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CHAPTER THREE:
CONCRETE JOB CONTROL

Once the Contractor has an approved concrete mix design and the concrete plant has been approved for use on INDOT projects, the Contractor is ready to begin placement of the concrete mixture at the contract site. INDOT Specifications include several job control tests required for both the freshly mixed concrete and the hardened concrete. Several items need to be discussed to understand the complete process of accepting concrete on INDOT contracts.

The Technician is required to determine if the concrete plant has CAPP approved aggregates and approved cement, fly ash, and admixtures. The Technician also determines if all job control testing equipment has been calibrated and is in good working order. The sampling and testing methods required by the contract and the frequency of each test in accordance with the Frequency Manual should be reviewed.

MATERIALS

PCCP is normally constructed with paving concrete described in Section **500**. When high early strength pavement is required, additional cement may be added or high early strength cement may be used.

The proportions of materials vary with different types of concrete. Admixtures that affect the air content, water requirements, and the time required for the concrete to set may be required.

Concrete Mix Design (CMD) proportions are important to know before starting the paving operation. Concrete mix designs are the responsibility of the Contractor, both for QC/QA and non-QC/QA concrete. The Specifications give broad parameters for the Contractor to design an acceptable CMD. The design is reviewed and approved by INDOT. Some Specifications require the Contractor to conduct trial batch demonstrations prior to concrete pours on the contract. Mix designs for QC/QA contracts and concrete using fly ash or other pozzolans are examples of situations requiring trial batches. The Specifications should always be reviewed to determine if a trial batch is required. The PE/PS is required to have the CMD prior to placement of the concrete.

Paving concrete is basically composed of the following materials (Figure 3-1):

1) Fine aggregate, size No. 23 or gradation as identified in the QCP

2) Coarse aggregate, quality rating class AP, Size No. 8

3) Portland cement

4) Water

Additional materials that may be found in paving concrete are:

1) Fly Ash

2) Water-reducing admixture

3) Air-entraining admixture

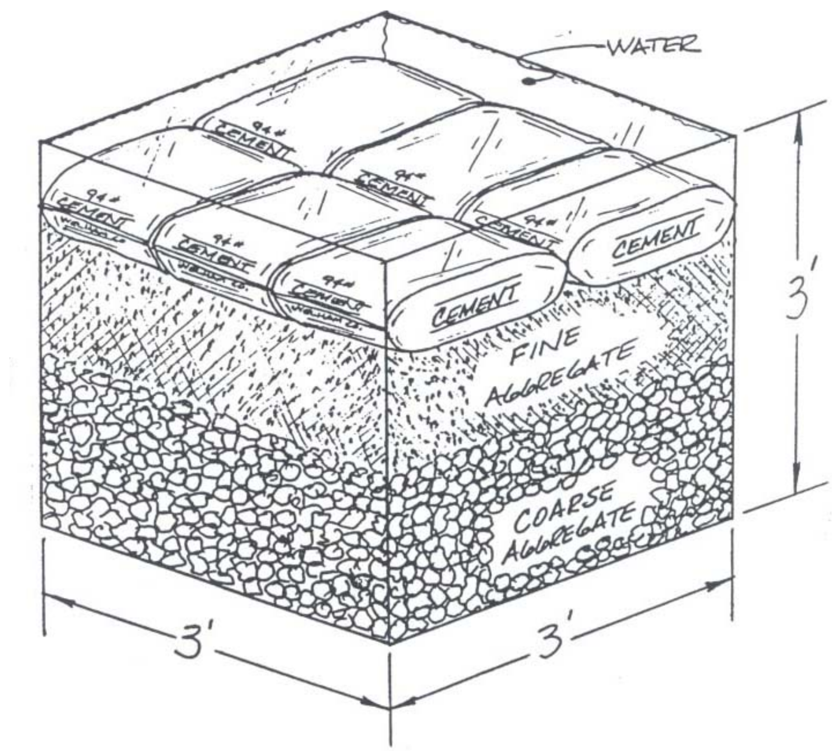


Figure 3-1. Concrete Materials

AGGREGATES

Two sizes of aggregates are used to produce paving concrete. Fine aggregate, size No. 23 natural sand and coarse aggregate size No. 8 crushed limestone, slag, or crushed/uncrushed gravel are used. The proportion of the aggregates is important to the integrity of the concrete and may affect the ultimate strength and the durability of the pavement. The fine aggregate is required to be 35 to 45% (35 to 50% for QC/QA) of the combined total weight of the coarse and fine aggregates (Figure 3-2).

