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7. Author(s)
K. Nam Shiu, H. G. Russell, H. Tabatabai

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5420 Old Orchard Road
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16. Abstract

This report describes the instrumentation program of Red River Bridge at Boyce, Louisiana. The objectives of the program were to measure and evaluate time-dependent deformations, deflections, and temperatures of the Red River Bridge superstructure. To achieve the objectives, field instrumentation was installed on the bridge structure before and during construction. Strain and temperature sensors were placed in three selected bridge segments of one bridge span. Measurements were made for a period of five years.

Concrete physical properties of the instrumented bridge segments were also measured. Measured properties included short-term and long-term properties of concrete cured under controlled laboratory conditions and under an outdoor environment representing the bridge site. Tests were conducted by Louisiana Transportation Research Center personnel. Results were used to evaluate time-dependent and thermal behavior of the Red River Bridge.

Using the actual material design mix, time-dependent analyses of the Red River Bridge during construction were performed. Design construction schedule was used in calculating bridge behavior during construction. Analytical results were then compared with measured strain readings from the instrumented

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Prestressed concrete, segmental bridges, time-dependent effects, field tests, creep, shrinkage, relaxation, temperature

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bridge segments. Good correlations were obtained between calculated values and measured data.

Long-term bridge deflections and pier rotations were also measured. Measurements provided a record of how the Red River Bridge behaved over a period of five years.

Measurements were also made over four 24-hour periods to determine thermal response due to the diurnal and seasonal temperature variations. Using the measured concrete strains and temperature data, non-linear temperature behavior was confirmed and its effects quantified. Restraint stresses across the three instrumented bridge sections and continuity thermal stresses were calculated. Statistical analyses were performed to evaluate the probability density function of the temperature differentials between top and bottom of the box-girder section. Shear stresses in the webs of the instrumented segments from diurnal temperature changes were calculated. Measured shear strains included continuity shear strains and torsional shear deformations.

INSTRUMENTATION OF THE RED RIVER BRIDGE AT BOYCE, LOUISIANA

FINAL REPORT

By

K. NAM SHIU
H. G. RUSSELL
H. TABATABAI
Construction Technology Laboratories, Inc.
5420 Old Orchard Road
Skokie, Illinois 60077

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This investigation was sponsored by the Louisiana Transportation Research Center (LTRC) and the Federal Highway Administration under State Project No. 736-07-18, Federal Aid Project No. HPR 0010 (005), and Research Project No. 82-3C. Mr. S. C. Shah, Research and Development Engineer of LTRC, and Dr. Ara Arman, Director of LTRC, coordinated the project. Mr. Masood Rasoulian, Concrete Research Engineer of LTRC, implemented all field and laboratory tests and coordinated schedules with Construction Technology Laboratories, Inc. (CTL) and the construction contractor. Their contribution to this investigation is appreciated. Special thanks are also due to Mr. John Gagnard, Field Project Engineer at Boyce, Louisiana, and his staff for their cooperation and assistance in providing access to the instrumented bridge segments as needed.

The knowledge gained through this study was used to field straighten damaged prototype girders. Four 20-foot long girders were straightened. Various heating configurations were studied along with the interaction of indeterminate behavior associated with composite girder/deck systems. These field studies showed the importance of understanding and controlling the jacking constraints used to expedite the process. This study has provided a significant increase in the understanding of the behavior of damaged steel during the heat-straightening process. Although additional research is needed, the method can safely be used on moderately damaged girders, even if they have been previously heat straightened.

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This investigation was sponsored by the Louisiana Transportation Research Center (LTRC) and the Federal Highway Administration under State Project No. 736-07-18, Federal Aid Project No. HPR 0010 (005), and Research Project No. 82-3C. Mr. S. C. Shah, Research and Development Engineer of LTRC, and Dr. Ara Arman, Director of LTRC, coordinated the project. Mr. Masood Rasoulian, Concrete Research Engineer of LTRC, implemented all field and laboratory tests and coordinated schedules with Construction Technology Laboratories, Inc. (CTL) and the construction contractor. Their contribution to this investigation is appreciated. Special thanks are also due to Mr. John Gagnard, Field Project Engineer at Boyce, Louisiana, and his staff for their cooperation and assistance in providing access to the instrumented bridge segments as needed.

IMPLEMENTATION STATEMENT

The results of this report illustrate the practicality of using heat straightening in bridge repair. The methodology described is applicable to the repair of damaged steel girders on overpasses and elements on bridge trusses. Since research is continuing, full implementation is not yet appropriate.

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1. INTRODUCTION

BACKGROUND

Damage caused by vehicle impact, mishandling, or fire is a perennial problem associated with structural steel bridge members. For almost half a century, heat-straightening techniques have been applied to bends and distortions in order to restore the original shape of steel elements. A few craftsmen, who have years of experience with heat straightening, perform the technique in the field with varying degrees of success. Some of these experts have mastered heat straightening, but the process is still considered more of an art than a science.

The ability to repair bent structural steel members in place, often without even the need for temporary shoring, has generated interest in heat straightening from the engineering profession. In recent years, engineers have begun to study the effects of heat applications on steel. However, much of the available research data is obscure, with contradictory remarks found in different publications. As a result, engineers faced with the dilemma of choosing the appropriate and most efficient method to repair a damaged steel structure have little organized and reliable data or information upon which to base their decisions. These engineers must rely primarily on their own judgment and the advice of experienced technicians. Two key issues must be addressed: Do heat-straightening repair procedures exist which do not compromise the structural integrity of the steel? And if so, how can such repairs be engineered to ensure adequate safety of the repaired structure both during and after repair? The primary goal of this research project is to answer these two questions by experimentally evaluating the aspects of heat-straightening techniques and developing engineering analysis an design peocedures for general applications. The project was initiated on June 10, 1985, with the sponsorship of the Louisiana Transportation Research Center (LTRC), the Louisiana Department of Transportation and Development (LADOTD), and the Federal Highway Administration (FHWA). The project was divided into four phases: (1) laboratory evaluation and initial analytical development; (2) field evaluation and refinement of the analytical model; (3) final field evaluation and development of an interactive computer model; and (4) documentation and training. This report is the final project report for the three-year study. In addition to summarizing research findings which have been submitted in several interim reports (6,7,8), new data from both the experimental and analytical phases is included. Through a synthesis of both previous and current research, this report provides a guide for the design of heat-straightening repairs.

OBJECTIVES

The specific objectives of this study can be summarized as follows:

1. Through a comprehensive literature review, define the state of the art as it relates to engineering applications of heat straightening.
2. Conduct an experimental program of heat-straightening plates and rolled shapes so that all important engineering parameters are defined and quantified.

3. Extend the experimental investigation to include field testing of the behavior of bridge girders during heat straightening.
4. Develop analytical models which can be used by the engineering profession to predict the behavior of damaged bridge elements during heat straightening.
5. Develop an engineering guide for heat-straightening repair of bridges.

SCOPE OF THE INVESTIGATION

The nature of research is exploratory, which means that direction and emphasis can change as new discoveries or patterns of behavior are uncovered. During the course of this project, that has certainly been the case. For example, after a cursory literature review, it would appear that the state of the art could be summarized as follows:

1. The basic mechanisms of heat straightening were well understood.
2. Fundamental parameters had been identified.
3. Vee heat behavior was fairly well-documented for simple plate elements.
4. The effect of heat straightening on material properties had been verified for a wide range of steels.
5. Actual field studies had verified basic behavior.
6. Practical applications depended primarily on the skill and knowledge of the practitioner as opposed to rigorous engineering analysis.

The original research plan was based on these premises with the goal of supplementing laboratory studies and developing engineered procedures for field applications. However, as the research progressed, it became apparent that these original assumptions were too broad. First, the basic mechanism of heat straightening was not well-understood in that the effects of both external restraints (jacking) and internal restraints (redundancy) were considered to be of minor concern rather than fundamental to the broad application of the process. Second, as a result of not identifying the importance of this parameter, there has been little documentation on the behavior of vee-heated plates subjected to varying degrees of constraint and even less on rolled shapes. Third, while a fair amount of research indicated that most material properties are unaffected by heat straightening, two important aspects have been overlooked: the influence of strain aging on ductility and residual stress distribution. Finally, the research information available was predicated almost entirely on laboratory studies of simple elements. The reported field investigations were qualitative rather than quantitative and thus could not serve as a building block for this research. Because of these voids in heat-straightening research, it was indeed true that the artisan practicing the trade was much more important than the engineer. The goal of this project was to develop guidelines to enable the engineer to assess the need for and direct the application of heat-straightening repairs.

This report is organized into chapters addressing the basic objectives. Chapter 2 forms a comprehensive literature review which compares misconceptions about heat straightening to documented facts. Since the basic cross section element of most steel structures is the flat plate, Chapter 3 addresses the behavior of plates subjected to heat straightening. An experimental evaluation of factors influencing heat straightening is given, along with an analytical model for describing this behavior. The behavior of rolled shapes, including experimental and analytical findings, is covered in Chapter 4. Chapter 5 describes the results of field tests on simulated prototype bridge girders. Chapter 6 provides a preliminary guide to engineers for implementing heat-straightening repairs. Chapter 7 presents conclusions and recommendations from the investigation.

2. SEPARATING FACT AND FABLE

INTRODUCTION

The structural behavior of steel systems repaired by heat straightening is not well understood by the engineering profession. A a consequence, most repair work of this type is not engineered, but rather left in the hands of a specialized contractor. Because of this lack of information, some engineers have tended to avoid the use of heat-straightening repair. While engineering research on the subject has progressed in recent years, a significant amount of information ha not been readily available to the profession. This fact, combined wit a lack of synthesis of available information, has led to speculation a contradictory statements as to various effects associated with the hea straightening process. The purpose of this chapter is to synthesize available knowledge into a state-of-the-art report on heat straighteni The format used will be to give some of the more common fables that ha arisen and then provide the documented facts related to each one. One of the most basic fables relates to the concept itself.

Fable.--Heat straightening of steel is a myth. The only way to straighten damaged steel is by cold or hot mechanical straightening.

Fact.--Heat straightening of steel can be traced in the literature to 1938, when Holt (31) wrote what appears to be the first paper describing heat-straightening procedures. A number of papers have followe that primarily describe basic techniques and successful field applications (20,22,30,32,33,37,44,46,55). The concept is based on using carefully controlled and applied heat without the use of an active force (although passive restraining forces are often used).

The basic element of steel construction is the flat plate. Rolled or built-up members consist of plate elements assembled to obtain an advantageous shape. Expertise in heat straightening therefore requires a thorough understanding of the behavior of plates during the heating and cooling process. There are two basic types of distortion generally associated with plates: bends about the strong axis, which are usually straightened with vee heats, and bends or bulges about the weak axis, which are usually straightened with line or spot heats. The large majority of damage encountered in practice consists of plate elements in structures bent about their strong axis. Thus, the vee heat can be considered the fundamental heat pattern associated with heat straightening. As shown in Figure 1, the heat is applied with a torch to a vee shape area, starting at the apex and progressing across the vee in a serpentine motion. The series of sketches in Figure 1 was generated from a comprehensive elasto-plastic, thermal and finite element analysis (24). The amplitudes of movement have been magnified for illustrative purposes and a full-depth vee heat is used. As the apex of the vee is heated, expansion occurs, producing the hump at the apex and a slight downward movement at the free end (Figure 1a). As heating continues, this expansion increases to produce a larger hump and more downward deflection. The cool portion ahead of the torch impedes the longitudinal expansion and also results in a plastic thickening of the material in the heated region. As the torch moves into the lower half of the plate, the hump begins to protrude from both top and bottom and the downward deflection trend is reversed (Figure 1b). At some point,

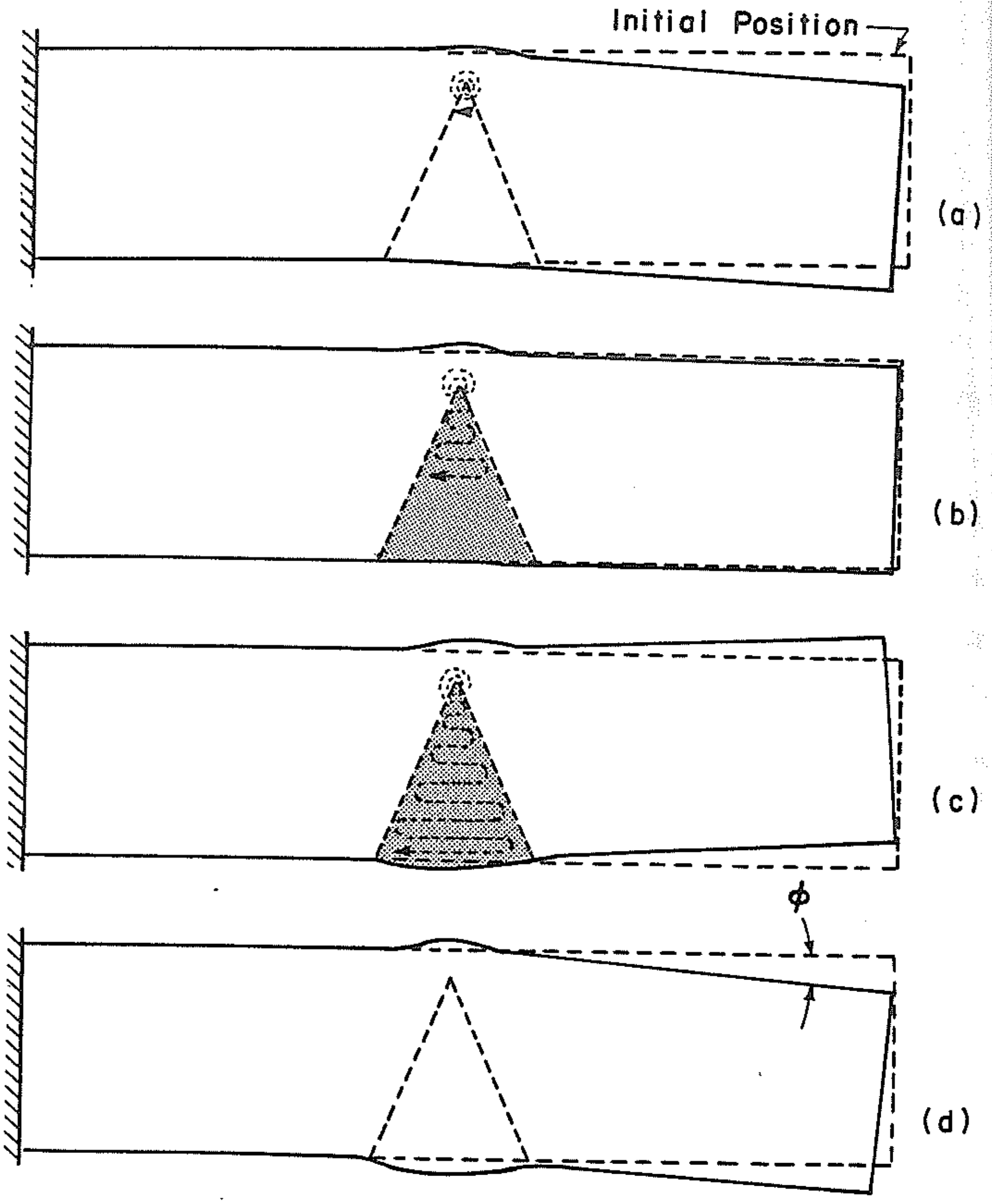


Figure 1. Stages of plate deformation as a vee heat applied to an initially straight plate (deformations are magnified for illustration purposes.

the plate will return to its original undeformed position, with only the top and bottom bulges plus plate thickening. As the torch nears the open side of the vee, the deflection becomes upward due to the expansion in the torch area (Figure 1c). This process continues until a short time after the torch is removed and the deflection reaches its maximum upward point. As cooling proceeds, the contraction on the open side of the vee creates downward movement again, until at some point, the plate is again in its original position with a bulge on the top and bottom. The latter stages of cooling produce a final downward deflection along with a slight bulge (Figure 1d). The angle of the vee will thus tend to close more than it originally opened, since some plastic flow has taken place during the expansion phase and there is little restraint to longitudinal contraction during cooling. The net result is a small but sharp change in the angle of the vee when the process is complete. The hump at top and bottom is quite small compared to the angle change and can be neglected. In addition, a net shortening of the member will occur, although this effect can be minimized by using a vee heat pattern which is less than the full depth of the member (55). Of course, if the member is already bent, the distortion can be removed by applying the vee heat to oppose the initial deformation: hence the idea of heat straightening. By judiciously applying vee heats to damaged members, curvature due to damage can be removed. Because the net change in curvature after one heating sequence is small, cycles of heating and cooling are often required to correct serious damage. A similar approach can be used on various rolled shapes or built-up members. For large or irregular initial bends, the heating can be done successively at a number of locations along the length of the member. While simple

The test sections consisted of three asphaltic concrete mixtures, two sand asphalt mixtures, four plant mix seals and two slurry seals. All of the test sections with the exception of the slurry seals were constructed under contract by Barber Brothers Construction Company of Baton Rouge. The two slurry seal sections were constructed by the District 61 maintenance forces.

Construction Control

Each of the various mixtures were controlled during construction. The asphaltic concrete and sand asphalt mixtures were tested at the plant and on the roadway for such properties as Marshall Stability, voids, voids filled, gradation, asphalt content and roadway density. The plant mix seals were tested for extracted gradation and asphalt content only, whereas the slurry seals were tested for gradation only. The Rex slurry-seal machine was calibrated prior to construction to determine the quantity of emulsion in the mixture. All of the average test results for the various test sections may be found in Table 1, Appendix A.

Each of the test sections were constructed in one lift with the exception of the slurry seals which were constructed in two lifts. The hot bituminous mixtures were spread with a spreader having automatic screed control to the approximate thickness mentioned in the description of the test sections.

Rolling of the asphaltic concrete mixtures was accomplished by a tandem, pneumatic and tandem in that order. The sand asphalt mixtures were rolled with a tandem only and the plant mix seals with a tandem and then a pneumatic roller. The slurry seals were rolled with a pneumatic roller only after curing of the emulsion.

Test Performed to Evaluate Test Sections

The evaluation of the test sections consisted of obtaining skid resistance values at zero, four, eight and eleven months after completion. Roughness results were also obtained at four and eleven months after completion. These tests results were compared for the various test sections and the relationship between skid resistance and volume of traffic obtained. The skid resistance was obtained by the Louisiana Department of Highways skid trailer (Figure 1).

The roughness results were used primarily to compare the riding surface between test sections after being subjected to traffic.

Visual observation was also used as a basis for evaluating the test sections.

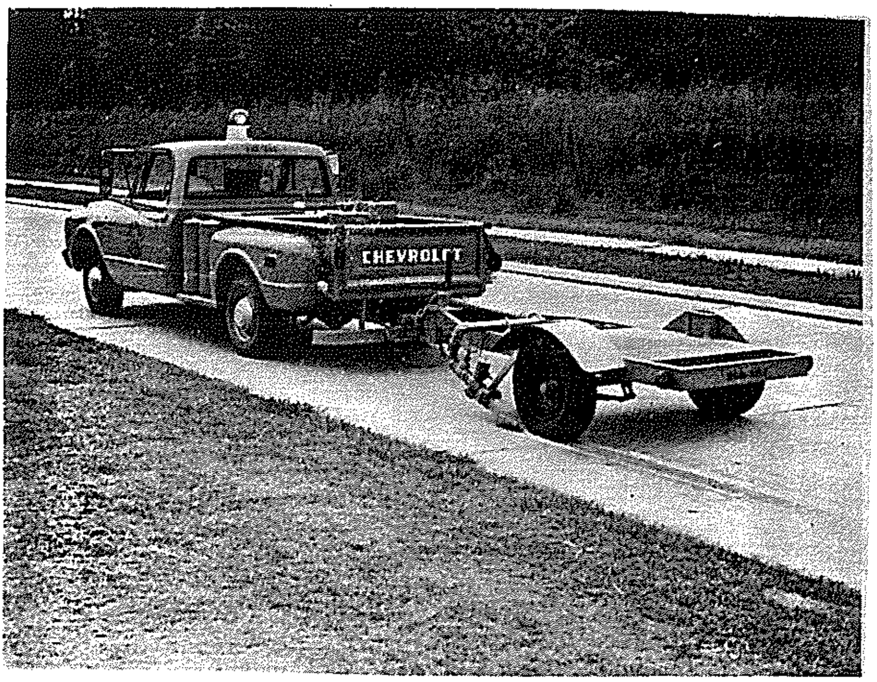


Figure 1 - Photograph of the skid trailer.

DISCUSSION OF RESULTS

The evaluation of the test sections were based primarily on comparative results for skid resistance, roughness and visual observation over an eleven month period. The test results obtained represented four different types of bituminous mixtures utilizing five different aggregate types. This provided a means of comparing results of asphaltic concrete, sand asphalt, plant mix seals and slurry seals, as well as, determining the most desirable aggregates for improving skid resistance.

Of the eleven test sections constructed each of the various type mixtures have been used in Louisiana before, with the exception of the plant mix seals and the Kentucky sand asphalt. Plant mix seals have been used for several years in a number of the Western States and all reports indicate excellent results.

Plant mix seals are somewhat different than most bituminous mixtures. As the name refers, a plant mix seal is merely a seal coat material mixed in a hot mix plant. The mix contains an asphalt coated aggregate without the use of sand or mineral filler. The gradation of the aggregate is as shown in Table 1, Appendix A for plant mix seals.

The materials are mixed in a hot mix plant at high asphalt contents and at temperatures below 260°F. The object of the high asphalt content and low mixing temperature is to obtain a greater film thickness of asphalt on the aggregate. The mix is applied through a conventional spreader and rolled with a tandem and pneumatic roller.

The Kentucky sand asphalt was constructed similar to other sand asphalts. The Kentucky sand is a asphalt impregnated quartz sandstone rock which contains approximately 3 1/2 to 41/2 percent natural bitumen. Additional asphalt is added to the Kentucky sand as in other sand asphalt mixtures.

Problems Encountered During Construction

There were certain problems encountered during construction for some of the test sections. On one of the Kentucky sand asphalt sections the material began to ravel out after approximately two days of traffic. This pitting or ravelling only occurred in one lane for a distance of approximately 200 feet. Figure 2 shows two photographs of the pitting that occurred. The reason for this has never definitely been determined, however, it is believed that it was possibly due to improper mixing of one or two batches at the plant. The length of the pitting was approximately the distance one truck load of material would cover. Since a manual batch plant was being used it was assumed that an error was made during batching. Improper mixing would be difficult to see visually since the sand is already black from the natural asphalt in it. The bad section was taken out and replaced and there was no other detrimental effects observed on the Kentucky sand asphalt sections.

Another less severe problem occurred while constructing the expanded clay plant mix seal. The specifications state that the mix when discharged from the pugmill should not exceed 260°F, however, on one particular truck the mix was approximately 300°F which resulted in some of the asphalt dripping to the bottom of the truck. This was not detrimental to the mix on the roadway, however, it did cause some of the mix to stick to the truck bed when dumping the mix into the spreader. Figure 3 shows a photograph of what may occur when heating the mixture above 250°F on a plant mix seal.

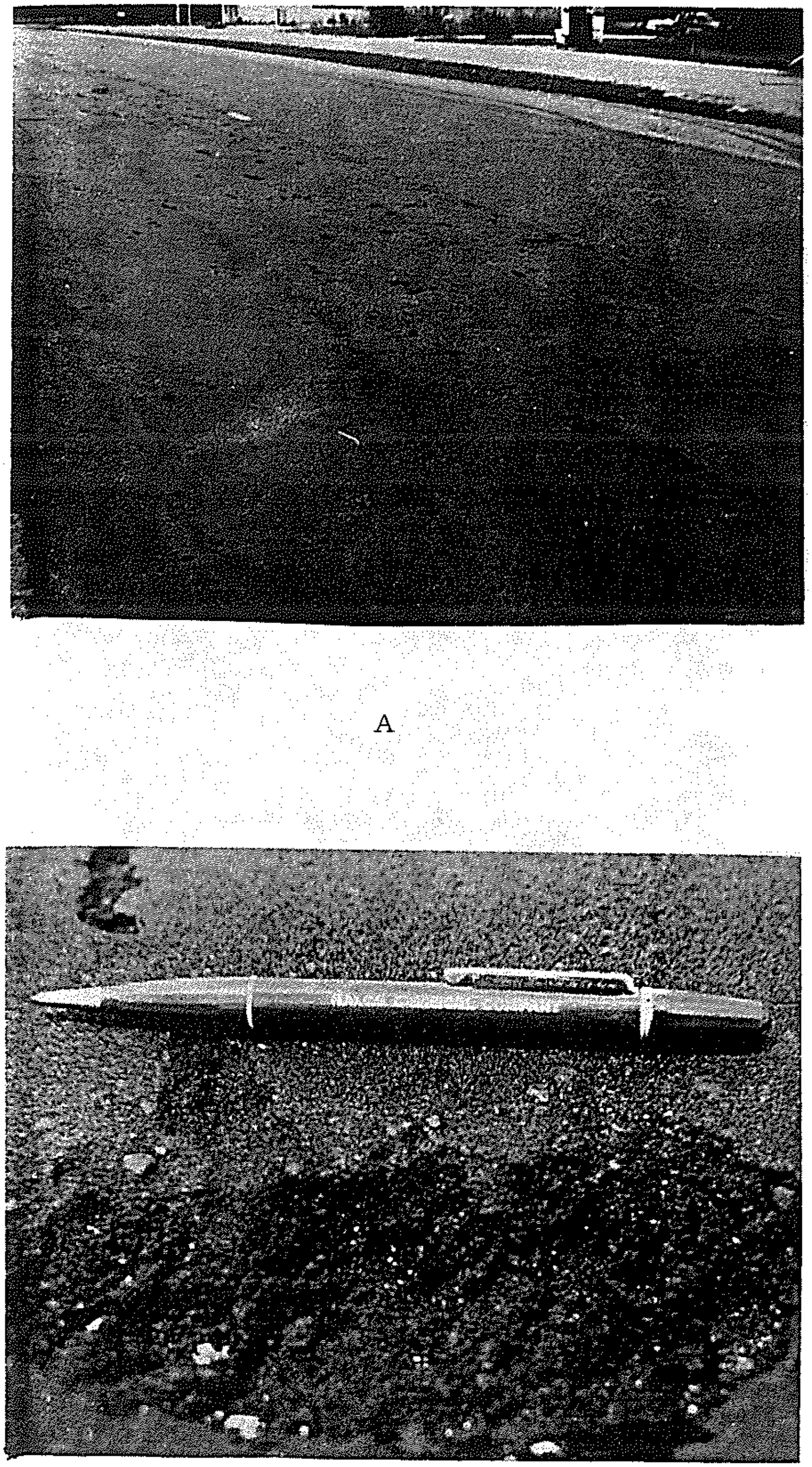


Figure 2 - Photograph of failures in the Kentucky Sand Asphalt sections.

The mix at the bottom of the truck bed may not appear to be very critical, however, it will cause more mix to accumulate on succeeding loads, in addition to being very difficult to clean at the end of the day. It is recommended that a soap solution be used to wet down the truck bed before each load to prevent the mix from sticking.

Figure 3 - Photograph of overheated Plant Mix Seal sticking to truckbed.

Skid Resistance

The most important results of this study is the skid resistant qualities of the various mixtures. Skid resistance was obtained on most of the test sections immediately after completion and at four, eight and eleven months after completion. The skid resistance values are referred to as skid numbers, which is merely the coefficient of friction multiplied by 100. The skid resistance was obtained at speeds of 20, 40 and 60 miles per hour however, 40 miles per hour is the standard accepted speed to run skid measurements and therefore most of the evaluation was based on skid numbers at 40 miles per hour.

Of the eleven test sections constructed,two of the mixtures were not included in the complete evaluation of the surfaces. A comparison of the average skid numbers for all the test section are shown in Table 3 of Appendix A. As indicated by the table,the Louisiana sand asphalt has the lowest skid numbers of all the test sections. There is no universal skid number at 40 miles per hour designating whether the skid resistance is satisfactory. However, the Bureau of Public Roads has tenatively set a skid value of 35 plus as acceptable when tested at 40 miles per hour.

The skid number of the Louisiana sand asphalt at 40 miles per hour was 33, which was below the Bureau of Public Roads standard. There were also reports that the Louisiana sand asphalt section was slick when wet, causing several vehicles to leave the roadway at relatively low speeds. For this reason it was decided to construct a slurry seal over the Louisiana sand asphalt section and therefore a full evaluation of the sand asphalt was not made.

The other mixture not included in the full evaluation is the granite slurry seal. Skid resistance was measured and recorded as shown in Table 3 of Appendix A. There is some question as to whether or not these values are representative of a granite slurry seal. The uncertainty of the validity of these results have stemmed from problems encountered during construction. The problems resulted from the quickset cationic emulsion "breaking" in the spreader box, causing the operator to add more water to the slurry which proved to be excessive, thereby causing the emulsion to float to the top of the surface. This resulted in having less granite aggregate in the mix causing a less skid resistant surface. Therefore it was decided that the skid numbers be reported in the tables, but comparisons of the granite slurry seal with the other mixtures was not made.

There are several factors that affect skid resistance of a surface. Probably the most influential are:surface texture, type of aggregate, and the resistance to polishing under traffic. Appendix B consists of a series of photographs showing the appearance and surface texture of the various test sections.

As indicated in Appendix B, there is a variety of surface textures as well as aggregate types. This is most important in studying skid resistance.

Figure 4 shows the relationship of the average skid numbers at 40 miles per hour versus time and traffic. In most cases the skid numbers increased from immediately after construction to four months and the asphaltic concrete mixtures had an additional increase after eight months before a slight decrease

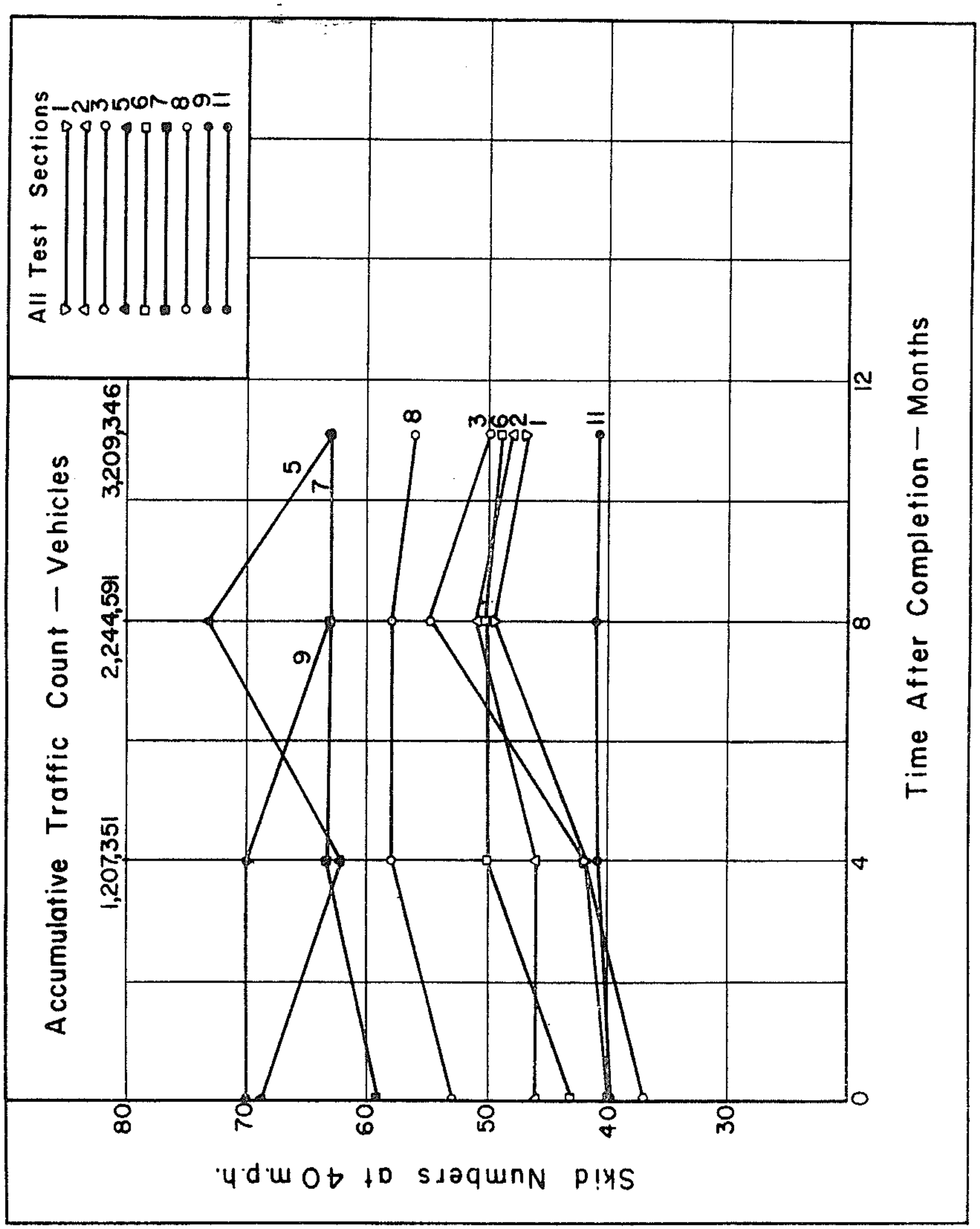


Figure 4 - Relationship of skid numbers at 40 MPH versus time and traffic for all test sections.

at eleven months. The skid numbers on the Kentucky sand asphalt were erratic as there was a drop at four months an increase at eight and another decrease at eleven months. The Kentucky sand did give the highest skid number of all the test sections with a value of 73 at eight months. However, the skid number dropped to 63 at eleven months, which is equivalent to that obtained by the expanded clay plant mix seal for the same period of time.

The expanded clay slurry seal section had skid numbers of 70 up to four months of traffic and dropped to 63 at eight months. The eleven month interval for the slurry seals were not yet due since the slurry seals were constructed approximately three months after the other test sections. Results will be obtained at longer intervals on the slurry seals, as well as, on the other test sections.

The total traffic count on the test sections after eleven months was 3,209,346 vehicles as determined by a traffic station near the job site. The eleven month results indicate a slight decrease in the skid numbers for the asphaltic concrete sections, however, there does not appear to be any excessive polishing of the aggregate.

Figure 5 shows the skid number versus time for the Kentucky sand and asphaltic concrete test sections only. In each case the asphaltic concrete sections showed an increase of skid resistance up to eight months or 2,244,591 vehicles after which a slight decrease occurred at eleven months. It is interesting to note that of the asphaltic concrete mixtures, the expanded clay hot mix had a lower skid number at zero and four months after completion. It has been proven on past studies that the expanded clay hot mixes have superior skid resistant qualities to the standard crushed gravel hot mixes, due primarily to the nature of the coarse expanded clay aggregate.

The Kentucky sand asphalt as shown in Figure 5 did give very high skid numbers, however there was some difficulty in obtaining a satisfactory riding surface and it is believed that the cost for shipping the material into Louisiana would be prohibitive.

