual-Dial Hydraulic Cylinder Testing Frame**

Lever on left has three positions, Neutral, in the middle, Load, lever down, and lever up, Release. Lever with small knob in middle controls the loading rate, fully clockwise to the left is closed with no piston motion, fully counterclockwise to the right, the piston moves as fast as possible (no need to turn silver knob). Setting-up favors the right, testing the left. The buttons on the right turn the machine on and off.

**Do not operate electric pump in Release position while piston is fully down!**

**Procedure**: Modulus of Elasticity Testing
**Reference: ASTM C 469**

1. Place specimen in marking frame used for ASTM C 496 and scribe alignment lines on the top and bottom of the cylinder, and using a ruler, along the sides coincident with the lines on the top and bottom. Turn the cylinder over until the lines on the top and bottom line-up again, then again using a ruler scribe another line, diametrically opposite the line already drawn. Mark the central 6 inches of the cylinder along the axial lines (don't measure from the ends).
2. Attach the compressometer to the specimen, making sure the two upper compressometer screws align with the marks on the side of the cylinder, in the central part of the cylinder.
3. Place the lower unbonded cap into the machine, place the cylinder and compressometer into the cap, then fit the top cap in place.
4. Load the specimen to approx 40% of the maximum expected compressive load, then unload almost to about 500 lbs. Use this compressometer dial reading for strain equal to zero.
5. Carefully reapply load until the dial gage reads a deflection equal to 0.0005 strain, record the load into Chart 6-3.
6. At the specified rate load the specimen to 40% of fc, (fc needs to be known) record the deflection, compute the strain and enter in into Table 6-3.
7. Compute the slope between the two points (0.00005, $P_{0.00005}/A$), ($e_{40\%fc}$, $P_{40\%fc}/A$) to determine E.

$$E = \frac{(\sigma_{40\% fc} - \sigma_{\varepsilon=0.0005)})}{(\varepsilon_{40\% fc} - 0.00005)}$$

8. Enter into Table 6-3.
9. Using the simple equation $E = 57000\sqrt{f_c^{'}}$ from ACI 318, compute E and enter into Table 6-3. Compare with measured value.

| Table 6-3 Modulus of Elasticity Testing Data | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Design $f_c^{'}$** | **$P_{0.00005}$** | **$e_{40\%fc}$** | **$P_{40\%fc}$** | **(e, 40%fc)** | **E** | $E = 57000\sqrt{f_c^{'}}$ | **% diff** |
| 3000 | | | | | | | |
| 4000 | | | | | | | |
| 5000 | | | | | | | |
| 6000 | | | | | | | |

Questions

1. ACI 211 was used to design the mixes for this experiment. What is your evaluation of this method? Did your results turn-out as expected? How well did the other groups achieve their design goals?

2. What were your mix proportions? Show the step-by-step detailed ACI 211 design, for values taken tables or charts, reference the table or chart with the selected value.

3. On average, how well did the absolute volume method meet the design goals, i.e., slump, air and strength (consider the results from all groups for slump, air, and strength)? If you did not meet your goals how would you modify the mix for the next trial batch? (apply step 9)

   How well did the other groups meet their design goals, i.e., slump, air and strength (consider the results from all groups for slump, air, and strength)?

   Evaluate, overall, how well ACI 211 was able to produce a first trial batch. Was it easy to understand and use?

4. What percentage of the real 28-day strength was developed by the 7$^{th}$ day? (By the first day?)

5. What was the relationship between the Splitting Tensile Test ($f_f'$) and the Compressive Strength ($f_c'$)? (Consider $f_t'/ f_c'$ for all mixes)? What was the average percentage? How does this compare to reference values for the tensile strength of concrete?

6. How well did the Forced Resonance Method of ASTM C 215 predict the actual E value?

7. How well did the ACI equation for the modulus of elasticity: $E = 57000\sqrt{f_c'}$ predict the actual Modulus of Elasticity?

# Testing of ACI 211 for Concrete Design

**Motivation: Test the accuracy of ACI 211 AVM design. Does it work? If 4500 psi concrete is designed, does 4500 psi concrete result?**

**Method: Compare AVM design results to actual results**

## Experimental Design Details

Detailed ACI 211 Absolute Volume Method Design
9 steps to concrete design

Other ACI Predictions
Tension strength, Modulus of Elasticity, Dynamic Modulus
Fresh concrete testing
Hardened concrete testing, Non-Destructive Testing

## Testing Details

**ACI 211 Absolute Volume Method Design** for your mix
Significance of method
Values needed for design taken from pervious testing

**Table 1: Values Chosen for Design**

| | Selected Value |
|---|---|
| Max Size | |
| Fine Modulus | |
| CA DRBD | |
| CA RD | |
| FA RD | |
| CA Moist % | |
| CA Abs % | |
| FA Moist % | |
| FA Abs % | |