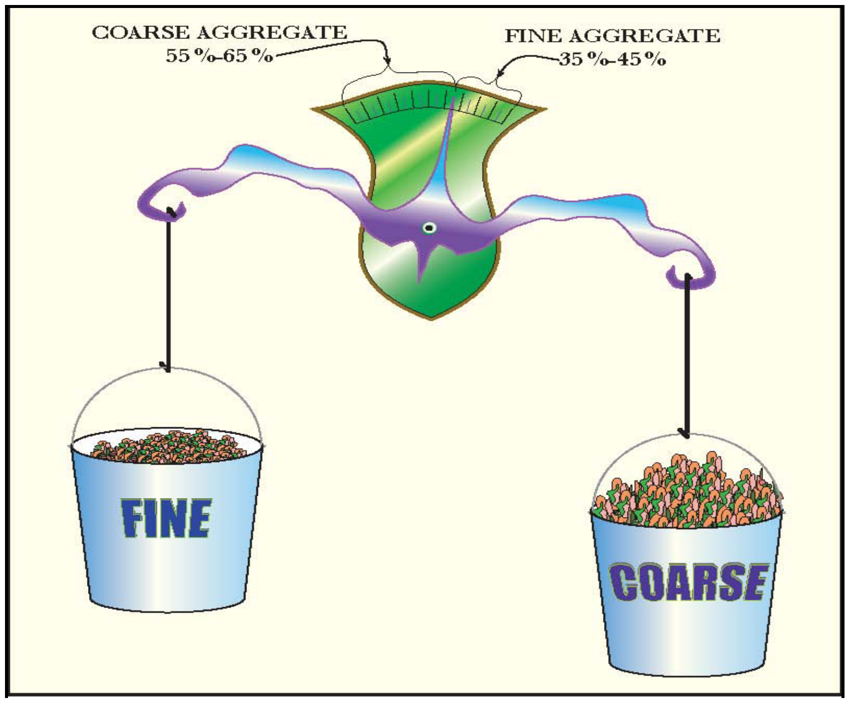


Figure 3-2. FA/CA Proportion

PORTLAND CEMENT

There are many different types of cement available for concrete. Only the following five are discussed:

1) Portland cement, Type I

2) Air-entrained Portland cement, Type I-A

3) Air-entrained Portland-pozzolan cement, Type IP-A

4) High early strength cement, Type III

5) Air-entrained high early strength cement, Type III-A

Under normal conditions Portland cement, Type I is used in paving concrete. Air-entrained Portland cement, Type I-A, is cement that has been entrained with air during the manufacturing process and requires less air-entraining agent to be added to obtain the required air content. Portland-pozzolan cement, Type IP is similar to Type I, except that the cement also contains a pozzolan, such as fly ash, to reduce the cost. Air-entrained Portland-pozzolan cement, Type IP-A is similar to Type I-A, except that this cement also contains a pozzolan. When Portland cement, Type IP-A is used, the fly ash specifications are also required. Portland cement, Type III obtains a high early strength. Portland cement, Type III-A is similar to Type III except that this cement contains entrained air from the manufacturing process.

Unless otherwise specified, each cubic yard of paving concrete contains 564 lbs (six bags) of cement. A yield test is conducted at the paving site as soon as the first load begins discharging. The results of this test determine the actual amount of cement in each cubic yard of concrete. If the cement content is determined to be high, the aggregate batch weights are required to be increased to lower the total cement content. If the cement content is too low, the aggregate batch weights are decreased to increase the cement content.

FLY ASH

Fly ash is a powdery by-product of coal fired electrical generating plants which has excellent structural properties like cement. The use of fly ash reduces the cost of concrete, but may extend the time needed to achieve the proper strength for opening the pavement to traffic. When fly ash is used, beams (Figure 3-3) are required to be made during each pour. The flexural strength of these beams is the only factor used to determine the opening of the pavement to traffic.