Figure 6 shows the skid numbers versus time for the plant mix seals and expanded clay slurry seal sections. The plant mix seal curves showed similar trends. There was an increase in skid resistance from zero to four months and very little change from four to eleven months even though being subjected to over two million more vehicles. This would indicate that skid resistance on plant mix seals tend to level off quicker than a mix that contains sand and

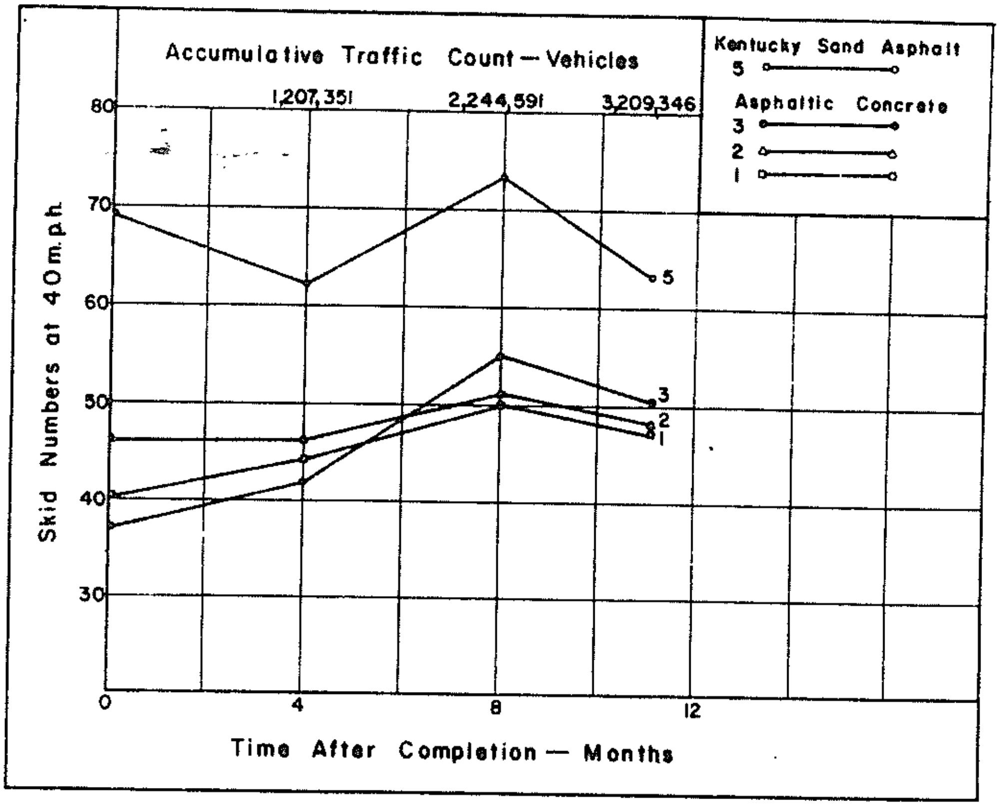


Figure 5 - Relationship of skid numbers at 40 MPH versus time and traffic for the Asphaltic Concrete and Kentucky Sand Asphalt sections.

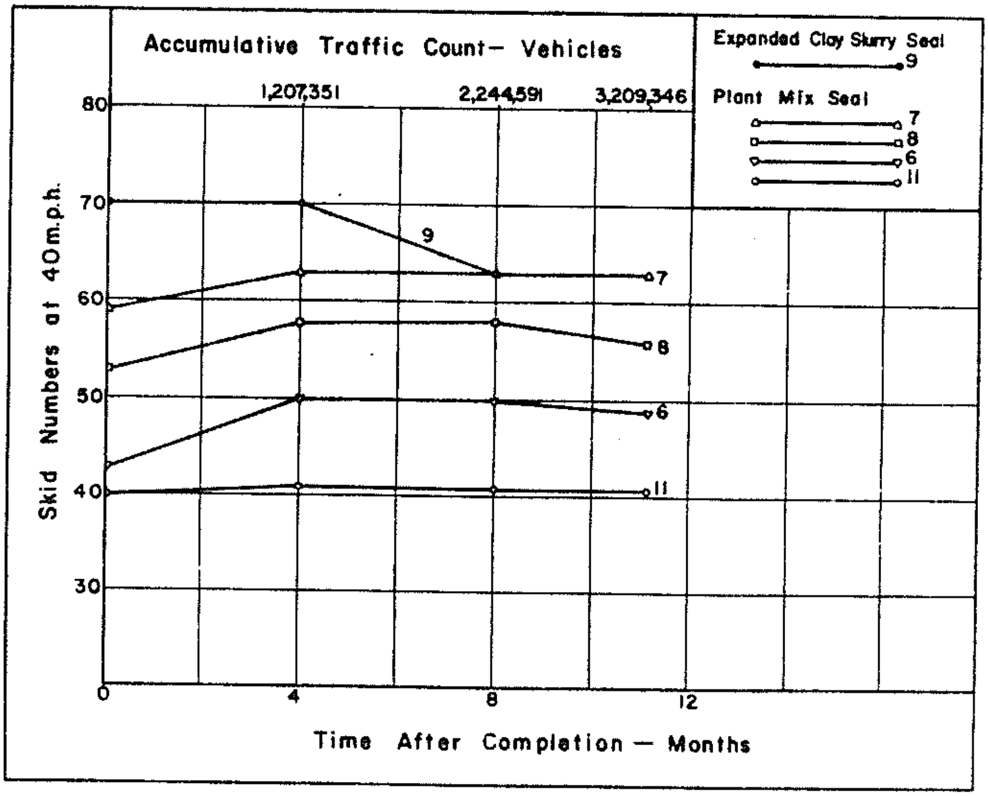


Figure 6 - Relationship of skid numbers at 40 MPH versus time and traffic for the Plant Mix Seals and expanded Clay Slurry Seal.

coarse aggregate. It also seems reasonable that the plant mix seal would maintain a constant skid resistance, as long as, the aggregate being used is not susceptible to excessive polishing.

Figure 6 also illustrates the importance of the type of aggregate used in the mix. Each of the plant mix seals conformed to the same gradation requirements, however, the expanded clay and slag plant mix seals had superior skid resistance to the crushed gravel seals. Again this is characteristic of the aggregate. It is very interesting to note that the 95 percent crushed gravel seal was superior to the 75 percent crushed gravel seal, indicating that increased angularity of a particular aggregate should result in higher skid resistance.

The expanded clay slurry seal shows extremely high skid numbers at zero and four months after completion and a decrease equivalent to that of the expanded clay plant mix seal after eight months of traffic. Additional results will be obtained on all the test section, however, it is anticipated that the slurry seal will fall below that of the plant mix seals with increasing traffic although maintaining a satisfactory skid resistance value.

Although the adopted speed for running skid resistance is presently 40 miles per hour, it is very important to know how the skid resistance changes with increasing speeds since the speed limits on most highways are above 40 miles per hour. Figure 7 shows bar graphs illustrating the percent decrease in skid numbers at eight months for the various test sections when testing from 40 to 60 miles per hour. The bar graphs indicate that the percent change in skid resistance varies on different surfaces, depending again on the surface texture, type of aggregate and its susceptibility to hydroplaning. Of the nine sections in Figure 7, the plant mix seals and expanded clay slurry seal showed the least percent decrease in skid numbers when testing from 40 to 60 miles per hour. The 75 percent crushed gravel plant mix seal was higher than all but one of the other mixes, indicating the importance of crushed aggregate in a gravel plant mix seal. It is believed that plant mix seals are less susceptible to hydroplaning than the dense graded hot mixes due to its open graded texture.

Roughness

One of the other important criteria in which the test sections were evaluated was roughness. Roughness measurements were taken on all of the test sections at four and eleven months after construction. The results in Figure 8

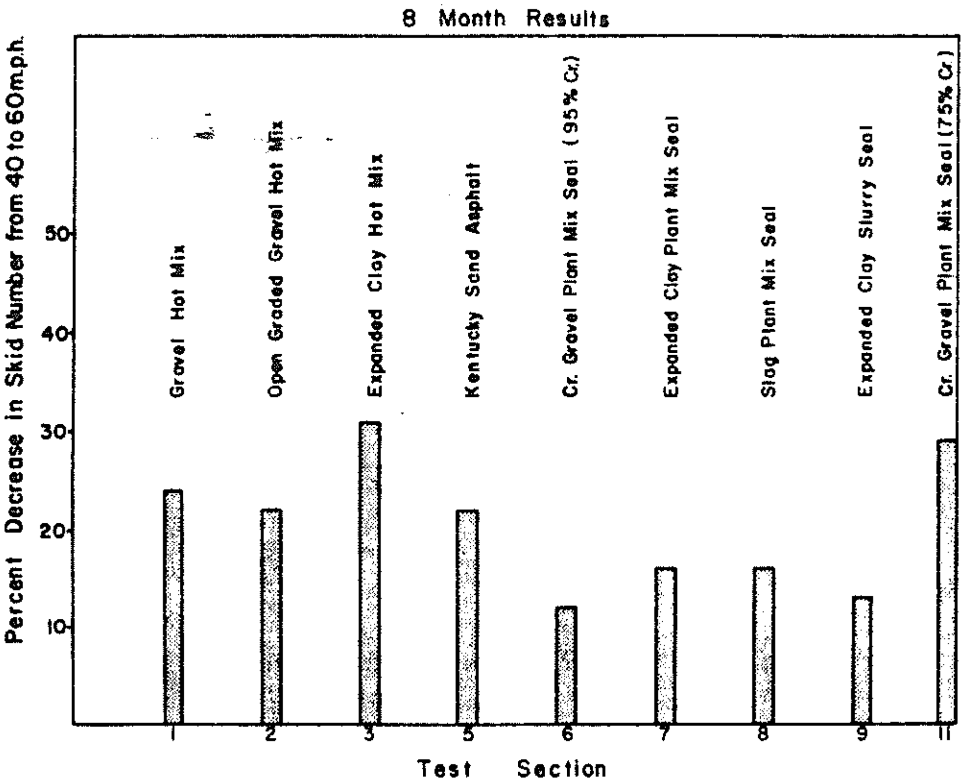


Figure 7 - The eight month results for the percent decrease in skid numbers from 40 to 60 MPH.

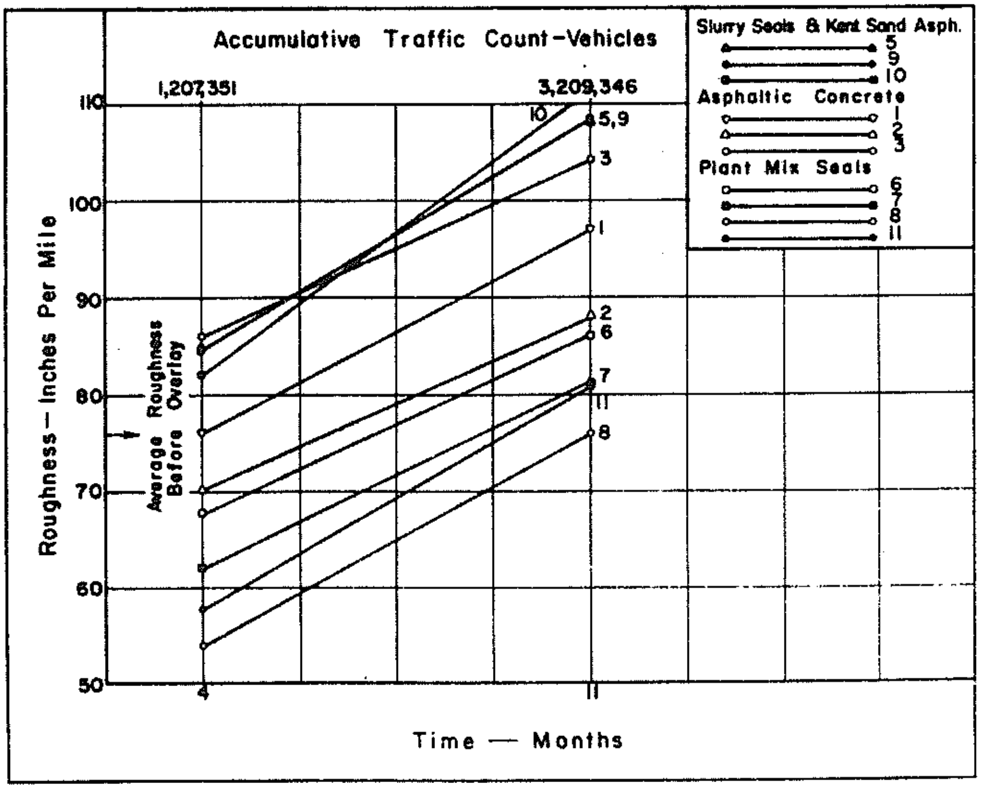


Figure 8 - Relationship of roughness versus time and traffic for all of the test sections.

shows that the plant mix seals had the lowest roughness of all the test section. The slurry seals and Kentucky sand asphalt gave the highest roughness values at both four and eleven months. The average roughness of the roadway before overlay was approximately 76 inches per mile. After eleven months and three million vehicles the plant mix seals show a roughness range of 76 to 81 which for all practical purposes may be rated as good, as based on the following description.

Adjective Description	Roughness Values Inches Per Mile Flexible Pavement
Very Good	Less than 65
Good	65-80
Fair	80-100
Rough	More than 100

This is considered very good for a surface that is only approximately 5/8 of an inch thick. The asphaltic concrete mixtures ranged from 88 to 104 and the slurry seals and Kentucky sand asphalt from 108 to 111.

In general the plant mix seals appear to be most satisfactory for use as a thin skid resistant surface. It is easy to construct and results in higher skid numbers with lower roughness values. Although a complete cost estimate cannot be made from this project, it is believed that the cost per square yard will be very competitive with most other types of seal coats being used.

CONCLUSIONS

1. Of the four different types of surface courses evaluated, namely plant mix seal, asphaltic concrete, sand asphalt and slurry seal; the plant mix seals possessed the most desirable features, such as: ease of construction, high skid resistance and low roughness values.

2. After being subjected to traffic for eleven months (3,209,346 vehicles) the Kentucky sand asphalt and expanded clay plant mix seal possessed the highest skid numbers of 63 at 40 miles per hour than any of the other test sections.

3. The expanded clay slurry seal had an average skid number of 63 after eight months or 2,244,591 vehicles.

4. The skid numbers for the plant mix seals increased, with traffic, up to four months and leveled off up to eleven months. The asphaltic concrete mixtures increased at four and eight months and slightly decreased at eleven months.

5. The crushed gravel plant mix seal with 95 percent crushed material had an average skid number of 49 at 40 miles per hour as compared to only 41 for the 75 percent crushed gravel seal after eleven months of traffic. This clearly indicates that when using gravel plant mix seal, a minimum of 95 percent curshed material should be required.

6. The percent decrease in the average skid numbers when testing at 40 and 60 miles per hour was the least (12 to 16 percent) on the plant mix seals and the expanded clay slurry seal, with the exception of the 75 percent crushed gravel plant mix seal which decreased as much as 29 percent. The other test sections decreased in skid numbers in the range of 22 to 31 percent.

7. The plant mix seals showed the least amount of roughness after eleven months of traffic. The range of roughness values in inches per mile were 108 to 111 for the slurry seals and Kentucky sand sections, and from 88 to 104 for the asphaltic concrete and from 76 to 81 for the plant mix seals.

APPENDIX "A"

AVERAGE PHYSICAL PROPERTIES OF THE VARIOUS BITUMINOUS MIXTURES
TEST RESULTS OF ASPHALT CEMENT
AVERAGE SKID NUMBERS
AVERAGE ROUGHNESS RESULTS

TABLE 1

AVERAGE PHYSICAL PROPERTIES OF THE VARIOUS BITUMINOUS MIXTURES

Test Section 1 - Type IV Hot Mix, Crushed Gravel (Control)

Mineral Aggregate -	95%	
Asphalt Content -	5%	(AC-3 60/70 penetration)
Crushed Aggregate -	79%	

Lab. Specific Gravity -	2.339
Voids -%	5.3
Voids Filled	68.2
Marshall Stability lbs.	1885
Flow 1/100"	12
Roadway Density -%	96.3

Extracted Gradation

U.S. Sieve	Percent Passing
3/4"	100
1/2"	98
3/8"	86
No. 4	59
No. 10	44
No. 40	30
No. 80	13
No. 200	9

Test Section 2 - Open Graded Crushed Gravel Mix

Mineral Aggregate -	95%	
Asphalt Content -	5%	(AC-3 60/70 penetration)
Crushed Aggregate -	85%	

Lab. Specific Gravity -	2.302
Voids -%	5.9
Voids Filled -%	65.7
Marshall Stability lbs.	2041
Flow 1/100"	9
Roadway Density %	93.2

Extracted Gradation

U.S. Sieve	Percent Passing
3/4"	100
1/2"	98
3/8"	87
No. 4	66
No. 10	43
No. 40	23
No. 80	7
No. 200	4

TABLE 1 (cont'd)

Test Section 3 - Type 4 Expanded Clay Hot Mix

Mineral Aggregate -	92.5	
Asphalt Content -	7.5	(AC-3 60/70 penetration)

Lab. Specific Gravity -	1.722
Voids %	7.9
Voids Filled %	63.6
Marshall Stability lbs.	1496
Flow 1/100"	8
Roadway Density %	96.5

Extracted Gradation

U.S. Sieve	Percent Passing
3/4"	100
1/2"	98
3/8"	89
No. 4	73
No. 10	66
No. 40	45
No. 80	16
No. 200	10

Test Section 4 - Louisiana Sand Asphalt

Mineral Aggregate -	93.5	
Asphalt Content % -	6.5	(AC-3 60/70 Penetration)

Lab. Specific Gravity -	2.225
Voids %	8.1
Voids Filled %	63.4
Marshall Stability lbs.	802
Flow 1/100"	12
Roadway Density %	94.0

Extracted Gradation

U.S. Sieve	Percent Passing
No. 4	100
No. 10	92
No. 40	59
No. 80	18
No. 200	9

TABLE 1 (cont'd)

Test Section 5 - Kentucky Sand Asphalt

Mineral Aggregate -	94.5%	
Asphalt Content -	5.5%	(AC-3 60/70 penetration)

Lab. Specific Gravity -	2.068
Voids -%	10.3
Voids Filled -%	51.9
Marshall Stability lbs.	1082
Flow 1/100"	10
Roadway Density %	92.3

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
No. 4	98
No. 100	13

Test Section 6 - Gravel Plant Mix Seal (95% crushed)

Mineral Aggregate -	93%	
Asphalt Content -	7%	(AC-3 60/70 penetration with 0.5% Redicote 80-S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	98
No. 4	46
No. 10	13
No. 40	4
No. 200	1

TABLE 1 (Cont'd)

Test Section 7 - Expanded Clay Plant Mix Seal

Mineral Aggregate - 84%
Asphalt Content - 16% (AC-3 60/70 penetration with 0.5% Redicote 80.S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	98
No. 4	49
No. 10	10
No. 40	2
No. 100	1

Test Section 8 - Slag Plant Mix Seal

Mineral Aggregate - 91%
Asphalt Content - 9% (AC-3 60/70 penetration with 0.5% Redicote 80-S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	98
No. 4	41
No. 10	6
No. 40	2
No. 100	1

TABLE 1 (cont'd)

Test Section 9 - Expanded Clay Slurry Seal

Emulsion Content - 25% by volume of Aggregate (Chevron Quickset Cationic Emulsion)

Gradation

U.S. Sieve	Percent Passing
3/8"	100
No. 4	100
No. 16	54
No. 50	23
No. 100	15
No. 200	11

Test Section 10 - Granite Slurry Seal

Emulsion Content - 35% by volume of Aggregate (Bitucote-Blakat Cationic Emulsion)

Gradation

U.S. Sieve	Percent Passing
3/8"	100
No. 4	99
No. 16	48
No. 50	20
No. 100	9
No. 200	5

Test Section 11 - Gravel Plant Mix Seal (75% crushed)

Mineral Aggregate -	93%	
Asphalt Content -	7%	(AC-3 60/70 penetration with 0.5% Redicote 80-S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	96
No. 4	53
No. 10	26
No. 40	11
No. 100	2

TABLE 2

TEST OF ASPHALT CEMENT

Laboratory Number	6352
Specific Gravity 77°F.	1.031
Specific Gravity 60°F.	1.034
Wt. Per Gallon at 60°F., lbs.	8.620
Flash Point, C.O.C., °F.	610
Viscosity	
Saybolt Furol Sec. @ 275°F.	309
Absolute @ 140°F, Poises	4088
Penetration @ 39.2°F, 200G., 60 sec.	25
Penetration @ 77°F, 100G., 5 sec.	62
Thin Film Oven Test	
Loss % @ 325°F, 5 hrs.	.03
Penetration of Residue @ 77°F.	45
Residue Penetration, % of Original	72.6
Ductility of Residue @ 77°F.	100+
Solubility in CS_2%	99.82
Homogeniety Test	Negative
Mixing Temperature	319-326

Remarks: This sample conforms to the specifications for A. C.-3.

TABLE 3

AVERAGE SKID NUMBERS AT VARIOUS TIME INTERVALS AFTER COMPLETION

	AVERAGE SKID NUMBERS											
	0-Months			4-Months			8-Months			11-Months		
	20mph	40mph	60mph	20mph	40mph	60mph	20mph	40mph	60mph	20mph	40mph	60mph
1. Control-Gravel Hot Mix Type 1	55	40	33	-	44	-	60	50	38	56	47	37
2. Open Graded Gravel Mix	60	46	39	-	46	-	58	51	40	58	48	38
3. Expanded Clay Hot Mix Type 4	56	37	29	-	42	-	64	55	38	65	50	38
4. Louisiana Sand Asphalt	48	33	23	-	-	-	-	-	-	-	-	-
5. Kentucky Sand Asphalt	74	69	60	-	62	-	76	73	57	71	63	50
6. Crushed Gravel Plant Mix Seal (95% Crushed)	55	43	40	-	50	-	55	50	44	53	49	44
7. Expanded Clay Plant Mix Seal	70	59	51	-	63	-	75	63	53	70	63	50
8. Slag Plant Mix Seal	62	53	49	-	58	-	63	58	49	57	56	49
9. Expanded Clay Slurry Seal (La.)	77	70	63	81	70	59	64	63	55	-	-	-
10. Granite Slurry Seal	50	41	26	51	38	30	48	36	28	-	-	-
11. Crushed Gravel Plant Mix Seal (75% Crushed)	52	40	36	-	41	-	51	41	29	50	41	-

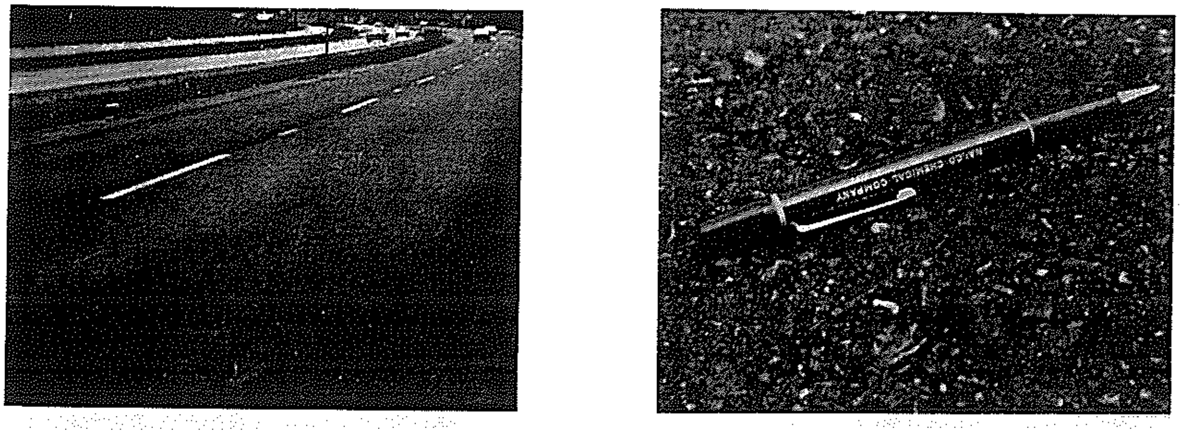
TABLE 4

AVERAGE ROUGHNESS RESULTS

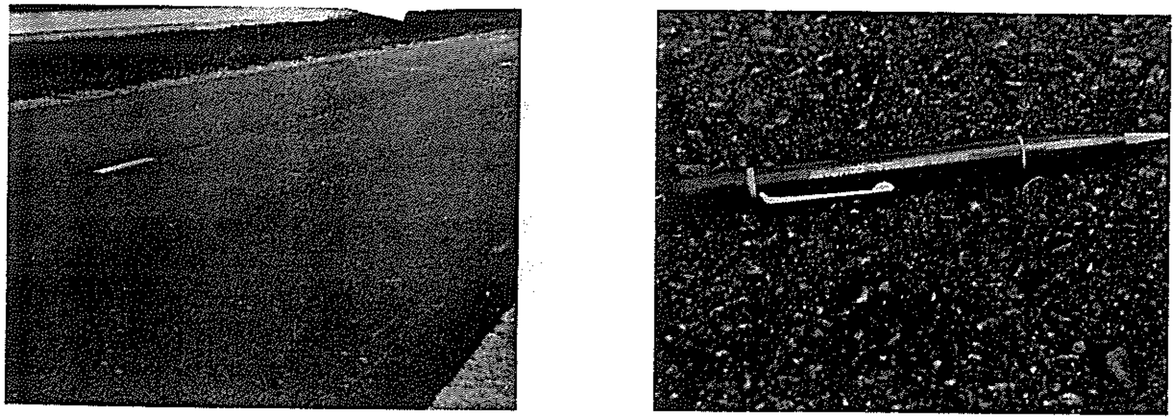
Test Section	ROUGHNESS	
	4 MONTHS	11 MONTHS
1. Control-Gravel Hot Mix Type 1	76	97
2. Open Graded Gravel Mix	70	88
3. Expanded Clay Hot Mix Type 4	86	104
4. Louisiana Sand Asphalt	80	-
5. Kentucky Sand Asphalt	85	108
6. Crushed Gravel Plant Mix Seal (95% Crushed)	68	86
7. Expanded Clay Plant Mix Seal	62	81
8. Slag Plant Mix Seal	54	76
9. Expanded Clay Slurry Seal (La.)	85	108
10. Granite Slurry Seal	82	111
11. Crushed Gravel Plant Mix Seal (75% Crushed)	58	81

APPENDIX "B"

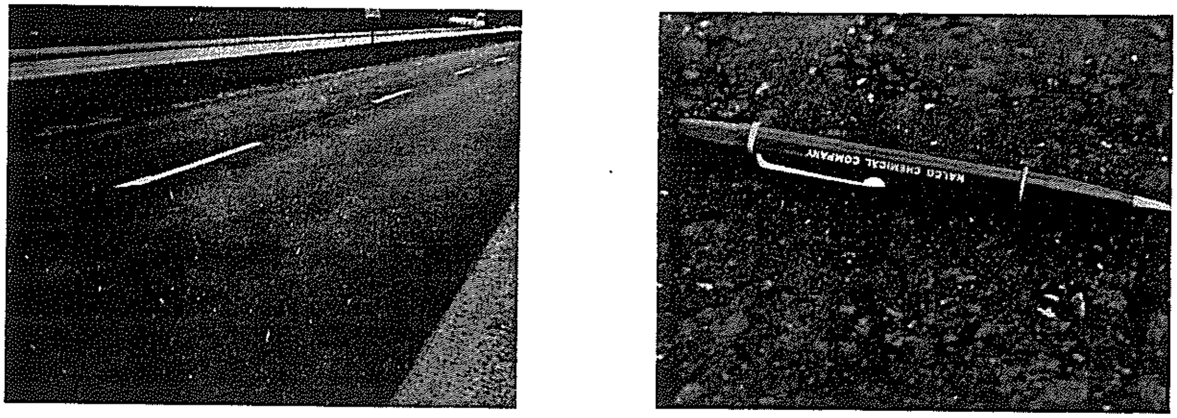
PHOTOGRAPHS OF THE VARIOUS TEST SECTIONS



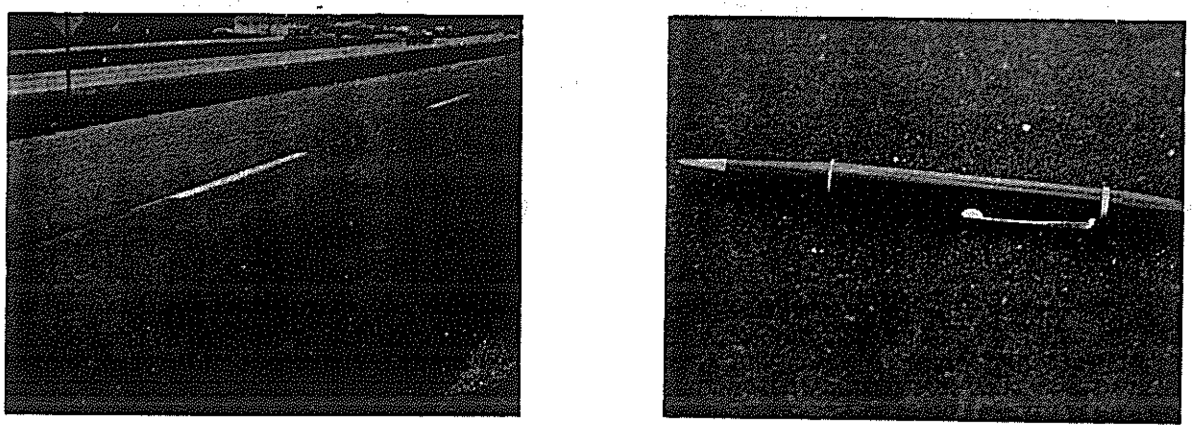
Section 1- Type 1 Crushed Gravel Mix



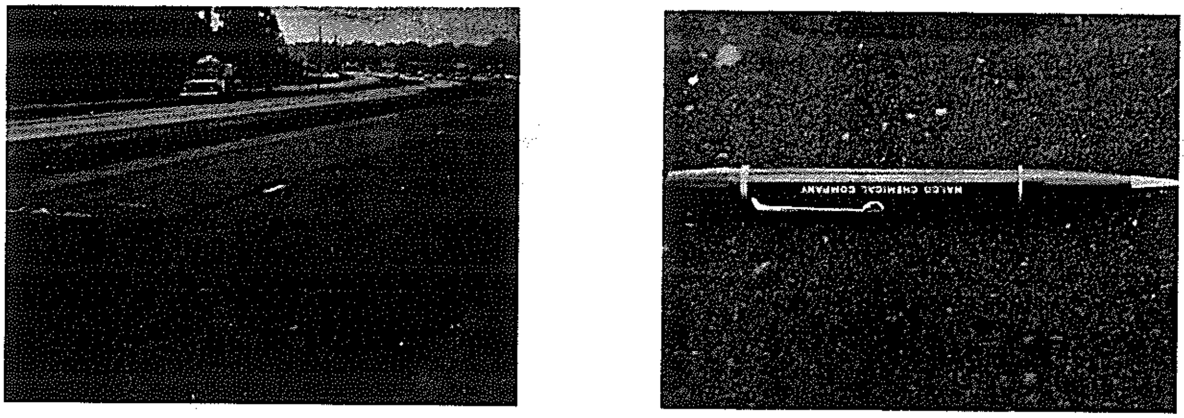
Section 2- Open Graded Crushed Gravel Mix



Section 3- Type 4 Expanded Clay Hot Mix

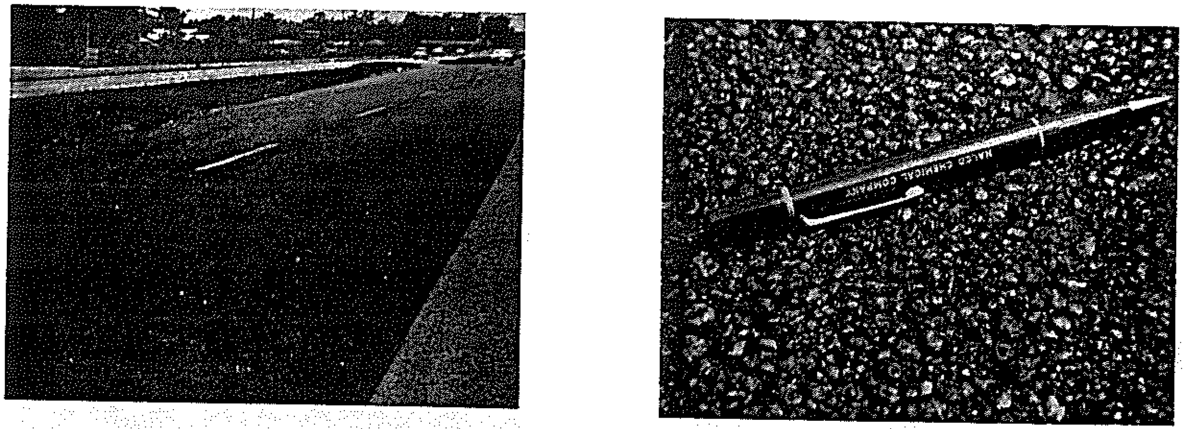


Section 4- Louisiana Sand Asphalt



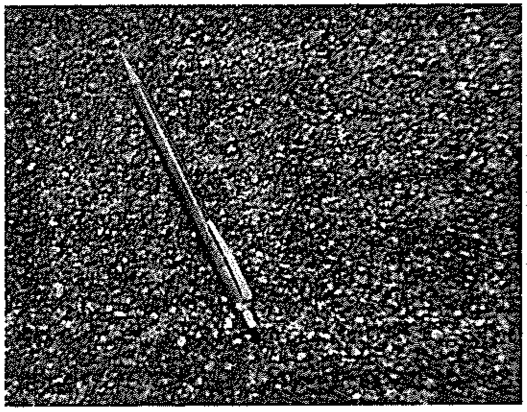
Section 5- Kentucky Sand Asphalt

Section 6- Crushed Gravel Plant Mix Seal

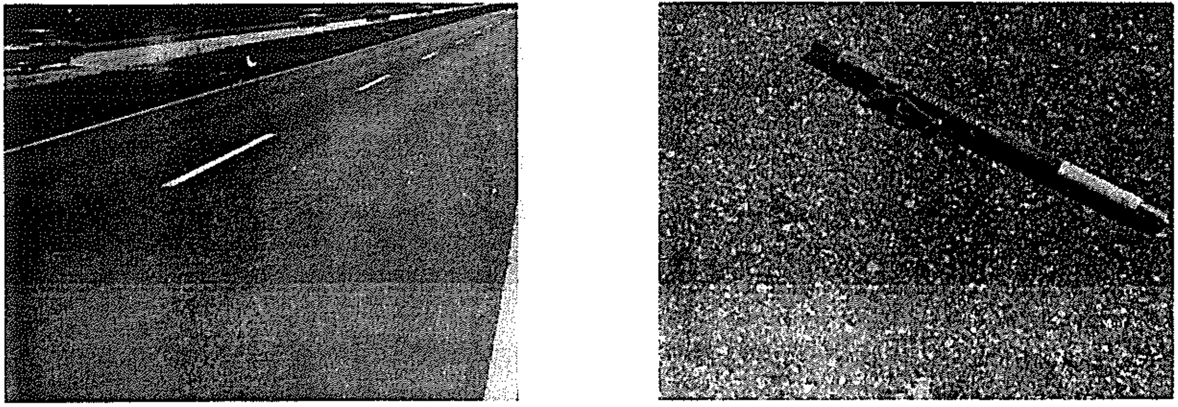


Section 7- Expanded Clay Plant Mix Seal

Section 8- Slag Plant Mix Seal



Section 9- Expanded Clay Slurry Seal



Section 10- Granite Slurry Seal

in principle, the wide variety of structural shapes, damage, and structural configurations likely to be encountered in practice mak difficult to establish guidelines. In addition, the varied methods heating and restraining during the repair process complicate the pi even further.

STRESS-STRAIN CHARACTERISTICS

Fable.--Since the coefficient of thermal expansion for steel increases with temperature, the hotter the better when applying a ve heat.

Fact.--One of the most fundamental aspects of heat straightenin the thermal expansion behavior of steel. The coefficient of thermal expansion (CTE) is a measure of the rate of strain per degree tempera ture. This coefficient varies directly with temperature such that th rate of expansion increases as temperature increases (10,19,45,50,52, 60). Plots showing the variation of the CTE are given in Figure 2. Most curves of this type do not exceed a temperature of 1200° to 1400 because research has shown (23) that the CTE varies in an irregular manner over the range of temperatures between 1300° to 1600°F. If onl the CTE were considered, "the hotter the better" might be acceptable. However, a number of other factors addressed here negate this assumption.

Fable.--The modulus of elasticity for steel is permanently altered after heat straightening.

