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Lampiran 1.

Designation: D 570 – 98 An American National Standard

Standard Test Method for Water Absorption of Plastics[1]

This standard is issued under the fixed designation D 570; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the relative rate of absorption of water by plastics when immersed. This test method is intended to apply to the testing of all types of plastics, including cast, hot-molded, and cold-molded resinous products, and both homogeneous and laminated plastics in rod and tube form and in sheets 0.13 mm (0.005 in.) or greater in thickness.

1.2 The values given in SI units are to be regarded as the standard. The values stated in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—ISO 62 is technically equivalent to this test method.

2. Referenced Documents

2.1 *ASTM Standards:*

D 647 Practice for Design of Molds for Test Specimens of Plastic Molding Materials[2]

2.2 *ISO Standard:*

ISO 62 Plastics—Determination of Water Absorption[3]

3. Significance and Use

3.1 This test method for rate of water absorption has two chief functions: first, as a guide to the proportion of water absorbed by a material and consequently, in those cases where the relationships between moisture and electrical or mechanical properties, dimensions, or appearance have been determined, as a guide to the effects of exposure to water or humid conditions on such properties; and second, as a control test on the uniformity of a product. This second function is particularly applicable to sheet, rod, and tube arms when the test is made on the finished product.

3.2 Comparison of water absorption values of various plastics can be made on the basis of values obtained in accordance with 7.1 and 7.4.

3.3 Ideal diffusion of liquids[4] into polymers is a function of the square root of immersion time. Time to saturation is strongly dependent on specimen thickness. For example, Table 1 shows the time to approximate time saturation for various thickness of nylon-6.

3.4 The moisture content of a plastic is very intimately related to such properties as electrical insulation resistance, dielectric losses, mechanical strength, appearance, and dimensions. The effect upon these properties of change in moisture content due to water absorption depends largely on the type of exposure (by immersion in water or by exposure to high humidity), shape of the part, and inherent properties of the plastic. With nonhomogeneous materials, such as laminated forms, the rate of water absorption may be widely different through each edge and surface. Even for otherwise homogeneous materials, it may be slightly greater through cut edges than through molded surfaces. Consequently, attempts to correlate water absorption with the surface area must generally be limited to closely related materials and to similarly shaped specimens: For materials of widely varying density, relation between water-absorption values on a volume as well as a weight basis may need to be considered.

4. Apparatus

4.1 *Balance*—An analytical balance capable of reading 0.0001 g.

4.2 *Oven*, capable of maintaining uniform temperatures of 50 ± 3°C (122 ± 5.4°F) and of 105 to 110°C (221 to 230°F).

5. Test Specimen

5.1 The test specimen for molded plastics shall be in the form of a disk 50.8 mm (2 in.) in diameter and 3.2 mm (⅛ in.) in thickness (see Note 2). Permissible variations in thickness are ±0.18 mm (±0.007 in.) for hot-molded and ±0.30 mm (±0.012 in.) for cold-molded or cast materials.

NOTE 2—The disk mold prescribed in the Molds for Disk Test Specimens Section of Practice D 647 is suitable for molding disk test

[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D 20.50 on Permanence Properties.
Current edition approved July 10, 1998. Published January 1999. Originally published as D 570 – 40 T. Last previous edition D 570 – 95.

[2] Discontinued 1994; replaced by D 1896, D 3419, D 3641, D 4703, and D 5227. See 1994 *Annual Book of ASTM Standards*, Vol 08.01.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[4] Additional information regarding diffusion of liquids in polymers can be found in the following references: (*1*) *Diffusion, Mass Transfer in Fluid Systems*, E. L. Cussler, Cambridge University Press, 1985, ISBN 0-521-29846-6, (*2*) *Diffusion in Polymers*, J. Crank and G. S. Park, Academic Press, 1968, and (*3*) "Permeation, Diffusion, and Sorption of Gases and Vapors," R. M. Felder and G. S. Huvard, in *Methods of Experimental Physics*, Vol 16C, 1980, Academic Press.

TABLE 1 Time to Saturation for Various Thickness of Nylon-6

Thickness, mm	Typical Time to 95 % Saturation, h
1	100
2	400
3.2	1 000
10	10 000
25	62 000

specimens of thermosetting materials but not thermoplastic materials.

5.2 *ISO Standard Specimen*—The test specimen for homogeneous plastics shall be 60 by 60 by 1 mm. Tolerance for the 60-mm dimension is ±2 mm and ±0.05 mm for the 1-mm thickness. This test method and ISO 62 are technically equivalent when the test specimen described in 5.2 is used.

5.3 The test specimen for sheets shall be in the form of a bar 76.2 mm (3 in.) long by 25.4 mm (1 in.) wide by the thickness of the material. When comparison of absorption values with molded plastics is desired, specimens 3.2 mm (⅛ in.) thick should be used. Permissible variations in thickness shall be 0.20 mm (±0.008 in.) except for asbestos-fabric-base phenolic laminated materials or other materials which have greater standard commercial tolerances.

5.4 The test specimen for rods shall be 25.4 mm (1 in.) long for rods 25.4 mm in diameter or under and 12.7 mm (½ in.) long for larger-diameter rods. The diameter of the specimen shall be the diameter of the finished rod.

5.5 The test specimen for tubes less than 76 mm (3 in.) in inside diameter shall be the full section of the tube and 25.4 mm (1 in.) long. For tubes 76 mm (3 in.) or more in inside diameter, a rectangular specimen shall be cut 76 mm in length in the circumferential direction of the tube and 25.4 mm in width lengthwise of the tube.

5.6 The test specimens for sheets, rods, and tubes shall be machined, sawed, or sheared from the sample so as to have smooth edges free from cracks. The cut edges shall be made smooth by finishing with No. 0 or finer sandpaper or emery cloth. Sawing, machining, and sandpapering operations shall be slow enough so that the material is not heated appreciably.

NOTE 3—If there is any oil on the surface of the specimen when received or as a result of machining operations, wash the specimen with a cloth wet with gasoline to remove oil, wipe with a dry cloth, and allow to stand in air for 2 h to permit evaporation of the gasoline. If gasoline attacks the plastic, use some suitable solvent or detergent that will evaporate within the 2-h period.

5.7 The dimensions listed in the following table for the various specimens shall be measured to the nearest 0.025 mm (0.001 in.). Dimensions not listed shall be measured within 0.8 mm (±1⁄32 in.).

Type of Specimen	Dimensions to Be Measured to the Nearest 0.025 mm (0.001 in.)
Molded disk	thickness
Sheet	thickness
Rod	length and diameter
Tube	inside and outside diameter, and wall thickness

6. Conditioning

6.1 Three specimens shall be conditioned as follows:

6.1.1 Specimens of materials whose water-absorption value would be appreciably affected by temperatures in the neighborhood of 110°C (230°F), shall be dried in an oven for 24 h at 50 ± 3°C (122 ± 5.4°F), cooled in a desiccator, and immediately weighed to the nearest 0.001 g.

NOTE 4—If a static charge interferes with the weighing, lightly rub the surface of the specimens with a grounded conductor.

6.1.2 Specimens of materials, such as phenolic laminated plastics and other products whose water-absorption value has been shown not to be appreciably affected by temperatures up to 110°C (230°F), shall be dried in an oven for 1 h at 105 to 110°C (221 to 230°F).

6.1.3 When data for comparison with absorption values for other plastics are desired, the specimens shall be dried in an oven for 24 h at 50 ± 3°C (122 ± 5.4°F), cooled in a desiccator, and immediately weighed to the nearest 0.001 g.

7. Procedure

7.1 *Twenty-Four Hour Immersion*—The conditioned specimens shall be placed in a container of distilled water maintained at a temperature of 23 ± 1°C (73.4 ± 1.8°F), and shall rest on edge and be entirely immersed. At the end of 24, +½, −0 h, the specimens shall be removed from the water one at a time, all surface water wiped off with a dry cloth, and weighed to the nearest 0.001 g immediately. If the specimen is 1⁄16 in. or less in thickness, it shall be put in a weighing bottle immediately after wiping and weighed in the bottle.

7.2 *Two-Hour Immersion*—For all thicknesses of materials having a relatively high rate of absorption, and for thin specimens of other materials which may show a significant weight increase in 2 h, the specimens shall be tested as described in 7.1 except that the time of immersion shall be reduced to 120 ± 4 min.

7.3 *Repeated Immersion*—A specimen may be weighed to the nearest 0.001 g after 2-h immersion, replaced in the water, and weighed again after 24 h.

NOTE 5—In using this test method the amount of water absorbed in 24 h may be less than it would have been had the immersion not been interrupted.

7.4 *Long-Term Immersion*—To determine the total water absorbed when substantially saturated, the conditioned specimens shall be tested as described in 7.1 except that at the end of 24 h they shall be removed from the water, wiped free of surface moisture with a dry cloth, weighed to the nearest 0.001 g immediately, and then replaced in the water. The weighings shall be repeated at the end of the first week and every two weeks thereafter until the increase in weight per two-week period, as shown by three consecutive weighings, averages less than 1 % of the total increase in weight or 5 mg, whichever is greater; the specimen shall then be considered substantially saturated. The difference between the substantially saturated weight and the dry weight shall be considered as the water absorbed when substantially saturated.

7.5 *Two-Hour Boiling Water Immersion*—The conditioned specimens shall be placed in a container of boiling distilled water, and shall be supported on edge and be entirely immersed. At the end of 120 ± 4 min, the specimens shall be removed from the water and cooled in distilled water maintained at room temperature. After 15 ± 1 min, the specimens shall be removed from the water, one at a time, all surface water removed with a dry cloth, and the specimens weighed to the nearest 0.001 g immediately. If the specimen is 1⁄16 in. or less in thickness, it shall be weighed in a weighing bottle.

7.6 *One-Half-Hour Boiling Water Immersion*—For all thicknesses of materials having a relatively high rate of absorption and for thin specimens of other materials which may show a significant weight increase in ½ h, the specimens shall be tested as described in 7.5, except that the time of immersion shall be reduced to 30 ± 1 min.

7.7 *Immersion at 50°C*—The conditioned specimens shall be tested as described in 7.5, except that the time and temperature of immersion shall be 48 ± 1 h and 50 ± 1°C (122.0 ± 1.8°F), respectively, and cooling in water before weighing shall be omitted.

7.8 When data for comparison with absorption values for other plastics are desired, the 24-h immersion procedure described in 7.1 and the equilibrium value determined in 7.4 shall be used.

8. Reconditioning

8.1 When materials are known or suspected to contain any appreciable amount of water-soluble ingredients, the specimens, after immersion, shall be weighed, and then reconditioned for the same time and temperature as used in the original drying period. They shall then be cooled in a desiccator and immediately reweighed. If the reconditioned weight is lower than the conditioned weight, the difference shall be considered as water-soluble matter lost during the immersion test. For such materials, the water-absorption value shall be taken as the sum of the increase in weight on immersion and of the weight of the water-soluble matter.

9. Calculation and Report

9.1 The report shall include the values for each specimen and the average for the three specimens as follows:

9.1.1 Dimensions of the specimens before test, measured in accordance with 5.6, and reported to the nearest 0.025 mm (0.001 in.),

9.1.2 Conditioning time and temperature,

9.1.3 Immersion procedure used,

9.1.4 Time of immersion (long-term immersion procedure only),

9.1.5 Percentage increase in weight during immersion, calculated to the nearest 0.01 % as follows:

$$\text{Increase in weight, \%} = \frac{\text{wet weight} - \text{conditioned weight}}{\text{conditioned weight}} \times 100$$

9.1.6 Percentage of soluble matter lost during immersion, if determined, calculated to the nearest 0.01 % as follows (see Note 6):

$$\text{Soluble matter lost, \%} = \frac{\text{conditioned weight} - \text{reconditioned weight}}{\text{conditioned weight}} \times 100$$

NOTE 6—When the weight on reconditioning the specimen after immersion in water exceeds the conditioned weight prior to immersion, report "none" under 9.1.6.

9.1.7 For long-term immersion procedure only, prepare a graph of the increase in weight as a function of the square root of each immersion time. The initial slope of this graph is proportional to the diffusion constant of water in the plastic. The plateau region with little or no change in weight as a function of the square root of immersion time represents the saturation water content of the plastic.

NOTE 7—Deviation from the initial slope and plateau model indicates that simple diffusion may be a poor model for determining water content. In such cases, additional studies are suggested to determine a better model for water absorption.

9.1.8 The percentage of water absorbed, which is the sum of the values in 9.1.5 and 9.1.6, and

9.1.9 Any observations as to warping, cracking, or change in appearance of the specimens.

10. Precision and Bias [5]

10.1 *Precision*—An interlaboratory test program was carried out using the procedure outlined in 7.1, involving three laboratories and three materials. Analysis of this data yields the following coefficients of variation (average of three replicates).

	Within Laboratories	Between Laboratories
Average absorption above 1 % (2 materials)	2.33 %	4.89 %
Average absorption below 0.2 % (1 material)	9.01 %	16.63 %

NOTE 8—A round robin is currently under way to more completely determine repeatability and reproducibility of this test method.

10.2 *Bias*—No justifiable statement on the bias of this test method can be made, since the true value of the property cannot be established by an accepted referee method.

11. Keywords

11.1 absorption; immersion; plastics; water

[5] Supporting data are available from ASTM Headquarters. Request RR: D-20-1064.

Lampiran 2.

Designation: D 790 – 02

An American National Standard

Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[1]

This standard is issued under the fixed designation D 790; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 These test methods cover the determination of flexural properties of unreinforced and reinforced plastics, including high-modulus composites and electrical insulating materials in the form of rectangular bars molded directly or cut from sheets, plates, or molded shapes. These test methods are generally applicable to both rigid and semirigid materials. However, flexural strength cannot be determined for those materials that do not break or that do not fail in the outer surface of the test specimen within the 5.0 % strain limit of these test methods. These test methods utilize a three-point loading system applied to a simply supported beam. A four-point loading system method can be found in Test Method D 6272.

1.1.1 *Procedure A*, designed principally for materials that break at comparatively small deflections.

1.1.2 *Procedure B*, designed particularly for those materials that undergo large deflections during testing.

1.1.3 Procedure A shall be used for measurement of flexural properties, particularly flexural modulus, unless the material specification states otherwise. Procedure B may be used for measurement of flexural strength only. Tangent modulus data obtained by Procedure A tends to exhibit lower standard deviations than comparable data obtained by means of Procedure B.

1.2 Comparative tests may be run in accordance with either procedure, provided that the procedure is found satisfactory for the material being tested.

1.3 The values stated in SI units are to be regarded as the standard. The values provided in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—These test methods are not technically equivalent to ISO 178.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics for Testing[2]
D 638 Test Method for Tensile Properties of Plastics[2]
D 883 Terminology Relating to Plastics[2]
D 4000 Classification System for Specifying Plastic Materials[3]
D 5947 Test Methods for Physical Dimensions of Solid Plastic Specimens[4]
D 6272 Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending[4]
E 4 Practices for Force Verification of Testing Machines[5]
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[6]

3. Terminology

3.1 *Definitions*—Definitions of terms applying to these test methods appear in Terminology D 883 and Annex A1 of Test Method D 638.

4. Summary of Test Method

4.1 A bar of rectangular cross section rests on two supports and is loaded by means of a loading nose midway between the supports (see Fig. 1). A support span-to-depth ratio of 16:1 shall be used unless there is reason to suspect that a larger span-to-depth ratio may be required, as may be the case for certain laminated materials (see Section 7 and Note 8 for guidance).

4.2 The specimen is deflected until rupture occurs in the outer surface of the test specimen or until a maximum strain (see 12.7) of 5.0 % is reached, whichever occurs first.

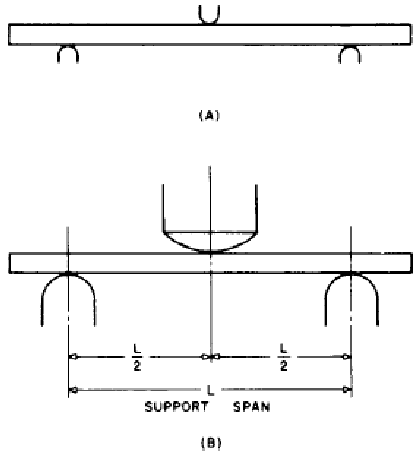
4.3 Procedure A employs a strain rate of 0.01 mm/mm/min (0.01 in./in./min) and is the preferred procedure for this test method, while Procedure B employs a strain rate of 0.10 mm/mm/min (0.10 in./in./min).

[1] These test methods are under the jurisdiction of ASTM Committee D20 on Plastics and are the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

Current edition approved April 10, 2002. Published June 2002. Originally published as D 790 – 70. Last previous edition D 790 – 00.

[2] *Annual Book of ASTM Standards*, Vol 08.01.
[3] *Annual Book of ASTM Standards*, Vol 08.02.
[4] *Annual Book of ASTM Standards*, Vol 08.03.
[5] *Annual Book of ASTM Standards*, Vol 03.01.
[6] *Annual Book of ASTM Standards*, Vol 14.02.

***A Summary of Changes section appears at the end of this standard.**



NOTE—(*a*) Minimum radius = 3.2 mm (⅛ in.). (*b*) Maximum radius supports 1.6 times specimen depth; maximum radius loading nose = 4 times specimen depth.

FIG. 1 Allowable Range of Loading Nose and Support Radii

5. Significance and Use

5.1 Flexural properties as determined by these test methods are especially useful for quality control and specification purposes.

5.2 Materials that do not fail by the maximum strain allowed under these test methods (3-point bend) may be more suited to a 4-point bend test. The basic difference between the two test methods is in the location of the maximum bending moment and maximum axial fiber stresses. The maximum axial fiber stresses occur on a line under the loading nose in 3-point bending and over the area between the loading noses in 4-point bending.

5.3 Flexural properties may vary with specimen depth, temperature, atmospheric conditions, and the difference in rate of straining as specified in Procedures A and B (see also Note 8).

5.4 Before proceeding with these test methods, reference should be made to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters, or combination thereof, covered in the materials specification shall take precedence over those mentioned in these test methods. If there are no material specifications, then the default conditions apply. Table 1 in Classification System D 4000 lists the ASTM materials standards that currently exist for plastics.

6. Apparatus

6.1 *Testing Machine*— A properly calibrated testing machine that can be operated at constant rates of crosshead motion over the range indicated, and in which the error in the load measuring system shall not exceed ±1 % of the maximum load expected to be measured. It shall be equipped with a deflection measuring device. The stiffness of the testing machine shall be such that the total elastic deformation of the system does not exceed 1 % of the total deflection of the test specimen during testing, or appropriate corrections shall be made. The load indicating mechanism shall be essentially free from inertial lag at the crosshead rate used. The accuracy of the testing machine shall be verified in accordance with Practices E 4.