Figure 3-3. Flexural Concrete Beam

The two types of fly ash used in PCCP are Class C and Class F. Class C fly ash has better structural qualities than Class F and is therefore the preferred type of fly ash used. Generally, fly ash may be used between April 1 and October 15. Special permission is required to use fly ash outside of this time frame.

Fly ash may be substituted for up to 20 % of the cement used in paving concrete. Fly ash is replaced at 1.25 times the weight of the cement removed. The weight of the fly ash is added to the weight of the cement before the yield calculations are determined.

WATER

When water is added to the cement, the setting and curing process begins. In a central-mix plant this process occurs in the mixing drum, and in a transit mix this process occurs in the truck mixer. Only clean, potable water may be used. Contaminated water may contain materials which are detrimental to the concrete after placement.

After the water is added to the mix, the concrete is required to be placed within 90 minutes, if hauled in truck mixers or truck agitators. If the hauling vehicles have no agitators, this time is reduced to 30 minutes. The time the water is added to the concrete is stamped on the ticket at the concrete plant.

The amount of water added at the plant varies from day to day depending upon the moisture contents of the fine and coarse aggregates used. If an overnight rain has caused the stockpiled materials to become wetter than the day before, less water is required to be added at the plant. Materials exposed to hot, dry conditions for several days require more water to be added. The mixture is required to contain no more water than is necessary to produce a concrete that is workable, plastic, and meets the slump requirements; however, the water-cementitious ratio is required to meet the Specification limits at all times.

TESTING EQUIPMENT CALIBRATION

All concrete job-control testing equipment is required to be calibrated at the proper frequency. The calibration process includes sieves, electronic scales, air test equipment, slump equipment, thermometers, and equipment for determination of the unit weight of concrete. Flexural strength testing machines and compressive strength testing machines are required to be calibrated annually and after being moved. INDOT compressive strength testing machines are calibrated by companies under contract to INDOT.

Compressive strength and flexural strength testing machines used by the Contractor on QC/QA contracts and testing machines at precast concrete plants are required to also be calibrated. The calibrations of the equipment at these locations are the responsibility of the Contractor or the Supplier. Calibration documentation should be produced by the Contractor or Supplier for each testing machine and reviewed by INDOT personnel prior to the use of the testing machine for testing concrete for INDOT work.

The following documents should be reviewed for calibration:

1) **AASHTO T 152 -** Air Meter and Unit Weight Containers

2) **ITM 902 –** Sieves

3) **ITM 903 –** Ovens

4) **ITM 910 –** Electronic Balances

5) **ITM 911 -** Slump Cones

REFENCED DOCUMENTS

ITM and AASHTO test methods are used for concrete job control. INDOT Specifications contain several exceptions to the AASHTO test methods. If there are INDOT exceptions to AASHTO, then INDOT Specifications take precedent over AASHTO test methods. The AASHTO test methods and Section **505** should be reviewed for any corresponding exceptions. The Supplemental Specifications and/or Special Provisions of a contract may have additional or different exceptions than those found in Section **505**. All three documents should be reviewed prior to placing concrete on the contract.

SAFETY

Prolonged exposure of skin and tissue to the cement in concrete may be harmful. Therefore, plastic or latex gloves are recommended during the sampling and testing of concrete. Protective eye wear is also recommended because concrete may splatter during testing.

SAMPLING CONCRETE

AASHTO T 141 is the test method required for sampling freshly mixed concrete. An exception to this test method that INDOT allows is that the entire sample may be obtained from one portion of the load. Obtaining a representative sample of the concrete to be tested is important for assuring an accurate determination of the concrete properties. If any sample is improperly taken, then the test results are not acceptable. Representative material is important for samples taken by the Contractor for job control, samples taken by independent testing companies, and samples that are used to appeal INDOT test results. Although **AASHTO T 141** does not define the sampling container, other test methods are very specific on acceptable types of containers. A wheelbarrow meets the requirements of all the AASHTO test methods used for acceptance testing of concrete by INDOT and therefore is generally used as the sampling and mixing container.

