A STUDY OF TEST METHOD TEX-413-A "DETERMINATION OF DELETERIOUS MATERIAL AND/OR CRUSHED PARTICLES IN MINERAL AGGREGATE"

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PREFACE

This report is the result of laboratory comparison of eleven partially crushed gravel samples. The existing Test Method Tex-413-A, "Determination of Deleterious Material and/or Crushed Particles in Mineral Aggregate," describes a procedure for determining the percentage, by weight or particle count, of deleterious material or crushed particles in aggregates. The determination of deleterious particles or crushed particles is a very laborious and expensive one, man power wise, since each particle has to be handled, inspected and counted.

Only one sample that was investigated contained deleterious material. The remaining samples were clean and, therefore, offered no possibilities of making determinations for deleterious material.

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I. SUBJECT

Deleterious material is defined in various specifications as clay lumps, shale, soft, friable or laminated particles, vegetable matter, or other objectional material.

Crushed particles are aggregates that have one or more crushed faces. Currently there are 6 items in the book of specifications which deal with crushed particle count. It should be noted that the materials tested herein were clean enough that the determination of crushed particles only was a matter of real concern.

II. PURPOSE

The purpose of this report is to show a comparison between the present method of determining the percentage of deleterious by weight or the percentage of crushed faces by count and a new proposed method.

The method of determining the number of crushed faces in small size aggregates, particularly in the No. 4, 1/4-inch and 3/8-inch size range is very time consuming since many samples of material could contain 15,000 or more particles. This amount of counting and inspection requires great concentration and dedication on the part of a technician to accurately determine the correct numbers when counting so many small particles.

III. CONCLUSIONS

From the data collected and observation of the technicians, who were quite capable, it was concluded as follows:

1. The counting of large numbers of particles, particularly in the range of 4000 upwards, is very time consuming and results in considerable eye strain and/or fatigue to the technician making the determinations. Some small silicious gravels and like materials may result in requiring over 15,000 particles to be studied and counted by present methods. It was concluded that smaller numbers of particles to inspect for crushed faces would result in higher quality work.

2. A study of the data from Tables I and II show that the determination of crushed faces by the present method are equal or 8% higher on the average in nine of eleven samples. Sieve analyses showed the vast majority of all materials tested to be passing the 1/2-inch sieve and that counting was therefore performed predominantly on this minus 1/2-inch sieve material.

3. The number of particles on the 1/2"-3/8" and 3/8" to No. 4 sizes were the particles most likely to cause error in the weighted results since these particles predominate in specification samples. Test quantities of these sizes have been increased in the recommended method, Appendix II, in order to minimize these errors should they exist.

IV. RECOMMENDATIONS

1. It is recommended that no change be made in the section "Determination by Weight" in Test Method Tex-413-A which has to do with deleterious material since not enough samples having deleterious material were studied.

2. It is recommended that the proposed method outlined in Appendix II be approved to replace "Particle Count" under the present Test Method Tex-413-A. In order to retain the desired accuracy the minimum individual fraction test weights will be as follows:

Sieve Size	Min. Wt. Sample (gms)
+3/4"	2000
3/4"-5/8"	1000
5/8"-1/2"	500
1/2"-3/8"	350
3/8"-No. 4	200

V. MATERIALS

The samples that were compared were either routine samples or samples that were manufactured in the laboratory. Manufactured samples consisted of samples of uncrushed gravels combined with samples of crushed gravels. The resulting samples were well blended and then split down to required sample size by use of a sample splitter.

VI. EQUIPMENT

The following items of equipment are required.

1. Scale or balance of at least 4500 grams capacity and accurate within 0.1 percent of the test load at any point within the range of use and sensitive to 0.1 gram.
2. Sample splitter or quartering cloth.
3. Drying oven maintained at a temperature of 230 $\pm$ 9 F.
4. Round pans.

5. Set of Standard U.S. Sieves (A.S.T.M. E 11 Specifications).

6. A small spatula having a blade 4 inches long and 3/4 inch wide.

VII. PROCEDURE FOR ACQUIRING DATA IN THIS STUDY

A sample was selected and tested in accordance with existing Test Method and a sample of the same material was tested by the proposed method.

