

## **การทดสอบในรายวิชา 2101 302 Material Testing Lab.**

**B2 Transverse, Compression and Absorption Tests of Bricks**

**S6 Direct Shear Test of Steel**

**S7 Brinell Hardness Test of Ferrous Metal**

**S8 Tension Test of Wire and Wire Rope**

**S9 Flexure Test of Cast Iron**

**S10 Tension Test of Steel**

**S11 Nail Withdrawal Test**

**S12 Torsion Shear Test of Steel**

**T1 Flexure Test of Wood**

**T2 Compression Test of Wood Paralleled to Grain**

**T3 Compression Test of Wood Perpendicular to Grain**

**T4 Shear Test of Wood Paralleled to Grain**

**T6 Hardness Test of Wood**

**T9 Impact Test of Wood**

**T11 Test of Time Bolt Joint (Load Paralleled Paralleled to Grain)**

**MATERIALS TESTING LABORATORY**  
**FACULTY OF ENGINEERING**  
**CHULALONGKORN UNIVERSITY**

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**TEST No. B2**

**TRANSVERSE, COMPRESSION AND ABSORPTION TESTS OF BRICKS**

<b>PURPOSE</b>	To determine the modulus of ruptures of bricks in transverse test, the maximum compressive stress and the percentage of absorption by immersing under water
<b>REFERENCE</b>	ASTM
<b>SPECIMEN</b>	Brick
<b>APPARATUS</b>	Testing machine arranged for transverse test

## TRANSVERSE TEST

The brick is supported on rocker bearings at a span length of 7 inches, then load is applied at the center of the span with the uniform rate up to its fracture. The speed should not be more than 1,000 kg per minute or speed of the movable cross head should not more than 0.05 inch per minute.

Usually, paving brick is tested edge-wise and building brick is tested flat-wise. Hence in this case, two bricks are tested flat-wise and the other two are tested flat-wise.

The modulus of rupture is calculated from the flexure formulae

$$\text{Modulus of rupture, } R = \frac{(3 P L)}{(2 b d^2)} \quad (1)$$

where  $P$  is the center breaking load, kg

$L$  is the span length, cm

$b$  is the width of brick, cm and

$d$  is the depth of brick, cm.

## DATA

	Specimen No. 1	Specimen No. 2	Specimen No. 3	Specimen No. 4
Kind of bricks or brand	.....	.....	.....	.....
Size, width x depth x length (cm)	.....	.....	.....	.....
Weight (kg)	.....	.....	.....	.....
Span length, $L$ (cm.)	.....	.....	.....	.....
Position (edge-wise or flat-wise)	.....	.....	.....	.....
Center breaking load, $P$ (kg)	.....	.....	.....	.....
Modulus of rupture, $R$ (ksc)	.....	.....	.....	.....
Sketch of ruptured specimen				

## COMPRESSION TEST

Use four half-bricks broken in the previous transverse test. Usually, paving brick is tested edge-wise and building brick is tested flat-wise. Hence, two half-bricks are tested edge-wise and the other two half-bricks are tested flat-wise. Coat each specimen with shellac and allow it to dry thoroughly, then the edge and flat faces are capped with the plaster of Paris to prevent the absorption of moisture. Use the compressing plate with the spherical seating so that the load is normal to the transverse section of the specimen without causing any bending stress due to the eccentric loading. The load is applied continuously at the uniform rate up to the point of fracture. Calculate the crushing stress by dividing the maximum load by the cross sectional area of the specimen.

### DATA

	Specimen	Specimen	Specimen	Specimen
	No. 1	No. 2	No. 3	No. 4
Cross sectional dimension, b x d (cm)	.....	.....	.....	.....
Cross sectional area, A (sq. cm)	.....	.....	.....	.....
Position (edge-wise or flat-wise)	.....	.....	.....	.....
Crushing load, P (kg)	.....	.....	.....	.....
Crushing stress, P/A (ksc)	.....	.....	.....	.....

## ABSORPTION TEST

The purpose of this test is to determine the percentage of absorption by immersing the specimen under water for a certain period of time.

Use the remaining four halves of bricks from the transverse test. First weigh the specimen dry and then weigh them again after being immersed under water for half an hour. Then replace the specimens under water and weigh them again after an interval of 24 hours. The wet specimens should be wiped off the surface water with damp cloth and weighing shall be completed within 5 minute after removing the specimens from the bath.

$$\text{Percentage of absorption} = \frac{(W' - W)}{W} \times 100 \quad (2)$$

where  $W$  is the dry weight of brick, kg and

$W'$  is the weight of brick after 1/2 and 24 hours immersion.

The absorption of water of brick is one measure of ascertaining the durability of brick for structural purposes. Porous brick will become rapidly disintegrated under the action of water.

### DATA

	Specimen	Specimen	Specimen	Specimen
	No. 1	No. 2	No. 3	No. 4
Dry weight, $W$ (kg)	.....	.....	.....	.....
$W'$ after 1/2 hour immersion (kg)	.....	.....	.....	.....
$W'$ after 24 hours immersion (kg)	.....	.....	.....	.....
% Absorption after 1/2 hour immersion	.....	.....	.....	.....
% Absorption after 24 hours immersion	.....	.....	.....	.....

## SAMPLE OF CALCULATION

### TRANSVERSE TEST

Specimen No. .... Position .....

$$\begin{aligned} \text{Modulus of rupture, R} &= (3 P L) / (2 b d^2) \\ &= ..... \\ &= ..... \text{ ksc} \end{aligned}$$

### COMPRESSION TEST

Specimen No. .... Position .....

$$\begin{aligned} \text{Crushing stress of brick} &= P / \text{Compressive area} \\ &= ..... \\ &= ..... \text{ ksc} \end{aligned}$$

### ABSORPTION TEST

Specimen No. .... for ..... hour immersion

$$\begin{aligned} \text{Percentage of absorption} &= (W' - W) / W \times 100 \\ &= ..... \\ &= ..... \% \end{aligned}$$

## SUMMARY OF RESULTS

Average modulus of rupture of given bricks = ..... ksc  
Average crushing stress of given bricks = ..... ksc  
Average percentage of absorption after 1/2 hr. immersion = ..... %  
Average percentage of absorption after 24 hr. immersion = ..... %

## DISCUSSION AND CONCLUSIONS

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**TEST No. S6**

**DIRECT SHEAR TEST OF STEEL**

<b>PURPOSE</b>	To determine the shearing stress of steel bars both in single shear and double shear.
<b>REFERENCE</b>	ASTM JIS
<b>SPECIMEN</b>	Round steel bars of different sizes and grades
<b>APPARATUS</b>	Shear tool with dies for different sizes of specimens

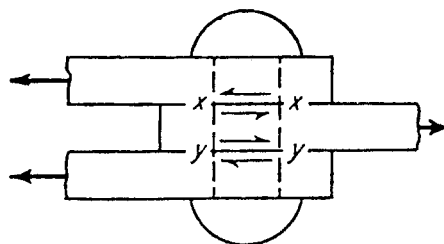
## SHEARING STRESS

**Shearing Stress** is stress that act paralleled to a plane, as distinguished from tensile and compressive stresses that act normal to a plane. Loading that produces shear conditions of principal interest in materials testing are as follows:

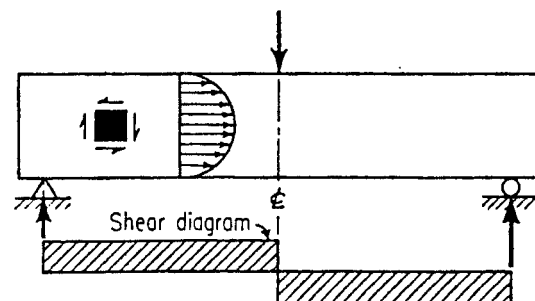
a. The resultants of paralleled but opposed forces act through the center of the sections that are spaced “infinitesimal” distances apart. It is conceivable in such cases that the shearing stresses over the sections should be uniform, and a state of pure shear would exist. This condition may be approached but is never realized practically. An approximation of this condition is the case of a rivet in shear.

b. The applied opposed forces are paralleled, act normal to a longitudinal axis of the body but are spaced finite distances apart. Then in addition to the shearing stresses produced, the bending stresses are set up. In the case of a rectangular beam subjected to the transverse loads, the shearing stresses on any cross section vary in intensity from zero at the upper and lower surfaces of the beam to a maximum at the neutral axis of the beam.

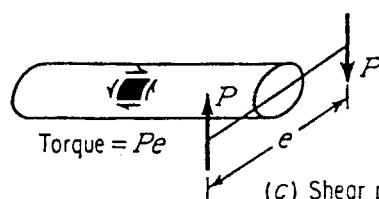
c. The applied forces are paralleled and opposite but do not lie in a plane containing the longitudinal axis of the body. Here a couple is set up which produces twisting about a longitudinal axis. This twisting action on one section of a body with respect to a continuous section is termed **torsion**.



