BLENDED AGGREGATE STUDY

Final Report

By

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Also, a very special thanks to Mr. R. S. Allen. Without his dedication to detail and tenacity in completing a rigorous testing schedule, this research could not have been accomplished.

ABSTRACT

Louisiana produces no naturally occurring skid resistant aggregate and, therefore, must import these aggregates at great expense.

In an effort to extend the yield of these aggregates, a laboratory investigation was initiated to determine the feasibility of blending these aggregates with aggregates of less skid quality while maintaining good skid resistance.

These evaluations were conducted by use of the Wessex Accelerated Polishing Machine and the British Portable Tester.

Laboratory results indicate that certain blends of aggregates are feasible.

IMPLEMENTATION STATEMENT

Laboratory results indicate additional research is required. The construction of field test sections of dense graded asphaltic concrete blends is necessary to determine if laboratory results can be duplicated in construction.

BACKGROUND

The Louisiana Department of Transportation and Development has been actively engaged in a program of reducing the skidding type of accident by the use of an "asphaltic concrete friction course" (A.C.F.C.). These friction courses consist of a thin, open-graded asphaltic overlay, incorporating a known skid resistant aggregate.

Currently, there are three major hindrances to the use of A.C.F.C., all are economic in nature. First, Louisiana produces no naturally occurring highly skid resistant aggregate; and, therefore, contractors must import these aggregates from other states at a much greater cost than local aggregate. Second, when the contractor's asphaltic concrete mixing plant is producing A.C.F.C., the contractor cannot supply standard mixes to other projects or other sub-contractors. This results in a cost to the contractor. Third, since A.C.F.C. is a thin overlay, the yield or the amount of area paved per ton is extremely large. Since the contractor's overhead to operate a plant is essentially the same whether the plant produces a great many tons of mix or just a few tons, this also results in a cost to the contractor. All of these increased costs are passed on to the Department when it specifies A.C.F.C. mixes.

With this in mind, it was the intention of this research study to ascertain the feasibility of blending highly skid resistant aggregates with locally available aggregates of lesser skid quality while still obtaining overlays with acceptable skid resistance. Such aggregate blends would then be used in dense graded asphaltic concrete wearing surfaces, thus reducing (possibly eliminating) the use of the very costly A.C.F.C. mixes.

RESEARCH EQUIPMENT

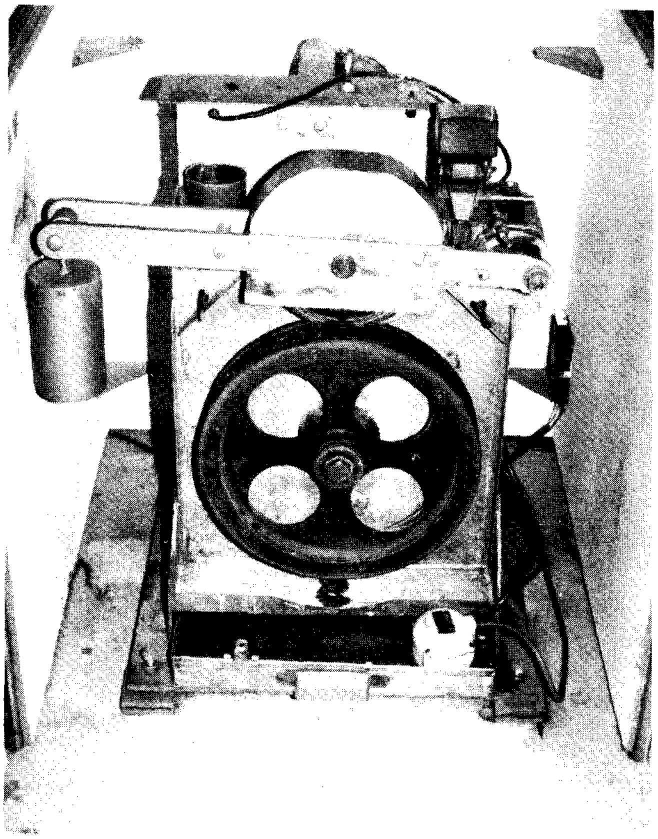
The evaluation of the individual aggregates as well as the various blends of aggregates was conducted by use of the test method referred to as "Accelerated Polish Test of Coarse Aggregate."

This procedure incorporates the use of two pieces of equipment: the Wessex Accelerated Polishing Machine and the British Portable Tester.

The Wessex Accelerated Polishing Machine, Figure 1, is an apparatus in which 14 coupons of test aggregate cast in a polyester resin, Figure 3, are mounted around the periphery of a steel wheel, Figure 4. A rubber tire wearing wheel is brought to bear against the aggregate surface on the steel wheel and the steel wheel is set into rotation. At the interface of the two wheels, silicon carbide grit and water are continuously fed at a constant rate for the entire nine-hour test period. A detailed description of the test procedure may be found in Appendix 1.

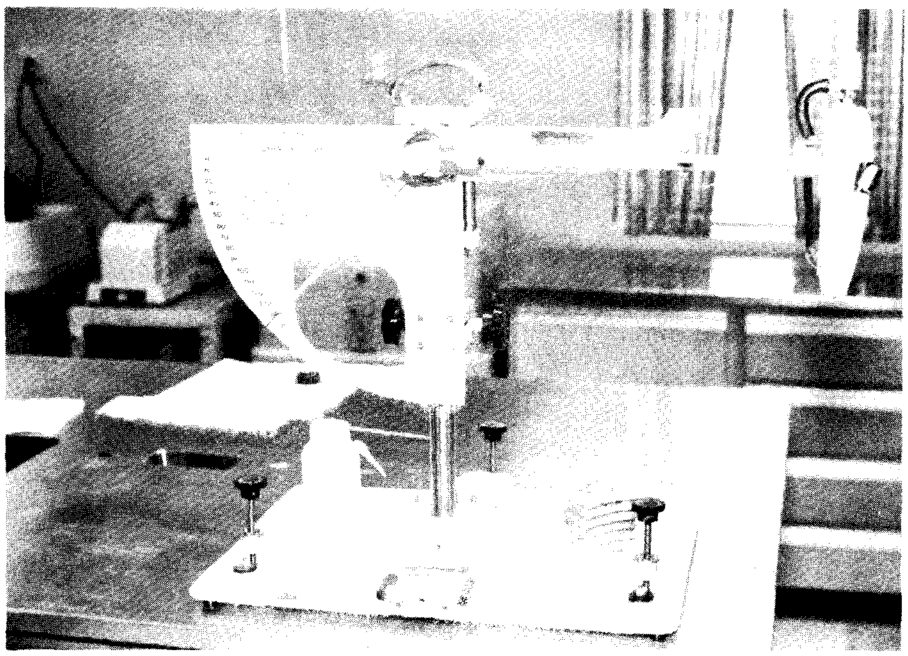
The British Portable Tester, Figure 2, is a pendulum-like device in which a spring-loaded rubber slider is caused to impact and slide across the wet surface of the individual test aggregate coupons. The loss of energy or the skid resistance of the aggregate is indicated on the scale of the tester. Prior to polishing, the measured values are recorded as Initial Friction Values and after polishing, as Polish Values. All these values were obtained in accordance with ASTM E303, a copy of which may be found in Appendix 2.

It should be noted that the Polish Value is a relative number and has no direct mathematical correlation to skid resistance measurements as determined by ASTM E-274. However, a relationship does exist in that aggregates that exhibit high Polish Values also give good performance as skid resistant aggregate.



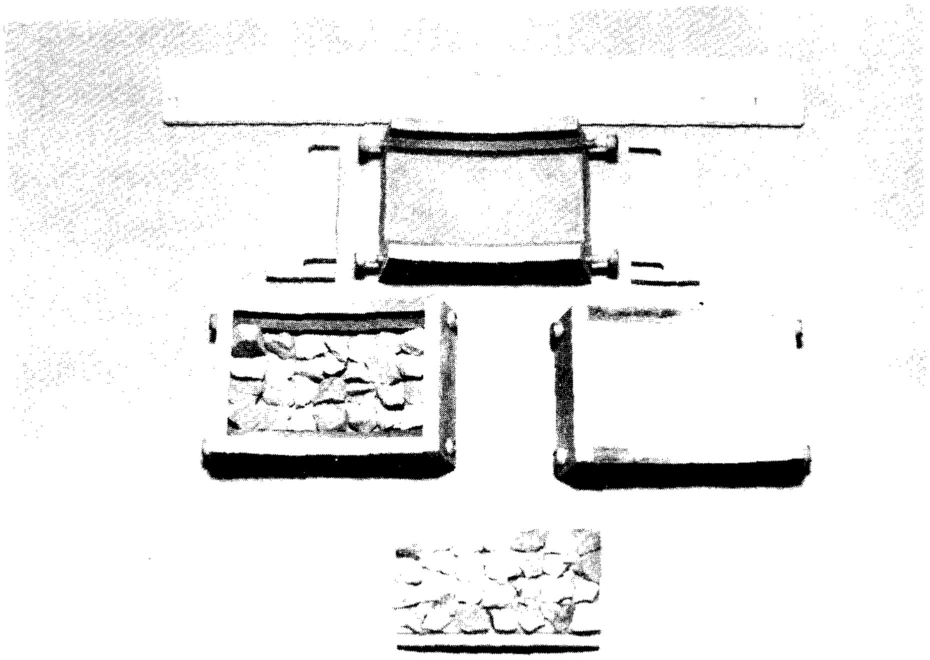
Wessex Accelerated Polishing Machine

FIGURE 1



British Portable Tester

FIGURE 2



Metal Molds with Test Coupons

FIGURE 3

Test Coupons Being Mounted on the Steel Wheel

FIGURE 4

METHODOLOGY

The aggregates used in this study were selected after the following two criteria were met: economic availability and past performance or known skid resistant properties.

As a result of applying these guidelines, the following aggregates were chosen: expanded clay aggregate; a blast furnace slag; rhyolite, a granitic type aggregate; novaculite, a dense, even-textured, siliceous material; tripolite, a highly porous siliceous aggregate; and a sandstone.

The other aggregates utilized in this study were those to be enhanced as regards to skid resistant properties. These were: indigenous chert* gravel in an uncrushed and crushed state and a dense limestone from an out-of-state source.

Before any attempt at blending of aggregates could be made, it was first necessary to determine the polish "history" of the individual aggregates under consideration. Therefore, several sets of coupons of the individual aggregates were cast and polished. It should be noted that one "set" is seven individual coupons.

The minimum number of coupons tested for any individual aggregate and for the subsequent blends of aggregate was 14, or two sets. However, if the polish values varied radically among the coupons within a set, or if the data between the two sets showed any major disparity, additional sets were tested.

The completion of this initial testing established the polish history, or an average polish value, for the aggregates. The results of this phase are shown in Table 1.

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*Chert is a "catch-all" term that covers a broad category of silicate minerals, such as flint, sard, etc.

TABLE 1

AVERAGE POLISH VALUES OF INDIVIDUAL AGGREGATES

Aggregate	P.V.
Uncrushed Chert*	26
Limestone	29
Crushed Chert*	32
Novaculite	37
Sandstone	38
Slag	38
Rhyolite	39
Expanded Clay	50
Tripolite	50

*Locally available aggregate.

The next step was to blend the various aggregates. Initially, the percentages of skid resistant aggregate to be blended were 25, 40, 60 and 75. However, after the first two sets were polished, it became obvious that the necessary data could be achieved with blends of 25, 50 and 75 percent.

ANALYSIS OF RESULTS

Before any analyses of the results can be undertaken, it is necessary to answer a question. What is the lowest Polish Value of any aggregate that will reflect good performance in asphaltic concrete?

As cited in the Acknowledgements of this report, the assistance of the Texas Department of Highways and Public Transportation, Division of Materials and Tests, has been beyond value. From their many years of experience, they have developed the following policy as shown in Table 2.

TABLE 2

MINIMUM ACCEPTABLE POLISH VALUES

Traffic Volume	Min. Acceptable P.V.
750 - 1500	30
1501 - 2500	32
2501 - 5000+	35
All Interstate	35

Since all the naturally occurring skid resistant aggregate must be imported into the state at a great cost and since the in-state manufactured aggregate is of comparable cost, it was decided, using the results of Table 1, that 35 would be the minimum acceptable Polish Value.

As the initial test results became available, this data was plotted with percent blend versus Polish Value and the curves drawn.

It became apparent after the first few sets of curves were plotted that the results were linear in nature (Figure 5). Therefore, in order to more accurately draw the curves, all the data was subjected to mathematical linear regression. In addition to the linear regression, the slope of the straightline curve and the correlation of the curve to the theoretical curve were noted on each graph of the various blends. These graphs of the individual blends are located in Appendix 3.

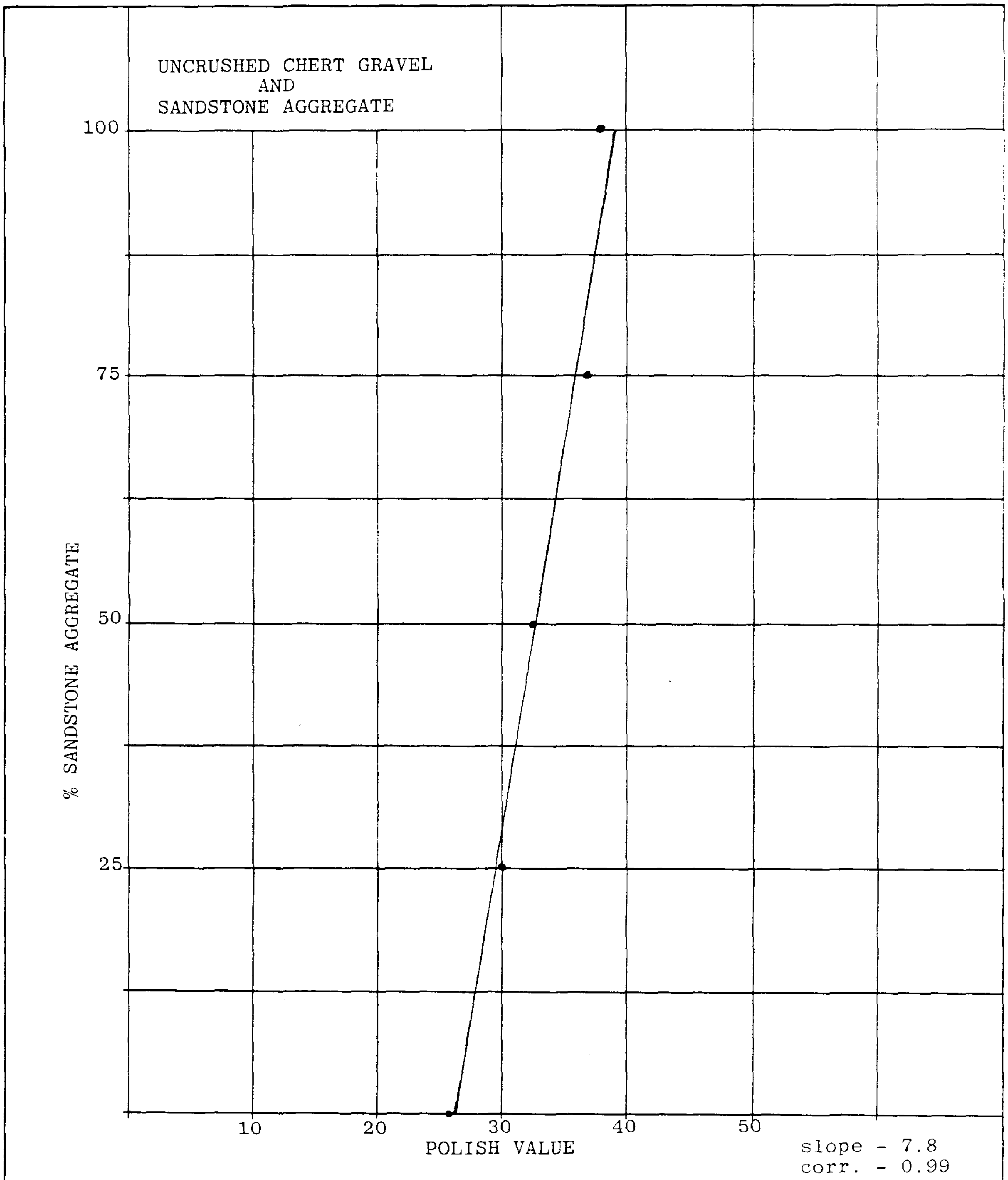
A series of blends was conducted on uncrushed chert gravel, then limestone and crushed chert gravel. The results of this testing are recapitulated in the following table:

TABLE 3

PERCENT OF ENHANCING AGGREGATE
NECESSARY TO ACHIEVE A MINIMUM PV OF 35

	Uncrushed Chert Gravel	Crushed Chert Gravel	Limestone
Expanded Clay	49	20	40
Novaculite	89	66	87
Rhyolite	77	38	67
Sandstone	67	33	59
Slag	79	56	86
Tripolite	43	10	32

Initial perusal of this data was somewhat disappointing. The percentages of skid resistant aggregate necessary to achieve the minimum required PV, in most cases, exceeded the anticipated percentage of 50 or less.



