ACCELERATED TRAFFIC TESTS FOR FLEXIBLE AIRFIELD PAVEMENTS

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SYNOPSIS

During 1942 and 1943 accelerated traffic tests were conducted at eight locations on existing flexible airfield pavements. The purpose of these tests was to secure pertinent information relative to the specific fields and, in addition, to supply data useful for general design criteria. The paper briefly reviews the summary report prepared by the U. S. Waterways Experiment Station for these tests and concludes that· (1) where a plasticity index value is used as a measure of quality the data indicate it should be less than 10. Where quality is measured by the CBR test the CBR should be in excess of 35 and probably about 70, (2) good compaction of the subgrade and base is essential to prevent detrimental consolidation from heavy wheel loads, and (3) construction joints are critical points in a soil-cement base.

The rapid expansion of the Army Air Forces during the early part of the war required the construction of hundreds of airfields. At that time the available criteria for the design and construction of flexible pavements were for highway loadings. A few fields were required for light trainer planes but by far the greater majority were for wheel loads of at least 15,000 lb and design wheel loads of 60,000 lb were not uncommon. In order to formulate design criteria for these heavier wheel loads, the Corps of Engineers initiated a comprehensive program of laboratory and field tests. One phase of this program consisted of accelerated traffic tests on eight existing airfield pavements. Tests were conducted at airports at the following locations: Beltsville, Maryland; Corpus Christi, Texas; Dothan, Alabama; Fargo, North Dakota; Grenier Field, New Hampshire; Lewistown, Montana; Natchitoches, Louisiana; and Richmond, Virginia.

The Waterways Experiment Station, at the request of the Office, Chief of Engineers, has summarized the original individual test reports prepared by the District Offices into one comprehensive report entitled, "Summary Report, Accelerated Traffic Tests." The report will be distributed to all interested governmental agencies and research organizations and in addition may be secured by individual purchase by writing the Director, U. S. Waterways Experiment Station, Vicksburg, Mississippi.

The general test procedures will be reviewed briefly in order that some idea may be obtained of the scope of the work. Tests were conducted on several types of subgrades and bases including two bases of soil-cement. The accelerated traffic tests at each field were conducted using loaded earth-moving equipment traveling along designated lanes on the pavement. Figure 1 shows a view of the test unit used at Dothan, Alabama. In general, the wheel loads ranged from 12,500 to 20,000 lb; however, wheel loads as great as 50,000 lb were used. The wheel load in the illustration is 50,000 lb and was secured by loading a 32-cu yd scraper. Traffic tests were continued until failure occurred or a specified number of coverages were completed. Visual observations were made of pavement behavior during the tests and measurements of permanent deformation of the pavement surface both during and after the traffic tests were obtained. In some tests, trenches were dug across traffic lanes to sample and inspect the condition of the base and subgrade materials after traffic. Plate bearing tests were run on the pavement surfaces and in a few cases on the underlying materials. Tests on soils included classification, moisture and density determinations, and California bearing ratio tests; at a few fields direct and triaxial shear tests were made.

It is not the intention of this paper to present the test results in detail, nor to discuss all phases presented in the summary report.

There are three points, however, which will be discussed here. They are: (1) base materials must be of good quality to prevent detrimental shear deformation under applied wheel loads; (2) subgrades and base courses must be well compacted to prevent detrimental consolidation under heavy wheel loads; and (3) construction joints are critical points in soil-cement bases.

The data relative to the base course materials are presented in Table 1. This table lists the test site, the wheel load used in the traffic test, the thickness of the wearing course, pertinent data with regard to the base; i.e., type, PI (plasticity index), percentage of saturation, and CBR, and contains brief remarks relative to the behavior of the base. Grenier Field is listed first. It has a cohesionless type base tested under nearly saturated conditions with a zero PI and a remolded and soaked CBR value in excess of 70, which was satisfactory for the 15,000-lb wheel loads used in the test. The next six fields listed have bases with PI values that range between 10 and 19 and CBR values that range from 9 to 35. The percentage of saturation is shown to be between 70 and 80 with the exception of Natchitoches where the value is 36. Shear deformation definitely occurred in all base materials except Natchitoches where it may have occurred but cannot be positively verified. Since the percentage of saturation is low at Natchitoches it is probable that the moisture content was insufficient to cause the base to be plastic. The fact that good quality base materials are essential if they are to withstand shear deformation under heavy wheel loads and in the presence of moisture is demonstrated. This fact is not new; however, it is so important that it can well be discussed at every opportunity. These data indicate that to prevent shear deformation under traffic the PI of a base, when subjected to high moisture content, must be less than 10 and that the strength of the material when measured by the CBR method must be more than 35. While the data from these tests are not sufficient to establish exact limits information from all sources combined have made it possible to set a maximum limit of 6 for the plasticity index. For wheel loads of 5,000 to 15,000 lb the CBR should be at least 50 and for wheel loads of 60,000 lb the CBR of the base should be about 80.

