# Highway Materials Survey in Tennessee

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This paper describes the aggregate survey conducted in 1948 and 1949 and published in 1950, and the present more detailed materials survey which was begun in 1959, discontinued, and then started again in 1962.

Due to a shortage of personnel, the present survey is being conducted on a part-time basis, and will probably require two years or more to complete. As the survey progresses, newer and better ideas and methods will no doubt be incorporated, but the basic plan as discussed in this paper will remain unchanged.

• IN 1950 the Division of Materials and Tests of the Tennessee Department of Highways published in book form county maps showing the location, type, and status of all known aggregate quarries and pits throughout the State. The 95 counties of the State are divided into four major divisions. The maps appear alphabetically by county according to division. Approximately two years was needed to check out thoroughly every quarry or pit site in the State for the original survey.

Each quarry or pit was examined, located on the county map (scale: 1 in. = 2 mi), and given a number. The status (active or inactive), type (limestone, marble, gravel, chert, and sand), and the owner or producer are also shown. The data on these maps are continually being brought up to date. As a quarry or pit is activated or deactivated, individuals possessing books are immediately notified of the changes. A complete revision of the original publication was issued in 1959.

## PRESENT MATERIALS SURVEY

With the need for tremendous quantities of higher standard aggregate materials in the construction of the Interstate System, it has become necessary to make a more detailed inventory of Tennessee's aggregate sources. This survey, which is presently under way, consists of preparing detailed columnar or geological sections of all major active quarries, gravel pits, and sand pits throughout the State. Surveys of inactive quarries and pits near proposed Interstate alignments where haul distances from active aggregate sources are great are also being made at this time. As progress is made and as time permits, the present survey will be expanded to include potential pit and quarry sites in areas where construction materials are relatively scarce. These columnar and geological sections along with quarry or pit location maps will be published in loose-leaf book form at the completion of the survey.

This survey is being conducted by geologists of the Division of Materials and Tests with the aid of materials engineers and inspectors. Each quarry or pit is measured directly and logged in as much detail as is considered necessary. The amount of detail usually depends on the type of rock materials being quarried. Characteristic samples from individual strata are collected during the logging operation and are described in detail on the work copy of the log which is kept on file. The published log generally does not contain the detail of the work copy unless it is believed to be of engineering significance.

In quarries, columnar sections are used to show vertical lithologic changes and thicknesses where there is little or no deformation of the strata, that is, folding and faulting (Fig. 1). Geological sections are used where there is considerable folding and faulting or where there are significant horizontal lithologic changes (Fig. 2). In some cases, as in the Hoover quarry (Fig. 3), a combination columnar-geological section has