INDOT test samples are obtained at the point of placement whenever possible. QC/QA PCCP samples are taken on the grade after the material has been placed by a material transfer machine, but before the concrete paver has distributed the mixture

INDOT allows two types of freshly mixed plastic concrete samples:

1) A composite sample consisting of two or more increments taken from the batch and mixed together in the sampling receptacle

2) One large increment taken from one portion of the load

The type of sample required is determined by the sampling technique method.

Regardless of where the sample is obtained, no more than 15 minutes should elapse between obtaining the first and final portions of the sample. Also, no sample is obtained before approximately 10 % of the load has been discharged or after approximately 90 % of the load has been discharged.

__SAMPLING FROM CONCRETE TRUCKS__

When sampling from a revolving drum truck mixer (transit-mix truck) or an agitator truck, the sample may be obtained by directing the chute to a wheelbarrow (Figure 3-4) or to a receptacle on the ground near the testing site. The sample is not obtained from the chute of the truck or from the discharge stream of the concrete when filling the receptacle.

Figure 3-4. Sampling from Truck

__SAMPLING FROM GRADE__

When sampled from the grade (Figure 3-5), the sample is taken before any machinery comes in contact with the concrete.

When the sample is obtained from a pile on the grade or the ground near the testing site, samples are taken from five different portions of the pile. The sample should not be contaminated with the base material.

After obtaining the concrete sample, all portions of the concrete are mixed together with a shovel the minimum amount necessary to obtain proper uniformity.

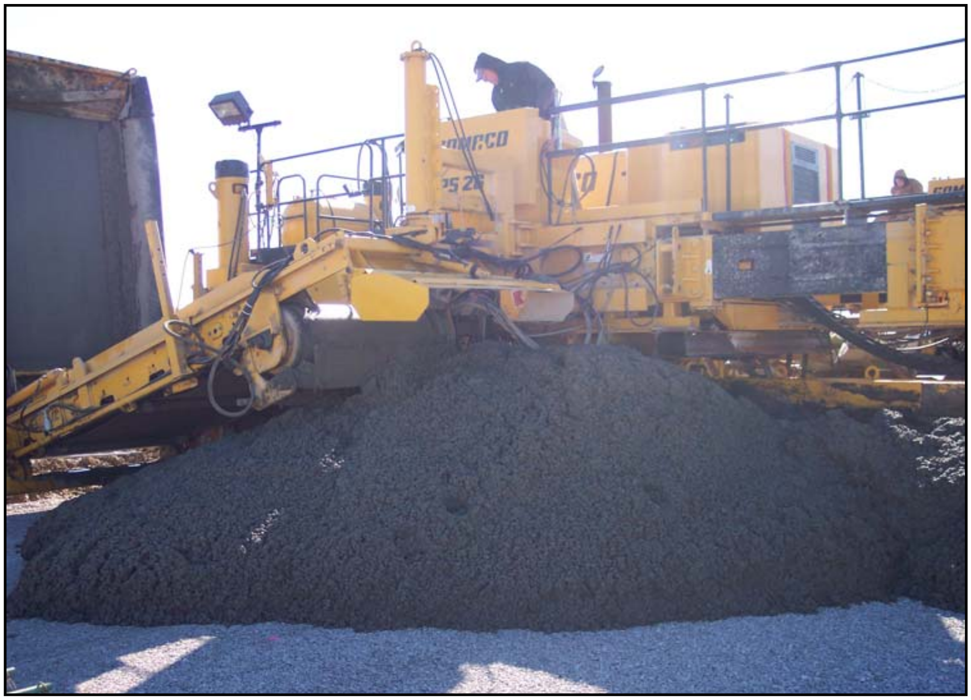


Figure 3-5. Sampling from Grade

SAMPLING FROM CENTRAL MIXED PLANTS

When a concrete sample is tested at a central mixed plant, such as would be required for a trial batch, the procedure for sampling the concrete is to have the plant discharge a load directly into the bucket of a loader (Figure 3-6).

