REPORT
OF A
PAVEMENT DESIGN

FOR

PROPOSED STREETS
COLLINDALE SIXTH FILING
FORT COLLINS, COLORADO

BARTRAN HOMES
FORT COLLINS, COLORADO
PROJECT NO. 5233-83

BY

EMPIRE LABORATORIES, INC.
214 NORTH HOWES STREET
FORT COLLINS, COLORADO 80521

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August 5, 1983

Bartran Homes
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Fort Collins, Colorado 80525

Attention: Mr. Larry Kleine

Gentlemen:

We are pleased to submit our Report of a Pavement Design prepared for the proposed streets in the Collindale Sixth Filing located in southeast Fort Collins, Colorado.

The accompanying report presents our findings in the subsurface and our recommendations for pavement design based upon these findings.

Very truly yours,

EMPIRE LABORATORIES, INC.

Neil R. Sherrod
Senior Engineering Geologist

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clc

cc: M & I, Inc. - John Sadaris

REPORT
OF A
PAVEMENT DESIGN

SCOPE

This report presents the results of a pavement design prepared for the proposed streets in Collindale Sixth Filing, Fort Collins, Colorado. The scope of the project included test borings and laboratory testing of samples obtained from these borings.

The objectives of this study were to (1) determine the soil and groundwater conditions at the site, (2) develop criteria for determining pavement design, and (3) make recommendations regarding pavement types and thicknesses for the proposed streets to be constructed at the site.

SITE EXPLORATION

The field exploration, carried out on July 27, 1983, consisted of drilling, logging, and sampling four (4) test borings. The locations of the test borings are shown on the Test Boring Location Plan included in Appendix A of this report. Boring logs prepared from the field logs are shown in Appendix A. These logs show soils encountered, location of sampling, and groundwater at the time of the exploration.

The borings were advanced with a four-inch diameter, continuous-type, power-flight auger drill. During the drilling operation, a geotechnical engineer from Empire Laboratories, Inc. was present and made continuous observations of the soils encountered.

SITE LOCATION AND DESCRIPTION

The proposed site is located between Lockwood Drive and Carlton Avenue in southeast Fort Collins, Colorado. More particularly, the site is described as Collindale Sixth Filing, a subdivision situate in the

south 1/2 of Section 30, Township 7 North, Range 68 West of the Sixth P.M., Fort Collins, Larimer County, Colorado.

The site consists of an undeveloped field covered with grasses and weeds. The property slopes to the east and has positive drainage in this direction. Portions of the streets have been rough cut in. The area to the north is fully developed.

LABORATORY TESTS AND EVALUATION

Samples obtained from the test borings were subjected to testing in the laboratory to provide a sound basis for evaluating the physical properties of the soils encountered. Moisture contents, dry unit weights, and the Atterberg limits were determined. A summary of the test results is included in Appendix B. A Hveem stabilometer test was run to determine the "R" value of representative subgrade material at the site, and a curve showing this data is included in Appendix B.

SOIL AND GROUNDWATER CONDITIONS

The soil profile at the site consists of strata of materials arranged in different combinations. In order of increasing depths, they are as follows:

(1) Silty Topsoil: The majority of the area tested is overlain by a six (6) inch layer of silty topsoil. The topsoil has been penetrated by root growth and organic matter and should not be used as roadway embankment or subgrade material.

(2) Sandy Silty Clay: This stratum underlies the topsoil and/or surface and extends to the depths explored. The silty clay is plastic, contains a large percentage of fine sand, and is damp to moist in its natural in situ condition.

(3) Groundwater: At the time of the investigation, free groundwater was encountered in Borings 2, 3, and 4 at the

site at depths seven (7) to nine (9) feet below the surface. No free groundwater was encountered in Boring 1 to the depths explored. Water levels in this area may be subject to change due to seasonal variations and irrigation demands on and/or adjacent to the site.

RECOMMENDATIONS AND DISCUSSION

It is our understanding that all streets within the Collindale Sixth Filing have been classified as residential and that these streets are to be paved.

Site Grading

It is recommended that the upper six (6) inches of topsoil encountered at the site be stripped and stockpiled for reuse in planted areas. The upper six (6) inches of the natural subgrade below filled areas should be scarified and recompacted at or wet of optimum moisture to at least ninety-five percent (95%) of Standard Proctor Density ASTM D 698-78. (See Appendix C.)