Typical Plot of Test Data

FIGURE 5

In the instances where the percentages were less than 50, some caution must be applied. These lower percentages may be due to differential wear of the aggregates blended. This is especially true in the use of expanded clay and tripolite.

The mechanics of differential wear is due to a disparity in the hardness of the aggregates blended. As an example, the blending of expanded clay with uncrushed chert gravel resulted in the softer expanded clay aggregate being abraded away at a greater rate than the much harder chert aggregate. This, in turn, left the uncrushed chert "perched" or having a much higher profile than the expanded clay.

Differential wear may be of benefit in regard to crushed chert gravel in that it might result in leaving the sharp edges of the aggregate more exposed, thus providing better skid resistance. However, in the case of uncrushed chert gravel and limestone, where there are no sharp edges, differential wear might result in just the opposite effect.

Another aspect to be considered in differential wear is the relative strength of the softer aggregate. As the harder aggregate becomes more exposed, it would be subjected to greater impact from traffic. It is unknown whether the softer aggregates could provide sufficient strength to prevent the perched aggregate from ravelling out of the mix.

CONCLUSIONS

The enhancement of uncrushed chert gravel by blending of aggregates does not seem practical. Allowing for those few percentages less than 50 percent due to differential wear, the percent of aggregate required to achieve the minimum PV is such that it would be almost as economical to design with 100 percent quality aggregate.

In addition to the high percentages, there is some doubt as to the ability of asphaltic concrete to achieve the necessary strengths or stabilities with blends of uncrushed chert gravel.

The blends with limestone, in most cases, are almost as high as those in uncrushed chert gravel, the exceptions being those blends made with sandstone and tripolite.

However, the data on the blends with crushed chert gravel indicates that it might be economically possible to achieve skid resistance by blending, particularly blends of rhyolite and sandstone.

RECOMMENDATIONS

Based on the data derived in this study, it is recommended that research be initiated into dense graded asphaltic concrete mix design and the subsequent construction of highway test sections, using crushed chert gravel blends.

APPENDIX 1

METHOD OF TEST FOR ACCELERATED POLISH OF COARSE AGGREGATE

METHOD OF TEST FOR
ACCELERATED POLISH OF COARSE AGGREGATE
DOTD DESIGNATION: TR 116

Scope

1. This test method describes a procedure for determining a relative measure of the extent to which aggregate in the wearing surface of the roadway will polish under traffic.

Definitions

2. (a) Initial friction value: The average of a set of initial readings on the test specimens before they are polished in the accelerated polishing machine.

(b) Polish value: The average of a set of readings on the test specimens after nine hours of polishing in the accelerated polishing machine.

Apparatus

3. (a) Wessex accelerated polishing machine based on a 1958 design by the Transport and Road Research Laboratory of Great Britain. It shall be mounted on a firm, level and non-resilient base of stone or concrete and shall include a cylindrical wheel having a flat-surface periphery and of such size and shape as to permit 14 specimens to be clamped onto the periphery to form a continuous surface of aggregate particles, 1.75 in. (44.45 mm) wide and 49 in. (1244.6 mm) in circumference, and a means of bringing the surface of a rubber-tired wheel 8 in. (203.2 mm) in diameter and 2 in. (50.8 mm) wide to bear on the aggregate specimens with a total load of 88 ± 1 lbf (391.44 ± 4.45 N).

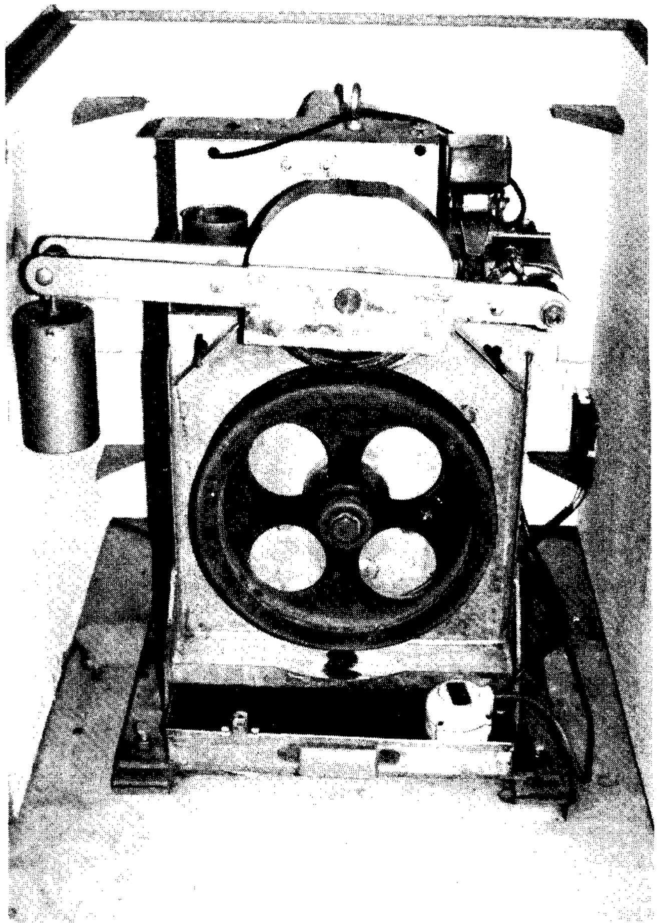


Figure 1

Wessex Accelerated Polishing Machine Showing Test Specimens Mounted on Specimen Wheel

(b) Metal molds - A number of accurately machined metal molds for preparing test specimens 3.50 in. (88.90 mm) long by 1.75 in. (44.45 mm) wide by 0.63 in. (16.0 mm) deep, and curved in the arc of a circle 16 in. (406.4 mm) in diameter.

(c) British Portable Tester for measuring the initial friction value and the polish value of the test specimens. The pendulum with slider and slider mount shall conform to Section 2 of ASTM E 303.

(d) Polyester resin and catalyst for bonding agent with a pot life of approximately 10 minutes and a curing time of 3 to 6 hours.

(e) Liquid, silicon base, mold release agent for use with polyester bonding agent.

(f) Silicon carbide grit (150 size).

(g) Supply of disposable cups and spatula or stirring rods for use in mixing the bonding agent.

(h) Tap water.

Sample

4. One full sample sack.

Preparation of Test Specimens

5. Seven specimens are required for each material and are to be prepared as follows:

(a) The aggregate to be tested shall pass the 1/2 in. (12.5 mm) sieve and be retained on the No. 4 (4.75 mm) sieve.

(b) The screened aggregate shall be thoroughly washed clean and dried.

(c) The molds shall be coated with the mold release agent.

(d) The aggregate particles shall be placed in the mold as a single layer as closely as possible. Aggregate particle orientation should allow an adequate surface area for polishing as well as bonding.

Note: When possible, use of flat, elongated and odd-shaped particles should be avoided. Generally they will cause difficulty in placement and will result in erratic polish values.

(e) Prepare the polyester resin and catalyst for bonding agent according to manufacturer's instructions. The consistency of the polyester shall be such as to allow it to spread onto and between the particles, but not so thin that it flows onto the curved mold surface.

(f) Fill prepared mold to capacity with the polyester bonding agent.

(g) Strike off the bonding agent level with the curved sides of the mold.

(h) Leave specimen in the mold for a sufficient length of time (3 to 6 hours) to allow the bonding agent to cure properly.

(i) Remove specimen from the mold.

(j) Dress the bottom side of the test specimens with belt sander if warping prevents proper placement on the polishing wheel or British Portable Tester base plate.

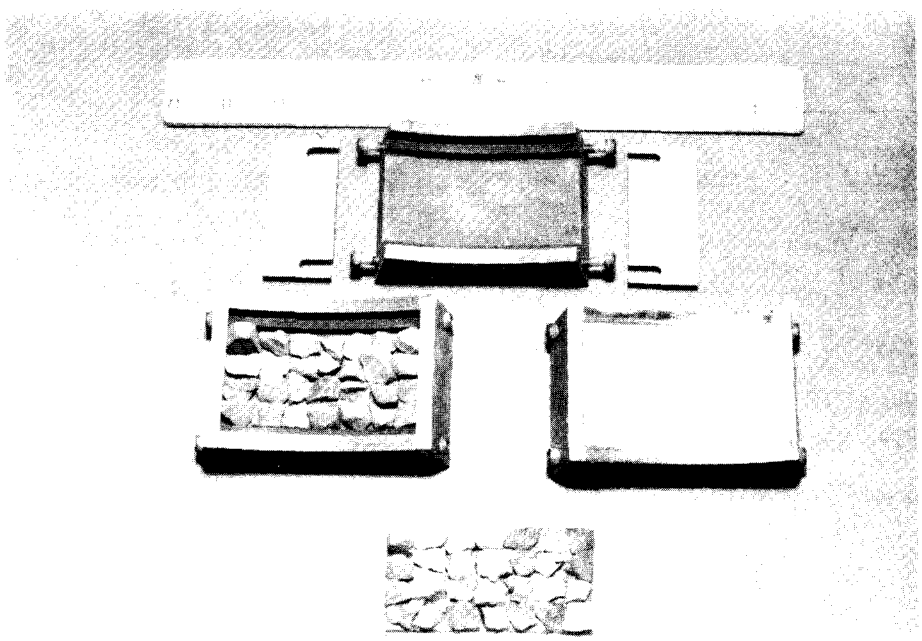


Figure 2

Metal Molds with Test Specimens

Procedure

6. (a) Calibrate the British Portable Tester in accordance with ASTM Designation: E 303, Measuring Surface Frictional Properties Using the British Portable Tester.

   (b) Determine the initial friction value of the prepared test specimens in accordance with ASTM E 303. The initial friction value is used for reference purposes. The test temperature shall be 22.2 ± 0.6 C (72 ± 2F).

   (c) A total of 14 specimens shall be clamped around the periphery of the specimen wheel of the Wessex accelerated polishing machine. A rubber O-ring is placed on both edges of the test specimens to hold them against the specimen wheel. The wheel flanges are then bolted into place pressing down upon the O-rings and edges of the specimens firmly holding them in place. A minimum of seven specimens of each material shall be tested at 22.2 ± 0.6 C (72 ± 2 F) to increase statistical accuracy. Dummy specimens may be used to fill the wheel completely if only one material is to be tested. The outer surfaces of the specimens shall then form a continuous strip of particles upon which the rubber tire shall ride freely without bumping or slipping.

   (d) The specimen wheel shall be brought to a speed of 320 ± 5 rpm. The rubber tire wearing wheel, inflated to 45 ± 2 psi (310.26 ± 13.79 kPa), shall be brought to bear against the specimen wheel and loaded to 88 ± 1 lbf (391.44 ± 4.45 N).

   (e) Silicon carbide grit (size 150) shall be continuously fed to the specimen wheel near the tire contact point at a continuous rate of 6 ± 2 grams per minute along with water fed at the rate of approximately 50 to 75 millilitres per minute.

(f) The polishing action shall be continued for a total period of nine hours. Downtime does not affect test results.

(g) The samples shall be removed from the specimen wheel and washed thoroughly to remove grit.

(h) After cleaning, the samples shall be tested for polish value with the British Portable Tester in accordance with ASTM E 303.

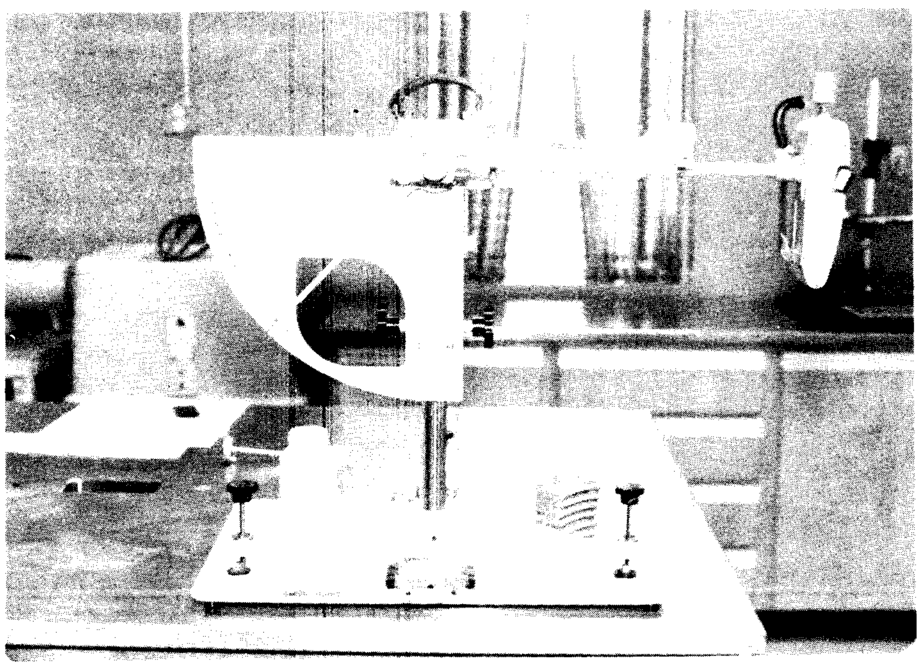


Figure 3

British Portable Tester

Report

7. The polish value shall be reported to the nearest whole number.

Normal testing time is 3 days.

APPENDIX 2

ASTM DESIGNATION E 303

STANDARD METHOD OF TEST FOR MEASURING SURFACE FRICTIONAL PROPERTIES USING THE BRITISH PORTABLE TESTER

Designation: E 303 – 74

Standard Method of Test for
MEASURING SURFACE FRICTIONAL PROPERTIES USING THE BRITISH PORTABLE TESTER[1]

This Standard is issued under the fixed designation E 303; 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.