TABLE 1 Flexural Strength

Material	Mean, 10^3 psi	Values Expressed in Units of % of 10^3 psi			
		V_r[A]	V_R[B]	r[C]	R[D]
ABS	9.99	1.59	6.05	4.44	17.2
DAP thermoset	14.3	6.58	6.58	18.6	18.6
Cast acrylic	16.3	1.67	11.3	4.73	32.0
GR polyester	19.5	1.43	2.14	4.05	6.08
GR polycarbonate	21.0	5.16	6.05	14.6	17.1
SMC	26.0	4.76	7.19	13.5	20.4

[A] V_r = within-laboratory coefficient of variation for the indicated material. It is obtained by first pooling the within-laboratory standard deviations of the test results from all of the participating laboratories: $Sr = [[(s_1)^2 + (s_2)^2 \ldots + (s_n)^2]/n]^{1/2}$ then V_r = (S_r divided by the overall average for the material) × 100.

[B] V_r = between-laboratory reproducibility, expressed as the coefficient of variation: $S_R = \{S_r^2 + S_L^2\}^{1/2}$ where S_L is the standard deviation of laboratory means. Then: V_R = (S_R divided by the overall average for the material) × 100.

[C] r = within-laboratory critical interval between two test results = 2.8 × V_r.

[D] R = between-laboratory critical interval between two test results = 2.8 × V_R.

6.2 *Loading Noses and Supports*—The loading nose and supports shall have cylindrical surfaces. In order to avoid excessive indentation, or failure due to stress concentration directly under the loading nose, the radii of the loading nose and supports shall be 5.0 ± 0.1 mm (0.197 ± 0.004 in.) unless otherwise specified or agreed upon between the interested clients. When other loading noses and supports are used they must comply with the following requirements: they shall have a minimum radius of 3.2 mm (⅛ in.) for all specimens, and for specimens 3.2 mm or greater in depth, the radius of the supports may be up to 1.6 times the specimen depth. They shall be this large if significant indentation or compressive failure occurs. The arc of the loading nose in contact with the specimen shall be sufficiently large to prevent contact of the specimen with the sides of the nose (see Fig. 1). The maximum radius of the loading nose shall be no more than 4 times the specimen depth.

NOTE 2—Test data have shown that the loading nose and support dimensions can influence the flexural modulus and flexural strength values. The loading nose dimension has the greater influence. Dimensions of the loading nose and supports must be specified in the material specification.

6.3 *Micrometers*— Suitable micrometers for measuring the width and thickness of the test specimen to an incremental discrimination of at least 0.025 mm (0.001 in.) should be used. All width and thickness measurements of rigid and semirigid plastics may be measured with a hand micrometer with ratchet. A suitable instrument for measuring the thickness of nonrigid test specimens shall have: a contact measuring pressure of 25 ± 2.5 kPa (3.6 ± 0.36 psi), a movable circular contact foot 6.35 ± 0.025 mm (0.250 ± 0.001 in.) in diameter and a lower fixed anvil large enough to extend beyond the contact foot in all directions and being parallel to the contact foot within 0.005 mm (0.002 in.) over the entire foot area. Flatness of foot and anvil shall conform to the portion of the Calibration section of Test Methods D 5947.

7. Test Specimens

7.1 The specimens may be cut from sheets, plates, or molded shapes, or may be molded to the desired finished dimensions. The actual dimensions used in Section 4.2, Calculation, shall be measured in accordance with Test Methods D 5947.

NOTE 3—Any necessary polishing of specimens shall be done only in the lengthwise direction of the specimen.

7.2 *Sheet Materials (Except Laminated Thermosetting Materials and Certain Materials Used for Electrical Insulation, Including Vulcanized Fiber and Glass Bonded Mica)*:

7.2.1 *Materials 1.6 mm (1⁄16 in.) or Greater in Thickness*—For flatwise tests, the depth of the specimen shall be the thickness of the material. For edgewise tests, the width of the specimen shall be the thickness of the sheet, and the depth shall not exceed the width (see Notes 4 and 5). For all tests, the support span shall be 16 (tolerance ±1) times the depth of the beam. Specimen width shall not exceed one fourth of the support span for specimens greater than 3.2 mm (1⁄8 in.) in depth. Specimens 3.2 mm or less in depth shall be 12.7 mm (1⁄2 in.) in width. The specimen shall be long enough to allow for overhanging on each end of at least 10 % of the support span, but in no case less than 6.4 mm (1⁄4 in.) on each end. Overhang shall be sufficient to prevent the specimen from slipping through the supports.

NOTE 4—Whenever possible, the original surface of the sheet shall be unaltered. However, where testing machine limitations make it impossible to follow the above criterion on the unaltered sheet, one or both surfaces shall be machined to provide the desired dimensions, and the location of the specimens with reference to the total depth shall be noted. The value obtained on specimens with machined surfaces may differ from those obtained on specimens with original surfaces. Consequently, any specifications for flexural properties on thicker sheets must state whether the original surfaces are to be retained or not. When only one surface was machined, it must be stated whether the machined surface was on the tension or compression side of the beam.

NOTE 5—Edgewise tests are not applicable for sheets that are so thin that specimens meeting these requirements cannot be cut. If specimen depth exceeds the width, buckling may occur.

7.2.2 *Materials Less than 1.6 mm (1⁄16 in.) in Thickness*—The specimen shall be 50.8 mm (2 in.) long by 12.7 mm (1⁄2 in.) wide, tested flatwise on a 25.4-mm (1-in.) support span.

NOTE 6—Use of the formulas for simple beams cited in these test methods for calculating results presumes that beam width is small in comparison with the support span. Therefore, the formulas do not apply rigorously to these dimensions.

NOTE 7—Where machine sensitivity is such that specimens of these dimensions cannot be measured, wider specimens or shorter support spans, or both, may be used, provided the support span-to-depth ratio is at least 14 to 1. All dimensions must be stated in the report (see also Note 6).

7.3 *Laminated Thermosetting Materials and Sheet and Plate Materials Used for Electrical Insulation, Including Vulcanized Fiber and Glass-Bonded Mica*—For paper-base and fabric-base grades over 25.4 mm (1 in.) in nominal thickness, the specimens shall be machined on both surfaces to a depth of 25.4 mm. For glass-base and nylon-base grades, specimens over 12.7 mm (1⁄2 in.) in nominal depth shall be machined on both surfaces to a depth of 12.7 mm. The support span-to-depth ratio shall be chosen such that failures occur in the outer fibers of the specimens, due only to the bending moment (see Note 8). Therefore, a ratio larger than 16:1 may be necessary (32:1 or 40:1 are recommended). When laminated materials exhibit low compressive strength perpendicular to the laminations, they shall be loaded with a large radius loading nose (up to four times the specimen depth to prevent premature damage to the outer fibers.

7.4 *Molding Materials (Thermoplastics and Thermosets)*—The recommended specimen for molding materials is 127 by 12.7 by 3.2 mm (5 by 1⁄2by 1⁄8 in.) tested flatwise on a support span, resulting in a support span-to-depth ratio of 16 (tolerance ±1). Thicker specimens should be avoided if they exhibit significant shrink marks or bubbles when molded.

7.5 *High-Strength Reinforced Composites, Including Highly Orthotropic Laminates*—The span-to-depth ratio shall be chosen such that failure occurs in the outer fibers of the specimens and is due only to the bending moment (see Note 8). A span-to-depth ratio larger than 16:1 may be necessary (32:1 or 40:1 are recommended). For some highly anisotropic composites, shear deformation can significantly influence modulus measurements, even at span-to-depth ratios as high as 40:1. Hence, for these materials, an increase in the span-to-depth ratio to 60:1 is recommended to eliminate shear effects when modulus data are required, it should also be noted that the flexural modulus of highly anisotropic laminates is a strong function of ply-stacking sequence and will not necessarily correlate with tensile modulus, which is not stacking-sequence dependent.

NOTE 8—As a general rule, support span-to-depth ratios of 16:1 are satisfactory when the ratio of the tensile strength to shear strength is less than 8 to 1, but the support span-to-depth ratio must be increased for composite laminates having relatively low shear strength in the plane of the laminate and relatively high tensile strength parallel to the support span.

8. Number of Test Specimens

8.1 Test at least five specimens for each sample in the case of isotropic materials or molded specimens.

8.2 For each sample of anisotropic material in sheet form, test at least five specimens for each of the following conditions. Recommended conditions are flatwise and edgewise tests on specimens cut in lengthwise and crosswise directions of the sheet. For the purposes of this test, "lengthwise" designates the principal axis of anisotropy and shall be interpreted to mean the direction of the sheet known to be stronger in flexure. "Crosswise" indicates the sheet direction known to be the weaker in flexure and shall be at 90° to the lengthwise direction.

9. Conditioning

9.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618 unless otherwise specified by contract or the relevant ASTM material specification. Reference pre-test conditioning, to settle disagreements, shall apply tolerances of ±1°C (1.8°F) and ±2 % relative humidity.

9.2 *Test Conditions*—Conduct the tests at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity unless otherwise specified by contract or the relevant ASTM material specification. Reference testing conditions, to settle disagreements, shall apply tolerances of ±1°C (1.8°F) and ±2 % relative humidity.

10. Procedure

10.1 *Procedure A*:

10.1.1 Use an untested specimen for each measurement. Measure the width and depth of the specimen to the nearest 0.03 mm (0.001 in.) at the center of the support span. For specimens less than 2.54 mm (0.100 in.) in depth, measure the depth to the nearest 0.003 mm (0.0005 in.). These measurements shall be made in accordance with Test Methods D 5947.

10.1.2 Determine the support span to be used as described in Section 7 and set the support span to within 1 % of the determined value.

10.1.3 For flexural fixtures that have continuously adjustable spans, measure the span accurately to the nearest 0.1 mm (0.004 in.) for spans less than 63 mm (2.5 in.) and to the nearest 0.3 mm (0.012 in.) for spans greater than or equal to 63 mm (2.5 in.). Use the actual measured span for all calculations. For flexural fixtures that have fixed machined span positions, verify the span distance the same as for adjustable spans at each machined position. This distance becomes the span for that position and is used for calculations applicable to all subsequent tests conducted at that position. See Annex A2 for information on the determination of and setting of the span.

10.1.4 Calculate the rate of crosshead motion as follows and set the machine for the rate of crosshead motion as calculated by Eq 1:

$$R = ZL^2/6d \tag{1}$$

where:
R = rate of crosshead motion, mm (in.)/min,
L = support span, mm (in.),
d = depth of beam, mm (in.), and
Z = rate of straining of the outer fiber, mm/mm/min (in./in./min). Z shall be equal to 0.01.

In no case shall the actual crosshead rate differ from that calculated using Eq 1, by more than ±10 %.

10.1.5 Align the loading nose and supports so that the axes of the cylindrical surfaces are parallel and the loading nose is midway between the supports. The parallelism of the apparatus may be checked by means of a plate with parallel grooves into which the loading nose and supports will fit when properly aligned (see A2.3). Center the specimen on the supports, with the long axis of the specimen perpendicular to the loading nose and supports.

10.1.6 Apply the load to the specimen at the specified crosshead rate, and take simultaneous load-deflection data. Measure deflection either by a gage under the specimen in contact with it at the center of the support span, the gage being mounted stationary relative to the specimen supports, or by measurement of the motion of the loading nose relative to the supports. Load-deflection curves may be plotted to determine the flexural strength, chord or secant modulus or the tangent modulus of elasticity, and the total work as measured by the area under the load-deflection curve. Perform the necessary toe compensation (see Annex A1) to correct for seating and indentation of the specimen and deflections in the machine.

10.1.7 Terminate the test when the maximum strain in the outer surface of the test specimen has reached 0.05 mm/mm (in./in.) or at break if break occurs prior to reaching the maximum strain (Notes 9 and 10). The deflection at which this strain will occur may be calculated by letting r equal 0.05 mm/mm (in./in.) in Eq 2:

$$D = rL^2/6d \tag{2}$$

where:
D = midspan deflection, mm (in.),
r = strain, mm/mm (in./in.),
L = support span, mm (in.), and
d = depth of beam, mm (in.).

NOTE 9—For some materials that do not yield or break within the 5 % strain limit when tested by Procedure A, the increased strain rate allowed by Procedure B (see 10.2) may induce the specimen to yield or break, or both, within the required 5 % strain limit.

NOTE 10—Beyond 5 % strain, this test method is not applicable. Some other mechanical property might be more relevant to characterize materials that neither yield nor break by either Procedure A or Procedure B within the 5 % strain limit (for example, Test Method D 638 may be considered).

10.2 *Procedure B*:

10.2.1 Use an untested specimen for each measurement.

10.2.2 Test conditions shall be identical to those described in 10.1, except that the rate of straining of the outer surface of the test specimen shall be 0.10 mm/mm (in./in.)/min.

10.2.3 If no break has occurred in the specimen by the time the maximum strain in the outer surface of the test specimen has reached 0.05 mm/mm (in./in.), discontinue the test (see Note 10).

11. Retests

11.1 Values for properties at rupture shall not be calculated for any specimen that breaks at some obvious, fortuitous flaw, unless such flaws constitute a variable being studied. Retests shall be made for any specimen on which values are not calculated.

12. Calculation

12.1 Toe compensation shall be made in accordance with Annex A1 unless it can be shown that the toe region of the curve is not due to the take-up of slack, seating of the specimen, or other artifact, but rather is an authentic material response.

12.2 *Flexural Stress* (σ_f)—When a homogeneous elastic material is tested in flexure as a simple beam supported at two points and loaded at the midpoint, the maximum stress in the outer surface of the test specimen occurs at the midpoint. This stress may be calculated for any point on the load-deflection curve by means of the following equation (see Notes 11-13):

$$\sigma_f = 3PL/2bd^2 \tag{3}$$

where:
σ = stress in the outer fibers at midpoint, MPa (psi),
P = load at a given point on the load-deflection curve, N (lbf),
L = support span, mm (in.),
b = width of beam tested, mm (in.), and

d = depth of beam tested, mm (in.).

NOTE 11—Eq 3 applies strictly to materials for which stress is linearly proportional to strain up to the point of rupture and for which the strains are small. Since this is not always the case, a slight error will be introduced if Eq 3 is used to calculate stress for materials that are not true Hookean materials. The equation is valid for obtaining comparison data and for specification purposes, but only up to a maximum fiber strain of 5 % in the outer surface of the test specimen for specimens tested by the procedures described herein.

NOTE 12—When testing highly orthotropic laminates, the maximum stress may not always occur in the outer surface of the test specimen.[7] Laminated beam theory must be applied to determine the maximum tensile stress at failure. If Eq 3 is used to calculate stress, it will yield an apparent strength based on homogeneous beam theory. This apparent strength is highly dependent on the ply-stacking sequence of highly orthotropic laminates.

NOTE 13—The preceding calculation is not valid if the specimen slips excessively between the supports.

12.3 *Flexural Stress for Beams Tested at Large Support Spans* (σ_f)—If support span-to-depth ratios greater than 16 to 1 are used such that deflections in excess of 10 % of the support span occur, the stress in the outer surface of the specimen for a simple beam can be reasonably approximated with the following equation (see Note 14):

$$\sigma_f = (3PL/2bd^2)[1 + 6(D/L)^2 - 4(d/L)(D/L)] \quad (4)$$

where:

σ_f, P, L, b, and d are the same as for Eq 3, and
D = deflection of the centerline of the specimen at the middle of the support span, mm (in.).

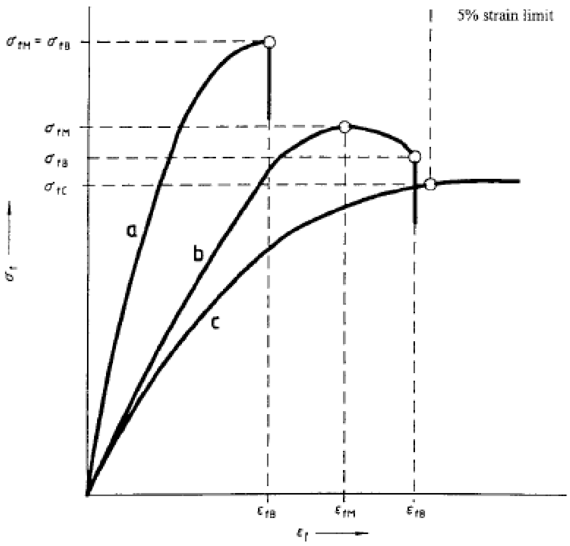
NOTE 14—When large support span-to-depth ratios are used, significant end forces are developed at the support noses which will affect the moment in a simple supported beam. Eq 4 includes additional terms that are an approximate correction factor for the influence of these end forces in large support span-to-depth ratio beams where relatively large deflections exist.

12.4 *Flexural Strength* (σ_{fM})—Maximum flexural stress sustained by the test specimen (see Note 12) during a bending test. It is calculated according to Eq 3 or Eq 4. Some materials that do not break at strains of up to 5 % may give a load deflection curve that shows a point at which the load does not increase with an increase in strain, that is, a yield point (Fig. 2, Curve B), *Y*. The flexural strength may be calculated for these materials by letting *P* (in Eq 3 or Eq 4) equal this point, *Y*.

12.5 *Flexural Offset Yield Strength*—Offset yield strength is the stress at which the stress-strain curve deviates by a given strain (offset) from the tangent to the initial straight line portion of the stress-strain curve. The value of the offset must be given whenever this property is calculated.

NOTE 15—This value may differ from flexural strength defined in 12.4. Both methods of calculation are described in the annex to Test Method D 638.

12.6 *Flexural Stress at Break* (σ_{fB})—Flexural stress at break of the test specimen during a bending test. It is calculated according to Eq 3 or Eq 4. Some materials may give a load deflection curve that shows a break point, *B*, without a yield point (Fig. 2, Curve a) in which case $\sigma_{fB} = \sigma_{fM}$. Other materials may give a yield deflection curve with both a yield and a break point, *B* (Fig. 2, Curve b). The flexural stress at break may be calculated for these materials by letting *P* (in Eq 3 or Eq 4) equal this point, *B*.



NOTE—Curve a: Specimen that breaks before yielding.
Curve b: Specimen that yields and then breaks before the 5 % strain limit.
Curve c: Specimen that neither yields nor breaks before the 5 % strain limit.

FIG. 2 Typical Curves of Flexural Stress (σ_f) Versus Flexural Strain (ϵ_f)

12.7 *Stress at a Given Strain*—The stress in the outer surface of a test specimen at a given strain may be calculated in accordance with Eq 3 or Eq 4 by letting *P* equal the load read from the load-deflection curve at the deflection corresponding to the desired strain (for highly orthotropic laminates, see Note 12).

