FEDERAL UNIVERSITY OYE-EKITI

FACULTY OF ENGINEERING AND TECHNOLOGY

STRENGTH OF MATERIALS

DEPARTMENT OF CIVIL ENGINEERING

200 LEVEL LABORATORY

MANUAL

TABLE OF CONTENTS

PREPARING LABORATORY REPORTS

The guideline below is used to prepare laboratory reports.

i. **Title:** This section contains the title of the test, the nature of the test and the specification number used.

ii. **Scope of the test:** A brief statement of the purpose and significance of the test should be indicated.

iii. **Apparatus:** Equipments used should be briefly described.

iv. **Materials:** The materials used or tested should be described.

v. **Theory:** This section summarizes the test/experiment or it gives us an overview of what the test is all about.

vi. **Definitions and Process Terminology:** This section contains terminology and definition of specific words and test related terms.

vii. **Procedure:** Clearly and concisely list the procedure in the order the test is carried out.

viii. **Raw Data:** This section contains the raw data gotten from the test. All laboratory data shall be submitted in tabular form.

ix. **Calculations and Results:** Observations relating to the behavior of the materials should be included. All equations or formulas used should be clearly indicated. Calculations should be properly checked. The results of the test should be summarized in tabular or graphical form.

x. **Figures and Diagrams:** This section contains clear and concise diagrams and/or figures in accordance with the laboratory requirement. Figures including the equipment front and side views, parts and panels can be displayed in this section.

xi. **Discussion:** There should be included a brief discussion in which attention is drawn to the silent facts shown by the tables and diagrams. The test results should be compared with the standard values.

xii. **Conclusion:** Include modification procedures, calibration procedures and any additional information that will be helpful.

xiii. **References (if applicable):** Include references to any manuals, documents or textbooks used in compiling the reports.

STRENGTH OF MATERIALS EQUIPMENTS

i. **Cement Sampler:** This device is used for obtaining samples for inspection from cement packed in barrels.

ii. **Hand Trowels:** It is used for mixing cement or concrete. The most convenient sizes are five-inch, six-inch and ten-inch trowels.

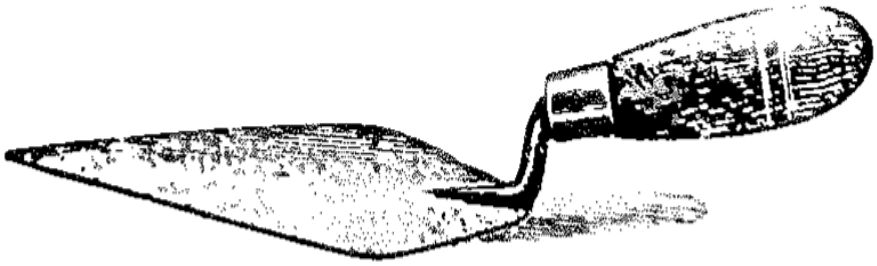

Fig. 8. — Mason's Trowel

iii. **Balances and Scales:** It is used for taking or measuring the weight of cement samples. E.g. Triple beam Balance, Digital Balance (Mettler Balance, Ohaus Balance Sartorius Balance, A & D Balance. Scientech Balance, MyWeigh Balance etc).

iv. **Measuring Glasses:** For the purpose of measuring the quantity of water to be used in making cement paste of mortar, a graduated cylinder is used.

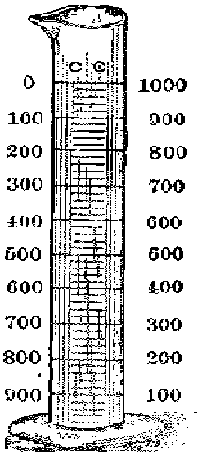

Fig. 13.—Graduated Cylinder

v. **Moulds:** Moulds ordinarily employed in making specimens for determining the tensile strength of cement are of two kinds: Individual moulds and Gang moulds.

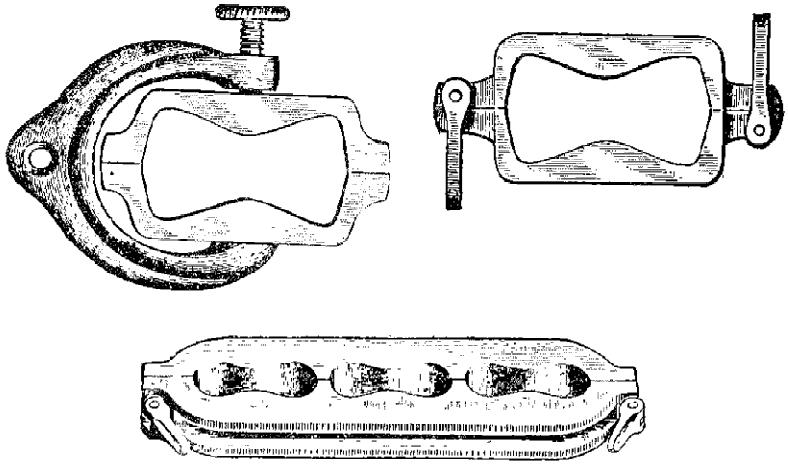

Fig. 17. — Briquette Molds

For the purpose of making specimens for compression tests of cement mortar, cube, beam or cylindrical moulds made of either cast iron or wood is used.

vi. **Universal Testing Machine (UTM WAW 2000B):** The UTM is used to test materials for the tensile strength and compressive strength. In addition, the UTM perform other tests like bending and shear tests. The UTM works on hydraulics employing the hydraulic system of pulleys and levers to move its machine parts.

