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STABILIZATION OF BEACH SAND WITH EMULSIFIED ASPHALT

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## INTRODUCTION

The primary purpose of the work described herein was the determination of the feasibility of providing a stabilized surface of beach sand through (1) the use of emulsified asphalt, (2) the mixed-in-place procedure, and (3) "compaction by traffic" of the stabilized area. The area so stabilized was planned to facilitate the crossing of a beach area by vehicles during the off-loading phase of an amphibious operation conducted at Camp Del Mar, California during April-May 1953.

## MATERIALS AND EQUIPMENT

The beach soil stabilized was a medium fine sand as indicated in the grain size distribution curve of Figure 1. The moisture content ranged from 1.1 to 9.3 per cent, the larger value being obtained near the foreshore area.

The emulsified asphalt used was slow-setting, Type SS-2 (American Bitumuls & Asphalt Co. designation DFM) which contained approximately 60 per cent solid phase and 40 per cent liquid. Penetration of the asphalt used in this emulsion was 40 - 90 (vendor's figures).

A Wood Roadmixer equipped with a helical spreader and a vibrating screed and drawn by a D-8 tractor was employed as the mixing-spreading unit. Two standard pontoons containing the emulsified asphalt were mounted on an Athey wagon and towed alongside the Roadmixer during the stabilization operation.

Compaction of the mixed material was accomplished by 5 ton, 6x6 dump trucks (Gross wt. = 22,000 lbs.). Limited use was made of a loaded wobble-wheel roller during the first portion of the work, but the largest share of the early compaction was realized through the use of the dump trucks.

## PROCEDURE

The area to be stabilized was staked out roughly, and wire, logs, and other debris were removed from the path of the mixer. The path to be travelled was back-bladed with a dozer, and the slope from the beach proper to an access road approximately 300 ft.

from the shore was flattened to facilitate operation of the Road-mixer. The quantity of emulsion necessary for the stabilization of this particular soil was estimated at 6 - 7 per cent (by weight of dry soil). Since emulsified asphalt does not lend itself to metering through the type meter with which the Roadmixer was equipped it was necessary to pre-calibrate a pressure gage on the mixer at the speed of travel of the machine to establish the quantity flowing through the pumps. Figure 2 is a sketch of the area stabilized. The areas indicated on the sketch as Road #1 and Road #2 and two-thirds of that area shown as Parking Area were stabilized on 16-17 April. The remainder was completed on 20 April. The reason for the time interval was that it was considered desirable to have a section of the area stabilized immediately prior to the off-loading operation.

The emulsion which was received from the vendor in tank trucks, was pumped into the pontoons on the Athey wagon. A flexible hose connected the pontoons to a pump on the mixer during the travelling-mixing operation. The mixer was set to pick up approximately 8 inches of the loose sand over a width of 11 ft. 6 in. After mixing, spreading, and some initial compaction from the vibrating screed the average thickness was found to be approximately 7 inches.

Mixing and spreading was accomplished at the rate of approximately 13 feet per minute and the pump on the mixer was set to deliver from 70 to 80 gallons per minute in order that the mixture would contain 6 - 7 per cent emulsion. This rate had to be varied when the speed of travel changed, such as on curves and on inclines, and the sufficiency of the emulsion in the mixture at these places was established by observation. Similarly, in those areas near the foreshore where the sand was wet, the percentage of emulsion had to be adjusted so that the final mixture was not too "mushy".

Adjacent lanes were placed with an overlap of approximately one foot and compaction by the dump trucks kneaded the material together to form one roadway. In some places gaps were left between adjacent lanes during mixing. These gaps were subsequently filled with material from a windrow of the mixture which was made for this purpose.

Compaction by the dump trucks followed immediately after the mixing operation and continued until a reasonably smooth surface

was obtained. When the ridges which were formed between the dual tires of the trucks by sinkage into the mixed material were "ironed out" it was considered that adequate compaction had been obtained.