1. Scope

1.1 This method covers the procedure for measuring surface frictional properties using the British Portable Skid Resistance Tester.[2] A method for calibration of the tester is included in the Annex.

1.2 The Bristish Portable Tester is a dynamic pendulum impact-type tester used to measure the energy loss when a rubber slider edge is propelled over a test surface. The tester is suited for laboratory as well as field tests on flat surfaces, and for polish value measurements on curved laboratory specimens from accelerated polishing-wheel tests.

1.3 The values measured, BPN = British Portable (Tester) Number for flat surfaces and polish values for accelerated polishing-wheel specimens, represent the frictional properties obtained with the apparatus and the procedures stated herein and do not necessarily agree or correlate with other slipperiness measuring equipment.

NOTE 1—BPN and polish values from similar types of surfaces will not be numerically equal, primarily because of the differences in slide length and surface shape. Theoretical correction of the polish values to obtain numerical equality, either by mathematical manipulation or by use of special measuring scales is not recommended.

2. Apparatus

2.1 *British Portable Tester* (*Fig. 1*)—The pendulum with slider and slider mount shall weigh 1500 ± 30 g. The distance of the center of gravity of the pendulum from the center of oscillation shall be 16.2 ± 0.2 in. (411 ± 5 mm). The tester shall be capable of vertical adjustment to provide a slider contact path of $4\frac{15}{16}$ ± $\frac{1}{16}$ in. (125 ± 1.6 mm) for tests on flat surfaces, and 3 ± $\frac{1}{16}$ in. (75 to 78 mm) for tests on polishing-wheel specimens. The spring and lever arrangement shown in Fig. 2 shall given an average normal slider load between the 3-in. (76.2-mm) wide slider and test surface of 2500 ± 100 g as measured by the method prescribed in the Annex.

2.2 *Slider*—The slider assembly shall consist of an aluminum backing plate to which is bonded a $\frac{1}{4}$ by 1 by 3-in. (6 by 25 by 75-mm) rubber strip for testing flat surfaces or a $\frac{1}{4}$ by 1 by $1\frac{1}{4}$-in. (6.35 by 25.4 by 31.8-mm) rubber strip for testing curved polishing-wheel specimens. The rubber compound shall be natural rubber meeting the requirements of the Road Research Laboratory[2] or synthetic rubber as specified in ASTM Specification E 501, for Standard Tire for Pavement Skid-Resistance Tests.[3]

2.2.1 New sliders shall be conditioned prior to use by making ten swings on No. 60 grade silicon carbide cloth[4] or equivalent under dry

[1] This method is under the jurisdiction of ASTM Committee E-17 on Skid Resistance and is the direct responsibility of Subcommittee E17.23 on Surface Characteristics.

Current edition approved Jan. 28, 1974. Published March 1974. Originally published as E 303 – 61 T. Last previous edition E 303 – 69.

[2] Giles, C. G. Sabey, Barbara E., and Carden, K. W. F., "Development and Performance of Portable Skid-Resistance Tester," *Road Research Technical Paper No. 66*, Road Research Laboratory, Dept. of Scientific and Industrial Research, England, 1964.

Kummer, H. W. and Moore, D. F. "Concept and Use of the British Portable Skid-Resistance Tester," *Report No. 6*, PDH-PSV Joint Road Friction Program, Dept. of Mechanical Engineering, The Pennsylvania State University, State College, Pa. 16802, June 1963.

[3] *Annual Book of ASTM Standards*, Part 15.

[4] Material known to be suitable for this purpose is available from 3 M Co., St. Paul, Minn., under the trade name of Type B Safety-Walk.

conditions. The swings shall be made with a tester adjusted as in Section 4.

2.2.2 Wear on the striking edge of the slider shall not exceed 1/8 in (3.2 mm) in the plane of the slider or 1/16 in. (1.6 mm) vertical to it, as illustrated in Fig. 3.

2.3 *Accessories:*

2.3.1 Contact path gage shall consist of a thin ruler suitably marked for measuring contact path length between 4 7/8 and 5.0 in. (124 and 127 mm) or between 2 15/16 and 3 1/16 in. (75 and 78 mm) as required for the particular test.

2.3.2 Miscellaneous equipment, such as water container, surface thermometer, and brush is recommended.

3. Test Specimen

3.1 *Field*—Field test surfaces shall be free of loose particles and flushed with clean water. The test surface does not have to be horizontal provided the instrument can be leveled in working position using only the leveling screws and the pendulum head will clear the surface.

3.2 *Laboratory*—Laboratory test panels shall be clean and free of loose particles and shall be held rigidly so as not to be moved by the force of the pendulum.

3.2.1 Flat laboratory test panels shall have a test surface of at least 3 1/2 by 6 in. (90 by 150 mm).

3.2.2 Accelerated laboratory polishing-wheel specimens shall have a test surface of at least 1 3/4 by 3 1/2 in. (45 by 90 mm) and shall be curved in the arc of a circle 16 in. (406 mm) in diameter.

4. Preparation of Apparatus

4.1 *Leveling*—Level the instrument accurately by turning leveling screws until the bubble is centered in the spirit level.

4.2 *Zero Adjustment*—Raise pendulum mechanism by loosening locking knob (directly behind pendulum pivot) and turn either of pair of head movement knobs at center of tester to allow slider to swing free of test surface. Tighten locking knob firmly. Place pendulum in release position and rotate the drag pointer counter clockwise until it comes to rest against adjustment screw on pendulum arm. Release pendulum and note pointer reading. If reading is not zero, loosen locking ring and rotate friction ring on bearing spindle slightly and lock again. Repeat test and adjust friction ring until the pendulum swing carries pointer to zero.

4.3 *Slide Length Adjustment:*

4.3.1 With pendulum hanging free, place spacer under adjusting screw of lifting handle. Lower pendulum so edge of slider just touches surface. Lock pendulum head firmly, raise lifting handle, and remove spacer.

4.3.2 Raise slider by lifting handle, move pendulum to right lower slider, and allow pendulum to move slowly to the left until edge of slider touches surface. Place gage beside slider and parallel to direction of swing to verify length of contact path. Raise slider, using lifting handle, and move pendulum to left, then slowly lower until slider edge again comes to rest on surface. If the length of the contact path is not between 4 7/8 and 5.0 in. (124 and 127 mm) on flat test specimens or between 2 15/16 and 3 1/16 in. (75 and 78 mm) on curved polishing-wheel specimens, measured from trailing edge to trailing edge of the rubber slide, adjust by raising or lowering instrument with the front leveling screws. Readjust level of instrument if necessary. Place pendulum in release position and rotate the drag pointer counter-clockwise until it comes to rest against adjustment screw on pendulum arm.

5. Procedure

5.1 Apply sufficient water to cover the test area thoroughly. Execute one swing, but do not record reading.

NOTE 2—Always catch the pendulum during the early portion of its return swing. While returning the pendulum to its starting position, raise the slider with its lifting handle to prevent contact between the slider and the test surface. Prior to each swing, the pointer should be returned until it rests against the adjustment screw.

5.2 Without delay, make four more swings, rewetting the test area each time and record the results.

5.3 Recheck the slide contact length in accordance with 4.3.

6. Report

6.1 The report shall include the following:

6.1.1 Individual values in BPN or polish value units,

6.1.2 Temperature of the test surface,

6.1.3 Type, age, condition, texture and location of test surface, 6.1.4 Type and source of aggregate for polish value tests, and

6.1.5 Type and age of the rubber slider.

7. Precision and Accuracy

NOTE 3—The following material pertains only to the precision and accuracy of BPN units.

7.1 Repeated tests show standard deviations as follows:

British rubber sliders	1.0 BPN unit
Rubber sliders (conforming to ASTM Specification E 501)	1.2 BPN units

In both cases the upper quartile of variability is represented in prevailing test instruments. As there is no marked correlation between standard deviation and arithmetic mean of sets of test values, it appears that standard deviations are pertinent to this test regardless of the average skid resistance being tested.

7.2 The relationship, if any exists, of observed BPN units to some "true" value of skid resistance has not and probably cannot be studied. As a result, precision and accuracy of this test in relation to a true skid resistance measure cannot be evaluated, and only repeatability is given for the method.

7.3 Determine the testing error as follows:

$$E = t\sigma n^{-1/2}$$

where:

E = testing error,
t = normal curve of 1.96 or 2.0 rounded,
σ = standard deviation of individual test results (BPN units), and
n = number of tests

7.4 In order to assure that the testing error stays within 1.0 BPN unit at a 95% confidence level (corresponding to a normal curve of 1.96 or 2.0 rounded), the following sample sizes are needed:

British natural rubber sliders	4
Synthetic rubber sliders (conforming to ASTM Specification E 501)	5

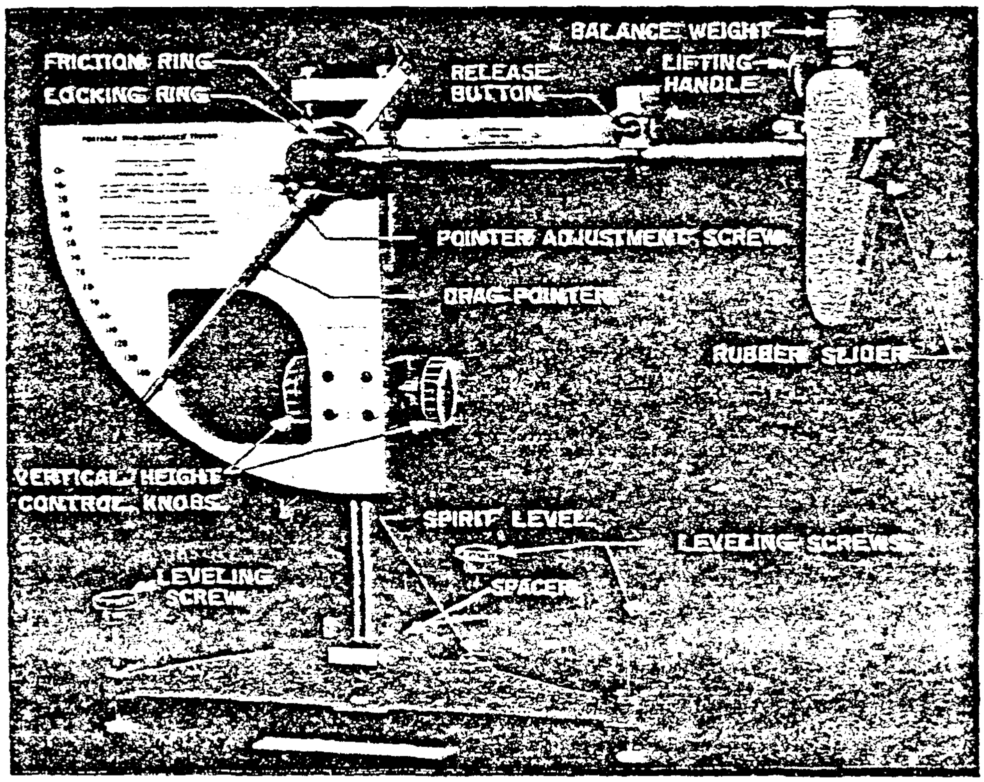


FIG. 1 British Portable Tester.

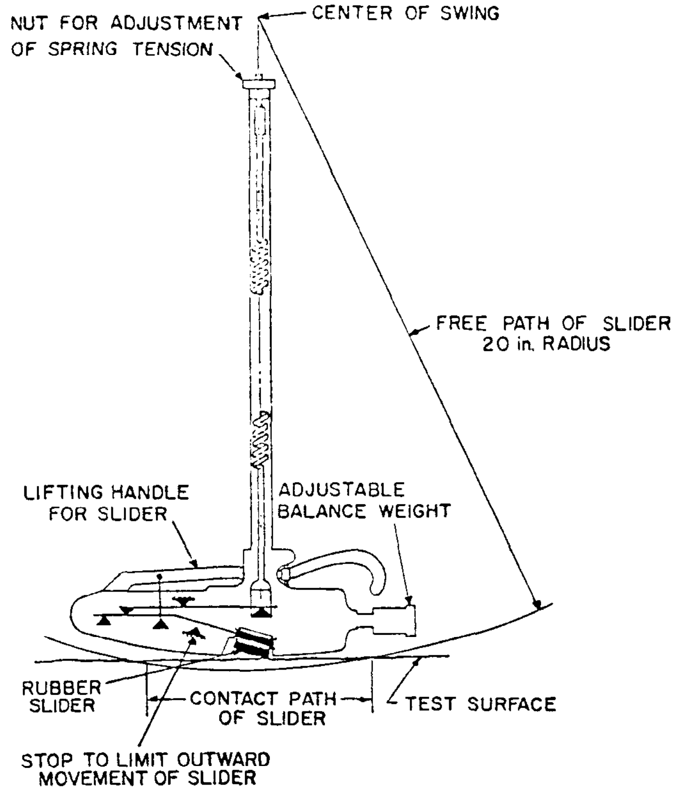


FIG. 2 Schematic Drawing of Pendulum Showing Spring and Lever Arrangement.

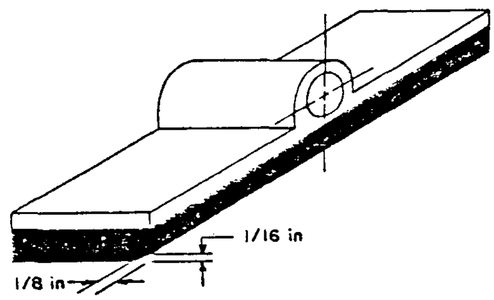


FIG. 3 Slider Assembly Illustrating the Maximum Wear on Striking Edge.

ANNEX

A1. CALIBRATION

A1.1 *Weight of Pendulum*—The pendulum arm with mounted rubber slider shall be disconnected from the instrument and weighed to the nearest 1 g.

A1.2 *Center of Gravity*—The center of gravity of the pendulum with a mounted rubber slider shall be determined by placing the pendulum assembly over a knife edge and experimentally locating the point of balance as shown in Fig. A1. The adapter nut shall be held at the far end of the arm by a light paper wedge. After the point of balance has been obtained, the position of the balance weight shall be adjusted until the sides of the pendulum foot are horizontal.

A1.3 *Distance of Center of Gravity from Center of Oscillation*—With the pendulum reconnected to the tester and knurled bearing cap removed, distance shall be measured from the center of oscillation (center of bearing nut) to the point of balance (center of gravity). This distance shall be measured directly to the nearest 0.04 in. (1 mm).

A1.4 *Slider Load*—The pendulum shall be clamped to a holder attached to the scale plate of the tester and the tester placed and leveled on a tripod stand as shown in Fig. A2. Insert the spacer. Adjust the pan balance with a bearing assembly (Note A1) on one pan and tare weights on the other pan so that the balance pointer is at center scale reading. The pendulum, with a slider, shall be lowered with the vertical height knobs of the tester until the slider is approximately 0.01 in. (0.25 mm) from the top surface of the bearing assembly. Lock vertical height knob and remove the spacer. This will cause an unbalance which shall be partially compensated by adding weights to the opposite pan to bring the indicator to within approximately 200 g of the center scale reading. To complete the balance procedure, the pointer is returned to the center scale reading, by adding water slowly into a graduated cylinder. Empty the cylinder and repeat pouring. Record the average weight required to raise slider so that the balance pointer is at the center of scale (Note A2). If the average, normal slider load between the 3-in. (76.2-mm) wide slider and the pan balance is not within the requirements stated in 2.1.1 adjust the spring tension nut illustrated in Fig. 2 and redetermine the slider load.