(a) Direct (double) shear in a rivet



(b) Shear in a homogeneous beam of rectangular section



(c) Shear produced by torsional loading

### Loadings producing shear force

## PROCEDURE

1. Determine the mean diameter from two readings at right angles to one another and at the section to be sheared.
2. Fix the specimen in the shear tool for testing in double shear, and apply load at a slow speed until rupture takes place. During the test note whether or not there is a yield point.
3. Record the maximum load and the character of fracture.
4. In making a single shear test, the specimen must extend sufficiently beneath the loading tool to avoid excessive bearing stress. Likewise, in the double shear test, the specimen must overlap both dies sufficiently to avoid high bearing stresses.

## DATA

Sample No.	Diameter, d (cm)	Area, A (sq. cm)	Load at Rupture, P (kg)	Shear Stress (ksc)	Remarks
<b>Nail</b>					
Single shear 1					
Single shear 2					
Single shear 3					
Double shear 1					
Double shear 2					
Double shear 3					
<b>Structural Steel</b>					
Single shear 1					
Single shear 2					
Single shear 3					
Double shear 1					
Double shear 2					
Double shear 3					

## SAMPLE OF CALCULATION

Samples No. ....

$$\text{Cross sectional area, } A = \frac{\pi d^2}{4} = \dots\dots\dots$$
$$= \dots\dots\dots \text{ sq. cm}$$

$$\text{Single shearing stress} = P / A = \dots\dots\dots$$
$$= \dots\dots\dots \text{ ksc}$$

$$\text{Double shearing stress} = P / ( 2 A ) = \dots\dots\dots$$
$$= \dots\dots\dots \text{ ksc}$$

## SUMMARY OF RESULTS

$$\text{Average single shear stress of Nail} = \dots\dots\dots \text{ ksc}$$

$$\text{Average double shear stress of Nail} = \dots\dots\dots \text{ ksc}$$

$$\text{Average single shear stress of Structural Steel} = \dots\dots\dots \text{ ksc}$$

$$\text{Average double shear stress of Structural Steel} = \dots\dots\dots \text{ ksc}$$

## DISCUSSION AND CONCLUSIONS

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**TEST No. S7**

**BRINELL HARDNESS TEST OF FERROUS METALS**

<b>PURPOSE</b>	To study the Brinell Hardness Test and to determine the Brinell Hardness Number (BHN) of the steel and the cast iron specimens.
<b>REFERENCE</b>	ASTM A370 E10
<b>SPECIMEN</b>	Two pieces of steel and cast iron
<b>APPARATUS</b>	Brinell hardness test equipment and microscope

## HARDNESS OF METALS

Hardness is a measurement of resistance of metals to abrasion, cutting, scratching, etc. Brinell hardness test is widely used to determine the resistance to permanent indentation.

### BRINELL METHOD

The Brinell test involves pressing a hardened steel ball into a test specimen. In accordance with the ASTM Specifications, the provisions of which are followed herein, it is customary to use a 10-mm dia. ball and a load of 3,000 kg for hard metals, 1,500 kg for metals of intermediate hardness, and 500 kg for soft materials. In the standard test, the full load is applied for a minimum of 15 seconds for ferrous metals and 30 seconds for softer metals, after which interval the load is released and the diameter of the indentation is measured to the nearest 0.02 mm with a microscope.

The Brinell Hardness Number, BHN is nominally the pressure per unit area, in kilogram per square millimeter, of the indentation that remains after the load is removed. It is obtained by dividing the applied load by the area of the surface of the indentation, which is assumed to be spherical.

$$\begin{aligned} \text{Brinell Hardness Number, BHN} &= \text{Load on Ball / Indented area} \\ &= P / ( 0.5 \pi D ( D - \sqrt{D^2 - d^2} ) ) \quad (1) \end{aligned}$$

where d, D = diameter of indentation and ball respectively, mm

P = ball load, kg

$$\text{Estimated tensile strength of steel specimen} = 510 \times \text{BHN psi or} \quad (2.a)$$

$$= 36 \times \text{BHN ksc} \quad (2.b)$$

## PROCEDURE

1. The distance from the center of indentation to the edge of the specimen or to the center of the adjacent indentations should be greater than 2.5 times the diameter of indentation. The thickness of the specimen is to be at least 10 times the depth of indentation.

2. The full load is applied continuously for 30 seconds for the steel, after which interval the load is released.

3. Measure the diameter of indentation to the nearest 0.02 mm with the microscope. The diameter is taking as the average of two readings taken at right angles to each other.

4. Make at least five determinations for each kind of specimen.



## SAMPLE OF CALCULATION

Specimen No. ....

$$\begin{aligned} \text{Brinell Hardness Number, BHN} &= \frac{P}{0.5\pi D(D - \sqrt{D^2 - d^2})} \\ &= \dots\dots\dots \\ &= \dots\dots\dots \text{ kg/sq. mm} \end{aligned}$$

$$\begin{aligned} \text{Estimated tensile strength of steel} &= 510 \times \text{BHN} \\ &= \dots\dots\dots \\ &= \dots\dots\dots \text{ psi} \\ &= 36 \times \text{BHN} \\ &= \dots\dots\dots \\ &= \dots\dots\dots \text{ ksc} \end{aligned}$$

## RESULTS

$$\begin{aligned} \text{Average Brinell Hardness Number of steel} &= \dots\dots\dots \text{ kg./sq. mm} \\ \text{Average Brinell Hardness Number of Cast Iron} &= \dots\dots\dots \text{ kg./sq. mm} \\ \text{Estimated tensile strength of steel} &= \dots\dots\dots \text{ psi} \\ &= \dots\dots\dots \text{ ksc} \end{aligned}$$

## DISCUSSION AND CONCLUSIONS

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**TEST No. S8**

**TENSION TEST OF WIRE AND WIRE ROPE**

**PURPOSE**

To determine the tensile stress and efficiency of the wire rope, the structure and ductility of wires of which it is made.

The properties to be determined are

1. Details of construction of wire rope including its diameter, number of strands, number and diameter of wires in a strand, type of center, type of lay and pitch of wires and strands
2. Tensile stress of each wire in one strand
3. Tensile stress and efficiency of wire rope

**REFERENCE**

ASTM

JIS

**SPECIMEN**

Wire rope and one strand from the same coil of rope

**APPARATUS**

Amstler universal testing machine of 1 ton and 20 tons capacity

Autograph testing Machine of 1 tons capacity

## TYPES AND CHARACTERISTICS OF WIRE ROPE

A wire rope is a cord made of strands of wire made of any ductile metal such as iron, steel or bronze, twisted together. Ordinary rope is composed of a number of strands and each strand contains group of wires, usually laid around a hemp center.

The **hemp center** is designed to support and lubricates the wire strands. Obviously, it is impossible to put enough lubricant in a rope during construction to last the life of the rope. Internal friction will be reduced and resistance to corrosion shall be increased if the rope is periodically treated with a lubricant that will adhere to the metal and penetrate to the hemp core. Such treatment is especially necessary if the rope is subjected to acid fumes or acid or salty water.

Most wire rope is made **right lay**, in which the strands are laid around the center, like right-hand screw threads.

The terms **regular lay** and **lang lay** refer to the type of rope construction in which for the **regular lay** (either left or right lay), the wires in the strand and the strands in the rope are laid in the opposite directions, thus making the wires on the outside of the rope lie paralleled with the axis of the rope. This regular lay is standard construction.

In the **lang lay** construction, both wires and stands are laid in the same direction, with the result that the wires, which now lie at an angle with the axis of the rope, have a greater exposed length and hence the wearing qualities of the rope are increased. The lang lay rope, although it has a high resistance to abrasion if not damaged, is not generally used because it is more liable to curl and kink and is difficult to handle, often being called a cranky line. Therefore, regular lay is more widely used.

The **efficiency** of a wire rope is computed by dividing its actual tensile stress by the average tensile stress of the individual wires in the rope and multiplying this ratio by 100 to convert to a percentage. It is always less than 100 and is usually about 80 to 85.

## **PROCEDURE**

### **TESTS OF WIRES**

1. Unravel the extra strand of rope. Note its construction.
2. Grip one of the wires in one head of the testing machine. Pull the other end of the wire taut and tighten the grip. Taking care that the clear length of the wire between the grip is at least 30 cm.
3. Apply a load that will stress the wire to not more than one-fourth of its ultimate strength, say 15 kg and then measure and record the average diameter of the wire.
4. Apply the load continuously at a speed of the movable head of not more than one inch per minute. Record the breaking load of the wire.
5. Repeat the same operation as above for all wires in one strand, or about 20 wires.
6. Compute the average tensile stress of the tested wires.