The corner of the area near the causeway section (see Figure 2) was enlarged by making several passes across the area. This increased the asphalt content of the material at this corner, which was considered desirable since it was expected that this area would be subjected to the most severe traffic conditions (turning movements, passage of tracked vehicles, etc.).

#### RESULTS

In all some 3700 square yards of beach area were stabilized by the method described using approximately 17,000 gallons of emulsified asphalt. An aerial view of the entire area after the stabilization was completed is shown in Figure 4.

Compaction by means of the heavy dump trucks produced a tight, flexible surface or skin which was able to support all wheeled vehicles operating over it. Tracked vehicles which used the roadway broke the surface but these breaks were repaired by tamping, rolling, or by the subsequent traffic of wheeled vehicles. The only break-through of the surface due to wheeled vehicles occurred under a heavily loaded semi-trailer making a tight turn at the enlarged corner near the causeway. This break-through was patched with material from a windrow.

The thickness of the skin increased with time, indicating that the emulsion was breaking or setting from the surface downward. Figure 3 shows the variation of moisture content with depth of the mixed material at one, four, and five days after placing and is an indication of the rate at which the asphalt emulsion was breaking.

Samples of the material from the completed roadway were taken and indicated residual asphalt contents as shown in Table 1. The last two samples listed in the table were taken in the area of the enlarged corner near the causeway. The average residual asphalt content of the samples taken (excluding the two mentioned above) was 4.4 per cent, indicating that 7.3 per cent of emulsion was used.

There were no differences apparent between the area stabilized

on 16-17 April and that stabilized on 20 April as far as their relative abilities to carry the traffic of the off-loading operation were concerned.

The average density of the mixed material after initial compaction was 98 lb. per cu. ft. Compression tests on 2-inch cubes cut from the surface (two weeks after placing) varied from 112 to 184 psi and averaged 155 psi. The average density of the samples used for compression tests was 105 lb. per ft.<sup>3</sup>.

Figure 5 is a view of the Parking Area during initial compaction and Figure 6 shows the same area under traffic during the off-loading operation. In Figure 7 may be seen the effect of operation of tracked vehicles on the surface at the enlarged corner near the causeway.

#### CONCLUSIONS

From the work on the stabilization of the beach area at Camp Del Mar the following conclusions are drawn:

1. Stabilization of a beach area through the use of slow setting emulsified asphalt and employing the mixed-in-place procedure is feasible.
2. The percentage of emulsion used is not particularly critical. In the work performed at Camp Del Mar the quantity varied from 5.7 per cent to 13.5 per cent (by weight of dry soil) and there were no differences apparent in the performance of the areas having widely different percentages of asphalt.
3. The moisture content of the sand being stabilized does not appear to be a critical factor. In this work the moisture content of the natural soil varied from 1.1 per cent to 9.3 per cent, the higher value obtaining in the foreshore area as indicated above. The mixture resulting from the addition of the emulsion to the soil of high moisture content was quite "mushy" immediately after mixing, but after compaction there was no apparent difference between the performance of this area and the performance of those areas of lower initial moisture content.

4. Compaction by traffic after initial compaction is effective in increasing the density and bearing capacity of an asphalt-stabilized sand. Some initial compaction is necessary, however, and this may be started immediately after the material has been mixed and spread. It appears that the most effective compaction is obtained by pneumatic rollers such as the wobble-wheel type or heavy trucks. A kneading action such as is obtained by a wheel or group of wheels advancing through (as distinguished from on) the mixture is believed necessary.
5. Observation of the actual off-loading phase of this operation and of the wheeled vehicles not using the stabilized roadway indicated that a military application of this method of stabilization is feasible. It was apparent that wheeled vehicles, particularly those towing loaded trailers experienced difficulty in traversing loose, dry sand of the beach. Thus the use of this type of roadway offers possibilities for expediting such an operation.

