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Technical Note N-620

AIRFIELD PAVEMENT EVALUATION - USMCAS YUMA, ARIZONA

BY

R. J. Lowe and W. R. Chamberlin

June 1964

U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California
AIRFIELD PAVEMENT EVALUATION - USMCAS YUMA, ARIZONA

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Type C

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ABSTRACT

The evaluation of the U. S. Marine Corps Air Station, Yuma, Arizona, is presented with the allowable gross load capacities of the runways, taxiways, and parking aprons for single, dual, and dual tandem wheel assembly aircraft as computed from the evaluation tests. Information is also included on the construction history, climatic data, and current aircraft traffic. Results of field and laboratory tests on the pavement and subsurface materials are included in the tables. The results of the evaluation show that only the old portion of the operations parking apron is being overloaded by military aircraft at the air station.

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INTRODUCTION

The purpose of the airfield pavement evaluation task is to determine the suitability of the pavement at the various Naval and Marine Corps air stations under the cognizance of the Bureau of Yards and Docks to accommodate the aircraft currently using the station and provide the designers with information on the physical properties of the pavement and pavement materials.

During the period from 13 January to 6 April 1964, field tests were conducted at the U. S. Marine Corps Air Station, Yuma, Arizona, to thoroughly evaluate the pavement used by aircraft at that station. Authority for this evaluation was granted U. S. Naval Civil Engineering Laboratory by the Bureau of Yards and Docks in April 1963. The evaluation consisted of surface plate loading tests on the asphaltic concrete pavements, sampling of the pavements, removal of the pavements, in-place testing of the base, subbase, and subgrade materials, and plate testing on the subgrade. Pertinent data relating to previous testing of the pavements, construction history, rainfall, and current traffic data are contained herein.

BACKGROUND

U. S. Marine Corps Air Station, Yuma, is located in Yuma County, 4 miles south and 1 mile east of Yuma, Arizona. The station is located south of and adjacent to U. S. Highway 80. An aerial photograph of the air station is shown in Figure 1. The airfield, formerly Yuma County Airport, still provides service to the county as its only commercial facility. One commercial airline has numerous flights in and out of the airfield each day.

The field has two major and two auxiliary runways. The two major runways, 03R-21L and 03L-21R, are respectively 9600 feet and 13,300 feet long. The auxiliary runways, 08-26 and 17-35, are at right angles to each other and are used principally by the commercial airlines except during unusual wind conditions when it is necessary for military aircraft to use runway 17-35. Runway 08-26 is 6200 feet long and lies in a generally east--west direction parallel to U. S. Highway 80. Runway 17-35 is 5700 feet long.

The air station covers nearly 4 square miles of desert alluvial plain which slopes gently southwestward in the vicinity of the base. The plain, which is known as the Yuma Desert, was formed from disintegrated rock debris washed out from the mountains in the east and include several hundred square miles between Yuma and the Mexican border.
The desert plain in the vicinity of the base has no natural drainage pattern. Ground water occurs at shallow depths in the flood plain of the nearby Colorado and Gila Rivers in the vicinity of Yuma and at depths of 80 to 100 feet in the alluvium underlying the adjoining portion of the desert plain surrounding the base. It is presumed that the ground water at the base is replenished by infiltration from the north, that is, from beneath the Gila River flood plain, and doubtless moves southwestward to the flood plain at the Colorado River south of Yuma. Water supply wells drilled on the air station showed static levels of approximately 100 feet deep when drilled.

CONSTRUCTION HISTORY

Original construction of the air station occurred during the period from 1941 to 1944. Information extracted from references (1) through (4) indicate that the three asphaltic concrete runways were built during the above period, and a new concrete runway and taxiway were constructed in 1960. Extensions to Runway 03R-21L were added in 1954 and 1955. The northeasterly end of the aircraft parking apron was replaced during 1963. A history of construction based on information available to the Laboratory is presented in Appendix A.

CURRENT AIRCRAFT TRAFFIC

A complete breakdown of the number of landings, takeoffs, and touch and go usage of individual runways at the airfield was not obtainable. Total usage for a 12-month period is shown in Table I.

The primary mission of the air station is training; therefore, all types of aircraft operated by the U. S. Marine Corps are stationed temporarily at Yuma from time to time. During the period of evaluation, the following aircraft were observed operating on the station: A4D, F8U, KC130, T38, T33, S-2, C-1, CH-37, CH-34, and occasionally an F4B. The commercial airline operating at Yuma operates F-27 aircraft. Many types of smaller planes and privately-owned converted B-26 aircraft operate out of the Yuma County Airport.

CLIMATIC DATA

The climate of Yuma is definitely of a desert origin. Indoor heating is necessary from late October until early April, but work can be conducted comfortably out of doors from 10 AM to 5 PM. The winter is generally a period of clear skies and abundant sunshine. The summers are long and hot. Afternoon temperatures reach 100 degrees on the average from June through September. Water content of the air from mid-July to mid-September is higher than might be expected over a desert.
Table I. Traffic Data for the U. S. Marine Corps
Air Station, Yuma, Arizona

<table>
<thead>
<tr>
<th>Date</th>
<th>Takeoffs</th>
<th>Landings</th>
<th>Touch &amp; Go</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 1963</td>
<td>3726</td>
<td>3799</td>
<td>2205</td>
</tr>
<tr>
<td>May 1963</td>
<td>4066</td>
<td>4102</td>
<td>2461</td>
</tr>
<tr>
<td>June 1963</td>
<td>4425</td>
<td>4380</td>
<td>2361</td>
</tr>
<tr>
<td>July 1963</td>
<td>4239</td>
<td>4262</td>
<td>2595</td>
</tr>
<tr>
<td>August 1963</td>
<td>4696</td>
<td>4674</td>
<td>2158</td>
</tr>
<tr>
<td>September 1963</td>
<td>2935</td>
<td>2948</td>
<td>2366</td>
</tr>
<tr>
<td>October 1963</td>
<td>4283</td>
<td>4259</td>
<td>3480</td>
</tr>
<tr>
<td>November 1963</td>
<td>5609</td>
<td>5619</td>
<td>3366</td>
</tr>
<tr>
<td>December 1963</td>
<td>5260</td>
<td>5294</td>
<td>2274</td>
</tr>
<tr>
<td>January 1964</td>
<td>5708</td>
<td>5712</td>
<td>3471</td>
</tr>
<tr>
<td>February 1964</td>
<td>5301</td>
<td>5323</td>
<td>3128</td>
</tr>
<tr>
<td>March 1964</td>
<td>4942</td>
<td>4953</td>
<td>1842</td>
</tr>
</tbody>
</table>

Average monthly
operations (based on
above 1-year report) 4599 4610 2642
area. This condition is created when the hot desert air balloons upwards, it draws moist-laden air in from the Gulf of Lower California which is relatively near. Evaporative coolers are very effective for cooling purposes during all the months except July, August, and September during which months the wet-bulb temperatures are frequently between 75 and 80 degrees, a condition that makes the ordinary water cooler somewhat ineffective. Yearly rainfall totals are very small. Average monthly temperatures and monthly precipitation data are presented in Appendix B for a few years picked at random. The record means are also shown in Appendix B.

CONDITION OF EXISTING PAVEMENT

A visual inspection of the airfield pavement during the period of evaluation indicated that the general condition of the asphaltic concrete pavement was from poor to fair. Considerable longitudinal and transverse cracking was apparent in the majority of the asphaltic concrete surface. Even where pavement conditions were poor however, no completely failed areas were noted.

The new portland cement concrete runway and adjoining taxiway were in excellent condition. Some spalling at construction joints was noted on both the runway and taxiway, but these spalled areas had been carefully repaired. The east end of the concrete parking apron has been recently replaced and is in excellent condition. The remainder of the parking apron is in from poor to fair condition. It is badly cracked in some areas, and in others there is vertical displacement at the joints.