### **ROPE TEST**

1. Sketch the wire rope showing both cross section and side view. Measure the pitch of the wires and the strands and observe the lay. Take complete notes so that a brief description of the construction can be included in the report. Measure the diameter of the rope, which is defined as the diameter of the circle will just enclose it.
2. Secure the wire rope in the heads of the testing machine and apply load at a moderate speed. Record the load when the first wire breaks, the maximum load, the character and location of fracture.
3. Pull the specimen apart, then measure the nominal size of the center and note the kind of the material from which it is made.
4. Compute the efficiency of the rope including the required properties.



## ROPE TEST

	Specimen No. 1	Specimen No. 2
Length of rope (cm)	.....	.....
Length between grips (cm)	.....	.....
Diameter of rope (cm)	.....	.....
Lay of strand	.....	.....
Pitch of strand per foot of rope	.....	.....
Number of strands in rope	.....	.....
Type of core	.....	.....
Load when the first wire breaks (kg)	.....	.....
Maximum load (kg)	.....	.....
Character and location of failure	.....	.....
Sketch of Wire Rope Structure		

## SAMPLE OF CALCULATION

### TEST OF WIRES

Specimen No. ....

$$\begin{aligned} \text{Tensile stress of wire} &= (\text{Breaking load, kg}) / (\text{Area of wire, sq. cm}) \\ &= ..... \\ &= ..... \text{ ksc} \end{aligned}$$

### ROPE TEST

Specimen No. ....

$$\begin{aligned} \text{Actual tensile stress} &= (\text{Maximum load of rope, kg}) / (\text{Sum of area of all wires in rope, sq. cm}) \\ &= ..... \\ &= ..... \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Efficiency of wire rope} &= (\text{Actual tensile stress of rope} / \text{Average tensile stress of wires}) \times 100 \\ &= ..... \\ &= ..... \% \end{aligned}$$

## SUMMARY OF RESULTS

	Specimen No. 1	Specimen No. 2	Average
Tensile stress of wires (ksc)	.....	.....	.....
Actual tensile stress of wire rope (ksc)	.....	.....	.....
Efficiency of wire rope (%)	.....	.....	.....

## DISCUSSION AND CONCLUSIONS

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**TEST No. S9**

**FLEXURE TEST OF CAST IRON**

**PURPOSE**

To determine the stress and stiffness of the cast iron flexure bar.

The properties to be determined are

1. Yield load for an offset deflection of 0.5 mm (0.02 inches)
2. Fiber stress at yield load
3. Maximum flexure load
4. Modulus of rupture
5. Maximum deflection
6. Flexural secant modulus of elasticity at fiber stresses of 700 ksc and 1,400 ksc.
7. Type and character of fracture

**REFERENCE**

ASTM A48

JIS

**SPECIMEN**

Cast iron flexure bar 2.5 x 2.5 x 37 cm in size

**APPARATUS**

Amsler universal testing machine with 5 tons capacity and deflectometer

## FLEXURAL FORMULAE

The bending stress (flexural stress) at any distance  $C$  from the neutral axis of the beam section is determined by the **Flexural Formulae**.

$$f = (M C) / I \quad (1)$$

where  $f$  is the bending stress at the distance  $C$  from the neutral axis, (ksc = kg/sq. cm),

$M$  is the bending moment (kg-cm),

$C$  is the distance from the neutral axis of the beam section (cm),

$I$  is the moment of inertia of the beam section about its neutral axis ( $\text{cm}^4$ ).

If the considered beam having the span length  $L$  is loaded by the concentrated load  $P$  at the mid span point ( $L/2$ ). The beam section is rectangular section with the width  $b$  and depth  $d$ . The maximum bending stress (flexural stress) will be occurred at the extreme fiber of the section and can be determined by

$$M = P L / 4 \quad (2)$$

$$C = d / 2 \quad (3)$$

$$I = b d^3 / 12 \quad (4)$$

$$\text{Then } f = 3 P L / (2 b d^2) \quad (5)$$

The modulus of rupture  $R$  can be determined from

$$R = 3 P_{\max} L / (2 b d^2) \quad (6)$$

where  $R$  is modulus of rupture (ksc),

$P_{\max}$  is the maximum load at mid span (kg).

The modulus of elasticity can be determined from the flexural test by using the relation between load and deflection. In this case, the load - deflection relation is

$$\Delta = P L^3 / (48 E I) \quad (7)$$

where  $\Delta$  is the deflection of the beam at mid span (cm),

$P$  is the load at mid span (kg),

$L$  is the span length of beam (cm),

$E$  is the modulus of elasticity (ksc),

$I$  is the moment of inertia of beam section about its neutral axis (cm<sup>4</sup>).

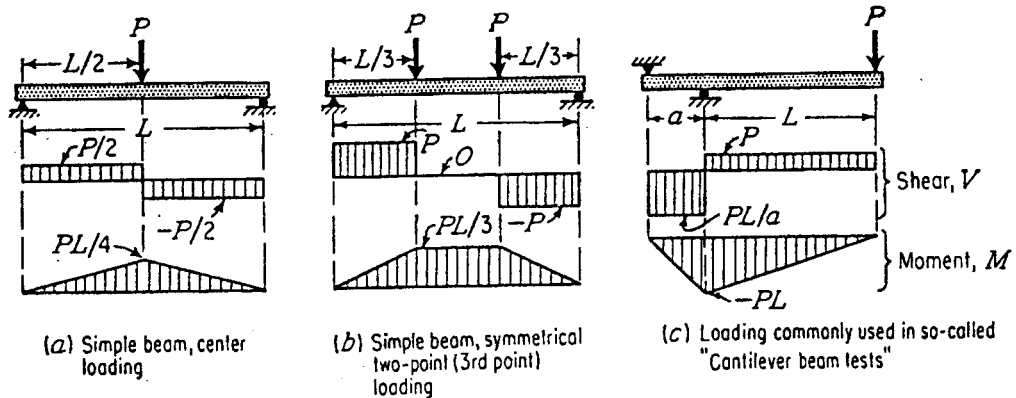
Then the modulus of elasticity can be determined by

$$E = P_f L^3 / (48 I \Delta_f) \quad (8)$$

where  $E$  is the modulus of elasticity (ksc),

$P_f$  is the load at produced the bending stresses  $f$  (kg),

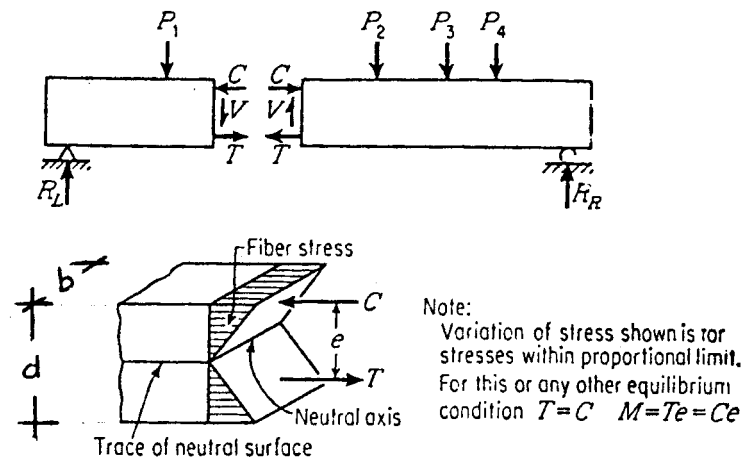
$\Delta_f$  is the mid span deflection at the corresponding load  $P_f$  (cm).



### Shear Force and Bending Moment Diagrams

## PROCEDURE

1. Measure dimensions of the bar at several places and record its mean values.
2. Fix the supports on the machine at 30 cm apart. Place the bar in position with its large dimension vertical. Mark the top of the bar for identification after rupture. Set the deflectometer to read zero.
3. Apply center loads at slow and uniform rate. Record loads and deflections at 100 kg increments up to the point of fracture.
4. Note the maximum load, the maximum deflection observed and the manner of failure.
5. Plot load-deflection curve, using loads as ordinates and center deflections as abscissas. Determine the yield load for an offset deflection of 0.5 mm.
6. Compute fiber stress at the yield load, the modulus of rupture and the secant modulus of elasticity.



### Bending moment of a beam



## SAMPLE OF CALCULATION

Specimen No. ....