#### RECOMMENDATIONS

Based on the limited work accomplished it is recommended that additional work be undertaken which will lead to the following:

1. The development of stabilization equipment which is more maneuverable and smaller in size and thus more easily transportable;
2. The development of pumps and meters which will more easily and more accurately deliver the emulsion to the mixer;
3. The development of compaction equipment of either the vibratory or pneumatic type which can be operated on the mixed material immediately following spreading. In this connection it is suggested that the possibility of combining the tanks containing the emulsion and the compactor be investigated;

4. The establishment of minimum roadway thicknesses necessary for military operations, combining with this the investigation of minimum asphalt contents for various thicknesses;
5. The establishment of the limitations of this method. Particular emphasis should be placed on determining the types of beaches on which this method of stabilization would or would not be applicable.

Table 1. Asphalt Content

Sample Number	Depth (inches)	Percent Asphalt	Percent* Emulsion
1	5	3.4	5.7
2	6	4.2	7.0
3	5	3.6	6.0
4	5½	4.2	7.0
5	5	5.8	9.6
6	5	4.3	7.2
7	4	3.6	6.0
8	5½	5.0	8.3
9	5½	5.5	9.2
10#	4½	8.1	13.5
11#	5½	7.6	12.7
Average 1-9		4.4	7.3

\* Based on 60% residual asphalt in emulsion.