Component Parts:

The machine is divided into three basic parts;

- Upper cross beam: This part of the machine is stationary.
- Motion cross beam: This part of the machine moves and its movement can be controlled with its control buttons (UP and DOWN). Its movement is clearly visible.
- Work bench: This part of the machine also moves but not like the motion cross beam. Its movement can only be noticed or seen on the scale attached to the UTM. It moves only during tests. The workbench also house important parts of the machine like the motor, hydraulic hose and chains etc.

DIAGRAM OF THE UNIVERSAL TESTING MACHINE (UTM WAW 2000B)

TENSILE STRENGTH TEST

Title: Tensile testing of metallic materials

Aim: The objective of this lab experiments is to incrementally load a steel bar till failure, while recording the value of the load and the change in length of the steel bar at each stage. Then based on the collected data,

- The material's stress-strain relationship is obtained.
- The following structural properties are determined: Modulus of elasticity, yield strength, ultimate tensile strength, failure strength and strain to failure.
- To determine the reduction of cross-sectional area.

Theory:

The most common material in construction besides concrete is steel. Concrete, though it has a high compressive strength, its tensile strength is usually much lower and mounts up to 8 – 12 % of its compressive strength. Steel, therefore, is used in concrete structural elements to bare tensile loads and bending moments.

The major components of steel are Iron and carbon which ranges between 0.01 and 1 percent. Sulfur, phosphorus, manganese, silicon and as much as 20 other alloys are present in steel and are added in various quantities to steel during its manufacturing process depending on the desired hardness, toughness and tensile strength of steel.

Reinforcing steel bars are usually manufactured in 3 different forms:
- Plain bars
- Deformed bars
- Plain & deformed wires

Plain Bars

Deformed Bars

Plain and deformed wires

The deformation in deformed steel bars is intended to increase the bonding between steel and concrete and to prevent slippage of the steel reinforcement bars.
Steel reinforcement bars are produced mainly with four different yield strengths, shown in the table below. The grade of steel indicates its yield strength in mpa.

Table showing Reinforcement Steel Strength

Type	σ_{yield} (psi)	σ_{yield} (MPa)	Grade
Type 1	40,000	300	40
Type 2	50,000	350	50
Type 3	60,000	400	60
Type 4	75,000	500	75

Apparatus:

- Universal Testing Machine (UTM WAW 2000B)
- Computer with MaxTest
- Extensometer
- Vernier Caliper
- Permanent marker
- Safety toolkit
- Ruler or measuring tape

Materials: Circular rod (Steel) with diameter ranging from 16mm to 70 mm

Procedure:

1. Label each specimen with your group's initials and an identification number (i.e., #1, #2, etc.) on each end.

2. Using the vernier caliper, take measurements of the length and the thickness and calculate the cross-sectional area.

3. Insert the work piece in between the jaws (upper and lower) of the UTM and tighten the jaws with the up and down clamp. Ensure that the work piece is held firmly between the jaws before you proceed.

4. Load the program “MaxTest” on the PC.

5. Set test type to “Tensile”.

6. Enter specimen information by first setting the MODE -> Analyse Mode. Next, under DATA, click on the “insert specimen information” to enter all the required details of your work piece like length, diameter and area.

7. Enter other parameters like Displacement, Speed, and Load to control the movement of the machine during operation and clear your values to zero to avoid negative readings before, during and after the test.

8. Set the MODE -> Test Mode to start test.

9. After failure, the machine will stop and return on its own if its set to “Stop while destroy” and “Auto return”, if not, stop the machine once failure occurs and the green arrow initially pointing upward, starts pointing downward. Click on the return button on “MaxTest” to return the machine to its original state.

Note: Remember to power off the machine after the test by clicking on the small red button on the control panel and open the “Oil Home Valve”. Use the big red button for emergency stopping of the machine in case of accident.