Figure 3-6. Loading a Bucket

The loader bucket is cleaned ahead of time to minimize any possible contamination of the sample. The loader then transports the material to the testing location where the concrete is sampled (Figure 3-7).

Figure 3-7. Sampling from a Loader

After sampling the concrete, all portions are thoroughly mixed together with a shovel the amount necessary to obtain proper uniformity (Figure 3-8).

Figure 3-8. Mixing Sample

TESTING CONCRETE

PRESSURE METHOD FOR AIR CONTENT

AASHTO T 152 is the required test method for determining the air content of freshly mixed concrete by the Pressure method. An aggregate correction factor is required and is dependent on the source of the fine aggregate, the source and the ledges of the coarse aggregates, and the percentages of each used in the mix. The aggregate correction factor should therefore be checked each time one of these factors changes. An aggregate correction factor determination is required for each CMD.

Figure 3-9. Type B Air Meter

The initial pressure line of the air meter is meter specific and is checked and recorded with the annual calibration. Air meters are required to be verified in the field every three months. Part of this verification is to check the initial pressure line. The calibration forms and field verification forms should accompany each air meter. Form SM 652 is used for reporting results of air content tests.

VOLUMETRIC METHOD FOR AIR CONTENT

The volumetric method for air content (**AASHTO T 196**) is required by INDOT when lightweight aggregate such as air-cooled blast furnace slag is specified, but may be used on concrete containing any type of aggregate.

Figure 3-10. Volumetric Air Meter

UNIT WEIGHT AND RELATIVE YIELD

AASHTO T 121 is the test method required for determining the unit weight and relative yield of the freshly mixed concrete. Section **702.05** requires that the relative yield of the concrete be determined in accordance with Section **505** and that the yield be 1.00 ± 0.02. **AASHTO T 121** requires the use of a 24-inch tamping rod and **AASHTO T 152** requires only a 16-inch tamping rod. Since the unit weight and the air content are generally determined at the same time, a 24-inch tamping rod is used to meet the requirements of both methods. Form SM 652 is used for reporting the test results.

SLUMP

Figure 3-11. Slump Cone

AASHTO T 119 is the test method required for determining the slump of the concrete. Slump requirements vary in the Specifications depending on the method of placement and on the purpose of the concrete. General-purpose concrete requires a slump of 2 to 4 inches. Form SM 652 is used for reporting the test results.

MAKING AND CURING TEST SPECIMENS IN THE FIELD

AASHTO T 23 is the test method used for making and curing concrete test specimens in the field. This procedure includes the methods used for flexural strength beams

FLEXURAL STRENGTH

Figure 3-12. Flexural Strength Machine

AASHTO T 97 is the test method used for determining the flexural strength of concrete beams. This test consists of breaking the test beams on a self-recording beam breaker and calculating the flexural strength results. Sections **502.18**, **702.05**, and **702.13(h)** include the flexural strength requirements.

The Specifications require a minimum flexural strength for opening the pavement to traffic, to remove forms for bridges and retaining walls, and for other requirements as may be noted in the contract Special Provisions. Sections **502.18** and 7**02.24** include examples of the requirements of the flexural strength. The Frequency Manual should be reviewed for the sampling and testing frequency. Pages 3-15 and 3-16 include examples of a flexural beam chart and the factors necessary to determine the flexural strength.

WATER/CEMENTITIOUS RATIO

ITM 403 is used for determining the water/cementitious ratio of concrete. Representative sampling of the fine aggregate and the coarse aggregate for moisture content is critical to determine this value on the day of the concrete pour. If the moisture content of the aggregates changes (i.e. overnight rain), then the batch weights are required to be changed accordingly to maintain the proper proportions of materials to produce a cubic yard of concrete. The forms required to calculate the W/C ratio are:

1) SM 652 -- Yield, Slump, and Air Content Report
2) IT 628 -- Water/Cementitious Ratio Report
3) IT 571 -- Flexural Strength Report

Form SM 652 is used to report the results performed on the freshly mixed concrete. This form is to be completed daily and is the basis for acceptance of the concrete.

