

CORPS OF ENGINEERS PROCEDURE IN THE DEVELOPMENT OF A NEW LIMESTONE OR DOLOMITE SOURCE

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ABSTRACT

Procedure for approval by the U. S. Army Corps of Engineers of a new source of aggregate is in three phases. Phase 1 consists of an investigation of a quarry or proposed quarry by district geologist and laboratory geologist and/or petrographer. The quarry face or suitable outcrop is logged in detail or, if exposures are poor, cores may be taken to determine whether further investigations are warranted.

Phase 2 consists of thorough laboratory testing. Cores and crushed material are subjected to a number of acceptance and quality tests for soundness, absorption, abrasion, reactivity, and other properties. Petrographic analysis is also made. Phase 3 is a physical and economic study of the site and involves determining quantity of stone available, amount and character of overburden, condition of haul roads and distance to rail shipping point, plant flow sheets and capacity, aggregate sizes produced, and approximate price of material at plant.

The U. S. Army Corps of Engineers approves millions of tons of limestone and dolomite aggregate annually for use in connection with civil and military construction programs, including the construction of concrete dams, spillways, airfields, highways, tunnels, and buildings. Approximately 75 per cent of all aggregate used by the Corps of Engineers is limestone and dolomite.

Economy is one of the most important factors in the selection of suitable sources of aggregate. Therefore, because the use of local materials produces the greatest possible economy, the investigation of aggregate sources should begin at the site of the proposed construction. The investigation should be made by engineer-geologist teams so that the geologist's knowledge of rock formations and the engineer's knowledge of quarrying, processing, and transportation of aggregate may be pooled to locate the best potential sources. The engineer is the final arbiter in the selection of a source of aggregate.

PHASE 1

The procedure for approval of a new source of limestone or dolomite aggregate consists of three phases. Phase one consists of a field investigation of the quarry or potential quarry by a geologist or a geologist-petrographer team acquainted with the requirements for concrete aggregates. If the face of the quarry or a suitable outcrop is accessible, a thorough geologic appraisal is made. Particular attention is given to structural geology, stratigraphy, lithology, and overburden conditions. Data on thickness and attitude of beds, joint spacing, folding and faulting, lithologic changes, and presence of impurities are of utmost importance.

It is the responsibility of the field geologist to eliminate sources that, on the basis of his knowledge of the requirements for mineral aggregates, are definitely unsuitable as to either quantity or quality. It is also the geologist's responsibility to collect proper samples of the potential aggregate for petrographic examination by the appropriate Corps of Engineers laboratory. The importance of proper and representative sampling cannot be overemphasized; the effectiveness of the sampling will be enhanced materially by close liaison between the field geologist and the laboratory petrographer. The location, number, and diameter of cores; the type of other samples collected; and the completeness of the descriptive matter supplied by the field geologist are of prime importance to the investigation. It is the responsibility of the field geologist, also, to invite the petrographers from the Corps of Engineers laboratory to consult with him in the field about doubtful sources.

PHASE 2

Phase two consists of thorough petrographic and chemical tests of cores and/or crushed material from the quarry or deposit in question. As applied to concrete aggregate, petrography consists of the description and systematic classification of rocks by means of microscopic examination, micro-chemical tests, and certain physical tests, such as density, absorption, and coefficient of thermal expansion. Such petrographic data may provide either a basis on which the behavior of aggregates in concrete may be judged, in the absence of more comprehensive tests, or information supplementary to more comprehensive tests which will aid materially in the understanding of the probable behavior and quality of concrete containing these particular mineral aggregates.

PRELIMINARY EXAMINATION

The preliminary petrographic investigation of potential aggregate materials is designed to aid District personnel in judging which potential sources are of sufficiently promising quality to warrant further study. Such investigation is used as one of the bases of elimination in the survey of sources economically available to a given project.

For a preliminary petrographic study, the type of sampling recommended depends on the nature of the aggregate source. The following sources of material should be sampled as indicated in the following paragraphs:

A. Undeveloped deposits should be sampled by means of cores, drilled through the entire depth expected to be productive of sound material. Drilling of such cores should be in a direction essentially normal to the dominant structural trends of the rock. Massive structure may be sampled by "AX" ($1\frac{3}{16}$ "") cores. Thinly bedded or complex structures should be represented by cores not less in diameter than "NX" ($2\frac{1}{8}$ ""). There should be an adequate number of cores to cover the limits of the deposit necessary for the project under consideration. The entire footage of the recovered core should be included in the sample, with accurate data as to elevations, depths, and core losses.