NOTE A1—The bearing assembly may be a "ladder" bearing with a rigid, free-moving top plate or a similar arrangement so that no horizontal loads are introduced while measuring the vertical slider load.

NOTE A2—It may be necessary to move the pans of the balance up and down to "work" the spring in order to get smooth and consistent readings. If the measurements of the slider load are still irregular after "working" the spring, remove the side and bottom panels of the pendulum foot and inspect for cleanliness of the bearing surfaces and knife edges illustrated in Fig. 2 and redetermine the slider load.

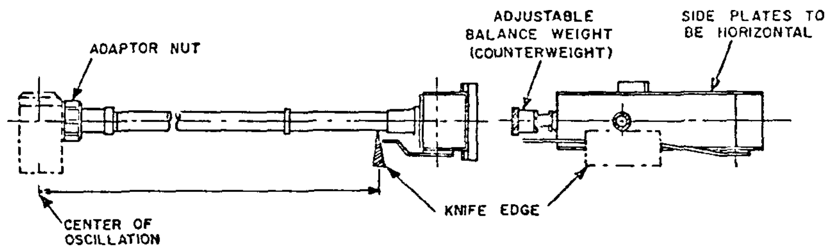


FIG. A1 Pendulum Assembly Showing Location of the Point of Balance.

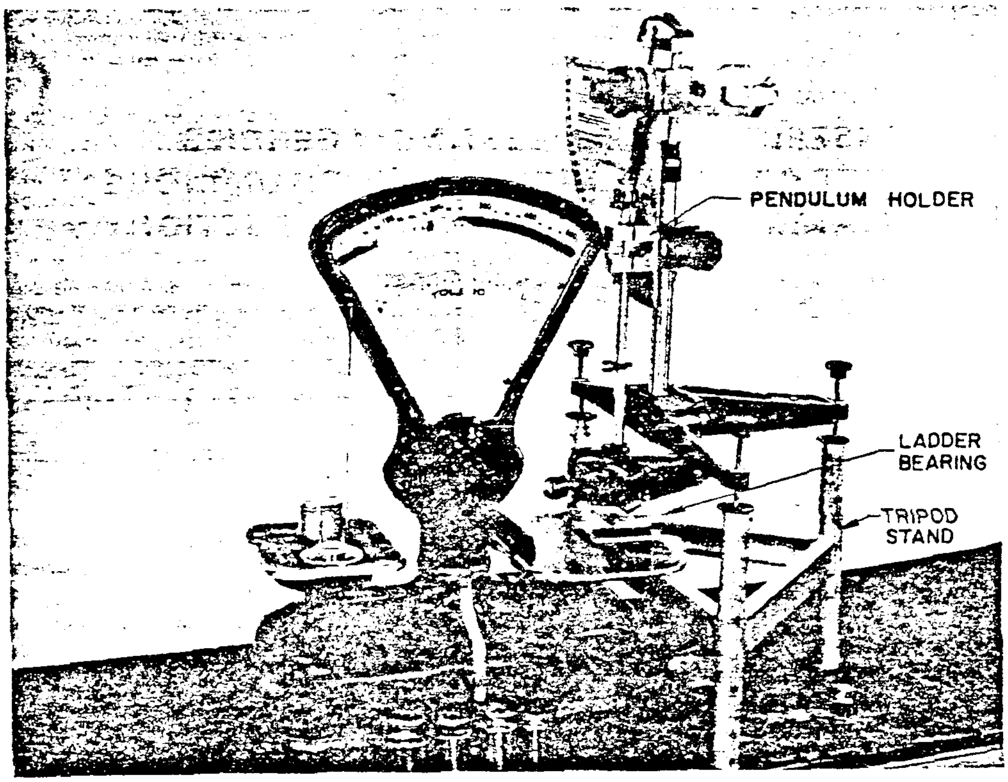
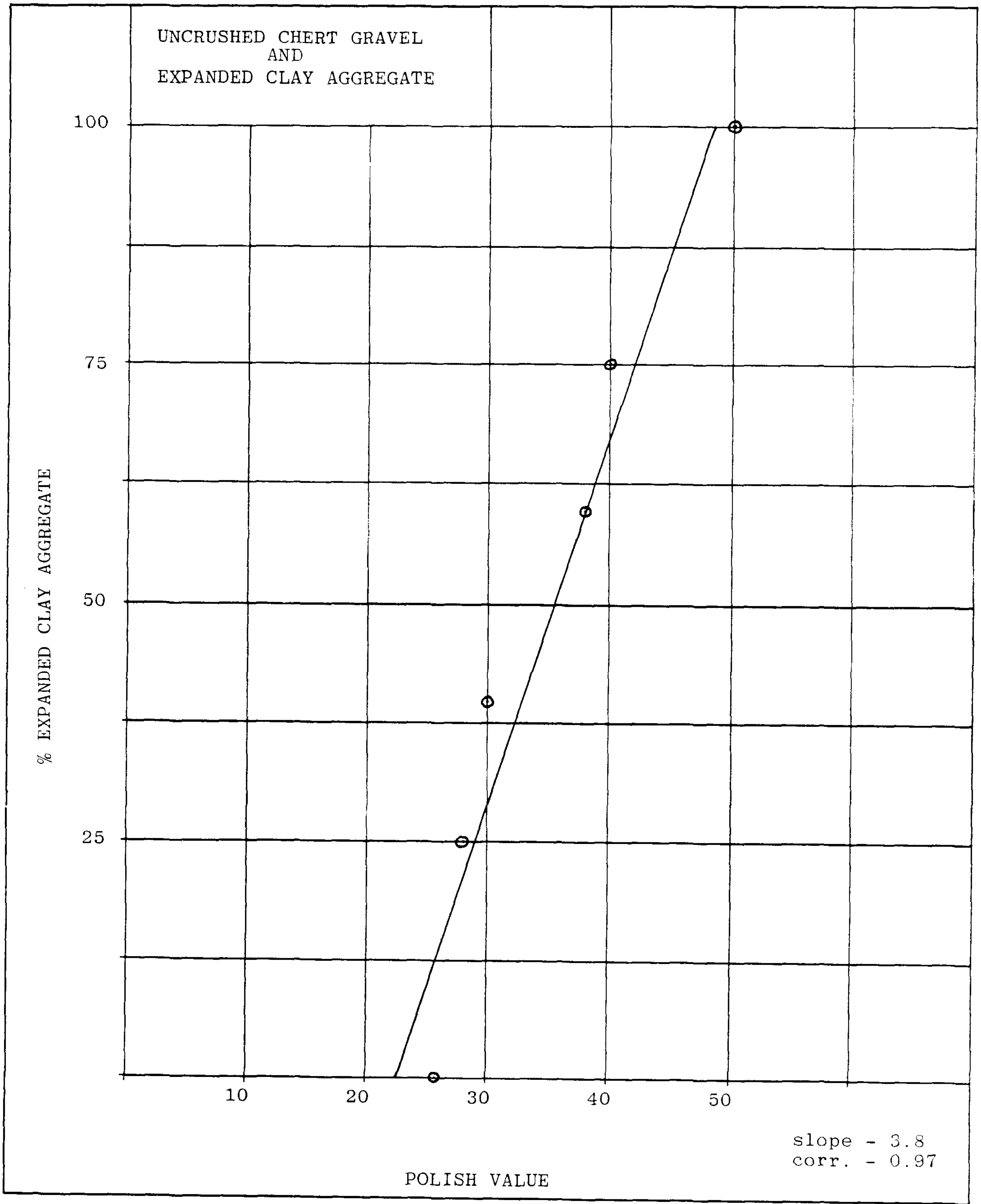


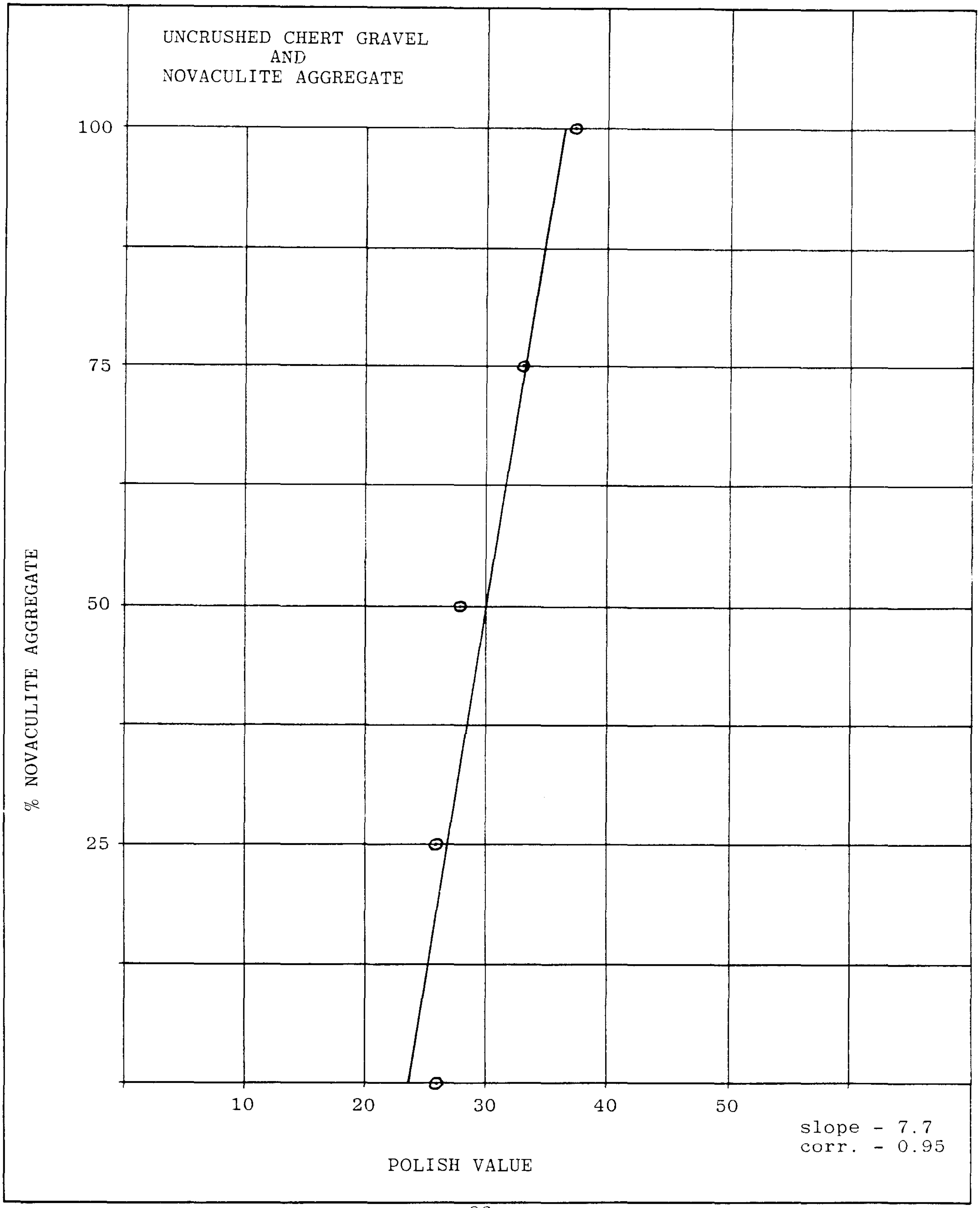
FIG. A2 Arrangement of the British Portable Tester, Showing Pendulum Assembly and Pan Balance Used to Measure Slider Load.

By publication of this standard no position is taken with respect to the validity of any patent rights in connection therewith, and the American Society for Testing and Materials does not undertake to insure anyone utilizing the standard against liability for infringement of any Letters Patent nor assume any such liability.

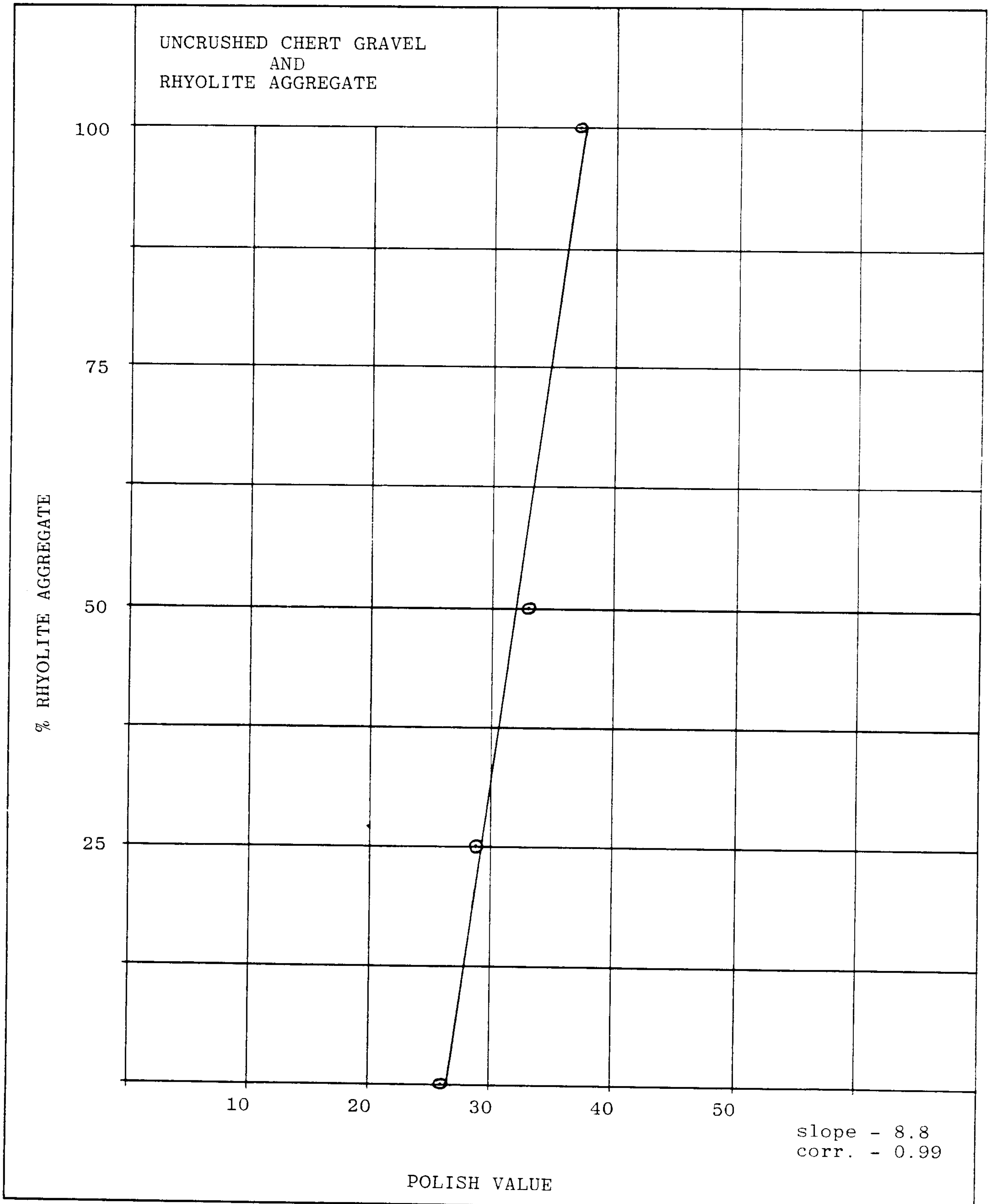
APPENDIX 3

GRAPHS OF TEST RESULTS


UNCRUSHED CHERT GRAVEL
AND
EXPANDED CLAY AGGREGATE
100
75
50
25
% EXPANDED CLAY AGGREGATE
10
20
30
40
50
slope - 3.8
corr. - 0.97
POLISH VALUE