12.8 *Flexural Strain*, ϵ_f—Nominal fractional change in the length of an element of the outer surface of the test specimen at midspan, where the maximum strain occurs. It may be calculated for any deflection using Eq 5:

$$\epsilon_f = 6Dd/L^2 \quad (5)$$

where:

ϵ_f = strain in the outer surface, mm/mm (in./in.),
D = maximum deflection of the center of the beam, mm (in.),
L = support span, mm (in.), and
d = depth, mm (in.).
D = maximum deflection of the center of the beam, mm (in.),
L = support span, mm (in.), and

[7] For a discussion of these effects, see Zweben, C., Smith, W. S., and Wardle, M. W., "Test Methods for Fiber Tensile Strength, Composite Flexural Modulus and Properties of Fabric-Reinforced Laminates, " *Composite Materials: Testing and Design (Fifth Conference), ASTM STP 674*, 1979, pp. 228–262.

d = depth, mm (in.).

12.9 *Modulus of Elasticity*:

12.9.1 *Tangent Modulus of Elasticity*—The tangent modulus of elasticity, often called the "modulus of elasticity," is the ratio, within the elastic limit, of stress to corresponding strain. It is calculated by drawing a tangent to the steepest initial straight-line portion of the load-deflection curve and using Eq 6 (for highly anisotropic composites, see Note 16).

$$E_B = L^3 m / 4bd^3 \quad (6)$$

where:

E_B = modulus of elasticity in bending, MPa (psi),
L = support span, mm (in.),
b = width of beam tested, mm (in.),
d = depth of beam tested, mm (in.), and
m = slope of the tangent to the initial straight-line portion of the load-deflection curve, N/mm (lbf/in.) of deflection.

NOTE 16—Shear deflections can seriously reduce the apparent modulus of highly anisotropic composites when they are tested at low span-to-depth ratios.[7] For this reason, a span-to-depth ratio of 60 to 1 is recommended for flexural modulus determinations on these composites. Flexural strength should be determined on a separate set of replicate specimens at a lower span-to-depth ratio that induces tensile failure in the outer fibers of the beam along its lower face. Since the flexural modulus of highly anisotropic laminates is a critical function of ply-stacking sequence, it will not necessarily correlate with tensile modulus, which is not stacking-sequence dependent.

12.9.2 *Secant Modulus*— The secant modulus is the ratio of stress to corresponding strain at any selected point on the stress-strain curve, that is, the slope of the straight line that joins the origin and a selected point on the actual stress-strain curve. It shall be expressed in megapascals (pounds per square inch). The selected point is chosen at a prespecified stress or strain in accordance with the appropriate material specification or by customer contract. It is calculated in accordance with Eq 6 by letting m equal the slope of the secant to the load-deflection curve. The chosen stress or strain point used for the determination of the secant shall be reported.

12.9.3 *Chord Modulus* (E_f)—The chord modulus may be calculated from two discrete points on the load deflection curve. The selected points are to be chosen at two prespecified stress or strain points in accordance with the appropriate material specification or by customer contract. The chosen stress or strain points used for the determination of the chord modulus shall be reported. Calculate the chord modulus, E_f using the following equation:

$$E_f = (\sigma_{f2} - \sigma_{f1})/(\epsilon_{f2} - \epsilon_{f1}) \quad (7)$$

where:

σ_{f2} and σ_{f1} are the flexural stresses, calculated from Eq 3 or Eq 4 and measured at the predefined points on the load deflection curve, and ϵ_{f2} and

ϵ_{f1} are the flexural strain values, calculated from Eq 5 and measured at the predetermined points on the load deflection curve.

12.10 *Arithmetic Mean*— For each series of tests, the arithmetic mean of all values obtained shall be calculated to three significant figures and reported as the "average value" for the particular property in question.

12.11 *Standard Deviation*—The standard deviation (estimated) shall be calculated as follows and be reported to two significant figures:

$$s = \sqrt{(\Sigma X^2 - n\bar{X}^2)/(n-1)} \quad (8)$$

where:

s = estimated standard deviation,
X = value of single observation,
n = number of observations, and
$\bar{X}$ = arithmetic mean of the set of observations.

13. Report

13.1 Report the following information:

13.1.1 Complete identification of the material tested, including type, source, manufacturer's code number, form, principal dimensions, and previous history (for laminated materials, ply-stacking sequence shall be reported),

13.1.2 Direction of cutting and loading specimens, when appropriate,

13.1.3 Conditioning procedure,

13.1.4 Depth and width of specimen,

13.1.5 Procedure used (A or B),

13.1.6 Support span length,

13.1.7 Support span-to-depth ratio if different than 16:1,

13.1.8 Radius of supports and loading noses if different than 5 mm,

13.1.9 Rate of crosshead motion,

13.1.10 Flexural strain at any given stress, average value and standard deviation,

13.1.11 If a specimen is rejected, reason(s) for rejection,

13.1.12 Tangent, secant, or chord modulus in bending, average value, standard deviation, and the strain level(s) used if secant or chord modulus,

13.1.13 Flexural strength (if desired), average value, and standard deviation,

13.1.14 Stress at any given strain up to and including 5 % (if desired), with strain used, average value, and standard deviation,

13.1.15 Flexural stress at break (if desired), average value,

TABLE 2 Flexural Modulus

Material	Mean, 10^3 psi	Values Expressed in units of % of 10^3 psi			
		V_r[A]	V_R[B]	r[C]	R[D]
ABS	338	4.79	7.69	13.6	21.8
DAP thermoset	485	2.89	7.18	8.15	20.4
Cast acrylic	810	13.7	16.1	38.8	45.4
GR polyester	816	3.49	4.20	9.91	11.9
GR polycarbonate	1790	5.52	5.52	15.6	15.6
SMC	1950	10.9	13.8	30.8	39.1

[A] V_r = within-laboratory coefficient of variation for the indicated material. It is obtained by first pooling the within-laboratory standard deviations of the test results from all of the participating laboratories: $Sr = [[(s_1)^2 + (s_2)^2 \ldots + (s_n)^2]/n]^{1/2}$ then V_r = (S_r divided by the overall average for the material) × 100.

[B] V_r = between-laboratory reproducibility, expressed as the coefficient of variation: $S_R = \{S_r^2 + S_L^2\}^{1/2}$ where S_L is the standard deviation of laboratory means. Then: V_R = (S_R divided by the overall average for the material) × 100.

[C] r = within-laboratory critical interval between two test results = 2.8 × V_r.

[D] R = between-laboratory critical interval between two test results = 2.8 × V_R.

and standard deviation,

13.1.16 Type of behavior, whether yielding or rupture, or both, or other observations, occurring within the 5 % strain limit, and

13.1.17 Date of specific version of test used.

14. Precision and Bias [8]

14.1 Tables 1 and 2 are based on a round-robin test conducted in 1984, in accordance with Practice E 691, involving six materials tested by six laboratories using Procedure A. For each material, all the specimens were prepared at one source. Each "test result" was the average of five individual determinations. Each laboratory obtained two test results for each material.

NOTE 17—**Caution:** The following explanations of r and R (14.2-14.2.3) are intended only to present a meaningful way of considering the approximate precision of these test methods. The data given in Tables 2 and 3 should not be applied rigorously to the acceptance or rejection of materials, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of these test methods should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 14.2-14.2.3 would then be valid for such data.

[8] Supporting data are available from ASTM Headquarters. Request RR: D20 – 1128.

14.2 *Concept of "r" and "R" in* Tables 1 and 2—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages from testing five specimens for each test result, then:

14.2.1 *Repeatability*— Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the r value for that material. r is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

14.2.2 *Reproducibility*— Two test results obtained by different laboratories shall be judged not equivalent if they differ by more than the R value for that material. R is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

14.2.3 The judgments in 14.2.1 and 14.2.2 will have an approximately 95 % (0.95) probability of being correct.

14.3 *Bias*—No statement may be made about the bias of these test methods, as there is no standard reference material or reference test method that is applicable.

15. Keywords

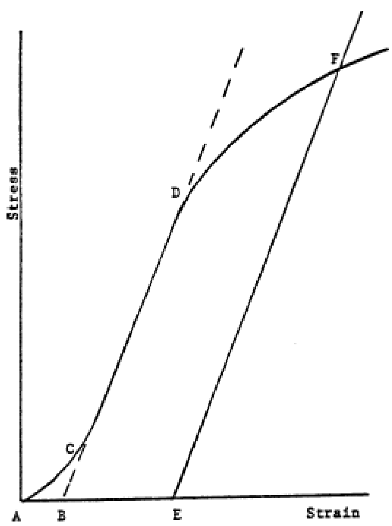
15.1 flexural properties; plastics; stiffness; strength

ANNEXES

(Mandatory Information)

A1. TOE COMPENSATION

A1.1 In a typical stress-strain curve (see Fig. A1.1) there is a toe region, *AC,* that does not represent a property of the material. It is an artifact caused by a takeup of slack and alignment or seating of the specimen. In order to obtain correct values of such parameters as modulus, strain, and offset yield point, this artifact must be compensated for to give the corrected zero point on the strain or extension axis.

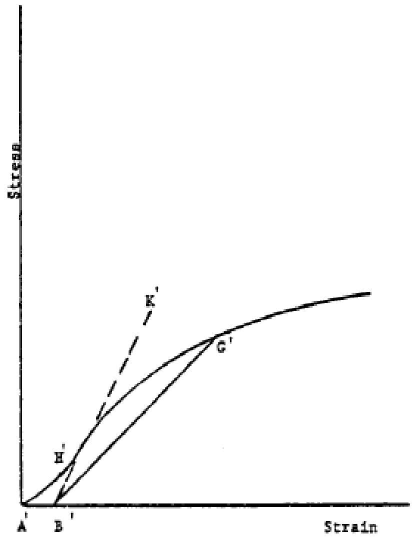


NOTE—Some chart recorders plot the mirror image of this graph.

FIG. A1.1 Material with Hookean Region

A1.2 In the case of a material exhibiting a region of Hookean (linear) behavior (see Fig. A1.1), a continuation of the linear *(CD)* region of the curve is constructed through the zero-stress axis. This intersection *(B)* is the corrected zero-strain point from which all extensions or strains must be measured, including the yield offset *(BE),* if applicable. The elastic modulus can be determined by dividing the stress at any point along the Line *CD* (or its extension) by the strain at the same point (measured from Point *B,* defined as zero-strain).

A1.3 In the case of a material that does not exhibit any linear region (see Fig. A1.2), the same kind of toe correction of the zero-strain point can be made by constructing a tangent to the maximum slope at the inflection Point *H′*. This is extended to intersect the strain axis at Point *B′*, the corrected zero-strain point. Using Point *B′* as zero strain, the stress at any point *(G′)* on the curve can be divided by the strain at that point to obtain a secant modulus (slope of Line *B′ G′*). For those materials with no linear region, any attempt to use the tangent through



NOTE—Some chart recorders plot the mirror image of this graph.

FIG. A1.2 Material with No Hookean Region

the inflection point as a basis for determination of an offset yield point may result in unacceptable error.

A2. MEASURING AND SETTING SPAN

A2.1 For flexural fixtures that have adjustable spans, it is important that the span between the supports is maintained constant or the actual measured span is used in the calculation of stress, modulus, and strain, and the loading nose or noses are positioned and aligned properly with respect to the supports. Some simple steps as follows can improve the repeatability of your results when using these adjustable span fixtures.

A2.2 Measurement of Span:

A2.2.1 This technique is needed to ensure that the correct span, not an estimated span, is used in the calculation of results.

A2.2.2 Scribe a permanent line or mark at the exact center of the support where the specimen makes complete contact. The type of mark depends on whether the supports are fixed or rotatable (see Figs. A2.1 and A2.2).

A2.2.3 Using a vernier caliper with pointed tips that is readable to at least 0.1 mm (0.004 in.), measure the distance between the supports, and use this measurement of span in the calculations.

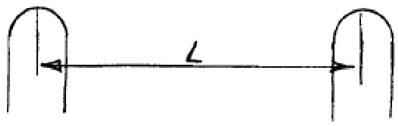


FIG. A2.1 Markings on Fixed Specimen Supports

FIG. A2.2 Markings on Rotatable Specimen Supports

A2.3 *Setting the Span and Alignment of Loading Nose(s)*—To ensure a consistent day-to-day setup of the span and ensure the alignment and proper positioning of the loading nose, simple jigs should be manufactured for each of the standard setups used. An example of a jig found to be useful is shown in Fig. A2.3.

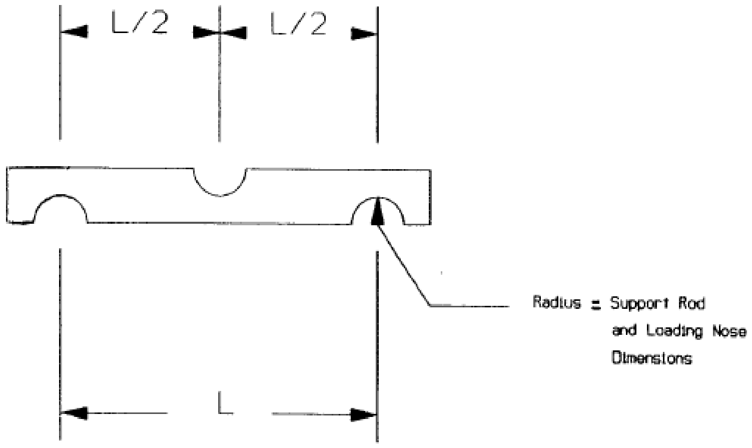


FIG. A2.3 Fixture Used to Set Loading Nose and Support Spacing and Alignment

SUMMARY OF CHANGES

This section identifies the location of selected changes to these test methods. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of these test methods. This section may also include descriptions of the changes or reasons for the changes, or both.

D 790 – 02:
(*1*) Revised 9.1 and 9.2.
D 790 – 00:
(*1*) Revised 12.1.
D 790 – 99:
(*1*) Revised 10.1.3.
D 790 – 98:
(*1*) Section 4.2 was rewritten extensively to bring this standard closer to ISO 178.
(*2*) Fig. 2 was added to clarify flexural behaviors that may be observed and to define what yielding and breaking behaviors look like, as well as the appropriate place to select these points on the stress strain curve.

Lampiran 3

Tabel 3.A. Persentase (%) Penyerapan Air Laut 28 Hari

Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	Massa (gr)	MC/hr (gr)	MC (%)	Massa (gr)	MC/hr (gr)	MC (%)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Berat Awal	***332.14***	Panel 1		***376.53***	Panel 2		***363.98***	Panel 3	
1	332.37	0.230	0.069	376.71	0.180	0.048	364.13	0.150	0.041
2	332.47	0.330	0.099	376.91	0.380	0.101	364.14	0.160	0.044
3	332.55	0.410	0.123	377.04	0.510	0.135	364.14	0.160	0.044
4	332.79	0.650	0.196	377.08	0.550	0.146	364.24	0.260	0.071
5	332.87	0.730	0.220	377.10	0.570	0.151	364.24	0.260	0.071
6	332.96	0.820	0.247	377.19	0.660	0.175	364.25	0.270	0.074
7	333.09	0.950	0.286	377.31	0.780	0.207	364.43	0.450	0.124
8	333.23	1.090	0.328	377.44	0.910	0.242	364.51	0.530	0.146
9	333.44	1.300	0.391	377.60	1.070	0.284	364.62	0.640	0.176
10	333.55	1.410	0.425	377.71	1.180	0.313	364.71	0.730	0.201
11	333.65	1.510	0.455	377.81	1.280	0.340	364.82	0.840	0.231
12	333.89	1.750	0.527	377.92	1.390	0.369	364.88	0.900	0.247
13	334.11	1.970	0.593	378.16	1.630	0.433	365.02	1.040	0.286
14	334.55	2.410	0.726	378.63	2.100	0.558	365.48	1.500	0.412
15	334.61	2.470	0.744	378.68	2.150	0.571	365.58	1.600	0.440
16	334.75	2.610	0.786	378.76	2.230	0.592	365.64	1.660	0.456
17	334.78	2.640	0.795	378.88	2.350	0.624	365.65	1.670	0.459
18	334.87	2.730	0.822	378.93	2.400	0.637	365.72	1.740	0.478
19	335.06	2.920	0.879	379.10	2.570	0.683	365.77	1.790	0.492
20	335.16	3.020	0.909	379.12	2.590	0.688	365.92	1.940	0.533
21	335.26	3.120	0.939	379.22	2.690	0.714	366.01	2.030	0.558
22	335.45	3.310	0.997	379.36	2.830	0.752	366.07	2.090	0.574
23	335.51	3.370	1.015	379.44	2.910	0.773	366.19	2.210	0.607
24	335.56	3.420	1.030	379.49	2.960	0.786	366.18	2.200	0.604
25	335.70	3.560	1.072	379.64	3.110	0.826	366.29	2.310	0.635
26	335.73	3.590	1.081	379.70	3.170	0.842	366.34	2.360	0.648
27	335.93	3.790	1.141	379.80	3.270	0.868	366.47	2.490	0.684
28	336.03	3.890	1.171	379.95	3.420	0.908	366.55	2.570	0.706

Tabel 3. B. Persentase (%) Penyerapan Air Laut 56 Hari

Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	Massa (gr)	MC/hr (gr)	MC (%)	Massa (gr)	MC/hr (gr)	MC (%)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Berat Awal	***332.14***	Panel 1		376.53	Panel 2		363.98	Panel 3	
29	336.21	4.070	1.225	380.04	3.510	0.932	366.63	2.650	0.728
30	336.25	4.110	1.237	380.17	3.640	0.967	366.78	2.800	0.769
31	336.51	4.370	1.316	380.24	3.710	0.985	366.89	2.910	0.799
32	336.60	4.460	1.343	380.37	3.840	1.020	367.00	3.020	0.830
33	336.77	4.630	1.394	380.51	3.980	1.057	367.16	3.180	0.874
34	336.87	4.730	1.424	380.66	4.130	1.097	367.23	3.250	0.893
35	336.65	4.510	1.358	380.47	3.940	1.046	367.03	3.050	0.838
36	336.82	4.680	1.409	380.60	4.070	1.081	367.20	3.220	0.885
37	336.99	4.850	1.460	380.69	4.160	1.105	367.23	3.250	0.893
38	337.07	4.930	1.484	380.79	4.260	1.131	367.35	3.370	0.926
39	337.18	5.040	1.517	380.89	4.360	1.158	367.43	3.450	0.948
40	337.39	5.250	1.581	381.09	4.560	1.211	367.54	3.560	0.978
41	337.18	5.040	1.517	381.01	4.480	1.190	367.51	3.530	0.970
42	337.35	5.210	1.569	381.16	4.630	1.230	367.58	3.600	0.989
43	337.33	5.190	1.563	381.21	4.680	1.243	367.70	3.720	1.022
44	337.43	5.290	1.593	381.23	4.700	1.248	367.72	3.740	1.028
45	337.56	5.420	1.632	381.28	4.750	1.262	367.78	3.800	1.044
46	337.73	5.590	1.683	381.40	4.870	1.293	367.88	3.900	1.071
47	337.80	5.660	1.704	381.50	4.970	1.320	367.96	3.980	1.093
48	337.64	5.500	1.656	381.47	4.940	1.312	367.91	3.930	1.080
49	337.79	5.650	1.701	381.58	5.050	1.341	367.97	3.990	1.096
50	337.92	5.780	1.740	381.67	5.140	1.365	368.09	4.110	1.129
51	337.95	5.810	1.749	381.70	5.170	1.373	368.14	4.160	1.143
52	338.02	5.880	1.770	381.76	5.230	1.389	368.18	4.200	1.154
53	338.07	5.930	1.785	381.83	5.300	1.408	368.25	4.270	1.173
54	338.08	5.940	1.788	381.85	5.320	1.413	368.26	4.280	1.176
55	338.16	6.020	1.812	381.89	5.360	1.424	368.33	4.350	1.195
56	338.50	6.360	1.915	382.17	5.640	1.498	368.47	4.490	1.234