B. Operating quarries in which stock piles of the material produced are available should be represented by not less than 100 pounds or 110 pieces, whichever is larger, of each size of produced material. The samples from stock piles should be composed of representative reductions of larger samples collected, with due consideration for segregation in the piles.

C. Exposed faces of nonproducing quarries where stock piles of processed material are not available should be represented by not less than 3 pounds from each distinctive stratum or bed, with no piece weighing less than one pound.

All samples of material must be accompanied by a full description of the deposit, including geographic location and owner, areal geology, depths and elevations, and any available information as to previous use. The name, location, size, and type of proposed structure in which the material may be used should also be provided, as well as the name of the geologist responsible for the sampling. A copy of the data should be attached to the letter of transmittal which requests the desired testing.

The report covering the preliminary petrographic analysis will contain recommendations as to what type and size of samples may be required for a complete petrographic analysis.

COMPLETE INVESTIGATION

A complete petrographic investigation is an integral part of any comprehensive study of the overall suitability of a material for its intended use. Samples to be used for this investigation are usually selected from the larger quantities submitted to the Division Laboratory for the comprehensive survey of the whole project. However, whether or not a comprehensive investigation is made, the

quantities and types of samples described below are the minima required for the complete petrographic analysis, and therefore must be provided for this purpose. Much of the material collected for the complete petrographic examination may also be made available, later, for other tests.

For a complete petrographic study, sampling of the following sources of material is not unlike that of the preliminary investigation.

A. Undeveloped deposits, or quarries which have been abandoned for many years, should be sampled by means of cores drilled normal to the rock structure through the entire depth expected to be productive of sound material. For this complete petrographic investigation, however, cores should not be less than 4 inches in diameter.

B. Operating quarries in which stock piles of the material produced are available should be sampled as prescribed above, but, more specifically, according to the following requirements:

Sieve Size	Weight (lbs)
3-6 inch	*1,000
1½-3 inch	200
¾-1½ inch	100
No. 4¾ inch	50
Sand	50

*or not less than 300 pieces.

Where the full range of size and grading of material is not being produced, sampling should be as prescribed for undeveloped quarries.

C. Exposed faces of non-producing quarries, where fresh stock piles of processed material are not available, should be sampled by the collection of not less than 5 pounds of the material in each distinctive exposed stratum or bed, with no piece weighing less than one pound. Each sample from outcrop or exposed face should be carefully marked with proper identification of elevation, depth or thickness of stratum, and other significant data.

The following acceptance and quality tests are included in the complete petrographic examination:

1. Size analysis by sieving
2. Test for soundness by use of magnesium or sodium sulfate
3. Determination of specific gravity and absorption
4. Los Angeles abrasion test for coarse aggregate
5. Determination of organic impurities in fine aggregate
6. Determination of soft particles in coarse aggregate
7. Separation into fractions by specific gravity
8. Determination of unit weight
9. Quick chemical test for reactivity
10. Mortar Bar Expansion test for reactivity
11. Petrographic analysis, including identification of constituents and per cent of each, and particle shape analysis
12. Determination of durability by rapid freezing and thawing
13. Determination of durability in heating-cooling and wetting-drying
14. Determination of durability of concrete under slow freezing and thawing
15. Determination of coefficient of linear thermal expansion
16. Toughness of rock by drilling normal to principal bedding plane

PHASE 3

Phase three consists of a physical and economic study. This includes information on extent and description of the property, approximate quantities of stone available, quantity and character of overburden, type, grade, and condition of haul roads, nearest rail shipping point, plant flow sheets and capacity, aggregate size produced and size limitations, availability of fine blending sand, service

record of aggregate, transportation facilities and charges to site, and approximate price of material at the plant.

All three phases of investigation are necessary before the U. S. Army Corps of Engineers can approve a new source of aggregate.

REFERENCES

- Corps of Engineers.** 1958. Conference on Recommended Practice for Petrographic Investigations of Aggregate for Concrete, Washington, D. C., 1958, Office, Chief of Engineers.
- Corps of Engineers.** 1963. "Investigation and Selection of Materials" in *EM 1110-2-2000*, Office, Chief of Engineers, Washington, D. C., 15 December.
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