REPORT OF SUBSURFACE EXPLORATION AND ENGINEERING EVALUATION PAVEMENT DESIGN FOR LOCKWOOD FOLLY SUBDIVISION

SUPPLY, NORTH CAROLINA
F&R PROJECT NO. J64-082T

Prepared For:

LOCKWOOD FOLLY PROPERTY OWNERS ASSOCIATION
3198 Marshview Drive
Supply, North Carolina 28462

Prepared By:

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October 5, 2007

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October 5, 2007

Mr. Pat Hogan
Lockwood Folly Home Owners Association
3198 Marshview Drive
Supply, North Carolina 28462

Re: Report of Subsurface Exploration and Engineering Evaluation
Pavement Design for Lockwood Folly Subdivision
Supply, North Carolina
F&R Project No. J64-082T

Dear Mr. Hogan:

Froehling and Robertson, Inc. (F&R) has completed the authorized geotechnical study for the above referenced project in Supply, North Carolina. This report contains a brief description of the project information provided to F&R, a general description of the site and subsurface conditions encountered during the subsurface exploration, and our geotechnical engineering recommendations for the proposed pavement construction. This report was performed in general accordance with F&R Proposal No. 0864-076G, dated August 14, 2007.

We are available to review with you the recommendations presented herein and answer questions that you may have regarding our geotechnical report. We have enjoyed working with you and look forward to our continued association as your geotechnical consultant on the remainder of this project and on future projects you may have.

Respectfully submitted,
FROEHLING & ROBERTSON, INC.

Miguel Santiago, P.E.
Geotechnical Engineer

Gilles Bellot, P.E.
Fayetteville Branch Manager

1.0 PURPOSE OF EXPLORATION

The purpose of this exploration was to obtain information regarding the general subsurface conditions within the existing pavement areas, conduct pertinent field and laboratory testing to assess the engineering characteristics of the pavement and subsurface materials, and to provide general recommendations regarding the geotechnical aspects of site preparation and pavement design.

This report contains the following items:

- Site & Boring Location Plans;
- Hand Auger Boring Logs;
- Kessler DCP Logs;
- Laboratory test results;
- A review of the subsurface conditions encountered with comments on the regional geology;
- A general evaluation of the existing pavements and subsurface conditions encountered;
- Recommendations for the design and construction of a flexible pavement system.

2.0 PROJECT INFORMATION

The proposed project is located within the existing Lockwood Folly subdivision in Supply, North Carolina, (See Figure I in Appendix I for the approximate location of the site). The subdivision consists of both existing homes and/or homes under construction. The plans that you submitted to us on behalf of the Lockwood Folly Homeowners Association, show that the access to the subdivision consists of one primary road named Clubhouse Drive and several secondary and tertiary streets.

It is our understanding that the existing streets of the Lockwood Folly Subdivision consist of an asphaltic surface with a sandy subbase. At the time of our site visit on August 15, 2007, the existing streets showed signs of distress at different locations. We observed several areas of pavement depressions and others with minor to severe alligator cracking. You have indicated that the existing pavement would be approximately 20 to 22 years old.

3.0 EXPLORATION PROCEDURES

As part of our exploration, F&R performed 20 asphalt cores, 20 Kessler Dynamic Cone Penetrometer Borings (KDCP) and 4 Dynamic Cone Penetrometer hand auger borings to evaluate the subgrade soils to a depth of 3 feet below the existing asphalt. Please refer to Figure 2, Appendix I for the approximate asphalt cores and boring locations. The soil samples collected during our exploration were labeled and transported to F&R's laboratory for evaluation and testing.

3.1 Field Procedures

3.1.1 Kessler DCP Testing: In order to evaluate the existing pavement thicknesses and underlying subgrade soils, twenty pavement cores (T-1 through T-20) were performed at the approximate locations shown on the attached "Boring Location Plan" (Figure 2) included in Appendix I. The pavement cores were performed in accordance with generally accepted procedures using an electric core drill and a 6-inch diameter diamond-tipped core barrel. The asphalt samples obtained from our coring operations were measured, marked and placed in plastic bags and transported to our office for further evaluation.