UNCRUSHED CHERT GRAVEL
AND
NOVACULITE AGGREGATE
100
75
50
25
% NOVACULITE AGGREGATE
10
20
30
40
50
POLISH VALUE
slope - 7.7
corr. - 0.95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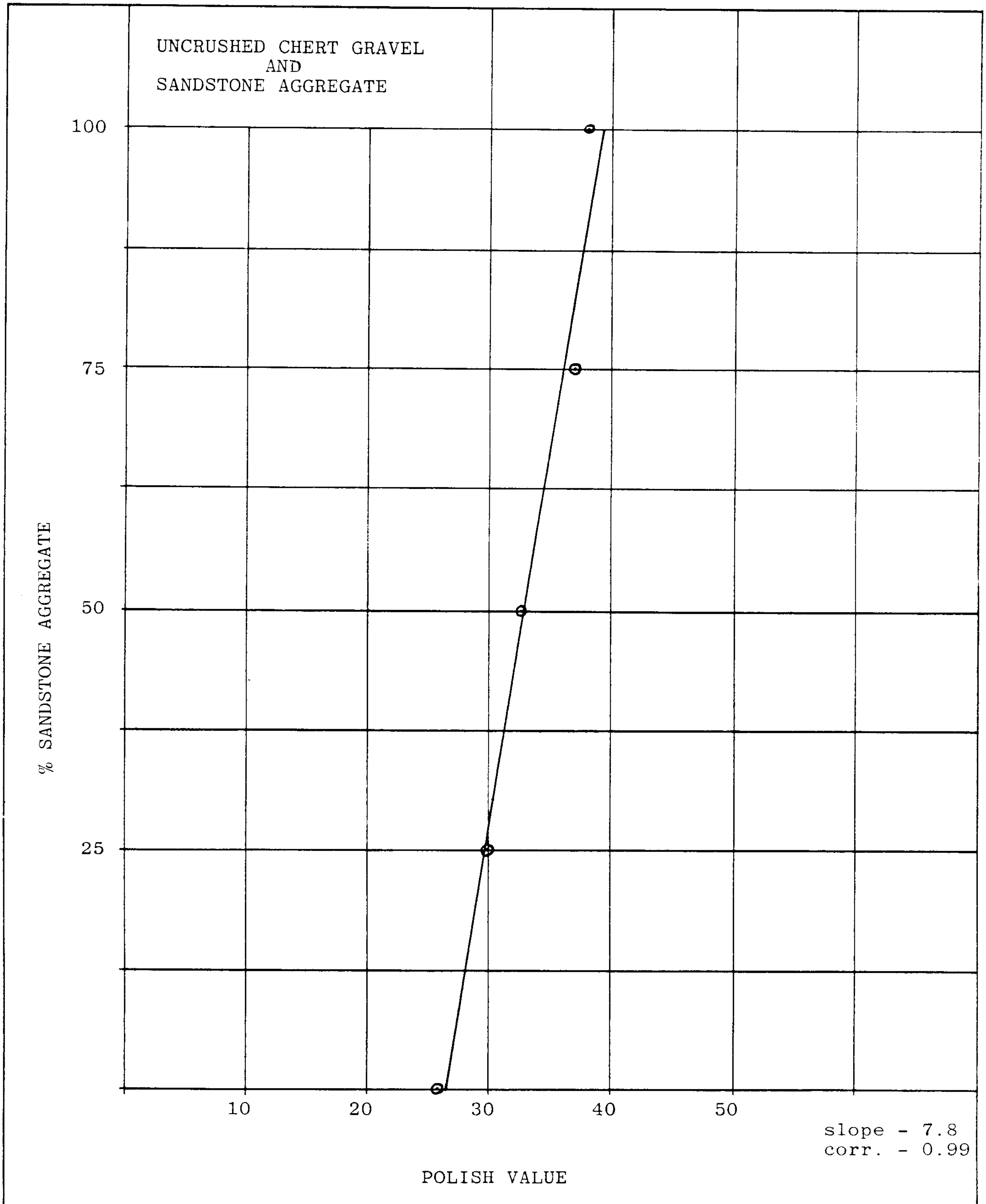
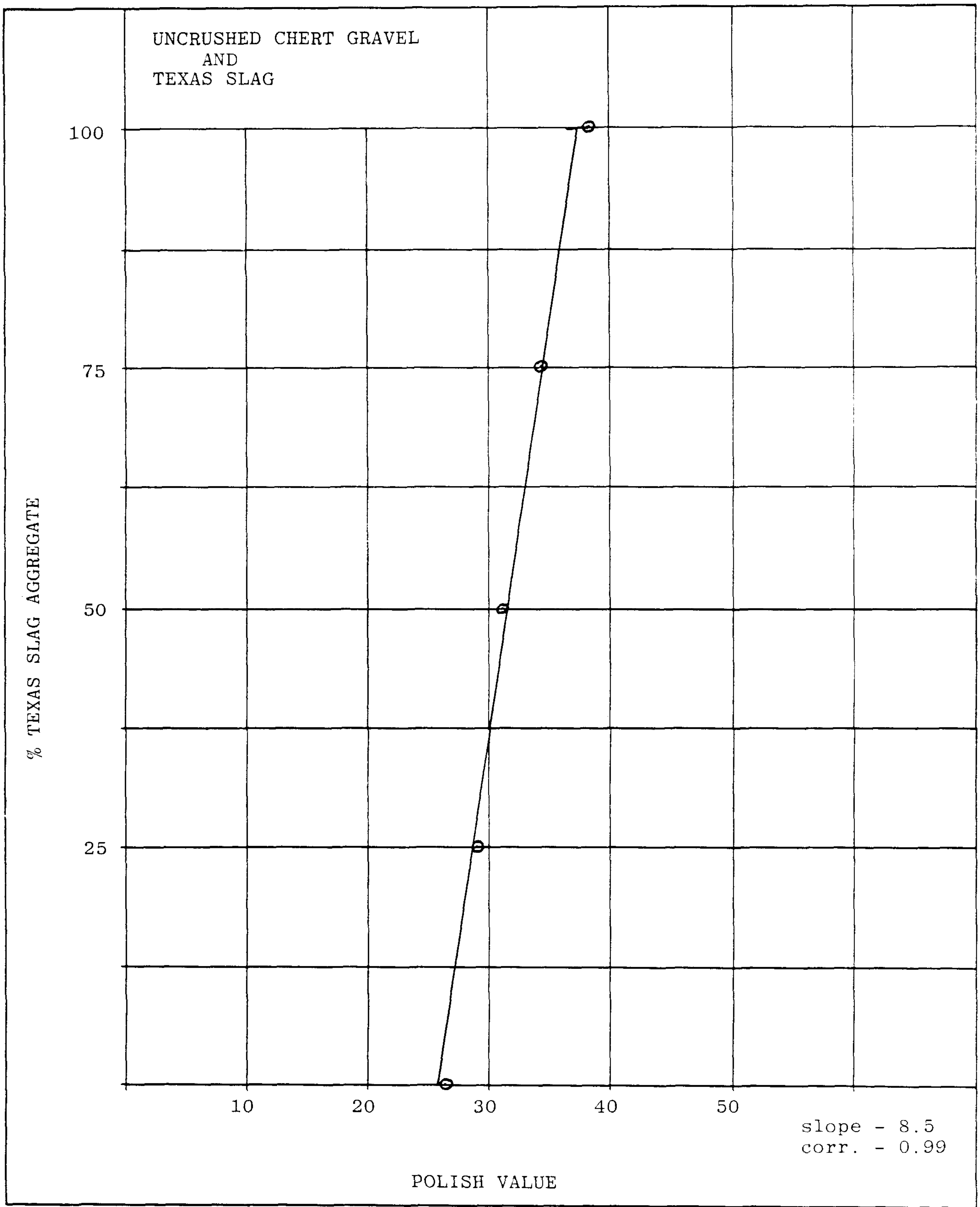
AND
RHYOLITE AGGREGATE
100
75
50
25
% RHYOLITE AGGREGATE
10
20
30
40
50
slope - 8.8
corr. - 0.99
POLISH VALUE


UNCRUSHED CHERT GRAVEL
AND
SANDSTONE AGGREGATE
100
75
50
25
% SANDSTONE AGGREGATE
10
20
30
40
50
slope - 7.8
corr. - 0.99
POLISH VALUE


UNCRUSHED CHERT GRAVEL
AND
TEXAS SLAG
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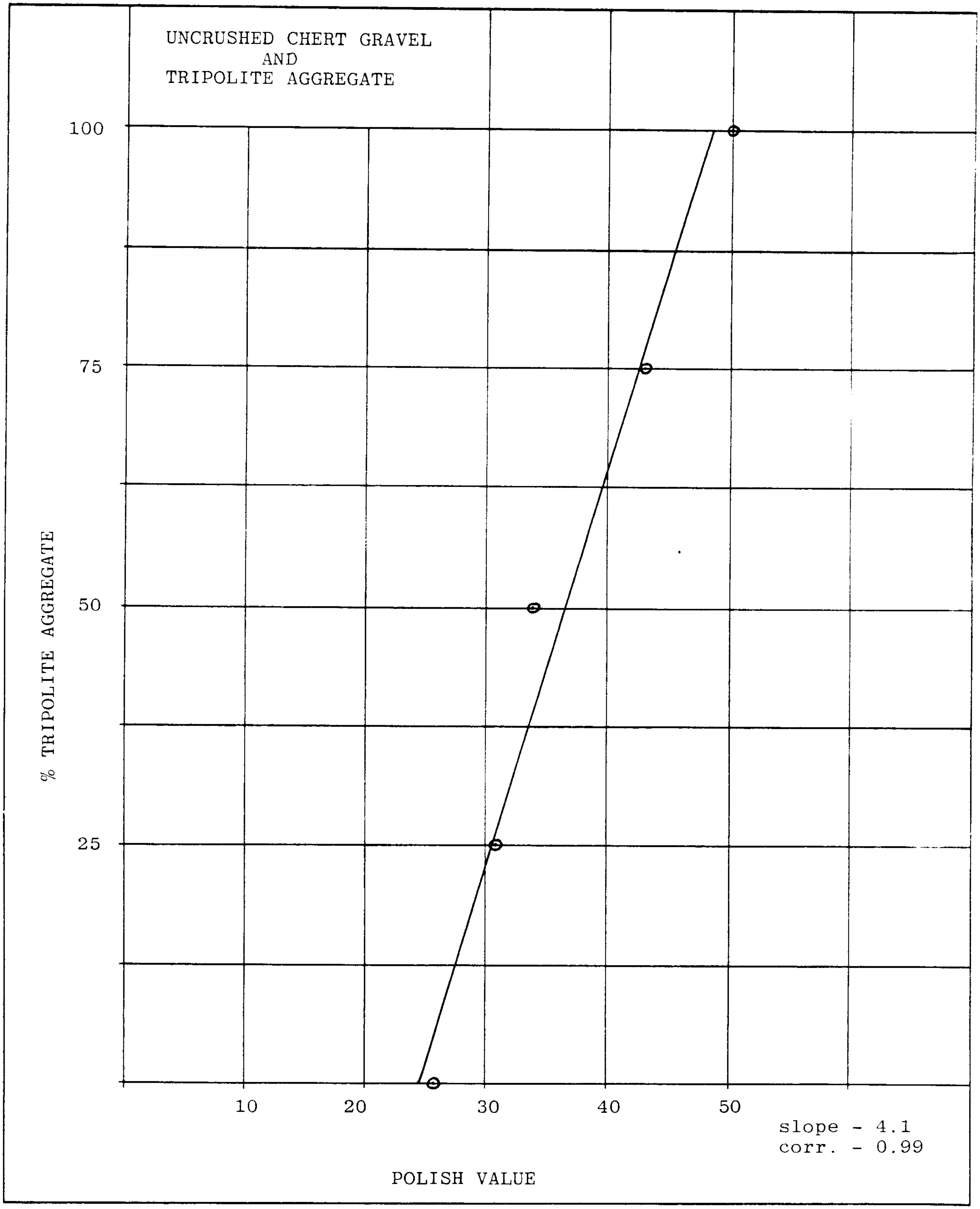
75
50
25
% TEXAS SLAG AGGREGATE
10
20
30
40
50
slope - 8.5
corr. - 0.99
POLISH VALUE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AND
TRIPOLITE AGGREGATE
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% TRIPOLITE AGGREGATE
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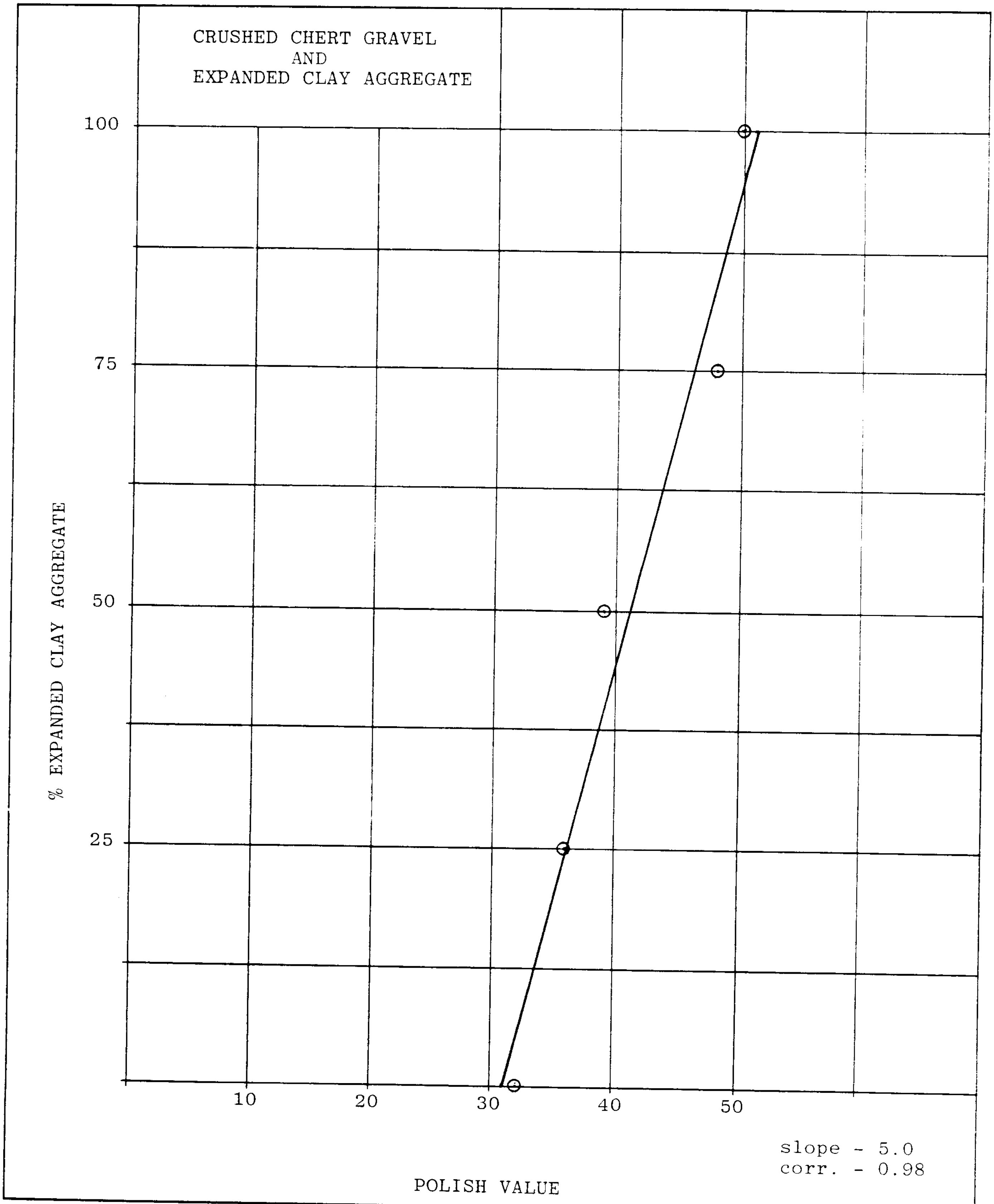
20
30
40
50
slope - 4.1
corr. - 0.99
POLISH VALUE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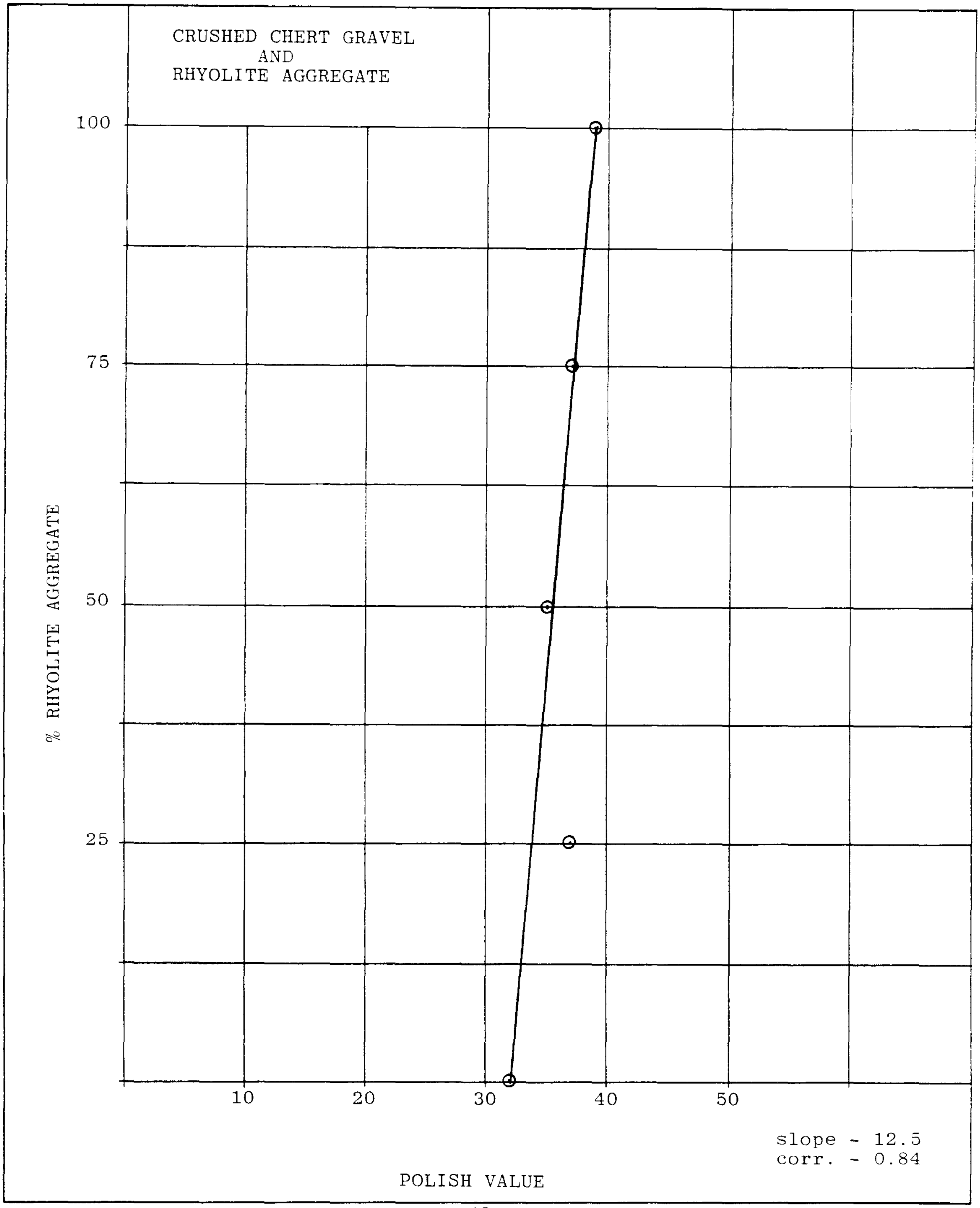
AND
EXPANDED CLAY AGGREGATE
100
75
50
25
% EXPANDED CLAY AGGREGATE
10
20
30
40
50
slope - 5.0
corr. - 0.98
POLISH VALUE