# Samples taken from area in which mixer made more than one pass.



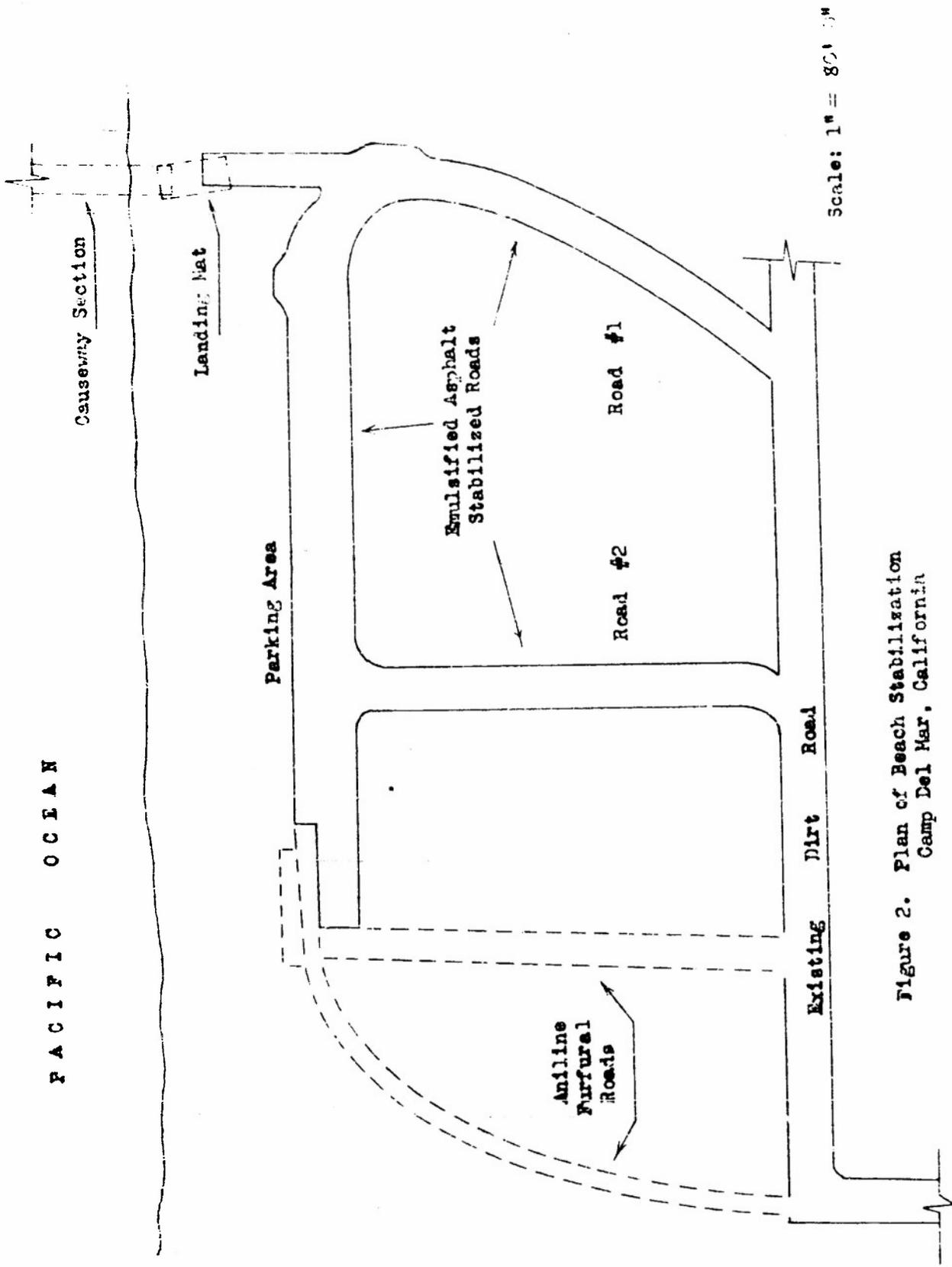


Figure 2. Plan of Beach Stabilization  