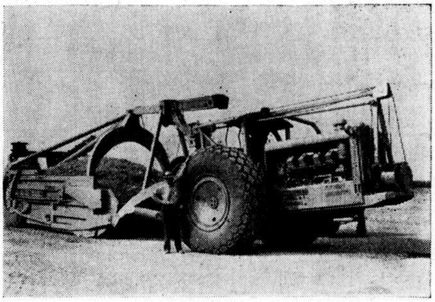


Figure 1. General View of Model A3 Tournapull

TABLE 1
ACCELERATED TRAFFIC TESTS—BASE MATERIALS

Test Site	Wheel Load	Wearing Course	Base: Type	Base: PI	Base: CBR	Approx. Percent Saturation	Behavior of Base
	lb	*in.*					
Grenier	15,000		Sand-gravel	0	71[a]	100	Satisfactory, except for poor surface
Corpus Christi	15,000	5	Clay-sand	11	23	81	Not quite satisfactory
Dothan	20,000 & 50,000	2	Sand-clay	18	10	70	Shear and consolidation in base
Lewistown	12,000	2	Sand-gravel	10	28[a]		Localized failure due to clay lenses in base with high moisture
Natchitoches	15,000	2	Sand-clay-gravel	11	35	36	No definite indication of shear
Richmond	15,000	2½	Sand-clay-gravel	19			Shear deformation and consolidation where moisture content was high
Fargo	12,500, 20,000 & 30,000	6 (Soil-cement)	Sand-clay	13	9	81	Shear and consolidation in sand-clay base under 20,000- and 30,000-lb wheel loads
Beltsville	15,000	1½	Soil-cement				Failure at joint in soil-cement

[a] Remolded and soaked value.

In several of the tests inadequate compaction of the base or subgrade materials during construction resulted in consolidation of the materials under traffic with consequent excessive deformations of the pavement surface. In a few of the tests, the degree of compaction was satisfactory to the extent that no detrimental consolidation took place. It was possible in some instances to determine from inspection of cross sections and trench profiles whether the deformations were caused by consolidation or shear deformation. Figure 2 illustrates typical pavement surface deformations as obtained at Dothan, Alabama. The lack of any pronounced upheaval indicates that probably most of the deformation was due to consolidation. A typical trench profile from the test at Natchitoches, Louisiana, is shown on Figure 3. In this particular case, shear deformation and consolidation in both the base and subgrade materials are illustrated. Shear deformation is shown by the slight upheaval at each edge of the traffic lane, and consolidation is apparent because the volume of displacement in the traffic lane cannot be attributed entirely to lateral movement. Table 2 shows the results of density tests on base and subgrade materials for six of the fields studied; density data were not available for Beltsville and Richmond. The percentage of modified AASHO maximum density is shown for before and after traffic conditions where such information was available. The table shows that before traffic the base at Corpus Christi was compacted to 99 percent of modified Proctor density and the subgrade at a depth of 15 in. was compacted to 96 percent. No density data are available after the traffic tests, but the cross sections show no deformation, which indicates that no increase in density occurred. The 5-in. base at Grenier increased from 104 to 109 percent of modified density during traffic, and the subgrade 5 in. below the surface increased from 95 to 97 percent. This increase resulted in some deformation. At Lewistown very little change in the density of the base is noted which is somewhat sur-