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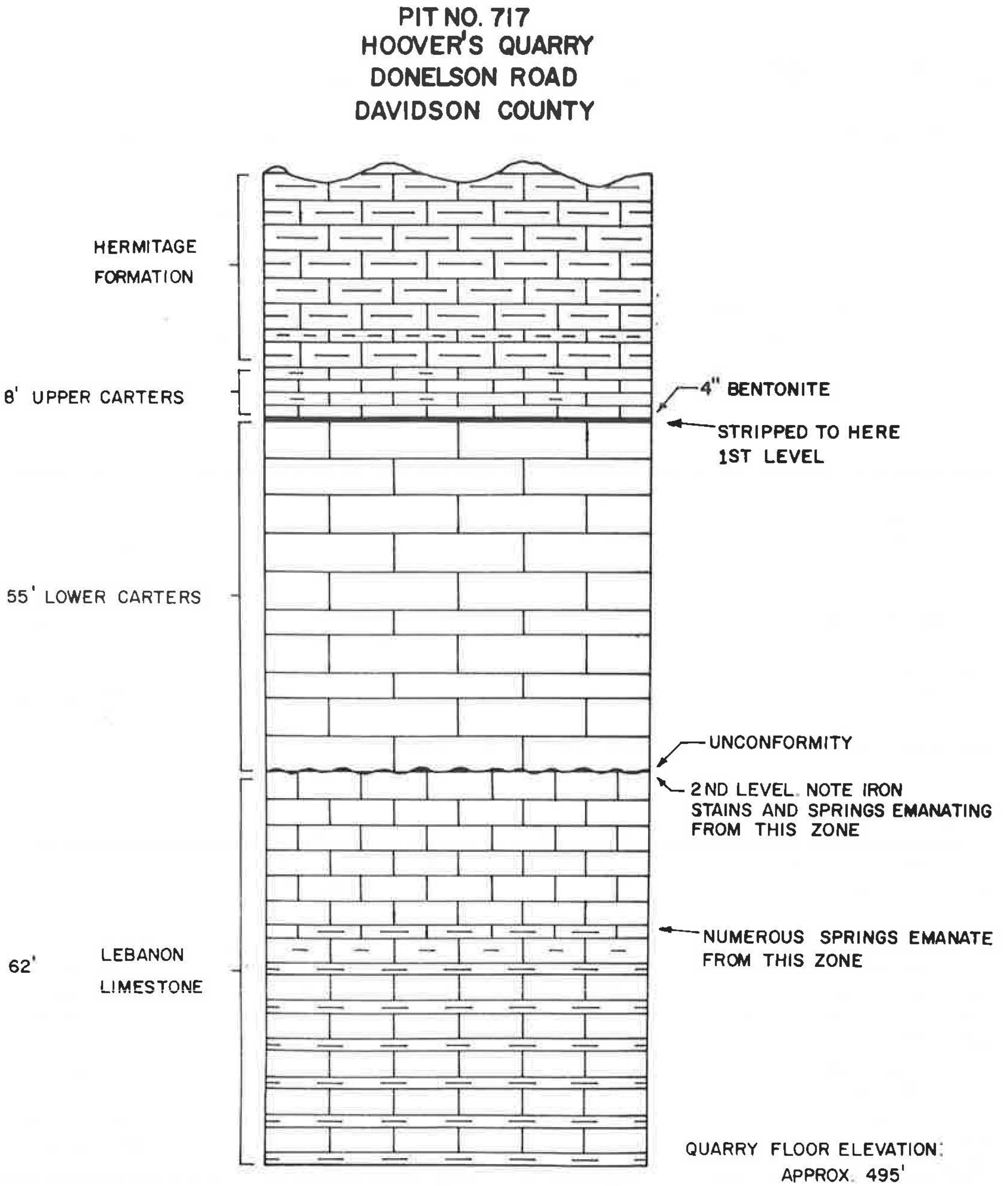



Figure 1. Columnar section showing two well-known and extensively quarried formations (Lower Carters and Lebanon) in Central Tennessee.

been used. When the structure of a quarry is not so complex as to warrant a geological section, and the dip of the strata is relatively uniform and in one direction, it is often necessary to make several logs along the direction of dip to show the complete sequence of strata being quarried (Fig. 4).

Measurements of individual strata in quarries with faces less than 100 ft, or where the strata are quarried in lifts up to 50 ft, are accomplished directly with a steel tape.

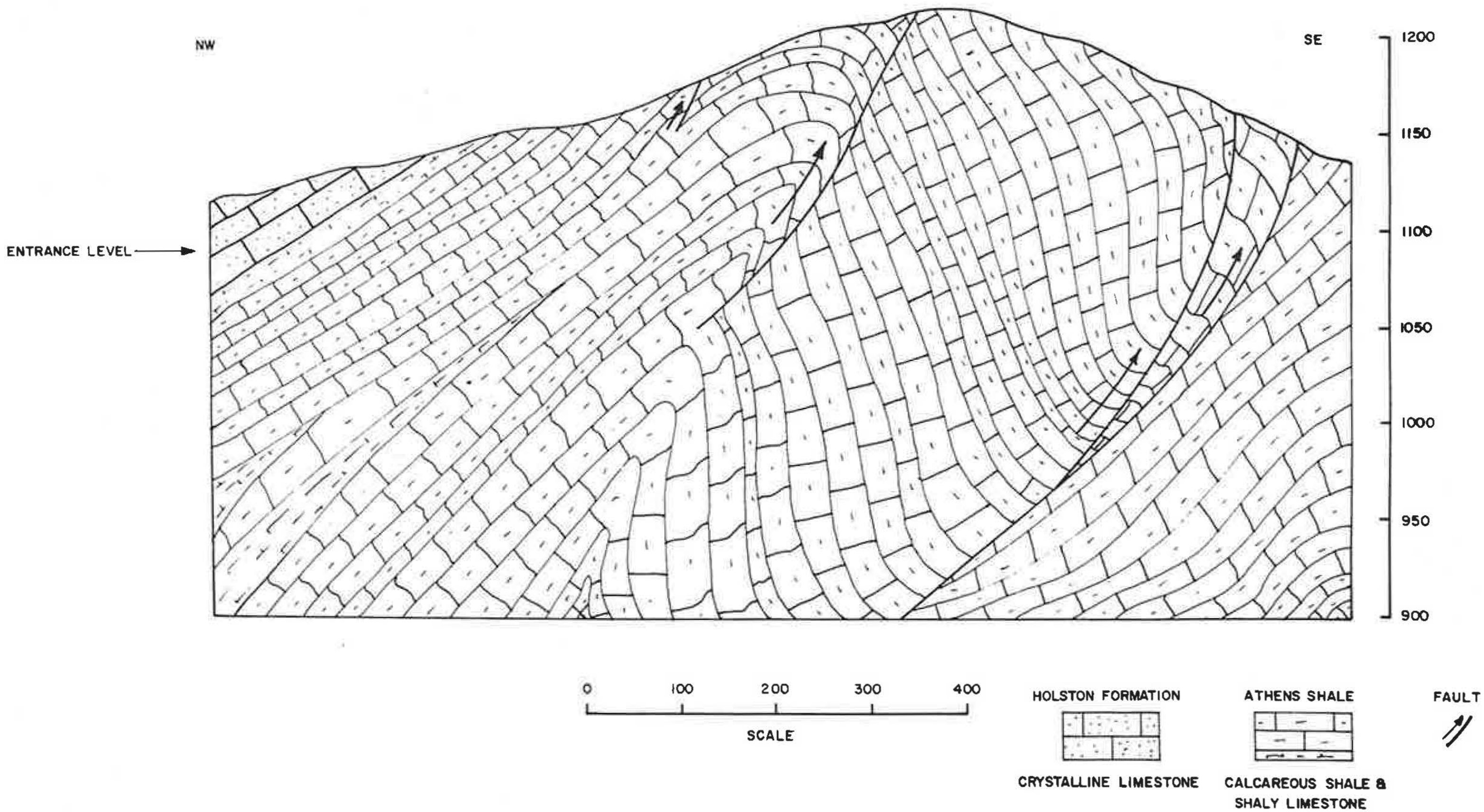



Figure 2. A generalized northwest-southeast geological section showing complexity of Webb quarry in McMinn County.

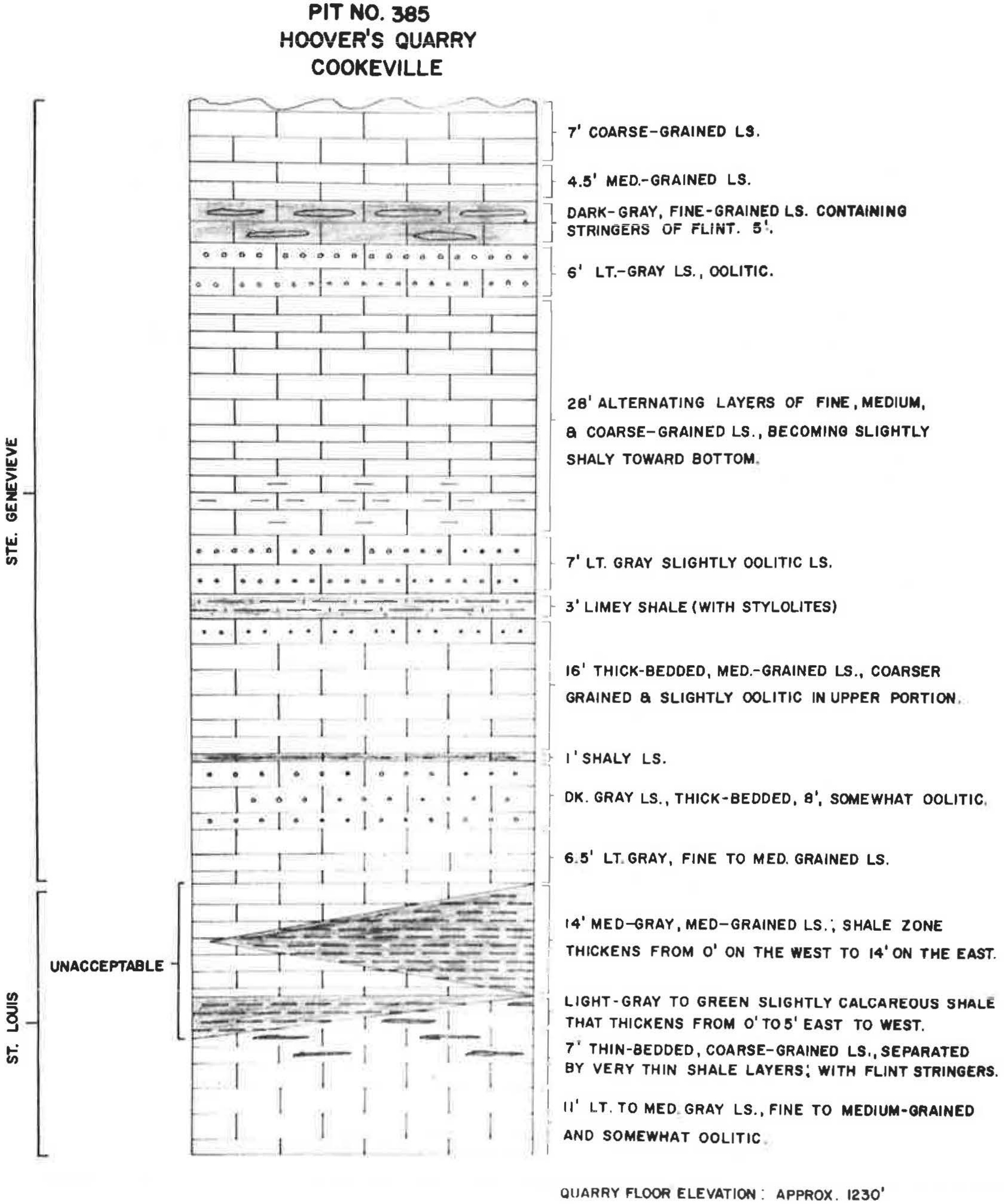



Figure 3. Combination columnar-geological section of quarry shown in Figure 1.

A rope or chain, graduated in 5-ft sections with red cloth strips that can be seen against the quarry face, is used for higher quarry faces. One end of the rope is weighted so that it does not lag or drape when hanging from a ledge or quarried level.

The most completely exposed section in the quarry is usually chosen as the section to be logged. However, due to the inaccessibility of some of the strata in the higher faces, the log may be drawn as a composite of strata studied in different, more accessible areas of the quarry.

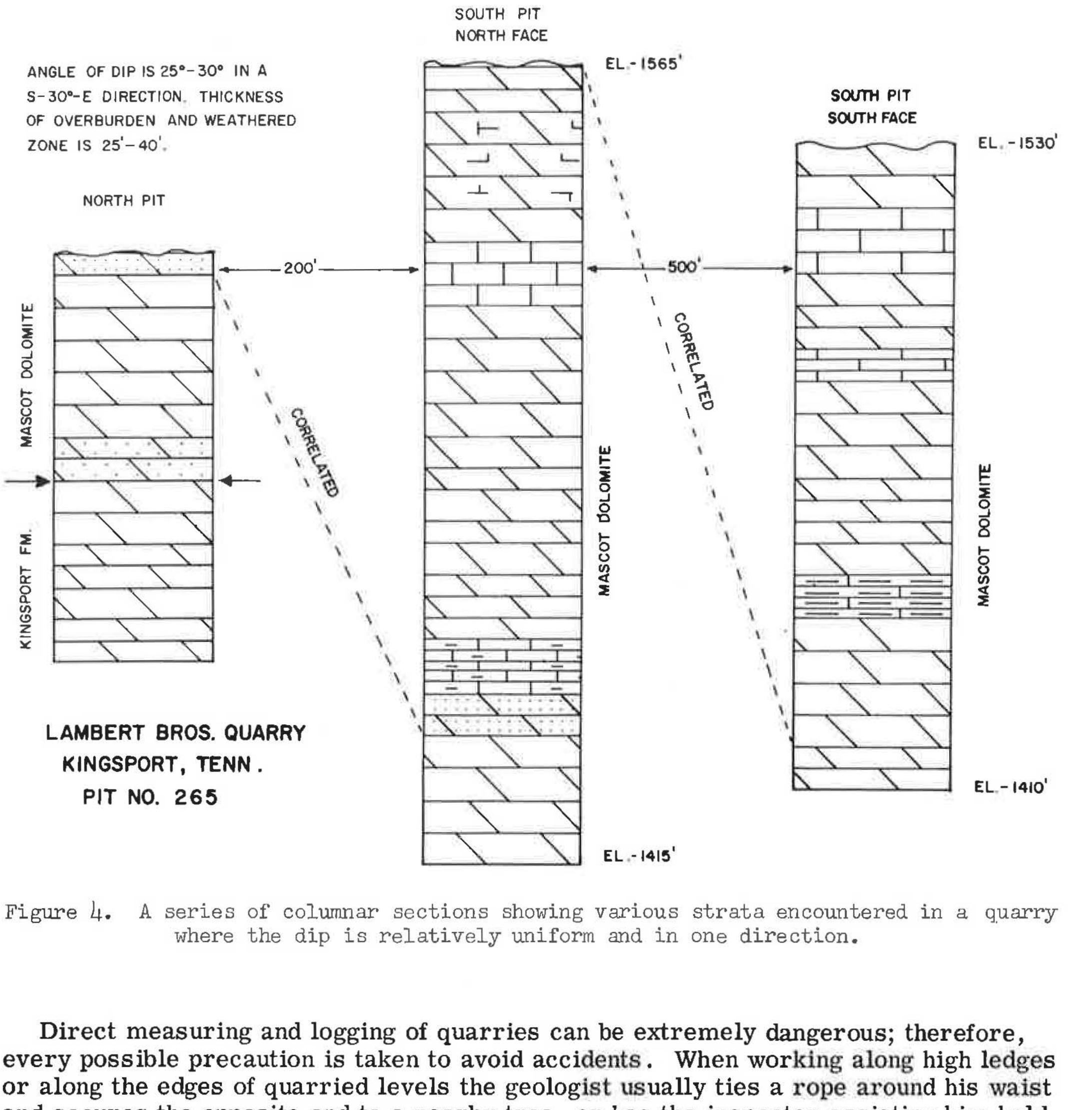



Figure 4. A series of columnar sections showing various strata encountered in a quarry where the dip is relatively uniform and in one direction.

Direct measuring and logging of quarries can be extremely dangerous; therefore, every possible precaution is taken to avoid accidents. When working along high ledges or along the edges of quarried levels the geologist usually ties a rope around his waist and secures the opposite end to a nearby tree, or has the inspector assisting him hold the loose end. Also, his Brunton compass, geological hammer, etc., are attached to his belt so that both hands are free for climbing. A hard hat is worn for protection against falling rock.

The scale of the log depends on the detail needed, as well as on the height of the quarry face. The scale is controlled also, of course, by the size of the paper used in the publication, which in this case will be $8\frac{1}{2} \times 11$ in. Quarries and pits with less than 100-ft faces are usually logged with a scale of 5 or 10 ft to 1 in. Quarries with faces greater than 100 ft, but again depending on the amount of detail required, may have a scale of 1 in. = 15 ft or 1 in. = 20 ft. Still smaller scales have been used in three or four instances where the geology is highly complex and the dimensions of the quarry are of unusual proportions. The Webb quarry (Fig. 2) is such an example.

In logging gravel deposits, the geologist usually describes and samples for testing the soil materials associated with the deposit; the reason being that these gravels normally do not contain sufficient fines (minus 40 sieve material), and it is often necessary to blend a suitable soil binder with the gravel to meet the specification. In West Tennessee, due mainly to the fact that there are no other materials available, gravel is the main base and aggregate source. A recent primary project in that part of the State called for a base material with the following specification:

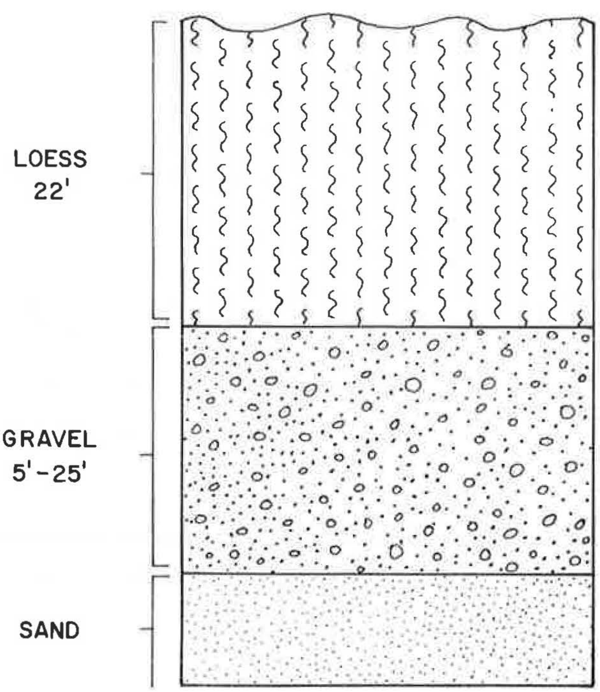
| Sieve Size | Total Percent Passing (Dry Wt.) |
|---|---|
| $1\frac{1}{4}$ in. | 100 |
| 1 in. | 95-100 |
| $\frac{3}{8}$ in. | 50-80 |
| 4 M | 36-65 |
| 16 M | 20-40 |
| 100 M | 8-15 |

The fraction passing the number 40 sieve (soil filler) shall have a liquid limit not greater than twenty-five (25), and a plasticity index not greater than six (6).

A gravel deposit like the one shown in Figure 5 was located nearby. However, because the gravel contained insufficient minus 40 sieve material, 10 percent binder derived from the loessial deposit overlying the gravel was added to form the specified mix.

In a more recent gravel-base project in Central Tennessee a sufficient quantity of gravel was located, but a binder that could meet the liquid limit requirements of the

PIT NO. 388
MEMPHIS STONE CO.
CURVE
LAUDERDALE COUNTY




ELEVATION AT TOP OF PIT: APPROX. 475'

| | | |
|---|---|---|
| SAMPLE NO. | 1 | 2 |
| DEPTH, FT. | 5'-7' | 12'-15' |
| GRADATION - % PASSING | | |
| SIEVE NO. | | |
| 40 M | 100 | 100 |
| 100 M | 99 | 99 |
| 200 M | 97 | 98 |
| % SILT | 83 | 88 |
| % CLAY | 14 | 10 |
| LL | 33 | 31 |
| PL | 29 | 25 |
| PI | 4 | 6 |
| TYPE | A-4(8) | |
| P. DENSITY | 107 | 106 |
| O. MOISTURE | 13 | 12 |

— LOESS

SEE TABLE I FOR GRAVEL GRADATION

| | |
|---|---|
| GRADATION - % PASSING | |
| SIEVE NO. | |
| 10 M | 100% |
| 40 M | 74% |
| 100 M | 10% |
| 200 M | 8% |
| % SILT | 4% |
| % CLAY | 4% |
| NON-PLASTIC | |
| TYPE | A-3(0) |

— SAND

Figure 5. A typical gravel deposit in West Tennessee.

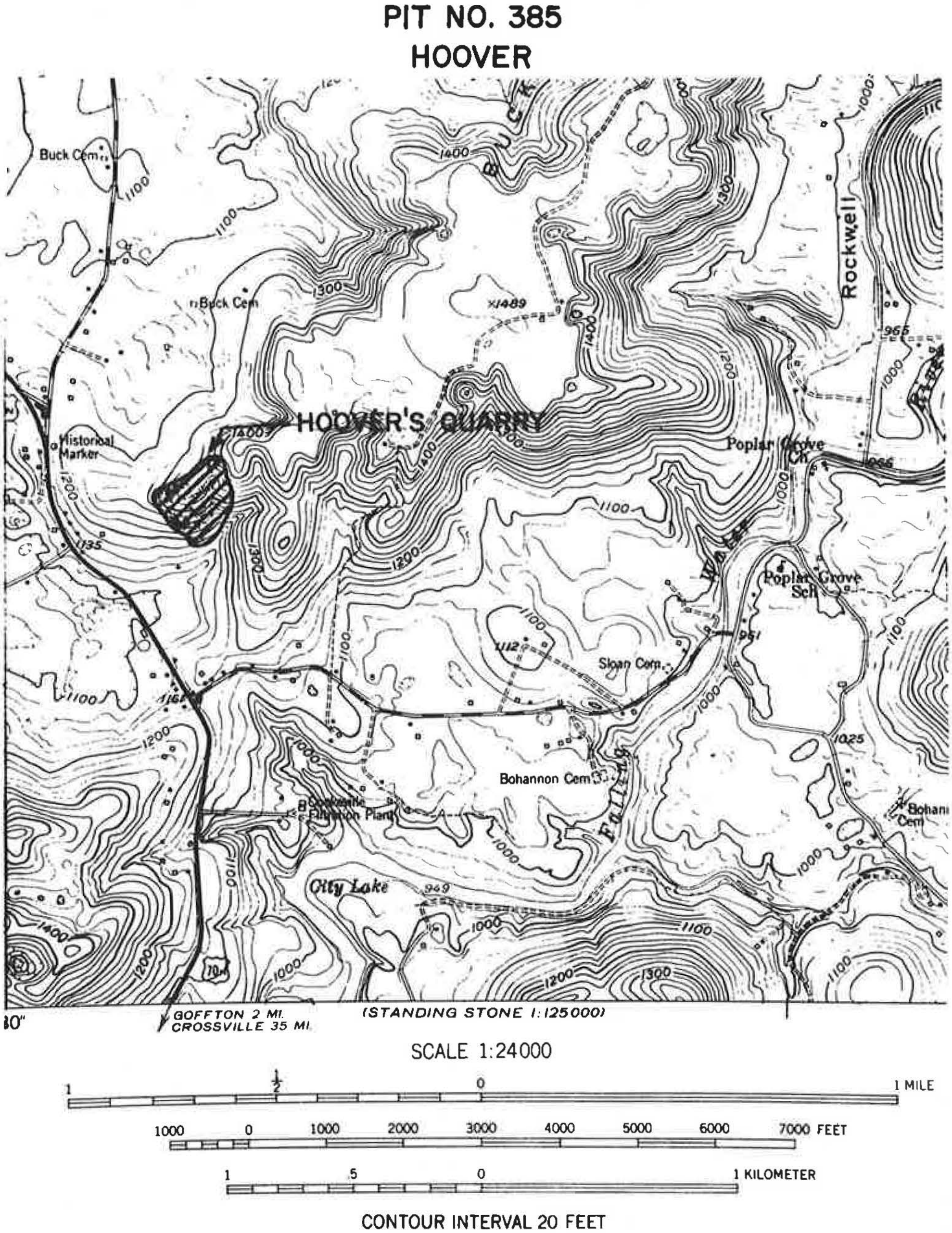



Figure 6. Typical example of a pit location map.

total mix specification could not be found in the project area. This, unfortunately, was not discovered until after construction had begun. The gravel base had been bid as an alternate by the contractor in lieu of crushed stone. This is an unusual case but it is an excellent example of the importance of considering every item, no matter how small, in making a materials survey.

The quarry and pit locations are spotted on 6-in. square cut-outs of U.S. Geological Survey, Corps of Engineers, or Tennessee Valley Authority topographic maps (Fig. 6).

Most maps are of the 7½-min quadrangle size (1 in. = 2,000 ft), with 15-min quadrangles (1 in. = 1 mi) being used where the larger scale maps are not available.

Elevations of quarry and pit floors, formation tops, etc., are determined with an aneroid barometer or taken directly from topographic maps. A Brunton compass is used to determine angles and directions of dip of the strata.

When a particular geologic formation is quarried extensively and the formation is relatively uniform over a wide area, then, to avoid repetition, only formation names, thicknesses, etc., are shown on the drawing (Fig. 1). These important aggregate-source-formations will be discussed in the text of the report in conjunction with the physiographic provinces in which they occur. In many cases, however, a description of the strata is given directly on the illustrated section (Fig. 3).

Once a quarry or pit has been logged, it is revisited periodically to determine if any new strata have been uncovered or if there have been any lateral changes in the strata already logged. If significant changes are noted, a new log is issued to replace the outdated log which can be easily removed from the loose-leaf binder.

Typical test data from each quarry or pit will be tabulated in the back of the publication (Table 1). These data, taken from the files of the Division of Materials and Tests, include results of tests conducted on quality samples over a period of three or four years. From these tables the user of the report should get some idea of the consistency of the materials furnished by the various quarries. Normally, test results from six or eight samples are given, depending on how long the quarry or pit has been operating or how many quality samples have been taken.

TABLE 1

| COUNTY | PIT NO. | DATE | MAP PAGE NO. | SP. GRAVITY +4 | SP. GRAVITY −4 | DENSITY PCF (DRY) | OPTIMUM MOISTURE | LIQUID LIMIT | PLASTIC LIMIT | P.I. | SOUNDNESS | L.A. WEAR | GRADATION—% PASSING 2 | 1½ | 1 | 3/4 | 1/2 | 3/8 | 4 | 10 | 20 | 40 | 60 | 100 | 200 | % SILT | % CLAY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KNOX | 411 | 11-2-60 | 27 | 2.75 | | | | | | | 98.8 | 19 | | | | | | | | | | | | | | | |
| KNOX | 411 | 5-8-61 | 27 | 2.70 | | | | | | | 99.4 | 19 | | | | | | | | | | | | | | | |
| KNOX | 411 | 5-10-62 | 27 | 2.74 | | | | | | | 99.2 | 19 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| KNOX | 316 | 3-23-60 | 29 | 2.78 | | | | | | | 99.1 | 19.5 | | | | | | | | | | | | | | | |
| KNOX | 316 | 4-19-61 | 29 | 2.79 | | | | | | | 99.4 | 16.8 | | | | | | | | | | | | | | | |
| KNOX | 316 | 4-24-62 | 29 | 2.79 | | | | | | | 99 | 19.9 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PUTNAM | 385 | 5-2-62 | 67 | 2.68 | | | | | | | 95.5 | 22.4 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| HAMILTON | 260 | 8-2-60 | 59 | 2.75 | | | | | | | 80.8 | 23 | | | | | | | | | | | | | | | |
| HAMILTON | 260 | 3-28-61 | 59 | 2.71 | | | | | | | 97.4 | 24.6 | | | | | | | | | | | | | | | |
| HAMILTON | 260 | 3-6-62 | 59 | 2.74 | | | | | | | 98.1 | 24.4 | | | | | | | | | | | | | | | |
| HAMILTON | 260 | 6-13-62 | 59 | 2.72 | | | | | | | 94.2 | 23 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DAVIDSON | 717 | 3-8-61 | 73 | 2.69 | | | | | | | 93.9 | 22.4 | | | | | | | | | | | | | | | |
| DAVIDSON | 717 | 10-16-61 | 73 | 2.68 | | | | | | | 97.3 | 23 | | | | | | | | | | | | | | | |
| DAVIDSON | 717 | 4-12-62 | 73 | 2.68 | | | | | | | 96.7 | 23.2 | | | | | | | | | | | | | | | |
| DAVIDSON | 717 | 7-23-62 | 73 | 2.69 | | | | | | | 97.2 | 26.8 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LAUDERDALE | 388 | 9-12-62 | 89 | 2.46 | 2.60 | | | 25 | 16 | 9 | | | 98 | 93 | 87 | 81 | | 68 | 54 | 47 | | 12 | | 5 | 5 | 2 | 3 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MCMINN | 267 | 9-7-60 | 63 | 2.70 | | | | | | | 95.9 | 15.8 | | | | | | | | | | | | | | | |
| MCMINN | 267 | 1-20-61 | 63 | 2.70 | | | | | | | 94.4 | 19.4 | | | | | | | | | | | | | | | |
| MCMINN | 267 | 1-17-62 | 63 | 2.71 | | | | | | | 91.0 | 18.0 | | | | | | | | | | | | | | | |
| MCMINN | 267 | 7-26-62 | 63 | 2.70 | | | | | | | 91.8 | 21.0 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OVERTON | 150 | 10-13-60 | 65 | 2.64 | | | | | | | 94.5 | 28.8 | | | | | | | | | | | | | | | |
| OVERTON | 150 | 5-9-61 | 65 | 2.65 | | | | | | | 94.7 | 26.1 | | | | | | | | | | | | | | | |
| OVERTON | 150 | 7-17-62 | 65 | 2.68 | | | | | | | 96.2 | 25.0 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# CONCLUSION

The present inventory has enabled geologists and engineers to become more familiar with the construction characteristics of the various formations quarried throughout the State. The problem formations and problem strata within formations, as well as the quarries in which they occur, having been pinpointed, can now be more easily checked and controlled.

This survey has also served to some extent as a teaching program for quarry inspectors, for in learning some of the basic principles of petrography and lithology from the geologist, and by studying the quarry foot by foot with the geologist, they have become better qualified as aggregate inspectors.

Research conducted on the skid-resistant qualities of various pavement aggregates has proved that aggregates derived from some geological formations are more skid resistant than others. This inventory should prove useful in the location of these more skid-resistant aggregate-producing formations and strata.

Both the original and the present surveys have enabled the Division of Materials and Tests to furnish the Plans Department, for their cost estimates, accurate and prompt information concerning haul distances from accepted quarry or pit sites to proposed construction sites.

The determination of construction material needs versus availability has been greatly facilitated by the issuance of the aggregate deposit location maps. The present survey should prove even more valuable as a source of such information.