A. The procedure for the method for determination by weight of deleterious material is as follows. Due to the small number of samples tested the existing and current test method is recommended.

1. Determine the sieve analysis on the plus No. 4 portion of a representative portion of the sample using the following sieves: 3/4", 5/8", 1/2", 3/8" and No. 4. Do not consider the -No. 4 material.

2. Carefully quarter the processed aggregate again to obtain a representative portion that when separated on the No. 4 sieve, the retained portion will furnish the approximate amounts listed below where those sizes exist in significant amounts in the test sample. Separate the test sample on the No. 4 sieve.

Sieve Sizes	Approx. Wt. (gms)
+3/4"	2000
3/4"-5/8"	1000
5/8"-1/2"	500
1/2"-3/8"	250
3/8"-No. 4	100

Note: If this test is run in conjunction with Test Method Tex-406-A, "Materials Finer Than No. 200 Sieve in Mineral Aggregates (Decantation Test for Concrete Aggregates)," retain the minus No. 4 fraction for recombining and further testing. When this test is a single determination, the minus No. 4 material may be discarded.

3. Dry the aggregate retained on the No. 4 sieve to constant weight at 230 F $\pm$ 9 F.

4. From the dried sample and for the sieve sizes present, weigh out the amounts for each size as given in paragraph 2 above, and record the weight to the nearest estimated 0.1 gram. Record the sample weight as W_T. Keep each sized portion in separate pans.

5. Beginning with the largest size material:
   a. Spread the particles on a large enough area of the work bench so that the individual particles can be carefully inspected.
   b. Use the edge of the spatula to separate particles of deleterious materials from the remainder of the sample by sliding them into separate piles.
   c. Weigh the various individual fractions of deleterious material to the nearest estimated 0.1 gram and record as W_1, W_2, etc.

6. Continue until all pans of material of different sieve sizes have been separated or classified.

B. The procedure for determining crushed particles by count is:

1. Follow the procedure set forth in Determination by Weight, above, concerning the sample preparation and size.

2. Spread the pan of material containing the largest size particles on a smooth surface, preferably of a contrasting color to that of the aggregate to be tested.

3. Closely examine the surface of each aggregate particle, separating them into two or more piles according to the condition of each particle.

4. After the fraction has been separated into two or more piles, count the number of particles in each pile.

5. Continue examining and counting the other fractions (sizes) of the test sample until all are completed.

VIII. CALCULATIONS, TEST DATA AND RESULTS

Data which was accumulated from testing of samples was used in the formulas below.

Calculate the percentage of deleterious material in each size of the aggregate as follows:

$$\% \text{ in each size} = \frac{W_1}{W_F}, \text{ etc. } \times 100$$

Where:

W_F = weight of test fraction or of that size

W_1 = weight of clay lumps in that size

W_2 = weight of shale in that size

W_3 = weight of soft or friable particles in that size

W_4 = weight of laminated particles in that size.

Calculate the weighted percentage of deleterious material in the sample as follows:

$$\text{Percent} = \frac{W_1\ S_1}{W_{F1}} + \frac{W_1\ S_2}{W_{F2}} + \frac{W_1\ S_3}{W_{F3}} + \text{etc.}$$

Where: W_1 = same as W_1 above

S_1, S_2 and S_3, etc. = percentages of total sample of sieve sizes given in par. 2, VII, and determined in par. 1, VII.

W_{F1}, W_{F2}, W_{F3}, etc. = total weight of fractions of samples for S_1, S_2, S_3, etc.

Substitute W_2, W_3 and W_4 for W_1 in calculating the percentage of shale, soft particles or laminated particles.

% total deleterious material = sum of weighted percentages for $W_1 + W_2 + W_3 + W_4$.

Determine the percentage of crushed particles (those having one or more crushed faces) as follows:

$$\% \text{ Crushed particles (each fraction)} = \frac{N_F}{N_T} \times 100\%$$

Where:

N_F = number of crushed particles for that fraction or size

N_T = total number of particles for that fraction or size.

Specifications require the percentage of crushed particles by count only.

The following formula was used to determine the weighted percentage of crushed particles on both a count and weight basis through appropriate substitution of counts and/or weights.