Fact.--The modulus of elasticity does decrease with increasing temperature. At 1400°F the modulus for steel typically decreases

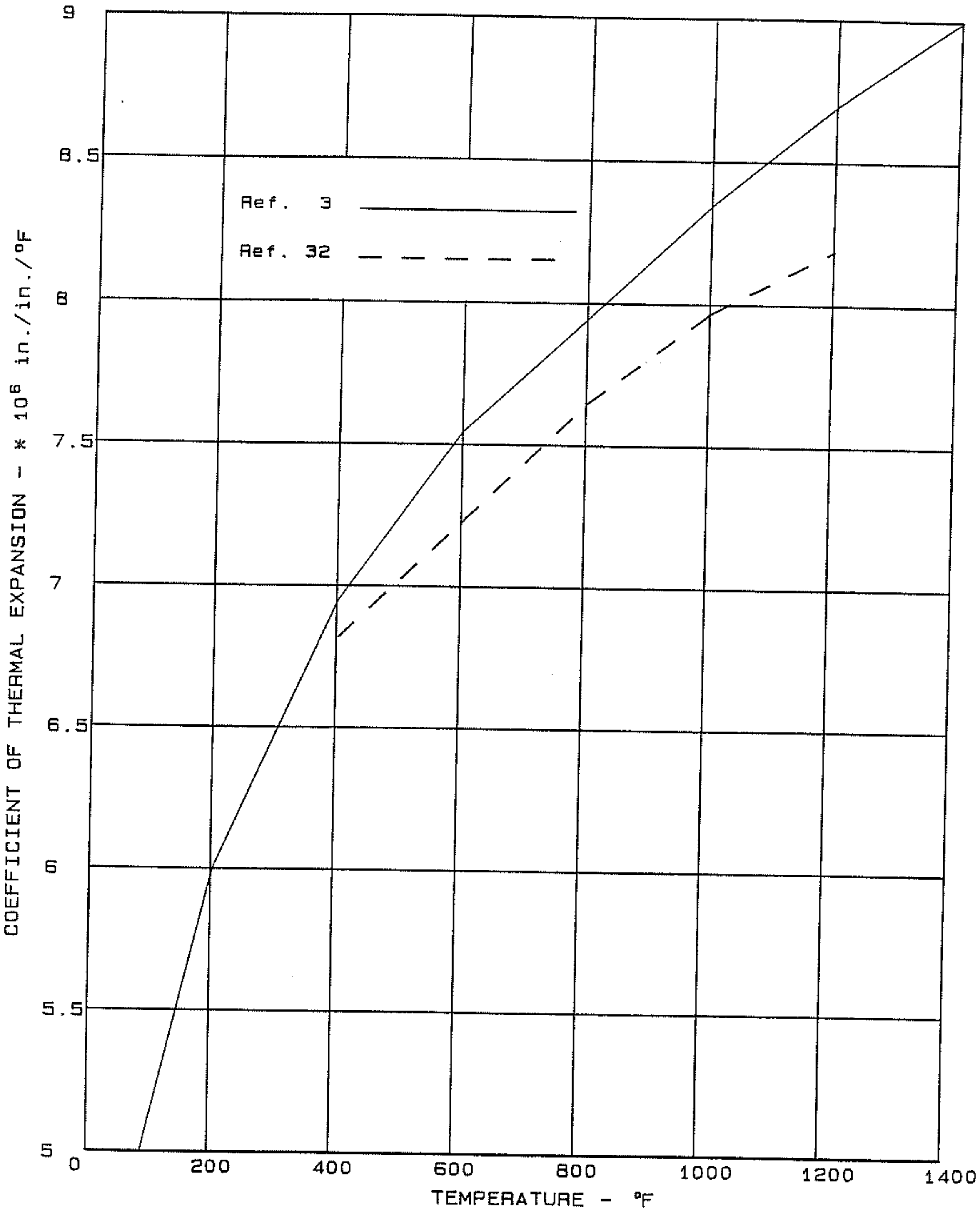


Figure 2. Coefficient of thermal expansion vs. temperature.

one-third of its value at room temperature. The variation in modulus is plotted in Figure 3 for typical carbon steels. Only two investigators have reported the results of measuring the modulus of elasticity after the heat-straightening process has been completed. Neither Horton (35) nor Nicholls and Weerth (45,60) indicated the number of tensile specimens tested and only average values were given. As indicated in Table 1, these tests showed that no appreciable change occurs in the modulus of elasticity after completing the heat-straightening process where the material had cooled to room temperature. Even during heat straightening, the effect of change in modulus is relatively small because the yield stress is also reduced. Thus at 1200°F the strain at initial yield is only 25 percent greater than the yield strain at room temperature.

Fable.--Heat straightening should never be used without temporary shoring since the heating effect may weaken the steel and produce a collapse.

Fact.--It is common knowledge that high heat reduces the yield stress of steel to very low values. A plot of the yield stress versus temperature is shown in Figure 4 for various steels. It can be seen that the yield stress may be on the order of one-half its original value when the temperature reaches 1200° to 1400°F. Yield stresses are rarely plotted for temperatures above 1400°F because the values become so low. For example, at temperatures in the range of 1600° to 1800°F, the yield stress is between 5 and 15 percent of its value at room temperature (19). This behavior is one important reason why the metal temperature during heat straightening should not exceed 1200° to 1400°F. When temperatures are limited to this range, the yield stress will be on the

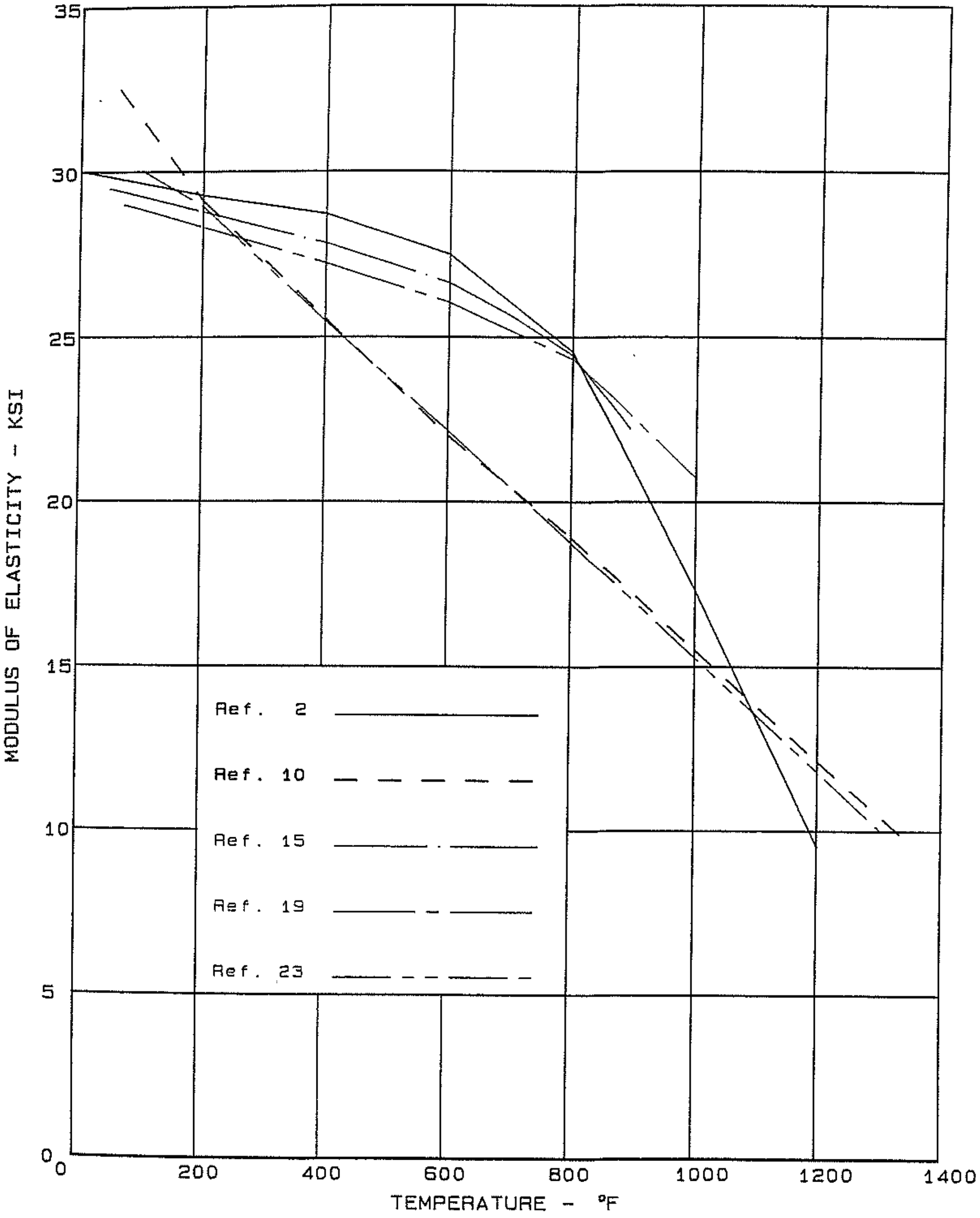


Figure 3. Modulus of elasticity vs. temperature.

	Steel		Heat Conditions				Tensile Coupon Results[1]				Charpy Results			
	Design.	σ_y (ksi)	Elev. Temp. °F	Time (min)	Cooling	Applied Strains	Yield Stress $\frac{\sigma_y}{\text{nom. }\sigma_y}$	Elong. in 2" $\frac{\Delta \ell}{\text{nom. }\Delta \ell}$	Tensile Stress $\frac{\sigma_{ult}}{\text{nom. }\sigma_u}$	$\frac{E}{\text{nom. E}}$	Temp.	$\frac{\text{Impact Energy}}{\text{Nom. Impact Energy}}$	T_{50} - Nom. T_{50}[2]	Ref.
on	A-7^4	33	1100-1200	after five	air	dead + residual	1.13	1.63	1.02		--	--	--	2
				after five & V-heat	air	dead + residual	1.17	0.59	1.00		--	--	--	
				after five & V-heat	air	dead + residual	1.22	0.75	1.00		--	--	--	
				after five & V-heat	air	dead + residual	1.18	0.85	1.01		--	--	--	
				after five & V-heat	air	dead + residual	1.32	0.73	1.00		--	--	--	
				after five & V-heat	air	dead + residual	1.14	0.77	1.00		--	--	--	
				after five & V-heat	air	dead + residual	1.42	0.63	1.04		--	--	--	
	A-36^3	36	1100-1200	from V-heat	air	residual	1.00	0.87	1.01		--	--	--	3
	A36^5	36	1000	after line heat	air	residual	1.18	0.96	1.06		--	--	--	4
			1000	after line heat	air	residual	1.08	0.94	1.07		--	--	--	
			1000	after line heat	air	residual	1.06	0.93	1.07		--	--	--	
			1000	after line heat	air	residual	0.90	0.96	1.06		--	--	--	
			1000	after line heat	air	residual	0.97	0.96	1.04		--	--	--	
			1000	after line heat	air	residual	1.05	0.96	1.04		--	--	--	
			1000	after line heat	air	residual	1.01	1.00	1.04		--	--	--	
			1000	after line heat	air	residual	0.97	1.00	1.04		--	--	--	
			1000	after line heat	air	residual	1.00	1.00	1.04		--	--	--	
	A36	36	1200	--	air	25% yield	1.03^3	0.75^3	1.05	1.00	--	--	--	5,6
	A36	36	1200	--	air	25% yield	1.00^3	0.87^3	1.01	1.00	--	--	--	3
	ABS-B	40	1300	1/2	air	--	--	--	--		upper shelf	1.09	- 3	7
			1300	5	air	--	1.07	0.97	0.98		upper shelf	1.14	16	
			1300	5	quench	--	1.10	1.03	1.03		upper shelf	1.29	30	
			1100	1/2	air	--	--	--	--		upper shelf	1.02	20	
			1100	5	quench	--	--	--	--		upper shelf	1.00	- 2	
			800	1/2	air	--	--	--	--		upper shelf	1.10	- 2	
			800	5	air	--	--	--	--		upper shelf	1.14	-14	
			1300	10	air	5% tensile	1.13	1.04	1.02		upper shelf	1.04	15	

LE 1 (continued)

Steel		Heat Conditions					Tensile Coupon Results[1]				Charpy Results			
Type	Design.	σ_y (ksi)	Elev. Temp. °F	Time (min)	Cooling	Applied Strains	Yield Stress $\frac{\sigma_y}{\text{nom. }\sigma_y}$	Elong. in 2" $\frac{\Delta\ell}{\text{nom. }\Delta\ell}$	Tensile Stress $\frac{\sigma_{ult}}{\text{nom. }\sigma_u}$	$\frac{E}{\text{nom. }E}$	Temp.	$\frac{\text{Impact Energy}}{\text{Nom. Impact Energy}}$	T_{50} − Nom. T_{50}[2]	Ref.
			1300	10	air	5% comp.	1.04	0.82	0.99		upper shelf	1.20	29	
			1100	10	air	5% tensile	--	--	--		upper shelf	1.04	18	
			1100	10	air	5% comp.	--	--	--		upper shelf	1.07	26	
Heat-Treated Construc-tional Alloy	NAXTRA-100	100	1300	1/2	air		--	--	--		upper shelf	1.09	- 4	7
			1300	5	air		0.90	0.84	0.93		upper shelf	1.09	- 4	
			1300	5	quench		0.93	0.82	0.96		upper shelf	1.16	-21	
			1100	1/2	air		--	--	--		upper shelf	1.02	-17	
			1100	10	air		--	--	--		upper shelf	1.00	0	
			900	1/2	air		--	--	--		upper shelf	1.00	10	
			900	10	air		--	--	--		upper shelf	1.00	10	
			800	1/2	air		--	--	--		upper shelf	1.00	0	
			800	5	air		--	--	--		upper shelf	1.00	0	
			1300	10	air	5% tensile	0.83	0.79	0.90		upper shelf	1.36	-54	
			1300	10	air	5% comp.	0.81	0.77	0.89		upper shelf	1.40	- 8	
			1100	10	air	5% tensile	--	--	--		upper shelf	1.24	-11	
			1100	10	air	5% comp.	--	--	--		upper shelf	1.18	-11	
	A514-F	100	1300	5	air		1.01	0.90	1.00		upper shelf	1.02	<-12	7
			1300	5	quench		1.01	0.94	1.00		upper shelf	1.00	<-12	
			1100	5	air		--	--	--		upper shelf	1.00	0	
			800	5	air		--	--	--		upper shelf	1.00	0	
			1300	10	air	5% tensile	0.88	0.78	0.93		upper shelf	1.11	<-12	
			1300	10	air	5% comp.	0.84	0.76	0.92		upper shelf	1.04	<-12	
			1300	10	air	2% tensile	--	--	--		upper shelf	1.16	<-12	
			1300	10	air	2% comp.	--	--	--		upper shelf	1.13	<-12	
			1100	10	air	5% tensile	--	--	--		upper shelf	1.07	<-12	
			1100	10	air	5% comp.	--	--	--		upper shelf	1.04	<-12	
	Armco QTC	100	900	1/4	quench	--	1.02	1.10	1.00		upper shelf	0.98	- 8	9
			1100	1/4	quench	--	1.01	1.08	1.00		upper shelf	1.00	-14	
			1300	1/4	quench	--	1.04	1.03	1.00		upper shelf	1.03	<-21	
			900-1050	1/15	quench	residual	0.98	0.88	1.06		upper shelf	1.03	<-17	
	A517-A	100	1100-1200	--	quench	--	--	--	--		--	--	113[6]	47
			1100-1200	--	quench	--	--	--	--		--	--	75[6]	
			1300-1400	--	quench	--	--	--	--		--	--	205[6]	
			1300-1400	--	quench	--	--	--	--		--	--	108[6]	

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[1] Nominal values are from tests of as received steel.

[2] Temp. at which 50% of upper shelf energy was absorbed.

[3] Average of unspecified number of specimens.

[4] Nominals are for A-7: $\sigma_y = 33$, % elong. = 24, $\sigma_u = 60$.

[5] Nominals are for A-36: $\sigma_y = 36$, % elong. = 34, $\sigma_u = 67$.

[6] Results are from drop weight tear test where T_{50} is the transition temperature at which the fracture contains 50% shear area.

Type	Design.	σ_y (ksi)	Elev. Temp. °F	Time (min)	Cooling	Applied Strains	Yield Stress $\frac{\sigma_y}{\text{nom. }\sigma_y}$	Elong. in 2" $\frac{\Delta\ell}{\text{nom. }\Delta\ell}$	Tensile Stress $\frac{\sigma_{ult}}{\text{nom. }\sigma_u}$	$\frac{E}{\text{nom. }E}$	Temp.	Impact Energy / Nom. Impact Energy	T_{50} - Nom. T_{50}	Ref.
			1300	10	air	5% comp.	1.14	0.92	1.03		upper shelf	1.10	45	
			1100	10	air	5% tensile	--	--	--		upper shelf	0.93	29	
			1100	10	air	5% comp.	--	--	--		upper shelf	0.98	11	
	ABS-B		1300-1400	--	quench	--	--	--	--		--	--	18^{6}	26
High Strength Low Alloy	ABS-C		1300	1/2	air	--	--	--	--		upper shelf	0.99	21	7
			1300	5	air	--	0.98	0.83	0.98		upper shelf	0.99	36	
			1300	5	quench	--	1.03	0.79	1.05		upper shelf	0.96	47	
			1100	1/2	air	--	--	--	--		upper shelf	0.93	26	
			800	1/2	air	--	--	--	--		upper shelf	0.97	23	
			800	5	air	--	--	--	--		upper shelf	0.95	37	
	A441	50	1300	1/2	air	--	--	--	--		upper shelf	0.99	- 3	7
			1300	5	air	--	1.03	0.84	0.99		upper shelf	1.02	13	
			1300	5	quench	--	1.04	0.83	1.02		upper shelf	0.94	30	
			1100	1/2	air	--	--	--	--		upper shelf	0.92	10	
			800	1/2	air	--	--	--	--		upper shelf	0.97	10	
			800	5	air	--	--	--	--		upper shelf	0.92	36	
	A441		1100-1200	--	quench	--	--	--	--		--	--	16^{6}	47
			1300-1400	--	quench	--	--	--	--		--	--	12^{6}	
	Not Specified	50	1100-1300	from V-heat	air	residual	1.03	0.83	1.01		0	1.33	--	8
			1100-1300		air	residual	1.03	0.79	1.00		35	1.00	--	
											65	1.17	--	
Heat-Treated High Strength Carbon	A537-A	50	1300	1/2	air	--	--	--	--		upper shelf	1.00	-60	7
			1300	5	air	--	1.06	0.91	0.94		upper shelf	1.00	-51	
			1300	5	quench	--	1.13	0.91	0.96		upper shelf	1.00	- 6	
			1100	1/2	air	--	--	--	--		upper shelf	0.94	-61	
			800	1/2	air	--	--	--	--		upper shelf	0.98	-26	
			800	5	air	--	--	--	--		upper shelf	0.98	-41	
			1300	10	air	5% tensile	1.12	0.87	0.95		upper shelf	0.99	-19	
			1300	10	air	5% comp.	1.10	0.84	0.94		upper shelf	0.99	3	
			1100	10	air	5% tensile	--	--	--		upper shelf	0.92	- 6	
			1100	10	air	5% comp.	--	--	--		upper shelf	0.92	-13	
	A537-A		1100-1200	--	quench	--	--	--	--		--	--	25^{6}	47
			1300-1400	--	quench	--	--	--	--		--	--	28^{6}	
	A537-B	60	1300	1/2	air		--	--	--		upper shelf	1.13	36	7
			1300	5	air		1.02	0.81	0.99		upper shelf	1.11	18	
			1300	5	quench		1.05	0.88	1.05		upper shelf	1.10	-29	
			1100	1/2	air		--	--	--		upper shelf	1.00	33	
			1100	5	quench		--	--	--		upper shelf	1.00	8	
	Steel		800	1/2	air		--	--	--		upper shelf	1.00	0	
			800	5	air		--	--	--		upper shelf	1.09	5	
			1300	10	air	5% tensile	1.04	0.86	0.99		upper shelf	1.13	2	

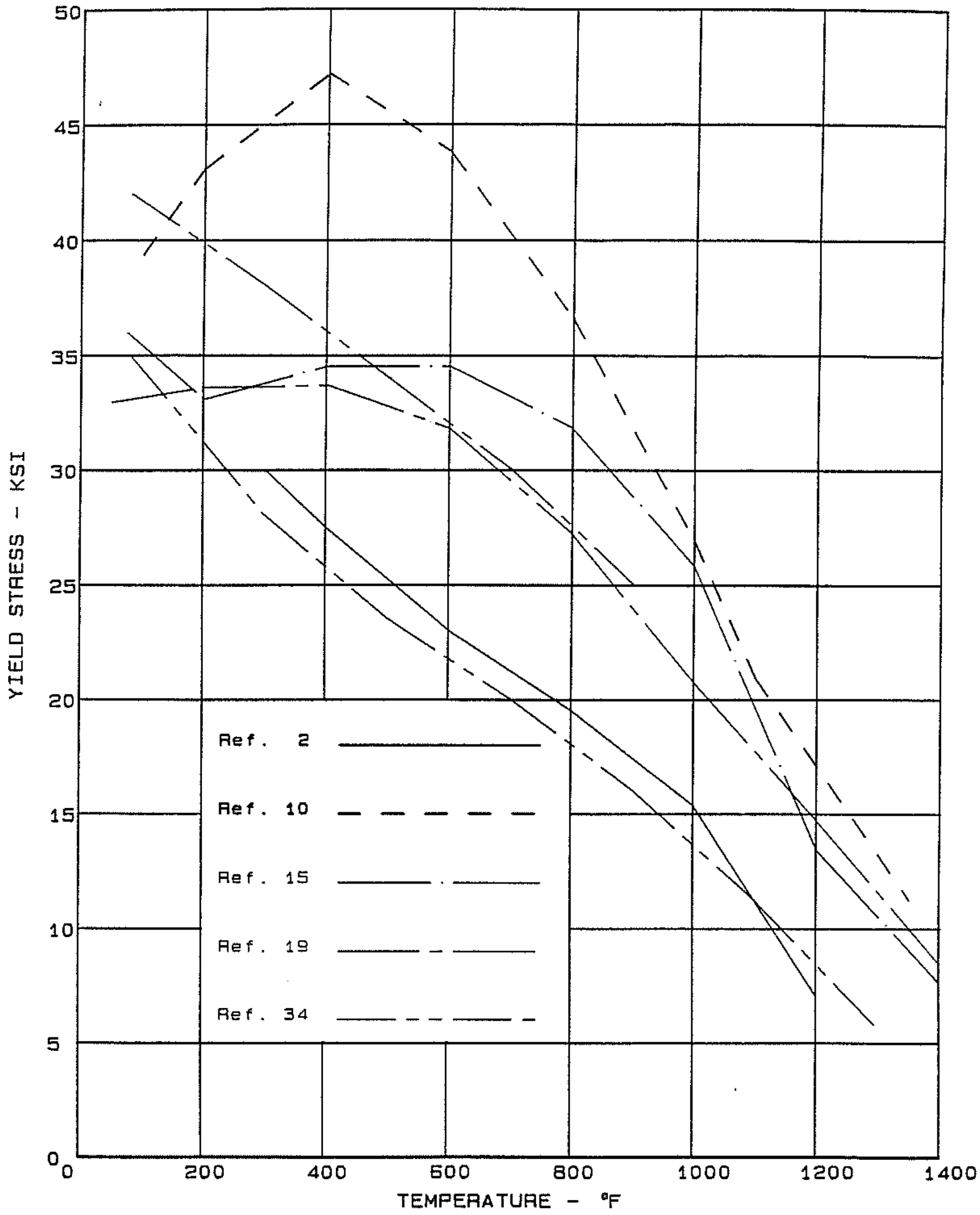

Figure 4. Yield stress vs. temperature.

The test sections consisted of three asphaltic concrete mixtures, two sand asphalt mixtures, four plant mix seals and two slurry seals. All of the test sections with the exception of the slurry seals were constructed under contract by Barber Brothers Construction Company of Baton Rouge. The two slurry seal sections were constructed by the District 61 maintenance forces.

Construction Control

Each of the various mixtures were controlled during construction. The asphaltic concrete and sand asphalt mixtures were tested at the plant and on the roadway for such properties as Marshall Stability, voids, voids filled, gradation, asphalt content and roadway density. The plant mix seals were tested for extracted gradation and asphalt content only, whereas the slurry seals were tested for gradation only. The Rex slurry-seal machine was calibrated prior to construction to determine the quantity of emulsion in the mixture. All of the average test results for the various test sections may be found in Table 1, Appendix A.

Each of the test sections were constructed in one lift with the exception of the slurry seals which were constructed in two lifts. The hot bituminous mixtures were spread with a spreader having automatic screed control to the approximate thickness mentioned in the description of the test sections.

Rolling of the asphaltic concrete mixtures was accomplished by a tandem, pneumatic and tandem in that order. The sand asphalt mixtures were rolled with a tandem only and the plant mix seals with a tandem and then a pneumatic roller. The slurry seals were rolled with a pneumatic roller only after curing of the emulsion.

Test Performed to Evaluate Test Sections

The evaluation of the test sections consisted of obtaining skid resistance values at zero, four, eight and eleven months after completion. Roughness results were also obtained at four and eleven months after completion. These tests results were compared for the various test sections and the relationship between skid resistance and volume of traffic obtained. The skid resistance was obtained by the Louisiana Department of Highways skid trailer (Figure 1).

The roughness results were used primarily to compare the riding surface between test sections after being subjected to traffic.

Visual observation was also used as a basis for evaluating the test sections.

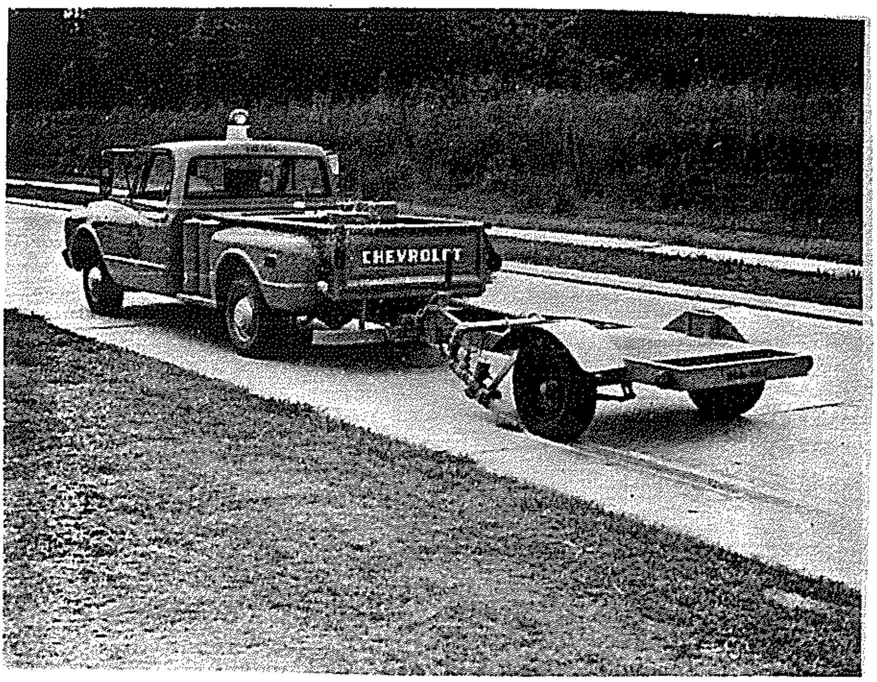

Figure 1 - Photograph of the skid trailer.

DISCUSSION OF RESULTS

The evaluation of the test sections were based primarily on comparative results for skid resistance, roughness and visual observation over an eleven month period. The test results obtained represented four different types of bituminous mixtures utilizing five different aggregate types. This provided a means of comparing results of asphaltic concrete, sand asphalt, plant mix seals and slurry seals, as well as, determining the most desirable aggregates for improving skid resistance.

Of the eleven test sections constructed each of the various type mixtures have been used in Louisiana before, with the exception of the plant mix seals and the Kentucky sand asphalt. Plant mix seals have been used for several years in a number of the Western States and all reports indicate excellent results.

All formations differ in their electrical conductivity and conversely their resistivity. These differences are due mostly to the physical properties of the formations and/or to the fluids which the formations contain and not so much their mineralogy or the chemistry of the mineral grains themselves. Some dense formations (a physical property) will be highly resistant to the flow of electrical current because they have such small amounts of pore space and therefore contain very little fluid. By the same token, loose formations are less resistant because of their usually higher moisture content. Clays, because of their characteristically high porosity or void ratio, are less resistant than sands. The resistivity curve then is a result of measurements of the difference of potential impressed on two electrodes by an outside current which is sent into the ground.

The other half of the electric log is the SP curve. This curve depends on the fact that porous formations contain water of varying degrees of saltiness. These fluids generate various amounts of natural electricity current by themselves. This natural electricity is called self or spontaneous potential. It is a measure of the electromotive force occurring when the water in the drilling mud is squeezed into the porous permeable formations in the bore hole. These electromotive forces can be measured and used to help identify the nature of the generating fluid, the kind of formation containing it, and give an indication of the porous zones. Thus, the self potential curve is often referred to as the "porosity curve."

Figure 3, below, is an idealized example of an electric log showing the different situations encountered in the bore hole. The formations marked dense are dense formations with little pore space; therefore they contain little fluid and are highly resistive to the passage of current. Both the self potential and resistivity curves are shown.

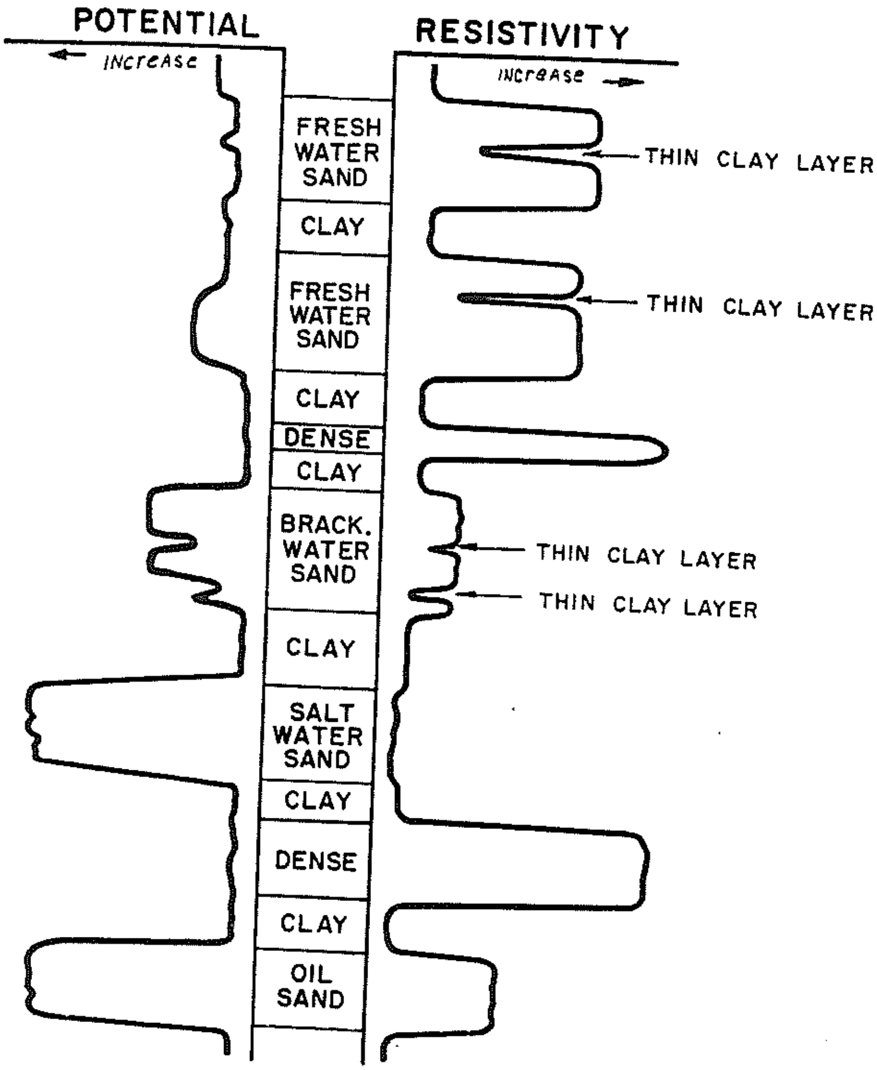

FIGURE 3: Idealized Electric Log

The resistivity and SP measurements are made with an instrument called a sonde. The sonde is a rod insulated with rubber on which electrical wires are fastened, ending in terminals called electrodes. It is lowered into the bore hole on the end of an electrical cable. From batteries at the surface, known amounts of electricity are sent down the cable to the sonde.

The current passes out of the sonde electrodes into the surrounding formations. Formations opposite the sonde will conduct a certain amount of current, depending on their characteristic resistivity. Return flow of the current is picked up by the sonde and sent back up the surveying cable to the surface. At the same time, the amount of self potential in the formation is measured and also sent back up the cable. At the surface, wires of the cable carry the currents of electricity to a galvanometer.

An ink pen is attached to the galvanometer, and a trace of the deflections is made on a moving strip of paper. Thus, with the chart moving at the rate of 1 inch per 20 feet, a permanent record of the resistivity and self potential curves are read together. One curve by itself is hard to interpret without the other.

The other type of log used in the investigations was the gamma ray log. Radioactivity can be defined as the spontaneous change of the atoms of one element into another. During this change, alpha, beta, and gamma rays are given off. The alpha and beta rays may be said to be low-energy rays.

The gamma rays are high-energy rays and can be measured and recorded to produce the gamma ray curve of the radio activity well log. With the gamma ray log, an outside electrical current is used in recording the log.

With the function switch in the gamma ray position, the right-hand recorder channel and range switch serve for the gamma ray log, and the left-hand recorder is disabled. The gamma ray signal on the cable is in the form of random negative pulses, approximately 10 volts high and 25 microseconds long. The average rate of these pulses is determined by the gamma ray signal conditioning circuitry which provides the recorder circuit input with a DC signal proportional to this rate. Ranging is accomplished at the recorder input by attenuation of the signal. Averaging time is adjustable by means of the time constant switch.

A gamma ray sonde is used to record the gamma log. This sonde has its own built-in batteries. It contains a scintillation detection crystal. When the crystal is subjected to small amounts of gamma radiation from the formations, a current is produced. The magnitude of this current is directly proportional to the intensity of the gamma radiation that penetrates the crystal from the surrounding layers. This minute current is amplified and transmitted up the logging cable to the recorder. Here, through additional amplifiers and sensitivity controls, the variable intensity of the current is graphed by a pen-type recorder on a moving strip of paper. This is the gamma ray curve of the radioactivity well log.

Field Procedure

The first month or so was spent in familiarization of the Geophysical personnel with the operation and use of the Neltronic logger and how to best fit the logging procedure into the sampling procedures of the Soils Exploration Unit of the Materials Section. Once the Geophysical personnel became familiar with the use of the equipment, logs were gathered from different parts of the state.

The actual logging procedure was one of observation and the physical taking of the logs. As the Soils Exploration Unit went through its sampling procedure, personnel from the Geophysical Unit would be on hand to observe the samples brought out of the hole. The driller's log book was also read to get a general picture of the foundation profile according to the driller. After the Soils Exploration drilling rigs were moved from over the hole, Geophysical personnel would then set up the Neltronic logging equipment.

The first step was to position a tripod over the hole to run the cable down the hole. After the electric logging sonde or probe was attached to the armored electric cable and the probe was lowered to the bottom of the drill hole, the depth was noted. Both the self potential log and resistivity log were recorded on the same trip up the hole accomplished manually by a hand crank. A "ground" was produced by running a second electrode to a shallow surface hole filled with water. The function switch was placed in the electric position and the millivolt (MV) and ohmmeter (Ohm/m) range switches were set for the proper sensitivity of the self potential log and resistivity log respectively. Sometimes, several electric logs had to be run at different sensitivity settings to keep the recording pens on scale. One sensitivity setting might be on scale in clay, but the pens would run off scale when sand was encountered; therefore, another setting was needed to keep the pens on scale for the entire trip up the hole. The log was produced on the upward trip only. After a satisfactory set of self potential and resistivity logs was produced for the hole, the function switch was turned off, and the electric log probe was removed.

The gamma ray logging sonde was attached to the cable and lowered to the bottom of the hole, and the depth noted. The function switch was placed in the gamma position, the CPS (cycles per second) sensitivity range was set, and the TC (time constant) was also set. The gamma ray probe was also manually cranked up the hole at a slightly slower rate than the electric log sonde because gamma ray radiation was not steady, but passed from a maximum to a minimum value in regular sequence. Gamma ray logging was conducted at a rate slow enough to record the "average" rate of emission of gamma rays from each bed or stratum in the bore hole. Any gamma rays which were recorded came from the formations within a few inches of the walls of the bore hole; therefore, this curve was considered a shallow inspection of the strata through which it was run. After a satisfactory gamma log was taken, the function switch was turned off, and the logging operation was completed.