Enumerate the 9 steps in detail, cite values from tables with neat computations.
Conclude with table showing amounts of materials.

| | Wt per cu. yd. | Wt per cu. ft. | Batch Wt |
|---|---|---|---|
| Water | | | |
| Cement | | | |
| Coarse Agg | | | |
| Fine Aggregate | | | |

**Check then Mix**

**Fresh Concrete Testing**
Temperature, C 1064
Slump, C 143
Air, C 231
Yield, C 138
Making and curing cylinders, C 31

**Hardened Concrete Testing**
Compressive Strength, C 39. C1231
Splitting Tensile Strength, C 496
Modulus of Elasticity, C 469

## Other Results

# Measured Concrete Properties

| Property | Unit | Expectation | 3000 | 4000 | 5000 | 6000 |
|---|---|---|---|---|---|---|
| Slump | inches | **3-4** inch | | | | |
| Unit Weight | $lb/ft^3$ | | | | | |
| % Air Pressure | | | | | | |
| % Air Gravemetric | % | | | | | |
| Yield | | **1** | | | | |
| Compressive Strength 1-day | psi | | | | | |
| Compressive Strength 7-day | psi | | | | | |
| Compressive Strength 28-day | psi | | | | | |
| Splitting Strength | psi | | | | | |
| Modulus of Elasticity | psi | | | | | |
| Lb. cement cubic yard | pounds | | | | | |
| Cement efficiency = psi/lb.cement cu. yd. | psi/lb. | | | | | |

## Conclusions

Discussion of Table 2
Suitability of ACI 211 for design purposes. On average how close does the method come to producing the expected values?
General observations on ACI 211design and concrete property testing procedures

## Questions (Answer in narrative form in general observations section of conclusions.)

1. ACI 211 was used to design the mixes for this experiment. What is your evaluation of this method? Was it easy to understand and use? How did your results turn-out?
2. What were your mix proportions? Show the step-by-step detailed ACI 211 design, for values taken tables or charts, reference the table or chart with the selected value.
3. On average, how well did the absolute volume method meet the design goals, i.e., slump, air and strength (consider the results from all groups for slump, air, and strength)? If you did not meet your goals how would you modify the mix for the next trial batch? (use cement effieiency to adjust strength, and advise of Step 9, section 6.3.9. for adjustment of slump and air)

   How well did the other groups meet their design goals, i.e., slump, air and strength?

   Evaluate, overall, how well ACI 211 was able to produce a first trial batch, generally high, low, or what?
4. What percentage of the 28-day strength was developed by the 7th day? (By the first day?)
5. What was the relationship between the Splitting Tensile Test ($f_f'$) and the Compressive Strength ($f_c'$)? (Consider $f_t'/f_c'$ for all mixes)? What was the average percentage. How does this compare to reference values for the tensile strength of concrete?
6. How well did the Forced Resonance Method of ASTM C 215 predict the actual E value?
7. How well did the ACI equation for the modulus of elasticity: $E = 57000\sqrt{f_c'}$ predict the actual Modulus of Elasticity? How well did the E value predict the Strength?

# Laboratory 7
# Admixtures and Fibers

**Scope of Work**:
1. To study the effects of various admixtures and fibers on the density (unit weight), air content, slump, and strength of concrete cylinders.
2. To gain additional practice applying and explaining the ASTM tests for slump, density, air %, and strength.

**Apparatus**:
1. Basic concrete constituents
2. Air entraining agent, high-range water-reducer, steel fibers, polyfibers
3. 2 ½ Cubic Foot Concrete Mixer
4. Thermometer
5. Slump Cone w/paraphernalia
6. 100 lb. Scale
7. Pressure Air Meter w/paraphernalia
8. 20 4x8 inch cylinder molds w/paraphernalia
9. Cylinder testing machine w/paraphernalia

**Reference**: ASTM C 1064, C 143, C 138, C 238, C 31, and C 39

**Procedure**:
1. Produce about 1.6 cubic foot of the base concrete mix by combining **20.2** lbs. Water, **35.35** lbs. Cement, **105** lbs. ¾ coarse aggregate, and **73.77** lbs. sand. After thorough mixing, test and recite the slump, Fresh unit weight, and pressure Air %. Record results in Table 7-1. Make four 4 x 8 inch concrete test cylinders.