The extreme fiber stress at the yield load (0.5 mm offset)

$$f = (3 P_{\text{off}} L) / (2 b d^2)$$

$$= \dots\dots\dots = \dots\dots\dots \text{ ksc}$$

Modulus of rupture  $R = (3 P_{\text{max}} L) / (2 b d^2)$

$$= \dots\dots\dots = \dots\dots\dots \text{ ksc}$$

Flexural modulus of elasticity

a) At the fiber stress of 700 ksc

Load at fiber stress of 700 ksc,  $P_{700} = (2 \times 700 b d^2) / (3 L)$

$$= \dots\dots\dots$$

$$= \dots\dots\dots \text{ kg}$$

Secant modulus of elasticity,  $E_{700} = (P_{700} L^3) / (48 I \Delta_{700})$

(read  $\Delta_{700}$  from curve)

$$= \dots\dots\dots$$

$$= \dots\dots\dots \text{ ksc}$$

b) At the fiber stress of 1,400 ksc

Load at fiber stress of 1,400 ksc,  $P_{1400} = (2 \times 1,400 b d^2) / (3 L)$

$$= \dots\dots\dots$$

$$= \dots\dots\dots \text{ kg}$$

Secant modulus of elasticity,  $E_{1400} = (P_{1400} L^3) / (48 I \Delta_{1400})$

( read  $\Delta_{1400}$  from curve)

$$= \dots\dots\dots$$

$$= \dots\dots\dots \text{ ksc}$$

## SUMMARY OF RESULTS

	Specimen No. 1	Specimen No. 2
Yield load for an offset deflection of 0.5 mm (kg)	.....	.....
Fiber stress at yield load (ksc)	.....	.....
Maximum load (kg)	.....	.....
Modulus of rupture (ksc)	.....	.....
Maximum deflection (cm)	.....	.....
Flexural secant modulus of elasticity (ksc)		
a) At fiber stress 700 ksc	.....	.....
b) At fiber stress 1,400 ksc	.....	.....
Type and character of failure	.....	.....

## DISCUSSION AND CONCLUSIONS

**MATERIALS TESTING LABORATORY**  
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**TEST No. S10**  
**TENSION TEST OF STEEL**

**PROPOSE**

To determine the stress and several elastic and inelastic properties of the ductile steel, to observe the behavior of the material under load and to study its fracture. The specific properties to be determined are

1. Elastic stress in tension
  - a) Proportional limit ( P.L.)
  - b) Upper and lower yield points
  - c) Yield tensile stress for an offset of 0.1% strain
2. Ductility
  - a) Final elongation in each 2.5 cm of length
  - b) Percentage of elongation in 5 and 20 cm
  - c) Percentage of area reduction
3. Modulus of elasticity
4. Modulus of resilience
5. Type and character of fracture

**REFERENCE**

ASTM A370 E8

JIS

**SPECIMEN**

Low carbon steel bars.

**APPARATUS**

Extensometer with 20 cm gage length.

## PROCEDURE

1. Determine the average cross sectional dimensions of the specimen with a micrometer screw gage. Scribe a line along the bar and, with a center punch, slightly marks 20 cm gage length symmetrical within the length of the bar. Also marks 2.5 cm of length within the gage length and make other marks 2.5 cm of length within the gage length and make other marks 2.5 cm outside the gage length at each end.

2. Firmly grip the upper end of the specimen in the fix head of the testing machine. Place the specimen so that punch marks face the front of the machine.

3. Measure the gage length and determine the multiplication ratio the extensometer. Determine the value of the divisions on the dial indicator. Firmly attach the extensometer to the specimen so that its axis coincides with the axis of the specimen and remove the spacer bar (if any). Adjust the testing machine and the extensometer to read zero, setting the latter so that most of its capacity will be available. Grip the lower end of the specimen, taking care not to jam the extensometer.

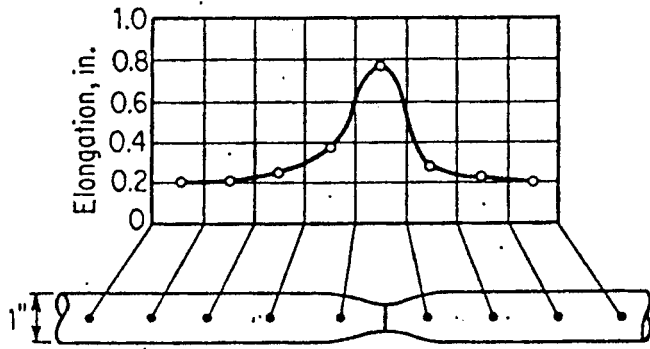
4. Select the suitable increments of load to secure at least 15 readings below the probable proportional limit. Apply load at slow speed, and take simultaneous observations of load and elongation without stopping the machine. Continue loading until the yield point is passed, then stop the machine (but hold the load) to remove the extensometer.

5. Again apply the load continuously. When the gage length was increased 0.25 cm in the 20 cm gage length, as measured with the dividers and scale, read the corresponding load. Thereafter, for each 5 mm increase in the gage length, read the load. Record the maximum and breaking loads.

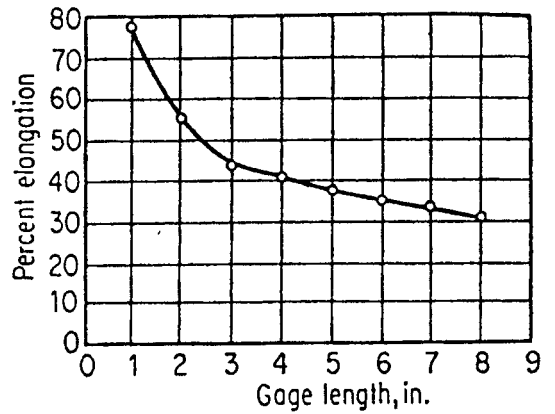
6. Remove the broken specimen from the machine. Observe the location and character of the fracture and measure the dimensions of the smallest section. Fit the broken parts together and measure the gage length and the intervals between intermediate punch marks.

7. Plot a stress-strain diagram for the test on the first sheet and on the second sheet, plot a graph showing the elongation in each 2.5 cm of gage length as ordinates and the number of 2.5 cm divisions as abscissas and connect the plotted points by straight lines. Indicate the location of the fracture on this graph.

8. Compute all properties required. For the percentage of elongation in 5 cm, use 5 cm length most nearly center of the fracture.

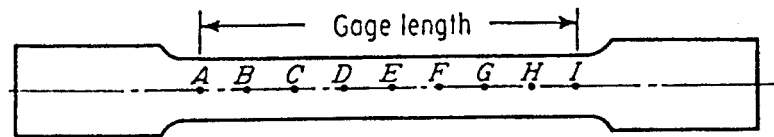


(a) Elongation in each inch



(b) Percent elongation vs. gage length

### Effect of gauge length on percentage of elongation



For breaks between *C* and *G*; Elongation = Final *AI* - Original *AI*

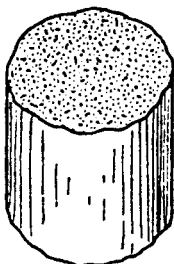
For breaks between *A* and *C* but nearer *B* than *A*;

Elongation = Final (*AC* + 2*CF*) - Original *AI*

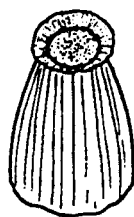
For breaks within one half division of *A*; Elongation = Final 2*AE* - Original *AI*

### Determination of approximate elongation for breaks outside

#### middle-third of gauge length



(a)  
Flat,  
granular,  
cleavage



(b)  
Cup-cone,  
silky



(c)  
Partial  
cup-cone,  
silky



(d)  
"Star  
fracture"



(e)  
Irregular,  
fibrous



(f)  
Cup-cone,  
silky  
(flat specimen)

### Typical tensile fractures of metals



## SAMPLE OF CALCULATION

Specimen No. ....

Tensile stress at Proportional Limit	= .....	= ..... ksc
Tensile stress at Upper yield point	= .....	= ..... ksc
Tensile stress at Lower yield point	= .....	= ..... ksc
Yield stress for an offset of 0.1% strain	= .....	= ..... ksc
Ultimate tensile stress	= .....	= ..... ksc
Percentage elongation in 5 cm	= .....	= ..... %
Percentage elongation in 20 cm	= .....	= ..... %
Percentage of area reduction	= .....	= ..... %
Modulus of elasticity	= .....	= ..... ksc
Modulus of resilience	= .....	= ..... kg-cm/cc

## SUMMARY OF RESULTS

	Specimen No. 1	Specimen No. 2
Average diameter of specimen before test, d (cm)	.....	.....
Reduced diameter after test, d' (cm)	.....	.....
Tensile stress at Proportional Limit (ksc)	.....	.....
Tensile stress at Upper yield point (ksc)	.....	.....
Tensile stress at Lower yield point (ksc)	.....	.....
Yield stress for an offset of 0.1% strain (ksc)	.....	.....
Ultimate tensile stress (ksc)	.....	.....
Percentage elongation in 5 cm (%)	.....	.....
Percentage elongation in 20 cm (%)	.....	.....
Percentage of area reduction (%)	.....	.....
Modulus of elasticity (ksc)	.....	.....
Modulus of resilience (kg-cm/cc)	.....	.....