Records of the state project numbers, log numbers, types of logs (electric or gamma), dates, station numbers and locations, and the depths reached by the logging probe were kept in a field book. A record was also kept as to the sensitivity settings on each log run. Any other pertinent information such as the distance of water level in the bore hole, amount of casing in the hole, etc., was also recorded in the field book.

DISCUSSION OF RESULTS

Electric Logging

The first portion of the analysis of the data is taken up with the electric logs; a discussion of the gamma ray logs follows:

It should be recalled that we had intended to use a statistical analysis to correlate our log values on the self potential and resistivity curves to determine engineering parameters of the soils encountered. These engineering parameters included such things as soil type, density, shear strength, plastic limit, liquid limit, etc. A regression analysis of the importance of each of these engineering parameters to the electrical values was to be attempted. In an attempt to fulfill this requirement, a total of 175 logs were run on 39 holes in 13 different locations. Only example logs are included in the text, and only the useable or most representative logs are presented in the appendix

An inherent problem in the logging system was that it was not possible to define a finite value for the resistivity and self potential curves. Due to different conditions in the bore hole, the sensitivity controls had to be set differently for each hole. One sensitivity setting, say 10 MV and 20 Ohms, might have been on scale for one hole, but the same setting was off scale in another hole in the same area. The second hole might have required sensitivity settings of

20 MV and 50 Ohms in order to keep the pens on scale. This situation was encountered on several different bore holes in the same general area. When a good "on scale" log was produced, it was not possible to tell where a finite base line value would be on the resistivity or self potential curves. The sensitivity setting might be set on 20 Ohms, but it was not possible to establish where the 20 Ohms base line crossed the resistivity curve. The same problem held true for the self potential curve. Because it was not possible to establish what the electrical values for the curves represented as numbers, a statistical analysis could not be run on the curves.

Through visual interpretations of the electric logs, it was possible to determine some of the conditions encountered in the bore holes. Where there was a definite break between a fine grained material and a granular material, the electric logs picked up this break well.

On the log shown as Figure 4, there is a definite break, near 30 feet, from a granular material in the bottom of the hole to fine grained material in the top 30 feet. The resistivity curves moves to the left and stays fairly straight from around 30 feet to the surface. Below 30 feet is a sandy material, and above is a clayey material.

Figure 5 shows a granular material from 85 feet up to 74 feet, then a fine grained clayey layer from 74 feet to 68 feet, back to granular material from 68 feet up to 50 feet, and finally back into a fine grained material in the top 50 feet. A organic layer shows around 24 feet, where the SP curve increases and the

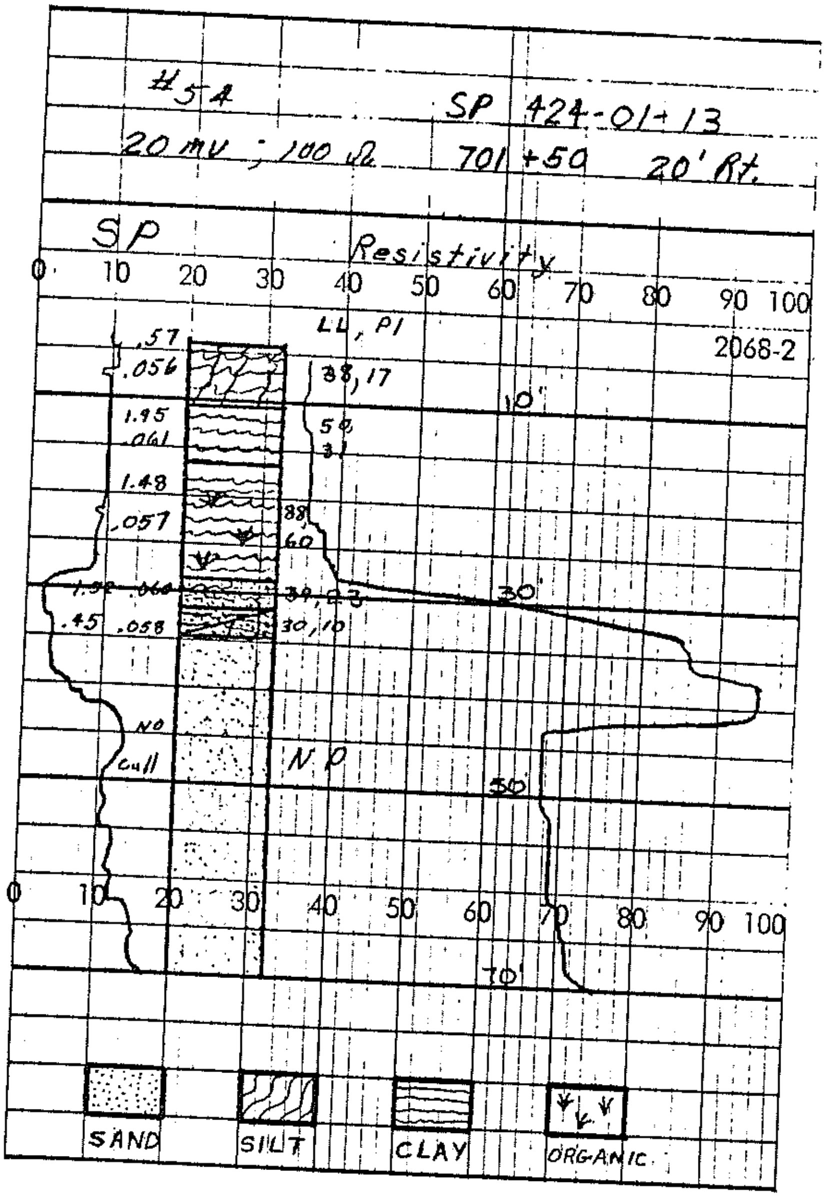

FIGURE 4: Electric Log - State Project Number 424-01-13

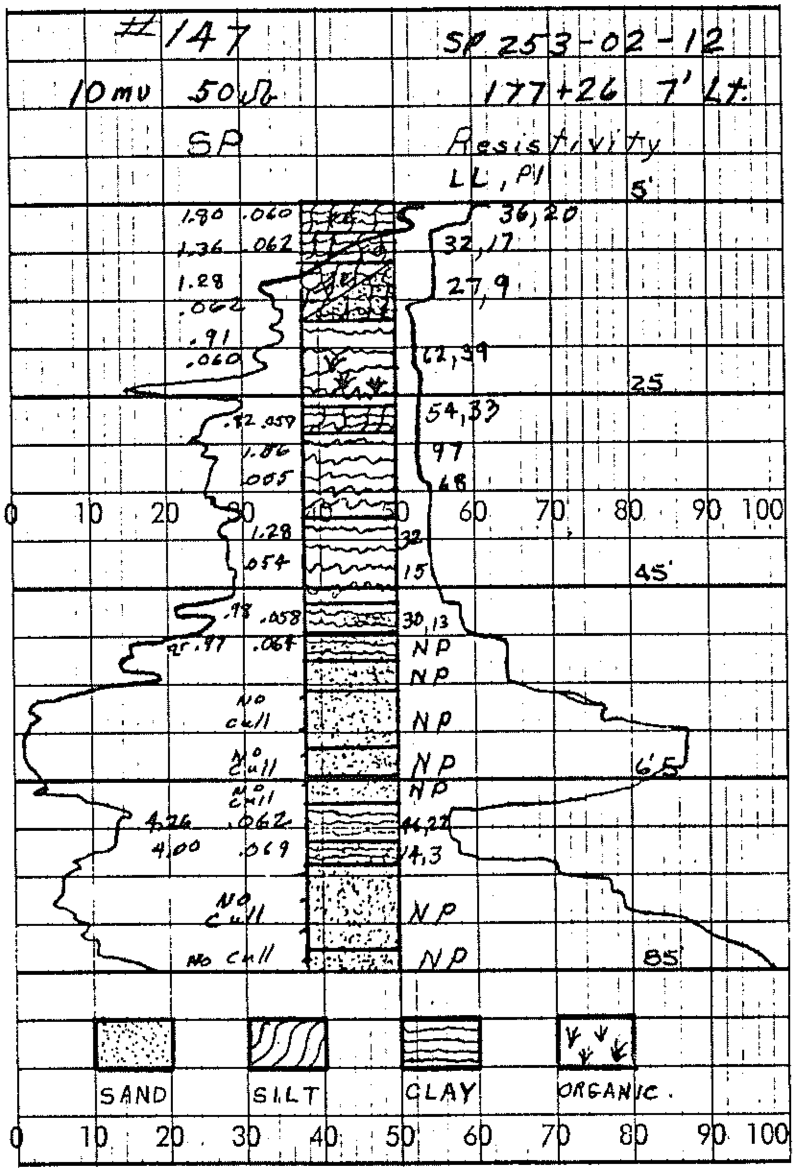

FIGURE 5: Electric Log - State Project Number 253-02-12

resistivity curve decreases. Granular materials generally show when the resistivity increases and the SP also increases. Fine grained materials show as both resistivity and SP curves decrease.

Figure 6 shows a clayey layer (the sampling crew apparently missed in their field description). This layer shows up well on the resistivity and self potential curves at the 50 foot level. Another clayey layer is around 41 feet.

Gamma Ray Logging

The gamma ray logs showed little when a correlation between the log and the driller's log was attempted. Figure 7 is an example of a gamma ray log alongside the driller's log data. In sandy material at the bottom of the hole, the gamma ray log generally stays to the left, then moves to the right at 75 - 67 feet in a clayey layer and back to the left above 67 feet in sand. Around 50 feet the soil turns into a plastic material and remains plastic to the top, but no correlation with these parameters was found. The gamma ray curve did not show a definite soil change break boundry, but gradually changed from one to the other and was very difficult to interpret because of this gradual change. Therefore, little could be made of the gamma curves.

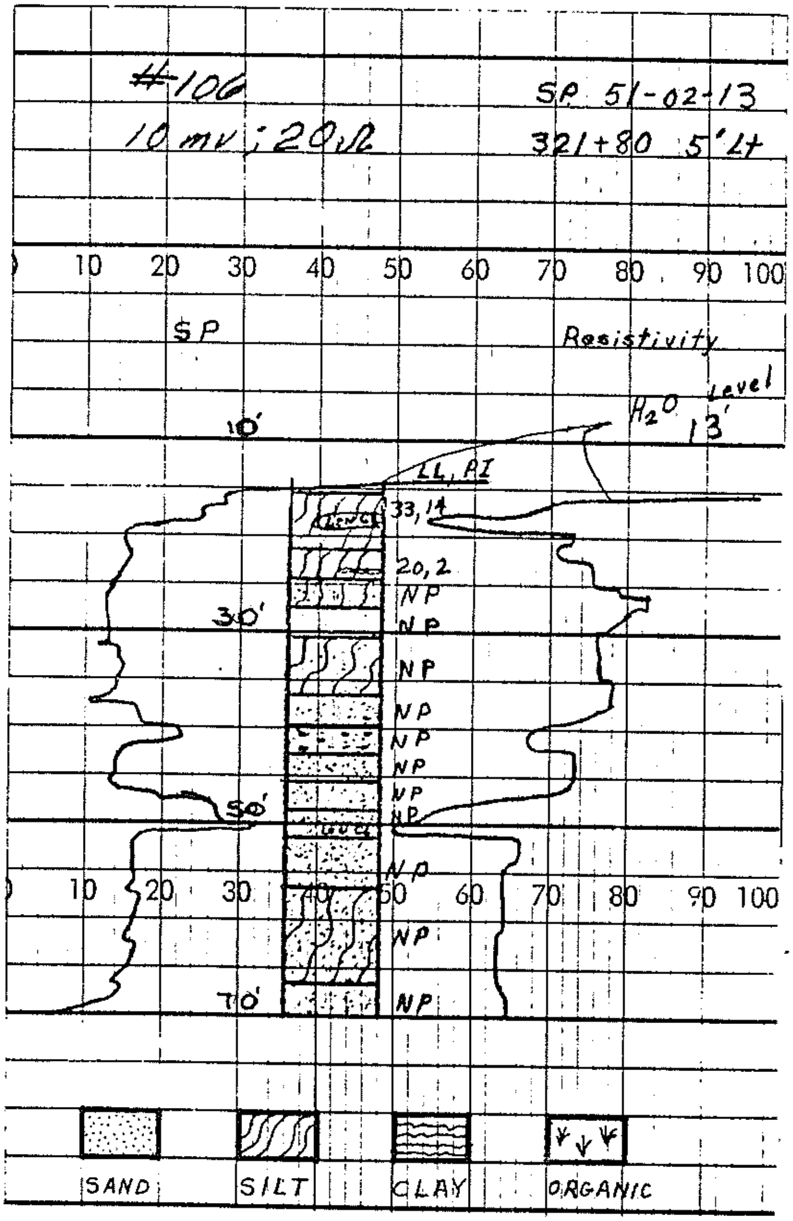

FIGURE 6: Electric Log - State Project Number 51-02-13

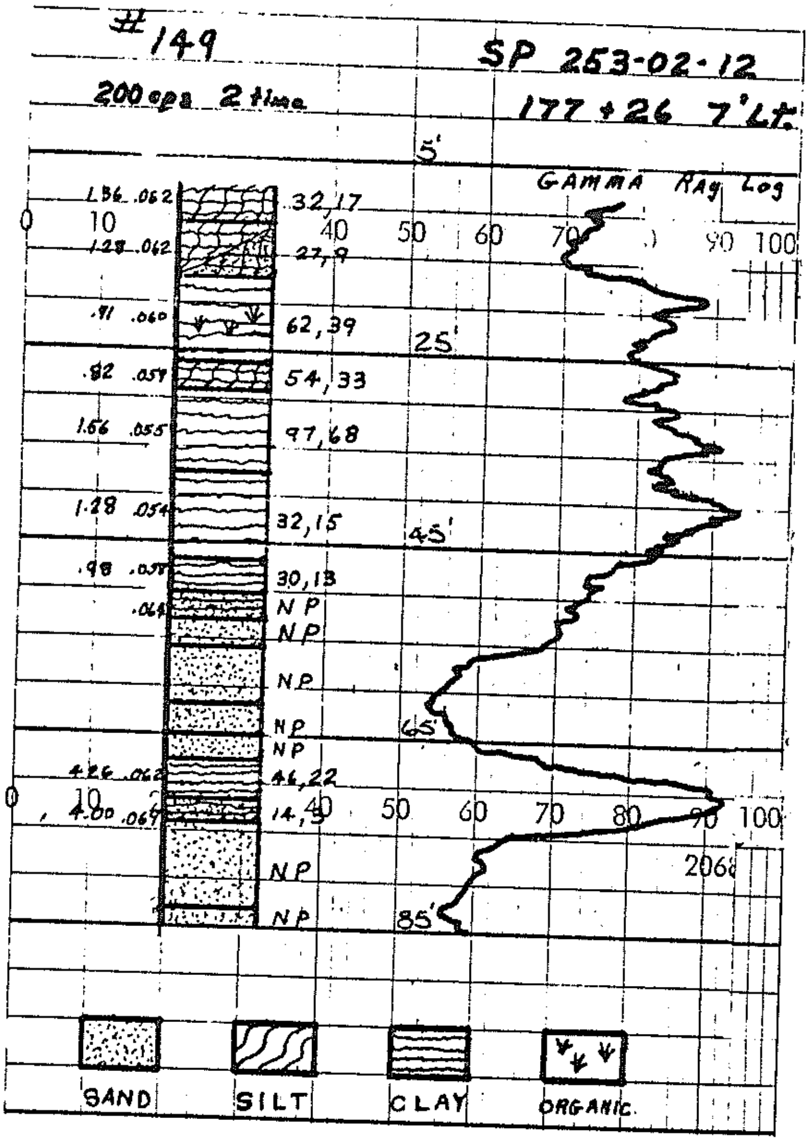

FIGURE 7: Gamma Ray Log - State Project Number 253-02-12

CONCLUSION

As a whole, the electric logs and gamma ray logs do not seem to be of satisfactory use in defining engineering parameters for highway work. Since it was not possible to establish what the electrical values of the self potential cuves and resistivity curves were, no correlation could be made with engineering parameters such as density, shear strength, plastic limit, liquid limit, etc. However, through a visual interpretation of the resistivity and self potential curves, an idea of general soil types encountered, depths, and thicknesses of soil formations could be formed.

Many times here in Louisiana it is necessary to search for non-plastic or low plasticity select materials on the bottoms of bodies of water. This logging system could be used instead of the continuous sampling procedure with rotary rigs now used. The system would only require a hole and would do away with the innumerable round trips up and down the bore hole to continuously sample the materials encountered. Electric logging could also be used as a comparative tool to assist in better physical sampling or logging of a sampled drill hole. Using the electric log would enable the Materials Section to pick a more representative sample of each strata to be tested for engineering parameters. Rather than just picking a sample which visually appears to be an average sample core, the self potential and resistivity curves should be interpreted to select a depth for the most truly representative sample of the strata under investigation.

RECOMMENDATIONS

In spite of the shortcomings of these devices with respect to identification of engineering parameters, it is recommended that electric logs be run on each boring location after completion of drilling. The device is relatively easy to operate and consumes only a short time, particularly after the operator becomes familiar with the unit. Its cost is less than $1,000 without the gamma ray detection tool. Gamma ray logging is not recommended.

Examples of the information to be gained are presented below:

1. Electric logs added to the standard boring sheets as a part of the boring log itself in a manner such as has been presented herein with the SP curve to the left of the boring diagram and the resistivity curve to the right will balance the value reporting system. 2. Continuity of beds across the construction project shows up well. Often thin layers of material are missed by the drilling crews, but these will normally show up on electric logs. 3. Additionally, SP and resistivity traces can point out thinly laminated formations that are normally identified by laboratory tests as intermediate mixtures of the textural types. "Varved clays" are principal examples found in Louisiana's subsurface. These are old lake bed deposits made up of thin layers (1/4" to 1/2" thick) of light colored silts interbedded with slightly thicker laminations of clay, the two combining to form a strata several feet thick. These beds are difficult to distinguish using laboratory tests for it is simply impractical, if not impossible,

to test the two materials separately. As a result, the driller's log is refuted by the test data, and the engineer has to guess which is right. With the use of electric logging, additional supporting data will be supplied.

This type of information becomes especially valuable when a foundation cross section is necessary. For instance, varved clays along with other more granular soils serve as drainage layers during consolidation. Correlation of layers between drill holes must certainly be enhanced with electric logging.

4. Finally, as more experience is gained with logging more information will become evident from the curves. Location of the water table may be determined in certain geographic locations, a unit weight range may become more perceivable with usage, and even an idea of porosity may be interpreted with intelligent study after a period of time.

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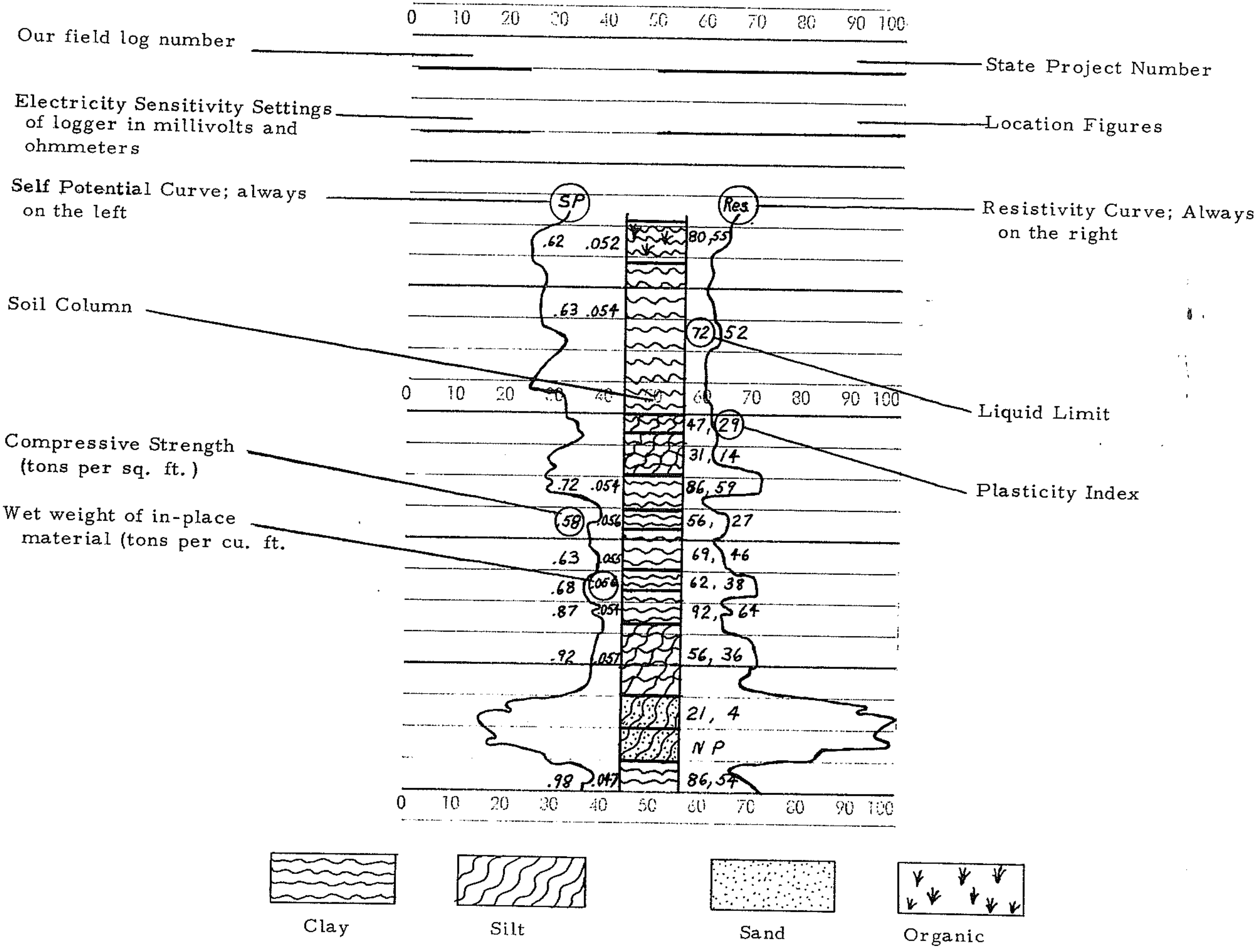
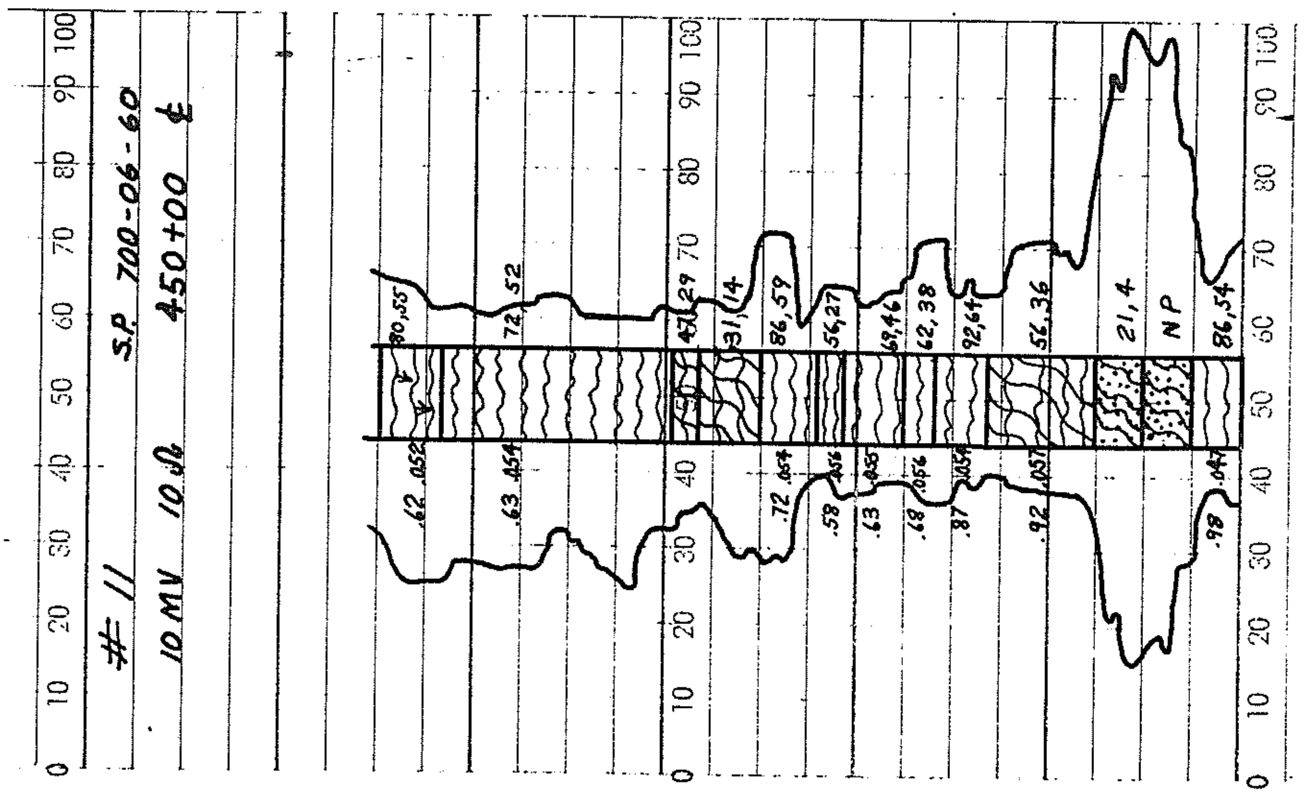
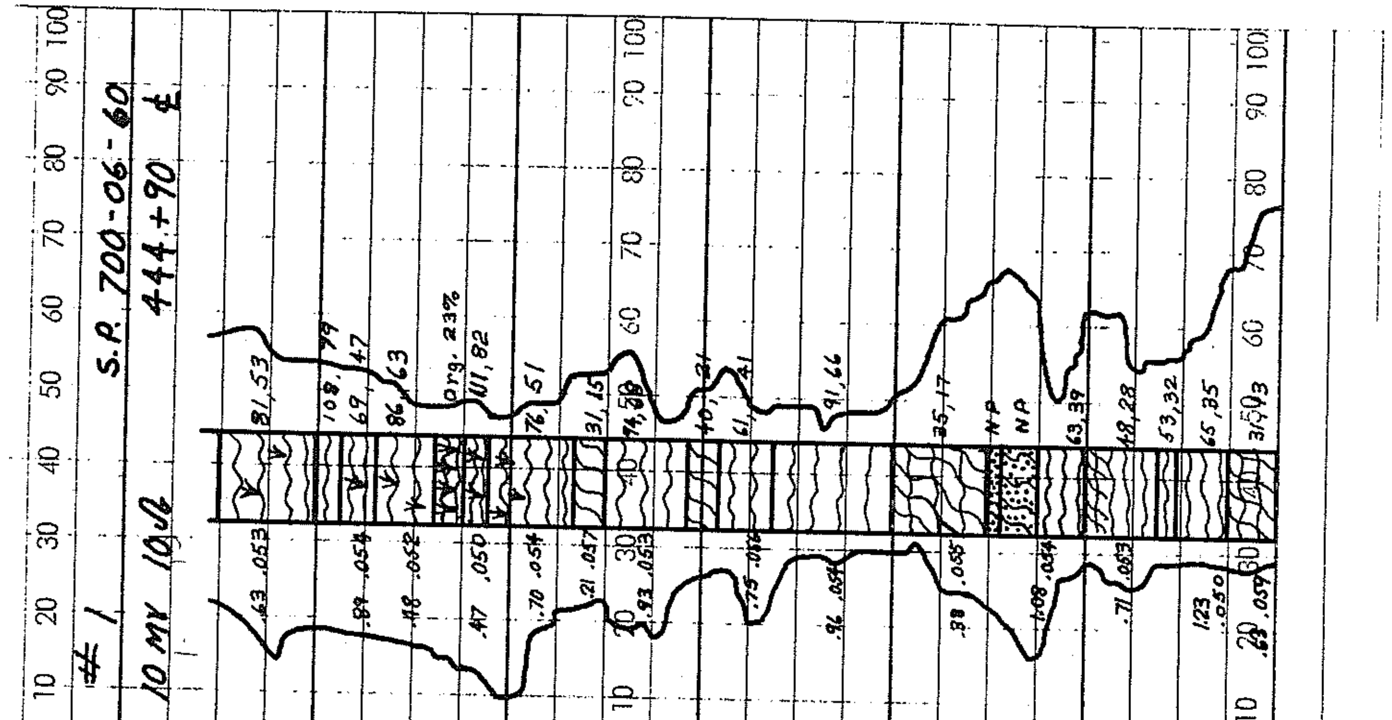
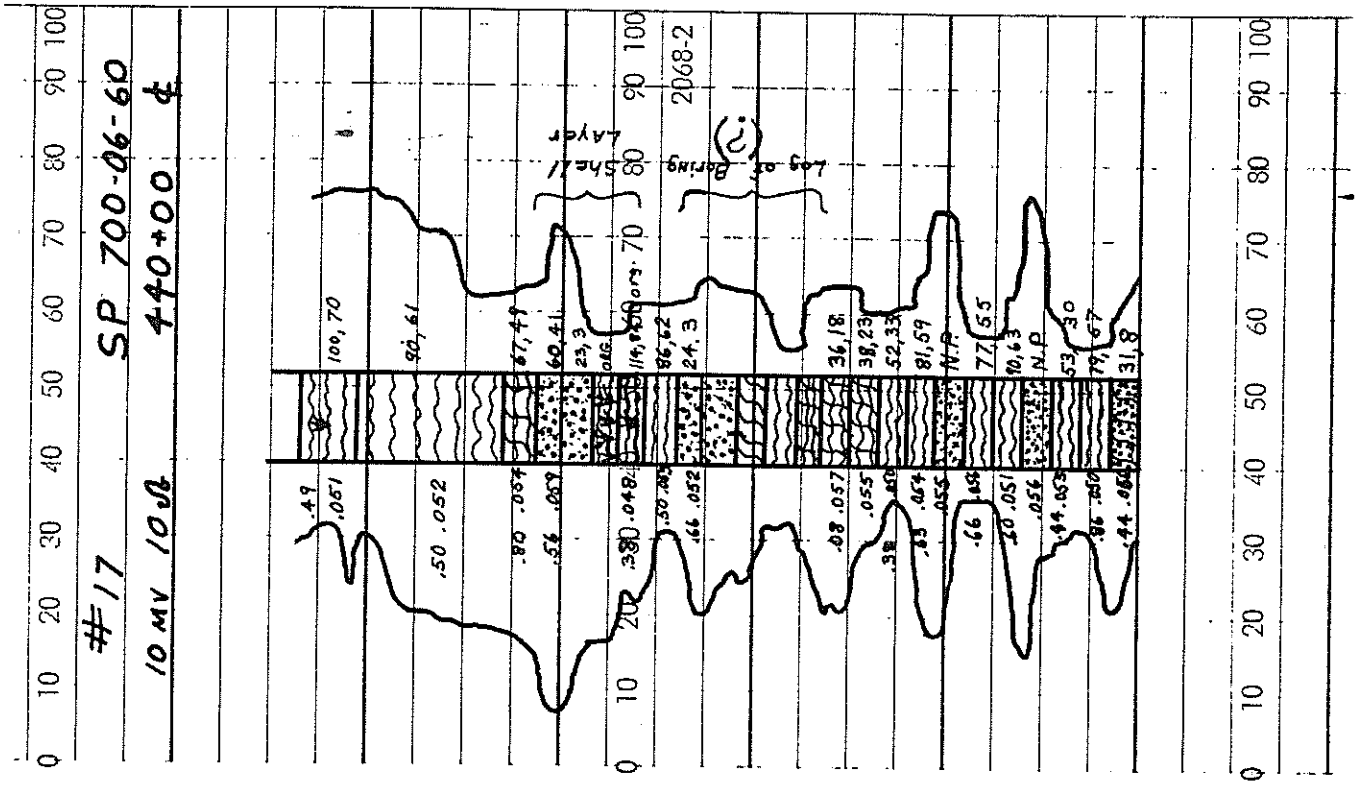
APPENDIX