Camp Del Mar, California

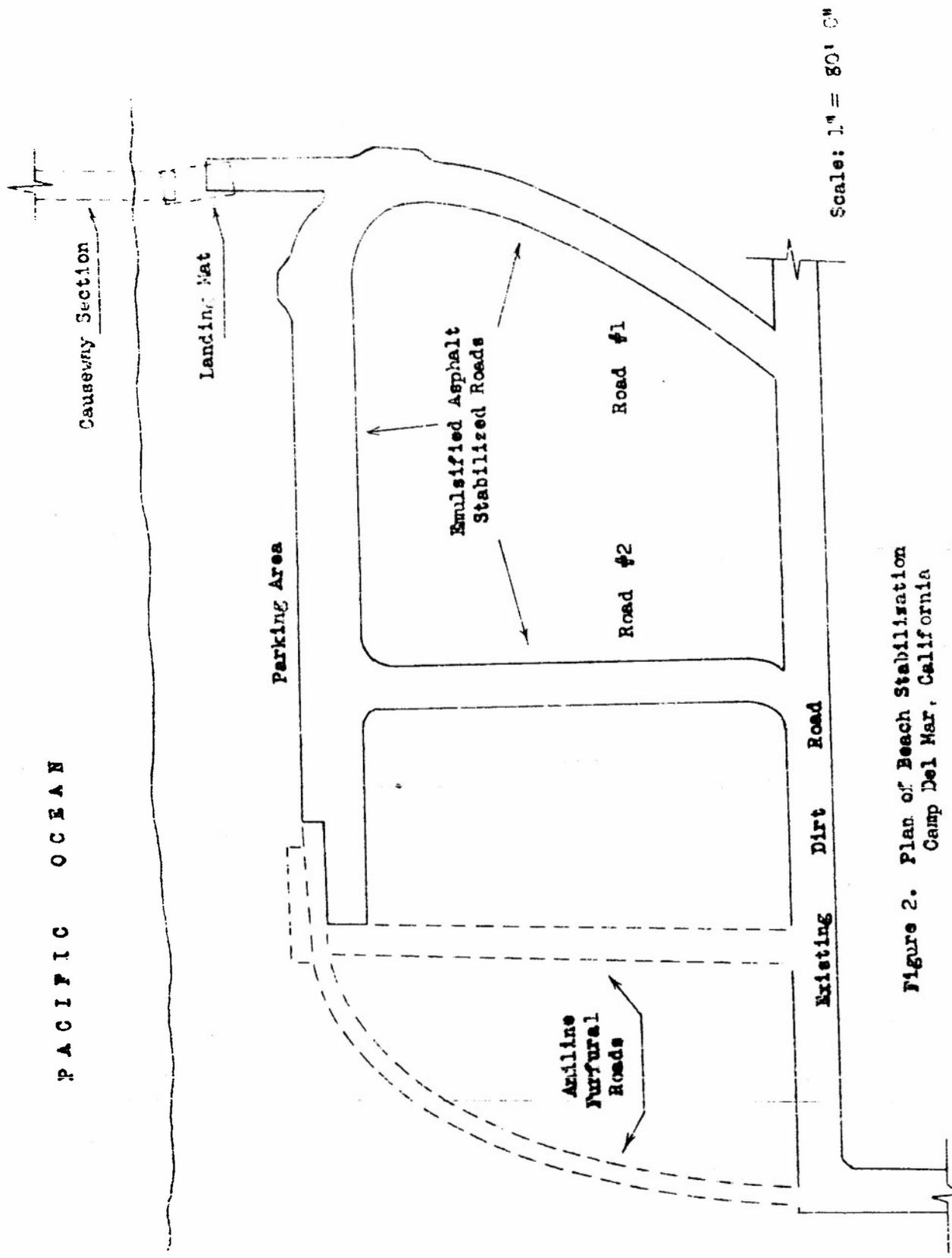


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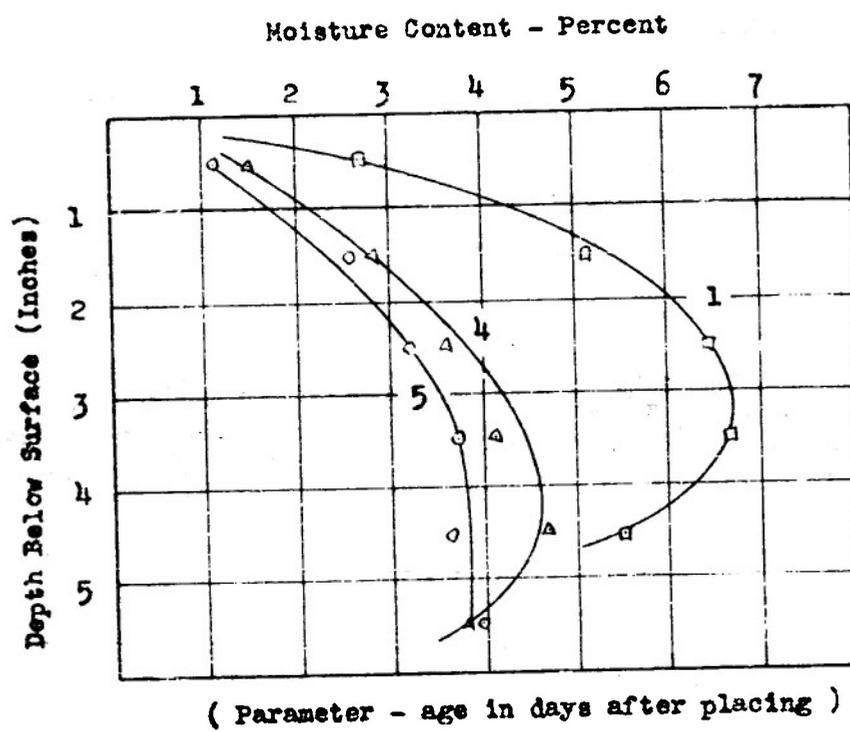