All fill should consist of the on-site soils or imported material having an "R" value of 6 or greater, and this material should be approved by the geotechnical engineer. Any fill placed at the site should be placed in uniform six (6) to eight (8) inch lifts and compacted at or wet of optimum moisture to at least ninety-five percent (95%) of Standard Proctor Density ASTM D 698-78. The finished subgrade in cut sections below streets should be scarified a minimum of six (6) inches and recompacted at or wet of optimum moisture to at least ninety-five percent (95%) of Standard Proctor Density ASTM D 698-78. It is recommended that all stripping, subgrade preparation, and fill placement be inspected by the geotechnical engineer. Field density tests should be taken in the compacted subgrade and fill under the supervision of the geotechnical engineer to insure proper compaction.

Flexible Pavement

It is our opinion that flexible pavement is suitable for the proposed street construction at the site. A flexible pavement alternate should consist of asphaltic concrete underlain by crushed aggregate base course and subbase or asphaltic concrete underlain by plant mix bituminous base course. Using the City of Fort Collins "Design Criteria and Standards for Streets," a serviceability index of 2.0, a regional factor of 0.75 , an "R" value of 6, a twenty (20) year design life, an eighteen (18) kip equivalent daily load application of 5 as provided by the City of Fort Collins, and a weighted structural number of 2.15, the following pavement thicknesses are recommended for all streets within Collindale Sixth Filing:

Asphaltic Concrete	2½"
Crushed Aggregate Base Course	4"
Select Subbase	6"
Total Pavement Thickness	12½"

Asphaltic Concrete	2"
Plant Mix Bituminous Base Course	4"
Total Pavement Thickness	6"

The select subbase and crushed aggregate base course should meet City of Fort Collins specifications. The subgrade below the proposed asphalt pavement should be prepared in accordance with the recommendations discussed in the "Site Grading" section of this report. Upon proper preparation of the subgrade, the subbase and base course should be placed and compacted at optimum moisture to at least ninety-five percent (95%) of Standard Proctor Density ASTM D 698-78. (See Appendix C.)

It is recommended that the asphaltic concrete and/or plant mix bituminous base be placed in two (2) to three (3) inch lifts. All plant mix base course and asphaltic concrete shall meet City of Fort Collins specifications and should be placed in accordance with these specifications. All subbase material shall have an "R" value of 69 or

greater, the crushed aggregate base course shall have an "R" value of 78 or greater, the plant mix bituminous base course shall have an Rt value of 90 or greater, and the asphaltic concrete shall have an Rt value of 95 or greater. Field density tests should be taken in the aggregate base, bituminous base, and asphalt under the direction of the geotechnical engineer.

Rigid Pavement

A feasible pavement alternate at the site would be rigid pavement. Using the eighteen (18) kip equivalent daily load application described above, a modulus of subgrade reaction of one hundred (100) pounds per square inch per inch based on an "R" value of 6, a design life of twenty (20) years, and concrete designed with a modulus of rupture of five hundred fifty (550) pounds per square inch, the following pavement thickness for all streets within Collindale Sixth Filing is recommended:

Nonreinforced Concrete - 4½"

Subgrade below proposed streets should be prepared in accordance with the recommendations discussed in the "Site Grading" section of this report. Concrete pavement should be placed directly on the subgrade that has been uniformly and properly prepared in accordance with the above recommendations. All concrete used in the paving shall meet ASTM specifications, and all aggregate shall conform to ASTM C-33 specifications. The concrete should be designed with a minimum modulus of rupture of five hundred fifty (550) pounds per square inch in twenty-eight (28) days. It is recommended that laboratory mix designs be done to determine the proper proportions of aggregates, cement, and water necessary to meet these requirements. It is essential that the concrete have a low water-cement ratio, an adequate cement factor, and sufficient quantities of entrained air. Joints should be carefully designed and constructed in accordance with the City of Fort Collins "Design Criteria and Standards for Streets" to insure good performance of the pavement. It is recommended that all concrete pavement be

placed in accordance with City of Fort Collins specifications. If paving is done during cold weather, acceptable cold weather procedures as outlined in the City specifications should be utilized. The concrete pavement should be properly cured and protected in accordance with the above specifications. Concrete injured by frost should be removed and replaced. It is recommended that the pavement not be opened to traffic until a flexural strength of four hundred (400) pounds per square inch is obtained or a minimum of fourteen (14) days after the concrete has been placed.