Upon completion of coring the asphalt, Kessler Dynamic Cone Penetrometer (Kessler DCP) testing was performed at all core locations. The Kessler DCP test procedure involves driving the DCP tip into the soil using a 17.6 pound hammer falling from a height of 22.6 inches. The total penetration for a given number of blows is measured and recorded in millimeters per blow, which is then used to estimate the in-situ California Bearing Ratio (CBR) value.

3.1.2 Hand Auger Borings: In order to further evaluate the subgrade soils, hand auger borings with Dynamic Cone Penetrometer (DCP) tests were performed at boring locations T-8, T-12, T-16 and T-20, with the approximate locations shown on the attached "Boring Location Plan" (Figure 2) included in Appendix I. The borings were performed to a depth of approximately 3 feet below the existing pavement surface.

The DCP test procedure involves first seating the conical point of the penetrometer two inches into the bearing materials to assure that the conical point is completely embedded. The conical point is then driven in 1-3/4 inch increments using a 15-pound weight falling from a height of 20 inches. The penetrometer reading is the number of blows required to drive the conical point 1-3/4 inches. Typically, the conical point is then driven an additional increment of 1-3/4 inches and the penetrometer readings are recorded. When properly evaluated, the penetrometer test results can provide an index for estimating soil strength and relative density.

The pavement core locations were backfilled and asphalt patched immediately upon completion of our field testing operations. Any excess materials removed from the coring locations were disposed of prior to leaving the site.

3.1.3 Visual Soil Classification: Near-surface soil samples were obtained during the field operations were placed in plastic bags and transported to F&R's office to be visually observed and classified by a geotechnical engineer using the Unified Soil Classification System (USCS). The near-surface soil classifications are provided on the individual "DCP Boring Logs" included in this report (See Hand Auger Boring Logs, Appendix II).

3.1.4 Laboratory Testing

Based on visual observation of the obtained samples, F&R selected and subjected nineteen soil samples to a laboratory testing program consisting of routine geotechnical index testing, (i.e. Natural Moisture Content, Atterberg Limits and Grain Size Distribution analysis) in general accordance with applicable ASTM standards.

The CBR values of on-site soils ranged from 11.4 to 34.3. Based on the laboratory test results and our past experience with similar soils, a CBR value of 11 was used for the pavement design. A summary of the laboratory test results is presented in the following Table 1.

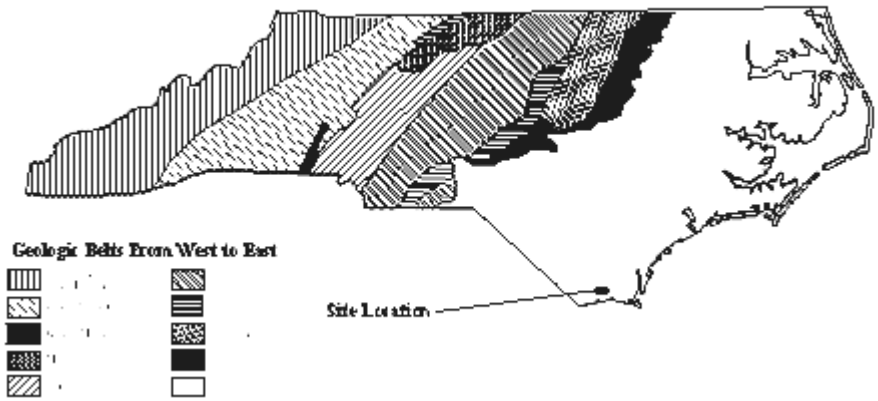
Table 1: Laboratory Test Results

Sample #	Natural Moisture Content (%)	Atterberg Limits		Grain Size Distribution Percent Passing		USCS Soil Class.	CBR Value
		LL	PI	# 4	#200		
T-1	---	---	---	---	---	---	31
T-2	7.2	NP	NP	95.0	15.0	SM	34.3
T-3	10.6	NP	NP	91.0	18.0	SM	16.4
T-4	8.3	NP	NP	95.0	14.0	SM	12.4
T-5	9.2	NP	NP	95.0	21.0	SM	13.7
T-6	12.0	NP	NP	95.0	23.0	SM	12.1
T-7	10.0	NP	NP	92.0	13.0	SM	12.4
T-8	17.5	NP	NP	88.0	14.0	SM	27.2
T-9	14.2	NP	NP	87.0	21.0	SM	15.9
T-10	10.5	NP	NP	77.0	16.0	SM	11.9
T-11	10.5	NP	NP	86.0	20.0	SM	12.4
T-12	11.8	NP	NP	90.0	15.0	SM	14.3
T-13	9.6	NP	NP	86.0	15.0	SM	11.8
T-14	9.8	NP	NP	90.0	14.0	SM	27.1
T-15	9.5	NP	NP	96.0	16.0	SM	22.4
T-16	13.2	NP	NP	92.0	27.0	SM	11.9
T-17	18.6	NP	NP	88.0	14.0	SM	11.5
T-18	10.6	NP	NP	94.0	12.0	SM	26.4
T-19	10.4	NP	NP	86.0	14.0	SM	11.7
T-20	9.6	NP	NP	95.0	13.0	SM	11.6