The W/C ratio calculation is determined on each class of concrete at least once per contract and is used to determine the amount of free water in the concrete batch. The free water is the total of all water added at the jobsite plus the water on the aggregates in excess of the amount of water required to satisfy the absorption of the fine and the coarse aggregates.

Free water is expressed in pounds of water per pound of cement and the ratio of the two is called the water to cementitious ratio. If pozzolans are included in the concrete mixture, then the weight of pozzolans is added to the cement weight for this calculation. A form in **ITM 403** is used to calculate the W/C ratio.

CURING CONCRETE

The proper curing method for concrete is essential during the early stages after the concrete is placed to allow the concrete to develop strength and durability. Proper curing is intended to allow the moisture in the concrete to evaporate slowly. Satisfactory curing is obtained by keeping the concrete cool and wet during the summer curing period and not allowing the concrete to freeze during the winter months. Sections **501.20**, **502.11**, **504.04** and **702.22** contain acceptable methods of protection from freezing and the proper curing methods.

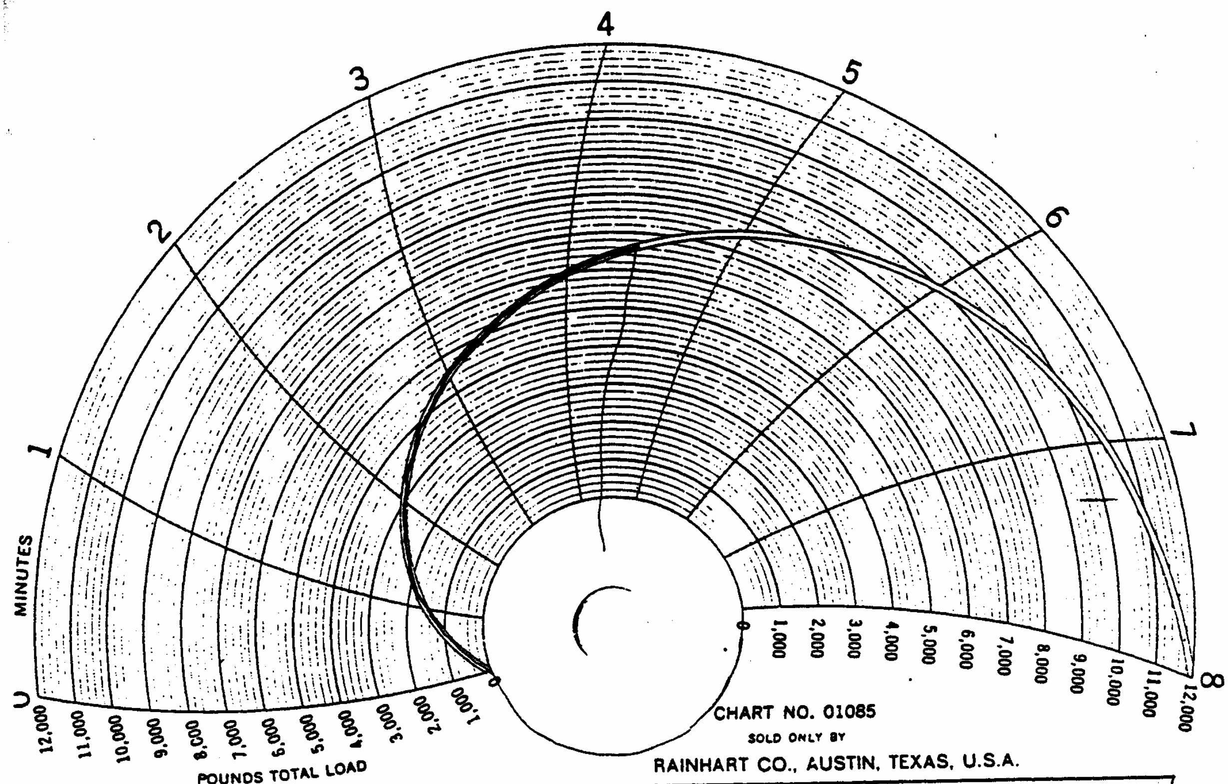
FAILED MATERIALS

Non-QC/QA concrete items require frequent job control tests for unit weight, air content, and slump. These test results are reported on form SM 652 and are taken during the placement of the concrete. Test results that are not within the Specification requirements require corrective action by the Contractor to bring the next series of tests into compliance. Changes in additive rates of admixtures, changes in the amount of water added, or changes in the batch weights of the aggregates may be necessary to bring the subsequent tests into compliance.