The general visual condition survey of the pavements is presented in Appendix C. Photographs showing typical pavement conditions noted during the evaluation can be seen in Figures 2 through 8.

Field Investigation

Field investigation consisted of surface plate loading tests on the asphaltic concrete pavements, obtaining cores from both asphaltic concrete and portland cement concrete pavements, sampling of the pavements for subsequent laboratory testing, digging of test pits to determine in-place density and moisture contents of the base, subbase, and subgrade, obtaining of samples of the base, subbase, and subgrade materials for laboratory testing, plate load testing of the subgrade, and augering to a depth of 5 feet to visually classify the subgrade materials to this depth. In general, field tests were spaced on 1000-foot centers on runways and taxiways and one test per 20,000 square yards of aprons. Test locations in a typical plate loading test layout are shown in Figure 9.
Figure 4. Area of Runway 03R-21L showing effect of jet blast on surface. USMCAS Yuma, Arizona.
Figure 8. Intersection of Runways 17-35 and 03R-21L showing wide open cracks. USMCAS
At each location on the asphaltic concrete pavements, a series of plate loading tests were performed on the surface using 8, 15, 24, and 30-inch-diameter plates in a pattern as shown on Figure 9. During the plate load tests, load was applied in increments to each plate until a total deflection of 0.20 inch was obtained or the capacity of the load cart (100,000 pounds) was reached. In accordance with ASTM D1195-57 procedure, each load increment was maintained until the deflection did not exceed 0.001 inch per minute for 3 successive minutes before the next load was applied. In addition to the plate loading tests, three 3-inch-diameter cores were obtained, and a 4- by 4-foot test pit was dug to perform tests on the underlying materials. Upon removal of the asphaltic concrete pavement, in-place density and moisture tests were run on the base course, and a 75-pound sample of the base material was obtained for laboratory testing. The test pit was then dug to the top of the subbase (if one was present) and then to the subgrade, and with the same procedure being followed on each layer. On the surface of the subgrade, a plate loading test was performed using a 30-inch-diameter plate. Upon completion of the plate bearing tests, an auger hole was drilled to a depth of 5 feet to visually classify the subgrade materials.

At each test location on the portland cement concrete pavements, three 6-inch-diameter cores were obtained. In addition, on the old portion of the operations parking apron two 4-foot square concrete slabs were obtained for subsequent flexural beam testing. At these two locations, subsurface testing was performed in the same manner as under the asphaltic concrete pavements.

At the USMCAS Yuma, a total of 142 surface plate loading tests and 36 subgrade plate tests were performed, 102 3-inch-diameter asphaltic concrete cores, 51 6-inch-diameter portland cement concrete cores, 36 test pits, 67 in-place densities, 67 soil samples, 34 12- by 12-inch asphaltic concrete pavement sections, and two 4- by 4-foot portland cement concrete pavement sections were obtained.

LABORATORY TESTING

In the laboratory the following determinations were made of the properties of the materials obtained in the field:

Asphaltic concrete

- thickness
- bulk specific gravity ASTM-D1075-54 (section 4)
- strength of cores ASTM-D1074-60 (unconfined compression)
TEST RESULTS

Asphaltic Concrete Pavements

The results of the plate loading tests conducted on the surface of the asphaltic concrete pavements are presented in Appendix D. The loads causing 0.15 inch deflections on the 8-inch and 30-inch plate tests were
used for computing the allowable gross aircraft loads for the asphaltic concrete pavements in accordance with Figure 13-1 of NAVDOCKS DM-21. The graphic method for determining these allowable gross aircraft loads for tire pressures of 150 and 400 psi are presented in Appendix E for each of the asphaltic concrete pavements. A summary of the pavement load ratings as obtained from the curves in Appendix E are shown in Table II.

Results of the laboratory tests performed on the asphaltic concrete cores and the recovered asphaltic concrete pavement sections are shown in Table III. Gradations of the recovered aggregates are presented in Appendix F.

Portland Cement Concrete Pavements

Tensile splitting tests were performed on all concrete cores obtained from the portland cement concrete pavements. Flexural strength test beams were cut from the two pavement sections obtained from the Operations parking apron and were tested in the laboratory to determine the modulus of rupture of the in-place concrete. The results of the tensile splitting tests and the modulus of rupture obtained from the field-cut beams and from 60-day strengths of field control beams made at the time Runway 03L-21R and Taxiway 4 were constructed (in 1960) are presented in Table V. Using these data a ratio of flexural strength to tensile splitting strength at each location was developed, and an average ratio of 1.29 was determined. Using this average ratio, flexural strengths were computed, and concrete working strengths for the concrete in place were computed as shown also in Table V. With these data and the modulus of subgrade reaction, "K", for the various pavements, as obtained from this evaluation or previous evaluations, the allowable load rating for the portland cement concrete pavements were computed in accordance with example 13-1 of NAVDOCKS DM-21. The load ratings for the portland cement concrete pavements are shown in Table VI.

Subsurface Materials

Gradations of the base, subbase, and subgrade materials are presented in Appendix F. Results of the 30-inch-diameter plate loading tests performed on the subgrade and the calculated modulus of subgrade reaction, "K", are presented in Appendix G. "K", the modulus of subgrade reaction, is also tabulated in Tables IV and VI. Results of the laboratory tests performed on the base, subbase, and subgrade materials are shown in Table IV. Typical curves for moisture-density relationship and California bearing ratio for a sample of the base and the subgrade are presented in Appendix H. Logs of each of the test pits including the auger hole log are presented in Appendix I.
Table II. Load Ratings for Asphaltic Concrete Pavements, USMCAS Yuma, Arizona

<table>
<thead>
<tr>
<th>Location</th>
<th>Runways</th>
<th>150 psi Tires</th>
<th>400 psi Tires</th>
<th>150 psi Tires</th>
<th>150 psi Tires</th>
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<tr>
<td></td>
<td>03R-21L</td>
<td>266,000</td>
<td>162,000</td>
<td>345,000</td>
<td>518,000</td>
</tr>
<tr>
<td></td>
<td>08-26</td>
<td>105,000</td>
<td>63,000</td>
<td>137,000</td>
<td>206,000</td>
</tr>
<tr>
<td></td>
<td>17-35</td>
<td>130,000</td>
<td>72,000</td>
<td>171,000</td>
<td>255,000</td>
</tr>
<tr>
<td></td>
<td>Taxiways</td>
<td>158,000</td>
<td>101,000</td>
<td>206,000</td>
<td>308,000</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>152,000</td>
<td>74,000</td>
<td>198,000</td>
<td>295,000</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>107,000</td>
<td>67,000</td>
<td>139,000</td>
<td>209,000</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>264,000</td>
<td>78,000</td>
<td>344,000</td>
<td>514,000</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>312,000</td>
<td>95,000</td>
<td>400,000</td>
<td>610,000</td>
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<tr>
<td></td>
<td>6A</td>
<td>282,000</td>
<td>175,000</td>
<td>366,000</td>
<td>550,000</td>
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</table>
### Table III. Laboratory Test Results of Asphallic Concrete Pavement Specimens, USMCA Tumu, Arizona