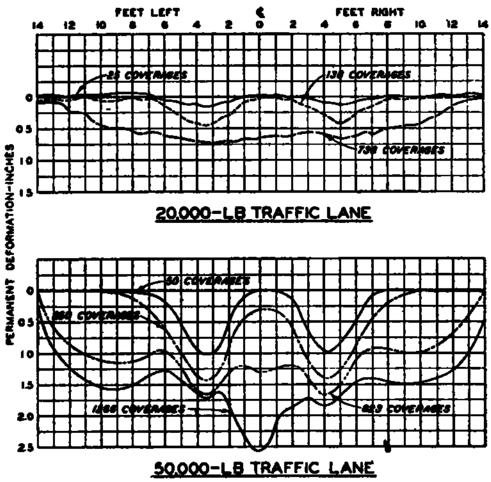
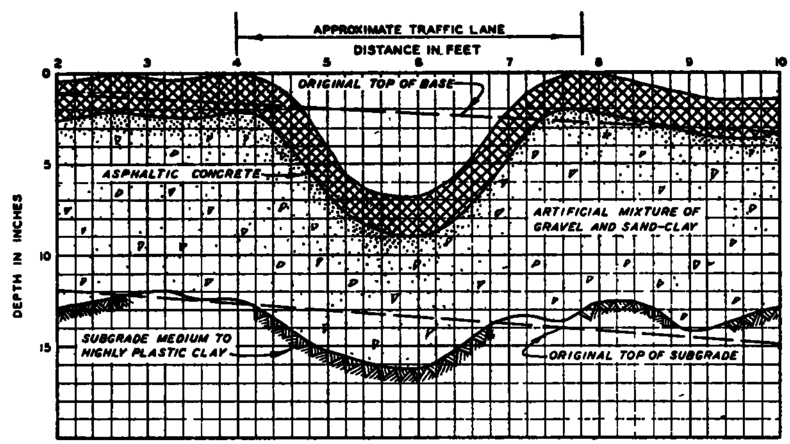


Figure 2. Typical Pavement Cross-Sections



TRENCH IN NORTH TURNAROUND

Figure 3. Trench Profile—Natchitoches Municipal Airport

TABLE 2
ACCELERATED TRAFFIC TESTS—COMPACTION DATA

Test Site	Wheel Load	Base: Type	Base: Thickness above Layer	Base: Before Traffic, Dry Wt. lb. per cu. ft.	Base: Before Traffic, % Mod. Density	Base: After Traffic, Dry Wt. lb. per cu. ft.	Base: After Traffic, % Mod. Density	Subgrade: Type	Subgrade: Thickness above Layer	Subgrade: Before Traffic, Dry Wt. lb. per cu ft.	Subgrade: Before Traffic, % Mod. Density	Subgrade: After Traffic, Dry Wt. lb. per cu ft.	Subgrade: After Traffic, % Mod. Desity	Deformation of Pavement Surface
	lb		*in.*						*in.*					
Corpus Christi	15,000	Clay-sand	5	114	99			Clay	15	97	96			Very little deformation
Grenier	15,000	Sand-gravel		144	104	151	109	Sand	5	103	95	105	97	Some deformation
Lewistown	12,000	Sand-gravel	2	122	88	121	87	Silty clay	16			98	91	Very little deformation
Dothan	20,000 & 50,000	Sand-clay	2	101	89			Sandy clay	9	114	90			Deformations up to ¾ in. in 20,000-lb lane; greater than 2 in. in 50,000-lb lane
Fargo	12,500	Sand-clay	6	112	89			Clay	24	88	83			Some deformation
Natchitoches	15,000	Sand-clay-gravel	2	115	86			Silty clay	12	97	86	102	93	Some deformation

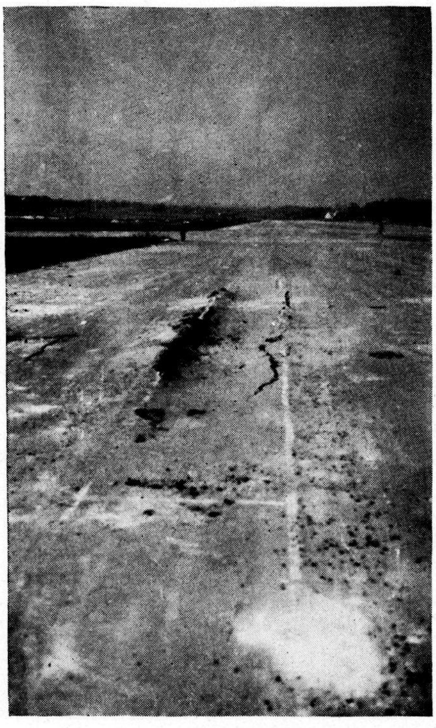


Figure 4. Failure Along Construction Joint in Soil Cement Base—Construction Joint is Along the left edge of the Traffic Lane as shown in the picture.