Determine the weighted percentage of crushed particles as follows:

$$\% \text{ (Weighted)} = \frac{N_{F1}S_1}{N_{T1}} + \frac{N_{F2}S_2}{N_{T2}} + \frac{N_{F3}S_3}{N_{T3}} + \text{etc.}$$

Where:

N_{F1}, N_{F2}, N_{F3}, etc. are numbers of crushed particles from fractions or sizes 1, 2, 3, etc.

N_{T1}, N_{T2}, N_{T3}, etc. are total number of particles from fractions or sizes 1, 2, 3, etc.

S_1, S_2, S_3, etc. are percentages of total sample of sieve sizes given in par. 2, Determination by Weight, and as determined in par. 1, Test Method Tex-401-A, Determination by Weight.

Test Record Forms

Record test data on Form D9-A-3 and report the weighted percentage of crushed particles to the nearest whole number on Form 272.

Table I

Sample Number 72-4590-A

By Weight	Present Method	Proposed Method
Deleterious	3.5%	3.0%
Crushed Faces	55.4%	55.4%

By Particle Count	Present Method	Proposed Method
Deleterious	4.2%	5.3%
Crushed Faces	58.3%	40.7%
Number of Particles	14,422	437
Time required	9 hours	1 hour

Routine sample received for testing which contained deleterious material. (Soft particles) Note that deleterious material by weight (Specifications) checked well whereas crushed faces by particle count was low by the proposed method.

Table II

Crushed Faces

	Present Method				Proposed Method			
Sample No.	Percent By Weight	Percent By Count	No. of Particles	Time (Hrs)	Percent* By Weight	Percent* By Count	No. of Particles	Time (Hrs)
1	46.0	42.9	2010	7	46.7	42.8	285	1
1A	27.0	35.0	2032	4	53.8	44.9	495	1
2	51.9	64.4	2134	9	51.9	55.7	407	2
2A	54.4	52.3	1312	2	56.3	53.7	164	1/2
3	42.0	43.4	7584	10	39.5	41.1	487	1
3A	56.4	63.3	2213	3	71.0	69.6	608	1
4	80.6	89.8	3793	3	80.6	82.3	376	3/4
5	95.6	96.5	2801	3	95.9	96.2	290	1
6	70.6	77.7	3288	4	65.7	70.4	370	1
7	93.8	94.1	3825	8	91.0	93.9	679	3

* Weighted

These samples were manufactured in the laboratory.

APPENDIX I

Texas Highway Department

Materials and Tests Division

DETERMINATION OF DELETERIOUS MATERIAL AND/OR CRUSHED PARTICLES IN MINERAL AGGREGATE

Scope

This test method describes a procedure for determining the percentage, by weight or particle count, of deleterious material or crushed particles in aggregates. Deleterious material is defined in various specifications as clay lumps, shale, soft, friable or laminated particles, vegetable matter, or other objectionable material.

Apparatus

1. Balance or scale of at least 4500 grams capacity, sensitive to 0.1 gram, accurate to 0.5 gram, meeting requirements of Test Method Tex-901-K Class III-D balance or Class IV-A scales.
2. Balance of at least 300 grams capacity, sensitive to .01 gram, accurate to 0.5 gram, meeting requirements of Test Method Tex-901-K Class III-A balance, for weighing deleterious materials of 50 grams or less.
3. Sample splitter or quartering cloth
4. Drying oven maintained at a temperature of $230^{\circ} \pm 9^{\circ}F$.
5. Graniteware pans
6. Sieve - a No. 4 sieve
7. A small spatula having a blade 4 inches long and 3/4 inch wide

Test Record Forms

Record test data on Form D9-A-3 and report the percentage of crushed particles to the nearest whole number on Form 272.

DETERMINATION BY WEIGHT

Procedure

1. Carefully quarter the processed aggregate submitted for testing to obtain a representative portion of material which when separated on the No. 4 sieve the retained particles will weigh approximately 2000 grams.

2. Separate the test sample by means of the No. 4 sieve. If this test is run in conjunction with Test Method Tex-406-A, retain the minus No. 4 fraction for recombining and testing under Tex-406-A. If this test is a single determination, the minus No. 4 material may be discarded.