CRUSHED CHERT GRAVEL
AND
RHYOLITE AGGREGATE
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% RHYOLITE AGGREGATE
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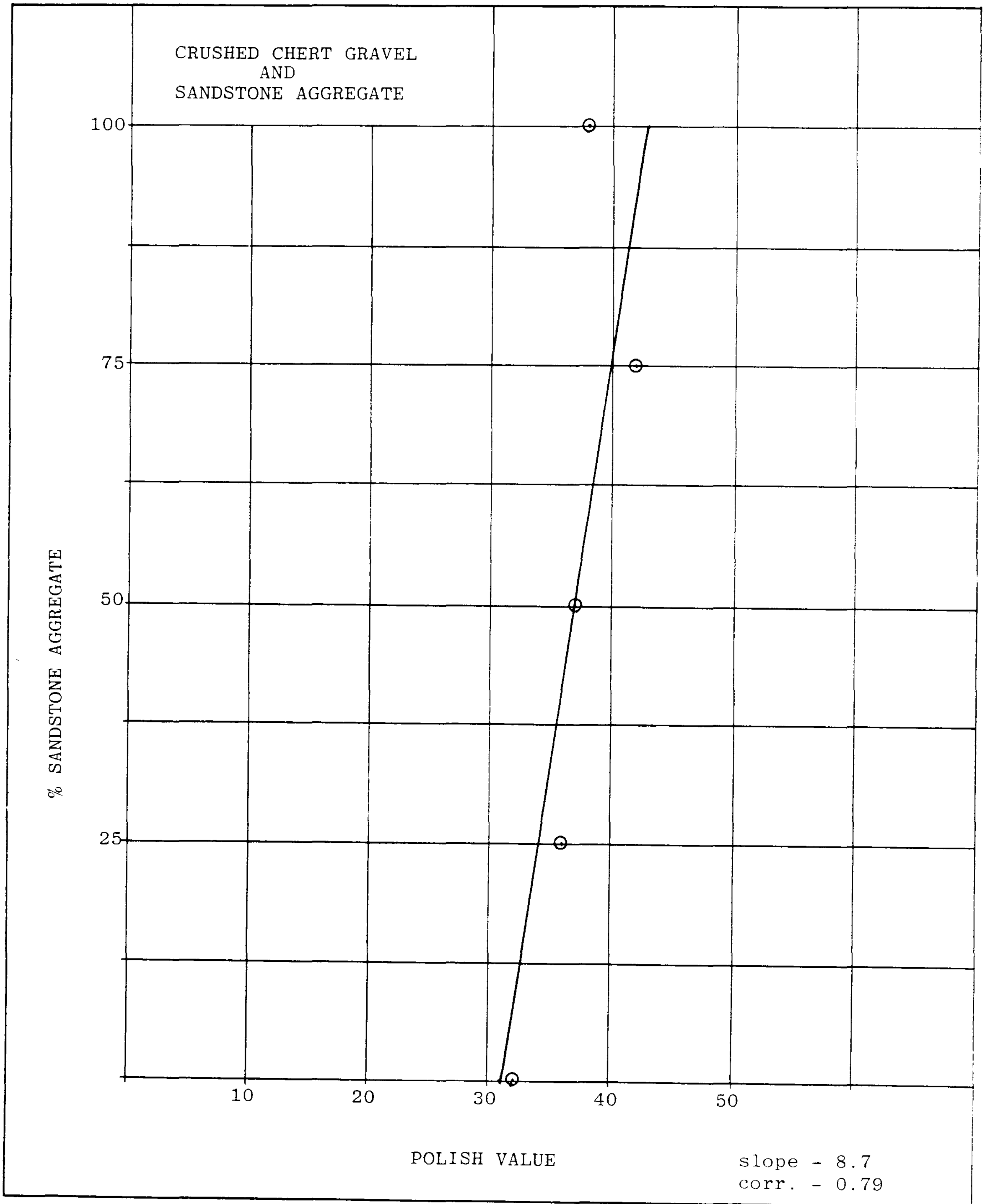
20
30
40
50
slope - 12.5
corr. - 0.84
POLISH VALUE


CRUSHED CHERT GRAVEL
AND
SANDSTONE AGGREGATE
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50
25
% SANDSTONE AGGREGATE
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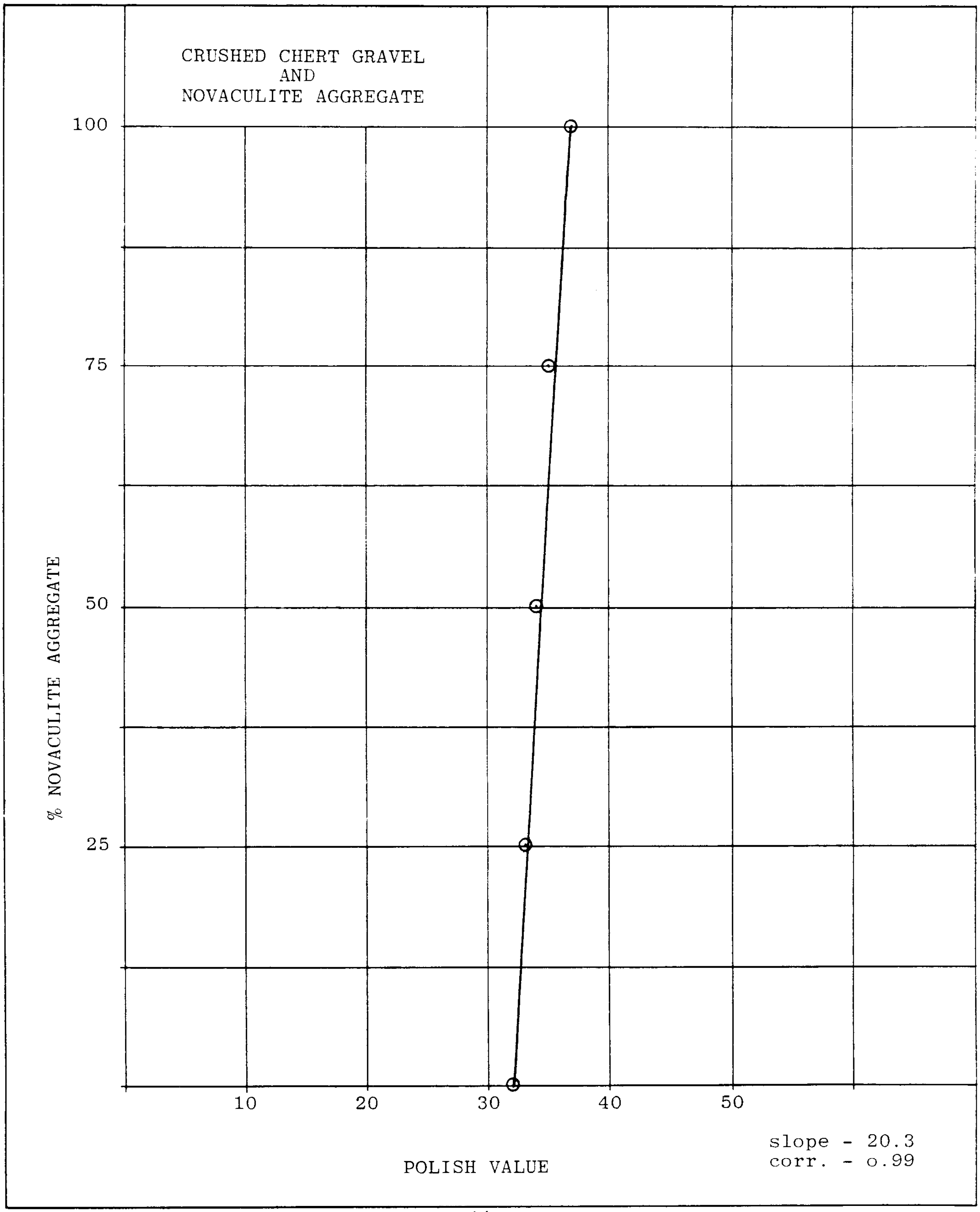
20
30
40
50
POLISH VALUE
slope - 8.7
corr. - 0.79