Analysis and Results:

- Plot the stress-strain curve and analyze the graph.
- Determine yield strength σ_{yd}, using the 0.2% offset method.
- Calculate (or use your stress-strain plot) the ultimate tensile strength.

$$\sigma_{t,ult} = P_{max} / A_0$$

Where:

$\sigma_{t,ult}$ = ultimate tensile strength, MPa (psi)

P_{max} = maximum load carried by the specimen during the test, KN

A_0 = original cross-sectional area of specimen, mm^2

• Calculate the strain to failure, or elongation

$$\% \text{ Elongation} = (L_f - L_0) / L_0 \times 100$$

Where:

L_f = gauge length after failure, mm

L_0 = original gauge length, mm

• Calculate the modulus of elasticity

$$E = \sigma/\varepsilon$$

Where:

E = Modulus of elasticity, Mpa (psi)

σ = stress, Mpa (psi)

ε = corresponding strain, mm/min

• Calculate (or use your stress-strain plot) the failure strength

$$\sigma_f = P_f / A_0$$

Where:

σ_f = failure strength, MPa (psi)

P_f = final load carried by the specimen during the test, KN

A_0 = original cross-sectional area of specimen, mm^2

• Calculate the reduction of cross-sectional area

$$\%Reduction = (A_0 - A_f) / A_0 \times 100$$

Where:

A_f = cross-sectional area after failure, mm^2

To calculate the cross-sectional area after failure, fit the ends of the fractured specimen together and measure the mean diameter or width and thickness at the smallest cross-section.

• Calculate the percentage error (%Error)

$E_{Experimental} = \Delta\sigma/\Delta\varepsilon$ i.e. the slope of the graph

$E_{Theoretical, steel} = 29 \times 100^6$ psi

$$\%\ Error = \frac{(E_{Experimental} - E_{Theoretical, steel})}{E_{Theoretical, steel}} \times 100$$

Table of values

		Before Test		After Test		From Data					
Spec. #	**Material**	A_0	L_0	A_f	L_f	σ_{yd}	$\sigma_{t,ult}$	σ_f	**E**	**%Elong**	**%Red. Area**
1.											
2.											
3.											
4.											
5.											

COMPRESSIVE STRENGTH TEST

Aim: To test for the compressive strength of concrete or cement mortar

Apparatus:

- Mixing equipments
- Concrete moulds
- Tamping rod
- Curing tank or pond
- Universal Testing Machine (UTM WAW 2000B).

Materials:

Cement, Fine aggregates, Coarse aggregates and water

Procedure:

- Mix a required quantity of concrete by the job's design mix proportion. E.g. mix 370 gm of standard sand, 185gm of cement and 555gm.
- Add water quantity (P/4 + 3.0) % of combined weight of cement and sand and mix the three ingredients thoroughly until the mixture is of uniform colour. The time of mixing should be less than three minutes and not more than four minutes.
- Cast the mixed concrete into moulds.
- Using the tamping rod, ensure an even distribution of concrete in the mould by apply the concrete in 3 layers and tamping 35 blows per layer.
- Level the concrete with the top of the mould and smoothen out the rough surface with a hand trowel.
- Remove the concrete after 24 hours from their moulds and cure for some days in the curing tank of pond before crushing.
- Take the cube out of water and dry with cloth at 7, 14 and 28 days.
- Measure the dimensions (L x B) of the cube.
- Crush the cured concrete at 7, 14 and 28 days of curing with the Universal Testing Machine (UTM) to give the various strengths of the concrete after 7, 14 and 28days of casting.

Crushing of concrete cubes using the Universal Testing Machine (UTM WAW 2000B):

Procedure:

1. Label each specimen with your group's initials and an identification number (i.e., #1, #2, etc.) on each concrete cube.

2. Using the meter rule, take measurements of the length and width of the concrete cube and calculate the cross-sectional area.

3. Insert the work piece in between the Platens (upper and lower) of the UTM and lower the upper platen to rest slightly on top of the work piece. Ensure that the work piece is properly position and well seated at the center of the platen before you proceed.

4. Load the program "MaxTest" on the PC.

5. Set test type to "Compression".

6. Enter specimen information by first setting the MODE -> Analyse Mode. Next, under DATA, click on the "insert specimen information" to enter all the required details of your work piece like length, diameter and area.

7. Enter other parameters like Displacement, Speed, and Load to control the movement of the machine during operation and clear your values to zero to avoid negative readings before, during and after the test.

8. Set the MODE -> Test Mode to start test.

9. After failure, the machine will stop and return on its own if its set to "Stop while destroy" and "Auto return", if not, stop the machine once failure occurs and the green arrow initially pointing upward, starts pointing downward. Click on the return button on "MaxTest" to return the machine to its original state.

Note: Remember to power off the machine after the test by clicking on the small red button on the control panel and open the "Oil Home Valve". Use the big red button for emergency stopping of the machine in case of accident.

Tabulation

(a) For 7 days strength:

Sl.No.	Length (L) in mm	Breadth (B) in mm	Load (P) in N	compressive strength in N/mm^2
1				
2				
3				

Average compressive strength =

(b) For 14 days strength:

Sl.No.	Length (L) in mm	Breadth (B) in mm	Load (P) in N	compressive strength in N/mm^2
1				
2				
3				

Average compressive strength =

(c) For 28 days strength:

Sl.No.	Length (L) in mm	Breadth (B) in mm	Load (P) in N	compressive strength in N/mm^2
1				
2				
3				

Average compressive strength =

Questions:

1. What is the grade of concrete?

2. Mention 5 safety precautions you observed during the test.

Result:

1. Compressive strength of concrete at 7 days = …… N/mm^2

2. Compressive strength of concrete at 14 days = …… N/mm^2

3. Compressive strength of concrete at 28 days = …… N/mm^2