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Thickness of A.C.</th>
<th>Average Bulk Specific Gravity of 2&quot; Die Cores</th>
<th>Average Compressive Strength</th>
<th>Percent Asphalt</th>
<th>Specific Gravity at 57°F</th>
<th>Ductility at 55°F</th>
<th>Percent Voides Filled with Asphallic</th>
<th>Total Mix</th>
<th>Total Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runway 03-21L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1550</td>
<td>4.2</td>
<td>2.36</td>
<td>1054</td>
<td>Surface 6.4</td>
<td>2.72</td>
<td>13</td>
<td>150+</td>
<td>1.0</td>
<td>3.3</td>
</tr>
<tr>
<td>2550</td>
<td>4.3</td>
<td>2.39</td>
<td>842</td>
<td>Surface 6.9</td>
<td>2.69</td>
<td>15</td>
<td>142</td>
<td>0.6</td>
<td>0.8</td>
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<tr>
<td>3550</td>
<td>15.7</td>
<td>2.33</td>
<td>927</td>
<td>Surface 4.8</td>
<td>2.68</td>
<td>8</td>
<td>5.7</td>
<td>0.0</td>
<td>5.2</td>
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<tr>
<td>4550</td>
<td>7.3</td>
<td>2.27</td>
<td>880</td>
<td>Surface 5.9</td>
<td>2.68</td>
<td>8</td>
<td>11.4</td>
<td>0.2</td>
<td>2.8</td>
</tr>
<tr>
<td>5550</td>
<td>7.2</td>
<td>2.20</td>
<td>744</td>
<td>Surface 5.0</td>
<td>2.69</td>
<td>6</td>
<td>35.7</td>
<td>0.1</td>
<td>6.6</td>
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<tr>
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<td>2.29</td>
<td>803</td>
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<td>2.67</td>
<td>10</td>
<td>9.3</td>
<td>0.1</td>
<td>2.7</td>
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<td>7550</td>
<td>7.0</td>
<td>2.25</td>
<td>851</td>
<td>NO PAVEMENT SAMPLE</td>
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<tr>
<td>8550</td>
<td>9.7</td>
<td>2.28</td>
<td>927</td>
<td>Surface 5.7</td>
<td>2.69</td>
<td>7</td>
<td>10.0</td>
<td>0.2</td>
<td>4.5</td>
</tr>
<tr>
<td>9550</td>
<td>5.1</td>
<td>2.30</td>
<td>880</td>
<td>Surface 6.8</td>
<td>2.67</td>
<td>6</td>
<td>12.3</td>
<td>0.4</td>
<td>7.3</td>
</tr>
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</table>

| Runway 08-16 |                           |                                            |                               |                 |                        |                 |                                     |          |          |
| 8400      | 4.4                      | 2.25                                       | 854                           | 6.7             | 2.68                   | 4               | 3.6                   | 0.5      | 7.8      |
| 16400     | 6.8                      | 2.26                                       | 757                           | 6.7             | 2.68                   | 6               | 0.6                   | 0.5      | 6.4      |
| 26400     | 6.4                      | 2.26                                       | 728                           | 5.4             | 7.65                   | ASPHALT FOAMED | 8.2                   | 59.1     |
| 66000     | 6.1                      | 2.12                                       | 711                           | 7.1             | 2.67                   | 2               | 0.6                   | 0.0      | 6.6      |
| 56000     | 6.5                      | 2.10                                       | 477                           | 6.3             | 2.66                   | 2               | 0.1                   | 0.0      | 12.9     |

| Runway 17-15 |                           |                                            |                               |                 |                        |                 |                                     |          |          |
| 7400      | 1.8                      | 2.21                                       | TOO SHORT                     | 6.0             | 2.67                   | 5               | 0.3                   | 0.0      | 9.1      |
| 19400     | 3.0                      | 2.29                                       | 888                           | 5.3             | 2.68                   | 5               | 1.3                   | 0.3      | 7.3      |
| 29400     | 3.5                      | 2.29                                       | 861                           | 5.7             | 2.69                   | 6               | 1.7                   | 0.2      | 6.6      |
| 39400     | 6.4                      | 2.29                                       | 631                           | 5.2             | 2.68                   | 2               | 1.2                   | 0.2      | 7.2      |
| 49400     | 5.5                      | 2.25                                       | 711                           | 6.1             | 2.68                   | 5               | 2.5                   | 0.5      | 4.3      |

| Taxiway 1 |                           |                                            |                               |                 |                        |                 |                                     |          |          |
|           | 12400                    | 6.2                                        | 2.44                           | 291             | 6.2                    | 2.71            | 21                    | 5.7      | 0.4      |
|           | 22400                    | 3.5                                        | 2.41                           | 330             | 6.3                    | 2.70            | 23                    | 6.1      | 1.2      |
|           | 32400                    | 3.7                                        | 2.38                           | 354             | 4.7                    | 2.70            | ASPHALT FOAMED        | 5.7      |
|           | 41400                    | 3.2                                        | 2.27                           | 632             | 5.0                    | 2.70            | 5                     | 0.5      | 10.8     |

| Taxiway 1-4 |                           |                                            |                               |                 |                        |                 |                                     |          |          |
| 5400      | 3.3                      | 2.33                                       | 511                           | 6.5             | 2.68                   | 16              | 24.7                  | 0.5      | 6.8      |
| 6400      | 4.2                      | 2.37                                       | 473                           | 5.9             | 2.69                   | 28              | 16.0                  | 6.5      | 3.3      |

| Taxiway 2 |                           |                                            |                               |                 |                        |                 |                                     |          |          |
| 2400      | 1.6                      | 2.25                                       | TOO SHORT                     | 5.9             | 2.70                   | 16              | 35.4                  | 0.5      | 4.5      |
| 9400      | 1.2                      | 2.33                                       | TOO SHORT                     | 5.8             | 2.69                   | 19              | 76.2                  | 5.0      | 5.3      |

| Taxiway 6 |                           |                                            |                               |                 |                        |                 |                                     |          |          |
|           | 1550 Offset              | Surface 3.1                                 | TOO SHORT                     | 5.4             | 2.68                   | 18              | 103                   | 1.5      | 5.3      |
|           |                          | Binder 3.8                                  | 820                           | 4.7             | 2.70                   | 19              | 150+                  | 4.0      | 4.0      |
|           |                          | Surface 1.5                                 | TOO SHORT                     | 5.9             | 2.69                   | 22              | 150+                  | 6.6      | 2.9      |
|           |                          | Binder 2.3                                  | 6.1                           | 6.1             | 2.70                   | 24              | 150+                  | 11.0     | 2.8      |
|           |                          | Surface 1.5                                 | 7.0                           | 7.0             | 2.70                   | 34              | 150+                  | 7.2      | 3.7      |
|           |                          | Binder 2.5                                  | 4.7                           | 4.7             | 2.70                   | 39              | 150+                  | 22.5     | 2.9      |

| Taxiway 6-4 |                           |                                            |                               |                 |                        |                 |                                     |          |          |
| 6400      | 2.6                      | 2.31                                       | 1391                          | 5.1             | 2.67                   | 5               | 0.8                   | 0.5      | 6.5      |
| 16400     | 3.0                      | 2.33                                       | 1217                          | 4.7             | 2.69                   | 5               | 1.8                   | 0.0      | 6.8      |

- **Total Mix**: 65.3, 66.7, 55.8, 64.1, 65.6, 50.1, 58.8, 82.0, 67.7, 61.6, 75.6, 97.9, 97.9, 82.3, 83.7, 79.3, 64.0, 61.2
Table IV. Results of Tests on Base, Subbase, and Subgrade Materials, USMCAS Yuma, Arizona