## DISCUSSION AND CONCLUSIONS

**MATERIALS TESTING LABORATORY**  
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**CHULALONGKORN UNIVERSITY**

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**TEST No. S11**  
**NAIL WITHDRAWAL TEST**

**PURPOSE**

To study the withdrawal test of nails and to determine

1. The withdrawal resistance of nails driven into both side and end grains
2. Approximate value of the constant K in the formula  $P = K G^{2.5} D$  for each specimen
3. The moisture content and specific gravity of wood

**REFERENCES**

ASTM D143

**SPECIMEN**

Clear wood 5 x 5 x 15 cm and 6 cm-long nails

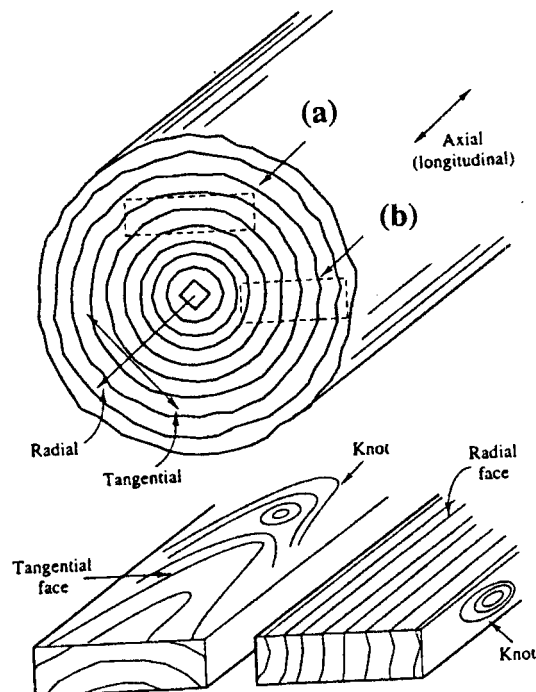
**APPARATUS**

Special apparatus for Nail withdrawal test

## PROCEDURE

### Nail Withdrawal Test

1. Measure the actual dimensions of wood specimens to the nearest 0.2 mm and weigh them to the nearest gram. Measure the diameter of nails to the nearest 0.1 mm.
2. Nails shall be driven at the right angles to the face of the specimen to a total penetration of 3 cm. One nail on end surface. Nails on tangential and radial surfaces should not be driven in line with each other.
3. All nails in a specimen shall be withdrawn immediately after driving.
4. The load shall be applied continuously throughout the test at the rate of motion of the movable cross head of 2 mm per minute. Record the maximum load.
5. A moisture specimen shall be cut from the tested specimen for the size of 1 x 1 x 3 cm for the determination of the moisture content and the specific gravity, G.



**Manner of cutting of log a) flat-sawn b) edge-sawn (quarter-sawn)**

## Moisture Content Test

1. All loose splinter shall be removed and the wood sample shall be weighed to the nearest 0.01 gm. Record this weight as the original weight of the specimen.
2. The moisture sample shall be open-piled in the oven and dried at the temperature of 103 +/- 2 degrees Celsius for about 2 hours or until approximately constant weight is attained, after which the oven-dry weight shall be determined to the nearest 0.01 gm.
3. The loss in weight, expressed in the percentage of the oven-dry weight as above determined, shall be considered as the moisture content of the specimen.

## Specific Gravity of Wood

1. Weigh the specimen to the nearest 0.01 gm.
2. Fill the reservoir with mercury and take the first reading when the level of the mercury is at the index, then move back the piston to lower the mercury.
3. Take off the stopper and the wire pincer inside the reservoir and insert the specimen in vertical position and put the pincer again on the top of the specimen. Push it in until the specimen is completely submerged in the mercury.
4. Next screw the stopper and turn the handle until the mercury level is constant and take the second reading. Lower the mercury and unscrew the stopper then take out the specimen. One revolution of the micrometer tube corresponds to 0.3 cc which is equal to one division of the gradations on the cylinder of the micrometer screw.
5. The difference between two readings multiplied by 0.3 gives the volume of the specimen in cc.

**DATA**

**Moisture Content and Specific Gravity**

Specimen	Weight, W (gm)	Dry weight, W' (gm)	Volume (cc)	Moisture content (%)	Specific Gravity, G

**Nail Withdrawal Resistance**

	Specimen No. 1	Specimen No. 2	Specimen No. 3	Specimen No. 4
Dimension (cm x cm x cm)	.....	.....	.....	.....
Weight (gram)	.....	.....	.....	.....

Specimen No.	Surface	Nail Dia., D(cm)	Penetration (cm)	Max. Load (kg)
	Radial Surface			
	Tangential Surface			
	End Surface			
	Radial Surface			
	Tangential Surface			
	End Surface			
	Radial Surface			
	Tangential Surface			
	End Surface			
	Radial Surface			
	Tangential Surface			
	End Surface			

## SAMPLE OF CALCULATION

Specimen No. ....

$$\begin{aligned} \text{Moisture Content} &= (W - W') / W' \times 100 \\ &= ..... \\ &= ..... \% \end{aligned}$$

$$\begin{aligned} \text{Specific Gravity, } G &= \text{Dry Weight / Volume of specimen} \\ &= ..... \\ &= ..... \end{aligned}$$

$$\begin{aligned} \text{Nail withdrawal resistance, } P &= \text{Max. withdrawal load / Length of penetration} \\ &= ..... \\ &= ..... \text{ kg/cm of penetration} \end{aligned}$$

$$\begin{aligned} \text{Value of Constant } K &= P / (G^{2.5} D) \\ &= ..... \\ &= ..... \end{aligned}$$

## SUMMARY OF RESULTS

	<b>Specimen</b>	<b>Specimen</b>	<b>Specimen</b>	<b>Specimen</b>
	<b>No. 1</b>	<b>No. 2</b>	<b>No. 3</b>	<b>No. 4</b>
Moisture Content (%)	.....	.....	.....	.....
Specific Gravity, G	.....	.....	.....	.....
Withdrawal Resistance (kg/cm)				
Radial Surface	.....	.....	.....	.....
Tangential Surface	.....	.....	.....	.....
End Surface	.....	.....	.....	.....
Value of Constant, K				
Radial Surface	.....	.....	.....	.....
Tangential Surface	.....	.....	.....	.....
End Surface	.....	.....	.....	.....

## DISCUSSION AND CONCLUSIONS

**MATERIALS TESTING LABORATORY**  
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**TEST No. S12**

**TORSIONAL SHEAR TEST OF STEEL**

**PURPOSE**

To determine the behavior of the ductile steel when subjected to torsion and to obtain the following torsional properties:

1. Shearing stress at Proportional Limit by using torsion formula
2. Yield shearing stress at an offset of 0.001 radian per cm of gage length by using torsion formula
3. Shearing modulus of rupture
4. Modulus of rigidity
5. Average energy absorbed per unit volume at Proportional Limit
6. Approximate percentage of elongation at outer fiber at failure
7. Probable tensile stress at Proportional Limit

**REFERENCE**

ASTM

JIS

**SPECIMEN**

Round steel bars.

**APPARATUS**

Torsion testing machine and troptometer

## TORSION FORMULA

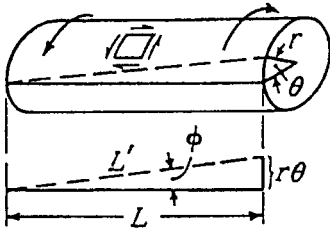


Fig. A Strain relations of twisted cylinder

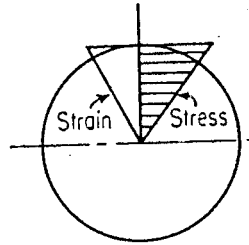


Fig. B Stress-strain variation within Proportional Limit

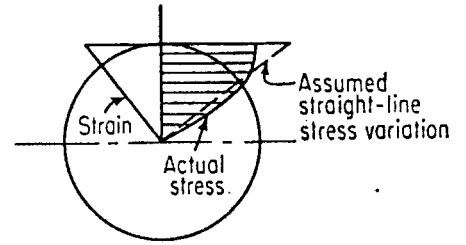


Fig. C Stress-strain variation above Proportional Limit

Various stress and strain relations for cylinder pieces in torsion are stated below in terms of the following symbols:

$T$  is torque or torsional moment

$J$  is the polar moment of inertia  $= (\pi r^4 / 2)$  for circular section

$\phi$  is the shearing strain

$r$  is the radius of a cylindrical test piece.

$L$  is the distance between collars of the strainometer

$\theta$  is the angle of twist measured over the distance  $L$

$\tau$  is the shearing stress in extreme fiber

$E_s$  is the modulus of rigidity or shearing modulus of elasticity

From geometrical relations between the various elements of the circular bar subjected to torsion (see Fig. A), the shearing strain can be determined by

$$\phi = r \theta / L \quad (1)$$

Within the elastic range all evidence indicates that the shearing strains are proportional to the distance from the axis of twist. This relation appears also to hold approximately above the Proportional Limit. Within the limit of proportionality,

$$\tau = \phi E_s = (r \theta / L) E_s \quad (2)$$

The stress varies linearly from zero at the axis of twist to the maximum at the extreme fiber and varies directly with the angle of twist, ( see Fig. B). By summing up the stresses over the entire cross section, the relation between shearing stress on extreme fiber and the applied torque may be found.