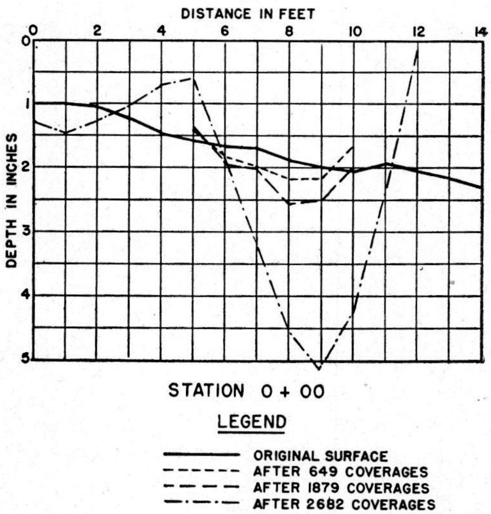


Figure 5. Pavement Cross-Sections, Traffic Test C, Beltsville, Maryland

prising since the value is considered to be rather low. The density in the subgrade at a depth of 16 in. was 91 percent after traffic. These values were apparently adequate since only small deformations are noted. At Dothan the base had a density of 89 and the subgrade at a depth of 9 in. a density of 90 percent. Upon completion of the tests, ¾-in. deformations were measured in the 20,000-lb traffic lane while 2-in. deformations were recorded in the 50,000-lb lane. It is evident that heavier loads will either compact a base to higher densities or the subgrade to a higher density at a greater depth or both. The base at Fargo had a

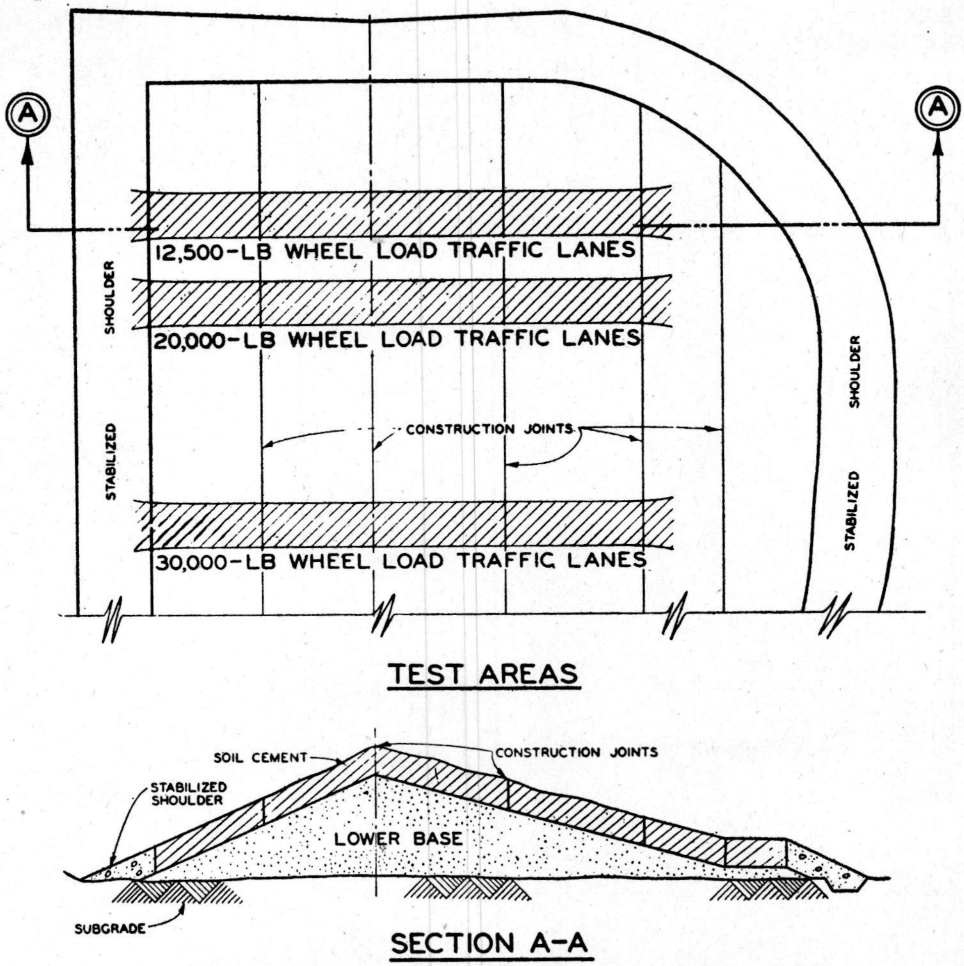


Figure 6. Accelerated Traffic Tests Municipal Airport, Fargo, North Dakota, Test Areas