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Dry Density</th>
<th>Optimum Moisture Content</th>
<th>In-Place Density % of max. dry Density</th>
<th>In-Place Moisture Content</th>
<th>C.B.R.*</th>
<th>Plasticity Index</th>
<th>Specific Gravity</th>
<th>Subgrade Modulus K in pci</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taxiway 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+00 Base</td>
<td>137.8</td>
<td>7.2</td>
<td>132.5</td>
<td>96.2</td>
<td>1.8</td>
<td>80</td>
<td>NP</td>
<td>2.65</td>
</tr>
<tr>
<td>Substrate</td>
<td>118.5</td>
<td>9.4</td>
<td>119.9</td>
<td>101.2</td>
<td>2.8</td>
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<td>139.5</td>
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<td>100.5</td>
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<td>95.7</td>
<td>97.5</td>
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Table IV: Results of Tests on Base, Subbase, and Subgrade Materials, UNSCAS Yuma, Arizona (Continued)
Table IV. Results of Tests on Base, Subbase, and Subgrade Materials, USMCAS Yuma, Arizona (Continued)

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Dry Density</th>
<th>Optimum Moisture Content</th>
<th>In-Place Density lbs/cu.ft.</th>
<th>% of max. dry density</th>
<th>In-Place Moisture Content</th>
<th>C.B.R.*</th>
<th>Plasticity Index</th>
<th>Specific Gravity</th>
<th>Subgrade Modulus K in pci</th>
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<tr>
<td>Runway 03R-21L 85+00</td>
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<td>Base</td>
<td>138.4</td>
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* C.B.R. values were obtained by correlation of in-place densities with laboratory CBR-density studies.
Table V. Results of Tests on Portland Cement Concrete Pavement Specimens, USMCAS Yuma, Arizona

<table>
<thead>
<tr>
<th>Location</th>
<th>Pavement Thickness (inches)</th>
<th>Field Control Flexural Strength (1960 Data)</th>
<th>Tensile Strength (psi)</th>
<th>Ratio of Flexural Strength to Tensile Strength (2)/(3)</th>
<th>Flexural Strength Based on Average Ratio of 1.29 (psi) ((3)x1.29)</th>
<th>Concrete Working Strength (psi) (5)/1.4</th>
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<td>10+50 Lane &quot;C&quot;</td>
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<td>783</td>
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<td>51+50</td>
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<td>81+50 Lane &quot;L&quot;</td>
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<td>101+75 Lane &quot;J&quot;</td>
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<td>670</td>
<td>689**</td>
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<td>600</td>
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<td>774</td>
<td>553</td>
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<td>650*</td>
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<td>1.18</td>
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<td>863</td>
<td>616</td>
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<tr>
<td>Taxiway 6 Offset</td>
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<td>649</td>
<td>---</td>
<td>837</td>
<td>598</td>
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* Beams taken from pavements during May 1964 and tested at NCEL.
** Re-bars in break.
*** Not included in average.
Table VI. Load Ratings for Portland Cement Concrete Pavements

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Concrete Pavement Thickness (inches)</th>
<th>Average Concrete Working Stress (w.s.) (psi)</th>
<th>K Value</th>
<th>Single Wheel Gear Loads (kips) Corrected for K &amp; Working Stress (DM-21 Figures 11-5 &amp; 11-6)</th>
<th>Allowable Gross Aircraft Loads (kips) For Aircraft With (DM-21 Figure 11-5 or 11-6)</th>
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<td>150 psi Tires</td>
<td>400 psi Tires</td>
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<td>517</td>
<td>500</td>
<td>62</td>
<td>49</td>
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<tr>
<td>Runway 03R-21L (Ends)</td>
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<td>569</td>
<td>200</td>
<td>95</td>
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<tr>
<td>Runway 17-35' (Ends)</td>
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<td>538</td>
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<td>13.2</td>
<td>499</td>
<td>500</td>
<td>90</td>
<td>72</td>
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<td>Taxiway 1 Parking Apron</td>
<td>5.7</td>
<td>553</td>
<td>500</td>
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<td>Operations Parking Apron (Old Section)</td>
<td>5.6</td>
<td>421</td>
<td>165</td>
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<tr>
<td>Operations Parking Apron (New Section)</td>
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<td>616</td>
<td>500</td>
<td>91</td>
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<td>Taxiway 6 Offset</td>
<td>15.0</td>
<td>598</td>
<td>300</td>
<td>102</td>
<td>80</td>
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CONCLUSIONS

A review of the calculated allowable gross aircraft loads as shown on Tables II and VI indicated that from a load-carrying standpoint all the pavements used by military aircraft with the exception of the old portion of the operations parking apron are capable of carrying the loads imposed by aircraft in use today at the air station. Visual inspection of the asphaltic concrete pavements showed that all pavements required crack and surface sealing. A review of the laboratory tests conducted on the recovered materials from the asphaltic concrete pavements shows that, with only a few exceptions, the asphalt has become hard (aged) as would be expected. The penetration of the asphalt recovered from the older pavements which was originally 85 to 100 penetration was between 1 and 28 while that from some of the newer pavements was as high as 46. Ductility of the asphalt ranged between 0.1 and 150 centimeters for the older asphalts at 77°F and between 0.0 and 9.7 centimeters at 45°F. In-place moisture content of the subgrade materials was as high as 8.8 percent, and optimum moistures were as high as 10.4 percent. All sub-surface materials were found to be non-plastic and had California bearing ratios ranging from a low of 23 to 100+.

RECOMMENDATIONS

It is recommended that frequent condition surveys of the pavements at USMCAS Yuma be conducted. It is further recommended that surface sealing of the asphaltic concrete pavements be considered.

REFERENCES


Appendix A

CONSTRUCTION HISTORY FOR USMCAS YUMA, ARIZONA
## Appendix A

### CONSTRUCTION HISTORY FOR USMCAS YUMA, ARIZONA

<table>
<thead>
<tr>
<th>Station</th>
<th>Section from Surface to Subgrade</th>
<th>Date Constructed</th>
<th>Date Strengthened</th>
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<tbody>
<tr>
<td>Runway 03R-21L 30+00 to 98+00</td>
<td>5&quot; - 11.5&quot; AC 7&quot; - 14&quot; Base Crusher Run 4&quot; - 6&quot; Compacted Native Material</td>
<td>1941</td>
<td>1952</td>
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<tr>
<td>10+00 to 30+00</td>
<td>4&quot; AC 10&quot; Base Crusher Run 4&quot; - 6&quot; Compacted Native Material</td>
<td>1954</td>
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<td>6+00 to 10+00</td>
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<tr>
<td>Runway 17-35 0+00 to 52+00</td>
<td>5&quot; AC 8&quot; - 11&quot; Base Crusher Run 4&quot; - 6&quot; Compacted Native Material</td>
<td>1941-42</td>
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<tr>
<td>Runway 03L-21R 0+00 to 133+00</td>
<td>10.8&quot; PCC 6&quot; Cement Stabilized Native Material</td>
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<tr>
<td>Runway 08-26 0+00 to 63+00</td>
<td>5&quot; AC 7&quot; - 9&quot; Base Crusher Run 4&quot; - 6&quot; Compacted Native Material</td>
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Appendix B

CLIMATOLOGICAL DATA FOR

USMCAS YUMA, ARIZONA
## Appendix B

### CLIMATOLOGICAL DATA FOR USMCAS YUMA, ARIZONA

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**RECORD**

**MEAN**

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<td>.00</td>
<td>T</td>
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<td>T</td>
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<td>.31</td>
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<td>.19</td>
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**RECORD**

**MEAN**

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<th>Year</th>
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<th>MIN</th>
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<td>1953</td>
<td>.09</td>
<td>.21</td>
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<td>1960</td>
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<td>.29</td>
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<td>1963</td>
<td>.48</td>
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</table>