Tabel 3. C. Persentase (%) Penyerapan Air Laut 84 Hari

Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	Massa (gr)	MC/hr (gr)	MC (%)	Massa (gr)	MC/hr (gr)	MC (%)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Berat Awal	***332.14***	Panel 1		376.53	Panel 2		363.98	Panel 3	
57	338.54	6.400	1.927	382.20	5.670	1.506	368.60	4.620	1.269
58	338.57	6.430	1.936	382.21	5.680	1.509	368.64	4.660	1.280
59	338.55	6.410	1.930	382.25	5.720	1.519	368.71	4.730	1.300
60	338.70	6.560	1.975	382.32	5.790	1.538	368.73	4.750	1.305
61	338.67	6.530	1.966	382.35	5.820	1.546	368.78	4.800	1.319
62	338.75	6.610	1.990	382.47	5.940	1.578	368.88	4.900	1.346
63	338.80	6.660	2.005	382.54	6.010	1.596	368.95	4.970	1.365
64	338.82	6.680	2.011	382.55	6.020	1.599	369.03	5.050	1.387
65	338.85	6.710	2.020	382.61	6.080	1.615	369.06	5.080	1.396
66	339.01	6.870	2.068	382.63	6.100	1.620	369.12	5.140	1.412
67	339.05	6.910	2.080	382.70	6.170	1.639	369.13	5.150	1.415
68	339.04	6.900	2.077	382.73	6.200	1.647	369.13	5.150	1.415
69	339.06	6.920	2.083	382.73	6.200	1.647	369.14	5.160	1.418
70	339.04	6.900	2.077	382.76	6.230	1.655	369.20	5.220	1.434
71	339.00	6.860	2.065	382.71	6.180	1.641	369.20	5.220	1.434
72	339.04	6.900	2.077	382.71	6.180	1.641	369.22	5.240	1.440
73	339.24	7.100	2.138	382.92	6.390	1.697	369.38	5.400	1.484
74	339.17	7.030	2.117	382.89	6.360	1.689	369.34	5.360	1.473
75	339.28	7.140	2.150	383.03	6.500	1.726	369.29	5.310	1.459
76	339.29	7.150	2.153	382.99	6.460	1.716	369.39	5.410	1.486
77	339.32	7.180	2.162	383.02	6.490	1.724	369.54	5.560	1.528
78	339.26	7.120	2.144	382.98	6.450	1.713	369.50	5.520	1.517
79	339.30	7.160	2.156	383.09	6.560	1.742	369.55	5.570	1.530
80	339.34	7.200	2.168	383.09	6.560	1.742	369.56	5.580	1.533
81	339.38	7.240	2.180	383.16	6.630	1.761	369.63	5.650	1.552
82	339.44	7.300	2.198	383.21	6.680	1.774	369.67	5.690	1.563
83	339.63	7.490	2.255	383.24	6.710	1.782	369.77	5.790	1.591
84	339.63	7.490	2.255	383.27	6.740	1.790	369.77	5.790	1.591

Tabel 3. E. Mutu serat rami lokal, serat referensi serat kapas, dan serat rami asal Cina

Jenis uji	Referensi rami	Referensi kapas	Hasil uji rami lokal	Hasil uji rami Cina
Panjang serat (mm)	120– 50	20–30	Stp 54,6–68,0	Stp 54–57
Kehalusan (denier)	3–7	1,0–1,7	4,6–4,9	4,2–5,1
Berat jenis (g/cm3)	1,5	1,54	1,40–1, 46	1,5
Kekuatan (g/denier)	5–8	1,9–3,6	4,0–7,5	6,5
Mulur (%)	2–4	4–8	3,6–4,9	4,0–4,4
***Moisture regain* (%)**	**12**	8,5	8,2–10	9,2–10,1
Serat menggumpal	-	-	14,2–21,7	0,3
Pengaruh panas	Rusak, 200^{o}C	Rusak, 200^{o}C	Rusak, 200^{o}C	Rusak, 200^{o}C
Pengaruh alkali	Menggelembung	Menggelembung	Menggelembung	Menggelembung
Pengaruh oksidator	Kurang tahan oksidator kuat	Tahan peroksida dan hipoklorit	Kurang tahan oksidator kuat	Kurang tahan oksidator kuat

Persyaratan Mutu Serat Rami Dan Teknologi Untuk Industri Tekstil
Dalam Mendukung Pilot Project Agribisnis Rami Di Kabupaten Garut Balai Besar Tekstil, Bandung

Lampiran 4.

Tabel 4.A. Data Pengolahan Perendaman Material Komposit Tenunan Ramie Dengan Lama Perendaman 84 Hari.

Spesimen 1 **332.14**

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1	1	332.37	0.230	0.069	1	0.230	0.230	1	0.053	1.000	0.053	0.918
2	2	332.47	0.330	0.099	2	0.330	0.660	4	0.109	4.000	0.109	1.002
3	3	332.55	0.410	0.123	3	0.410	1.230	9	0.168	9.000	0.168	1.086
4	4	332.79	0.650	0.196	4	0.650	2.600	16	0.423	16.000	0.423	1.170
5	5	332.87	0.730	0.220	5	0.730	3.650	25	0.533	25.000	0.533	1.254
6	6	332.96	0.820	0.247	6	0.820	4.920	36	0.672	36.000	0.672	1.338
7	7	333.09	0.950	0.286	7	0.950	6.650	49	0.902	49.000	0.902	1.422
8	8	333.23	1.090	0.328	8	1.090	8.720	64	1.188	64.000	1.188	1.506
9	9	333.44	1.300	0.391	9	1.300	11.700	81	1.690	81.000	1.690	1.590
10	10	333.55	1.410	0.425	10	1.410	14.100	100	1.988	100.000	1.988	1.674
11	11	333.65	1.510	0.455	11	1.510	16.610	121	2.280	121.000	2.280	1.758
12	12	333.89	1.750	0.527	12	1.750	21.000	144	3.063	144.000	3.063	1.842
13	13	334.11	1.970	0.593	13	1.970	25.610	169	3.881	169.000	3.881	1.926
14	14	334.55	2.410	0.726	14	2.410	33.740	196	5.808	196.000	5.808	2.010
15	15	334.61	2.470	0.744	15	2.470	37.050	225	6.101	225.000	6.101	2.094
16	16	334.75	2.610	0.786	16	2.610	41.760	256	6.812	256.000	6.812	2.178
17	17	334.78	2.640	0.795	17	2.640	44.880	289	6.970	289.000	6.970	2.262
18	18	334.87	2.730	0.822	18	2.730	49.140	324	7.453	324.000	7.453	2.346
19	19	335.06	2.920	0.879	19	2.920	55.480	361	8.526	361.000	8.526	2.430
20	20	335.16	3.020	0.909	20	3.020	60.400	400	9.120	400.000	9.120	2.514
21	21	335.26	3.120	0.939	21	3.120	65.520	441	9.734	441.000	9.734	2.598
22	22	335.45	3.310	0.997	22	3.310	72.820	484	10.956	484.000	10.956	2.682
23	23	335.51	3.370	1.015	23	3.370	77.510	529	11.357	529.000	11.357	2.766
24	24	335.56	3.420	1.030	24	3.420	82.080	576	11.696	576.000	11.696	2.850
25	25	335.70	3.560	1.072	25	3.560	89.000	625	12.674	625.000	12.674	2.934
26	26	335.73	3.590	1.081	26	3.590	93.340	676	12.888	676.000	12.888	3.018
27	27	335.93	3.790	1.141	27	3.790	102.330	729	14.364	729.000	14.364	3.102
28	28	336.03	3.890	1.171	28	3.890	108.920	784	15.132	784.000	15.132	3.186

Spesimen 1 **332.14** *Lanjutan Spesimen 1*

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
29	29	336.21	4.070	1.225	29	4.070	118.030	841	16.565	841.000	16.565	3.270
30	30	336.25	4.110	1.237	30	4.110	123.300	900	16.892	900.000	16.892	3.354
31	31	336.51	4.370	1.316	31	4.370	135.470	961	19.097	961.000	19.097	3.438
32	32	336.60	4.460	1.343	32	4.460	142.720	1024	19.892	1024.000	19.892	3.522
33	33	336.77	4.630	1.394	33	4.630	152.790	1089	21.437	1089.000	21.437	3.606
34	34	336.87	4.730	1.424	34	4.730	160.820	1156	22.373	1156.000	22.373	3.690
35	35	336.65	4.510	1.358	35	4.510	157.850	1225	20.340	1225.000	20.340	3.774
36	36	336.82	4.680	1.409	36	4.680	168.480	1296	21.902	1296.000	21.902	3.858
37	37	336.99	4.850	1.460	37	4.850	179.450	1369	23.523	1369.000	23.523	3.942
38	38	337.07	4.930	1.484	38	4.930	187.340	1444	24.305	1444.000	24.305	4.026
39	39	337.18	5.040	1.517	39	5.040	196.560	1521	25.402	1521.000	25.402	4.110
40	40	337.39	5.250	1.581	40	5.250	210.000	1600	27.563	1600.000	27.563	4.194
41	41	337.18	5.040	1.517	41	5.040	206.640	1681	25.402	1681.000	25.402	4.278
42	42	337.35	5.210	1.569	42	5.210	218.820	1764	27.144	1764.000	27.144	4.362
43	43	337.33	5.190	1.563	43	5.190	223.170	1849	26.936	1849.000	26.936	4.446
44	44	337.43	5.290	1.593	44	5.290	232.760	1936	27.984	1936.000	27.984	4.530
45	45	337.56	5.420	1.632	45	5.420	243.900	2025	29.376	2025.000	29.376	4.614
46	46	337.73	5.590	1.683	46	5.590	257.140	2116	31.248	2116.000	31.248	4.698
47	47	337.80	5.660	1.704	47	5.660	266.020	2209	32.036	2209.000	32.036	4.782
48	48	337.64	5.500	1.656	48	5.500	264.000	2304	30.250	2304.000	30.250	4.866
49	49	337.79	5.650	1.701	49	5.650	276.850	2401	31.923	2401.000	31.923	4.950
50	50	337.92	5.780	1.740	50	5.780	289.000	2500	33.408	2500.000	33.408	5.034
51	51	337.95	5.810	1.749	51	5.810	296.310	2601	33.756	2601.000	33.756	5.118
52	52	338.02	5.880	1.770	52	5.880	305.760	2704	34.574	2704.000	34.574	5.202
53	53	338.07	5.930	1.785	53	5.930	314.290	2809	35.165	2809.000	35.165	5.286
54	54	338.08	5.940	1.788	54	5.940	320.760	2916	35.284	2916.000	35.284	5.370
55	55	338.16	6.020	1.812	55	6.020	331.100	3025	36.240	3025.000	36.240	5.454
56	56	338.50	6.360	1.915	56	6.360	356.160	3136	40.450	3136.000	40.450	5.538

Spesimen 1 **332.14** *Lanjutan Spesimen 1*

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
57	57	338.54	6.400	1.927	57	6.400	364.800	3249	40.960	3249.000	40.960	5.622
58	58	338.57	6.430	1.936	58	6.430	372.940	3364	41.345	3364.000	41.345	5.706
59	59	338.55	6.410	1.930	59	6.410	378.190	3481	41.088	3481.000	41.088	5.790
60	60	338.70	6.560	1.975	60	6.560	393.600	3600	43.034	3600.000	43.034	5.874
61	61	338.67	6.530	1.966	61	6.530	398.330	3721	42.641	3721.000	42.641	5.958
62	62	338.75	6.610	1.990	62	6.610	409.820	3844	43.692	3844.000	43.692	6.042
63	63	338.80	6.660	2.005	63	6.660	419.580	3969	44.356	3969.000	44.356	6.126
64	64	338.82	6.680	2.011	64	6.680	427.520	4096	44.622	4096.000	44.622	6.210
65	65	338.85	6.710	2.020	65	6.710	436.150	4225	45.024	4225.000	45.024	6.294
66	66	339.01	6.870	2.068	66	6.870	453.420	4356	47.197	4356.000	47.197	6.378
67	67	339.05	6.910	2.080	67	6.910	462.970	4489	47.748	4489.000	47.748	6.462
68	68	339.04	6.900	2.077	68	6.900	469.200	4624	47.610	4624.000	47.610	6.546
69	69	339.06	6.920	2.083	69	6.920	477.480	4761	47.886	4761.000	47.886	6.630
70	70	339.04	6.900	2.077	70	6.900	483.000	4900	47.610	4900.000	47.610	6.714
71	71	339.00	6.860	2.065	71	6.860	487.060	5041	47.060	5041.000	47.060	6.798
72	72	339.04	6.900	2.077	72	6.900	496.800	5184	47.610	5184.000	47.610	6.882
73	73	339.24	7.100	2.138	73	7.100	518.300	5329	50.410	5329.000	50.410	6.966
74	74	339.17	7.030	2.117	74	7.030	520.220	5476	49.421	5476.000	49.421	7.050
75	75	339.28	7.140	2.150	75	7.140	535.500	5625	50.980	5625.000	50.980	7.134
76	76	339.29	7.150	2.153	76	7.150	543.400	5776	51.123	5776.000	51.123	7.218
77	77	339.32	7.180	2.162	77	7.180	552.860	5929	51.552	5929.000	51.552	7.302
78	78	339.26	7.120	2.144	78	7.120	555.360	6084	50.694	6084.000	50.694	7.386
79	79	339.30	7.160	2.156	79	7.160	565.640	6241	51.266	6241.000	51.266	7.470
80	80	339.34	7.200	2.168	80	7.200	576.000	6400	51.840	6400.000	51.840	7.554
81	81	339.38	7.240	2.180	81	7.240	586.440	6561	52.418	6561.000	52.418	7.638
82	82	339.44	7.300	2.198	82	7.300	598.600	6724	53.290	6724.000	53.290	7.722
83	83	339.63	7.490	2.255	83	7.490	621.670	6889	56.100	6889.000	56.100	7.806
84	84	339.63	7.490	2.255	84	7.490	629.160	7056	56.100	7056.000	56.100	7.890
Jumlah		***28969.790***	***407.750***	***130.356***	***3582***	***413.750***	***21217.150***	***201128***	***2301.683***	***201132***	***2305.683***	
Rata-Rata		***329.202***	***4.741***	***1.516***	***42***	***4.811***	***246.711***	***2339***	***26.764***			

Spesimen 2 376.53

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1	1	376.71	0.180	0.048	1	0.180	0.180	1	0.032	1652.517	16.874	0.918
2	2	376.91	0.380	0.101	2	0.380	0.760	4	0.144	1572.215	15.271	1.002
3	3	377.04	0.510	0.135	3	0.510	1.530	9	0.260	1493.912	14.272	1.086
4	4	377.08	0.550	0.146	4	0.550	2.200	16	0.303	1417.610	13.971	1.170
5	5	377.10	0.570	0.151	5	0.570	2.850	25	0.325	1343.308	13.822	1.254
6	6	377.19	0.660	0.175	6	0.660	3.960	36	0.436	1271.005	13.161	1.338
7	7	377.31	0.780	0.207	7	0.780	5.460	49	0.608	1200.703	12.305	1.422
8	8	377.44	0.910	0.242	8	0.910	7.280	64	0.828	1132.401	11.409	1.506
9	9	377.60	1.070	0.284	9	1.070	9.630	81	1.145	1066.098	10.354	1.590
10	10	377.71	1.180	0.313	10	1.180	11.800	100	1.392	1001.796	9.658	1.674
11	11	377.81	1.280	0.340	11	1.280	14.080	121	1.638	939.494	9.047	1.758
12	12	377.92	1.390	0.369	12	1.390	16.680	144	1.932	879.191	8.397	1.842
13	13	378.16	1.630	0.433	13	1.630	21.190	169	2.657	820.889	7.064	1.926
14	14	378.63	2.100	0.558	14	2.100	29.400	196	4.410	764.587	4.786	2.010
15	15	378.68	2.150	0.571	15	2.150	32.250	225	4.623	710.284	4.570	2.094
16	16	378.76	2.230	0.592	16	2.230	35.680	256	4.973	657.982	4.235	2.178
17	17	378.88	2.350	0.624	17	2.350	39.950	289	5.523	607.680	3.755	2.262
18	18	378.93	2.400	0.637	18	2.400	43.200	324	5.760	559.378	3.564	2.346
19	19	379.10	2.570	0.683	19	2.570	48.830	361	6.605	513.075	2.951	2.430
20	20	379.12	2.590	0.688	20	2.590	51.800	400	6.708	468.773	2.882	2.514
21	21	379.22	2.690	0.714	21	2.690	56.490	441	7.236	426.471	2.553	2.598
22	22	379.36	2.830	0.752	22	2.830	62.260	484	8.009	386.168	2.125	2.682
23	23	379.44	2.910	0.773	23	2.910	66.930	529	8.468	347.866	1.898	2.766
24	24	379.49	2.960	0.786	24	2.960	71.040	576	8.762	311.564	1.763	2.850
25	25	379.64	3.110	0.826	25	3.110	77.750	625	9.672	277.261	1.387	2.934
26	26	379.70	3.170	0.842	26	3.170	82.420	676	10.049	244.959	1.249	3.018
27	27	379.80	3.270	0.868	27	3.270	88.290	729	10.693	214.657	1.036	3.102
28	28	379.95	3.420	0.908	28	3.420	95.760	784	11.696	186.354	0.753	3.186