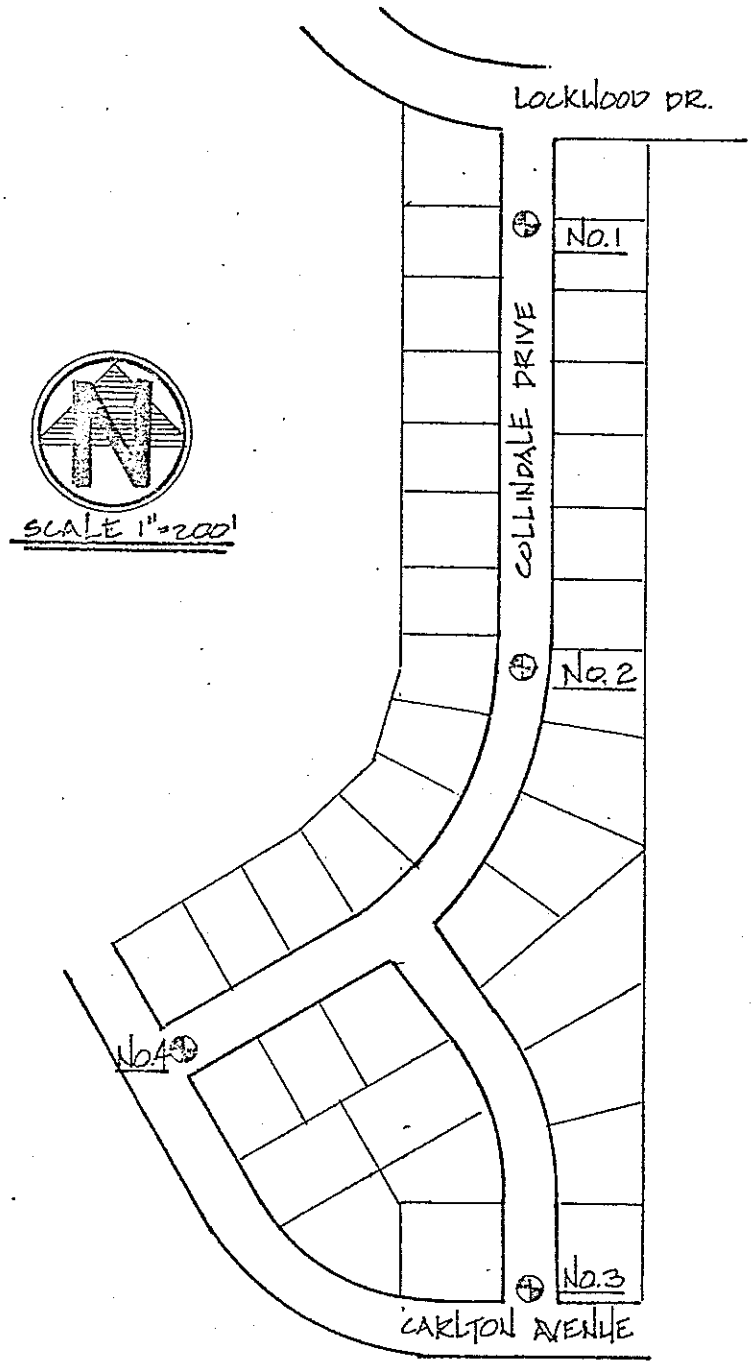
GENERAL COMMENTS

This report has been prepared to aid in the evaluation of the property and to assist the engineer in the design of this project. In the event that any changes in the street grade or designs are planned, the conclusions and recommendations contained in this report will not be considered valid unless said changes are reviewed and conclusions of this report modified or approved in writing by Empire Laboratories, Inc., the geotechnical engineer of record.

Every effort was made to provide comprehensive site coverage through careful locations of the test borings, while keeping the site investigation economically feasible. Variations in soil and groundwater conditions between test borings may be encountered during construction. In order to permit correlation between the reported subsurface conditions and the actual conditions encountered during construction and to aid in carrying out the plans and specifications as originally contemplated, it is recommended that Empire Laboratories, Inc. be retained to perform continuous construction review during the excavation and foundation phases of the work. Empire Laboratories, Inc. assumes no responsibility for compliance with the recommendations included in this report unless they have been retained to perform adequate on-site construction review during the course of subgrade preparation and pavement placement.

APPENDIX A.