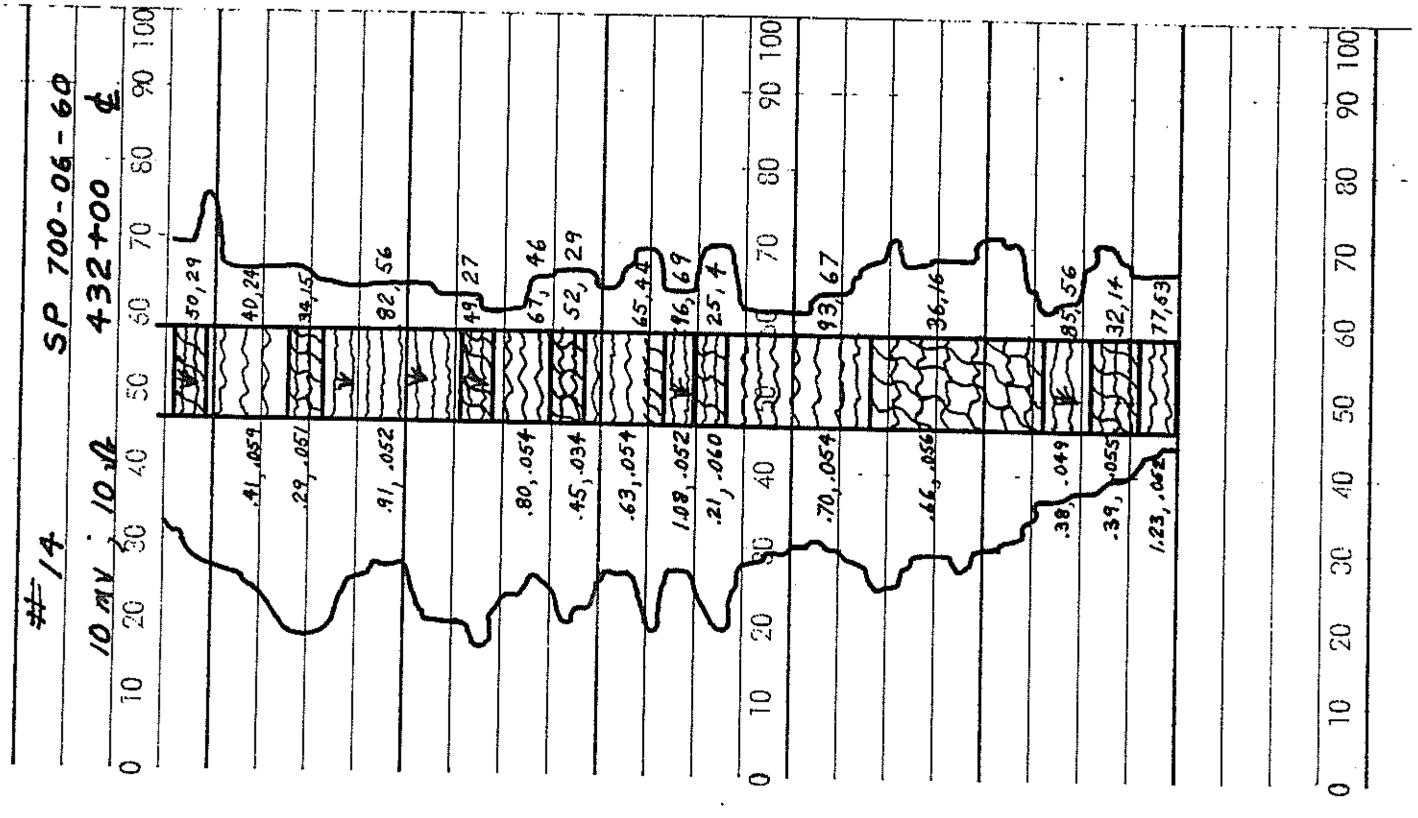


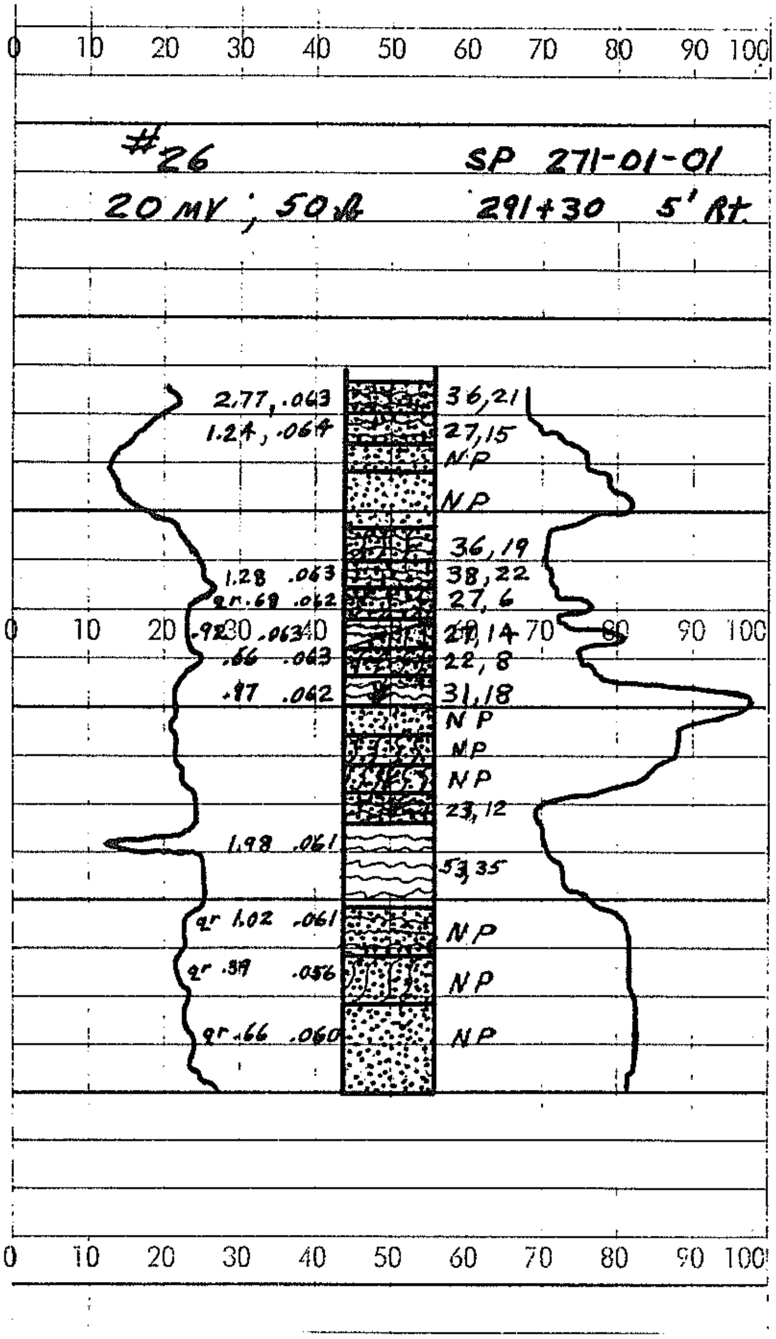
TYPICAL LEGEND SHOWING INFORMATION CONTAINED ON LOGS

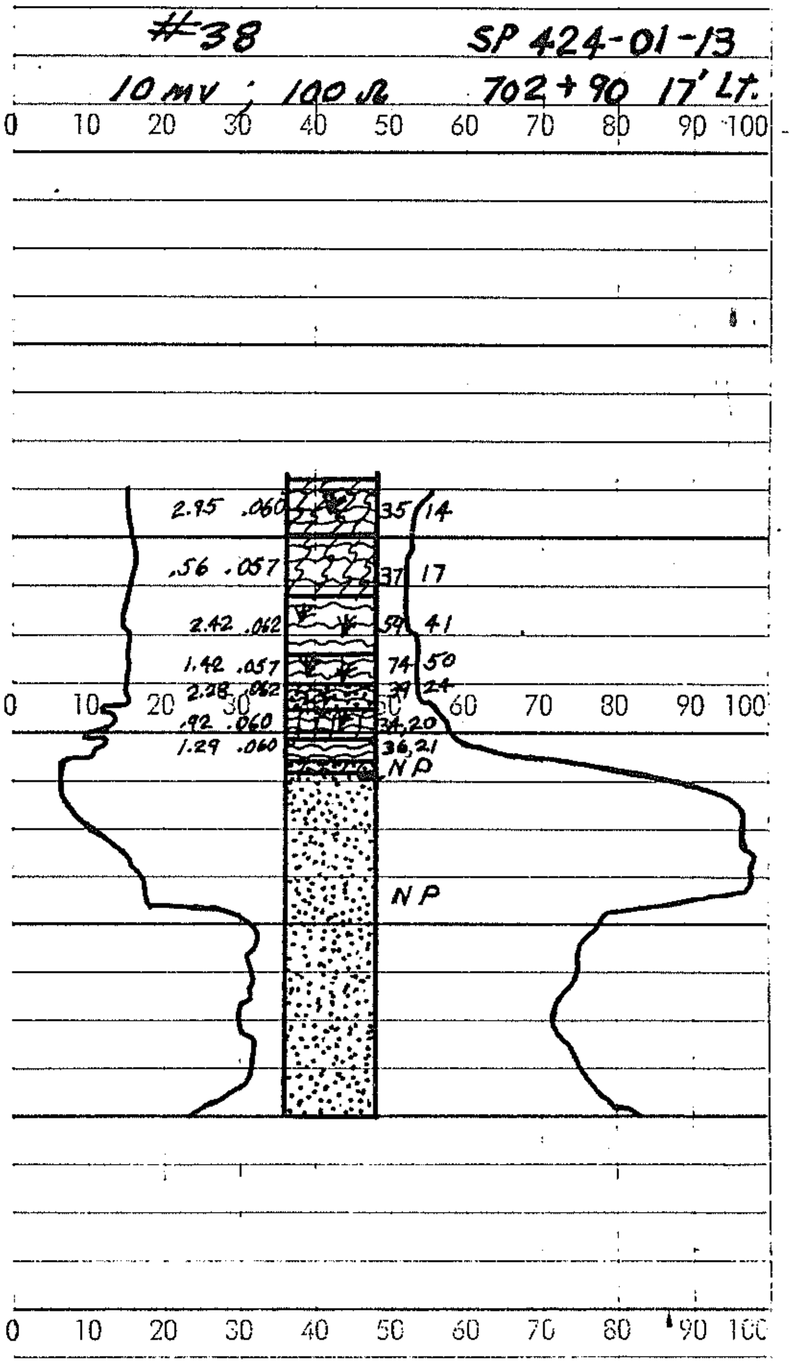

#11
10 MV 10Ω
S.P. 700-06-60
450+00 ℄
0 10 20 30 40 50 60 70 80 90 100
NP

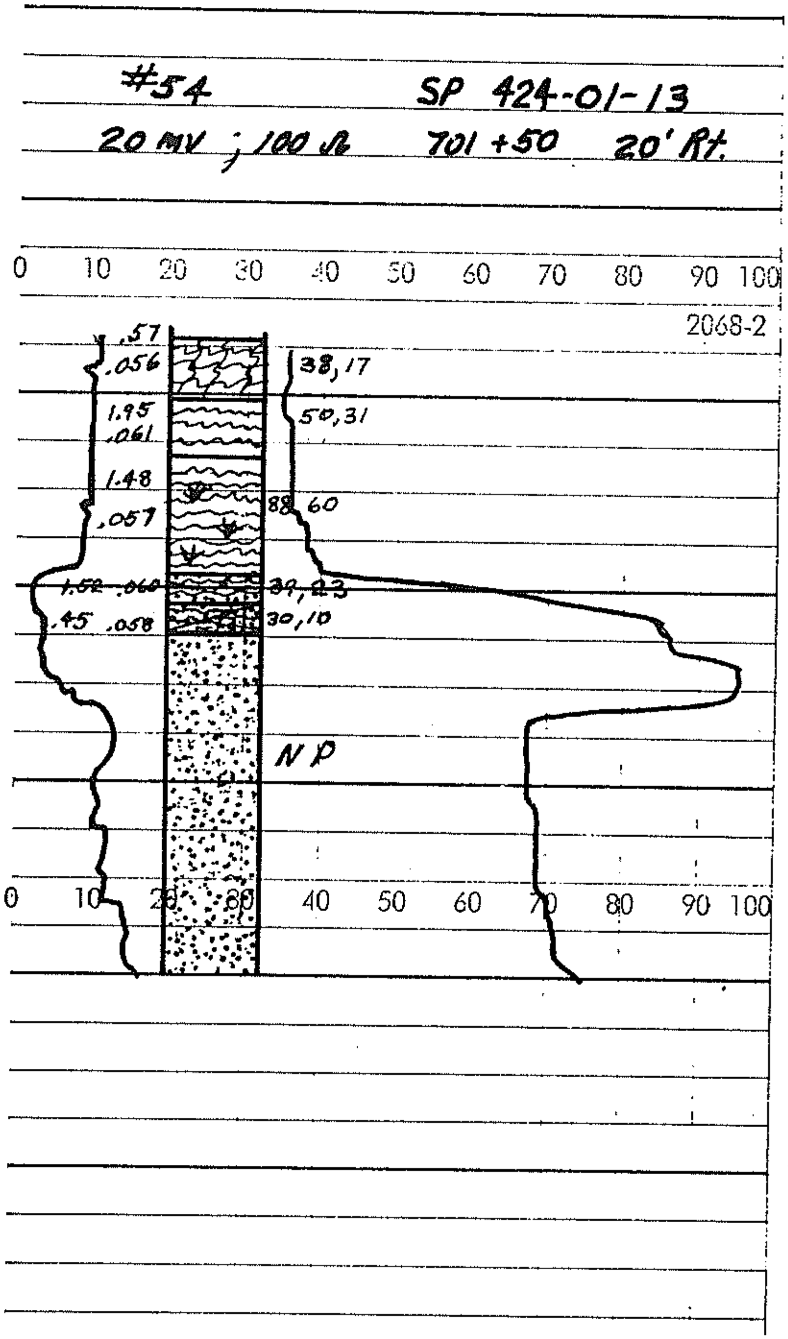

#1
10 MV 10Ω
S.P. 700-06-60
444+90 ℄
0 10 20 30 40 50 60 70 80 90 100
org. 23%
NP
NP

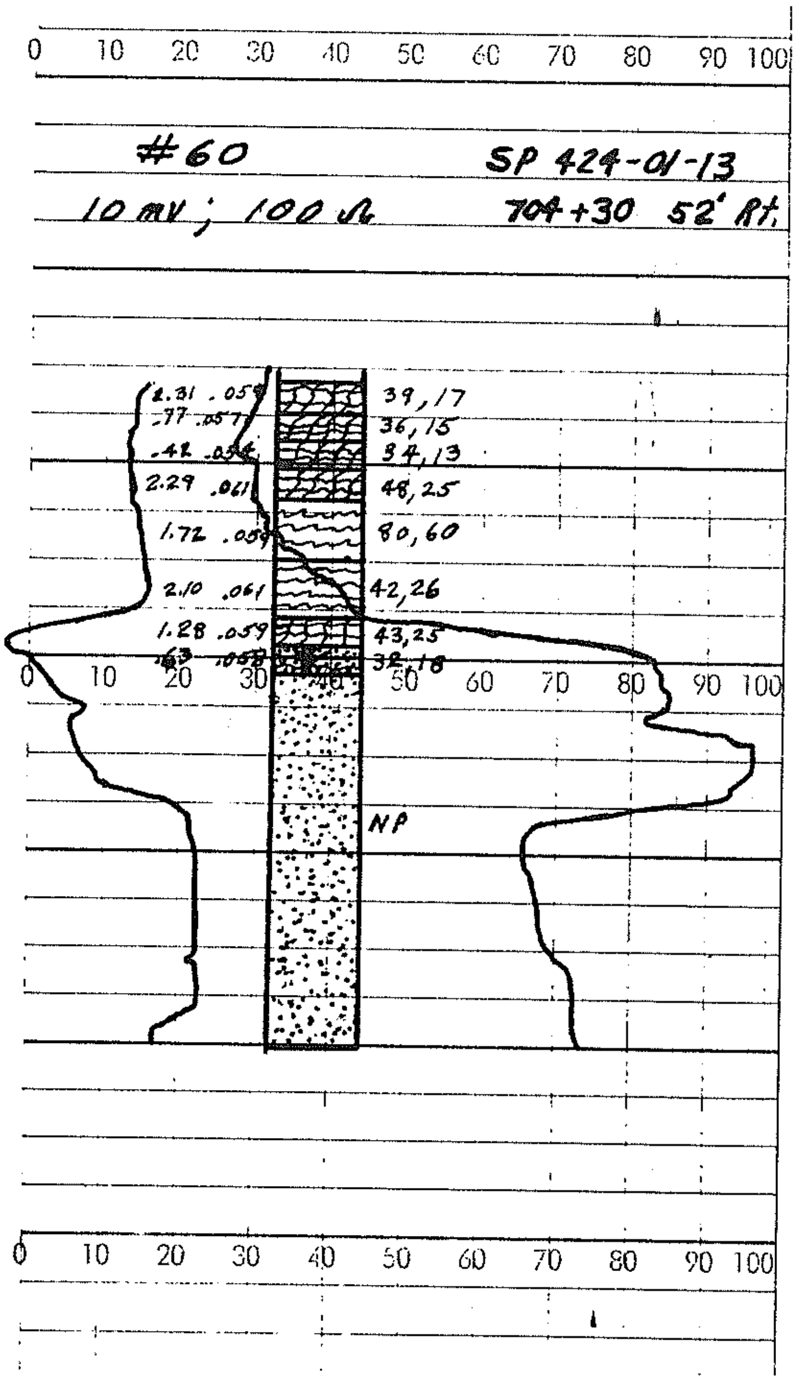

#17
10 MV 10 Ω
SP 700-06-60
440+00 ℄
2068-2
Shell Layer
Log of Boring (?)
0 10 20 30 40 50 60 70 80 90 100

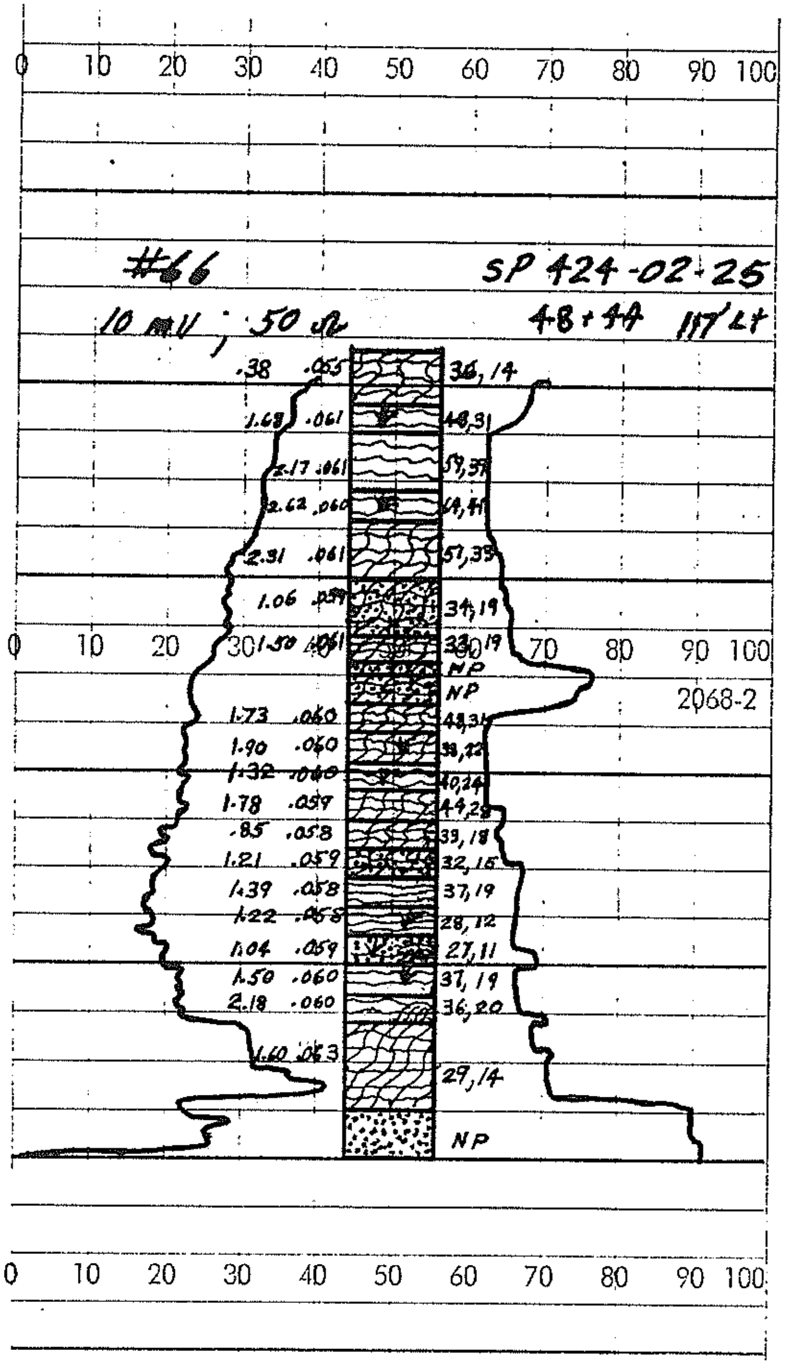

#14
10 MV 10 Ω
SP 700-06-60
432+00 ℄
0 10 20 30 40 50 60 70 80 90 100

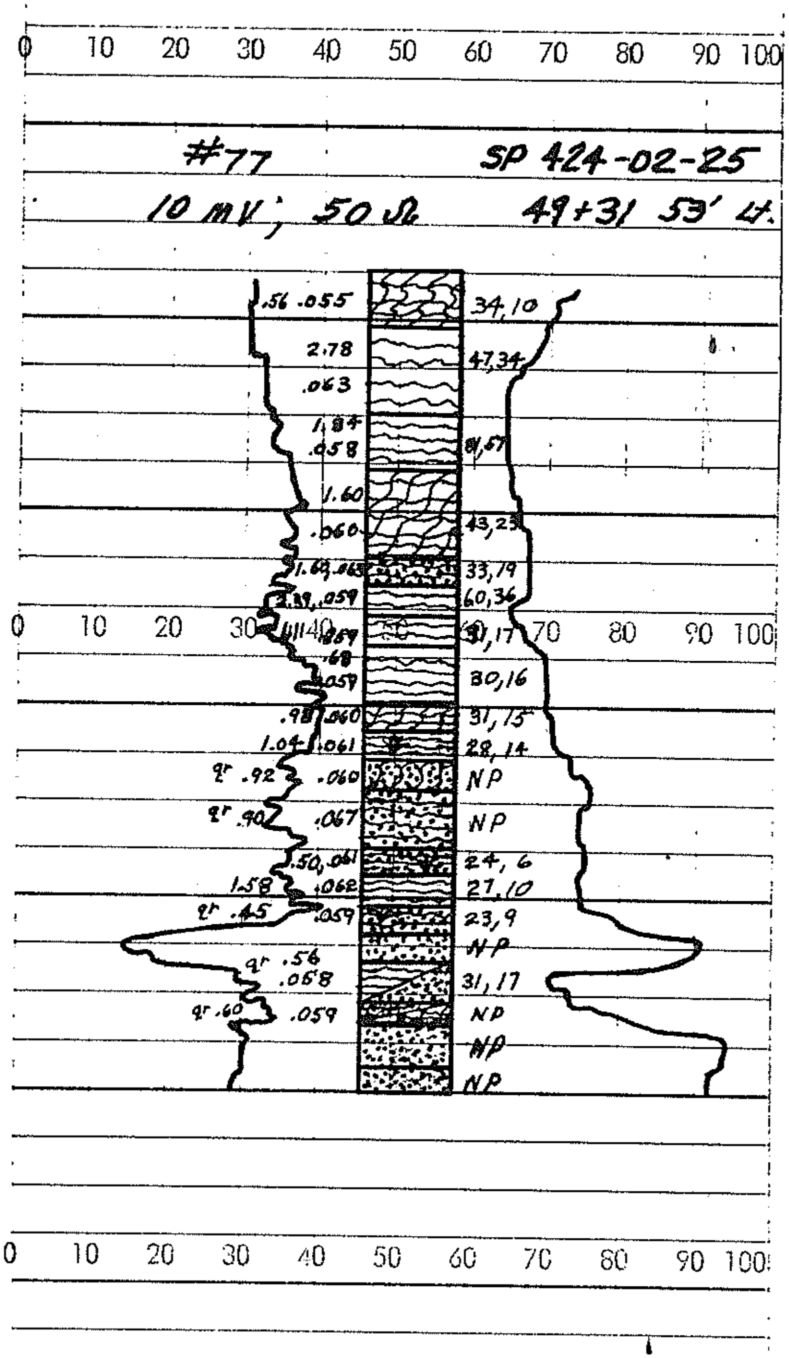

#26
SP 271-01-01
20 MV ; 50Ω
291+30 5' Rt.
0 10 20 30 40 50 60 70 80 90 100
2.77, .063
36,21
1.24, .064
27,15
NP
NP
36,19
1.28 .063
38,22
gr .69 .062
27,6
.92 .063
29,14
.66 .063
22,8
.97 .062
31,18
NP
NP
NP
23,12
1.98 .061
53,35
gr 1.02 .061
NP
gr .59 .056
NP
gr .66 .060
NP

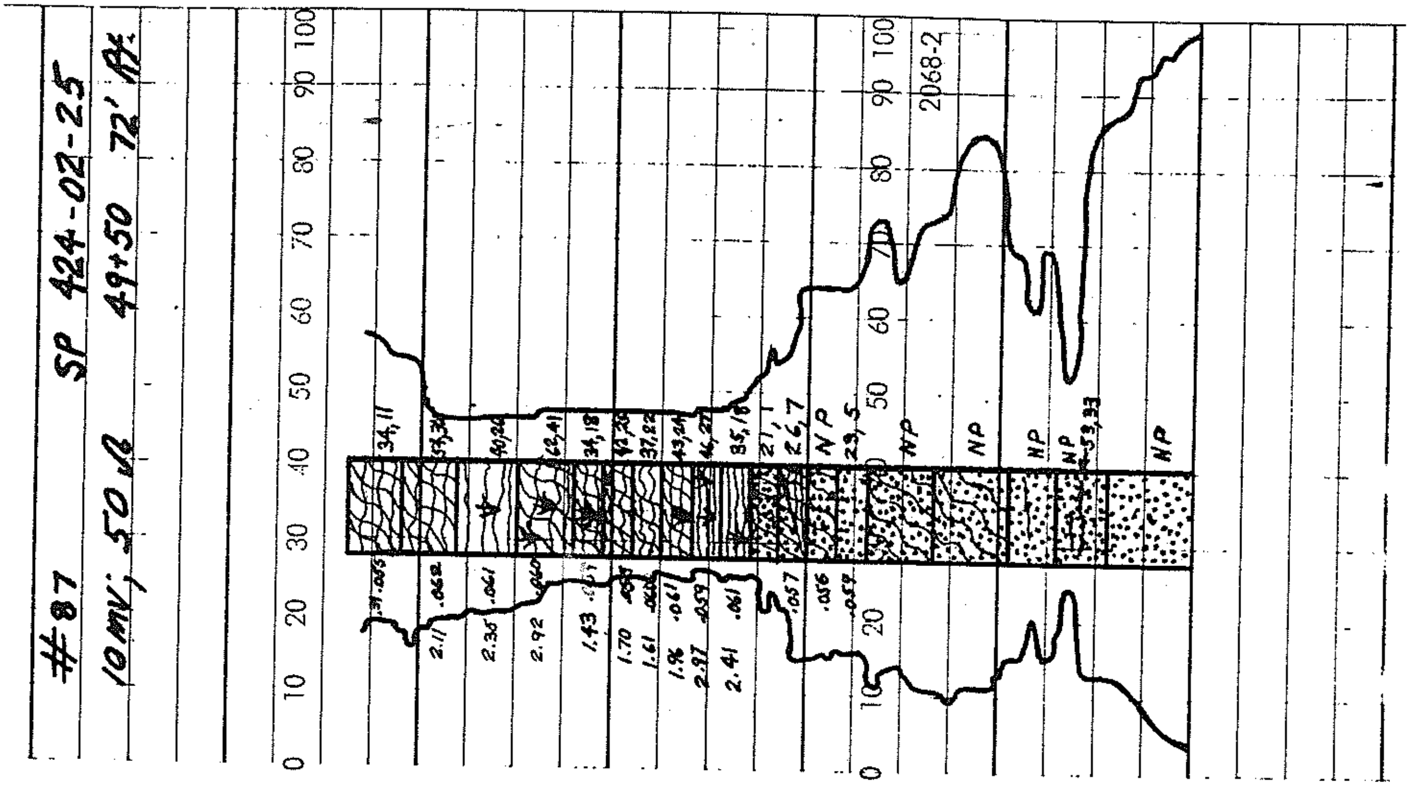

#38
SP 424-01-13
10 MV ; 100Ω
702+90 17' Lt.
0 10 20 30 40 50 60 70 80 90 100
2.95 .060
35 14
.56 .057
37 17
2.42 .062
59 41
1.42 .057
74 50
2.28 .062
39 24
.92 .060
34,20
1.29 .060
36,21
NP
NP

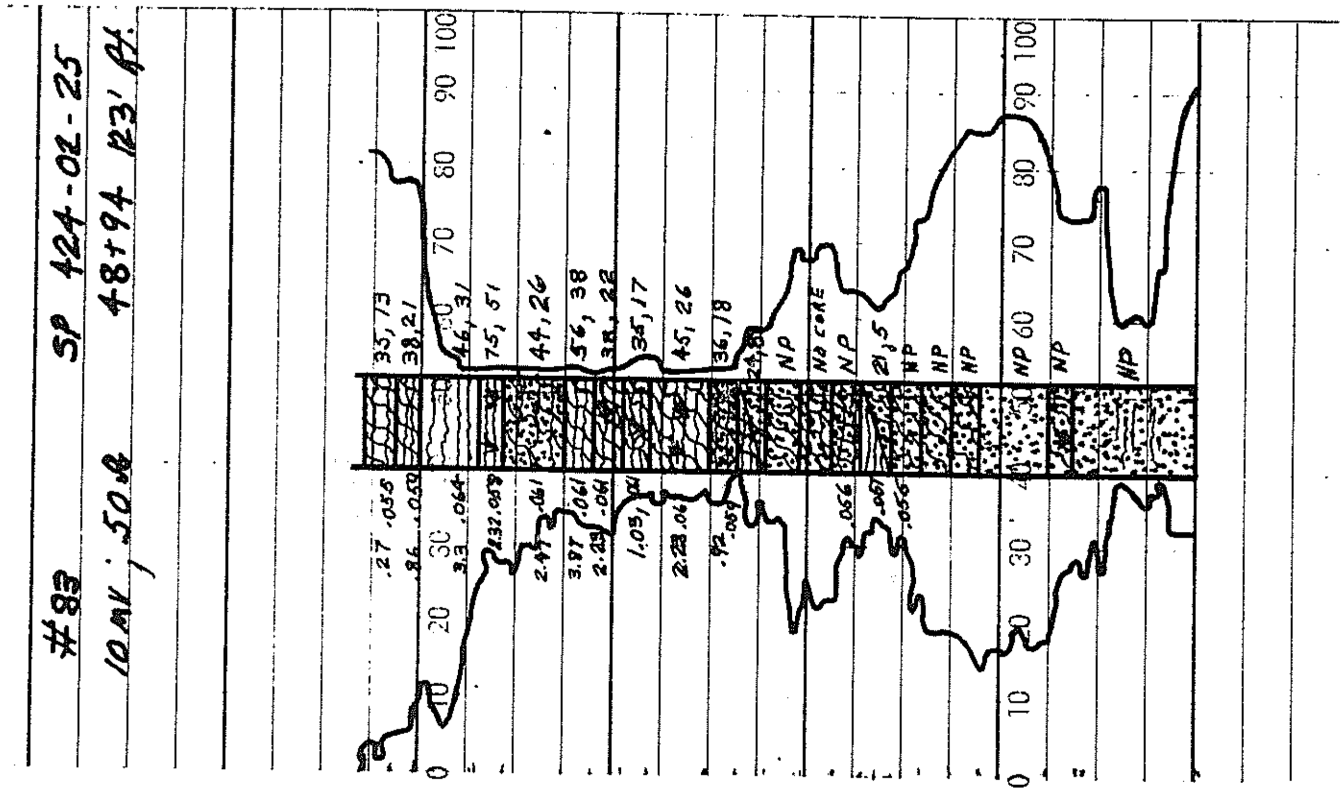

#54
SP 424-01-13
20 mv ; 100 Ω
701 +50
20' Rt.
0 10 20 30 40 50 60 70 80 90 100
2068-2
.57
.056
38,17
1.95
.061
50,31
1.48
.057
88 60
1.52 .060
39,23
.45 .058
30,10
NP
0 10 20 30 40 50 60 70 80 90 100

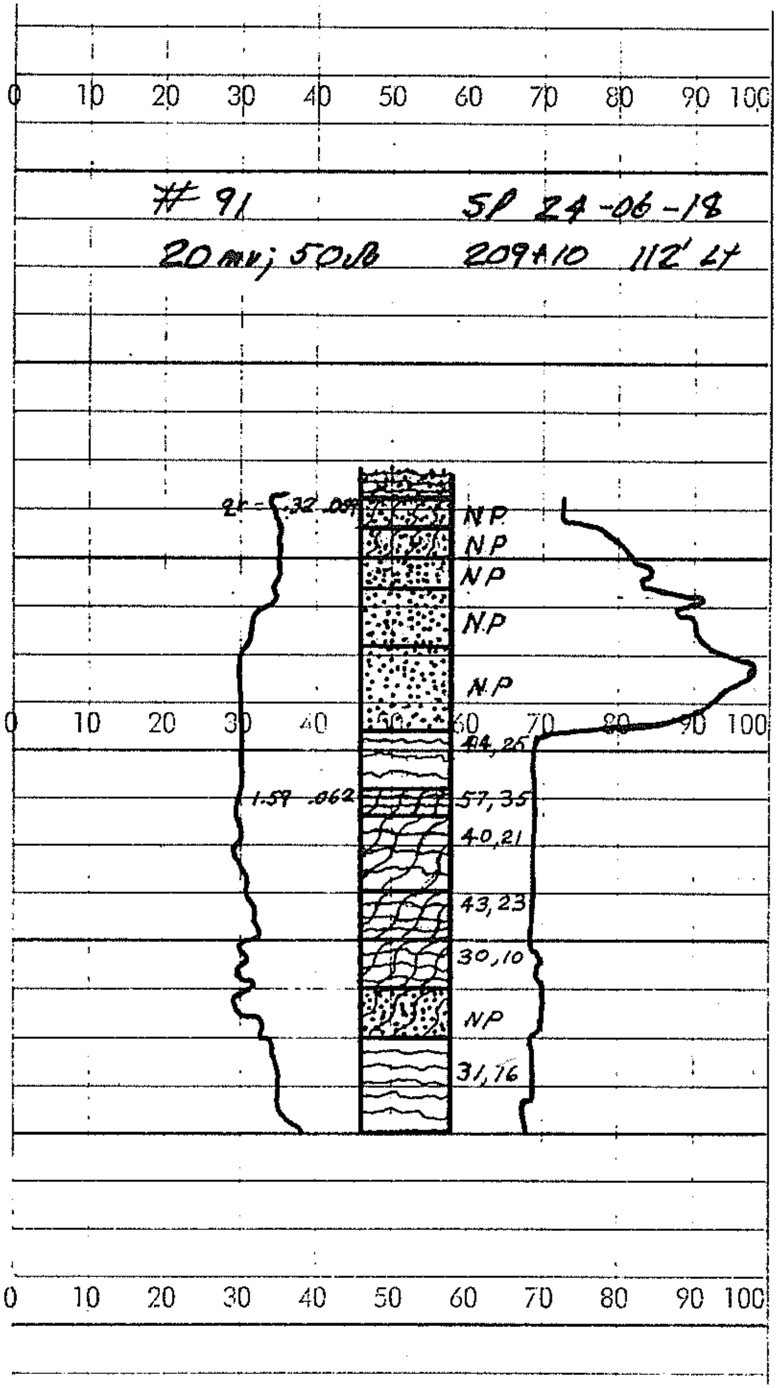

0 10 20 30 40 50 60 70 80 90 100
#60
SP 424-01-13
10 mv ; 100 Ω
704+30
52' Rt.
2.31 .059
39,17
.77 .057
36,15
.42 .056
34,13
2.29 .061
48,25
1.72 .059
80,60
2.10 .061
42,26
1.28 .059
43,25
.63 .058
32,18
0 10 20 30 40 50 60 70 80 90 100
NP
0 10 20 30 40 50 60 70 80 90 100

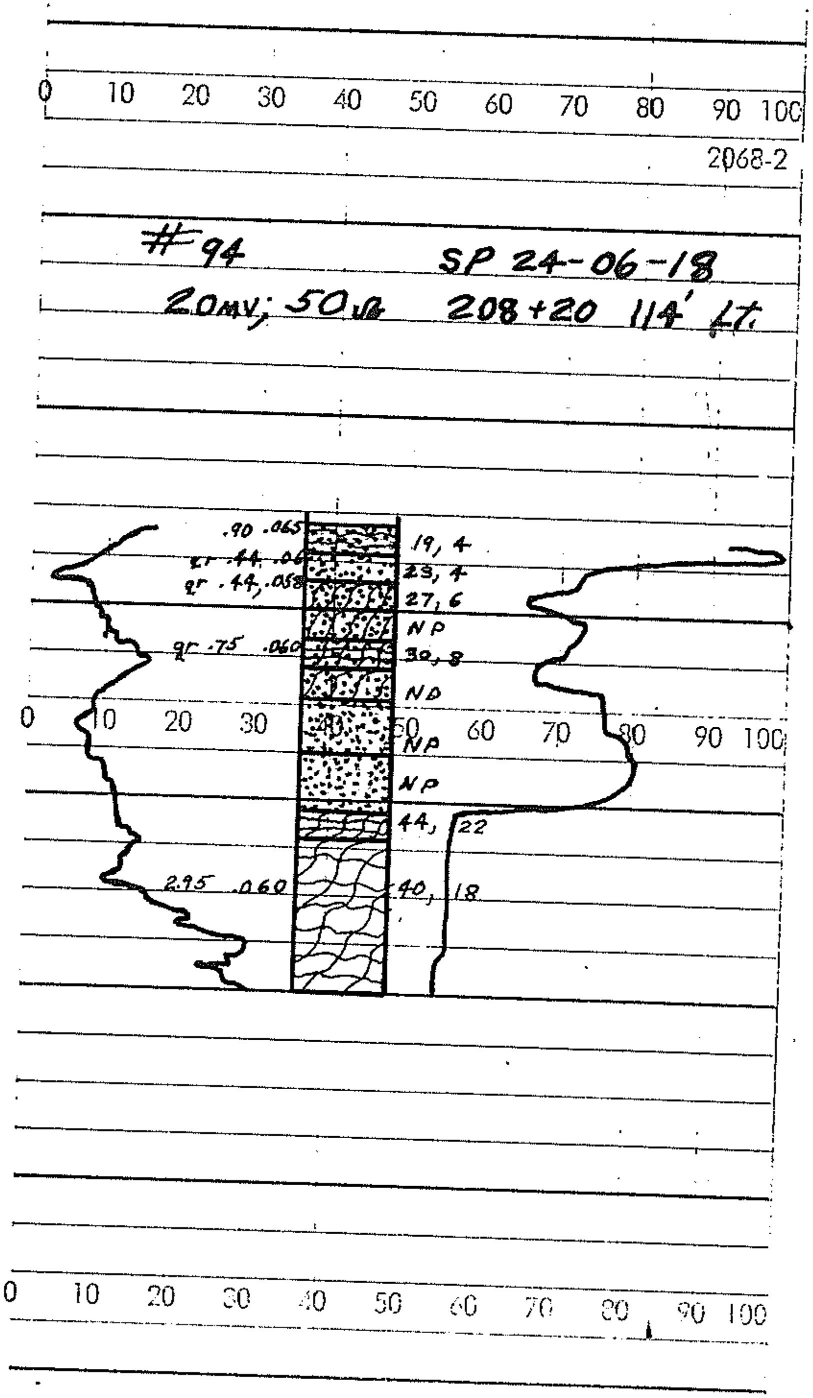

0 10 20 30 40 50 60 70 80 90 100
#66
SP 424-02-25
10 mV; 50 Ω
48+44 117' Lt
.38 .055 36,14
1.68 .061 48,31
2.17 .061 59,57
2.62 .060 58,41
2.31 .061 57,35
1.06 .059 34,19
1.50 .061 33,19
NP
NP
2068-2
1.73 .060 48,31
1.90 .060 38,22
1.32 .060 40,24
1.78 .059 44,28
.85 .058 39,18
1.21 .059 32,15
1.39 .058 37,19
1.22 .058 28,12
1.04 .059 27,11
1.50 .060 37,19
2.18 .060 36,20
1.60 .053
29,14
NP