Spesimen 2 376.53 *Lanjutan Spesimen 2*

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
29	29	380.04	3.510	0.932	29	3.510	101.790	841	12.320	160.052	0.605	3.270
30	30	380.17	3.640	0.967	30	3.640	109.200	900	13.250	135.750	0.420	3.354
31	31	380.24	3.710	0.985	31	3.710	115.010	961	13.764	113.447	0.334	3.438
32	32	380.37	3.840	1.020	32	3.840	122.880	1024	14.746	93.145	0.201	3.522
33	33	380.51	3.980	1.057	33	3.980	131.340	1089	15.840	74.843	0.095	3.606
34	34	380.66	4.130	1.097	34	4.130	140.420	1156	17.057	58.540	0.025	3.690
35	35	380.47	3.940	1.046	35	3.940	137.900	1225	15.524	44.238	0.121	3.774
36	36	380.60	4.070	1.081	36	4.070	146.520	1296	16.565	31.936	0.047	3.858
37	37	380.69	4.160	1.105	37	4.160	153.920	1369	17.306	21.633	0.016	3.942
38	38	380.79	4.260	1.131	38	4.260	161.880	1444	18.148	13.331	0.001	4.026
39	39	380.89	4.360	1.158	39	4.360	170.040	1521	19.010	7.029	0.005	4.110
40	40	381.09	4.560	1.211	40	4.560	182.400	1600	20.794	2.726	0.074	4.194
41	41	381.01	4.480	1.190	41	4.480	183.680	1681	20.070	0.424	0.037	4.278
42	42	381.16	4.630	1.230	42	4.630	194.460	1764	21.437	0.122	0.117	4.362
43	43	381.21	4.680	1.243	43	4.680	201.240	1849	21.902	1.819	0.154	4.446
44	44	381.23	4.700	1.248	44	4.700	206.800	1936	22.090	5.517	0.170	4.530
45	45	381.28	4.750	1.262	45	4.750	213.750	2025	22.563	11.215	0.214	4.614
46	46	381.40	4.870	1.293	46	4.870	224.020	2116	23.717	18.912	0.339	4.698
47	47	381.50	4.970	1.320	47	4.970	233.590	2209	24.701	28.610	0.465	4.782
48	48	381.47	4.940	1.312	48	4.940	237.120	2304	24.404	40.308	0.425	4.866
49	49	381.58	5.050	1.341	49	5.050	247.450	2401	25.503	54.005	0.581	4.950
50	50	381.67	5.140	1.365	50	5.140	257.000	2500	26.420	69.703	0.726	5.034
51	51	381.70	5.170	1.373	51	5.170	263.670	2601	26.729	87.401	0.778	5.118
52	52	381.76	5.230	1.389	52	5.230	271.960	2704	27.353	107.098	0.888	5.202
53	53	381.83	5.300	1.408	53	5.300	280.900	2809	28.090	128.796	1.025	5.286
54	54	381.85	5.320	1.413	54	5.320	287.280	2916	28.302	152.494	1.065	5.370
55	55	381.89	5.360	1.424	55	5.360	294.800	3025	28.730	178.191	1.150	5.454
56	56	382.17	5.640	1.498	56	5.640	315.840	3136	31.810	205.889	1.828	5.538

Spesimen 2 376.53 *Lanjutan Spesimen 2*

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
57	57	382.20	5.670	1.506	57	5.670	323.190	3249	32.149	235.587	1.911	5.622
58	58	382.21	5.680	1.509	58	5.680	329.440	3364	32.262	267.284	1.938	5.706
59	59	382.25	5.720	1.519	59	5.720	337.480	3481	32.718	300.982	2.051	5.790
60	60	382.32	5.790	1.538	60	5.790	347.400	3600	33.524	336.680	2.257	5.874
61	61	382.35	5.820	1.546	61	5.820	355.020	3721	33.872	374.378	2.348	5.958
62	62	382.47	5.940	1.578	62	5.940	368.280	3844	35.284	414.075	2.730	6.042
63	63	382.54	6.010	1.596	63	6.010	378.630	3969	36.120	455.773	2.966	6.126
64	64	382.55	6.020	1.599	64	6.020	385.280	4096	36.240	499.471	3.001	6.210
65	65	382.61	6.080	1.615	65	6.080	395.200	4225	36.966	545.168	3.212	6.294
66	66	382.63	6.100	1.620	66	6.100	402.600	4356	37.210	592.866	3.284	6.378
67	67	382.70	6.170	1.639	67	6.170	413.390	4489	38.069	642.564	3.543	6.462
68	68	382.73	6.200	1.647	68	6.200	421.600	4624	38.440	694.261	3.657	6.546
69	69	382.73	6.200	1.647	69	6.200	427.800	4761	38.440	747.959	3.657	6.630
70	70	382.76	6.230	1.655	70	6.230	436.100	4900	38.813	803.657	3.772	6.714
71	71	382.71	6.180	1.641	71	6.180	438.780	5041	38.192	861.354	3.580	6.798
72	72	382.71	6.180	1.641	72	6.180	444.960	5184	38.192	921.052	3.580	6.882
73	73	382.92	6.390	1.697	73	6.390	466.470	5329	40.832	982.750	4.419	6.966
74	74	382.89	6.360	1.689	74	6.360	470.640	5476	40.450	1046.447	4.294	7.050
75	75	383.03	6.500	1.726	75	6.500	487.500	5625	42.250	1112.145	4.894	7.134
76	76	382.99	6.460	1.716	76	6.460	490.960	5776	41.732	1179.843	4.718	7.218
77	77	383.02	6.490	1.724	77	6.490	499.730	5929	42.120	1249.540	4.850	7.302
78	78	382.98	6.450	1.713	78	6.450	503.100	6084	41.603	1321.238	4.675	7.386
79	79	383.09	6.560	1.742	79	6.560	518.240	6241	43.034	1394.936	5.163	7.470
80	80	383.09	6.560	1.742	80	6.560	524.800	6400	43.034	1470.633	5.163	7.554
81	81	383.16	6.630	1.761	81	6.630	537.030	6561	43.957	1548.331	5.486	7.638
82	82	383.21	6.680	1.774	82	6.680	547.760	6724	44.622	1628.029	5.723	7.722
83	83	383.24	6.710	1.782	83	6.710	556.930	6889	45.024	1709.726	5.867	7.806
84	84	383.27	6.740	1.790	84	6.740	566.160	7056	45.428	1793.424	6.013	7.890
Jumlah		***32742.330***	***362.750***	***104.216***	***3582***	***368.750***	***18956.980***	***201128***	***1833.605***	***49468***	***339.770***	
Rata-Rata		***372.072***	***4.218***	***1.212***	***41.651***	***4.288***	***220.430***	***2339***	***21.321***			

Spesimen 3 363.98

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1	1	364.13	0.150	0.041	1	0.150	0.150	1	0.022	1652.517	11.050	0.918
2	2	364.14	0.160	0.044	2	0.160	0.320	4	0.026	1572.215	10.984	1.002
3	3	364.14	0.160	0.044	3	0.160	0.480	9	0.026	1493.912	10.984	1.086
4	4	364.24	0.260	0.071	4	0.260	1.040	16	0.068	1417.610	10.331	1.170
5	5	364.24	0.260	0.071	5	0.260	1.300	25	0.068	1343.308	10.331	1.254
6	6	364.25	0.270	0.074	6	0.270	1.620	36	0.073	1271.005	10.267	1.338
7	7	364.43	0.450	0.124	7	0.450	3.150	49	0.202	1200.703	9.146	1.422
8	8	364.51	0.530	0.146	8	0.530	4.240	64	0.281	1132.401	8.668	1.506
9	9	364.62	0.640	0.176	9	0.640	5.760	81	0.410	1066.098	8.033	1.590
10	10	364.71	0.730	0.201	10	0.730	7.300	100	0.533	1001.796	7.531	1.674
11	11	364.82	0.840	0.231	11	0.840	9.240	121	0.706	939.494	6.939	1.758
12	12	364.88	0.900	0.247	12	0.900	10.800	144	0.810	879.191	6.626	1.842
13	13	365.02	1.040	0.286	13	1.040	13.520	169	1.082	820.889	5.925	1.926
14	14	365.48	1.500	0.412	14	1.500	21.000	196	2.250	764.587	3.897	2.010
15	15	365.58	1.600	0.440	15	1.600	24.000	225	2.560	710.284	3.513	2.094
16	16	365.64	1.660	0.456	16	1.660	26.560	256	2.756	657.982	3.291	2.178
17	17	365.65	1.670	0.459	17	1.670	28.390	289	2.789	607.680	3.255	2.262
18	18	365.72	1.740	0.478	18	1.740	31.320	324	3.028	559.378	3.007	2.346
19	19	365.77	1.790	0.492	19	1.790	34.010	361	3.204	513.075	2.836	2.430
20	20	365.92	1.940	0.533	20	1.940	38.800	400	3.764	468.773	2.354	2.514
21	21	366.01	2.030	0.558	21	2.030	42.630	441	4.121	426.471	2.086	2.598
22	22	366.07	2.090	0.574	22	2.090	45.980	484	4.368	386.168	1.916	2.682
23	23	366.19	2.210	0.607	23	2.210	50.830	529	4.884	347.866	1.598	2.766
24	24	366.18	2.200	0.604	24	2.200	52.800	576	4.840	311.564	1.624	2.850
25	25	366.29	2.310	0.635	25	2.310	57.750	625	5.336	277.261	1.355	2.934
26	26	366.34	2.360	0.648	26	2.360	61.360	676	5.570	244.959	1.241	3.018
27	27	366.47	2.490	0.684	27	2.490	67.230	729	6.200	214.657	0.969	3.102
28	28	366.55	2.570	0.706	28	2.570	71.960	784	6.605	186.354	0.818	3.186

Spesimen 3 **363.98** ***Lanjutan Spesimen 3***

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
29	29	366.63	2.650	0.728	29	2.650	76.850	841	7.022	160.052	0.679	3.270
30	30	366.78	2.800	0.769	30	2.800	84.000	900	7.840	135.750	0.455	3.354
31	31	366.89	2.910	0.799	31	2.910	90.210	961	8.468	113.447	0.318	3.438
32	32	367.00	3.020	0.830	32	3.020	96.640	1024	9.120	93.145	0.206	3.522
33	33	367.16	3.180	0.874	33	3.180	104.940	1089	10.112	74.843	0.087	3.606
34	34	367.23	3.250	0.893	34	3.250	110.500	1156	10.563	58.540	0.050	3.690
35	35	367.03	3.050	0.838	35	3.050	106.750	1225	9.302	44.238	0.180	3.774
36	36	367.20	3.220	0.885	36	3.220	115.920	1296	10.368	31.936	0.065	3.858
37	37	367.23	3.250	0.893	37	3.250	120.250	1369	10.563	21.633	0.050	3.942
38	38	367.35	3.370	0.926	38	3.370	128.060	1444	11.357	13.331	0.011	4.026
39	39	367.43	3.450	0.948	39	3.450	134.550	1521	11.902	7.029	0.001	4.110
40	40	367.54	3.560	0.978	40	3.560	142.400	1600	12.674	2.726	0.007	4.194
41	41	367.51	3.530	0.970	41	3.530	144.730	1681	12.461	0.424	0.003	4.278
42	42	367.58	3.600	0.989	42	3.600	151.200	1764	12.960	0.122	0.016	4.362
43	43	367.70	3.720	1.022	43	3.720	159.960	1849	13.838	1.819	0.060	4.446
44	44	367.72	3.740	1.028	44	3.740	164.560	1936	13.988	5.517	0.071	4.530
45	45	367.78	3.800	1.044	45	3.800	171.000	2025	14.440	11.215	0.106	4.614
46	46	367.88	3.900	1.071	46	3.900	179.400	2116	15.210	18.912	0.181	4.698
47	47	367.96	3.980	1.093	47	3.980	187.060	2209	15.840	28.610	0.256	4.782
48	48	367.91	3.930	1.080	48	3.930	188.640	2304	15.445	40.308	0.208	4.866
49	49	367.97	3.990	1.096	49	3.990	195.510	2401	15.920	54.005	0.266	4.950
50	50	368.09	4.110	1.129	50	4.110	205.500	2500	16.892	69.703	0.404	5.034
51	51	368.14	4.160	1.143	51	4.160	212.160	2601	17.306	87.401	0.470	5.118
52	52	368.18	4.200	1.154	52	4.200	218.400	2704	17.640	107.098	0.527	5.202
53	53	368.25	4.270	1.173	53	4.270	226.310	2809	18.233	128.796	0.633	5.286
54	54	368.26	4.280	1.176	54	4.280	231.120	2916	18.318	152.494	0.649	5.370
55	55	368.33	4.350	1.195	55	4.350	239.250	3025	18.922	178.191	0.767	5.454
56	56	368.47	4.490	1.234	56	4.490	251.440	3136	20.160	205.889	1.032	5.538

Spesimen 3 363.98 *Lanjutan Spesimen 3*

No	Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	MC (%)	X_1	Y_1	X_1Y_1	X^2	Y^2	$(X_1-\bar{X})^2$	$(Y_1-\bar{Y})^2$	$\hat{Y}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
57	57	368.60	4.620	1.269	57	4.620	263.340	3249	21.344	235.587	1.313	5.622
58	58	368.64	4.660	1.280	58	4.660	270.280	3364	21.716	267.284	1.406	5.706
59	59	368.71	4.730	1.300	59	4.730	279.070	3481	22.373	300.982	1.577	5.790
60	60	368.73	4.750	1.305	60	4.750	285.000	3600	22.563	336.680	1.628	5.874
61	61	368.78	4.800	1.319	61	4.800	292.800	3721	23.040	374.378	1.758	5.958
62	62	368.88	4.900	1.346	62	4.900	303.800	3844	24.010	414.075	2.033	6.042
63	63	368.95	4.970	1.365	63	4.970	313.110	3969	24.701	455.773	2.237	6.126
64	64	369.03	5.050	1.387	64	5.050	323.200	4096	25.502	499.471	2.483	6.210
65	65	369.06	5.080	1.396	65	5.080	330.200	4225	25.806	545.168	2.579	6.294
66	66	369.12	5.140	1.412	66	5.140	339.240	4356	26.420	592.866	2.775	6.378
67	67	369.13	5.150	1.415	67	5.150	345.050	4489	26.522	642.564	2.808	6.462
68	68	369.13	5.150	1.415	68	5.150	350.200	4624	26.522	694.261	2.808	6.546
69	69	369.14	5.160	1.418	69	5.160	356.040	4761	26.626	747.959	2.842	6.630
70	70	369.20	5.220	1.434	70	5.220	365.400	4900	27.248	803.657	3.048	6.714
71	71	369.20	5.220	1.434	71	5.220	370.620	5041	27.248	861.354	3.048	6.798
72	72	369.22	5.240	1.440	72	5.240	377.280	5184	27.458	921.052	3.118	6.882
73	73	369.38	5.400	1.484	73	5.400	394.200	5329	29.160	982.750	3.709	6.966
74	74	369.34	5.360	1.473	74	5.360	396.640	5476	28.730	1046.447	3.556	7.050
75	75	369.29	5.310	1.459	75	5.310	398.250	5625	28.196	1112.145	3.370	7.134
76	76	369.39	5.410	1.486	76	5.410	411.160	5776	29.268	1179.843	3.747	7.218
77	77	369.54	5.560	1.528	77	5.560	428.120	5929	30.914	1249.540	4.351	7.302
78	78	369.50	5.520	1.517	78	5.520	430.560	6084	30.470	1321.238	4.185	7.386
79	79	369.55	5.570	1.530	79	5.570	440.030	6241	31.025	1394.936	4.392	7.470
80	80	369.56	5.580	1.533	80	5.580	446.400	6400	31.136	1470.633	4.434	7.554
81	81	369.63	5.650	1.552	81	5.650	457.650	6561	31.922	1548.331	4.734	7.638
82	82	369.67	5.690	1.563	82	5.690	466.580	6724	32.376	1628.029	4.910	7.722
83	83	369.77	5.790	1.591	83	5.790	480.570	6889	33.524	1709.726	5.363	7.806
84	84	369.77	5.790	1.591	84	5.790	486.360	7056	33.524	1793.424	5.363	7.890
Jumlah		*31593.060*	*292.780*	*88.241*	*3582*	*298.780*	*15568.000*	*201128*	*1232.790*	*49468*	*271.910*	
Rata-Rata		*359.012*	*3.404*	*1.026*	*41.651*	*3.474*	*181.023*	*2339*	*14.335*			

Tabel 4.B. Hasil Pengolahan Data Perendaman Material Komposit Tenunan Ramie Dengan Lama Perendaman 84 Hari.

Spesimen	Lama Perendaman (n)	ΣX_1	ΣY_1	$\Sigma X_1 Y_1$	ΣX^2	ΣY^2	$\bar{X}$	$\bar{Y}$	S_X	S_Y	a	b	r
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Kepingan 1	84 Hari	3570	399.750	21201.150	201110	2281.683	42.500	4.759	24.247	2.125	1.134	0.085	0.947
Kepingan 2		3570	354.750	18940.980	201110	1813.605	42.500	4.223	24.247	1.938	0.897	0.078	0.958
Kepingan 3		3570	284.780	15552.000	201110	1212.790	42.500	3.390	24.247	1.716	0.422	0.069	0.973

Tabel 4.C. Pengamatan Pertambahan Berat Material 28 Hari

Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	Massa (gr)	MC/hr (gr)	Massa (gr)	MC/hr (gr)
Berat Awal	332.14	Kepingan 1	376.53	Kepingan 2	363.98	Kepingan 3
Variabel X Independent (Waktu)	Pertambahan Berat Kepingan 1, 2 dan 3 (gram)					
	Variabel Y Dependent (Berat)					
X	**Y 1**		**Y2**		**Y3**	
1	*2*	*3*	*4*	*5*	*6*	*7*
1	332.37	0.230	376.71	0.180	364.13	0.150
2	332.47	0.330	376.91	0.380	364.14	0.160
3	332.55	0.410	377.04	0.510	364.14	0.160
4	332.79	0.650	377.08	0.550	364.24	0.260
5	332.87	0.730	377.10	0.570	364.24	0.260
6	332.96	0.820	377.19	0.660	364.25	0.270
7	333.09	0.950	377.31	0.780	364.43	0.450
8	333.23	1.090	377.44	0.910	364.51	0.530
9	333.44	1.300	377.60	1.070	364.62	0.640
10	333.55	1.410	377.71	1.180	364.71	0.730
11	333.65	1.510	377.81	1.280	364.82	0.840
12	333.89	1.750	377.92	1.390	364.88	0.900
13	334.11	1.970	378.16	1.630	365.02	1.040
14	334.55	2.410	378.63	2.100	365.48	1.500
15	334.61	2.470	378.68	2.150	365.58	1.600
16	334.75	2.610	378.76	2.230	365.64	1.660
17	334.78	2.640	378.88	2.350	365.65	1.670
18	334.87	2.730	378.93	2.400	365.72	1.740
19	335.06	2.920	379.10	2.570	365.77	1.790
20	335.16	3.020	379.12	2.590	365.92	1.940
21	335.26	3.120	379.22	2.690	366.01	2.030
22	335.45	3.310	379.36	2.830	366.07	2.090
23	335.51	3.370	379.44	2.910	366.19	2.210
24	335.56	3.420	379.49	2.960	366.18	2.200
25	335.70	3.560	379.64	3.110	366.29	2.310
26	335.73	3.590	379.70	3.170	366.34	2.360
27	335.93	3.790	379.80	3.270	366.47	2.490
28	336.03	3.890	379.95	3.420	366.55	2.570