TEST BORING LOCATION PLAN



KEY TO BORING LOGS


TOPSOIL


GRAVEL


FILL


SAND & GRAVEL


SILT


SILTY SAND & GRAVEL


CLAYEY SILT


COBBLES


SANDY SILT


SAND, GRAVEL & COBBLES


CLAY


WEATHERED BEDROCK


SILTY CLAY


SILTSTONE BEDROCK


SANDY CLAY


CLAYSTONE BEDROCK


SAND


SANDSTONE BEDROCK


SILTY SAND


LIMESTONE


CLAYEY SAND


GRANITE


SANDY SILTY CLAY


SHELBY TUBE SAMPLE

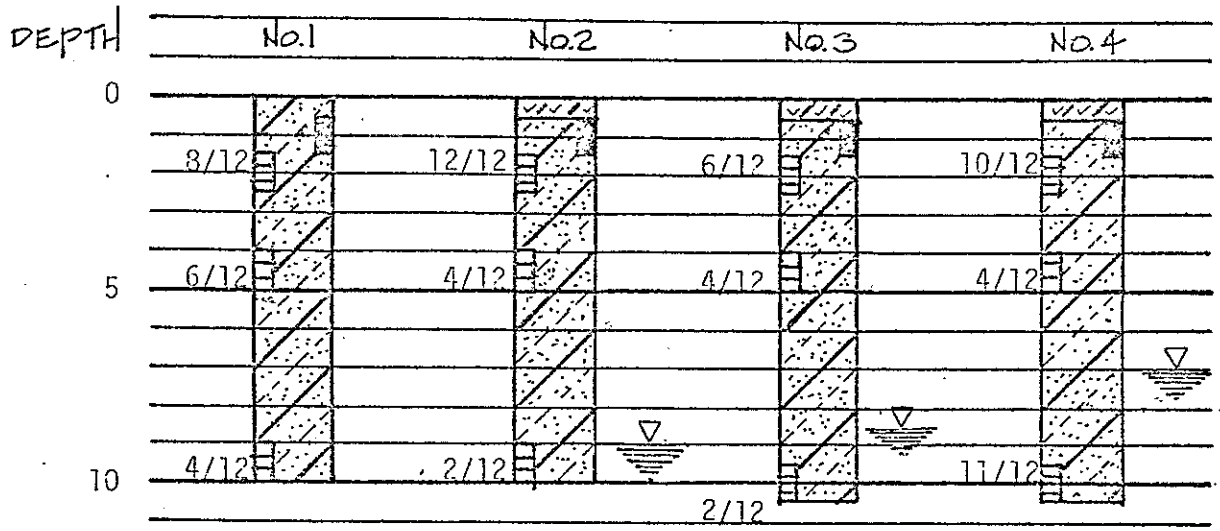

STANDARD PENETRATION DRIVE SAMPLER


WATER TABLE 0 HOURS AFTER DRILLING

HOLE CAVED

5/12 Indicates that 5 blows of a 140 pound hammer falling 30 inches was required to penetrate 12 inches.

LOG OF BORINGS



APPENDIX B.