Failing tests of freshly mixed concrete are not necessarily reason for rejection or removal of that concrete from use in final products but may be reason to make batch weight adjustments. Adjustments are required to be documented on subsequent SM 652 reports along with passing values when the test results are brought into compliance. Test results not meeting the Specification requirements should be brought to the attention of the PE/PS or Area Engineer for possible action. Each failing test should be discussed with the PE/PS.

FORM I.T. 571A

State Form 21083



CONCRETE BEAM FLEXURAL STRENGTH TEST - A.S.T.M. PROCEDURE C78

CONTRACTOR *Slick & Slicker Co.* PROJECT ________

BEAM NO. *1* MADE *9-26-92* TESTED *9-29-92* AGE *3 days*

LOAD *6600* LBS., WIDTH *6* IN., DEPTH *6 1/16* IN., FACTOR *0.0816*

FLEXURAL STRENGTH *540* PSI., SPECIFICATION *550* PSI.

REMARKS *This strength does not meet the minimum strength required as per Section 501.21*

TESTING AGENCY *INDOT*

TESTED BY *R L Prehara*

CHECKED BY ________

PRINTED IN U.S.A.

100 RECORDING CHARTS No. 01085

FOR THIRD POINT LOADING TESTS UNDER A.S.T.M. C-78 OR A.A.S.H.O. T-97

WITH RAINHART PORTABLE RECORDING BEAM BREAKERS, SERIES 415

FACTORS FOR CALCULATING MODULUS OF RUPTURE(*)

Multiply maximum recorded load in pounds by applicable factor from below, providing the fracture occurs within the middle 6 inches of the 18 inches test span. (If outside the middle 6 inches, see A.S.T.M. C-78 or A.A.S.H.O. T-97 designations)

BEAM DEPTH IN INCHES (d)	BEAM WIDTH IN INCHES -(b)- 5 11/16	5 3/4	5 13/16	5 7/8	5 15/16	6	6 1/16	6 1/8	6 3/16	6 1/4	6 5/16
5 11/16	.0978	.0968	0957	.0947	.0937	.0927	.0918	.0908	.0899	.0890	.0881
5 3/4	.0957	.0947	.0937	.0927	.0917	.0907	.0898	.0889	.0880	.0871	.0862
5 13/16	.0937	.0927	.0917	.0907	.0897	.0888	.0879	.0870	.0861	0852	.0844
5 7/8	.0917	.0907	.0897	.0888	.0878	.0869	.0860	.0851	.0843	.0834	.0826
5 15/16	.0898	.0888	.0878	.0869	.0860	.0851	.0842	.0833	.0825	.0817	.0809
6	.0879	.0870	.0860	.0851	.0842	.0833	.0825	.0816	.0808	.0800	.0792
6 1/16	.0861	.0852	.0843	.0834	.0825	.0816	.0808	.0799	.0791	.0784	.0776
6 1/8	.0844	.0834	.0825	.0817	.0808	.0800	.0791	.0783	.0775	.0768	.0760
6 3/16	.0827	.0818	.0809	.0800	.0792	.0784	.0775	.0767	.0760	.0752	.0745
6 1/4	.0810	.0801	.0793	.0784	.0776	.0768	.0760	.0752	.0745	.0737	.0730
6 5/16	.0794	.0786	.0777	.0769	.0761	.0753	.0745	.0737	.0730	.0723	.0716

(*) FACTORS CALCULATED FROM A.S.T.M. C-78 AND A.A.S.H.O. T-97 DESIGNATIONS AS FOLLOWS:- $R = \frac{Pl}{bd^2}$ WHERE

R = modulus of rupture in pounds per square inch

P = maximum applied load indicated by pressure recorder in pounds

l = span length (18 inches)

b = average width of specimen in inches

d = average depth of specimen in inches

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