Tabel 4.D. Pengamatan Pertambahan Berat Material 56 Hari

Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	Massa (gr)	MC/hr (gr)	Massa (gr)	MC/hr (gr)
Berat Awal	332.14	Kepingan 1	376.53	Kepingan 2	363.98	Kepingan 3
Variabel X Independent (Waktu)	Pertambahan Berat Kepingan 1, 2 dan 3 (gram)					
	Variabel Y Dependent (Berat)					
X	**Y 1**		**Y2**		**Y3**	
1	*2*	*3*	*4*	*5*	*6*	*7*
29	336.21	4.070	380.04	3.510	366.63	2.650
30	336.25	4.110	380.17	3.640	366.78	2.800
31	336.51	4.370	380.24	3.710	366.89	2.910
32	336.60	4.460	380.37	3.840	367.00	3.020
33	336.77	4.630	380.51	3.980	367.16	3.180
34	336.87	4.730	380.66	4.130	367.23	3.250
35	336.65	4.510	380.47	3.940	367.03	3.050
36	336.82	4.680	380.60	4.070	367.20	3.220
37	336.99	4.850	380.69	4.160	367.23	3.250
38	337.07	4.930	380.79	4.260	367.35	3.370
39	337.18	5.040	380.89	4.360	367.43	3.450
40	337.39	5.250	381.09	4.560	367.54	3.560
41	337.18	5.040	381.01	4.480	367.51	3.530
42	337.35	5.210	381.16	4.630	367.58	3.600
43	337.33	5.190	381.21	4.680	367.70	3.720
44	337.43	5.290	381.23	4.700	367.72	3.740
45	337.56	5.420	381.28	4.750	367.78	3.800
46	337.73	5.590	381.40	4.870	367.88	3.900
47	337.80	5.660	381.50	4.970	367.96	3.980
48	337.64	5.500	381.47	4.940	367.91	3.930
49	337.79	5.650	381.58	5.050	367.97	3.990
50	337.92	5.780	381.67	5.140	368.09	4.110
51	337.95	5.810	381.70	5.170	368.14	4.160
52	338.02	5.880	381.76	5.230	368.18	4.200
53	338.07	5.930	381.83	5.300	368.25	4.270
54	338.08	5.940	381.85	5.320	368.26	4.280
55	338.16	6.020	381.89	5.360	368.33	4.350
56	338.50	6.360	382.17	5.640	368.47	4.490

Tabel 4.E. Pengamatan Pertambahan Berat Material 84 Hari

Lama Perendaman (hari)	Massa (gr)	MC/hr (gr)	Massa (gr)	MC/hr (gr)	Massa (gr)	MC/hr (gr)
Berat Awal	332.14	Kepingan 1	376.53	Kepingan 2	363.98	Kepingan 3
Variabel X Independent (Waktu)	Pertambahan Berat Kepingan 1, 2 dan 3 (gram)					
	Variabel Y Dependent (Berat)					
X	Y 1		Y2		Y3	
1	*2*	*3*	*4*	*5*	*6*	*7*
57	338.54	6.400	382.20	5.670	368.60	4.620
58	338.57	6.430	382.21	5.680	368.64	4.660
59	338.55	6.410	382.25	5.720	368.71	4.730
60	338.70	6.560	382.32	5.790	368.73	4.750
61	338.67	6.530	382.35	5.820	368.78	4.800
62	338.75	6.610	382.47	5.940	368.88	4.900
63	338.80	6.660	382.54	6.010	368.95	4.970
64	338.82	6.680	382.55	6.020	369.03	5.050
65	338.85	6.710	382.61	6.080	369.06	5.080
66	339.01	6.870	382.63	6.100	369.12	5.140
67	339.05	6.910	382.70	6.170	369.13	5.150
68	339.04	6.900	382.73	6.200	369.13	5.150
69	339.06	6.920	382.73	6.200	369.14	5.160
70	339.04	6.900	382.76	6.230	369.20	5.220
71	339.00	6.860	382.71	6.180	369.20	5.220
72	339.04	6.900	382.71	6.180	369.22	5.240
73	339.24	7.100	382.92	6.390	369.38	5.400
74	339.17	7.030	382.89	6.360	369.34	5.360
75	339.28	7.140	383.03	6.500	369.29	5.310
76	339.29	7.150	382.99	6.460	369.39	5.410
77	339.32	7.180	383.02	6.490	369.54	5.560
78	339.26	7.120	382.98	6.450	369.50	5.520
79	339.30	7.160	383.09	6.560	369.55	5.570
80	339.34	7.200	383.09	6.560	369.56	5.580
81	339.38	7.240	383.16	6.630	369.63	5.650
82	339.44	7.300	383.21	6.680	369.67	5.690
83	339.63	7.490	383.24	6.710	369.77	5.790
84	339.63	7.490	383.27	6.740	369.77	5.790

Tabel 4. F. Proses pengolahan data dengan bantuan program SPSS (Statistical Product and Service Solution) version 17.0, outputnya tabel-tabel berikut dibawah ini.

Lama Perendaman 56 Hari

```
REGRESSION   /DESCRIPTIVES MEAN STDDEV CORR SIG N   /MISSING
LISTWISE   /STATISTICS COEFF OUTS R ANOVA   /CRITERIA=PIN(.05)
POUT(.10)   /NOORIGIN   /DEPENDENT Y2   /METHOD=ENTER X
/SCATTERPLOT=(*SRESID ,*ZPRED)   /RESIDUALS DURBIN NORM(ZRESID).
```

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Berat Material 2	4.2232	1.94942	84
Lama Perendaman	42.5000	24.39262	84

Correlations

		Berat Material 2	Lama Perendaman
Pearson Correlation	Berat Material 2	1.000	.979
	Lama Perendaman	.979	1.000
Sig. (1-tailed)	Berat Material 2	.	.000
	Lama Perendaman	.000	.
N	Berat Material 2	84	84
	Lama Perendaman	84	84

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Lama Perendaman[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Berat Material 2

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.979[a]	.959	.958	.39931	.044

a. Predictors: (Constant), Lama Perendaman

b. Dependent Variable: Berat Material 2

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	302.345	1	302.345	1896.183	.000[a]
	Residual	13.075	82	.159		
	Total	315.420	83			

a. Predictors: (Constant), Lama Perendaman

b. Dependent Variable: Berat Material 2

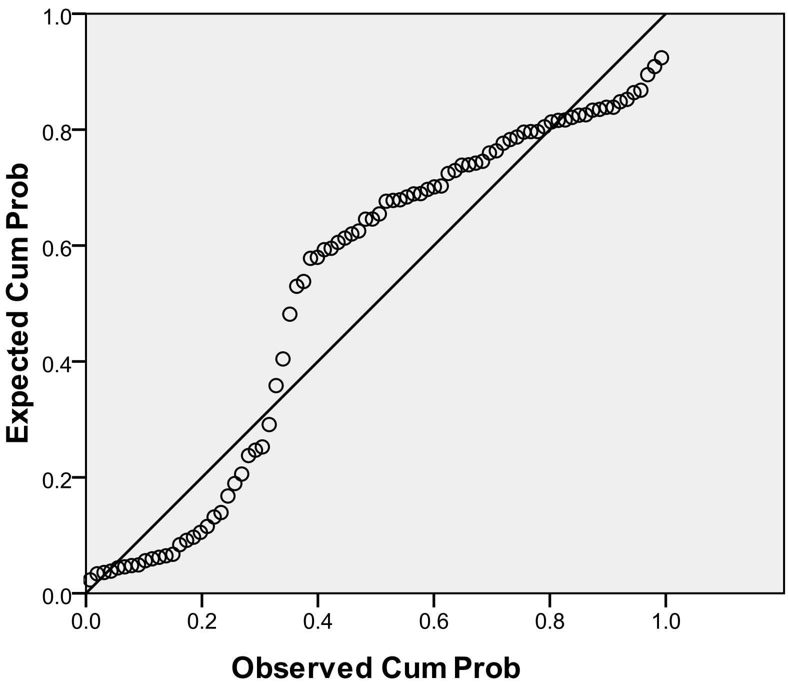
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.898	.088		10.212	.000
	Lama Perendaman	.078	.002	.979	43.545	.000

a. Dependent Variable: Berat Material 2

Normal P – P Plot of Regression Standardizer Residual

Dependent Variable: Berat Material 2



Lama Perendaman 84 Hari

```
REGRESSION   /DESCRIPTIVES MEAN STDDEV CORR SIG N   /MISSING
LISTWISE   /STATISTICS COEFF OUTS R ANOVA   /CRITERIA=PIN(.05)
POUT(.10)   /NOORIGIN   /DEPENDENT Y3   /METHOD=ENTER X
/SCATTERPLOT=(*SRESID ,*ZPRED)   /RESIDUALS DURBIN NORM(ZRESID).
```

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Berat Material 3	3.3902	1.72619	84
Lama Perendaman	42.5000	24.39262	84

Correlations

		Berat Material 3	Lama Perendaman
Pearson Correlation	Berat Material 3	1.000	.987
	Lama Perendaman	.987	1.000
Sig. (1-tailed)	Berat Material 3	.	.000
	Lama Perendaman	.000	.
N	Berat Material 3	84	84
	Lama Perendaman	84	84

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Lama Perendaman[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Berat Material 3

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.987[a]	.974	.974	.28078	.071

a. Predictors: (Constant), Lama Perendaman

b. Dependent Variable: Berat Material 3

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	240.854	1	240.854	3055.118	.000[a]
	Residual	6.465	82	.079		
	Total	247.318	83			

a. Predictors: (Constant), Lama Perendaman

b. Dependent Variable: Berat Material 3

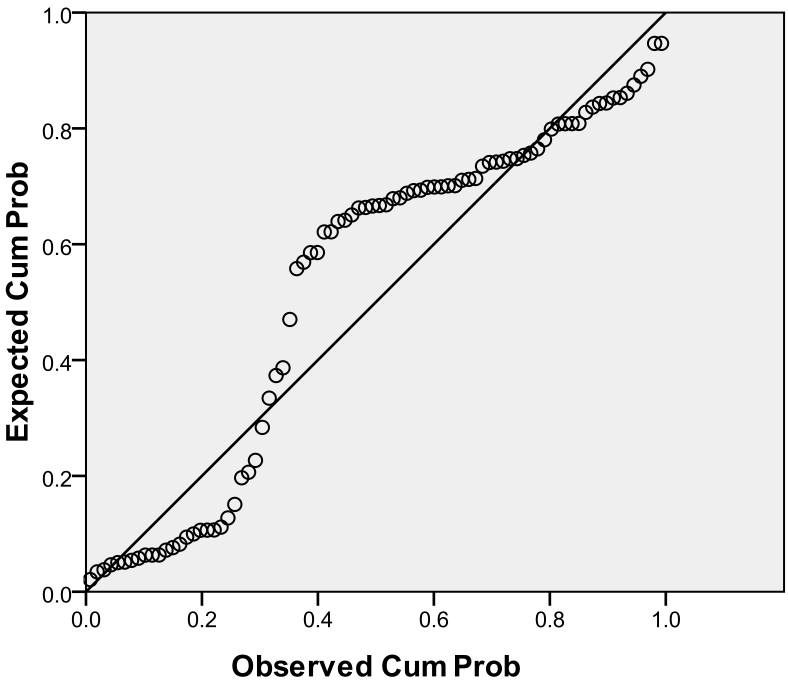
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.422	.062		6.829	.000
	Lama Perendaman	.070	.001	.987	55.273	.000

a. Dependent Variable: Berat Material 3

Normal P – P Plot of Regression Standardizer Residual

Dependent Variable: Berat Material 3



Tabel 4. G. Nilai-Nilai Chi Kuadrat

dk	Taraf signifikansi					
	50%	30%	20%	10%	5%	1%
1	0,455	1,074	1,642	2,706	3,841	6,635
2	1,386	2,408	3,219	4,605	5,991	9,210
3	2,366	3,665	4,642	6,251	7,815	11,341
4	3,357	4,878	5,989	7,779	9,488	13,277
5	4,351	6,064	7,289	9,236	11,070	15,086
6	5,348	7,231	8,558	10,645	12,592	16,812
7	6,346	8,383	9,803	12,017	14,067	18,475
8	7,344	9,524	11,030	13,362	15,507	20,090
9	8,343	10,656	12,242	14,684	16,919	21,666
10	9,342	11,781	13,442	15,987	18,307	23,209
11	10,341	12,899	14,631	17,275	19,675	24,725
12	11,340	14,011	15,812	18,549	21,026	26,217
13	12,340	15,119	16,985	19,812	22,362	27,688
14	13,339	16,222	18,151	21,064	23,685	29,141
15	14,339	17,322	19,311	22,307	24,996	30,578
16	15,338	18,418	20,465	23,542	26,296	32,000
17	16,338	19,511	21,615	24,769	27,587	33,409
18	17,338	20,601	22,760	25,989	28,869	34,805
19	18,338	21,689	23,900	27,204	30,144	36,191
20	19,337	22,775	25,038	28,412	31,410	37,566
21	20,337	23,858	26,171	29,615	32,671	38,932
22	21,337	24,939	27,301	30,813	33,924	40,289
23	22,337	26,018	28,429	32,007	35,172	41,638
24	23,337	27,096	29,553	33,196	35,415	42,980
25	24,337	28,172	30,675	34,382	37,652	44,314
26	25,336	29,246	31,795	35,563	38,885	45,642
27	26,336	30,319	32,912	36,741	40,113	46,963
28	27,336	31,391	34,027	37,916	41,337	48,278
29	28,336	32,461	35,139	39,087	42,557	49,588
30	29,336	33,530	36,250	40,256	43,773	50,892

[a]Sugiyono. (2011). *Statistika Untuk Penelitian*. Cetakan ke-18. Penerbit Alfabeta. Bandung.

Nilai-Nilai Chi Kuadrat		
dk	1%	5%
1	6.635	3.841
2	9.210	5.991
1.820	8.747	5.604

Lampiran 5

Tabel 5. A. Ukuran Spesimen Lentur untuk Kepingan

Lama Perendaman 28 Hari

Kepingan 1

Nomor	Spesimen		
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	16	4.25	4.35	4.05
2	16	4.1	4	3.95
3	16	4	4	3.9
4	15.98	4	3.95	3.95
5	16	4	4	3.9

Kepingan 2

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	15.9	3.75	3.75	3.75
2	16	3.7	3.7	3.7
3	16	3.7	3.7	3.7
4	15.98	3.75	3.75	3.7
5	16	3.85	3.85	3.8

Kepingan 3

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	16	4.4	4.3	4.3
2	15.85	4.4	4.35	4.3
3	16	4.5	4.45	4.4
4	15.95	4.3	4.3	4.25
5	15.9	4.3	4.3	4.3

Lama Perendaman 56 Hari

Kepingan 4

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	16	3.7	3.7	3.7
2	16	3.65	3.65	3.65
3	16	3.65	3.65	3.65
4	16	3.65	3.7	3.65
5	16	3.75	3.75	3.75

Kepingan 5

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	16	3.9	3.85	3.8
2	15.9	3.85	3.8	3.8
3	15.9	3.9	3.9	3.8
4	15.95	4	3.95	3.85
5	15.75	4.15	4.1	4.05

Kepingan 6

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	16	4	3.9	3.8
2	16	3.9	3.8	3.7
3	16	3.8	3.7	3.65
4	16	3.75	3.7	3.65
5	16	3.75	3.7	3.65

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Kepingan 7

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	16	4.1	4.08	4.06
2	15.75	4	4	4
3	16	3.94	3.94	3.92
4	15.8	4	3.96	4
5	15.9	4	4	4.1

Kepingan 8

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	15.9	3.6	3.6	3.65
2	15.9	3.55	3.55	3.6
3	15.9	3.6	3.6	3.6
4	15.8	3.7	3.7	3.7
5	16	3.8	3.8	3.8

Kepingan 9

Nomor	Spesimen			
	Lebar (mm)	Tebal (mm)		
		1	*2*	*3*
1	16	3.8	3.85	3.85
2	16	3.7	3.8	3.8
3	16	3.6	3.6	3.65
4	16	3.5	3.55	3.6
5	16	3.55	3.6	3.6

Tabel 5.B. Data Hasil Uji Lentur untuk per Kepingan .

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Kepingan 1

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	2.2	2.2	2.1	2.0	2.3
3	100	4.9	4.7	4.6	4.4	4.6
4	150	7.5	7.2	6.9	6.7	7.0
5	200	9.8	9.3	8.9	8.7	9.0
6	250	12.0	11.0	10.8	10.6	10.9
7	300	13.9	13.2	12.5	12.3	12.5
8	350	15.7	14.8	14.0	13.9	13.9
9	400	17.4	16.5	15.5	15.2	15.7
10	450	19.0	17.8	16.8	16.4	16.9
11	500	20.2	18.9	18.0	17.6	18.1
12	550	21.3	20.0	18.9	18.6	19.0
13	600	22.3	21.0	19.8	19.4	20.0
14	650	23.2	21.8	20.5	20.5	20.6
15	700		22.4	21.1	20.9	21.3
16	750		22.9	21.8	21.6	21.9
17	800					22.3
18	850					
19	900					

Kepingan 2

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	2.1	2.2	2.0	2.1	1.9
3	100	4.3	4.3	4.2	4.4	4.1
4	150	6.2	6.1	6.0	6.2	6.3
5	200	8.0	8.0	7.6	8.0	8.2
6	250	9.5	9.5	9.2	9.5	9.9
7	300	11.2	11.0	10.6	11.1	11.5
8	350	12.5	12.3	12.0	12.3	13.0
9	400	13.8	13.6	13.2	13.8	14.3
10	450	14.9	14.6	14.2	14.8	15.6
11	500	16.0	15.5	15.2	15.9	16.7
12	550	16.9	16.3	16.0	16.6	17.5
13	600	17.7	17.0	16.8	17.4	18.4
14	650	18.4	17.7	17.4	18.1	19.2
15	700	18.9	18.2	17.8	18.6	19.8
16	750	19.4	18.8		19.0	20.5
17	800	19.7				
18	850					
19	900					

Kepingan 3

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50			2.2	2.7	2.1
3	100	2.5	2.1	4.4	4.4	4.1
4	150	5.3	4.5	6.6	6.6	6.0
5	200	7.5	6.7	8.6	8.3	7.7
6	250	9.7	8.7	10.4	9.9	9.4
7	300	11.7	10.5	12.0	11.5	11.0
8	350	13.6	12.2	13.6	12.9	12.4
9	400	15.2	13.8	14.9	14.2	13.2
10	450	16.8	15.1	16.1	15.4	14.4
11	500	18.1	16.4	17.2	16.5	15.4
12	550	19.3	17.3	18.1	17.2	16.2
13	600	20.4	18.3	18.8	18.0	16.9
14	650	21.1	19.1	19.5	18.5	17.2
15	700	21.7	19.7	19.9	19.1	18.2
16	750	22.2	20.1		19.3	18.3
17	800	22.3	20.3		18.7	
18	850					
19	900					