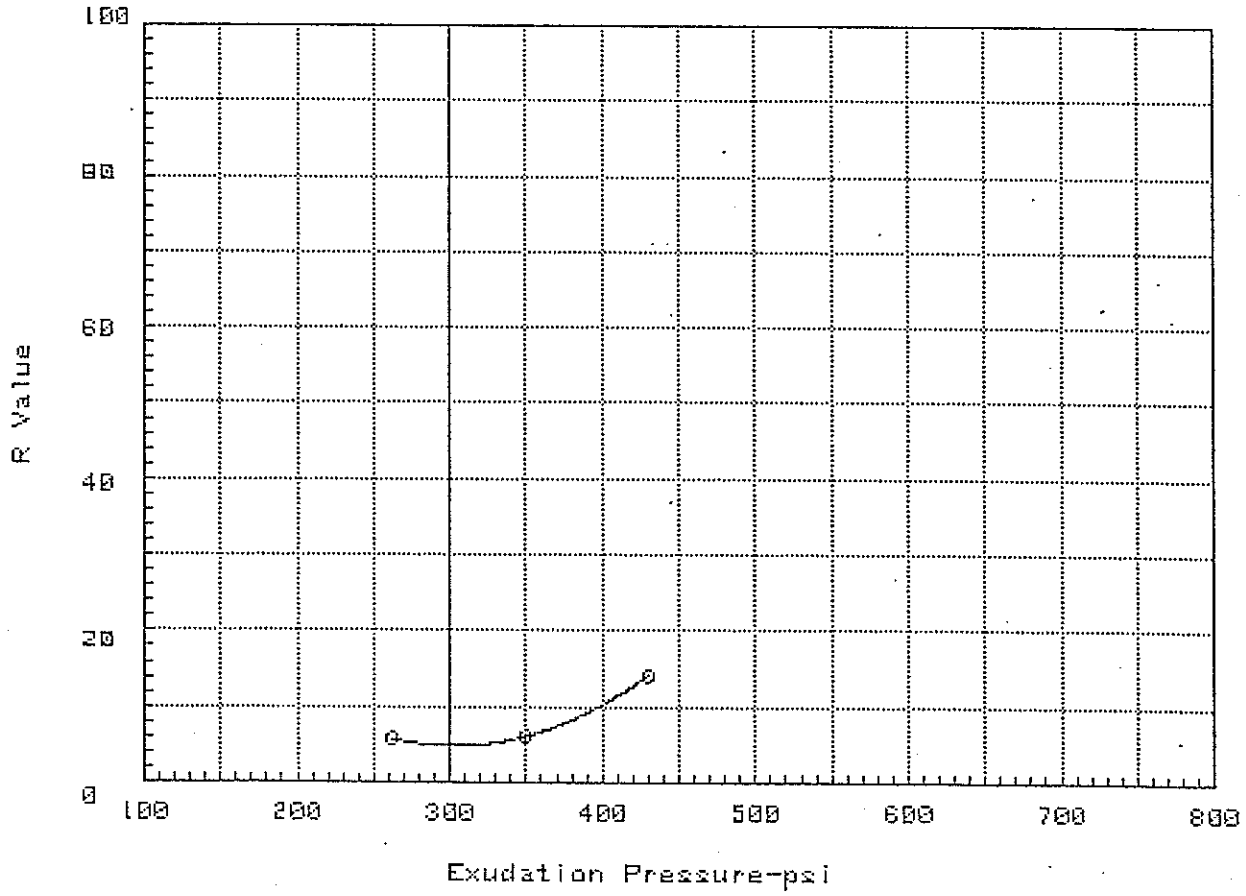
STABILOMETER
TEST RESULTS

Client BARTRAN HOMES

Project COLLINDALE SIXTH FILING

Boring 4 Depth 0.5 - 3.5

R Value at 300 psi exudation 5.8



Empire Laboratories, Inc.

"R" VALUE DATA

Boring No. Depth (Ft.)	Compaction Pressure (PSI)	Density (PCF)	Moisture (%)	Expansion Pressure (PSI)	Horizontal Pressure (PSI)*	Sample Height (In.)	R-Value** @ 300 PSI Exudation Pressure
4 @ 0.5-3.5'	0	94.7	28.4	0	145	2.67	5.7
	0	101.0	23.8	0	135	2.55	6.1
	100	107.1	20.6	0	128	2.50	14.1

* At 160 psi vertical pressure
** $100 - 100/((2.5/D)(160/Ph - 1) + 1)$

SUMMARY OF TEST RESULTS

Boring No.	Depth (Ft.)	Moisture (%)	Dry Density (PCF)	Compressive Strength (PSF)	Swell Pressure (PSF)	Soluble Sulfates (%)	pH	Liquid Limit (%)	Plasticity Index (%)	Group Index	Classification AASHTO USCS	Resistivity (OHM-CM)	Penetration Blows/In.
1	0.5-1.5	12.1	84.8										
	1.5-2.5	10.7											8/12
	4.0-5.0	10.9											6/12
	9.0-10.0	19.8											4/1[illegible]
Composite Sample													
	0.5-3.5							30.7	10.9	1.3	A-6(1); SC		
2	0.5-1.5	13.3	99.5					26.2	10.7	3.8	A-6(4); CL		
	1.5-2.5	15.0											12/12
	4.0-5.0	18.4											4/12
	9.0-10.0	21.4											2/12
3	0.5-1.5	14.4	100.9										
	1.5-2.5	16.8											6/12
	4.0-5.0	21.9											4/12
	9.5-10.5	15.8											2/12
Composite Sample													
	0.5-3.5							32.3	12.9	7.8	A-6(8); CL		

SUMMARY OF TEST RESULTS

Boring No.	Depth (Ft.)	Moisture (%)	Dry Density (PCF)	Compressive Strength (PSF)	Swell Pressure (PSF)	Soluble Sulfates (%)	pH	Liquid Limit (%)	Plasticity Index (%)	Group Index	Classification AASHTO USCS	Resistivity (OHM-CM)	Penetration Blows/In.
4	0.5-1.5	17.1	112.2										
	1.5-2.5	17.8											10/12
	4.0-5.0	27.2											4/12
	9.5-10.5	24.1											11/12
Composite Sample													
	0.5-3.5							32.5	16.7	10.6	A-6(11); CL		

APPENDIX C.