For the solid circular section, the maximum shearing stress is

$$\tau = T r / J = 2 T / (\pi r^3) \quad (3)$$

This relation is called the **Torsion Formula** and is applicable only to the solid circular section.

The modulus of rigidity in terms of torque and angle of twist can be expressed as

$$E_s = \tau / \phi = T L / (J \theta) = 2 T L / (\pi r^4 \theta) \quad (4)$$

It can be shown theoretically that the modulus of rigidity or shearing modulus of elasticity for homogeneous isotropic materials is about 40 percent of the modulus of elasticity in tension.

The elastic shearing stress of the ductile and the semi-ductile steels appears to be close to 0.6 of the elastic tensile stress.

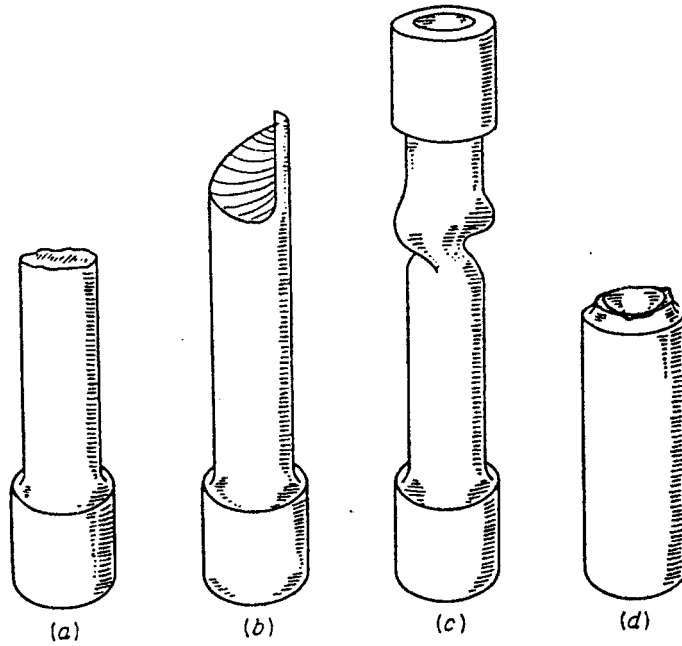
The ductility in a torsion test is determined by comparing the final fiber length  $L'$  (Fig. A) at rupture with the original fiber length or gage length  $L$ . The value of the final fiber length  $L'$  is computed by knowing  $L$ ,  $r$  and  $\theta$ , that is

$$L' = \sqrt{L^2 + (r\theta)^2} \quad (5)$$

The **ductility** is expressed as a percentage of elongation of the outer fiber and is equal to  $[(L' - L) / L] \times 100$ .

## PROCEDURE

1. With a micrometer screw gage, determine the mean diameter of the specimen near its mid length.
2. Note the gage length and the least reading of the troptometer. Securely clamp the instrument to the specimen, making certain that the axes of the troptometer and the test piece coincide and that the troptometer is in proper position for reading.
3. Adjust the torsion testing machine to read zero and then insert the specimen into the two ends. Check that each end is centered inside each head.
4. Gradually bring the grips in the ends to a firm equal bearing, take care not to displace the specimen. If tightening the grips produce some torque, operate the machine forward or reverse so that the torque will be reduced to zero.
5. Remove the troptometer spacer bars and set the instrument to read zero.
6. Apply load at a slow speed. Take readings of torque and angle of twist simultaneously without stopping the machine at 300 kg-cm increments. After the specimen shows definite signs of yielding, apply the load at higher speed until failure occurs. Note the character of fracture.
7. Plot two diagrams with the same origin showing the relation between torque in kg-cm as ordinates against angle of twist or sheer strain ( $\phi$ ) in radians per cm of gage length as abscissas. One diagram will extend to the yield strength with slope of not more than 60 degrees with the strain axis. The second diagram will show the curve for the entire test.
8. Determine the torque at Proportional Limit and the yield strength at the specified offset and mark them on the first diagram.
9. Compute the quantities required.



- (a) Solid bar of ductile material. Fracture on plane right section.
- (b) Solid bar of brittle material. Helicoidal fracture.
- (c) Tubular specimen of ductile material. Failure by buckling.
- (d) Tubular specimen of ductile material; short reduced section. Failure on plane right section.

### Typical failures in torsion



## SAMPLE OF CALCULATION

Specimen No. ....

$$\begin{aligned} \text{Shearing stress at Proportional Limit} &= 2 T_{PL} / (\pi r^3) \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Yield stress at and offset of 0.001 radian per cm of gage length} &= 2 T_{off} / (\pi r^3) \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Shearing modulus of rupture} &= 2 T_{max} / (\pi r^3) \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Modulus of rigidity, } E_s &= 2 T_{PL} L / (\pi r^4 \theta_{PL}) \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Average energy absorbed per unit volume at PL} &= \tau_{PL}^2 / (4 E_s) \\ &= \dots\dots\dots = \dots\dots\dots \text{ kg-cm/cc} \end{aligned}$$

$$\begin{aligned} \text{Final fiber length, } L' &= \sqrt{L^2 + (r \theta)^2} \\ &= \dots\dots\dots = \dots\dots\dots \text{ cm} \end{aligned}$$

$$\begin{aligned} \text{Approximate percentage of elongation} &= [(L' - L) / L] \times 100 \\ &= \dots\dots\dots = \dots\dots\dots \% \end{aligned}$$

$$\begin{aligned} \text{Probable tensile stress at Proportional Limit} &= (1/0.6) \times \text{Shearing stress at Proportional Limit} \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

## SUMMARY OF RESULTS

	Specimen No. 1	Specimen No. 2
Shearing stress at Proportional Limit (ksc)	.....	.....
Yield stress at an offset of 0.001 radian per cm of gage length (ksc)	.....	.....
Shearing modulus of rupture (ksc)	.....	.....
Modulus of rigidity (ksc)	.....	.....
Average energy absorbed per unit volume at Proportional Limit (kg-cm/cc)	.....	.....
Approximate percentage of elongation at failure (%)	.....	.....
Probable tensile stress at Proportional Limit (ksc)	.....	.....

## DISCUSSION AND CONCLUSIONS

**MATERIALS TESTING LABORATORY**  
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**TEST No. T1**  
**FLEXURE TEST OF WOOD**

**PURPOSE**

To determine the mechanical properties of wood subjected to bending.  
To observe the behavior of the material under load and study its failure.  
The specific properties to be determined are

1. The stress at the outer fiber at Proportional Limit
2. The modulus of rupture
3. The modulus of elasticity
4. The modulus of resilience
5. The maximum shearing stress
6. The approximate total work to ultimate load
7. Type of failure

**REFERENCE**

ASTM D143

JIS

**SPECIMEN**

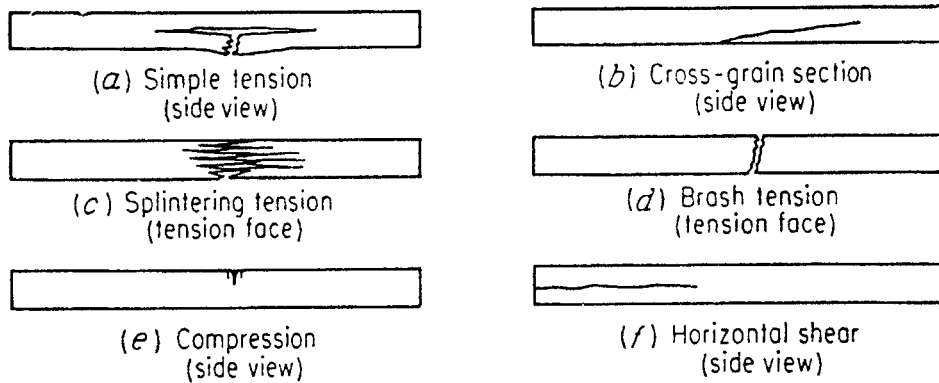
Clear wood specimen size 5 x 5 x 75 cm

**APPARATUS**

Amsler universal testing machine and deflectometer or dial gage

## PROCEDURE

1. Measure and weigh each specimen. Make a sketch of each specimen in perspective showing any defects and direction of rings on the end sections.
2. Set the beam supports for a 70 cm span. Place the specimen in position so that the tangential surface nearest to the pitch will face up when using a machine with downward load or face down when the beam is pulled upward with a loading shackle.
3. Adjust the deflectometer and the testing machine to read zero.
4. Apply the load continuously at a slow speed of 2.5 mm per minute. Take simultaneous load and deflectometer readings for increments of load that will give at least 20 readings below the ultimate. Secure reading at the ultimate load if possible.
5. Sketch the appearance of the failure.
6. Plot a curve showing the relation between the applied loads as the ordinates and the center deflections as the abscissas.
7. Calculate all values as required. Summarize results in tabular form.