CRUSHED CHERT GRAVEL
AND
NOVACULITE AGGREGATE
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% NOVACULITE AGGREGATE
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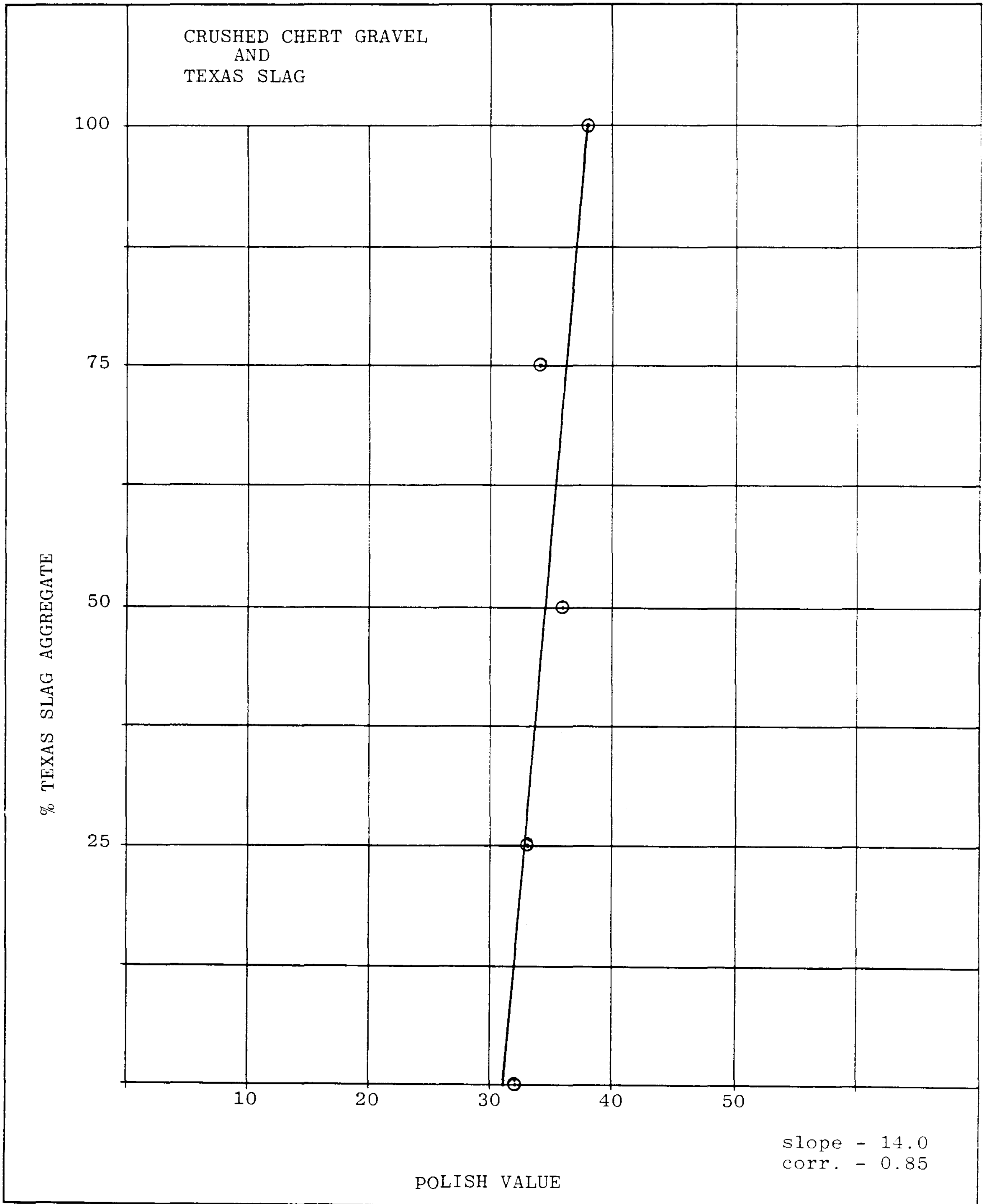
20
30
40
50
POLISH VALUE
slope - 20.3
corr. - o.99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AND
TEXAS SLAG
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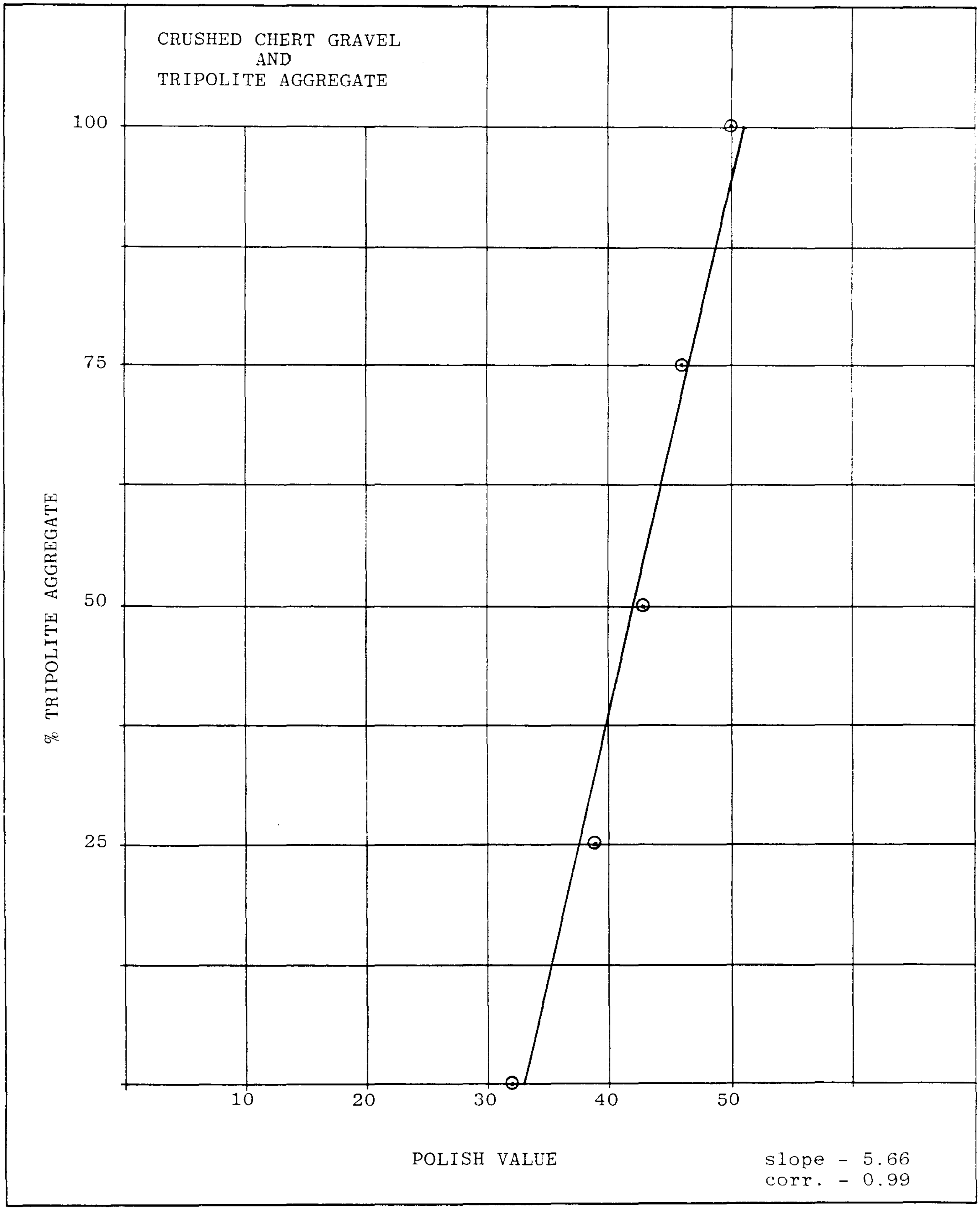
50
25
% TEXAS SLAG AGGREGATE
10
20
30
40
50
slope - 14.0
corr. - 0.85
POLISH VALUE


CRUSHED CHERT GRAVEL
AND
TRIPOLITE AGGREGATE
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% TRIPOLITE AGGREGATE
10
20
30
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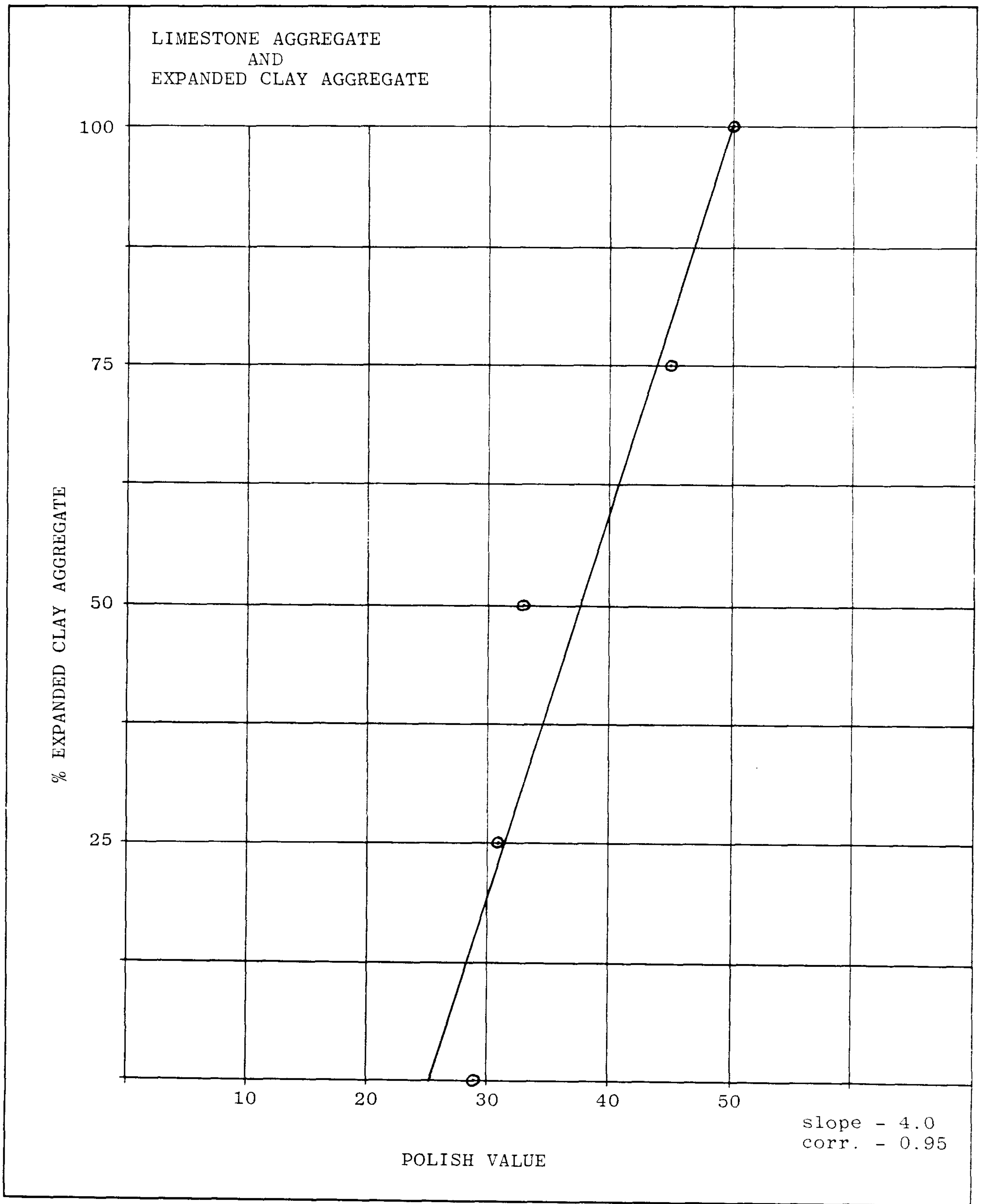
50
POLISH VALUE
slope - 5.66
corr. - 0.99


LIMESTONE AGGREGATE
AND
EXPANDED CLAY AGGREGATE
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75
50
25
% EXPANDED CLAY AGGREGATE
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20
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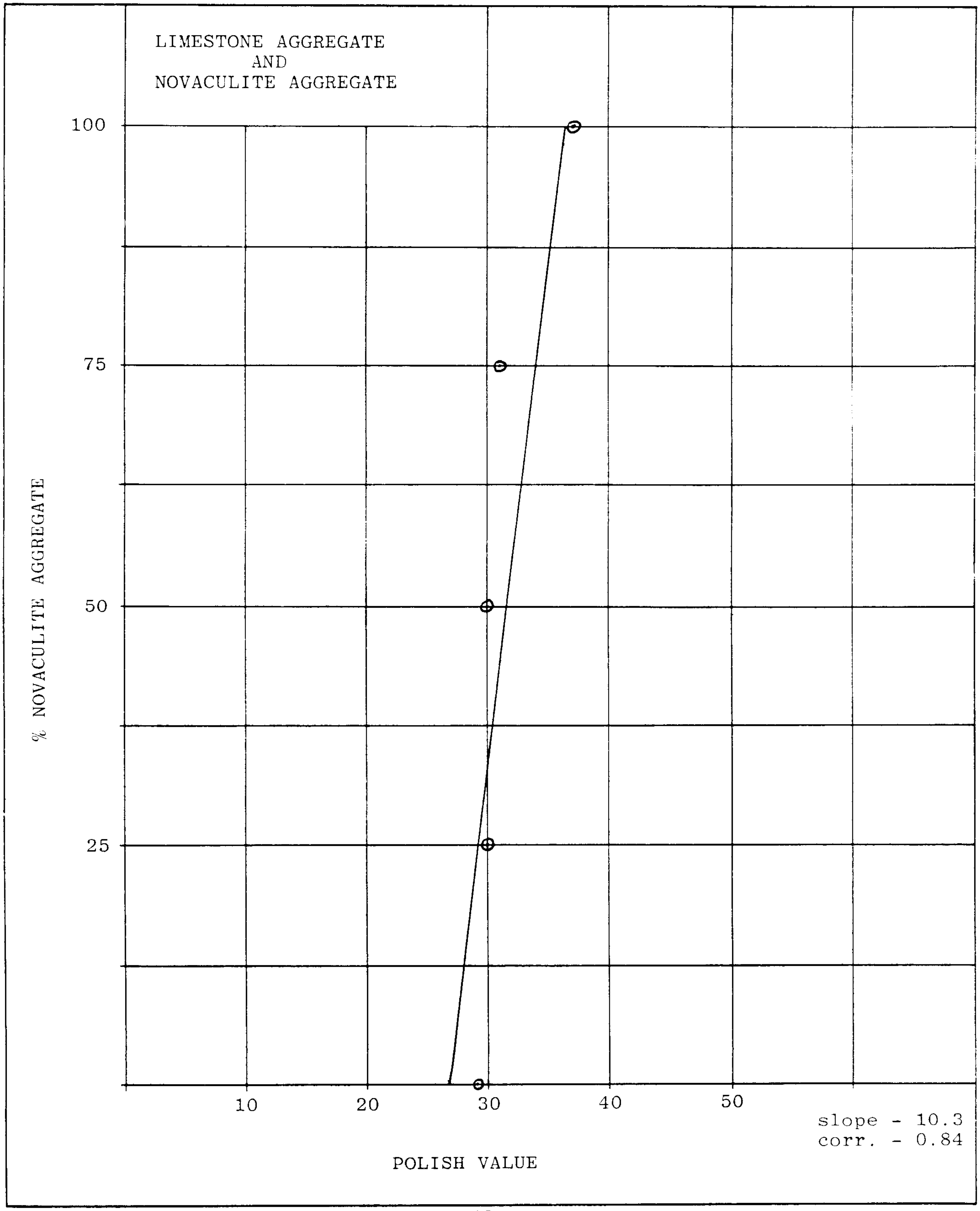
40
50
POLISH VALUE
slope - 4.0
corr. - 0.95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AND
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% NOVACULITE AGGREGATE
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30
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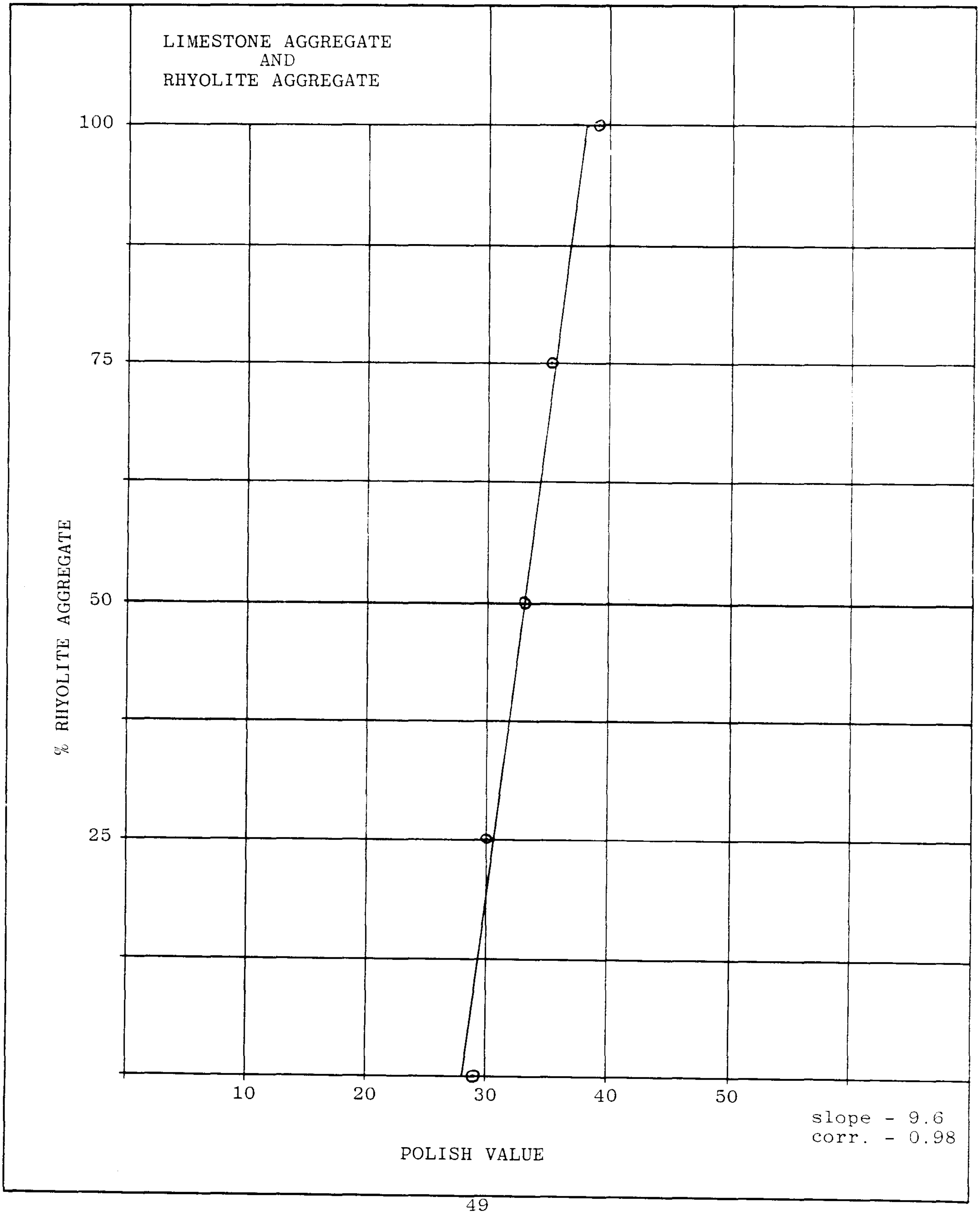
50
POLISH VALUE
slope - 10.3
corr. - 0.84