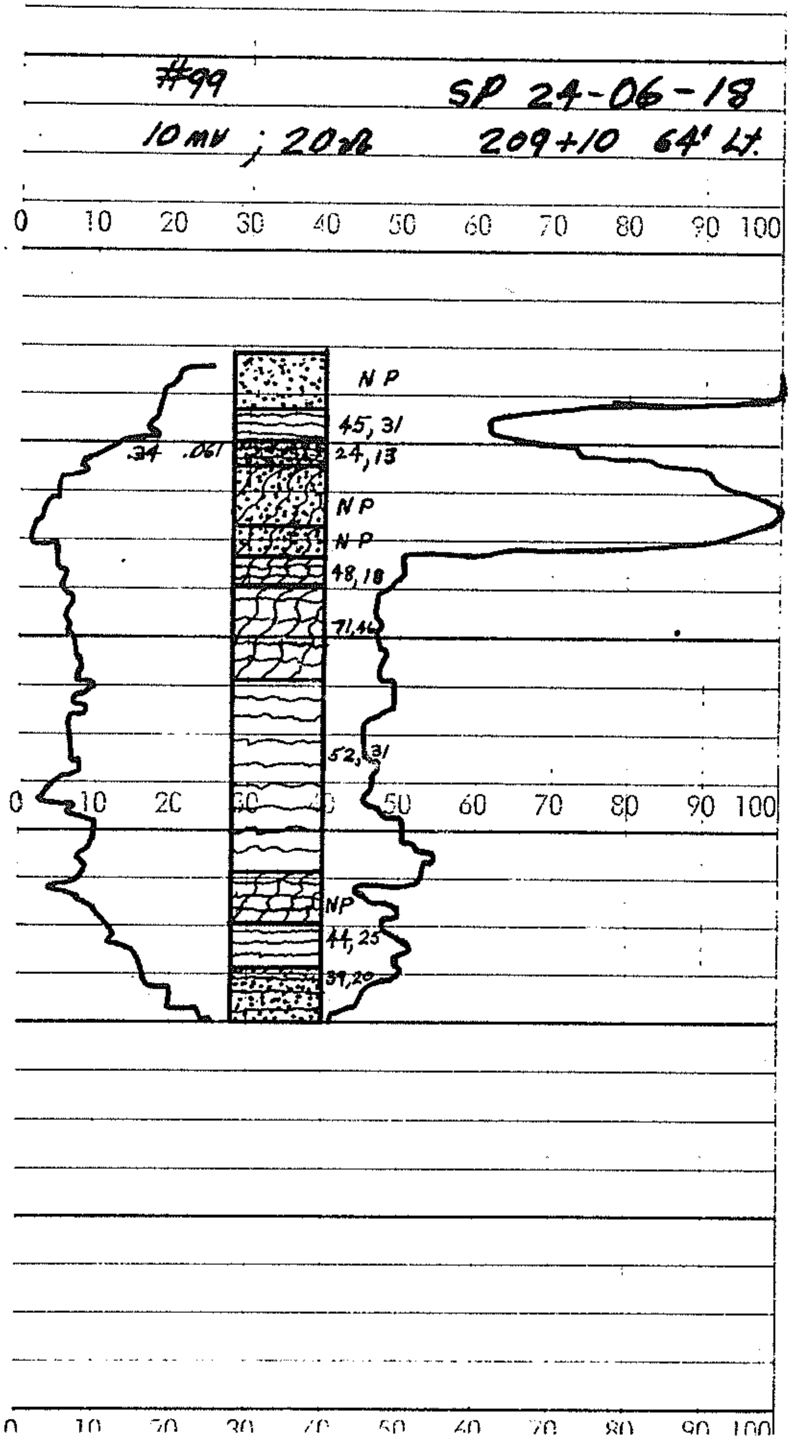

0 10 20 30 40 50 60 70 80 90 100
#77
SP 424-02-25
10 mV; 50 Ω
49+31 53' Lt.
.56 .055 34,10
2.78 47,34
.063
1.84 .058 81,57
1.60
.060 43,23
1.69 .063 33,19
2.39 .059 60,36
1.11 .059 30,17
.68 .059 30,16
.98 .060 31,15
1.04 .061 28,14
qr .92 .060 NP
qr .90 .067 NP
1.50 .061 24,6
1.58 .062 27,10
qr .45 .059 23,9
NP
qr .56 .058 31,17
qr .60 .059 NP
NP
NP

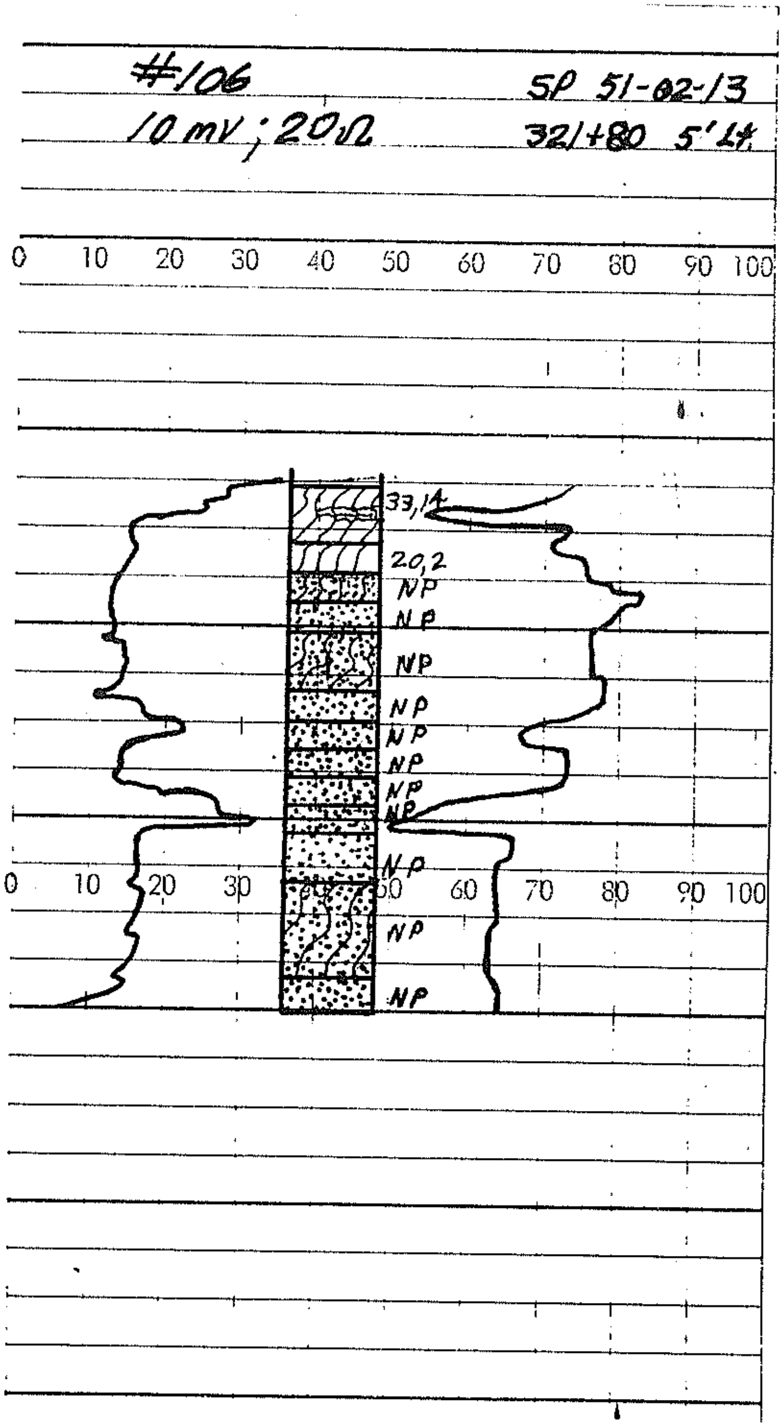

#87
SP 424-02-25
10MV; 50 Ω
49+50 72' Rt.
2068-2
0 10 20 30 40 50 60 70 80 90 100
NP
NP
NP
NP
NP
NP


#83
SP 424-02-25
10MV, 50Ω
48+94 123' Rt.
0 10 20 30 40 50 60 70 80 90 100
NP
No CORE
NP
NP
NP
NP
NP
NP

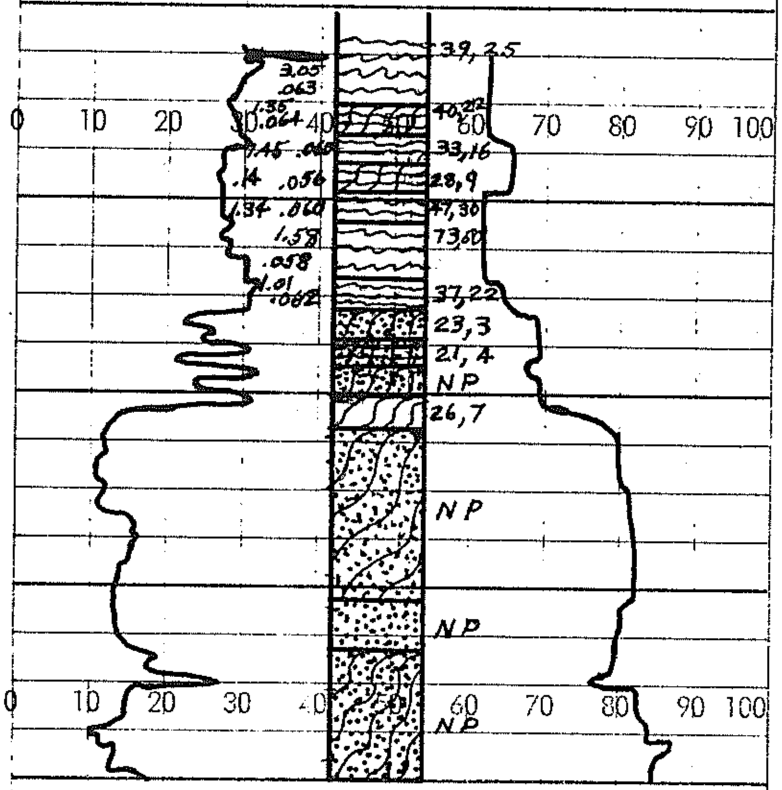

0 10 20 30 40 50 60 70 80 90 100
#91
SP 24-06-18
20mv; 50Ω
209+10 112' Lt
qr - .32 .059
NP
NP
NP
NP
NP
44,25
1.59 .062
57,35
40,21
43,23
30,10
NP
31,76


0 10 20 30 40 50 60 70 80 90 100
2068-2
#94
SP 24-06-18
20mv; 50Ω
208+20 114' Lt.
.90 .065
19, 4
qr .44 .06
23, 4
qr .44, .058
27, 6
NP
qr .75 .060
30, 8
ND
NP
NP
44, 22
2.95 .060
40, 18

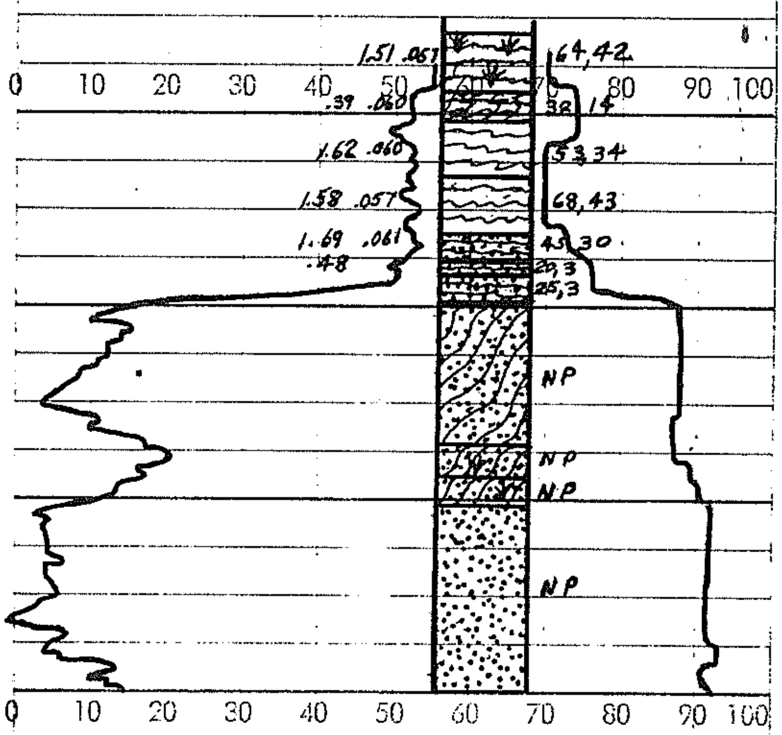

#99
SP 24-06-18
10 mv ; 20Ω
209+10 64' Lt.
0 10 20 30 40 50 60 70 80 90 100
N P
45, 31
.34 .061
24, 13
N P
N P
48, 18
71,46
52, 31
NP
44, 25
39, 20

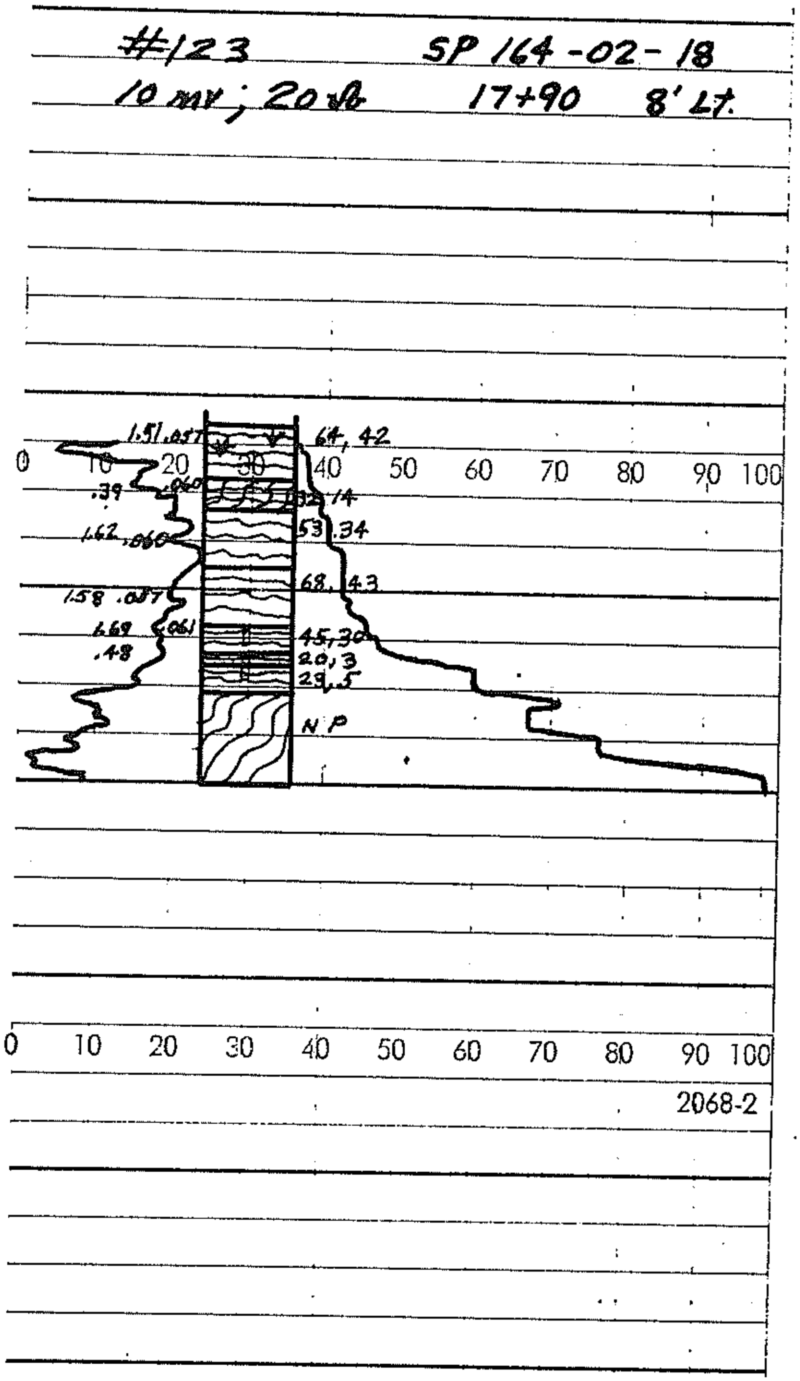

#106
SP 51-02-13
10 mv ; 20Ω
321+80 5' Lt.
0 10 20 30 40 50 60 70 80 90 100
33, 14
20, 2
NP
NP
NP
NP
NP
NP
NP
NP
NP
NP
NP

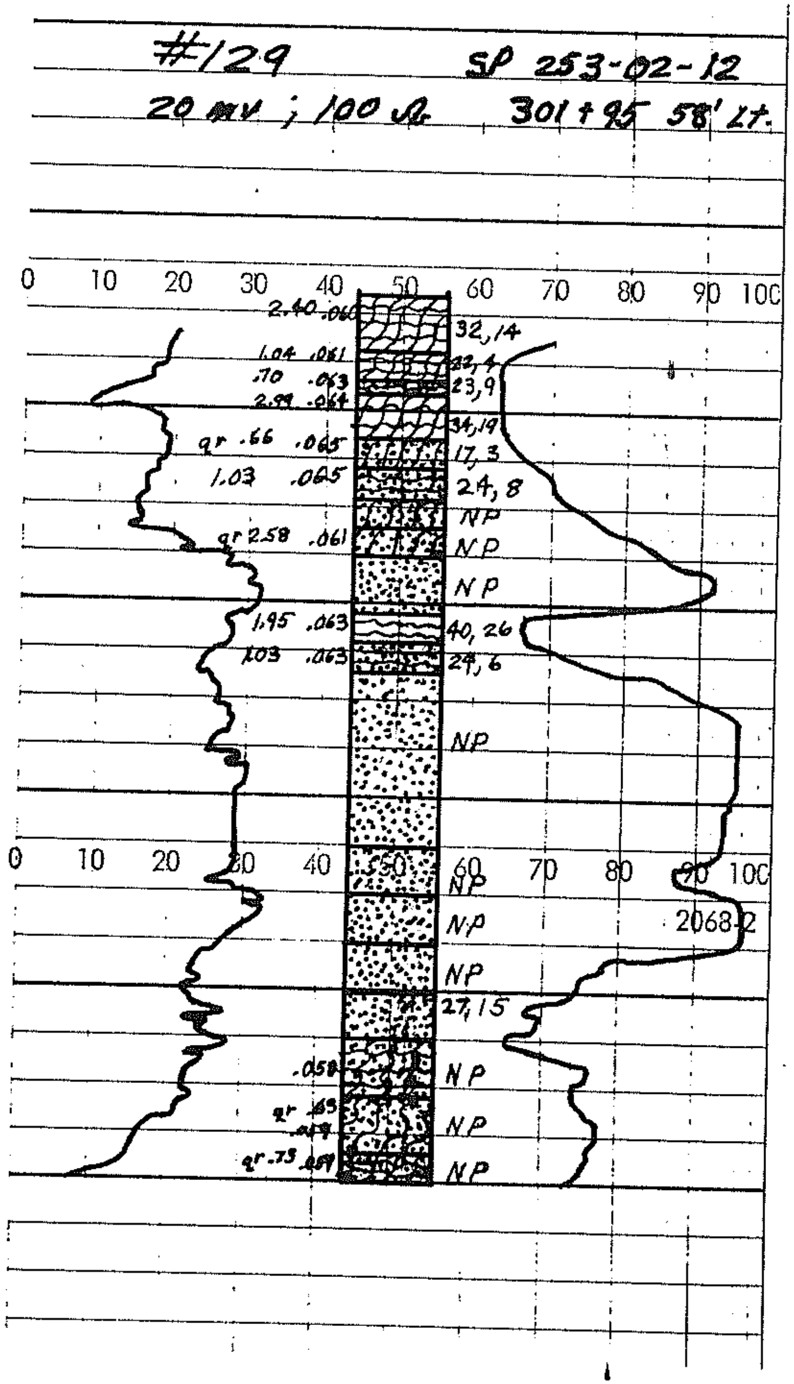
#112 SP 700-06-88
20 mv; 50Ω 195+20 275' Lt.

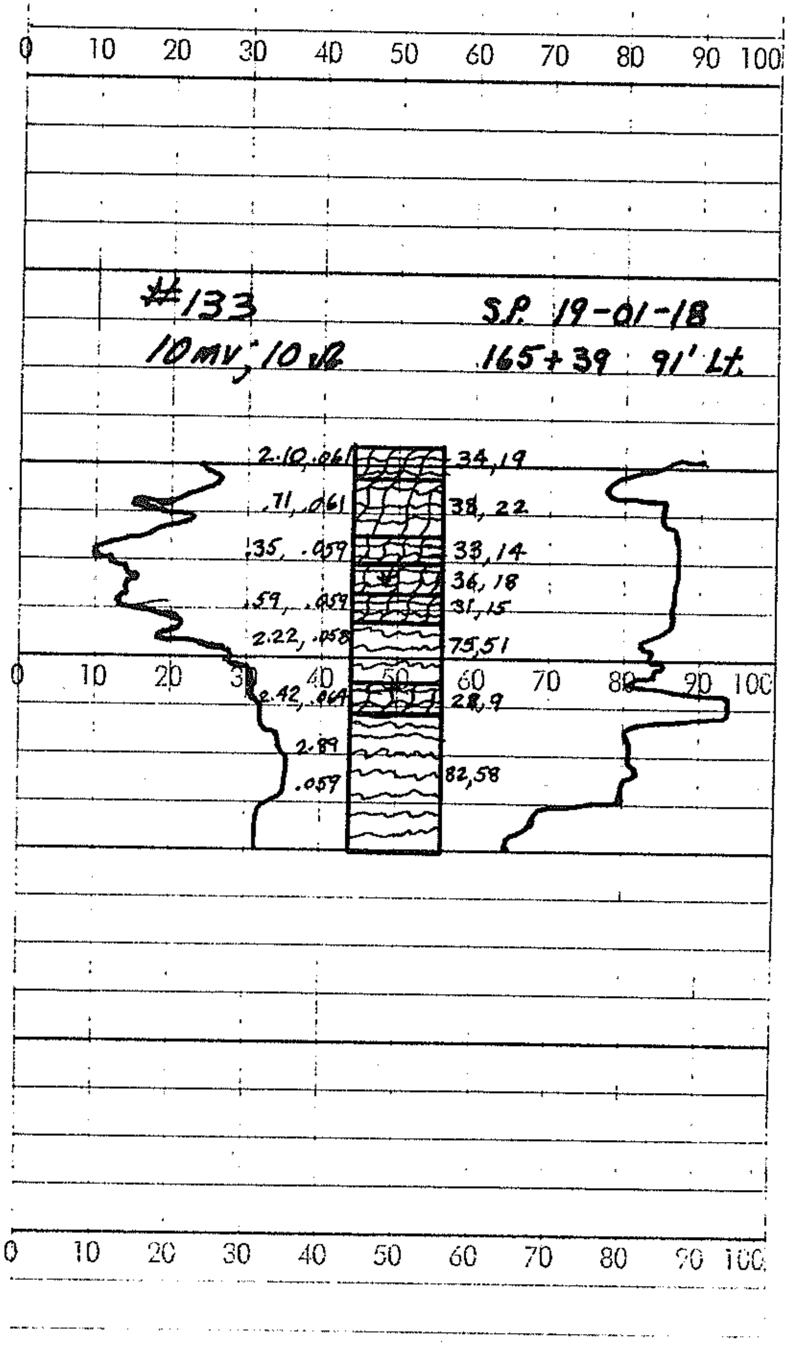


#18 SP 700-06-88
20 mv; 50Ω 195+20 135' Lt.

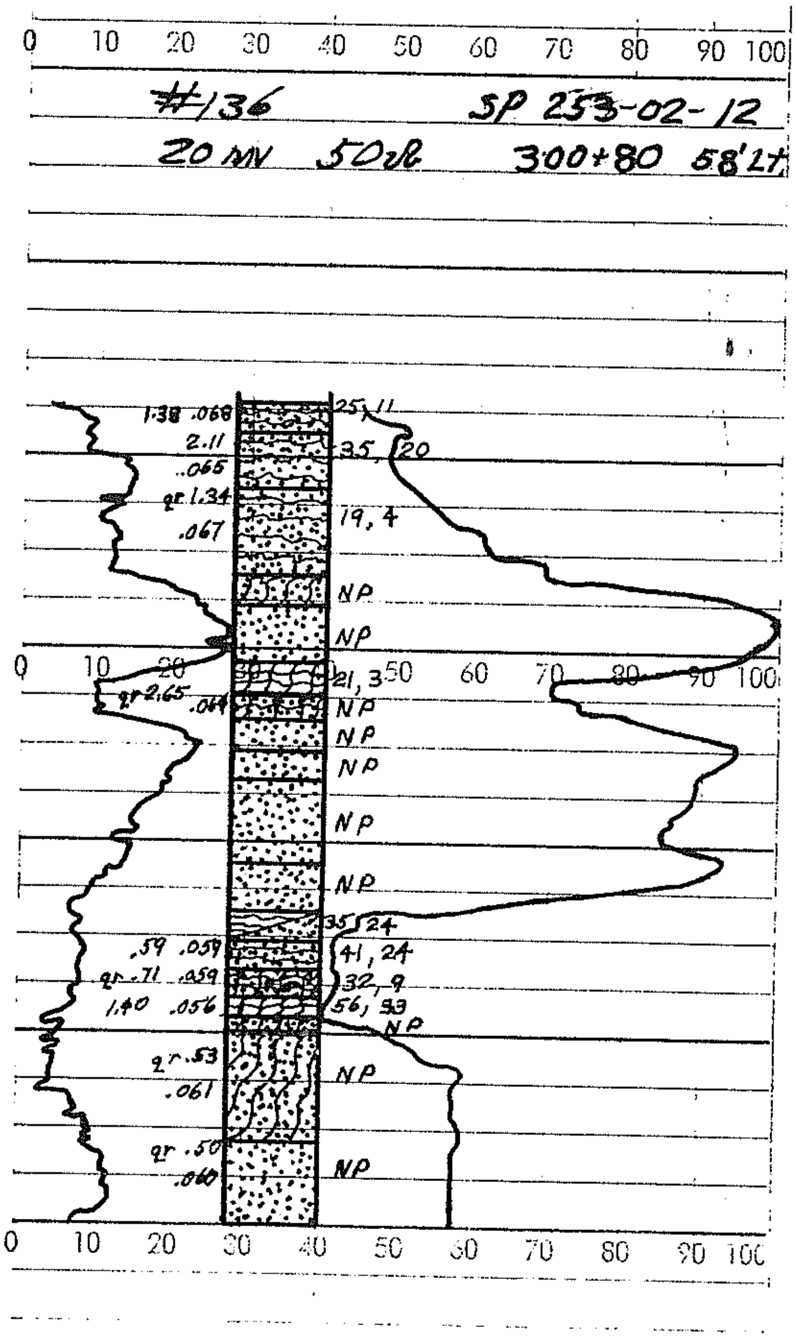



#123
SP 164-02-18
10 mv; 20 Ω
17+90
8' Lt.
0
10
20
30
40
50
60
70
80
90
100
1.51 .057
64, 42
.39
.060
32, 14
1.62 .060
53, 34
68, 43
1.58 .087
1.69 .061
.48
45, 30
20, 3
29, 5
N P
2068-2

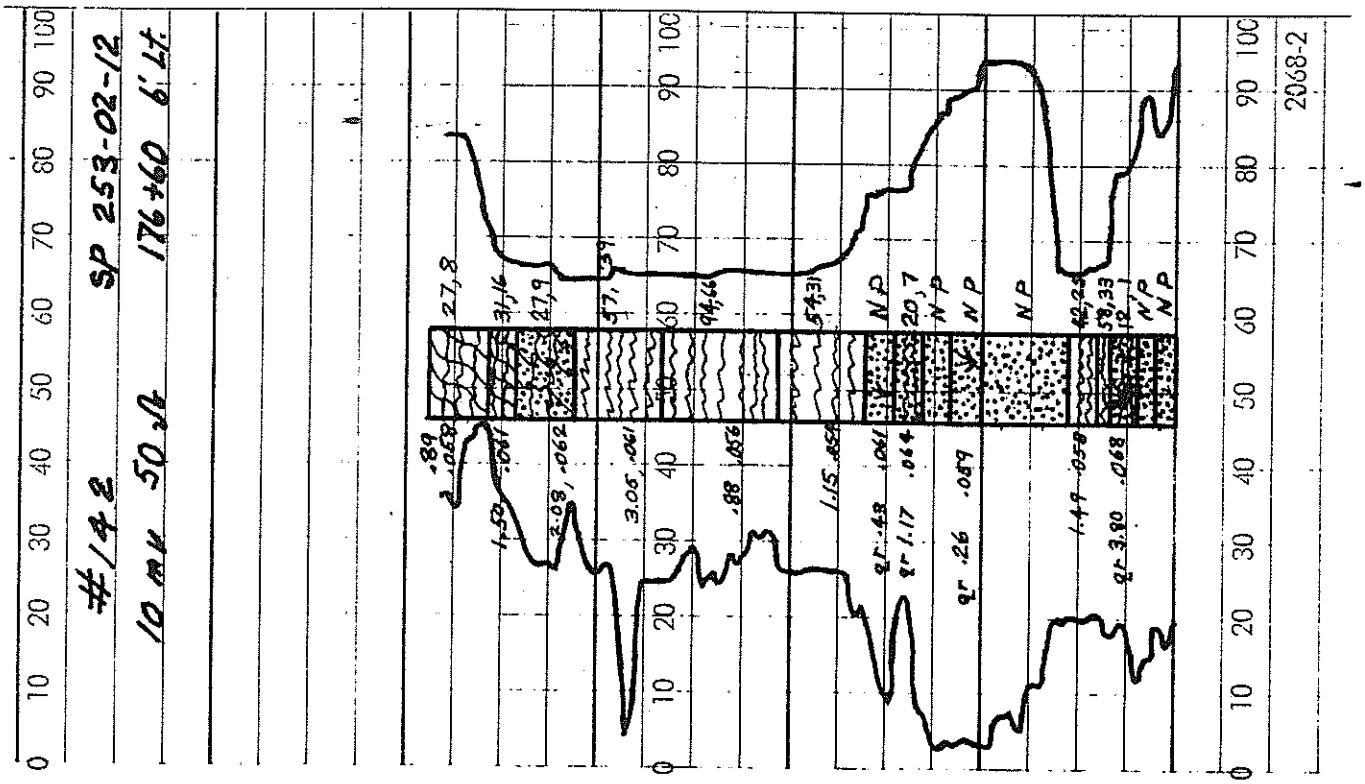

#129
SP 253-02-12
20 mv ; 100 Ω
301+95 58' Lt.
0
10
20
30
40
50
60
70
80
90
100
2.40 .060
32, 14
1.04 .061
32, 4
.70 .063
23, 9
2.99 .064
34, 19
qr .66 .065
17, 3
1.03 .065
24, 8
NP
qr 2.58 .061
NP
NP
1.95 .063
40, 26
1.03 .063
24, 6
NP
NP
NP
2068-2
27, 15
.058
NP
qr .65
.059
NP
qr .73 .059
NP

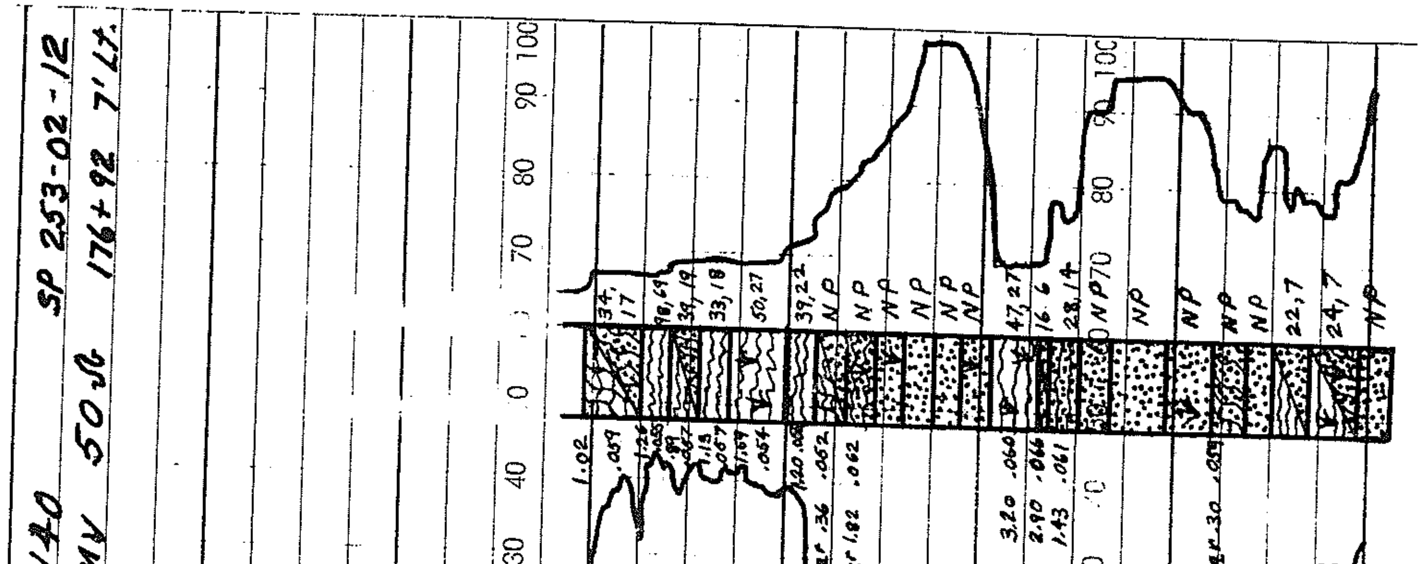


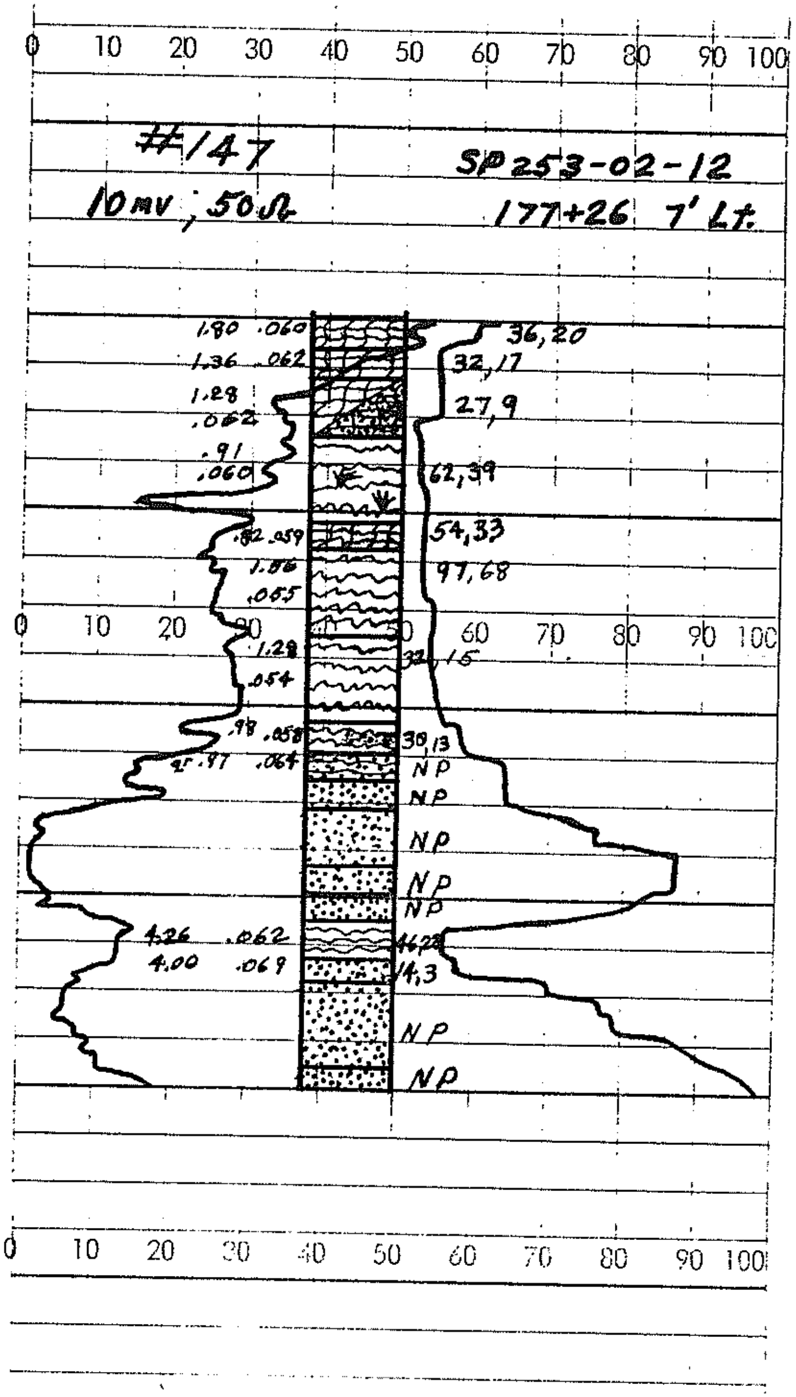
#133
SP 19-01-18
10mv, 10Ω
165+39 91' Lt.
0 10 20 30 40 50 60 70 80 90 100
2.10, .061
.71, .061
.35, .059
.59, .059
2.22, .058
2.42, .064
2.89
.059
34,19
38, 22
33, 14
36, 18
31, 15
75,51
28,9
82,58



#136
SP 253-02-12
20 MV 50Ω
300+80 58' Lt.
0 10 20 30 40 50 60 70 80 90 100
1.38 .068
2.11
.065
gr 1.34
.067
gr 2.65
.064
.59 .059
gr .71 .059
1.40 .056
gr .53
.061
gr .50
.060
25, 11
35, 20
19, 4
NP
NP
21, 3
NP
NP
NP
NP
NP
35, 24
41, 24
32, 9
56, 53
NP
NP
NP


#142
10 mV 50 Ω
SP 253-02-12
176+60 6' Lt.
0 10 20 30 40 50 60 70 80 90 100
2068-2


#140
10 MV 50 Ω
SP 253-02-12
176+92 7' Lt.
0 10 20 30 40 50 60 70 80 90 100


#147
10mv ; 50Ω
SP253-02-12
177+26 7' Lt.
0 10 20 30 40 50 60 70 80 90 100
1.80 .060
1.36 .062
1.28
.062
.91
.060
.82 .059
1.86
.065
1.28
.054
.98 .058
.97 .064
4.26 .062
4.00 .069
36,20
32,17
27,9
62,39
54,33
97,68
32,15
30,13
NP
NP
NP
NP
NP
14,22
14,3
NP
NP

Plant mix seals are somewhat different than most bituminous mixtures. As the name refers, a plant mix seal is merely a seal coat material mixed in a hot mix plant. The mix contains an asphalt coated aggregate without the use of sand or mineral filler. The gradation of the aggregate is as shown in Table 1, Appendix A for plant mix seals.