**Various modes of failure of wood beam**



**Sketch type of failure**

**SAMPLE OF CALCULATION**

**Specimen No.** .....

Flexural stress at outer fiber at PL,  $f_{PL}$  =  $3 P_{PL} L / (2 b d^2)$   
= ..... = ..... ksc

Modulus of rupture =  $3 P_{max} L / (2 b d^2)$   
= ..... = ..... ksc

Modulus of elasticity, E =  $P L^3 / (48 I \Delta)$  ( use P and  $\Delta$  at PL)  
= ..... = ..... ksc

Modulus of resilience =  $f_{PL}^2 / (18 E)$   
= ..... = ..... kg-cm/cc

Maximum shearing stress =  $3 P_{max} / (4 b d)$   
= ..... = ..... ksc

Approximate total work to ultimate load =  $( P_{max} \times \Delta_{max} ) / 2$   
= ..... = ..... kg-cm

## SUMMARY OF RESULTS

	Specimen No. 1	Specimen No. 2
Flexural stress at outer fiber at PL, $f_{PL}$ (ksc)	.....	.....
Modulus of Rupture (ksc)	.....	.....
Modulus of elasticity (ksc)	.....	.....
Modulus of resilience (kg-cm/cc)	.....	.....
Maximum shearing stress (ksc)	.....	.....
Approximate total work to ultimate load (kg-cm)	.....	.....

## DISCUSSION AND CONCLUSIONS

**MATERIALS TESTING LABORATORY**  
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**CHULALONGKORN UNIVERSITY**

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**TEST No. T2**

**COMPRESSION TEST OF WOOD PARALLELED TO GRAIN**

**PURPOSE**                      To study the behavior of wood under compression parallel to grain and to determine the following mechanical properties.

1. Elastic compressive stress at Proportional Limit
2. Yield compressive stress at an offset of 0.05% strain
3. Ultimate compressive stress
4. The modulus of elasticity
5. The modulus of resilience

**REFERENCE**                      ASTM D143

JIS

**SPECIMEN**                      Clear wood 5 x 5 x 20 cm specimen

**APPARATUS**                      Compressometer of 15 cm gage length

## PROCEDURE

1. The specimen shall be prepared with special care to ensure that the end grain surfaces will be parallel to each other and at right angles to the longitudinal axis. If deemed necessary, at least one plate of the testing machine shall be equipped with a spherical bearing to obtain uniform distribution of load over the ends of the specimen.

2. Measure the actual cross sectional dimensions to the nearest 0.2 mm and length of specimen to the nearest 0.5 mm and weigh to the nearest 0.1 gram.

3. Record the gage length and the multiplication ratio of the compressometer. Deformation shall be read to 0.002 mm.

4. Attach the compressometer to the specimen and center the specimen on the testing machine. Adjust the compressometer dials and load to read zero.

5. Apply load continuously throughout the test at a speed of 0.06 cm per minute.

6. Record load - deformation readings with load increment of 500 kg until the proportional limit is well passed. Remove the compressometer and load the specimen up to failure record the ultimate load.

7. Record type of failure for each specimen. Compression failures shall be classified according to the appearance of the fractured specimen. In case of two or more kinds of failures develop, all shall be described in the order of their occurrences, e.g. shearing followed by splitting. The failure shall also be sketched in its proper position on the data sheet.

8. Plot load - deformation curve and also mark proportional limit and yield strength on the curve. If the curve does not pass through the origin, correct the curve.

## TYPES OF FAILURE IN COMPRESSION

**CRUSHING** This term shall be used when the plane of rupture is approximately horizontal. (Fig. a)

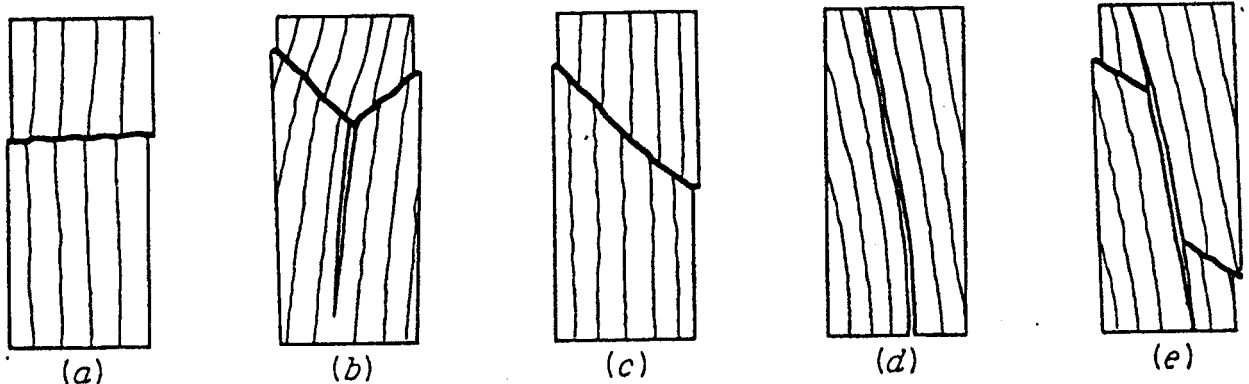
**WEDGE SPLIT** The direction of split, that is whether radial or tangential, shall be noted. (Fig. b)

**SHEARING** This term shall be used when the plane of rupture makes an angle of more than 45 degrees with the top of the specimen. (Fig. c)

**SPLITTING** This type of failure usually occurs in specimen having internal defects prior to test and shall be the basis for culling the specimen. (Fig. d)

**COMPRESSION AND SHEARING PARALLEL TO THE GRAIN** This failure usually occurs in cross-grained plane and shall be the basis for culling the specimen. (Fig. e)

**BROOMING OR ROLLING** This type of failure is usually associated with either an excess moisture contents at the ends of the specimen or improper cutting of the specimen, or both. This is not an acceptable type of failure and usually is associated with a reduced load. Consideration should be given to remedial conditions where this type of failure is observed.



(a) Crushing (plane of rupture approximately horizontal).

(b) Wedge split (note direction of split; radial or tangential).

(c) Shearing (plane of rupture at acute angle with horizontal).

(d) Splitting.

(e) Shearing and splitting parallel to grain. (Usually occurs in cross-grained pieces).

### Typical failures in compression



## SAMPLE OF CALCULATION

Specimen No. ....

$$\begin{aligned} \text{Compressive stress at PL, } f_{PL} &= \text{Load at PL / Cross sectional area} \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Yield compressive stress at 0.05\% offset} &= \text{Load at 0.05\% offset / Cross sectional area} \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Ultimate compressive stress} &= \text{Ultimate load / Cross sectional area} \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Modulus of elasticity, } E &= \text{Stress / Strain (at any point within PL)} \\ &= \dots\dots\dots = \dots\dots\dots \text{ ksc} \end{aligned}$$

$$\begin{aligned} \text{Modulus of resilience} &= 0.5 f_{PL}^2 / E \\ &= \dots\dots\dots = \dots\dots\dots \text{ kg-cm/cc} \end{aligned}$$

## SUMMARY OF RESULTS

	Specimen No. 1	Specimen No. 2
Compressive stress at PL, $f_{pL}$ (ksc)	.....	.....
Yield compressive stress at 0.05% offset (ksc)	.....	.....
Ultimate compressive stress (ksc)	.....	.....
Modulus of elasticity (ksc)	.....	.....
Modulus of resilience (kg-cm/cc)	.....	.....

## DISCUSSION AND CONCLUSIONS

**MATERIALS TESTING LABORATORY**  
**FACULTY OF ENGINEERING**  
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Date of tested .....

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**TEST No. T3**

**COMPRESSION TEST OF WOOD PERPENDICULAR TO GRAIN**

<b>PURPOSE</b>	To study the behavior of wood under compressive loading perpendicular to its grain and to determine the following mechanical properties <ol style="list-style-type: none"><li>1. The compressive stress at Proportional Limit</li><li>2. Yield stress at 0.05 % strain offset</li><li>3. The modulus of elasticity</li></ol>
<b>REFERENCE</b>	ASTM
<b>SPECIMEN</b>	Clear wood 5 x 5 x 15 cm in size
<b>APPARATUS</b>	Dial micrometer with bearing block







## SAMPLE OF CALCULATION

Specimen No. ....

Compressive stress at PL (from graph) = ..... ksc

Yield stress at 0.05% strain offset (from graph) = ..... ksc

Modulus of elasticity,  $E$  = Stress / Strain (at PL or within PL)  
= .....  
= ..... ksc

## SUMMARY OF RESULTS

	Specimen	Specimen	Specimen	Specimen
	No. 1	No. 2	No. 3	No. 4
Compressive stress at PL (ksc)	.....	.....	.....	.....
Yield stress at 0.05% strain offset (ksc)	.....	.....	.....	.....
Modulus of elasticity, $E$ (ksc)	.....	.....	.....	.....