APPENDIX C.

Suggested Specifications for Placement of Compacted Earth Fill and/or Backfills.

GENERAL

A soils engineer shall be on-site to provide continuous observation during filling and grading operations and shall be the owner's representative to inspect placement of all compacted fill and/or backfill on the project. The soils engineer shall approve all earth materials prior to their use, the methods of placing, and the degree of compaction obtained.

MATERIALS

Soils used for all compacted fill and backfill shall be approved by the soils engineer prior to their use. The upper two (2) feet of compacted earth backfill placed adjacent to exterior foundation walls shall be an impervious, nonexpansive material. No material, including rock, having a maximum dimension greater than six inches shall be placed in any fill. Any fill containing rock should be carefully mixed to avoid nesting and creation of voids. In no case shall frozen material be used as a fill and/or backfill material.

PREPARATION OF SUBGRADE

All topsoil, vegetation (including trees and brush), timber, debris, rubbish, and other unsuitable material shall be removed to a depth satisfactory to the soils engineer and disposed of by suitable means before beginning preparation of the subgrade. The subgrade surface of the area to be filled shall be scarified a minimum depth of six inches, moistened as necessary, and compacted in a manner specified below for the subsequent layers of fill. Fill shall not be placed on frozen or muddy ground.

PLACING FILL

No sod, brush, frozen or thawing material, or other unsuitable material shall be placed in the fill, and no fill shall be placed during unfavorable weather conditions. All clods shall be broken into small pieces, and distribution of material in the fill shall be such as to preclude the formation of lenses of material differing from the surrounding material. The materials shall be delivered to and spread on the fill surface in a manner which will result in a uniformly compacted fill. Each layer shall be thoroughly blade mixed during spreading to insure uniformity of material and moisture in each layer. Prior to compacting, each layer shall have a maximum thickness of eight inches, and its upper surface shall be approximately horizontal. Each successive 6" to 8" lift of fill being placed on slopes or hillsides should be benched into the existing slopes, providing good bond between the fill and existing ground.

MOISTURE CONTROL

While being compacted, the fill material in each layer shall as nearly as practical contain the amount of moisture required for optimum compaction or as specified, and the moisture shall be uniform throughout the fill. The contractor may be required to add necessary moisture to the fill material and to uniformly mix the water with the fill material if, in the opinion of the soils engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. If, in the opinion of the soils engineer, the material proposed for use in the compacted fill is too wet to permit adequate compaction, it shall be dried in an acceptable manner prior to placement and compaction.

COMPACTION

When an acceptable, uniform moisture content is obtained, each layer shall be compacted by a method acceptable to the soils engineer and as specified in the foregoing report as determined by applicable standards. Compaction shall be performed by rolling with approved tamping rollers,

pneumatic-tired rollers, three-wheel power rollers, vibratory compactors, or other approved equipment well-suited to the soil being compacted. If a sheepfoot roller is used, it shall be provided with cleaner bars attached in a manner which will prevent the accumulation of material between the tamper feet. The rollers should be designed so that effective weight can be increased.

MOISTURE-DENSITY DETERMINATION

Samples of representative fill materials to be placed shall be furnished by the contractor to the soils engineer for determination of maximum density and optimum moisture or percent of Relative Density for these materials. Tests for this determination will be made using methods conforming to requirements of ASTM D 698, ASTM D 1557, or ASTM D 2049. Copies of the results of these tests will be furnished to the owner, the project engineer, and the contractor. These test results shall be the basis of control for all compaction effort.

DENSITY TESTS

The density and moisture content of each layer of compacted fill will be determined by the soils engineer in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. Any material found not to comply with the minimum specified density shall be recompacted until the required density is obtained. Sufficient density tests shall be made and submitted to support the soils engineer's recommendations. The results of density tests will also be furnished to the owner, the project engineer, and the contractor by the soils engineer.