4.0 REGIONAL GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The referenced site is located within the Coastal Plain Province of North Carolina. The Coastal Plain Province is a broad flat plain with widely spaced low rolling hills. According to the *Geologic Map of North Carolina (1985)*, the site is specifically located within an area mapped as Cretaceous period deposits and is comprised of sedimentary deposits referred to as "Waccamaw Formation" (Tpyw). This formation is described as fossilferous sand with silt and clay and is bluish gray to tan loosely consolidated; it straddles the Pleistocene-Pliocene boundaries.



4.2 Subsurface Conditions

General subsurface conditions encountered at the site (Borings T-8, T-12, T-16 and T-20) during our subsurface exploration are described herein. For more detailed soil descriptions and stratifications at a particular test location, the respective "Hand Auger Boring Logs" contained in Appendix II should be reviewed. The horizontal stratification lines designating the interface between various strata on the "Hand Auger Boring Logs" represent approximate boundaries. The transition between different strata in the field is typically gradual in both the horizontal and vertical directions. No topographic information was provided to us at the time of our exploration; consequently, existing elevation data is not included on the individual "Hand Auger Boring logs".

4.3.1 Existing Pavement System

The existing pavement conditions encountered at the Lockwood Folly Subdivision were evaluated. Based on the results of the pavement cores performed, the existing asphalt pavement system consists of approximately ¾ to 2½ inches of asphalt surface course. Neither asphalt binder, nor ABC stone was encountered at the core locations. Please refer to Table 2 for thickness of the measured asphalt cores.

Table 2: Thickness of Existing Asphalt Pavement System

Core Number	Core Location	Approximate Pavement Thickness (in.)
		Asphalt Surface Course
T-1	Beginning Clubhouse Drive	2.5
T-2	Clubhouse Drive and Lake Pointe Drive	1.54
T-3	Clubhouse Drive and Golf Lake Drive	1.63
T-4	Clubhouse Drive and Fairway Ct. 4	1.5
T-5	Clubhouse Drive and Fairway Ct. 3	2
T-6	Fairway Ct. 3	2.13
T-7	Genoes Point Rd. Lots 314/315	1.88
T-8	Genoes Point Rd. Lot 301	1
T-9	Genoes Point Rd. Lot 14/36	1.75
T-10	Genoes Point Rd. Lot 3/47	1.27
T-11	Lockwood Lane, Lots 241/224	.75
T-12	Windward Village Lane, Lot 209	1.5
T-13	Windward Village Lane, Lot 27/32	2.5
T-14	Clubhouse Drive and Lockwood Lane, Lots 83/88	2
T-16	Purple Finch Lane, Lot 56	1.5
T-17	Purple Finch Lane, Lot 56, Lots 29/52	1.75
T-18	Purple Finch Lane, Lot 56, Lots 21/50	1.5

T-19	Clubhouse Drive, Lots 80/90	1.39
T-20	Clubhouse Drive and Marina Drive, Lots 54/359	1.75

4.3.2 Existing Roadway Subgrade Soils

Below the existing surface asphalt, relatively similar subgrade conditions were encountered at all cored locations. These consisted of medium to fine silty SAND (SM) with varying amounts of shell deposits. Hand auger locations T-8, T-12, T-16, and T-20 were augered to a depth of 3 feet; the soils encountered at these locations consisted of medium to fine silty SANDS (SM) down to boring termination depths.