T - Trace
Appendix C

VISUAL PAVEMENT CONDITION SURVEY

USMCAS YUMA, ARIZONA
<table>
<thead>
<tr>
<th>Pavement Facility</th>
<th>Type</th>
<th>Stationing</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runway 03R-21L</td>
<td>Asphaltic concrete</td>
<td>0+00-2+50</td>
<td>Fair - many longitudinal and transverse cracks from 0.5 to 0.75 inch wide - two areas have been patched.</td>
</tr>
<tr>
<td></td>
<td>Portland cement concrete</td>
<td>2+50-11+90</td>
<td>Excellent except for few spalled joints and surface blemishes due to wood chips, etc.</td>
</tr>
<tr>
<td></td>
<td>Asphaltic concrete</td>
<td>11+90-101+00</td>
<td>Poor - few good areas, map and/or open cracks prevail. Several areas have been eroded by jet blast. Some of the cracks are open to 1-inch. Spalling of these cracks was noted. Figures 2, 3, and 4 show general condition of this runway.</td>
</tr>
<tr>
<td>Runway 03L-21R</td>
<td>Portland cement concrete</td>
<td>All</td>
<td>Excellent - except for occasional hairline cracks penetrating through slab entire depth.</td>
</tr>
<tr>
<td>Runway 08-26</td>
<td>Asphaltic concrete</td>
<td>All</td>
<td>The entire runway is in very poor condition. Cracks penetrating the entire thickness of the pavement are closely spaced, open, full of sand, and cracked edges are curling. No crack sealing was evidenced. Figures 5 and 6 show general condition of this runway.</td>
</tr>
<tr>
<td>Runway 17-35</td>
<td>Portland cement concrete</td>
<td>0+00-4+25</td>
<td>Good - occasional hairline crack.</td>
</tr>
<tr>
<td></td>
<td>Asphaltic concrete</td>
<td>0+00-55+45</td>
<td>Poor - severe map, longitudinal and transverse cracking - some cracks 2 inches wide. Sand in open cracks was causing spalling and curling. Figures 7 and 8 are typical of the pavement conditions.</td>
</tr>
<tr>
<td>Pavement Facility Type</td>
<td>Stationing</td>
<td>Condition</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------</td>
<td>---------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Taxiway 1</td>
<td>Asphaltic concrete</td>
<td>All</td>
<td>Poor - severe map, longitudinal and transverse cracking. No maintenance was in evidence except an old slurry coat.</td>
</tr>
<tr>
<td>Taxiway 1-A</td>
<td>Asphaltic concrete</td>
<td>All</td>
<td>Good - open graded surface but free of cracks except for occasional longitudinal cracking.</td>
</tr>
<tr>
<td>Taxiway 1-B</td>
<td>Asphaltic concrete</td>
<td>All</td>
<td>Poor - severe map cracking to 0.6 inch wide with spalling and curling of open cracks. Crack pattern ranges from 3 inches between smaller cracks to several feet between the larger ones. Figures 5 and 6 are typical of this area also.</td>
</tr>
<tr>
<td>Taxiway 2</td>
<td>Asphaltic concrete</td>
<td>All</td>
<td>Fair - surface unsealed with longitudinal cracking. Transverse cracks near right edge. No cracks over 1/16 inch wide.</td>
</tr>
<tr>
<td>Taxiway 4</td>
<td>Portland cement concrete</td>
<td>All</td>
<td>Excellent - some spalling at construction joints was noted but had been carefully repaired and heavily seal-coated.</td>
</tr>
<tr>
<td>Taxiway 6</td>
<td>Asphaltic concrete</td>
<td>0+00 to -10+00</td>
<td>Fair - approximately one half the length was excellent. Remaining length had longitudinal and transverse cracks to 3/4-inch wide adjacent to Runway 03R-21L.</td>
</tr>
<tr>
<td>Taxiway 6-A</td>
<td>Asphaltic concrete</td>
<td>0+00-19+00</td>
<td>Fair to poor - longitudinal and transverse cracks to 3/4 inch wide.</td>
</tr>
<tr>
<td>Taxiway 6-A</td>
<td>Asphaltic concrete</td>
<td>All</td>
<td>Fair to poor - longitudinal and transverse crack to 0.5 inch wide. Patched areas - center portion seal coated at one time, outer edges open graded.</td>
</tr>
<tr>
<td>Pavement Facility</td>
<td>Type</td>
<td>Stationing</td>
<td>Condition</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------</td>
<td>------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Parking Apron</td>
<td>Portland cement, concrete</td>
<td>All</td>
<td>Area adjacent to Taxiway 5 and 6-A badly cracked with some vertical displacement at joints. East end adjacent to hangers recently replaced and in excellent condition. Central area good to poor with sections of severe cracking.</td>
</tr>
</tbody>
</table>
Appendix D

SURFACE PLATE LOAD TEST RESULTS
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

[Graph showing pressure vs. deflection with data points and curves]
PLATE BEARING TEST DATA

Pressure vs. Deflection
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 03R-21L

STATION
55+00
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on plate - lbs. per sq. in.

Settlement - (in.)

USMCAS Yuma, Arizona

Runway 03R-21L

55+00
PLATE BEARING TEST DATA

Pressure vs. Deflection

[Graph showing pressure vs. deflection with data points and lines indicating different settlements]
### TOTAL LOAD vs. DEFLECTION

<table>
<thead>
<tr>
<th>FACILITY</th>
<th>LOCATION</th>
<th>STATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>USMCAS Yuma, Arizona</td>
<td>Runway 03R-21L</td>
<td>75+00</td>
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</tbody>
</table>

**Graph Details:**
- **Y-axis:** Total Load - Kips
- **X-axis:** Settlement - (in.)
- Various load-deflection curves are plotted on the graph.
- The graph shows the relationship between total load and settlement for different locations.

**Note:** The graph includes multiple curves indicating different load scenarios or conditions.
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
1 Runway 08-26

STATION
6+00
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit load on plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
TOTAL LOAD vs. DEFLECTION

USMCA0 Yuma, Arizona

Runway 08-26

Station 46+00

TOTAL LOAD - Kips

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit load on plate - lbs. per sq. ft.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

![Graph showing pressure vs. deflection for plate bearing test data. The x-axis represents settlement in inches, and the y-axis represents unit load on plate in lbs. per sq. in. Several curves are shown for different settlement depths: 8', 15', 24', and 36'.]
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection
PLATE BEARING TEST DATA

Pressure vs. Deflection
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Taxiway T-1

STATION
12+00
PLATE BEARING TEST DATA

Pressure vs. Deflection

1500
1000
500

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Taxiway T-1

STATION
22+00

Graph showing the relationship between total load and deflection.
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCS Yuma, Arizona

LOCATION
Taxiway T-1

STATION
32+00

Settlement - (in.)

Total Load - Kips

0 0.05 0.10 0.15 0.20 0.25

0 10 20 30 40 50 60 70 80 90 100
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on plate - lb. per sq. in.

Settlement - (in.)
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Taxiway T-1

STATION
41+00
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)

1500
1000
500
100
50
10

Yuma, Arizona
Taxiway 1-A
5+00
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Taxiway 1-B

STATION
-2+00
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit load on plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection
TOTAL LOAD vs. DEFLECTION

FACILITY

LOCATION

STATION

USMCAS Yuma, Arizona

Taxiway 6

14+00

Settlement - (In.)

Total Load - Kips

0  5  10  15  20  25

0  10  20  30  40  50  60  70  80  90  100
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on Plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit load on plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit Load on plate - lbs. per sq. in.

Settlement - (in.)
PLATE BEARING TEST DATA

Pressure vs. Deflection

Unit load on plate - lbs. per sq. in.