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Kepingan 4

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	1.8	2.1	2.1	2.0	1.9
3	100	3.7	3.9	4.0	3.8	4.0
4	150	5.5	5.5	5.6	5.5	5.7
5	200	7.2	7.1	7.2	7.1	7.4
6	250	8.5	8.5	8.5	8.4	9.0
7	300	9.9	9.8	9.8	9.7	10.4
8	350	11.2	11.1	11.1	11.0	11.1
9	400	12.2	12.1	12.0	12.2	11.8
10	450	13.2	13.1	12.8	13.2	12.8
11	500	14.1	13.8	13.8	14.0	14.0
12	550	14.9	14.8	14.4	14.6	15.0
13	600	15.4	15.3	15.0	15.4	15.7
14	650	15.9	15.8	15.6	16.0	16.6
15	700		16.3	16.1	16.5	17.0
16	750		16.7		16.7	17.6
17	800		17.0			18.0
18	850					
19	900					

Kepingan 5

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	1.9	2.3	2.1	2.2	2.4
3	100	4.1	4.4	4.2	4.4	4.2
4	150	6.2	6.3	6.3	6.5	6.6
5	200	8.0	8.2	8.1	8.6	8.8
6	250	9.7	9.7	9.7	10.3	10.7
7	300	11.1	11.3	11.2	12.0	12.5
8	350	12.6	12.7	12.7	13.5	14.1
9	400	13.8	13.6	14.0	14.8	15.9
10	450	14.9	14.8	15.2	16.0	17.1
11	500	15.9	15.8	16.0	17.0	18.2
12	550	16.9	16.7	17.0	17.9	18.8
13	600	17.6	17.5	17.5	18.7	19.6
14	650	18.2	17.8	18.1	19.4	20.3
15	700	18.8		18.5	19.9	
16	750	19.2		18.8	20.3	
17	800	19.4				
18	850					
19	900					

Kepingan 6

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	2.3	2.3	2.1	2.0	1.8
3	100	4.5	4.2	4.0	3.3	3.7
4	150	6.6	6.2	5.9	5.6	5.4
5	200	8.4	7.8	7.5	7.2	7.2
6	250	10.1	9.3	9.0	8.6	8.5
7	300	11.6	10.8	10.3	10.0	9.8
8	350	12.9	12.0	11.6	11.2	11.1
9	400	14.2	13.2	12.7	12.3	12.2
10	450	15.5	14.3	13.7	13.3	13.2
11	500	16.1	15.1	14.5	14.1	14.0
12	550	16.9	15.9	15.6	14.9	14.8
13	600	17.5	16.5	16.0	15.6	15.5
14	650	18.1	17.0	16.5	16.0	16.0
15	700	18.6	17.5	17.0	16.6	16.5
16	750	18.9	17.9	17.5	16.9	16.8
17	800		18.1	17.8	17.3	17.1
18	850				17.5	
19	900					

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Kepingan 7

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	2.2	2.2	2.1	2.2	2.2
3	100	4.8	4.5	4.3	4.4	4.6
4	150	7.2	6.8	6.5	6.5	6.8
5	200	9.3	9.3	8.5	8.5	9.0
6	250	11.3	10.5	10.3	10.2	10.9
7	300	13.1	12.2	12.0	11.8	12.6
8	350	14.7	13.8	13.5	13.3	14.2
9	400	16.2	15.2	15.0	14.7	15.7
10	450	17.5	16.6	16.2	16.0	16.2
11	500		17.7	17.3	17.0	
12	550		18.5	18.2	17.8	
13	600		19.3	19.0	18.5	
14	650		19.9	19.7	19.2	
15	700			20.3	19.7	
16	750			20.6		
17	800					
18	850					
19	900					

Kepingan 8

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	1.5	1.7	1.6	1.9	2.3
3	100	3.3	3.4	3.3	3.5	4.5
4	150	4.8	5.0	4.8	5.2	6.6
5	200	6.4	6.3	6.4	6.4	8.0
6	250	7.6	7.6	7.6	7.9	9.4
7	300	8.9	8.8	8.9	9.2	10.9
8	350	10.1	9.8	10.0	10.3	12.1
9	400	11.0	11.0	11.1	11.5	13.4
10	450	12.1	11.8	12.0	12.4	14.5
11	500	13.0	12.6	13.0	13.3	15.4
12	550	13.6	13.4	13.8	14.1	16.2
13	600	14.1	14.0	14.2	14.7	17.0
14	650	14.8	14.5	14.9	15.3	17.5
15	700	15.3	15.0	15.5	15.8	18.1
16	750	15.6	15.5	15.8	16.1	18.3
17	800	16.0	15.6	16.1	16.5	
18	850	15.9	15.9	16.3		
19	900					

Kepingan 9

No.	Defleksi	BEBAN				
		Sp.1	Sp.2	Sp. 3	Sp. 4	Sp. 5
		P 1	P 2	P 3	P 4	P 5
1	0	0.0	0.0	0.0	0.0	0.0
2	50	1.8	2.0	2.0	1.5	1.8
3	100	4.0	3.8	3.7	3.3	3.3
4	150	6.1	5.8	5.3	4.9	4.9
5	200	7.8	7.2	6.9	6.3	6.3
6	250	9.5	8.6	8.2	7.6	7.6
7	300	11.1	10.0	9.4	8.8	8.9
8	350	12.8	11.2	10.6	10.0	10.0
9	400	13.7	12.3	11.6	11.0	10.9
10	450	14.8	13.3	12.6	11.9	11.9
11	500	15.8	14.2	13.4	12.8	12.6
12	550	16.6	14.9	14.2	13.4	13.3
13	600	17.4	15.6	14.7	14.1	13.9
14	650	18.1	16.2	15.2	14.8	14.5
15	700	18.6	16.7	15.7	15.0	15.0
16	750	19.0	17.0	16.1	15.4	15.5
17	800			16.6	15.8	15.8
18	850			16.7	16.0	16.0
19	900			16.7		

Tabel 5. C. Hasil Pengujian Lentur untuk per Kepingan .

Lama Perendaman 28 Hari

Kepingan 1

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	16	4.25	4.35	4.05	4.22	23.2	6.5
2	16	4.1	4	3.95	4.02	22.9	7.5
3	16	4	4	3.9	3.97	21.8	7.5
4	15.98	4	3.95	3.95	3.97	21.6	7.5
5	16	4	4	3.9	3.97	22.3	8

Kepingan 2

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	15.9	3.75	3.75	3.75	3.75	19.7	8
2	16	3.7	3.7	3.7	3.70	18.8	7.5
3	16	3.7	3.7	3.7	3.70	17.8	7
4	15.98	3.75	3.75	3.7	3.73	19.0	7.5
5	16	3.85	3.85	3.8	3.83	20.5	7.5

Kepingan 3

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	16	4.4	4.3	4.3	4.33	22.3	8
2	15.85	4.4	4.35	4.3	4.35	20.3	8
3	16	4.5	4.45	4.4	4.45	19.9	7
4	15.95	4.3	4.3	4.25	4.28	18.7	8
5	15.9	4.3	4.3	4.3	4.30	18.3	7.5

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Kepingan 4

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	16	3.7	3.7	3.7	3.70	15.9	6.5
2	16	3.65	3.65	3.65	3.65	17.0	8
3	16	3.65	3.65	3.65	3.65	16.1	7
4	16	3.65	3.7	3.65	3.67	16.7	7.5
5	16	3.75	3.75	3.75	3.75	18.0	8

Kepingan 5

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	16	3.9	3.85	3.8	3.85	19.4	8
2	15.9	3.85	3.8	3.8	3.82	17.8	6.5
3	15.9	3.9	3.9	3.8	3.87	18.8	7.5
4	15.95	4	3.95	3.85	3.93	20.3	7.5
5	15.75	4.15	4.1	4.05	4.10	20.3	6.5

Kepingan 6

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	16	4.1	4.08	4.06	4.08	17.5	4.5
2	15.75	4	4	4	4.00	19.9	6.5
3	16	3.94	3.94	3.92	3.93	20.6	7.5
4	15.8	4	3.96	4	3.99	19.7	7
5	15.9	4	4	4.1	4.03	16.2	4.5

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Kepingan 7

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	16	4	3.9	3.8	3.90	18.9	7.5
2	16	3.9	3.8	3.7	3.80	18.1	8
3	16	3.8	3.7	3.65	3.72	17.8	8
4	16	3.75	3.7	3.65	3.70	17.5	8.5
5	16	3.75	3.7	3.65	3.70	17.1	8

Kepingan 8

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	15.9	3.6	3.6	3.65	3.62	16	8
2	15.9	3.55	3.55	3.6	3.57	15.9	8.5
3	15.9	3.6	3.6	3.6	3.60	16.3	8.5
4	15.8	3.7	3.7	3.7	3.70	16.5	8
5	16	3.8	3.8	3.8	3.80	18.3	7.5

Kepingan 9

Nomor	Spesimen						Defleksi (mm)
	Lebar (mm)	Tebal (mm)				P maks. (Kg)	
		1	*2*	*3*	*Tebal rata-rata*		
1	16	3.8	3.85	3.85	3.83	19.0	7.5
2	16	3.7	3.8	3.8	3.77	17.0	7.5
3	16	3.6	3.6	3.65	3.62	16.7	8.5
4	16	3.5	3.55	3.6	3.55	16.0	8.5
5	16	3.55	3.6	3.6	3.58	16.0	8.5

Tabel 5. D. Hasil Perhitungan Lentur untuk material komposit tenunan ramie

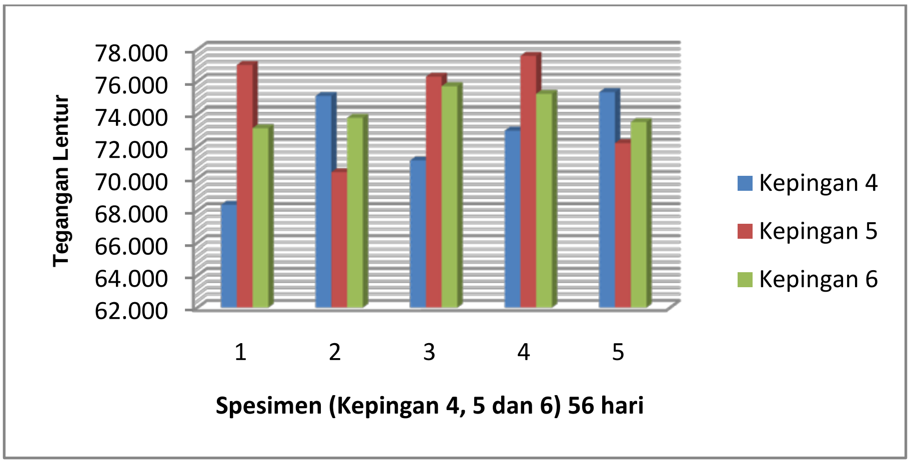
Nomor		Panjang Span	Lebar	Tebal	Defleksi	Beban Defleksi	P	σf	ϵf	Momen Inersia	EB	Ef
		(L = mm)	(b = mm)	(d = mm)	(D) mm	(kg)	(N)	(MPa)	(mm/mm)	(mm^4)	(MPa)	(GPa)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1	a	64	16	4.22	6.5	23.2	227.592	76.680	0.040	100.202	1908.386	1.908
	b	64	16	4.02	7.5	22.9	224.649	83.407	0.044	86.620	1888.535	1.889
	c	64	16	3.97	7.5	21.8	213.858	81.413	0.044	83.428	1866.606	1.867
	d	64	15.98	3.97	7.5	21.6	211.896	80.767	0.044	83.323	1851.796	1.852
	e	64	16	3.97	8	22.3	218.763	83.281	0.047	83.428	1790.079	1.790
								81.110	**0.044**	**87.400**	**1861.080**	**1.861**
2	a	64	15.9	3.75	8	19.7	193.257	82.975	0.044	69.873	1888.140	1.888
	b	64	16	3.70	7.5	18.8	184.428	80.830	0.041	67.537	1988.476	1.988
	c	64	16	3.70	7	17.8	174.618	76.531	0.038	67.537	2017.185	2.017
	d	64	15.98	3.73	7.5	19.0	186.390	80.482	0.041	69.107	1963.984	1.964
	e	64	16	3.83	7.5	20.5	201.105	82.258	0.042	74.909	1954.903	1.955
								80.615	**0.041**	**69.793**	**1962.538**	**1.963**
3	a	64	16	4.33	8	22.3	218.763	70.008	0.051	108.244	1379.686	1.380
	b	64	15.85	4.35	8	20.3	199.143	63.742	0.051	108.722	1250.426	1.250
	c	64	16	4.45	7	19.9	195.219	59.150	0.046	117.495	1296.295	1.296
	d	64	15.95	4.28	8	18.7	183.447	60.275	0.050	104.210	1201.735	1.202
	e	64	15.9	4.30	7.5	18.3	179.523	58.622	0.047	105.347	1240.899	1.241
								62.359	**0.049**	**108.803**	**1273.808**	**1.274**

Lanjutan Tabel Hasil Perhitungan Lentur ……..

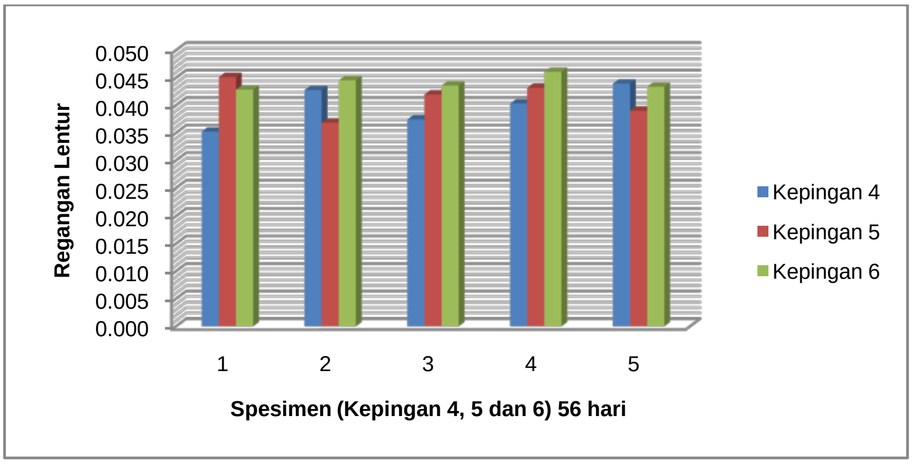
Nomor		Panjang Span	Lebar	Tebal	Defleksi	Beban Defleksi	P	σf	ϵf	Momen Inersia	EB	Ef
		(L = mm)	(b = mm)	(d = mm)	(D) mm	(kg)	(N)	(MPa)	(mm/mm)	(mm^4)	(MPa)	(GPa)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
4	a	64	16	3.70	6.5	15.9	155.979	68.362	0.035	67.537	1940.473	1.940
	b	64	16	3.65	8	17.0	166.770	75.108	0.043	64.836	1755.938	1.756
	c	64	16	3.65	7	16.1	157.941	71.131	0.037	64.836	1900.545	1.901
	d	64	16	3.67	7.5	16.7	163.827	72.980	0.040	65.908	1810.031	1.810
	e	64	16	3.75	8	18.0	176.580	75.341	0.044	70.313	1714.422	1.714
								72.584	**0.040**	**66.686**	**1824.282**	**1.824**
5	a	64	16	3.85	8	19.4	190.314	77.037	0.045	76.089	1707.491	1.707
	b	64	15.9	3.87	6.5	17.8	174.618	70.395	0.037	76.798	1910.406	1.910
	c	64	15.9	3.82	7.5	18.8	184.428	76.309	0.042	73.859	1818.270	1.818
	d	64	15.95	3.93	7.5	20.3	199.143	77.605	0.043	80.678	1797.403	1.797
	e	64	15.75	4.10	6.5	20.3	199.143	72.208	0.039	90.459	1849.692	1.850
								74.711	**0.041**	**79.577**	**1816.652**	**1.817**
6	a	64	16	3.90	7.5	18.9	185.409	73.140	0.043	79.092	1707.008	1.707
	b	64	16	3.80	8	18.1	177.561	73.779	0.045	73.163	1656.787	1.657
	c	64	16	3.72	8	17.8	174.618	75.710	0.044	68.638	1736.721	1.737
	d	64	16	3.70	8.5	17.5	171.675	75.241	0.046	67.537	1633.213	1.633
	e	64	16	3.70	8	17.1	167.751	73.521	0.043	67.537	1695.625	1.696
								74.278	**0.044**	**71.194**	**1685.871**	**1.686**

Lanjutan Tabel Hasil Perhitungan Lentur ……..