**Table 7-1**

| | Temp deg F | Slump inches | Unit Wgt lbs. cft | Presh Air% | Strength psi |
|---|---|---|---|---|---|
| Base mix | | | | | |
| AEA | | | | | |
| HRWR | | | | | |
| Polyfibers | | | | | |
| Steel fibers | | | | | |

2. Add **9** ml (1oz/cwt). air entraining agent to the remaining concrete and mix for two minutes. Test and recite slump and air % again to establish the effect of the AEA. Record results in Table 7-1. Make four more 4 x 8 inch concrete test cylinders. Did the concrete behave any differently than the base mix? Record your observations.
3. Add **37** ml (5 oz/cwt) HRWR to the batch and mixed again for a couple of minutes. Test and recite slump and air % one more time to establish the effect of the HRWR. Record results in Table 7-1. Make 4 more 4 x 8 inch concrete test

cylinders. Did the concrete behave any differently than the previous mixes? Record your observations.

4. Add **1.35** lbs.(2% of remaining volume) polyfibers to the remaining concrete, and mix once more for several minutes. Test and recite the slump and air % once again to establish the effect of the polyfibers. Record results in Table 7-1. Make 4 more 4 x 8 inch cylinders. Did the concrete behave any differently than the previous mixes? Record your observations.
5. Finally, add **6.53** lbs. (2% of remaining volume) steel fibers to the remaining concrete, and mix for the last time for a couple of minutes. Slump and air % will be tested and recited again to establish the effect of the steel fibers. Record results in Table 7-1. Make 4 last 4 x 8 inch cylinders and a 6x12 inch cylinder. Did the concrete behave any differently than the previous mixes? Record your observations.
6. Clean-up thoroughly, paying particular attention to the back side of the mixer blades.
7. After allowing the concrete to fully cure, test the strength of the various batches. Record results in Table 7-1.

**Analysis**:
Make five plots: the Temperature, the Slump, the Fresh Unit Weight, the Air %, and the Strength at each step.

**Questions**:
1. Check the computations for the admixture and fiber dosages. Are they correct? If you can not answer specifically, how would you figure this out?
2. What assumptions were made in this experiment that might affect the outcomes? (think about water, and time)
3. How did the addition of the AEA affect the mix?
4. How did the addition of the HRWR affect the mix?
5. How did the addition of the steel affect the mix?
6. How did the addition of the Steel fibers affect the mix?
7. Do some research (at least look into the ACI ***Manual of Concrete Practice***, on the web, or in the library, or PCA's ***Design and Control of Concrete Mixes,***) with proper citation, into the effects of admixtures and fibers on concrete. Did the experimental results agree with your readings?
8. What general and specific conclusions about the effects of admixtures on concrete can be made?
9. Under what circumstances might one recommend using each, or a combination, of these additions to concrete?

# Laboratory 8
# Testing of Concrete Masonry Units

**Scope of Work**:

9. To determine the Net Effective Area Compressive Strength
10. To determine the Gross Area Compressive Strength

**Apparatus**:

6. Scale
7. Balance suitable for under water weighing
8. Compression Testing Machine

**Procedure**:

**Reference: ASTM C 140**

12. Measure the Length, Width, and Depth, L,W, D of your samples.
13. Measure the air weight of the specimens. Record into Table 1.
14. Measure the weight of the specimen under water Record into Table 1.
15. Compute the Density, the Net Volume, net area, and the Gross Areas
16. Review instructions for QC-50 and TA-1248 from Lab 6
17. With no sample in the machine, practice making the piston move up and down. Reset the display to zero.
18. Set-up, reading live load. Center the sample on the testing machine platen. (Caution: the top platen weighs 60 lbs. and care must be taken to handle carefully, and test with care to avoid dropping platen on feet.)
19. Checking that the top and bottom stay centered in the machine, close the gap and apply a small load of a few thousand pounds.
20. Continuously and smoothly apply additional load, within the 40-50 range, until failure.
21. Read and record Max load into Table 1.
22. Compute compressive strength P/Anet, and P/Agros.
23. Record the Values of Interest for all groups into Table 2.

**Table 1. Raw Data and**

| | | | |
|---|---|---|---|
| L | Length | | |
| W | Width | | |
| H | Height | | |
| A | Dry weight | | |
| S | Subm Weight | | |
| D | Density | A/(A-S) | |
| Vnet | Net Volume | A/D | |
| Anet | Avg. Net area | Vnet*1728/H | |
| Agros | Gross Area | LxW | |
| | | | |
| Pmax | Max Load | | |
| Net Area Comp Strength | Anet fc | Pmax/Anet | |
| Gross Area Compressive Strength | Agross fc | Pmax/Agross | |

**Analysis of Block Sample Testing**

| | Group1 | Group2 | Group3 | Avg. | |
|---|---|---|---|---|---|
| Apparent Density (not standard) | | | | | lb./cu.ft. |
| Net Area | | | | | sq.in. |
| Net Area Comp Strength | | | | | psi |
| Gross Area Compressive Strength | | | | | psi |

**Table 2. Values of Interest**

## Questions

1. **Explain the average net area.**
2. **Explain the difference between the compressive strength computed on the gross area and the net areas.**
3. **What values were found.**