Settlement - (in.)
Appendix E

ALLOWABLE GROSS AIRCRAFT LOAD CURVES
ALLOWABLE GROSS AIRCRAFT WHEEL LOADS (KIPS)

<table>
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<th>SINGLE WHEEL GEAR</th>
<th>DUAL WHEEL GEAR</th>
<th>DUAL TANDEM GEAR</th>
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<tbody>
<tr>
<td>150 PSI TIRES</td>
<td>150 PSI</td>
<td>150 PSI</td>
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<tr>
<td>400 PSI TIRES</td>
<td>SWG X 1.30</td>
<td>SWG X 1.95</td>
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<tr>
<td>62</td>
<td>34</td>
<td>81</td>
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<tr>
<td>121</td>
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GRAPHIC METHOD FOR DETERMINING ALLOWABLE GROSS AIRCRAFT LOADS (Single Wheel Gear)
GRAPHIC METHOD FOR DETERMINING ALLOWABLE GROSS AIRCRAFT LOADS (Single Wheel Gear)

ALLOWABLE GROSS AIRCRAFT WHEEL LOADS (KIPS)

<table>
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<th>SINGLE WHEEL GEAR</th>
<th>DUAL WHEEL GEAR X 1.30</th>
<th>DUAL TANDEM GEAR X 1.95</th>
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<tbody>
<tr>
<td>150 PSI TIRES</td>
<td>400 PSI TIRES</td>
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<tr>
<td>75</td>
<td>48</td>
<td>98</td>
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LOADING PLATE RADIUS, INCHES
ALLOWABLE GROSS AIRCRAFT WHEEL LOADS (KIPS)

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<th>DUAL WHEEL GEAR</th>
<th>DUAL TANDEM GEAR</th>
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<td>150 PSI TIRES</td>
<td>SWG X 1.30</td>
<td>SWG X 1.95</td>
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GRAPHIC METHOD FOR DETERMINING ALLOWABLE GROSS AIRCRAFT LOADS (Single Wheel Gear)
### ALLOWABLE GROSS AIRCRAFT WHEEL LOADS (KIPS)

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<th>DUAL TANDEM GEAR</th>
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<tbody>
<tr>
<td>150 psi tires</td>
<td>400 psi tires</td>
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<td>1.30</td>
<td>1.30</td>
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<tr>
<td>148</td>
<td>45</td>
<td>192</td>
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<tr>
<td>150 psi tires</td>
<td>150 psi</td>
<td>289</td>
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**FACILITY**
US MCAS Yuma, Arizona

**LOCATION**
Taxiway 6

**DATE**
June 1964

**GRAPHIC METHOD FOR DETERMINING ALLOWABLE GROSS AIRCRAFT LOADS (Single Wheel Gear)**
ALLOWABLE GROSS AIRCRAFT WHEEL LOADS (KIPS)

<table>
<thead>
<tr>
<th>SINGLE WHEEL, GEAR</th>
<th>DUAL WHEEL GEAR X 1.30</th>
<th>DUAL TANDEM GEAR X 1.95</th>
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</thead>
<tbody>
<tr>
<td>150 PSI TIRES</td>
<td>400 PSI TIRES</td>
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<tr>
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<td>174</td>
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GRAPHIC METHOD FOR DETERMINING ALLOWABLE GROSS AIRCRAFT LOADS (Single Wheel Gear)
Appendix F

MECHANICAL ANALYSIS OF RECOVERED AND SUBSURFACE AGGREGATES
# Mechanical Analysis

## Grain Size in Millimeters - Bureau of Soils Classification

<table>
<thead>
<tr>
<th>GRAVEL</th>
<th>SAND</th>
<th>SILT</th>
<th>CLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

## Sieve Analysis

<table>
<thead>
<tr>
<th>Size of Opening in Inches</th>
<th>No. of Mesh Per Inch, U.S. Std.</th>
<th>Grain Size in mm</th>
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</thead>
<tbody>
<tr>
<td></td>
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</table>

## Job

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<table>
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<tr>
<td>US MCAS Yuma, Arizona</td>
<td></td>
</tr>
<tr>
<td>Taxiway 1 - Sta 41+00</td>
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## Location

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<table>
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<tr>
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<tr>
<td>Base, subbase and subgrade</td>
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## Plotted By

<p>| | |</p>
<table>
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<tr>
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<tr>
<td>KJD and RET</td>
<td></td>
</tr>
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</table>

## Date

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>June 1964</td>
<td></td>
</tr>
<tr>
<td>GRAVEL</td>
<td>SAND</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>VeryCoarse</td>
</tr>
</tbody>
</table>

GRAIN SIZE IN MILLIMETERS - BUREAU OF SOILS CLASSIFICATION

<table>
<thead>
<tr>
<th>SIZE OF OPENING IN INCHES</th>
<th>NO. OF MESH PER INCH, U.S. STD</th>
<th>GRAIN SIZE IN MM</th>
</tr>
</thead>
</table>

SIEVE ANALYSIS

HYDROMETER ANALYSIS

JOB
US MCAS Yuma, Arizona
Taxiway 1A - Sta 5+00

LOCATION
Top of base course
3 in. below top of A.C.

PLOTTED BY
KJD

DATE
June 1964
MECHANICAL ANALYSIS

GRAVEL
SAND
SILT
CLAY

GRAIN SIZE IN MILLIMETERS - BUREAU OF SOILS CLASSIFICATION

Base

Subgrade

SIZE OF OPENING IN INCHES

NO. OF MESH PER INCH, U.S.STD.

GRAIN SIZE IN MM

SIEVE ANALYSIS

HYDROMETER ANALYSIS

JOB
US MCAS Yuma, Arizona
Runway 03R-21L - Sta 55+00

LOCATION
Base course and subgrade

PLOTTED BY
KJD and RET

DATE
June 1964
MECHANICAL ANALYSIS

GRAVEL

SAND

VeryCoarse Coarse Medium Fine VeryFine

SILT

CLAY

GRAIN SIZE IN MILLIMETERS - BUREAU OF SOILS CLASSIFICATION

PERCENT FINE BY WEIGHT

100.0

90

80

70

60

50

40

30

20

10

0

PERCENT COARSER BY WEIGHT

100.0

90

80

70

60

50

40

30

20

10

0

SIZE OF OPENING IN INCHES

NO. OF MESH PER INCH, U.S. STD.

GRAIN SIZE IN MM.

SIEVE ANALYSIS

HYDROMETER ANALYSIS

JOB

US MCAS Yuma, Arizona
Runway 03R-21L - Sta 75+00

LOCATION

Base course and subgrade

PLOTTED BY

RET

DATE

June 1964
# Mechanical Analysis

## Grain Size in Millimeters - Bureau of Soils Classification

### Table: Grain Size Distribution

<table>
<thead>
<tr>
<th>Gravel</th>
<th>Sand</th>
<th>Silty</th>
<th>Clays</th>
</tr>
</thead>
<tbody>
<tr>
<td>VeryCoarse</td>
<td>Coarse</td>
<td>Medium</td>
<td>Fine</td>
</tr>
</tbody>
</table>

### Diagram:

- **Sieve Analysis:**
  - Size of Opening in Inches
  - No. of Mesh per Inch, U.S. Std.
  - Grain Size in Mm.