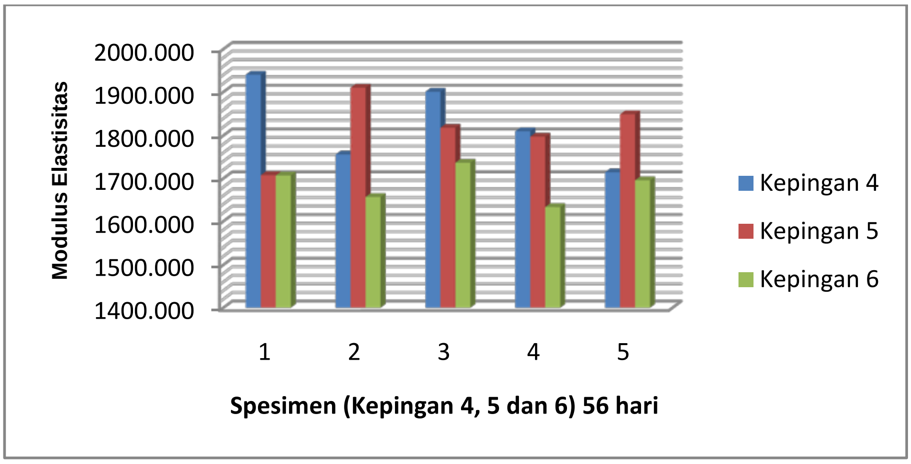
Nomor		Panjang Span	Lebar	Tebal	Defleksi	Beban Defleksi	P	σf	ϵf	Momen Inersia	EB	Ef
		(L = mm)	(b = mm)	(d = mm)	(D) mm	(kg)	(N)	(MPa)	(mm/mm)	(mm^4)	(MPa)	(GPa)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
7	a	64	16	4.08	4.5	17.5	171.675	61.878	0.027	90.556	2300.774	2.301
	b	64	15.75	4.00	6.5	19.9	195.219	74.369	0.038	84.000	1952.667	1.953
	c	64	16	3.93	7.5	20.6	202.086	78.506	0.043	80.931	1818.265	1.818
	d	64	15.8	3.99	7	19.7	193.257	73.757	0.041	83.636	1802.774	1.803
	e	64	15.9	4.03	4.5	16.2	158.922	59.081	0.027	86.722	2224.022	2.224
								69.518	**0.035**	**85.169**	**2019.701**	**2.020**
8	a	64	15.9	3.62	8	16	156.960	72.318	0.042	62.855	1704.732	1.705
	b	64	15.9	3.57	8.5	15.9	155.979	73.893	0.044	60.287	1662.361	1.662
	c	64	15.9	3.60	8.5	16.3	159.903	74.495	0.045	61.819	1661.931	1.662
	d	64	15.8	3.70	8	16.5	161.865	71.840	0.043	66.693	1656.840	1.657
	e	64	16	3.80	7.5	18.3	179.523	74.594	0.042	73.163	1786.767	1.787
								73.428	**0.043**	**64.963**	**1694.526**	**1.695**
9	a	64	16	3.83	7.5	19.0	186.390	76.239	0.042	74.909	1811.861	1.812
	b	64	16	3.77	7.5	17.0	166.770	70.402	0.041	71.444	1699.779	1.700
	c	64	16	3.62	8.5	16.7	163.827	75.010	0.045	63.251	1664.182	1.664
	d	64	16	3.55	8.5	16.0	156.960	74.728	0.044	59.652	1690.616	1.691
	e	64	16	3.58	8.5	16.0	156.960	73.481	0.045	61.177	1648.470	1.648
								73.972	**0.043**	**66.086**	**1702.982**	**1.703**



... (a)

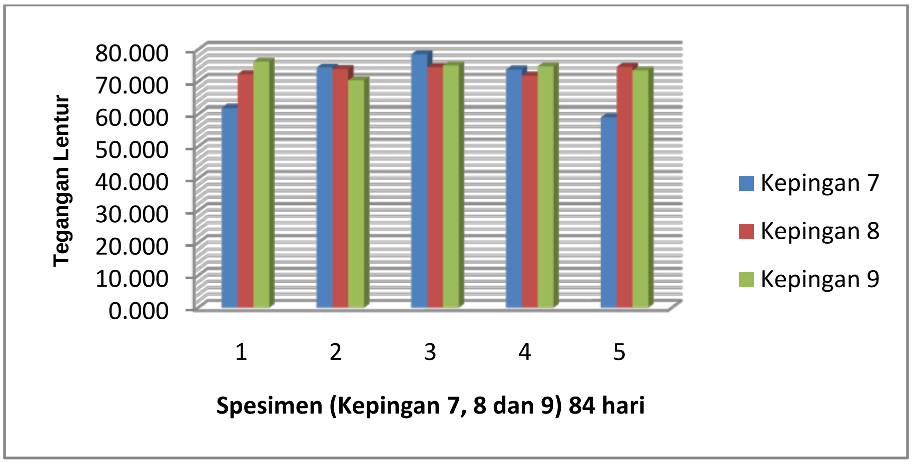


... (b)

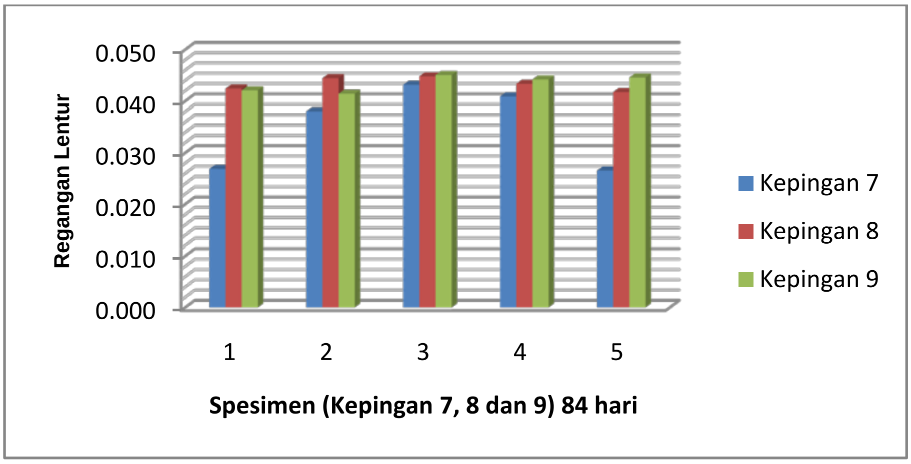


... (c)

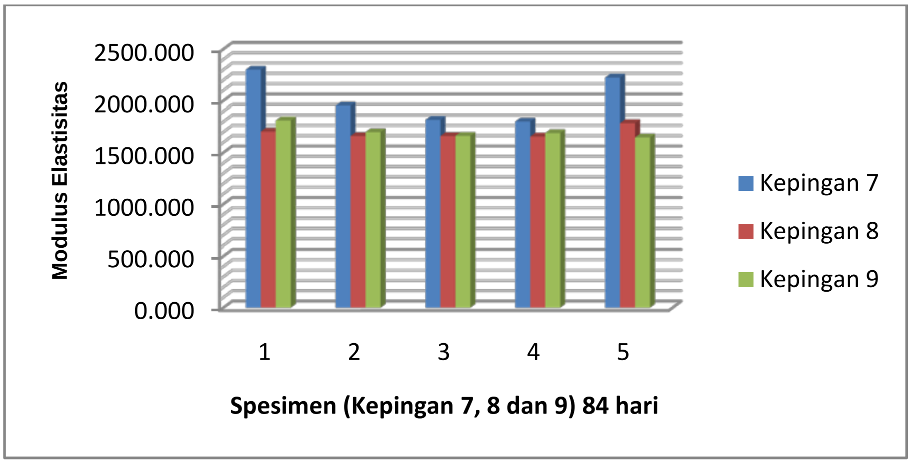
Gambar Diagram batang untuk (a) tegangan lentur maksimum, (b) regangan lentur dan (c) modulus elastisitas komposit tenunan ramie Vs spesimen pada kepingan dengan lama perendaman 56 hari.



... (a)



... (b)



... (c)

Gambar Diagram batang untuk (a) tegangan lentur maksimum, (b) regangan lentur dan (c) modulus elastisitas komposit tenunan ramie Vs spesimen pada kepingan dengan lama perendaman 84 hari

Tabel 5. E Hasil perhitungan lentur spesimen rata - rata material komposit tenunan ramie

Hari	Spesimen rata-rata per Kepingan	σf	εf	Momen Inersia	EB	Ef
		(MPa)	(mm/mm)	(mm^4)	(MPa)	(GPa)
1	*2*	*3*	*4*	*5*	*6*	*7*
28	1	81.110	0.044	87.400	1861.080	1.861
	2	80.615	0.041	69.793	1962.538	1.963
	3	62.359	0.049	108.803	1273.808	1.274
		74.695	0.045	88.665	1699.142	1.699
56	4	72.584	0.040	66.686	1824.282	1.824
	5	74.711	0.041	79.577	1816.652	1.817
	6	74.278	0.044	71.194	1685.871	1.686
		73.858	0.042	72.485	1775.602	1.776
84	7	69.518	0.035	85.169	2019.701	2.020
	8	73.428	0.043	64.963	1694.526	1.695
	9	73.972	0.043	66.086	1702.982	1.703
		72.306	0.041	72.073	1805.736	1.806

Lampiran 6.

Tabel 6.A. Konversi Satuan

Conversion Factors

Length	1 in = 2.54 cm = 25.4 mm
	1 m = 39.37 in
	1 Å = 10^{-10} m
Mass	1 lbm (pound-mass) = 453.6 g = 0.4536 kg
	1 kg = 2.204 lbm
Force	1 N = 0.2248 lbf (pound-force)
	1 lbf = 4.44 N
Stress	1 Pa = 1 N/m^2
	1 Pa = 0.145 x 10^{-3} lbf/in^2
	1 lbf/in^2 = 6.89 x 10^3 Pa
Energy	1 J = 1 N · m
	1 cal = 4.18 J
	1 eV = 1.60 x 10^{-19} J
Power	1 W = 1 J/s
Temperature	°C = K – 273
	K = °C + 273
	°C = (°F – 32) / 1.8
Current	1 A = 1 C/s
Density	1 g/cm^3 = 62.4 lbm/ft^3
ln x = 2.303 $\log_{10}{}^{x}$	

Tabel 6.B. Awalan S.I

Awalan	Simbol	Faktor Multiplikasi			
terra	T	10^{12}	=	1.000.000.000.000	
gigga	G	10^{9}	=	1.000.000.000	
mega	M	10^{6}	=	1.000.000	
kilo	k	10^{3}	=	1.000	
hector	h	10^{2}	=	100	
deka	da	10^{1}	=	10	
deci	d	10^{-1}	=		0.1
centi	c	10^{-2}	=		0.01
milli	m	10^{-3}	=		0.001
micro	µ	10^{-6}	=		000.001
nano	n	10^{-9}	=		0.000.000.001
pico	p	10^{-12}	=		0.000.000.000.001

Tabel 6.C. Konversi dari satuan yang biasa di AS ke Satuan SI

Satuan yang biasa di AS		**Faktor konversi pengali**		**Sama dengan Satuan SI**	
		Teliti	**Praktis**		
Percepatan					
Kaki per detik kuadrat	kaki/det ^{2}	0.3048^{0}	0.305	meter per detik kuadrat	m/det ^{2}
inci per detik kuadrat	Inci/det ^{2}	0.0254^{0}	0.0254	meter per detik kuadrat	m/det ^{2}
Luas					
kaki kuadrat	kaki ^{2}	0.09290304^{0}	0.0929	meter kuadrat	m ^{2}
inci kuadrat	inci ^{2}	645.16^{0}	645	millimeter kuadrat	mm ^{2}
Kerapatan (massa)					
slug per kaki kubik	slug/kaki ^{3}	515.379	515	kilogram per meter kubik	kg/m ^{3}
Energi, kerja					
kaki-pon	kaki-lb	1.35582	1.36	joule	J
kilowatt-jam	kWh	3.6^{0}	3.6	megajoule	MJ
Satuan panas Inggris	Btu	1055.06	1055	joule	J
Gaya					
pon	lb	4.44822	4.45	newton	N
kip (1000 pon)	k	4.44822	4.45	kilonewton	kN
Intensitas gaya					
pon per kaki	lb/kaki	14.5939	14.6	newton per meter	N/m
kip per kaki	k/kaki	14.5939	14.6	kilonewton per meter	kN/m
Panjang					
kaki	kaki	0.3048^{0}	0.305	meter	m
inci	inci	25.4^{0}	25.4	milimeter	mm
mil		1.609344^{0}	1.61	kilometer	km
Massa					
slug		14.5939	14.6	kilogram	kg
Momen gaya, torka					
kaki-pon	kaki-lb	1.35582	1.36	newton meter	N m
inci-pon	inci-lb	0.112985	0.113	newton meter	N m
kaki-kip	kaki-k	1.35582	1.36	kilonewton meter	kN m
inci-kip	inci-k	0.112985	0.113	kilonewton meter	kN m
Momen inersia (massa)					
slug kaki kuadrat		1.35582	1.36	kilogram meter kuadrat	kg m
Momen inersia					
(momen kedua and luas)					
inci pangkat empat	inci ^{4}	416.231	416.000	millimeter pangkat empat	mm ^{4}
inci pangkat empat	inci ^{4}	0.415231×10^{-4}	0.416×10^{-4}	meter pangkat empat	m ^{4}

Tabel 6.C. Konversi dari satuan yang biasa di AS ke Satuan SI (lanjutan)

Satuan yang biasa di AS		**Faktor konversi pengali**		**Sama dengan Satuan SI**	
		Teliti	**Praktis**		
Daya					
kaki – pon per detik	kaki-lb/det	1.35582	1.36	watt	W
kaki – pon per menit	kaki-lb/menit	0.0225970	0.0226	watt	W
daya kuda					
(550 kaki – pon per detik) hp		745.701	746	watt	W
Tekanan ; tegangan					
pon per kaki kuadrat	lb/kak i^2	47.8803	47.9	pascal (N.m ^{2})	Pa
pon per inci kuadrat	lb/inci ^{2}	6894.76	6890	pascal	Pa
kip per kaki kuadrat	k/kak i^2	47.8803	47.9	kilopascal	kPa
kip per inci kuadrat	k/inci ^{2}	6894.76	6890	kilopascal	kPa
Modulus tumpang					
inci pangkat tiga	inci ^{3}	16.3871	16.400	millimeter pangkat tiga	mm ^{3}
inci pangkat tiga	inci ^{3}	16.3871 x 10 $^{-4}$	16.4 x 10 $^{-4}$	meter pangkat tiga	m ^{3}
Berat spesifik (kecepatan berat)					
pon per kaki kubik	lb/kaki ^{3}	157.087	157	newton per meter kubik	N/m ^{3}
pon per inci kubik	lb/inci ^{3}	271.447	271	kilonewton per meter kubik	kN/m ^{3}
Kecepatan					
kaki per detik	kaki/det	0.3048^0	0.305	meter per detik	m/det
inci per detik	inci/det	0.0254^0	0.0254	meter per detik	m/det
inci per jam	inci/det	0.44704^0	0.447	meter per detik	m/det
mil per jam	mil/jam	1.609344^0	1.61	milometer per jam	km/jam
Volume					
kaki kubik	kaki ^{3}	0.0283168	0.0283	meter kubik	m ^{3}
inci kubik	inci ^{3}	16.3871 x 10 $^{-4}$	16.4 x 10 $^{-4}$	meter kubik	m ^{3}
inci kubik	inci ^{3}	16.3871	16.4	sentimeter kubik	cm ^{3}
galon		3.78541	3.79	liter	L
galon		0.00378541	0.00379	meter kubik	m ^{3}

- *Faktor konversi yang pasti*

Catatan : Untuk mengkonversikan Satuan SI ke Satuan yang biasa di AS, bagilah dengan factor konversi

Lampiran 7

Dokumentasi Penelitian

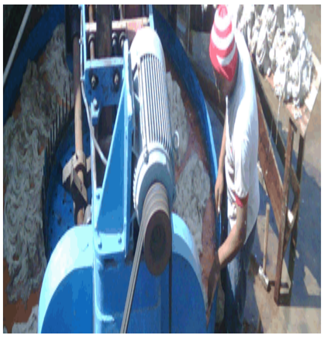


Tumbuhan / Tanaman Ramie (Boehmeria Nivea)

Mesin Pengolahan Rami

Mesin Pemisah Serat Ramie dengan Batangnya

Mesin Pembersih Ramie



Mesin Pemisah Ramie

Mesin Pelembut Serat Ramie

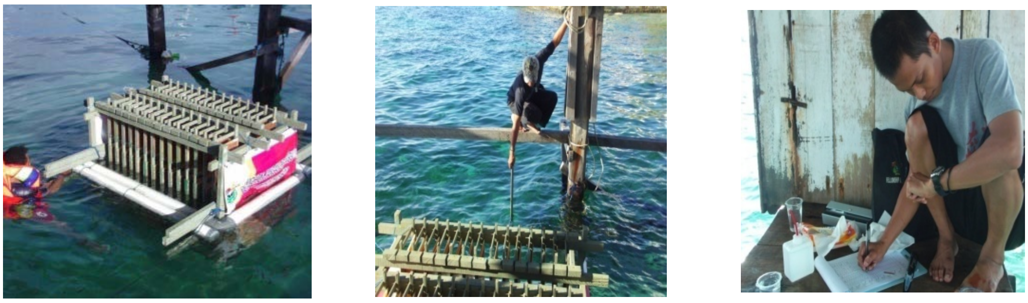
Mesin Cutting dan Opening

Serat ramie yang telah diproses Serat ramie menyerupai serat kapas dapat dipintal menjadi benang

Beberapa Benang Hasil Pengolahan Serat Ramie
Tekstil dari Ramie Peringkat No.2 setelah Sutera (Cotton nomor 7)

Lokasi Perendaman Materrial

Persiapan Perendaman Material



Pengambilan Data Lapangan

Penimbangan Material Komposit Tenunan Ramie

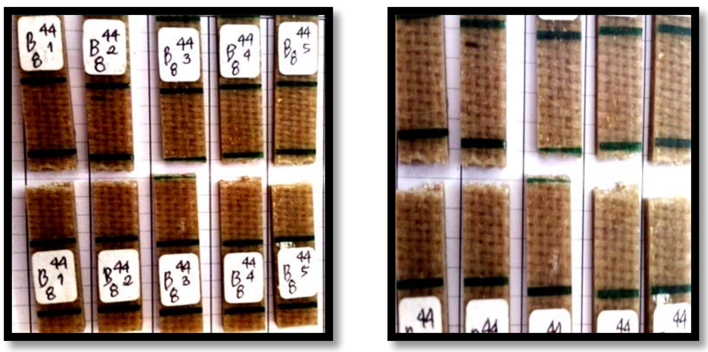
Pembuatan Spesimen Uji Lentur

Pengukuran Spesimen Uji Lentur

Spesimen Uji Lentur

Mesin Uji Lentur dan Pemasangan Spesimen Uji

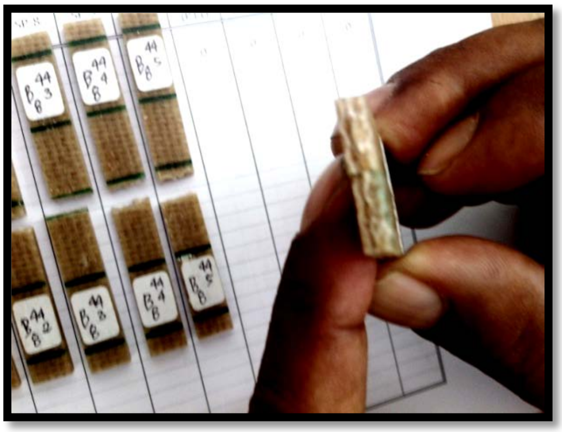
Pembacaan Hasil Pengujian Lentur



Spesimen setelah Uji Lentur

Patahan spesimen setelah Uji Lentur lama perendaman 28 hsri

Patahan spesimen setelah Uji Lentur lama perendaman 56 hari



Patahan spesimen setelah Uji Lentur lama perendaman 84 hari

MARINE STATION

Marine Station berlokasi di Pulau Barrang Lompo yang dapat ditempuh dengan Perahu Rakyat selama ± 45 menit dari Dermaga Kayu Bangkoang atau ± 15 menit dengan Speed Boat dari Dermaga POPSA.

Kegiatan yang dilakukan di Marine Station umumnya berhubungan dengan proses pembelajaran yaitu Praktikum dan Penelitian. Selain itu juga diadakan kursus singkat yang berhubungan dengan Teknik Selam, Inventarisasi Biota Laut dan Teknik-teknik Sumberdaya Laut untuk kepentingan Konservasi.

Untuk mendukung aktifitas di Marine Station, ada beberapa fasilitas yang dapat digunakan yaitu Hetchery dan peralatan selam. Selain itu terdapat Asrama Putra yang berkapasitas 48 tempat tidur, Asrama Putri yang berkapasitas 24 tempat tidur serta "Guest House" bagi para staf Unhas dan peneliti Luar Negeri. Asrama putra dan putrid juga sering digunakan untuk kepentingan masyarakat luar yang mengadakan training, musyawarah kerja dan lain-lain.