LIMESTONE AGGREGATE
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% RHYOLITE AGGREGATE
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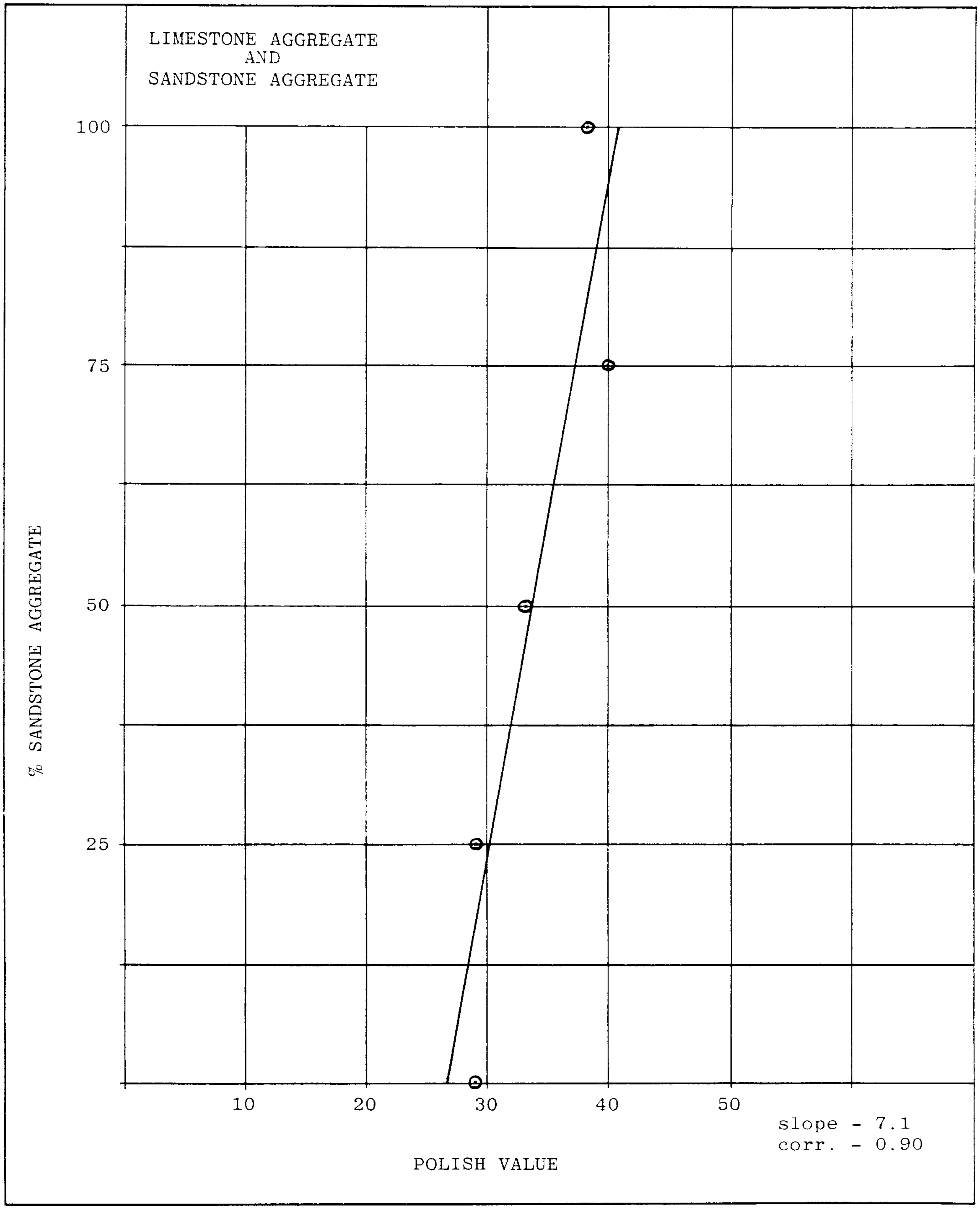
30
40
50
slope - 9.6
corr. - 0.98
POLISH VALUE


LIMESTONE AGGREGATE
AND
SANDSTONE AGGREGATE
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25
% SANDSTONE AGGREGATE
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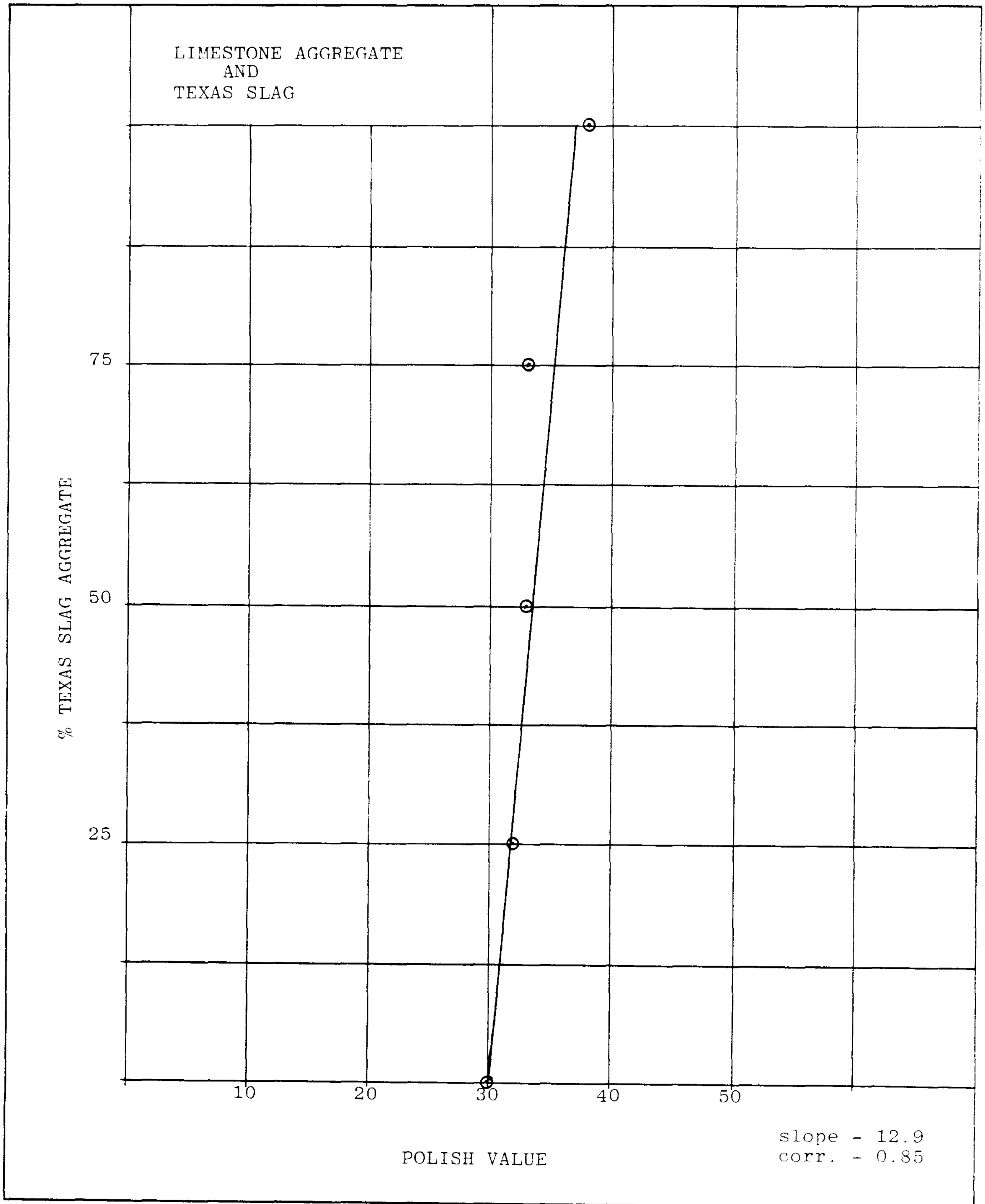
20
30
40
50
POLISH VALUE
slope - 7.1
corr. - 0.90


LIMESTONE AGGREGATE
AND
TEXAS SLAG
% TEXAS SLAG AGGREGATE
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50
25
10
20
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40
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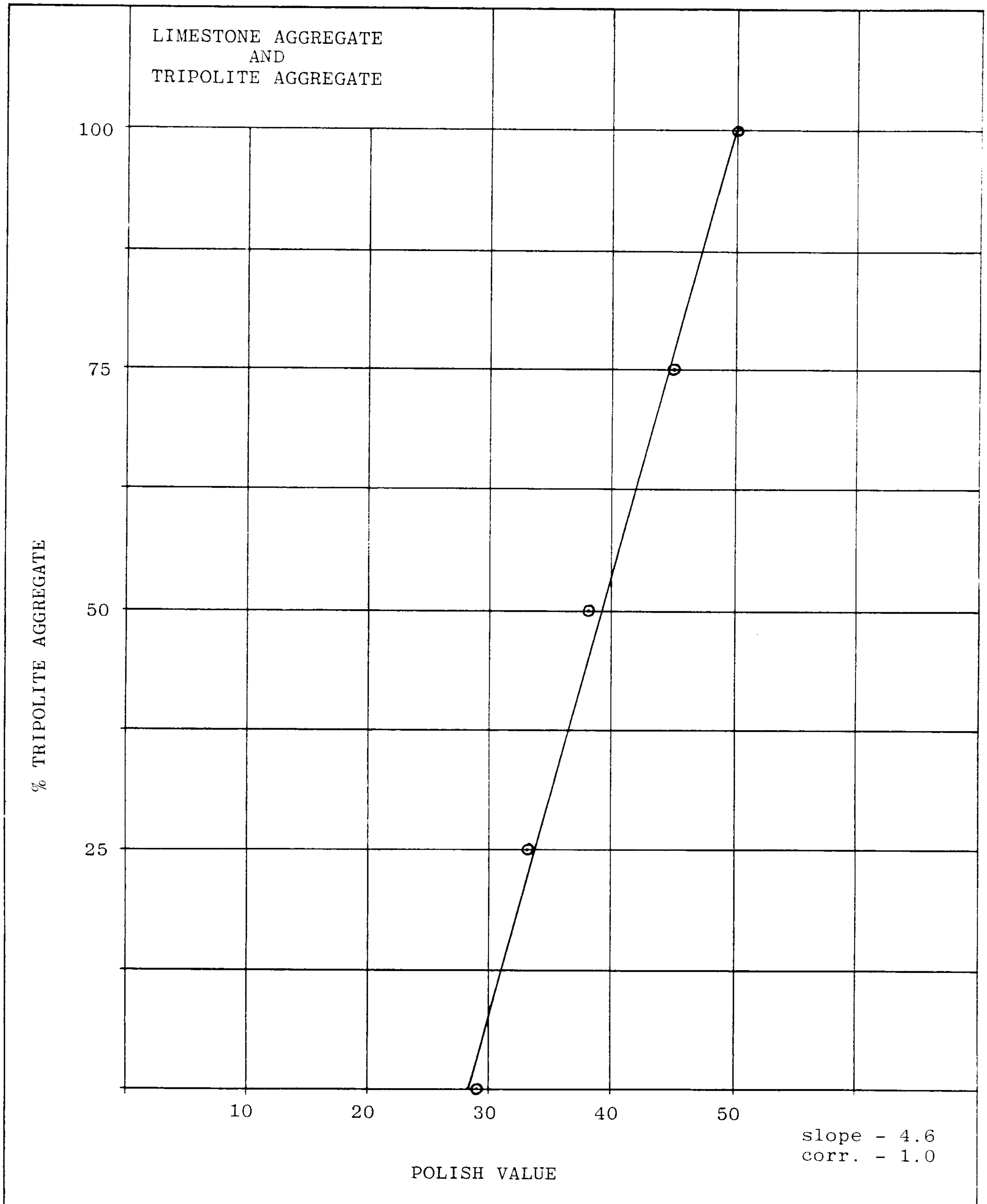
POLISH VALUE
slope - 12.9
corr. - 0.85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TRIPOLITE AGGREGATE
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75
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25
% TRIPOLITE AGGREGATE
10
20
30
40
50
slope - 4.6
corr. - 1.0
POLISH VALUE