5.0 PAVEMENT DESIGN

The pavement design calculations were completed for a design period of 20-years per NCDOT Subdivision Roads Minimum Construction Standards (January 1, 2000, edition) in accordance with the North Carolina Department of Transportation (NCDOT) Interim Pavement Design Procedure (NCDOT Pavement Management Unit - April 1, 2000). According to NCDOT Interim Pavement Design Procedure, the following equation is used for flexible pavement design:

$$Log W_{t18(80kN)} = 9.36*\log(SN+1) - 0.20+(G_t/(0.40+(1094/(SN+1)^{5.19})))+\log(1/R)+0.372*(SSV-3.0)$$

Where:

SN = required Structural Number

Log $W_{t18(80kN)}$ = number of 18 kip single axle load applications during design life

P_t = terminal serviceability = 2.5 per NCDOT Standard Roadway Specifications

R = regional factor = .5 for Brunswick County, per NCDOT Interim Pavement Design Procedures

SSV = soil support value = 5.32 * log (CBR) – 1.49

G_t = log ((4.2-P_t)/2.7)

The Lockwood Folly subdivision, at the present time is made of 365 single family dwellings. The existing streets are divided in three types primary, secondary and tertiary; types I (Heavy

Duty), II (Medium Duty) and III (Light Duty), respectively, depending on traffic patterns and expected vehicle volumes. The subdivision pavement sections were designed based on a trip generation factor of 7.5 trips/day/dwelling.

The design Average Daily Traffic (ADT) is calculated for the design pavement life of 20 years, assuming an annual growth rate (g) of 2 percent for a fully developed Subdivision Street. The ADT was modified to determine the equivalent 18-kip ESALs (N-value) based on the assumption that one percent and three percent of the total traffic is tractor-trailers and light weight truck traffic, respectively.

The Structural Number (SN) was calculated for a 20-year design life using a regional factor of 0.5 (for Brunswick County), terminal serviceability value of 2.5 and a Soil Support Value (SSV) of 4.050 and a California Bearing Ratio (CBR) of 11. The following Table 3, presents the recommended minimum pavement sections determined based on above calculations and utilizing coefficients of 0.44 for Asphalt Surface Course (SF9.5A and S9.5B) for the different pavement types.

Table 3: **Recommended Asphalt Pavement Sections (Please Refer to Figure 2, Appendix I for Color Coded Sections)**

Locations	Type	Asphalt Surface Course Thickness (SF9.5A) (Inches)	Asphalt Surface Course Thickness (S9.5B) (Inches)	Soil Type Base
Clubhouse Dr. (Subdivision Entrance to 2nd Intersection of Lockwood Ln.)	Type I	1.0	2.5	9.0
Lockwood Ln. to 2nd Intersection with Fairway Circle	Type I	1.0	2.5	9.0
Genoes Point Rd. From Intersection of Lockwood Ln. to the Intersection of Marina Dr. and Clubhouse Dr.	Type II	---	2.5	9.0
Lockwood Ln. from 2nd Intersection with Fairway Circle to its Intersection with Clubhouse Dr.	Type II	---	2.5	9.0
Windward Village Lane	Type II	---	2.5	9.0
Channel Side Drive from its Intersection with Atlantic Circle to the Intersection with Clubhouse Dr.	Type II	---	2.5	9.0
Purple Finch Ln.	Type II	---	2.5	9.0
Lake Pointe Dr., Golf Lake Dr., Folly Lake Ct, Lakeview Dr.	Type III	---	2.0	9.0
North Ct., Oyster Shoals, Myrtle Point, Golfview Ct., Atlantic Circle, Inlet Ct, Fairway 3 Ct., Fairway 4 Ct, Fairway 8 Ct., Fairway 9 Ct., Fox Squirrel Ln., Osprey Ct., Egret Ct., Lockwood Lane Ct., Fairway Circle and Bogie Ct.	Type III	---	2.0	9.0

5.1 New Asphalt Pavement Construction

The proposed new pavement system can be adequately supported on low plasticity soils (free of organic material and debris) or newly compacted fill placed in accordance with the recommendations contained in this report. Please note that some in-place densification and/or undercut may be required for the very loose to loose near-surface soils. The densification and/or undercut should be performed in accordance with the "Site Preparation" recommendations provided in this report.