- **Hydrometer Analysis:**
  - Percent Finer by Weight
  - Percent Coarser by Weight

### Job Information:

- **Location:** USMCAS Yuma, Arizona
- **Plot:** Runway 03R-21L - Station 65+00 Surface & Binder
- **Analysis:** AC Pavement
- **Plotter:** RET
- **Date:** June 1964
# MECHANICAL ANALYSIS

<table>
<thead>
<tr>
<th>GRAVEL</th>
<th>SAND</th>
<th>SILT</th>
<th>CLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VeryCoarse</td>
<td>Coarse</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Grain size in millimeters - Bureau of Soils Classification

<table>
<thead>
<tr>
<th>Size of Opening in Inches</th>
<th>No. of Mesh per Inch, U.S. Std.</th>
<th>Grain Size in Mm.</th>
</tr>
</thead>
</table>

**Sieve Analysis**

<table>
<thead>
<tr>
<th>Job</th>
<th>Location</th>
<th>Potted By</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>USMCAS Yuma, Arizona</td>
<td>Runway 08-26 - Station 36+00</td>
<td>AC Pavement</td>
<td>June 1964</td>
</tr>
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</table>
MECHANICAL ANALYSIS

<table>
<thead>
<tr>
<th>GRAVEL</th>
<th>SAND</th>
<th>SILT</th>
<th>CLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>VeryCoarse</td>
<td>Coarse</td>
<td>Medium</td>
<td>Fine</td>
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GRAIN SIZE IN MILLIMETERS - BUREAU OF SOILS CLASSIFICATION

SIEVE ANALYSIS

<table>
<thead>
<tr>
<th>SIZE OF OPENING IN INCHES</th>
<th>NO. OF MESH PER INCH, U.S. STD.</th>
<th>GRAIN SIZE IN MM.</th>
</tr>
</thead>
</table>

HYDROMETER ANALYSIS

<table>
<thead>
<tr>
<th>JOB</th>
<th>LOCATION</th>
<th>PLOTTED BY</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>USMCAS Yuma, Arizona</td>
<td>Runway 08-26 - Station 46+00</td>
<td>AC Pavement</td>
<td>June 1964</td>
</tr>
</tbody>
</table>
MECHANICAL ANALYSIS

<table>
<thead>
<tr>
<th>GRAVEL</th>
<th>SAND</th>
<th>SILT</th>
<th>CLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GRAIN SIZE IN MILLIMETERS - BUREAU OF SOILS CLASSIFICATION

JOB: USMCAUS Yuma, Arizona
LOCATION: Taxiway 1 - Station 22+00
PLOTTED BY: AC Pavement
DATE: June 1964
# MECHANICAL ANALYSIS

<table>
<thead>
<tr>
<th>GRAVEL</th>
<th>SAND</th>
<th>SILT</th>
<th>CLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>VeryCoarse</td>
<td>Coarse</td>
<td>Medium</td>
<td>Fine</td>
</tr>
</tbody>
</table>

GRAIN SIZE IN MILLIMETERS - BUREAU OF SOILS CLASSIFICATION

![Graph of grain size distribution](image)

**JOB**
US MCAS Yuma, Arizona
Operations Parking Apron - PA-2

**LOCATION**
10 inches below top
A.C.

**PLOTTED BY**
KJD

**DATE**
June 1964
Appendix G

SUBGRADE PLATE LOAD TEST RESULTS
TOTAL LOAD vs. DEFLECTION

FACILITY: USMGA, Yuma, Arizona
LOCATION: Taxiway I
STATION: 12+00

Subgrade Test

Settlement - (in.)

Total Load - Kips

0 0.05 0.10 0.15 0.20 0.25
0 10 20 30 40 50 60 70 80 90 100
UNIT LOAD vs. DEFLECTION

USNCS Yuma, Arizona
Subgrade Test

K = 710 psi

Unit Load - psi

Settlement - (in.)
Subgrade Test

TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Taxiway 1

STATION
32+00
UNIT LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Taxiway 1

STATION
32+00

Subgrade Test

K = 490 pci

Settlement (in.)

Unit Load (psi)
Subgrade Test

K = 420 psi
Subgrade Test

Unit Load - psi

 Settlement - (in.)

K = 470 pci
Subgrade Test

Unit Load vs. Deflection

K = 670 psi
Subgrade Test

TOTAL LOAD vs. DEFLECTION

FACILITY
USMCA S Yuma, Arizona

LOCATION
Taxiway 2

STATION
9+00

Graph showing the relationship between total load in kips and settlement in inches for a subgrade test.
Subgrade Test

Unit Load - psi

Settlement - (In.)

$E = 730$ pci
UNIT LOAD vs. DEFLECTION

UNIT LOAD - psi

Settlement (in.)

STATION

OFFSET

Yuma, Arizona

Subgrade Test

\( \kappa = 1020 \text{ psi} \)
Subgrade Test

Unit Load - psi vs. Settlement - (In.)

K = 1220 psi
<subgrade test>Subgrade Test</subgrade>
TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Taxiway 6-A

STATION
6+00

Subgrade Test

![Graph showing total load vs. deflection with a grid and data points.]

Settlement - (in.)
Subgrade Test

Total Load vs. Deflection

Facility: USMCAS Yuma, Arizona
Location: Taxiway 6-A
Station: 16+00
Subgrade Test

Unit Load vs. Deflection

USMCAS Yuma, Arizona

Taxiway 6-A

Station 16+00

K = 800 psi
Subgrade test

Unit load - psi

Settlement - (in.)

K = 280 psi
Subgrade test

Unit load - psi

0 10 20 30 40 50 60 70 80 90 100

Settlement - (in.)

0 .05 .1 .15 .2 .25

K = 440 psi
UNIT LOAD VS. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 17-35

STATION
29+00

Subgrade test

K = 590 pci
TOTAL LOAD vs. DEFLECTION

FACILITY LocA_ION STATION
USMCAS Yuma, Arizona Runway 17-35 49+00

Subgrade test

<table>
<thead>
<tr>
<th>Settlement - (In.)</th>
<th>0</th>
<th>0.05</th>
<th>0.10</th>
<th>0.15</th>
<th>0.20</th>
<th>0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Load - Kips</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

226
Subgrade test

Unit load - psi

Settlement - (in.)

K = 440 psi
Subgrade test

TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 08-26

STATION
6400
Subgrade test

Unit load - psi

Settlement - (in.)

$K = 270$ psi
TOTAL LOAD vs. DEFLECTION

SUBGRADE TEST

USMCA Yuma, Arizona

LOCATION: Runway 08-26
STATION: 16+00

FACILITY: USMCA Yuma, Arizona

TOTAL LOAD - Kips vs. SETTLEMENT - (in.)
Subgrade Test

Unit Load vs. Deflection

K = 510 psi

Settlement - (in.)

Unit Load - psi
Subgrade Test

- Unit Load - psi
- Total Load - kips
- Settlement - (in.)

K = 200 pci
Subgrade test

$K = 365 \text{ psi}$
Subgrade Test

Unit Load - psi

Total Load - kips

Settlement - (in.)

K = 215 pci
Subgrade Test

TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 03R-21L

STATION
15+50
Subgrade Test

Unit Load vs. Deflection

K = 1460 psi
Fig. 010

Subgrade Test

Total Load vs. Deflection

Location

USYCAS, Yuma, Arizona

Runway 03R-21L

Subgrade Test

Load Kips

Settlement (in.)

25+50
UNIT LOAD vs. DEFLECTION

Subgrade Test

K = 1000 pci

Facility: USMCAS Yuma, Arizona
Location: Runway 09R-21L
Station: 35+50
IIND NOEL 3960/20 (1-64)  
UNIT LOAD vs. DEFLECTION

FACILITY  
USMCAS Yuma, Arizona

LOCATION  
Runway 03R-21L

STATION  
45+00

Subgrade Test

Unit Load - psi

Settlement - (in.)

K = 590 psi
Subgrade Test

Unit Load vs. Deflection

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 03R-21L

STATION
55+00

K = 490 psi
UNIT LOAD vs. DEFLECTION

FACILITY: USMCAS Yuma, Arizona
LOCATION: Runway 03R-21L
STATION: 65+00

Subgrade Test

Unit Load - psi

Settlement - (in.)