Figure 3. Moisture Content vs. Depth

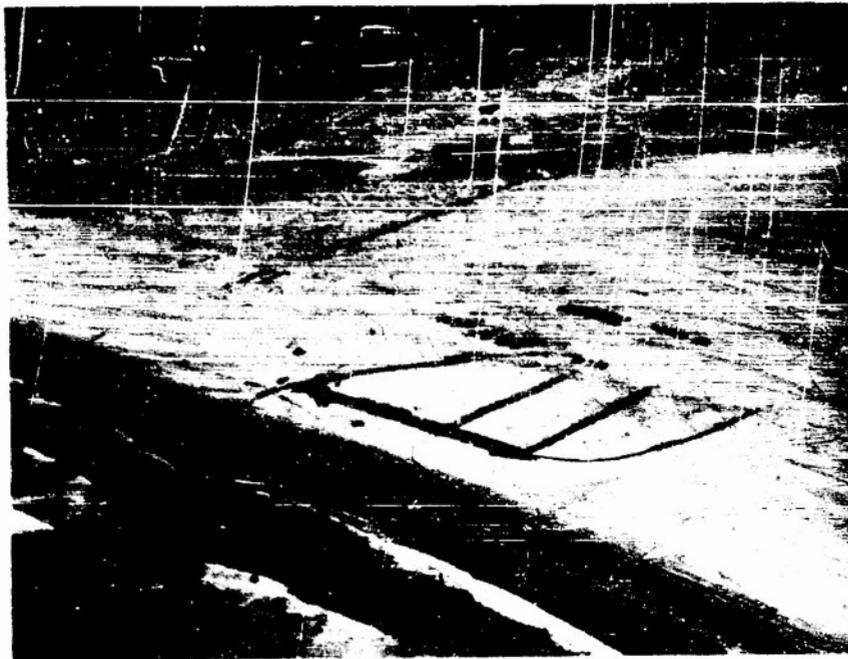


Figure 4. Aerial View of Stabilized Area (Light-colored strips - emulsified asphalt; darker strips - aniline-furfural).

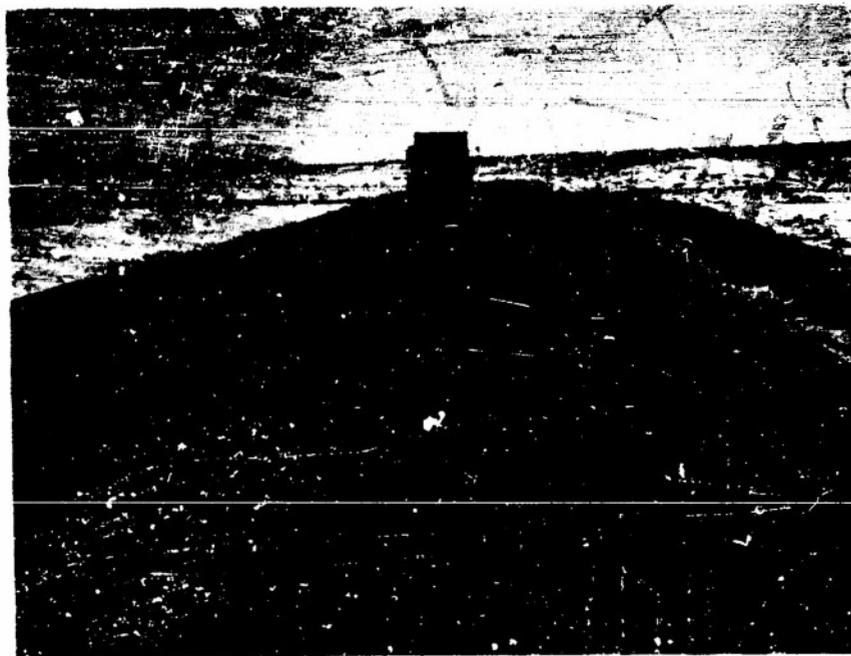


Figure 5. Parking area during initial compaction.



Figure 6. Parking area under traffic during off-loading operation.



Figure 7. Effect of operation of tracked vehicles on stabilized area.

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SUBJECT HEADINGS

DIV: Transportation (33)

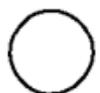
Soils - Compaction

SECT: Highway Transportation (2)

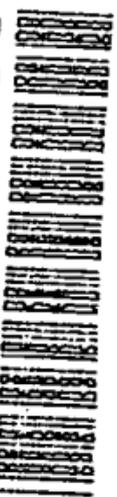
Soils - Bearing strength

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Soil Compaction  
Asphalt



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