Depending on the weather, construction activities, soil conditions of the at-grade soils, and disturbance of these soils during construction, some undercutting and/or scarifying, drying and recompaction of these materials may be required immediately prior to placing the asphalt course. A thorough evaluation such as proofrolling will determine the stability of the at-grade soils and should be made immediately prior to asphalt placement. All exposed subgrade soils should be compacted to achieve at least 100 percent of the in-place dry density as determined by the Standard Proctor, ASTM D698.

Proper drainage of the roadway areas is essential to the integrity of the subgrade soils. If free water is allowed to stand on the subgrade soils, these soils can experience a reduction in their support capability. As a result, we recommend that the finished subgrade surface be graded to promote drainage away from the pavement area.

5.2 GROUND WATER CONTROL

Based on the results of the testing performed, we do not anticipate that groundwater should be encountered during roadway grading operations. Please note, however, that groundwater levels can vary with seasonal and climatic changes. Therefore, if groundwater is encountered during construction, engineering personnel from our office should be notified immediately.

6.0 CONSTRUCTION RECOMMENDATIONS

Based on our site visit and our evaluation of the existing pavement we recommend that the streets of the Lockwood Folly subdivision be milled to completely remove the existing asphaltic concrete. After the streets are milled, the subgrade elevations should be adjusted to provide ample clearance for the new pavement section.

During grading operations, hidden features in the substratum, such as organic laden materials, trash, organics or other deleterious materials may be encountered within the roadway area. Generally, such features will require removal.

Roadway preparation monitoring by F&R personnel is recommended. Upon completion of the milling operations, the exposed soils near-grade areas should be proofrolled with a fully loaded double-axle dump truck or equivalently weighted equipment in order to identify unstable surface conditions and densified as needed and/or required with a 10 to 12 ton smooth drum vibratory roller. Areas that rut or pump when proofrolled and that cannot be stabilized after compaction with the vibratory roller should be undercut as directed by the geotechnical engineer and replaced with adequately compacted structural fill. All exposed subgrades should be compacted to 100 percent of the soils maximum dry density as determined by standard proctor, ASTM D698.

6.1 Fill Placement

Fill placed in undercut areas should be free of organics, roots or other deleterious materials. Fill soils should ***not*** contain more than five percent (by weight) organic material, nor have a plasticity index (PI) greater than 20, nor have a maximum dry density less than 90 pounds per cubic foot.

Compacted structural fill should consist of material classified as CL, ML, SC or SM per ASTM D-2487. Successful reuse of the excavated, on-site soils as compacted structural fill will depend on the moisture content and the plasticity of the soils encountered during excavation.

Once fill placement begins, field density tests should be performed by a qualified soils technician to document the degree of compaction being obtained in the field. Fill material should be placed in loose lifts not exceeding 8 to 10 inches in thickness. The moisture content of the fill soils should be within plus or minus 3 percentage points of the optimum moisture content at the time of placement based on the Standard Proctor Test (ASTM D-698). Some moisture conditioning of the soils (such as wetting and drying) may be required during the grading operation to obtain the required degree of compaction. Regular one-point proctors should be conducted to confirm that the most representative Proctor curve is being selected. The in-place dry density should equal or exceed 95 percent of the Standard Proctor Test (ASTM D-698) with the exception that the top 12 inches of subgrade should be compacted to at least 100 percent of the Standard Proctor maximum.

The contractor should exercise care after these soils have been compacted. If water is allowed to stand on the surface, these soils may become saturated and loose strength. Therefore, the roadway surface should be sloped to achieve positive drainage away from the pavement areas to minimize ponding. If the surface becomes excessively wet, fill operations should be halted and our geotechnical engineer consulted for guidance. Testing of the fill material and compaction monitoring by our engineering technician is recommended on a full-time basis during earthwork operations.

7.0 LIMITATIONS

This report has been prepared for the exclusive use of the Lockwood Folly Subdivision and/or their agents for specific application to the referenced property in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. These conclusions and recommendations do not reflect variations in subsurface conditions which could exist in unexplored areas of the site. Should such variations become apparent during construction, we reserve the right to re-evaluate our conclusions and recommendations based upon on-site observations of the conditions. In the event changes are made in the proposed construction plans, the recommendations presented in this report shall not be

considered valid unless reviewed by our firm and conclusions of this report modified or verified in writing.

A copy of this report, including the Geotechnical Data, is available in the Lockwood Folly Library.