## DISCUSSION AND CONCLUSIONS

**MATERIALS TESTING LABORATORY**  
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**TEST No. T4**

**SHEAR TEST OF WOOD PARALLELLED TO THE GRAIN**

<b>PURPOSE</b>	To determine the shearing stress of wood parallel to grain.
<b>REFERENCE</b>	ASTM
<b>SPECIMEN</b>	Standard 5 x 5 x 6.25 cm shear specimen
<b>APPARATUS</b>	Shear tool

## **SHEAR STRESS OF WOOD**

Shearing stress of wood is a measure of the ability of wood to resist forces that tend to cause one part of the material to slide or slip on another part adjacent to it. The tests are made on clear, straight grained, 5 cm by 6.25 cm blocks, notched to produce failure on 5 cm by 5 cm surface. These specimens are cut so that the load is applied and the block supported on end grain surfaces. It is important that the upper surface of the projecting lip be saw exactly paralleled to the base of the block. Stress in shear perpendicular to the grain is not measured because timber would fail from other causes before maximum load could be applied.

### **PROCEDURE**

1. Measure each specimen to 0.1 cm for the shearing dimensions and weigh to 0.1 gm. Note whether the shear is radial or tangential or some intermediate conditions, also note any defects.

2. Place the specimen in position in the shear tool. Adjust the cross bar at the rear of the tool so that the specimen will not twist when the load is applied, its axis is vertical and the lower end tests evenly on its support.

3. Center the shear tool in the testing machine and adjust the machine to read zero load. Bring the movable head into contact with the shearing tool at low speed; otherwise failure may occur before intended.

4. Apply the load at a speed of 6 mm per minute. Record the maximum load. Make a sketch of the ruptured specimen.

## DATA AND RESULTS

Specimen No.	Shearing Area (cm x cm)	Max. Load (kg)	Shear Stress (ksc)	Remarks

## DISCUSSION AND CONCLUSIONS

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**TEST No. T6**  
**HARDNESS TEST OF WOOD**

<b>PURPOSE</b>	To determine the hardness of wood
<b>REFERENCES</b>	ASTM
<b>SPECIMEN</b>	Clear wood 5 x 5 x 15 cm size
<b>APPARATUS</b>	A universal testing machine and wood hardness test equipment

## **HARDNESS OF WOOD**

**Hardness of wood** is a measure of its resistance to indentation, The standard hardness test, made to determine the resistance of wood to indentation by a steel punch or ball, is of value for comparative purpose only. There is little or no consistent difference between the hardness of the radial and tangential surfaces, but end hardness generally exceeds that determined from the sides of the piece. For this reason, wood products in which hardness is the governing factor, such as paving blocks, are so used that the end grain is exposed to service loads. The hardness tool consists of a punch with a hardness steel hemispherical end having a diameter of 1.13 cm and giving a projected area of 1 sq. cm. The load required to imbed the ball to one-half its diameter is the measure of hardness of wood.

### **PROCEDURE**

1. Fit the hardness tool into the movable head of the testing machine.
2. Weigh the specimen to the nearest gram. Place the specimen on the platform of the testing machine.
3. The load is applied through the ball continuously throughout the test at a speed of movable cross head of 8 mm per minute.
4. Record the load at which the ball has penetrated to one half its diameter by tightening of the collar against the specimen.
5. Make two penetrations on tangential surface and also on radial surface and one penetration one each end. The penetration shall be far enough from the edge to prevent splitting.

**DATA AND RESULTS**

Specimen	Weight (gm)	Penetration Load (kg)					
		Tangential		Radial		End	
		1	2	1	2	1	2

**DISCUSSION AND CONCLUSIONS**

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**TEST No. T9**  
**IMPACT TEST OF WOOD**

<b>PURPOSE</b>	To determine the energy required to break a wood specimen and also the maximum pressure withstood by the specimen which indicates the shock resistance of wood.
<b>REFERENCES</b>	ASTM E23
<b>SPECIMEN</b>	Clear wood 2 x 2 x 30 cm size
<b>APPARATUS</b>	Pendulum hammer impact testing machine

## PROCEDURE

1. Place the specimen on the supports at a span Length of 24 cm.
2. Place an aluminum bar at the support and adjust the bar so that a fresh spot is bearing against the ball.
3. Lift the hammer to its upper most position where it is held by the lever at the top of the machine. To allow it to drop, simply press on the lever.
4. To lower the hammer, lift the large weight at the end of the rope and the hammer will slowly fall back.
5. The energy required to break the bar is read directly from the scale. No calculation is necessary. Before starting the test always bring back the index to its lowest position.
6. Weight of hammer is 8.5 kg and height of fall is 120 cm. So that the energy of hammer is 10.2 kg-m. When the hammer breaks the specimen and goes to the other side, it can not fall back as it is held there by the rope brake. The brake drum must be clean so that it contains neither grease nor oil. The rope must be wound diagonally around the drum from left to right as seen in front of the machine. It is not necessary to grease the rope.
7. Maximum pressure at the support, P is calculated by the use of the following formula.

$$P = H \pi 0.5 D ( D - \sqrt{D^2 - d^2} ) \quad (1)$$

Where

P	=	Max. pressure (or ball load) at support (kg)
H	=	Brinell Hardness Number, for aluminum bar H = 18.9
D	=	Ball diameter (mm), in this test D= 10 mm
d	=	Diameter of imprint on aluminum bar (mm)

## DATA AND RESULTS

Specimen No.	Weight (gm)	Energy to break specimen (kg-m)	diameter of imprint, d (mm)	Max. pressure at support, P (kg)

Average energy required to break the wood specimen = ..... kg-m

Average max. pressure withstood by the wood specimen = ..... kg

## DISCUSSION AND CONCLUSIONS

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**TEST No. T11**

**TEST OF TIMBER BOLTED JOINT (LOAD PARALLELED TO GRAIN)**

**PURPOSE**

To study the behavior of bolted joints when the load is applied paralleled to the grain in compression and to determine

1. Load at Proportional Limit
2. Bearing stress at Proportional Limit of the timber specimen
3. Indicated load at first relaxation
4. Maximum load observed at a total slip of 15 mm
5. Type of joint failure

**REFERENCE**

ASTM D1761

**SPECIMEN**

Clear wood 5 x 10 x 40 cm, bolts and two metal splice plates

**APPARATUS**

A testing machine with a load range of about 5,000 kg and two dial gages with accuracy of 0.01 mm

## PROCEDURE

1. Measure thickness and width of the specimen to 0.1 mm and weigh it to the nearest 0.1 gm.
2. Record size of the bolt and diameter of the bolt hole (usually 1/8 inches greater than bolt diameter). Bearing plates or washers should be used and the bolt should not be tightly drawn.
3. The bolted joint shall be tested paralleled to the grain of wood in compression. Use the spherical bearing block in applying the load. Gages are attached on both sides to measure the slip of the joint.
4. Apply an initial load of 100 kg and set the dial gages to read zero. Mark a point 15 mm from the edge of the splice plate.
5. Apply the load continuously throughout the test at a rate of motion of the movable cross head of 0.8 mm per minute.
6. Take readings of the applied load and the corresponding slip with the load increment of 100 kg up to the first relaxation of the load indicated on the testing machine. Report this indicated load.
7. Continue the test until a total slip of 15 mm is reached and record the maximum load observed. Note and sketch the kind of failure of the joint.
8. Plot the load-slip curve with the applied load as the ordinate and the slip as abscissa. Determine the load at the proportional limit and the bearing stress at the proportional limit.

## DATA

	Specimen	Specimen	Specimen	Specimen
	No. 1	No. 2	No. 3	No. 4
Thickness of specimen (cm)	.....	.....	.....	.....
Width of specimen (cm)	.....	.....	.....	.....
Thickness of splice plate (cm)	.....	.....	.....	.....
Diameter of bolt (cm)	.....	.....	.....	.....
Diameter of bolt hole (cm)	.....	.....	.....	.....
Load at first relaxation (kg)	.....	.....	.....	.....
Max. load observed at 15 mm slip (kg)	.....	.....	.....	.....





## SAMPLE OF CALCULATION

Specimen No. ....

Load at the Proportional Limit,  $P_{PL}$  = ..... kg  
Length of bolt in wood specimen, L = ..... cm  
Diameter of bolt, d = ..... cm  
Bearing stress at PL =  $P_{PL} / (L d)$   
= ..... ksc

## SUMMARY OF RESULTS

	Specimen	Specimen	Specimen	Specimen
	No. 1	No. 2	No. 3	No. 4
Load at PL (kg)	.....	.....	.....	.....
Bearing stress at PL (ksc)	.....	.....	.....	.....
Indicated load at first relaxation (kg)	.....	.....	.....	.....
Load observed at 15 mm slip (kg)	.....	.....	.....	.....

## DISCUSSION AND CONCLUSIONS