The materials are mixed in a hot mix plant at high asphalt contents and at temperatures below 260°F. The object of the high asphalt content and low mixing temperature is to obtain a greater film thickness of asphalt on the aggregate. The mix is applied through a conventional spreader and rolled with a tandem and pneumatic roller.

The Kentucky sand asphalt was constructed similar to other sand asphalts. The Kentucky sand is a asphalt impregnated quartz sandstone rock which contains approximately 3 1/2 to 41/2 percent natural bitumen. Additional asphalt is added to the Kentucky sand as in other sand asphalt mixtures.

Problems Encountered During Construction

There were certain problems encountered during construction for some of the test sections. On one of the Kentucky sand asphalt sections the material began to ravel out after approximately two days of traffic. This pitting or ravelling only occurred in one lane for a distance of approximately 200 feet. Figure 2 shows two photographs of the pitting that occurred. The reason for this has never definitely been determined, however, it is believed that it was possibly due to improper mixing of one or two batches at the plant. The length of the pitting was approximately the distance one truck load of material would cover. Since a manual batch plant was being used it was assumed that an error was made during batching. Improper mixing would be difficult to see visually since the sand is already black from the natural asphalt in it. The bad section was taken out and replaced and there was no other detrimental effects observed on the Kentucky sand asphalt sections.

Another less severe problem occurred while constructing the expanded clay plant mix seal. The specifications state that the mix when discharged from the pugmill should not exceed 260°F, however, on one particular truck the mix was approximately 300°F which resulted in some of the asphalt dripping to the bottom of the truck. This was not detrimental to the mix on the roadway, however, it did cause some of the mix to stick to the truck bed when dumping the mix into the spreader. Figure 3 shows a photograph of what may occur when heating the mixture above 250°F on a plant mix seal.

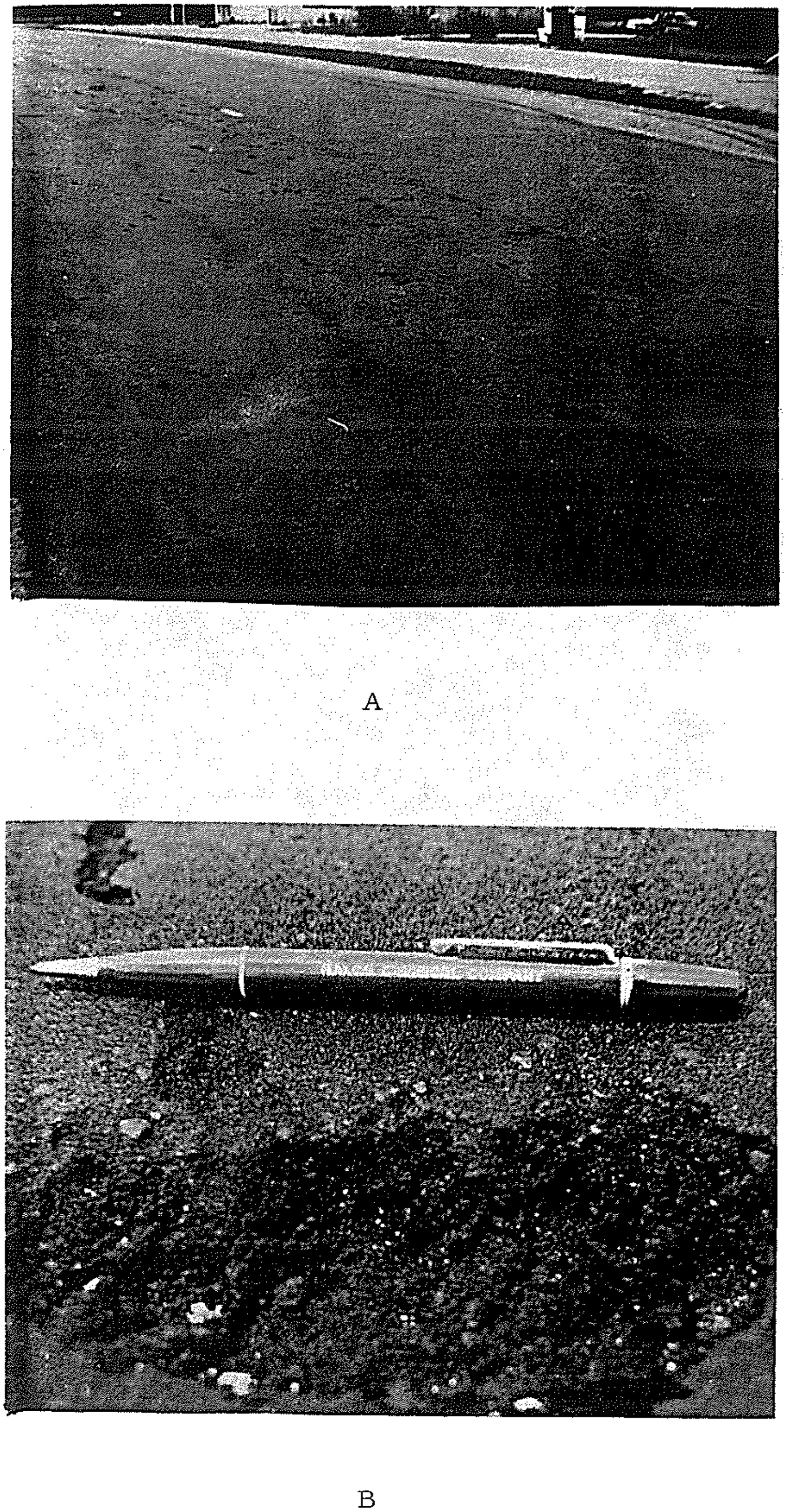


Figure 2 - Photograph of failures in the Kentucky Sand Asphalt sections.

The mix at the bottom of the truck bed may not appear to be very critical, however, it will cause more mix to accumulate on succeeding loads, in addition to being very difficult to clean at the end of the day. It is recommended that a soap solution be used to wet down the truck bed before each load to prevent the mix from sticking.

Figure 3 - Photograph of overheated Plant Mix Seal sticking to truckbed.

Skid Resistance

The most important results of this study is the skid resistant qualities of the various mixtures. Skid resistance was obtained on most of the test sections immediately after completion and at four, eight and eleven months after completion. The skid resistance values are referred to as skid numbers, which is merely the coefficient of friction multiplied by 100. The skid resistance was obtained at speeds of 20, 40 and 60 miles per hour however, 40 miles per hour is the standard accepted speed to run skid measurements and therefore most of the evaluation was based on skid numbers at 40 miles per hour.

Of the eleven test sections constructed,two of the mixtures were not included in the complete evaluation of the surfaces. A comparison of the average skid numbers for all the test section are shown in Table 3 of Appendix A. As indicated by the table,the Louisiana sand asphalt has the lowest skid numbers of all the test sections. There is no universal skid number at 40 miles per hour designating whether the skid resistance is satisfactory. However, the Bureau of Public Roads has tenatively set a skid value of 35 plus as acceptable when tested at 40 miles per hour.

The skid number of the Louisiana sand asphalt at 40 miles per hour was 33, which was below the Bureau of Public Roads standard. There were also reports that the Louisiana sand asphalt section was slick when wet, causing several vehicles to leave the roadway at relatively low speeds. For this reason it was decided to construct a slurry seal over the Louisiana sand asphalt section and therefore a full evaluation of the sand asphalt was not made.

The other mixture not included in the full evaluation is the granite slurry seal. Skid resistance was measured and recorded as shown in Table 3 of Appendix A. There is some question as to whether or not these values are representative of a granite slurry seal. The uncertainty of the validity of these results have stemmed from problems encountered during construction. The problems resulted from the quickset cationic emulsion "breaking" in the spreader box, causing the operator to add more water to the slurry which proved to be excessive, thereby causing the emulsion to float to the top of the surface. This resulted in having less granite aggregate in the mix causing a less skid resistant surface. Therefore it was decided that the skid numbers be reported in the tables, but comparisons of the granite slurry seal with the other mixtures was not made.

There are several factors that affect skid resistance of a surface. Probably the most influential are:surface texture, type of aggregate, and the resistance to polishing under traffic. Appendix B consists of a series of photographs showing the appearance and surface texture of the various test sections.

As indicated in Appendix B, there is a variety of surface textures as well as aggregate types. This is most important in studying skid resistance.

Figure 4 shows the relationship of the average skid numbers at 40 miles per hour versus time and traffic. In most cases the skid numbers increased from immediately after construction to four months and the asphaltic concrete mixtures had an additional increase after eight months before a slight decrease

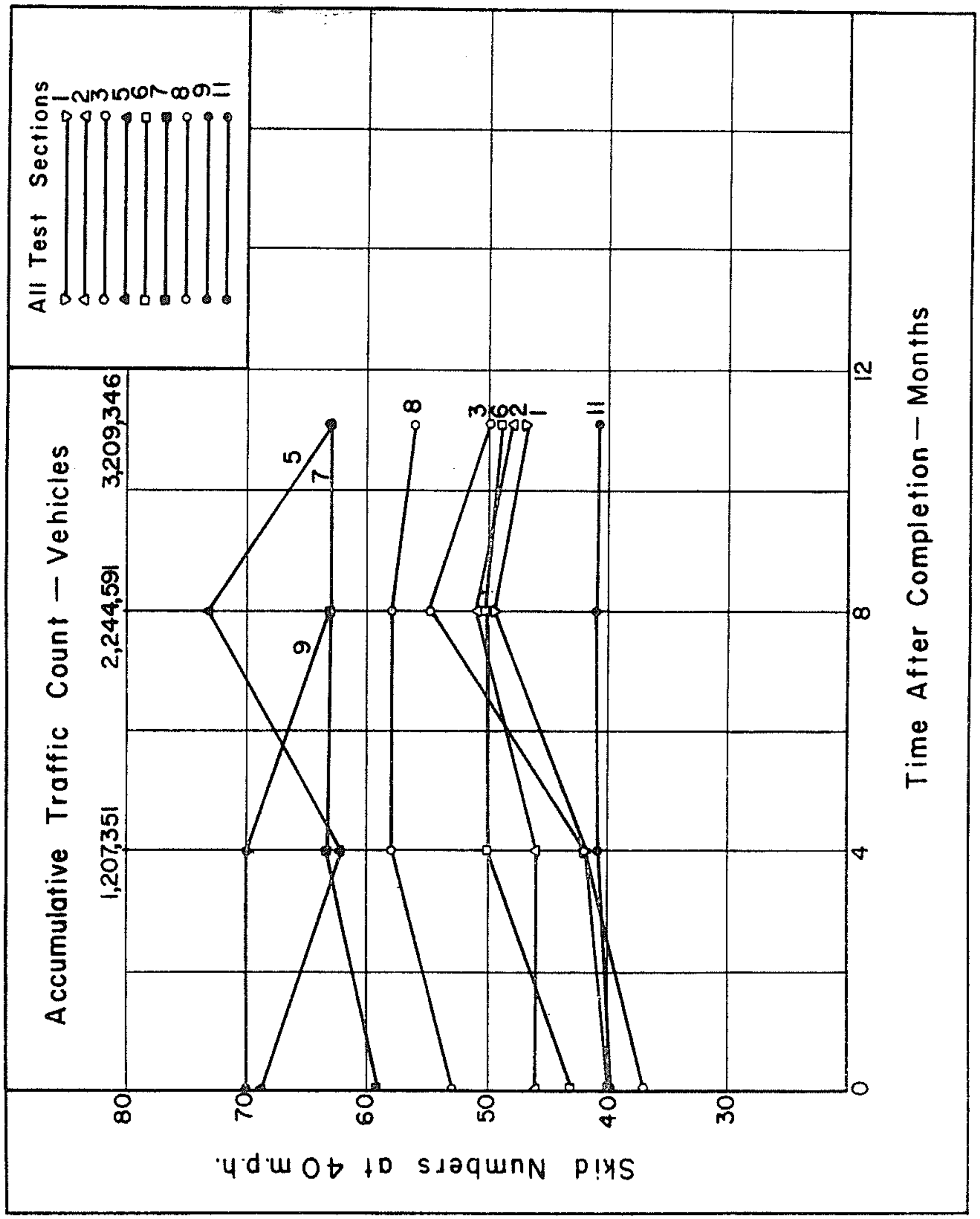


Figure 4 - Relationship of skid numbers at 40 MPH versus time and traffic for all test sections.

at eleven months. The skid numbers on the Kentucky sand asphalt were erratic as there was a drop at four months an increase at eight and another decrease at eleven months. The Kentucky sand did give the highest skid number of all the test sections with a value of 73 at eight months. However, the skid number dropped to 63 at eleven months, which is equivalent to that obtained by the expanded clay plant mix seal for the same period of time.

The expanded clay slurry seal section had skid numbers of 70 up to four months of traffic and dropped to 63 at eight months. The eleven month interval for the slurry seals were not yet due since the slurry seals were constructed approximately three months after the other test sections. Results will be obtained at longer intervals on the slurry seals, as well as, on the other test sections.

The total traffic count on the test sections after eleven months was 3,209,346 vehicles as determined by a traffic station near the job site. The eleven month results indicate a slight decrease in the skid numbers for the asphaltic concrete sections, however, there does not appear to be any excessive polishing of the aggregate.

Figure 5 shows the skid number versus time for the Kentucky sand and asphaltic concrete test sections only. In each case the asphaltic concrete sections showed an increase of skid resistance up to eight months or 2,244,591 vehicles after which a slight decrease occurred at eleven months. It is interesting to note that of the asphaltic concrete mixtures, the expanded clay hot mix had a lower skid number at zero and four months after completion. It has been proven on past studies that the expanded clay hot mixes have superior skid resistant qualities to the standard crushed gravel hot mixes, due primarily to the nature of the coarse expanded clay aggregate.

The Kentucky sand asphalt as shown in Figure 5 did give very high skid numbers, however there was some difficulty in obtaining a satisfactory riding surface and it is believed that the cost for shipping the material into Louisiana would be prohibitive.

Figure 6 shows the skid numbers versus time for the plant mix seals and expanded clay slurry seal sections. The plant mix seal curves showed similar trends. There was an increase in skid resistance from zero to four months and very little change from four to eleven months even though being subjected to over two million more vehicles. This would indicate that skid resistance on plant mix seals tend to level off quicker than a mix that contains sand and

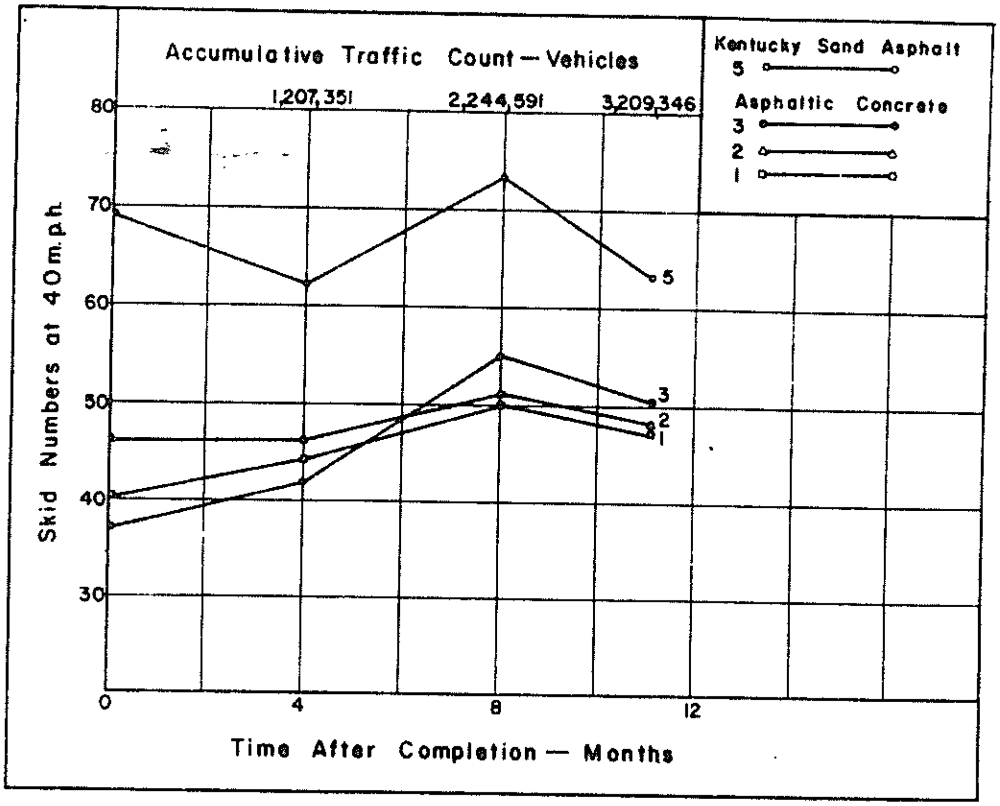


Figure 5 - Relationship of skid numbers at 40 MPH versus time and traffic for the Asphaltic Concrete and Kentucky Sand Asphalt sections.

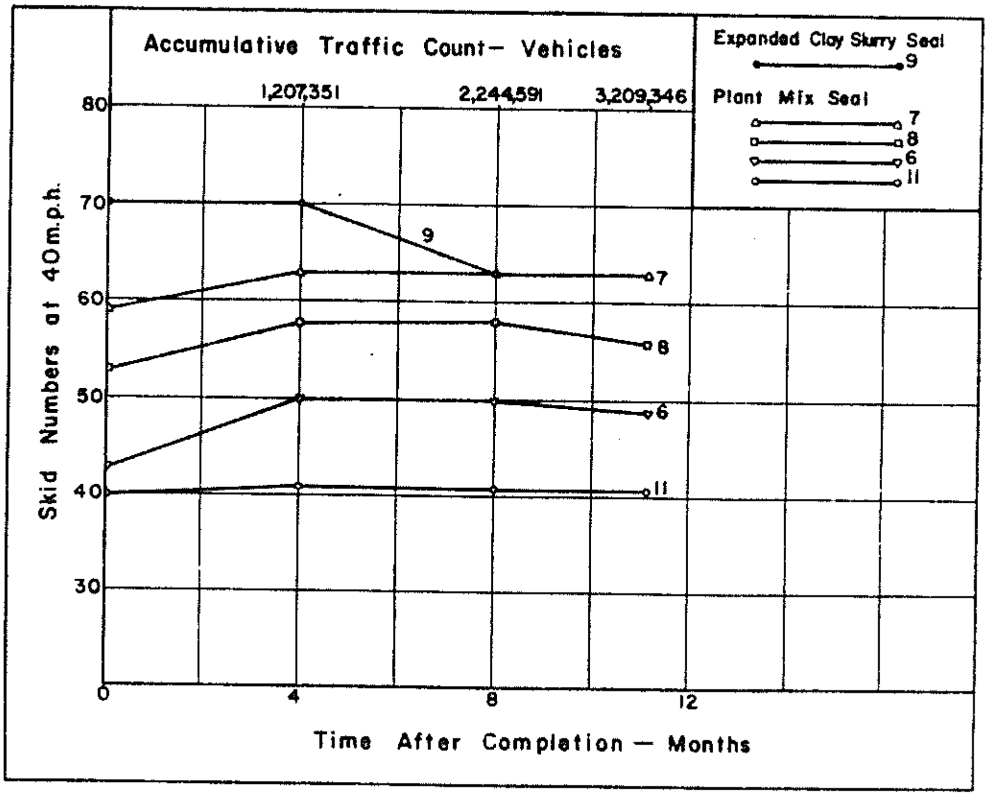


Figure 6 - Relationship of skid numbers at 40 MPH versus time and traffic for the Plant Mix Seals and expanded Clay Slurry Seal.

coarse aggregate. It also seems reasonable that the plant mix seal would maintain a constant skid resistance, as long as, the aggregate being used is not susceptible to excessive polishing.

Figure 6 also illustrates the importance of the type of aggregate used in the mix. Each of the plant mix seals conformed to the same gradation requirements, however, the expanded clay and slag plant mix seals had superior skid resistance to the crushed gravel seals. Again this is characteristic of the aggregate. It is very interesting to note that the 95 percent crushed gravel seal was superior to the 75 percent crushed gravel seal, indicating that increased angularity of a particular aggregate should result in higher skid resistance.

The expanded clay slurry seal shows extremely high skid numbers at zero and four months after completion and a decrease equivalent to that of the expanded clay plant mix seal after eight months of traffic. Additional results will be obtained on all the test section, however, it is anticipated that the slurry seal will fall below that of the plant mix seals with increasing traffic although maintaining a satisfactory skid resistance value.

Although the adopted speed for running skid resistance is presently 40 miles per hour, it is very important to know how the skid resistance changes with increasing speeds since the speed limits on most highways are above 40 miles per hour. Figure 7 shows bar graphs illustrating the percent decrease in skid numbers at eight months for the various test sections when testing from 40 to 60 miles per hour. The bar graphs indicate that the percent change in skid resistance varies on different surfaces, depending again on the surface texture, type of aggregate and its susceptibility to hydroplaning. Of the nine sections in Figure 7, the plant mix seals and expanded clay slurry seal showed the least percent decrease in skid numbers when testing from 40 to 60 miles per hour. The 75 percent crushed gravel plant mix seal was higher than all but one of the other mixes, indicating the importance of crushed aggregate in a gravel plant mix seal. It is believed that plant mix seals are less susceptible to hydroplaning than the dense graded hot mixes due to its open graded texture.

Roughness

One of the other important criteria in which the test sections were evaluated was roughness. Roughness measurements were taken on all of the test sections at four and eleven months after construction. The results in Figure 8

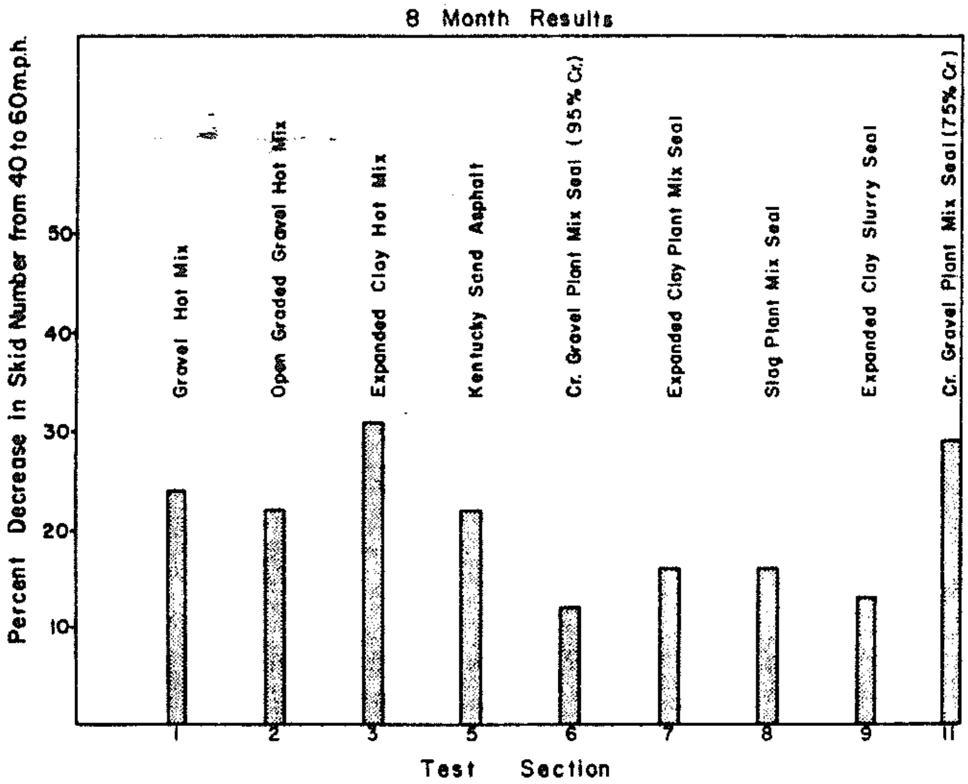


Figure 7 - The eight month results for the percent decrease in skid numbers from 40 to 60 MPH.

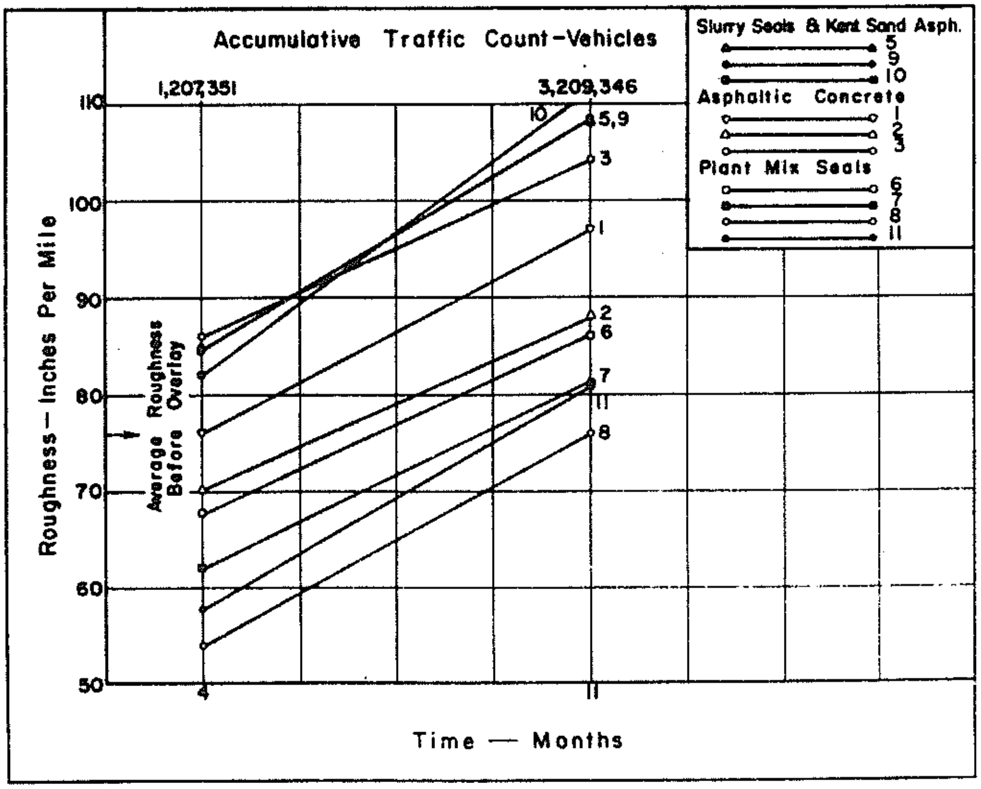


Figure 8 - Relationship of roughness versus time and traffic for all of the test sections.

shows that the plant mix seals had the lowest roughness of all the test section. The slurry seals and Kentucky sand asphalt gave the highest roughness values at both four and eleven months. The average roughness of the roadway before overlay was approximately 76 inches per mile. After eleven months and three million vehicles the plant mix seals show a roughness range of 76 to 81 which for all practical purposes may be rated as good, as based on the following description.

Adjective Description	Roughness Values Inches Per Mile Flexible Pavement
Very Good	Less than 65
Good	65-80
Fair	80-100
Rough	More than 100

This is considered very good for a surface that is only approximately 5/8 of an inch thick. The asphaltic concrete mixtures ranged from 88 to 104 and the slurry seals and Kentucky sand asphalt from 108 to 111.

In general the plant mix seals appear to be most satisfactory for use as a thin skid resistant surface. It is easy to construct and results in higher skid numbers with lower roughness values. Although a complete cost estimate cannot be made from this project, it is believed that the cost per square yard will be very competitive with most other types of seal coats being used.

CONCLUSIONS

1. Of the four different types of surface courses evaluated, namely plant mix seal, asphaltic concrete, sand asphalt and slurry seal; the plant mix seals possessed the most desirable features, such as: ease of construction, high skid resistance and low roughness values.

2. After being subjected to traffic for eleven months (3,209,346 vehicles) the Kentucky sand asphalt and expanded clay plant mix seal possessed the highest skid numbers of 63 at 40 miles per hour than any of the other test sections.

3. The expanded clay slurry seal had an average skid number of 63 after eight months or 2,244,591 vehicles.

4. The skid numbers for the plant mix seals increased, with traffic, up to four months and leveled off up to eleven months. The asphaltic concrete mixtures increased at four and eight months and slightly decreased at eleven months.

5. The crushed gravel plant mix seal with 95 percent crushed material had an average skid number of 49 at 40 miles per hour as compared to only 41 for the 75 percent crushed gravel seal after eleven months of traffic. This clearly indicates that when using gravel plant mix seal, a minimum of 95 percent curshed material should be required.

6. The percent decrease in the average skid numbers when testing at 40 and 60 miles per hour was the least (12 to 16 percent) on the plant mix seals and the expanded clay slurry seal, with the exception of the 75 percent crushed gravel plant mix seal which decreased as much as 29 percent. The other test sections decreased in skid numbers in the range of 22 to 31 percent.

7. The plant mix seals showed the least amount of roughness after eleven months of traffic. The range of roughness values in inches per mile were 108 to 111 for the slurry seals and Kentucky sand sections, and from 88 to 104 for the asphaltic concrete and from 76 to 81 for the plant mix seals.

APPENDIX "A"

AVERAGE PHYSICAL PROPERTIES OF THE VARIOUS BITUMINOUS MIXTURES
TEST RESULTS OF ASPHALT CEMENT
AVERAGE SKID NUMBERS
AVERAGE ROUGHNESS RESULTS

TABLE 1

AVERAGE PHYSICAL PROPERTIES OF THE VARIOUS BITUMINOUS MIXTURES

Test Section 1 - Type IV Hot Mix, Crushed Gravel (Control)

Mineral Aggregate -	95%	
Asphalt Content -	5%	(AC-3 60/70 penetration)
Crushed Aggregate -	79%	

Lab. Specific Gravity -	2.339
Voids -%	5.3
Voids Filled	68.2
Marshall Stability lbs.	1885
Flow 1/100"	12
Roadway Density -%	96.3

Extracted Gradation

U.S. Sieve	Percent Passing
3/4"	100
1/2"	98
3/8"	86
No. 4	59
No. 10	44
No. 40	30
No. 80	13
No. 200	9

Test Section 2 - Open Graded Crushed Gravel Mix

Mineral Aggregate -	95%	
Asphalt Content -	5%	(AC-3 60/70 penetration)
Crushed Aggregate -	85%	

Lab. Specific Gravity -	2.302
Voids -%	5.9
Voids Filled -%	65.7
Marshall Stability lbs.	2041
Flow 1/100"	9
Roadway Density %	93.2

Extracted Gradation

U.S. Sieve	Percent Passing
3/4"	100
1/2"	98
3/8"	87
No. 4	66
No. 10	43
No. 40	23
No. 80	7
No. 200	4

TABLE 1 (cont'd)

Test Section 3 - Type 4 Expanded Clay Hot Mix

Mineral Aggregate - 92.5
Asphalt Content - 7.5 (AC-3 60/70 penetration)

Lab. Specific Gravity	1.722
Voids %	7.9
Voids Filled %	63.6
Marshall Stability lbs.	1496
Flow 1/100"	8
Roadway Density %	96.5

Extracted Gradation

U.S. Sieve	Percent Passing
3/4"	100
1/2"	98
3/8"	89
No. 4	73
No. 10	66
No. 40	45
No. 80	16
No. 200	10

Test Section 4 - Louisiana Sand Asphalt

Mineral Aggregate - 93.5
Asphalt Content % - 6.5 (AC-3 60/70 Penetration)

Lab. Specific Gravity	2.225
Voids %	8.1
Voids Filled %	63.4
Marshall Stability lbs.	802
Flow 1/100"	12
Roadway Density %	94.0

Extracted Gradation

U.S. Sieve	Percent Passing
No. 4	100
No. 10	92
No. 40	59
No. 80	18
No. 200	9

TABLE 1 (cont'd)

Test Section 5 - Kentucky Sand Asphalt

Mineral Aggregate -	94.5%	
Asphalt Content -	5.5%	(AC-3 60/70 penetration)

Lab. Specific Gravity -	2.068
Voids -%	10.3
Voids Filled -%	51.9
Marshall Stability lbs.	1082
Flow 1/100"	10
Roadway Density %	92.3

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
No. 4	98
No. 100	13

Test Section 6 - Gravel Plant Mix Seal (95% crushed)

Mineral Aggregate -	93%	
Asphalt Content -	7%	(AC-3 60/70 penetration with 0.5% Redicote 80-S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	98
No. 4	46
No. 10	13
No. 40	4
No. 200	1

TABLE 1 (Cont'd)

Test Section 7 - Expanded Clay Plant Mix Seal

Mineral Aggregate -	84%	
Asphalt Content -	16%	(AC-3 60/70 penetration with 0.5% Redicote 80.S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	98
No. 4	49
No. 10	10
No. 40	2
No. 100	1

Test Section 8 - Slag Plant Mix Seal

Mineral Aggregate -	91%	
Asphalt Content -	9%	(AC-3 60/70 penetration with 0.5% Redicote 80-S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	98
No. 4	41
No. 10	6
No. 40	2
No. 100	1

TABLE 1 (cont'd)

Test Section 9 - Expanded Clay Slurry Seal

Emulsion Content - 25% by volume of Aggregate (Chevron Quickset Cationic Emulsion)

Gradation

U.S. Sieve	Percent Passing
3/8"	100
No. 4	100
No. 16	54
No. 50	23
No. 100	15
No. 200	11

Test Section 10 - Granite Slurry Seal

Emulsion Content - 35% by volume of Aggregate (Bitucote-Blakat Cationic Emulsion)

Gradation

U.S. Sieve	Percent Passing
3/8"	100
No. 4	99
No. 16	48
No. 50	20
No. 100	9
No. 200	5

TABLE 1 (cont'd)

Test Section 11 - Gravel Plant Mix Seal (75% crushed)

Mineral Aggregate -	93%	
Asphalt Content -	7%	(AC-3 60/70 penetration with 0.5% Redicote 80-S antistripping additive)

Extracted Gradation

U.S. Sieve	Percent Passing
1/2"	100
3/8"	96
No. 4	53
No. 10	26
No. 40	11
No. 100	2

TABLE 2

TEST OF ASPHALT CEMENT

Laboratory Number	6352
Specific Gravity 77°F.	1.031
Specific Gravity 60°F.	1.034
Wt. Per Gallon at 60°F., lbs.	8.620
Flash Point, C.O.C., °F.	610
Viscosity	
Saybolt Furol Sec. @ 275°F.	309
Absolute @ 140°F, Poises	4088
Penetration @ 39.2°F, 200G., 60 sec.	25
Penetration @ 77°F, 100G., 5 sec.	62
Thin Film Oven Test	
Loss % @ 325°F, 5 hrs.	.03
Penetration of Residue @ 77°F.	45
Residue Penetration, % of Original	72.6
Ductility of Residue @ 77°F.	100+
Solubility in CS_2%	99.82
Homogeniety Test	Negative
Mixing Temperature	319-326

Remarks: This sample conforms to the specifications for A. C.-3.