K = 500 pci
TOTAL LOAD vs. DEFLECTION

Subgrade Tests

Facility: USMCAS Yuma, Arizona
Location: Runway 03R-21L
Station: 75+00
UNIT LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 03R-21L

STATION
75+00

Subgrade Test

\[ K = 675 \text{ psi} \]
UNIT LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 03R-21L

STATION
85+00

Subgrade Test

Unit load - psi

Settlement - (in.)

K = 780 psi
UNIT LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Runway 03R-21L

STATION
93+50

Subgrade Test

Unit Load - psi

Settlement (in.)

K = 740 psi
IIND NCEL 3960/20 (1-64) Unit & TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Operations Parking Apron

STATION
PA-1

Subgrade test

Unit load - psi

Total load - kips

Settlement - (In.)

K = 165 pci
Unit & TOTAL LOAD vs. DEFLECTION

FACILITY
USMCAS Yuma, Arizona

LOCATION
Operations Parking Apron

STATION
PA-2

Subgrade Test

Unit load - psi

Total load - kips

Settlement - (in.)

K = 165 pci
Appendix H

TYPICAL MOISTURE-DENSITY RELATIONSHIP

AND CALIFORNIA BEARING RATIO CURVES
Moisture-Density Relationship

California Bearing Ratio
Appendix I

TEST PIT AND AUGER HOLE LOGS
Runway 08-26
Station 6400
AC 5" Asphalitic concrete
GP 9" Crushed stone and desert sand, coarse, damp, compact.
SP 4-6" Compacted sand subgrade.
SP-SM 60" Fine sand, brown, loose, damp.

Runway 08-26
Station 1600
AC 5" Asphalitic concrete
GP 3" Crushed stone and desert sand, coarse, damp, compact.
SP 4-6" Compacted sand subgrade.
SP-SM 60" Fine sand, brown, loose, damp.

Runway 08-26
Station 26400
AC 5" Asphalitic concrete
GP 8" Crushed stone and desert sand, coarse, damp, compact.
SM 4-6" Compacted sand subgrade.
SM 60" Fine sand, brown, loose, damp.

Runway 08-26
Station 3600
AC 5" Asphalitic concrete
GP 7" Crushed stone and desert sand, coarse, damp, compact.
SP-SM 4-6" Compacted sand subgrade.
SP-SM 60" Fine sand, brown, loose, damp.
Runway 03R-21L
Station 15+50

AC 4" Asphalitic concrete

GP 10" Crushed aggregate with sand, compacted, damp in place.

SP-SM 4-6" Compacted sand subgrade

Brown fine sand, damp.

Runway 03R-21L
Station 25+50

AC 4" Asphalitic concrete

GP-GM 11" Crushed aggregate with sand, compacted, damp.

SP-SM 4-6" Compacted sand subgrade

Runway 03R-21L
Station 35+50

AC 12" Asphalitic concrete

GP 7" Crushed aggregate with sand, compacted, slightly damp.

SP-SM 4-6" Compacted sand subgrade

Brown fine sand, dry.

Runway 03R-21L
Station 45+00

AC 9" Asphalitic concrete

GP 9" Crushed aggregate, gravel with sand, compacted, damp.

SP-SM 7" Brown silty sand, well compacted.

SP-SM 60" Light brown fine sand, damp.
Runway 03R-21L
Station 55+00
AC 11" Asphaltic concrete
GP 7" Sandy gravel, compact, dry.
SP-SM 6" Compacted sand subgrade.
CPZ
SP-SM 60" Brown fine sand, damp, loose.

Runway 03R-21L
Station 65+00
AC 12" Asphaltic concrete
GP 10" Sandy gravel, compact, dry.
SP-SM 6-7" Compacted sand subgrade.

Runway 03R-21L
Station 75+00
AC 7" Asphaltic concrete
GP 10" Sandy gravel, compact, dry.
SP-SM 6-7" Compacted sand subgrade.

Runway 03R-21L
Station 85+00
AC 9" Asphaltic concrete
GP 9" Sandy gravel, compact, dry.
SP-SM 6-7" Compacted sand subgrade.
SP-SM 60" Brown fine sand, damp, loose.
Runway 03R-21L
Station 93+00

AC 8" Asphallic concrete

GP 14" Sandy gravel, compact, dry.

SP-SM 6" Compacted sand subgrade.

SP-SM 50" Brown fine sand, damp, loose.

Taxiway 6-A
Station 6+00

AC 3" Asphallic concrete

GP 6" Sandy gravel, compact.

SP-SM 60" Brown fine sand, damp, loose.

Taxiway 6-A
Station 16+00

AC 3" Asphallic concrete

GP 6" Sandy gravel, compact.

SP-SM 60" Brown fine sand, damp, loose.
Runway 17-35
Station 7+00

- **AC** 5"
  - Asphallic concrete

- **GW** 8"
  - Crushed stone with
desert sand, damp,
compact.

- **SP-SM** 4-6"
  - Compacted sand
  subgrade.

- **SP-SM** 60"
  - Brown fine sand,
damp, loose with
  some clay lumps.

Runway 17-35
Station 19+00

- **AC** 5"
  - Asphallic concrete

- **GW** 10"
  - Crushed stone with
desert sand, damp,
compact.

- **SM** 4-6"
  - Compacted sand
  subgrade.

Runway 17-35
Station 29+00

- **AC** 5"
  - Asphallic concrete

- **GP** 11"
  - Crushed stone with
desert sand, damp,
compact.

- **SP** 4-6"
  - Compacted sand
  subgrade.

- **SP** 60"
  - Brown fine sand,
damp, loose.

Runway 17-35
Station 39+00

- **AC** 5"
  - Asphallic concrete

- **GP** 11"
  - Crushed stone with
desert sand, damp,
compact.

- **SP-SM** 4-6"
  - Compacted sand
  subgrade.

- **SP-SM** 60"
  - Brown fine sand,
damp, loose.
Runway 17-35
Station 49+00

AC 5" Asphallic concrete
Crushed stone with
desert sand, damp, compact.

GP 3" Compacted sand
subgrade.

SP-SM 60" Brown fine sand,
damp, loose.

Taxiway T-6
Station 6+00

AC 4" Asphallic concrete

GM 6" Base course

GM 4" Subbase

SM 6" Compacted sand
subgrade.

Taxiway T-6
Station 14+00

AC 4" Asphallic concrete

GM 6" Base course

GP-GM 4" Subbase

SM 6" Compacted sand
subgrade.

SM 60" Brown fine sand,
damp, loose.

Taxiway T-6
Station 1+50 Offset

AC 6" Asphallic concrete

GP 11" Crushed stone
with desert sand,
compacted, damp.

SM 6" Compacted sand
subgrade.

SM 6" Brown fine sand,
damp, loose.

SM 50" Brown fine sand
with trace of
gravel, damp,
loose.
Taxiway 1-A
Station 5+00

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>4&quot; Asphalistic concrete</td>
</tr>
<tr>
<td>GP-GM</td>
<td>14&quot; Crushed rock and brown sand, compacted, dry.</td>
</tr>
<tr>
<td>SM</td>
<td>4-6&quot; Compacted sand subgrade.</td>
</tr>
<tr>
<td>SM</td>
<td>60&quot; Brown fine sand, damp, loose.</td>
</tr>
</tbody>
</table>

Taxiway 1
Station 12+00

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>5&quot; Asphalistic concrete</td>
</tr>
<tr>
<td>GP</td>
<td>11&quot; Crushed rock and brown sand, compacted, dry.</td>
</tr>
<tr>
<td>SP-SM</td>
<td>4-6&quot; Compacted sand subgrade.</td>
</tr>
<tr>
<td>SP-SM</td>
<td>60&quot; Brown fine sand, damp, loose.</td>
</tr>
</tbody>
</table>