3. Dry the aggregate retained on the No. 4 sieve to constant weight at $230^{\circ} \pm 9^{\circ}F$. and obtain the dry weight to the nearest estimated 0.1 gram. Record this value as the total weight of test sample W_T.

4. Spread the sample out on a large enough area of the work bench so that the individual particles can be carefully inspected. Use the edge of the spatula to separate particles of deleterious materials from the remainder of sample by sliding them into separate piles.

5. Weigh the various individual fractions of deleterious material to the nearest estimated 0.1 gram and record as W_1, W_2, etc.

Calculations

Calculate the percentage of deleterious material in aggregate as follows:

$$\text{Percent} = \frac{W_{1, \text{etc.}}}{W_T} \times 100$$

Where:

W_T = weight of total test sample

W_1 = weight of clay lumps

W_2 = weight of shale

W_3 = weight of soft or friable particles

W_4 = weight of laminated particles

Note: The breaking of friable particles shall be accomplished by squeezing and rolling them between the thumb and forefinger. The fingernails shall not be used to break up the particles nor shall they be pressed against a hard surface.

PARTICLE COUNT

Follow the procedure set forth in the "weight method" (Tex-413-A) concerning the sample preparation and sample size.

Procedure

1. Spread the sample out on a flat smooth surface, preferably of a contrasting color to that of the aggregate being tested.

2. Closely examine the surface of each aggregate particle separating them into two or more separate piles according to the condition of each particle.

3. After the entire sample is separated into two or more piles, count the number of particles in each pile.

4. To determine the percentage of crushed particles (particles having one or more crushed faces), divide the number of particles in the "crushed" pile by the total number of particles in the total sample (summation of "crushed" pile and "uncrushed" pile) and multiply by 100.

APPENDIX II

Particle Count
(Crushed Faces)

Procedure

1. Using the techniques set forth in Test Method Tex-401-A, determine the sieve analysis on the plus No. 4 portion of a representative portion of the sample using the following sieves: 3/4", 5/8", 1/2", 3/8" and No. 4. Do not consider the -No. 4 material.

2. Carefully quarter the processed aggregate again to obtain a representative portion that when separated on the No. 4 sieve, that the retained portion will furnish the amounts listed below where those sizes exist in the sample. Separate the test sample on the No. 4 sieve.

Sieve Sizes	Min. Wt. (gms)
+3/4"	2000
3/4"-5/8"	1000
5/8"-1/2"	500
1/2"-3/8"	350
3/8"-No. 4	200

3. Dry the aggregate retained on the No. 4 sieve to constant weight at 230 F $\pm$ 9 F.

4. From the dried sample and for the sieve sizes present, weigh out the amounts for each size as given in paragraph 2 above, and record the weight to the nearest estimated 0.1 gram. Record the sample weight

as W_T. Keep each sized portion in separate pans.

5. Spread the pan of material containing the largest size particles on a smooth surface, preferably of a contrasting color to that of the aggregate to be tested.

6. Closely examine the surface of each aggregate particle, separating them into two or more piles according to the condition of each particle.

7. After the fraction has been separated into two or more piles, count the number of particles in each pile.

8. Continue examining and counting the other fractions (sizes) of the test sample until all are completed.

Calculations

Determine the percentage of crushed particles (those having one or more crushed faces) as follows:

$$\% \text{ Crushed particles (each fraction)} = \frac{N_F}{N_T} \times 100\%$$

Where:

N_F = number of crushed particles for that fraction or size

N_T = total number of particles for that fraction or size

Determine the weighted percentage of crushed particles as follows:

$$\% \text{ (Weighted)} = \frac{N_{F1}S1}{N_{T1}} + \frac{N_{F2}S2}{N_{T2}} + \frac{N_{F3}S3}{N_{T3}} + \text{etc.}$$

Where:

N_{F1}, N_{F2}, N_{F3}, etc. are numbers of crushed particles from fractions or sizes 1, 2, 3, etc.

N_{T1}, N_{T2}, N_{T3}, etc. are total numbers of particles from fractions or sizes 1, 2, 3, etc.

S_1, S_2, S_3, etc. are percentages of total sample of sieve sizes given in par. 2, Procedure, and as determined in par. 1, Procedure.

Report the weighted percentage of crushed particles to the nearest whole number.