TABLE 3

AVERAGE SKID NUMBERS AT VARIOUS TIME INTERVALS AFTER COMPLETION

	AVERAGE SKID NUMBERS											
	0-Months			4-Months			8-Months			11-Months		
	20mph	40mph	60mph	20mph	40mph	60mph	20mph	40mph	60mph	20mph	40mph	60mph
1. Control-Gravel Hot Mix Type 1	55	40	33	-	44	-	60	50	38	56	47	37
2. Open Graded Gravel Mix	60	46	39	-	46	-	58	51	40	58	48	38
3. Expanded Clay Hot Mix Type 4	56	37	29	-	42	-	64	55	38	65	50	38
4. Louisiana Sand Asphalt	48	33	23	-	-	-	-	-	-	-	-	-
5. Kentucky Sand Asphalt	74	69	60	-	62	-	76	73	57	71	63	50
6. Crushed Gravel Plant Mix Seal (95% Crushed)	55	43	40	-	50	-	55	50	44	53	49	44
7. Expanded Clay Plant Mix Seal	70	59	51	-	63	-	75	63	53	70	63	50
8. Slag Plant Mix Seal	62	53	49	-	58	-	63	58	49	57	56	49
9. Expanded Clay Slurry Seal (La.)	77	70	63	81	70	59	64	63	55	-	-	-
10. Granite Slurry Seal	50	41	26	51	38	30	48	36	28	-	-	-
11. Crushed Gravel Plant Mix Seal (75% Crushed)	52	40	36	-	41	-	51	41	29	50	41	-

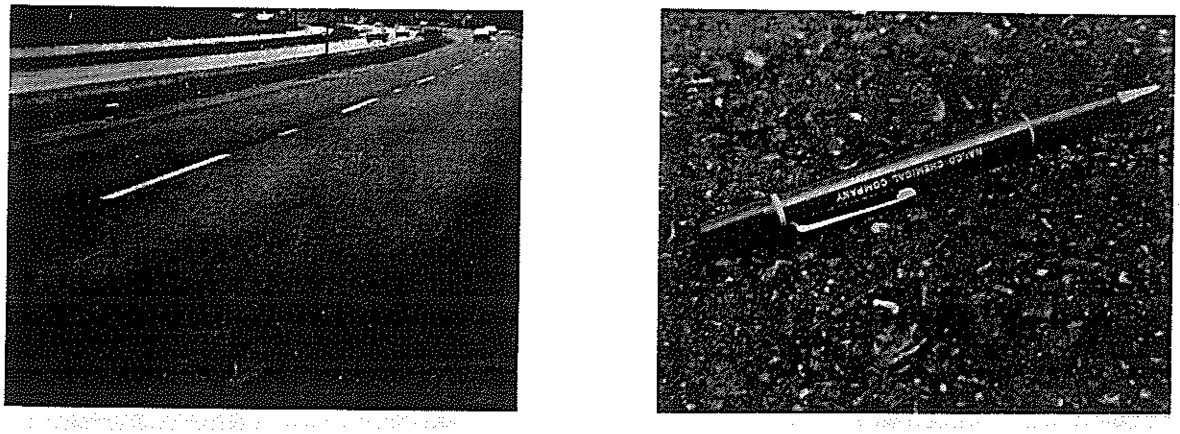
TABLE 4

AVERAGE ROUGHNESS RESULTS

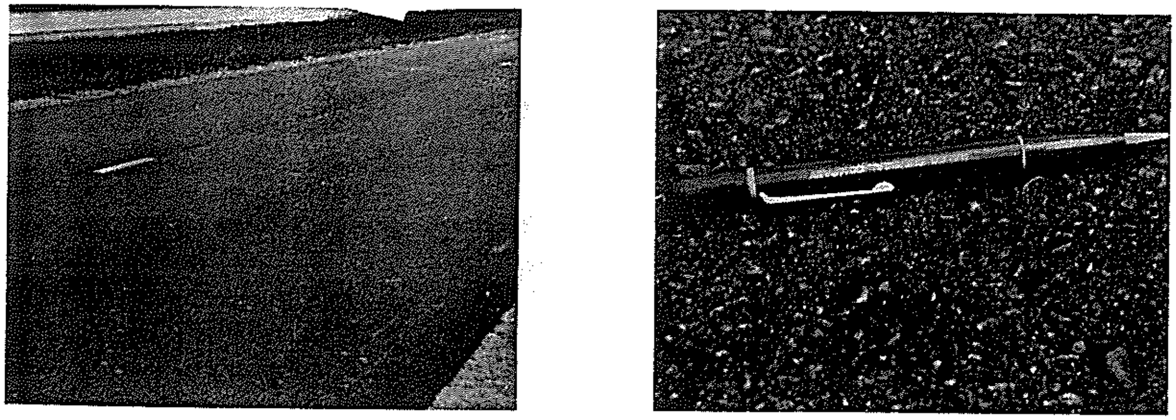
Test Section	ROUGHNESS 4 MONTHS	 11 MONTHS
1. Control-Gravel Hot Mix Type 1	76	97
2. Open Graded Gravel Mix	70	88
3. Expanded Clay Hot Mix Type 4	86	104
4. Louisiana Sand Asphalt	80	-
5. Kentucky Sand Asphalt	85	108
6. Crushed Gravel Plant Mix Seal (95% Crushed)	68	86
7. Expanded Clay Plant Mix Seal	62	81
8. Slag Plant Mix Seal	54	76
9. Expanded Clay Slurry Seal (La.)	85	108
10. Granite Slurry Seal	82	111
11. Crushed Gravel Plant Mix Seal (75% Crushed)	58	81

APPENDIX "B"

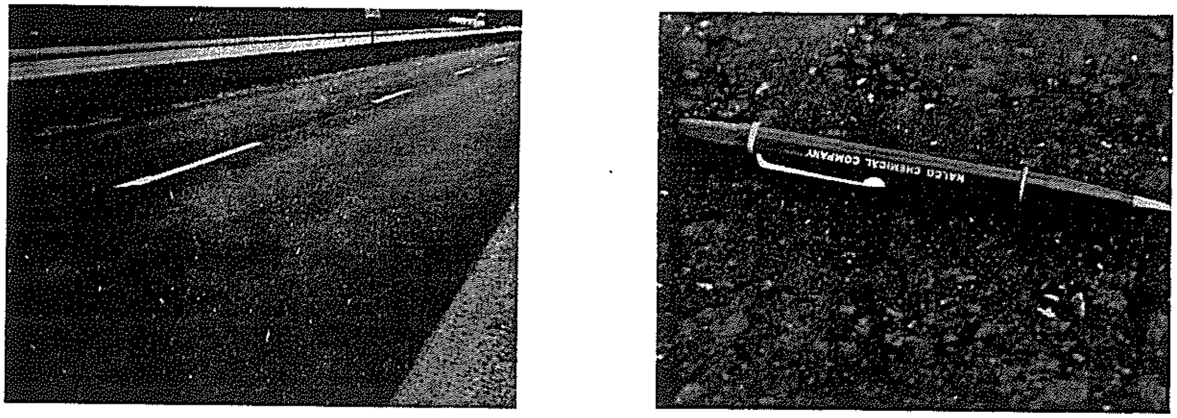
PHOTOGRAPHS OF THE VARIOUS TEST SECTIONS



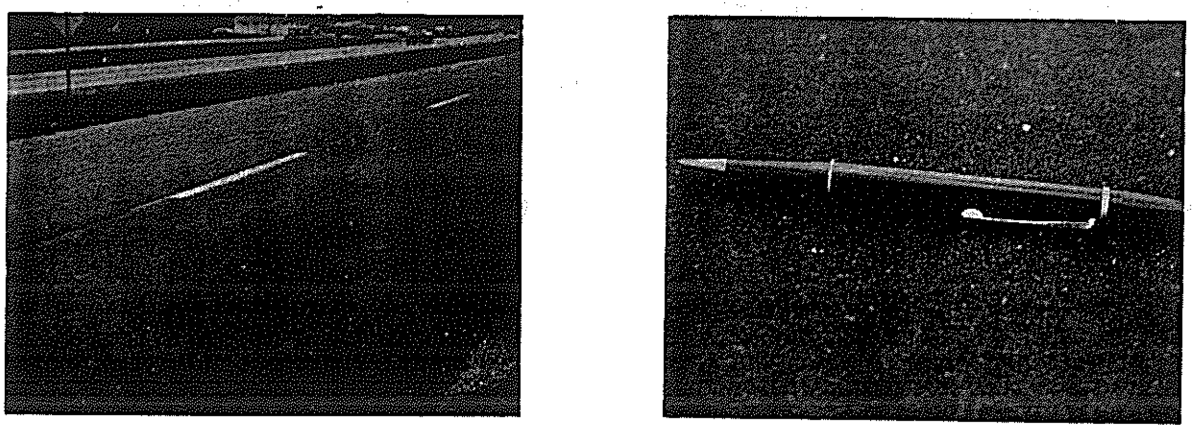
Section 1- Type 1 Crushed Gravel Mix



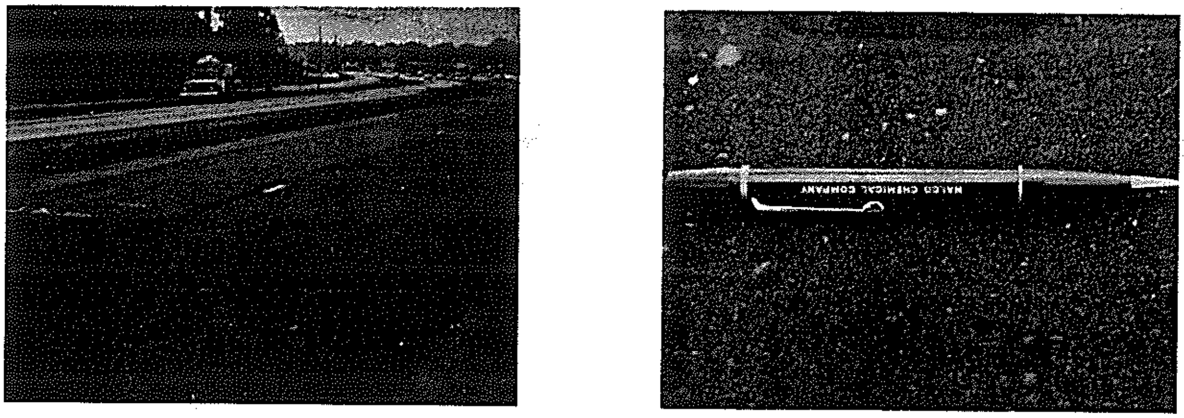
Section 2- Open Graded Crushed Gravel Mix



Section 3- Type 4 Expanded Clay Hot Mix

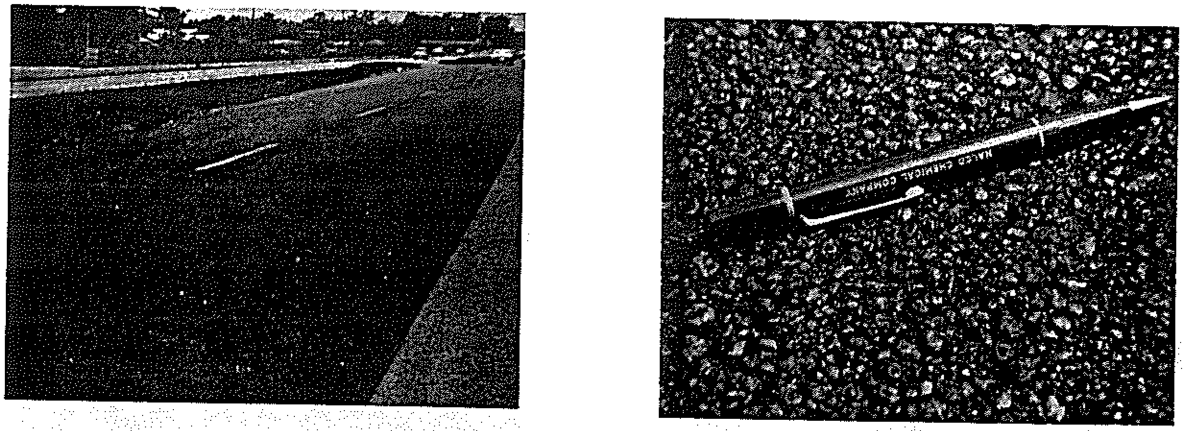


Section 4- Louisiana Sand Asphalt



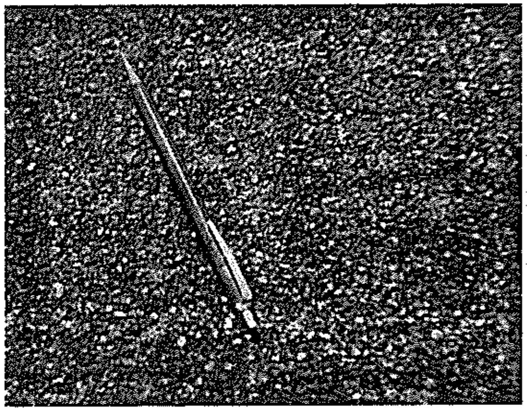
Section 5- Kentucky Sand Asphalt

Section 6- Crushed Gravel Plant Mix Seal

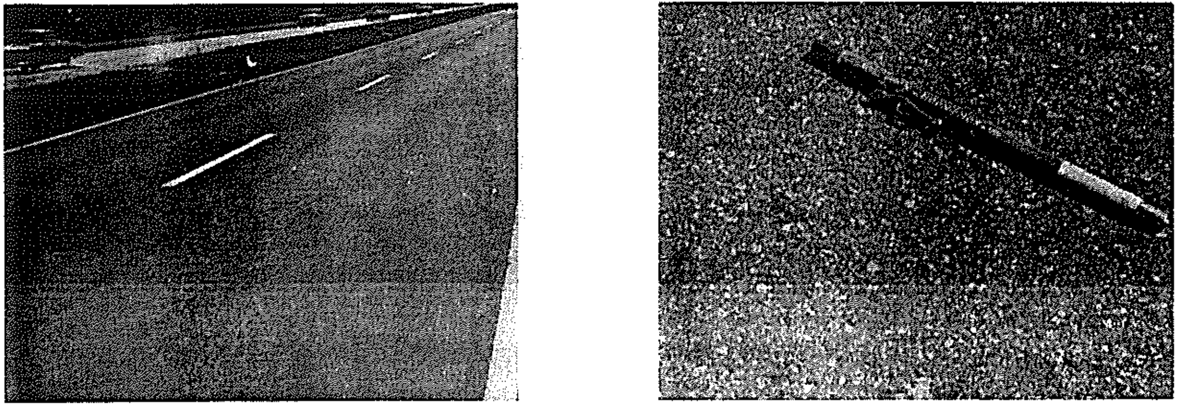


Section 7- Expanded Clay Plant Mix Seal

Section 8- Slag Plant Mix Seal



Section 9- Expanded Clay Slurry Seal



Section 10- Granite Slurry Seal

order of 50 percent of its original value. Consequently, if the design live load of the structure is at least equal to the dead load, heat straightening may be performed without shoring by removing (or controlling) the live loads. In addition, most heat-straightening procedures require that only a part of the cross section be heated. At any given time the average yield stress through a section will therefore be even greater than 50 percent of its original value. As a result, many applications of heat straightening can be safely completed without shoring. However, an engineer familiar with the live and dead load stress distributions should evaluate whether shoring should be used.

Fable.--Heat straightening permanently weakens a steel structure.

Fact.--Two criteria are usually used as a measure of steel strength: yield stress and maximum tensile stress. A number of researchers have measured the yield stress after the heating/cooling cycle of heat straightening to determine the modified characteristics. A summary of these test results is shown in Table 1. The tests on various types of steel represent over 50 specimens from nine investigations. It is apparent from this collection of data that in the long term, the heat-straightening process has a negligible effect on the yield stress when heating temperatures are kept below 1300°F. A similar conclusion can be drawn from an evaluation of the maximum tensile stress. Shown in Table 1 are results for maximum tensile stress corresponding to those for yield stress. Again, these changes are negligible. It should be noted that in most of the test results reported, the stress was measured on samples from the same piece before and after heating. These initial yields were used as the nominal values unless they were unavailable. In general, these initial values were larger than the rated stress for the grade in question. Therefore, the assumption of an unchanged yield and maximum tensile stress after heat straightening is indeed a valid one for all grades of steel as long as the temperature is limited to the practical working range of 1100° to 1300°F.

One early study (18) reported that flame cambering weakened I-beams. However, later discussions (29) indicated that the failure criteria was improperly applied, thus negating this conclusion.

Fable.--Heat straightening reduces steel ductility to unacceptable levels.

Fact.--Ductility is an index of the ability of steel to deform in the inelastic range. It is usually expressed as a percentage by comparing the difference between an initial gage length and its length after tensile fracture to the initial gage length. Ductility is important because it allows redistribution of high local stresses. Shown in Table 1 are comparisons of ductility before and after heat straightening. These data show that there is indeed a 10 to 20 percent decrease in ductility after heat straightening. While these changes in ductility characteristics are significant, the magnitude of the reduction is not large. However, all steel grades have demonstrated adequate ductility in field applications. As such, the measured reductions in ductility after heat straightening are small enough to be of little concern in normal construction applications.

FRACTURE CHARACTERISTICS

Fable.--Heat straightening produces brittle "hot" spots and thus should be avoided.

<u>Fact</u>.--The primary cause of brittle failures in steel is usually associated with geometrical discontinuities such as a sharp discontinuity or notch. Since heat straightening produces no new discontinuities, geometry would not be a factor in evaluating brittle-resistance. However, two other factors which influence brittleness--large strain rates and cold working--are often found during the damage inducement stage. To evaluate its fracture sensitivity, various researchers have tested heat-straightened steel. The resistance to fracture in the presence of a notch is widely used as a guide to the performance of steels in structures susceptible to brittle fracture.

The Charpy V-notch test is one of the most commonly used. A small rectangular bar with a V-shaped notch at its mid-length is simply supported at its ends as a beam and fractured by a blow from a swinging pendulum. The amount of energy required to fracture the specimen is calculated from the height to which the pendulum raises after breaking the specimen. The data are taken at a range of temperatures and a plot of energy versus temperature (on the abscissa) is generated. The resulting curve is S-shaped with an upper-limit asymptote of energy absorption as the temperature increases and a lower-limit asymptote as the temperature becomes small. These limits are referred to as the upper and lower shelf. One measure of brittleness is the upper energy limit. As can be seen from Table 1, there is no significant change in the upper-shelf energy absorption before and after the heat-straightening process for any grade of steel.

A second measure of the notch toughness can also be obtained from the Charpy tests. As shown in Table 1, the temperature at which 50 percent of the upper shelf energy was absorbed, T_{50}, is tabulated in terms of the difference between T_{50} and the nominal T_{50}. Positive differences represent a decrease in notch toughness, while negative numbers represent an increase. There is a considerable variation within a given steel grade. However, the average values indicate that only the high-strength, low alloy steels have a significant positive shift (32°F) and even this is relatively small.

Another measure of notch toughness is the fracture transition temperature. This temperature is the one in which the percentage of shear fracture is 50 percent of the cross section. Since plastic deformation is associated with shear fracture, a rating of the brittle-fracture resistance is obtained. Pattee et al. (47) used this criteria in evaluating several grades of steel that had been heat-straightened. The drop weight tear test was used instead of the Charpy test with the results also shown in Table 1. The fracture transition temperature changes are modest for all cases except the A517-A steel. Here there is a significant positive shift indicating a larger fracture sensitivity. It is interesting to note that a similar situation did not occur with the heat-treated constructional alloy steels given in Table 1.

In addition to the Charpy tests, Rockwell hardness tests have also been used on heat-straightened steel specimens. Changes in surface hardness before and after heating would indicate changes in mechanical properties. Pattee et al. (47) conducted Rockwell hardness tests on a range of steels from mild to constructional alloys. Harrison (26,28) conducted similar tests on mild steel specimens. Seven specimens compared by Pattee et al. had differences of less than six percent except for one specimen with a 15 percent difference. A comparison of 18 readings by Harrison taken within the heated vee portion of the two specimens showed a 3-percent difference or less. Both researchers found that the hardness values did not change appreciably before and after heat straightening.

An overview of the research data offers no basis for concluding that heat straightening should be avoided because of brittle-fracture concerns. Rather, it can be concluded that such strength reductions, if they exist, are minor.

Fable.--Fracture-critical members cannot be heat-straightened.

Fact.--Fracture-critical members are tension members, or tension components of members, whose failure would be expected to result in the collapse of the structure. Current research data such as shown in Table 1 provide no grounds for excluding fracture-critical members from heat straightening. Rather, results in this table provide there is strong and consistent evidence that properly executed heat straightening has no degrading effect on mild carbon steels and only minor effects on high-strength steels. Strength and brittleness aspects have already been discussed. The only other failure possibility of concern is fatigue.

Only one series of fatigue tests on flame-straightened members was found in the literature (2). In this case, three eye bars of A-7 steel were heat-shortened and then fatigue-cycled. When compared to similar specimens which had not been heated, the fatigue strength at both 500,000 and 1,000,000 cycles were similar. Although data is sparse, there is no indication that carbon steels will have a shortened fatigue life after heat straightening. However, more research is needed to evaluate this important aspect.

Shanafelt and Horn (55) have recommended that heat straightening be avoided on fracture-critical members without offering any justification other than conservatism. Since there is no hard evidence to justify the avoidance of heat straightening, the questions is not whether fracture critical members can be heat-straightened, but rather should they.

At this time there is one critical factor that must be considered. One ingredient is missing in heat-straightening technology: engineering analysis tools. The more accurate the analysis, the less conservatism is required. At present heat straightening is in the hands of the contractor. Even with guidelines such as Reference (55), the engineer has practically nothing similar to the analytical tools usually associated with structural engineering. For example, criteria as to number, location and angle of vee heats; effects of internal restraints; control of external restraints such as jacking; and effect of residual stresses have not been developed into analytical tools. As a consequence, even though evidence indicates that heat straightening can be used for fracture-critical members, it should probably not be used until more engineering control is available through analysis/design procedures.

TEMPERATURE CHARACTERISTICS

Fable.--Temperature is unimportant in heat straightening as long as the steel does not glow "red-hot."

Fact.--Because of the deleterious effect of high temperature on steel, the engineering community has tended to reject the heat-straightening method as a viable repair alternative. For example, a survey of 35 state transportation departments (55) indicated that only about one-half use heat straightening to repair steel bridges and only one-quarter use it more than occasionally. As a consequence, much of the research to date has addressed the effect of temperature on structural properties. Most structural steels used in the United States are carbon or low alloy steels. The fundamental behavior of all these steels at uniformly elevated temperatures is believed to be the same. The molecular structure remains unchanged at temperatures below the transition temperature of 1330°F (723°C). In average light, a very faint red glow will be visible at or around this point. As temperatures are increased above the transition temperature, molecular changes occur and the color brightens until the classic "red-hot" level is reached at around 2000°F. As long as the temperature changes occur slowly and uniformly throughout the member, cooling produces a complete reversal to the original molecular state without mechanical property changes. However, if the cooling is too sudden, phase reversal may not occur and brittleness or other property changes may result. In addition, concentrated applications of elevated temperature to small areas may produce permanent property changes, unusual residual stress patterns, and strain history retention. Control of temperature is therefore one of the most important aspects of heat straightening.

Fable.--Each grade of steel has a narrow temperature range for producing the heat-straightening effect and temperatures above or below this range will neither increase nor decrease the contraction effect.

Fact.--Theoretical studies considering perfect confinement have suggested that the minimum steel temperature to produce any permanent contraction in mild steel ranges from 450° to 500°F (55). However, Roeder (50,52) has found that a more practical minimum temperature for producing permanent deformations is between 600° to 700°F.

Above this minimum, investigators have differed as to the effect of temperature level on expected plastic rotation or permanent movement. The comprehensive testing program by Roeder (50,52) has shown that the resulting contraction from vee heats is directly proportional to the heating temperature up to at least 1600°F and is repeatable. It is likely that earlier researchers reached an erroneous conclusion on this limiting temperature because of a lack of test data combined with the fact that heat straightening does not lend itself to theoretical modeling where the conditions of restraint and heating are not ideal. The range of temperatures for heat straightening is quite large (600° to 1600°F), with the degree of movement proportional to the temperature.

Fable.--There is no ideal temperature for heat straightening.

Fact.--The ideal temperature for heat straightening depends on the grade of steel and type of heat. For carbon and low alloy steels, the theoretical limit is the phase transition temperature of 1330°F (50,52). For the constructional alloy steels, the limiting value is the tempering temperature of 1150°F (55). However, heat-straightening experiments at levels up to 1600°F for carbon steels (50,52) and 1300°F for constructional alloy steels (53,54) have been conducted without serious detrimental effects on the material properties (see Table 1). In addition, theories suggest that heats above a specified value will not increase the amount of straightening (55). Although experiments have shown that these theoretical maximums (which are based on simplifying assumptions) are too low (50), it is likely that practical limits do not greatly exceed the transition temperature. Researchers (50,52,55) have also observed that heats above the transition temperature have an inclination to produce: (1) out-of-plane distortion, (2) plate buckling, and (3) pitting and surface damage to the steel.

Taking all of these aspects into consideration, the consensus of researchers is that a temperature of about 1200°F should be used for carbon and low alloy steels while 1100°F should be used for constructional alloy steels. These values provide a safety factor of 200 to 400 degrees to account for operator errors and also produce relatively large movements as a result of the heat-straightening process.

Fable.--Temperature cannot be controlled manually to the degree necessary for heat straightening to become an accepted engineering procedure.

Fact.--The degree to which temperatures can be controlled by practitioners is an important consideration. Factors affecting the temperature include: size of the torch orifice, intensity of the flame, speed of torch movement, and thickness of the plate. Roeder (50,52) made careful temperature measurements and used experienced practitioners to make the vee heats in his experiments. He found that these practitioners, when judging the temperature by color, commonly misjudged by 100°F and in some cases as much as 200°F. The use of temperature-indicating crayons can be helpful. However, the flame tends to distort the results by blackening the crayon marks. The marks can be placed on the back side but this does not allow for the operator to see the results and make adjustments during the heating process. Contact pyrometers have not been widely used and tend to give erroneous results (55). Experiments by Graham (25) indicated that pyrometers gave readings of approximately 200°F below the value indicated by temperature crayons. Tests conducted by the writers verified that a contact pyrometer will give temperature values of 200°F below the actual. Thus, pyrometers must be calibrated for use in heat-straightening applications.

In practice, the most common procedure to determine temperature is by the color of the material adjacent to the tip of the torch. Since background lighting will influence this color, temperature crayons should be used to correlate the lighting to the color of the steel. In normal daylight or interior lighting conditions, a 1200°F temperature will be indicated by a satiny silver color near the torch tip. After cooling, the area should be gray in color. A cherry-red color during heating or a black color after cooling indicates that the heat was too hot. With little training, it is not unreasonable to expect practitioners to be able to meet tolerances of ± 200°F. This tolerance level can be reduced to ± 100°F with checks using temperature crayons or pyrometers. This obtainable level of accuracy should not limit the application of heat straightening in practice.

Fable.--Quenching should never be used to cool the steel after heat straightening.

Fact.--As can be seen from Table 1, quenching has been used on carbon, low alloy, and constructional alloy steels without adverse effects (53,54). In addition, Roeder's studies (50,52) showed that quenching increased the plastic deformation significantly. The advantage of quenching is that it allows for a rapid repetition of the heating/cooling cycle, thus expediting the repair. If quenching is used, care should be taken to ensure that temperatures remain below the transition temperature. Measurements by the writers have shown that the steel temperature at the tip of the torch (initially at 1200°F) drops approximately 200°F during the first few seconds after the torch is moved. Within 30 seconds, an additional 100°F decrease typically occurs (24). Roeder (50,52) has recommended that if quenching is used, it be applied at 30 seconds after completion of the heat to insure that temperatures are well below the phase transition temperature of the steel. Evidence thus indicates that quenching can be used with proper care in controlling the heating temperature.

APPLICATIONS FOR STRUCTURAL ELEMENTS

Fable.--While heat straightening may work under controlled laboratory conditions or in uncontrolled field applications, there are no documented field studies in which parameters were carefully measured and controlled.

Fact.--Moberg (41) has been the only investigator to conduct a controlled field study of heat-straightening repair for damaged members. Careful daily measurements were recorded on the Bothwell bridge in the state of Washington which was hit by an over-height vehicle. The initial damage was measured and daily measurements were taken as heat-straightening progressed. The restraining forces used were also carefully recorded. This work illustrated that heat-straightening repairs can be engineered.

Fable.--Heat straightening only works for simple bends of single curvature.

Fact.--Vee heats are used primarily for strong axis curvature correction in plate elements, while line heats and spot heats are used for weak axis corrections. Practically any type of damage can be heat-straightened. A vee heat produces a sharp point of curvature of small magnitude at the apex of the vee.

Since the plastic deformation is restricted primarily to the area of the vee heat (45,50,52), the angle change is a convenient measure of the distortion. This angle is shown in Figure 5 and will be referred to as the plastic rotation, ϕ. To produce a visually smooth curve over the length of the plate, a series of vee heats spaced along the length can be utilized. While in reality this approach will produce a series of discrete curvatures, the small angle changes will give the appearance of a smooth curve. By alternating the direction of the vees and varying the spacing, practically any type curvature (sharp, gradual, single, or multiple) can be removed. Since each heat produces small changes in curvature, a number of heating/cooling cycles are usually required to completely straighten a damaged member. In a similar manner, line and/or spot heats can be used to remove weak axis damage such as bulges or buckles.

Fable.--Heat straightening only works on thin plates.

Fact.--The bulk of the experimental data on vee heating plates can be found in two studies by Nicholls and Weerth (45) and Roeder (50,52), plus current work by the writers (8). In each of these investigations a number of plates were vee-heated and the deformations measured. Researchers have generally considered plate thickness to have a negligible effect on plastic rotation. The only reservation expressed has been that the plate should be thin enough to allow a relatively uniform penetration of the heat through the thickness (55). The practical limiting value is on the order of 3/4 to 1 inch. Thicker plates can be

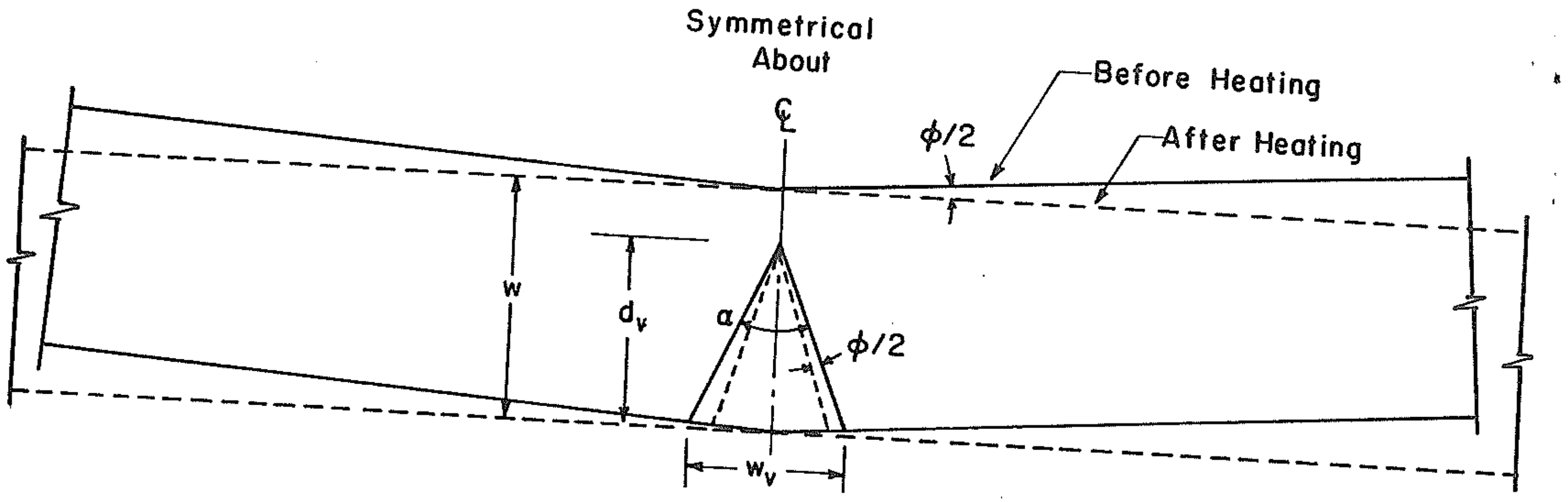


Figure 5. Vee heat geometry.

heated on both sides simultaneously to ensure a uniform distribution through the thickness. Members with cover plates usually require heating from both sides because of the interface. Results from the heating of plates with varying thicknesses as taken from current work by the writers and references (45,50,52) are shown in Figure 6 for various vee angles heated from 1100° to 1300°F. Also plotted is a second order parabola least squares curve fit for each thickness. The variations appear random, indicating that thickness is not a factor which influences plastic rotation during heat straightening as long as the heat fully penetrates the thickness.

Fable.--While heat straightening may work for simple plate elements, bends in rolled shapes are too complex for a rational approach.

Fact.--A wide variety of rolled shapes, including wide flanges, channels, angles and assemblies, have been straightened (or curved) in both laboratory (16,26,28,35,43,47,48,50,52,53,54) and field applications (17,20,22,26,28,30,31,32,37,41,42,43,46,49,56,57,59,61). