SAND COMPACTION STUDIES AT EGLIN FIELD, FLORIDA

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SYNOPSIS

A high degree of compaction is required in cohesionless sand subgrades to minimize rutting and roughening of flexible pavement surfaces carrying heavy airplane wheel loads. Studies were conducted by the Corps of Engineers at Eglin Field, Florida to secure information on practical methods of securing such compaction in uniform sand subgrades down to depths of 6 ft. below the pavement surface during construction Test sections were of sufficient size to permit traffic compaction by heavy grading equipment ranging from an RD-8 tractor to large earth moving equipment with loads up to 60,000 lb. per wheel Data were secured on the comparative effect of compacting soaked, sprinkled and dry sections.

Indications from the results point to the need of heavy loads and vibration to effect a satisfactory degree of compaction over the necessary depth range in sand subgrades. For the conditions which exist at Eglin Field the addition of moisture does not add materially to the compaction

The U. S. Engineer Department is conducting a comprehensive soil compaction investigation[1] to obtain field and laboratory information on the compaction characteristics of soils. The natural sand subgrade phase of this investigation was conducted at Eglin Field, Florida, for the specific purpose of determining the effectiveness of heavy tractors and heavy rubber-tired wheel loads in obtaining deep compaction of loose free draining sand subgrades An accelerated traffic test[2] conducted in 1943 in the Eglin Field area disclosed that excessive settlements in flexible pavement surfaces were caused by compaction in the underlying sand subgrade under continued heavy wheel load traffic.

Airfield pavements are now being designed for plane loads greatly in excess of the present B-29. Tentative design criteria for these very heavy bomber (VHB) pavements, have been established by the Office, Chief of Engineers. The requirements for sand subgrades states in part "Clean sand subgrade in unfilled areas and in areas of less than 2 ft. fill should be compacted to at least 100 per cent modified AASHO density to a depth of at least 2 ft. below the surface of the subgrade. The method used in compacting sand subgrades should be effective to produce compaction to at least 95 per cent modified AASHO density at a depth of 6 ft. below the pavement surface". These criteria provided a guide to the effectiveness of the various compacting methods and procedures used in this investigation.

Eglin Field is located 50 miles east of Pensacola, Florida, on the Gulf of Mexico. Subgrade conditions in this area are very uniform, the material being a medium to fine free draining sand with little or no silt and clay. With the exception of the areas near the Gulf, the groundwater level is about 15 to 25 ft. below the surface. The same auxiliary field used in the 1943 traffic tests was selected as the site for the sand compaction investigation.

The test layout comprised five sections as shown on Figure 1. Provision was made in each section for a ponded or soaked test area, a sprinkled test area, and a natural-moisture or so called "dry" test area. Each section was 275 ft. long with areas at both ends for maneuver and turnaround purposes. Sections 1 to 4 inclusive were 30 ft. wide, while section 5 was only 25 ft. wide. Other dimensions are shown on Figure 1.

Prior to testing, the sections were graded with an RD-8 tractor, 8-cu. yd. tournapull, and a tractor-drawn patrol. The top materials containing some grass, roots, etc. were

[1] A final report of all these investigations will be published by the U. S. Waterways Experiment Station, Vicksburg, Mississippi.

[2] See "Accelerated Traffic Tests at Eglin Field, Florida" by F. A. Robeson, *Proceedings*, Highway Research Board, Vol. 24, p. 55 (1944).

removed to a depth of 12 in. in the sprinkled and dry test areas, and to a depth of 18 to 24 in. in the ponded test areas, during this operation. The five sections were compacted as follows:

Section 1—RD 8 tractor weighing about 34,000 lb.—6, 12, and 18 coverages.[3] A view of this tractor in the ponded test area is shown in Figure 2. A view after tracking is given in Figure 3.

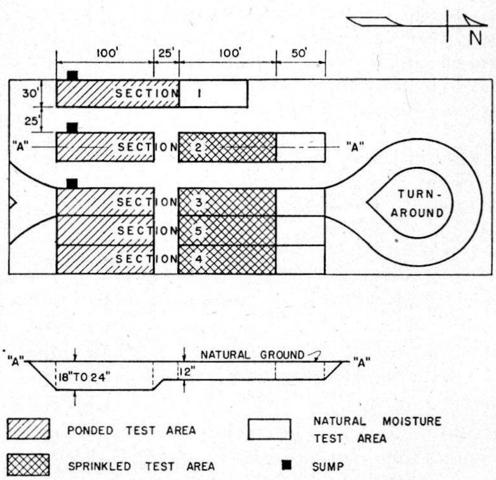

Figure 1. Layout of Sand Compaction Studies at Eglin Field, Florida.

Figure 2. RD-8 Tractor in Ponded Area of Section 1.

Section 2—Loaded 8-cu. yd. tournapull, gross weight, 60,000 lb. or 15,000 lb. per wheel—25 coverages. This unit had two 16-in. by 21-in. tires on the rear axle inflated to 45 p.s.i. and two worn 21-in. by 24-in. tires on the front axle inflated to 38 p.s.i. This vehicle can be seen in the background in Figure 4.

Section 3—Loaded model NU scraper tournapull, gross weight 240,000 lb., or 60,000 lb. per wheel—25 coverages. This unit had four 30-in. by 40-in. tires inflated to 45 p.s.i. See Figures 5 and 6.

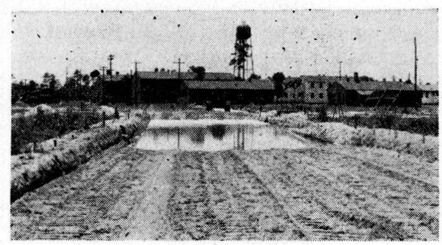

Figure 3. Section 1 after Tracking

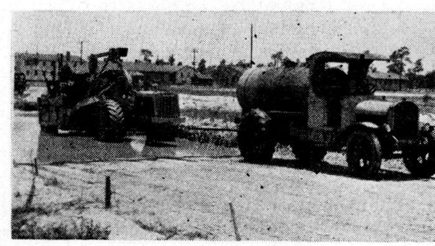

Figure 4. Tracking and Sprinkling Operations in Section 2.

Figure 5. General View of Tracking in Section 3.

Section 4—Loaded RD-8 tractor gross weight about 80,000 lb.—12 coverages. See Figure 7.

Section 5—Partially loaded model NU Scraper tournapull used for Section 3—Gross weight 140,000 lb. or 35,000 lb. per wheel—6 coverages.

Each of the ponded test areas was provided with a sump to which a 6 in. water line was run from a 75,000 gal. storage tank. A view of

[3] One coverage refers to a complete coverage of tractor treads or pneumatic tires over the area being compacted. Several trips are necessary to effect one coverage.

the sump with water discharging into it is shown in Figure 8. Just prior to start of tracking, the ponded area was flooded to a depth of 3 or 4 in. A 900 gal. capacity water wagon with sprinkler bar attached was used on the sprinkled test areas. This unit operated just ahead of the tracking equipment and applied approximately ½ gal. of water per square yard per trip to the area being compacted. (See Fig. 4.)

The effectiveness of each compaction procedure was measured by the resulting densities produced in the subgrade sand. A number of test pits were excavated for this purpose prior to and after grading operations, and at appropriate stages during the tracking oper-

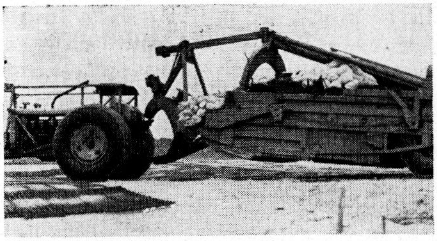

Figure 6. Large Tournapull Loaded to 60000-lb. Wheel Load.

Figure 8. Pipe Discharging Water into Sump for Ponded Area Test.

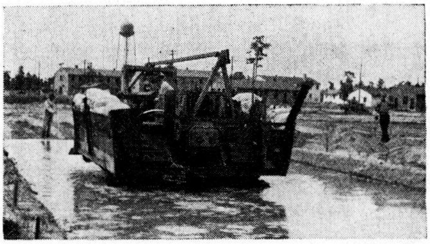

Figure 7. Loaded RD-8 Tractor Weighing 80000 lb. Tracking in Section 4.

Figure 9. Field Density Determination by Sand Displacement Method.

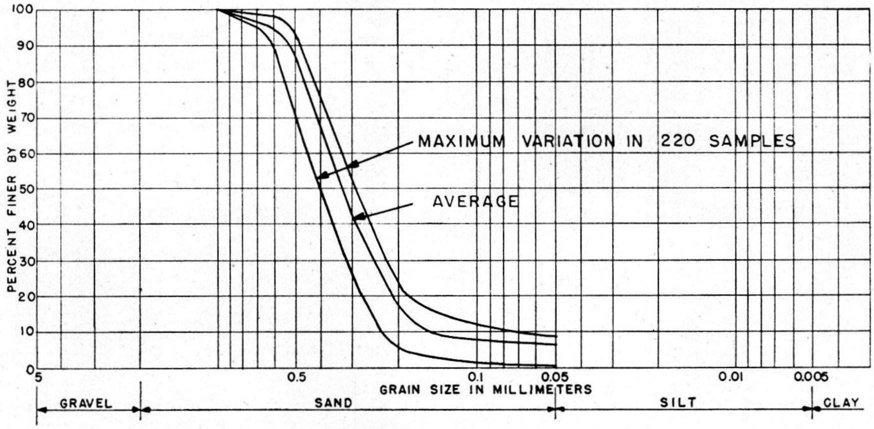

Figure 10. Mechanical Analyses of Sand Subgrade

ations. Densities and moisture contents were determined for each 1-ft. depth interval down to depths of 6 ft., using the sand-displacement method as illustrated in Figure 9. These were supplemented by cross-sections taken with a level to disclose vertical subsidence of the surface. Records were kept of the amounts of water used in the ponded areas and in the sprinkled areas.

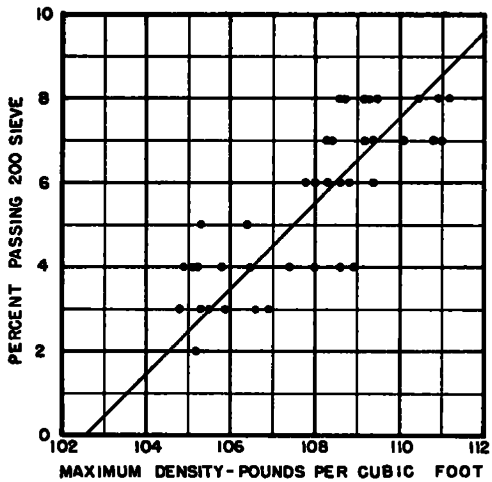

Figure 11. Maximum Density versus Per Cent Passing 200 Sieve.

Laboratory samples of the subgrade material were taken to represent each field density determination. These were tested for mechanical composition and maximum density In spite of the apparent uniformity of the subgrade sand, as indicated by the mechanical composition chart, Figure 10, a variation from 104 lb. per cu. ft to 112 lb per cu. ft in the values of maximum density as given by the Modified AASHO compaction test was noted in the results In order to eliminate the necessity of performing a separate compaction test on each sample, a relationship between the percentage passing the No 200 sieve and the maximum density was determined graphically for those samples on which the compaction test was run The resulting straight line is shown on Figure 11, and although the points are a trifle scattered, the relationship is within 2 lb. of the maximum

TABLE 1
DENSITY DATA FOR AREAS COMPACTED WITH TRACTORS
Percentage of Maximum Density

Depth (ft.)	Before Grading	After Grading	RD-8 Tractor (34,000 lb gross)					Loaded Tractor (80,000 lb gross)		
			Ponded Area			Dry Area		Ponded Area	Sprinkled Area	Dry Area
			6 Coverages	12 Coverages	18 Coverages	12 Coverages	18 Coverages	12 Coverages	12 Coverages	12 Coverages
0–1	90	97	101	98	95	99	98	99	102	102
1–2	88	94	97	95	94	97	94	102	101	102
2–3	86	92	92	93	93	93	90	100	97	97
3–4	86	90	92	90	91	88	88	96	94	95
4–5	87	90	92	91	89	91	90	96	94	92
5–6	88	91	90	91	90	89	88	94	94	93

TABLE 2
DENSITY DATA FOR AREAS COMPACTED WITH RUBBER-TIRED WHEELS
Percentage of Maximum Density

Depth (ft)	Before Grading	After Grading	25 Coverages 15,000-lb Wheel Load			6 Coverages 35,000-lb Wheel Load			25 Coverages 60,000-lb Wheel Load		
			Ponded Area	Sprinkled Area	Dry Area	Ponded Area	Sprinkled Area	Dry Area	Ponded Area	Sprinkled Area	Dry Area
0–1	90	97	98	97	103	101	103	104	101	106	102
1–2	88	94	102	98	98	108	103	103	104	104	101
2–3	86	92	95	93	94	102	99	99	102	103	102
3–4	86	90	85	87	90	96	95	94	97	98	97
4–5	87	90	88	88	88	96	95	95	94	96	96
5–6	88	91	92	89	92	95	94	94	94	94	96

density for the widest variation This plot was used for computing all the present compaction data given in Tables 1 and 2

The cross-section data taken at intervals throughout the test are summarized in Table 3. These data are somewhat erratic, due probably to the transportation of surface material by treads and wheels, and are considered less important than the density data. On the whole, they indicate the small benefit to compaction resulting from increasing the number of coverages. They also indicate that the compaction extends several feet below the 6-ft depth—for example, the density data indicate that a vertical settlement of about 4 in. occurred between grading operations and end of tracking in Section 3, while the cross sections indicate that about 6 inches did occur. If compaction was limited to material in the top 6 ft., these two figures should be the same. The cross sections served as a substitute for test pits at partial stages of each test and considerable time was saved over that required to excavate a test pit and perform the density tests

TABLE 3
SUMMARY OF CROSS-SECTION DATA

Item	Coverages	Settlement (in)					
		Saturated		Sprinkled		Dry	
		Max	Ave	Max	Ave	Max	Ave
RD-8 Tractor	6	2 0	1 0			1 2	0 8
	18	3 0	1 2			2 5	1 3
15,000-lb Wheel	6	4 0	3 0	3 5	2 0	2 5	1 5
	25	4 5	3 4	4 0	2 5	3 0	1 8
35,000-lb Wheel	6	5 5	3 5	4 0	2 8	3 5	2 8
60,000-lb Wheel	6	7 0	5 0	5 0	3 0	4 0	3 0
	25	8 0	6 0	7 2	5 5	6 0	4 8
80,000-lb Tractor	6	4 5	3 0	3 5	2 0	1 5	0 8
	25	4 5	2 5	4 0	2 5	3 5	2 0

The results of the density tests given in Tables 1 and 2, have been plotted in bar graph form along with the tentative minimum requirements for very heavy bomber pavement design, as shown on Figure 12 Since this study is only a part of a comprehensive compaction study, no general conclusions can be drawn from these results. However, for the conditions which exist at Eglin Field, the following comments and discussion of the results are indicated:

a Prior to grading, the Eglin Field sand to a depth of 5 ft. has a density between 85 and 90 per cent of the maximum as determined by the modified AASHO compaction test.

b Moderately light grading operations with the equipment normally used in this vicinity increases the density some 7 per cent in the top 2 ft. and some 3 per cent at 4- to 5-ft. depth. This is still considerably under the tentative VHB requirements.

c The equipment used gave results in this ascending order: RD-8 tractor, 15,000-lb. wheel load, loaded RD-8 tractor (80,000-lb. gross weight) 35,000-lb wheel load and 60,000-lb. wheel load. It appears that the Eglin Field subgrades can be compacted to the VHB requirements with wheel loads of the order of 35,000-lb.

d. Addition of water by sprinkling or ponding does not add materially to the degree of compaction being obtained This indication seems to be in direct conflict with engineering experience, such as compacting saturated beach sands and other cohesionless materials In order to obtain more information of the degree of saturation in the ponded areas, a test was made of the moisture contents in each successive 1-ft. depth interval down to a depth of 4 ft when free water was on the surface The results showed moisture contents ranging from 6 per cent to 8 per cent of the dry weight of the material indicating only 33 per cent saturation The reason for this became apparent when the water in the first section infiltrated into the subgrade, leaving a film of silt which had been brought into suspension by the churning action of the tracking This silt clogged the surface, rendering it less permeable than the material below the surface If complete saturation could have been attained a different result might have been found.

e Increase in density can be secured more easily by using a low number of coverages of a heavier load than by greatly increasing the number of coverages of a lighter load The results indicate that after about six coverages of any compacting unit, the benefit of additional coverages is slight

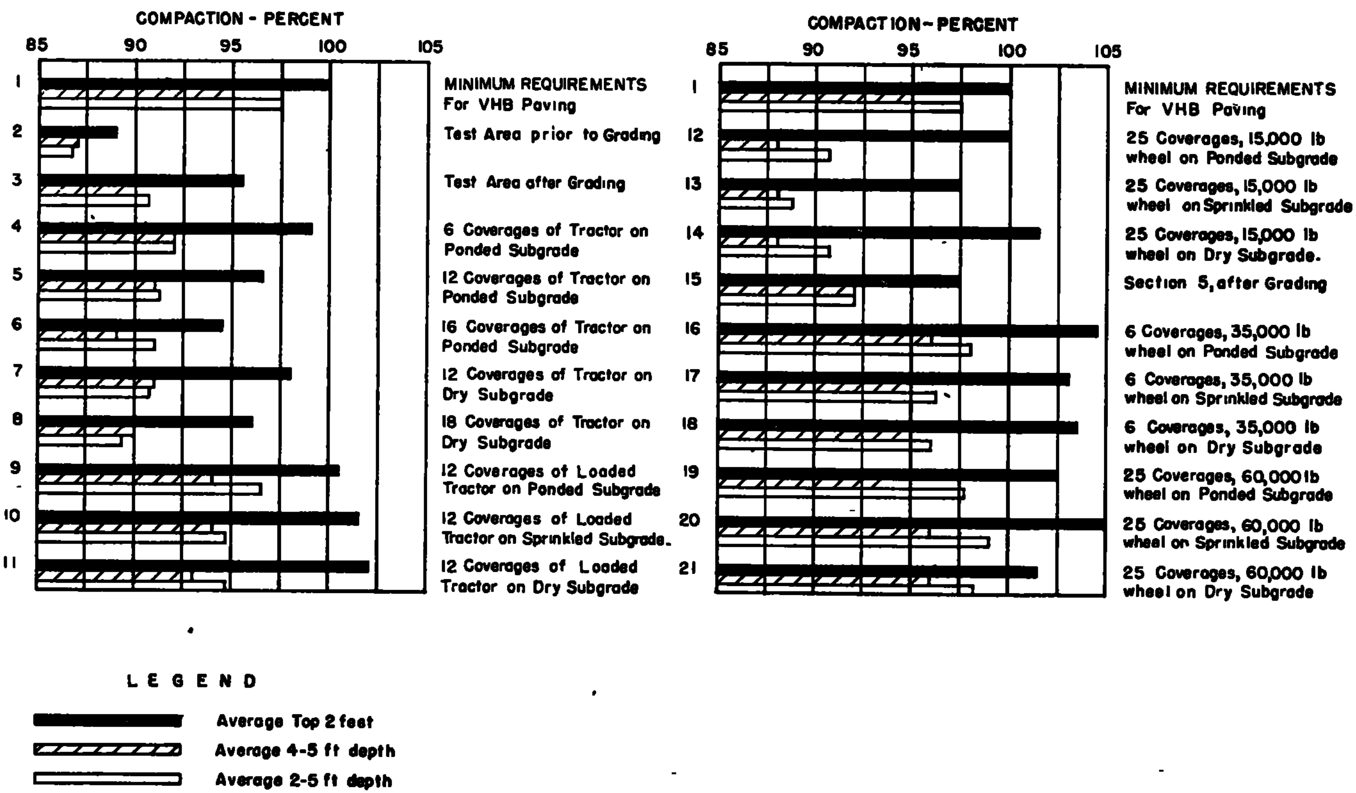

Figure 12. Bar Graph Summary of Density Results