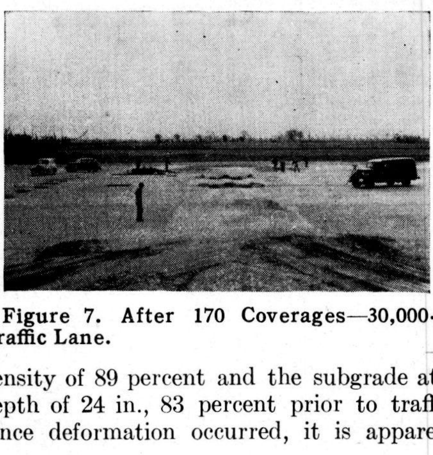


Figure 7. After 170 Coverages—30,000-lb Traffic Lane.

density of 89 percent and the subgrade at a depth of 24 in., 83 percent prior to traffic. Since deformation occurred, it is apparent that these values are low. The subgrade at Natchitoches increased from 86 to 93 percent of modified density at a depth of 12 in. when subjected to traffic of a 15,000-lb wheel load. Since definite deformation was measured, the base originally compacted to 86 percent also probably increased although data are not available. The data from all the tests indicate that the degree of compaction necessary to prevent detrimental deformation due to consolidation is dependent upon the type of material, the wheel load, and thickness of protective layer above. It is emphasized that adequate compaction of bases and subgrades is necessary to prevent detrimental consolidation even under relatively light wheel loads such as those used in these tests.

Soil-cement bases were constructed at two locations: Beltsville, Maryland, and Fargo, North Dakota. At Beltsville, the soil-cement base was a mixture of local sand and clay with approximately 10 percent cement by volume. The base was 6 in. thick and was constructed on a plastic subgrade in 25-ft lanes. In one test area, the traffic lane was located along a longitudinal construction joint. At the end of 227 coverages of a 15,000-lb wheel load, the base was pushed up along the construction joint for about three-fourths the length of the traffic lane and a large crack developed on the opposite side of the lane as illustrated in Figure 4. In a second test, the traffic lane was in the interior of a construction lane. No photograph is available for comparison; however, the cross-sections from this area illustrate the results. On Figure 5 it should be noted that deformations were in general about 1 in. or less until after the completion of more than 1800 coverages. It is pointed out in the summary report that the subgrade may have been stronger in the second test area, which might account for the ability of the soil-cement base to withstand the much larger number of coverages.

The soil-cement base at Fargo was constructed of a pit run sand and gravel mixed with a small percentage of soil binder and 10 percent by volume of cement. Figure 6 shows a plan and cross sections of the test areas. The soil-cement base was constructed in five longitudinal lanes ranging from 25 to 37.5 ft wide. Lanes for three traffic tests with 12,500-, 20,000-, and 30,000-lb wheel loads were located across the runway so that there were four construction joints in each test area. It should be noted that the crown of the runway was secured by increasing the thickness of the lower base from the edge to the center. The traffic tests were made before the bituminous wearing course had been placed. Failures occurred in all three of the traffic tests at from 10 to 130 coverages. The development of failure in each test was similar in that springing started at the edges of the runway and at the construction joints in the early stages of the test, followed by cracking and displacement of the soil-cement. Figure 7 shows the failure that took place at the construction joints for the 30,000-lb wheel load.

It is believed that the weakness of the construction joints in an important consideration and until they are eliminated or strengthened the soil-cement base must be evaluated on the basis of the strength of the joints rather than on the interior of the slab. Such an evaluation severely penalizes this type of construction since at both Beltsville and Fargo the interior of the base withstood a considerable amount of additional traffic without any particular distress after the joints had completely failed.

The results of the data presented in this paper are repeated here for the purpose of emphasis:

1. Base materials must be of high quality. Where a PI value is used as a measure of quality, the data indicate it should be low, certainly less than 10, and a PI less than 6 is recommended. Where quality is measured by the CBR test, the CBR should be in excess of 35 and probably can range from 50 to 80 dependent on the wheel load.

2. Good compaction of the subgrade and base is essential to prevent detrimental consolidation from heavy wheel loads. The percentage of density to which a base or subgrade should be compacted is dependent on the type of material, wheel load, and depth of protective layer above the item in question.

3. If the test areas cited are representative, construction joints are critical points in a soil-cement base and must be improved or eliminated before the base can be evaluated on the basis of the potential strength present in the interior of the slab.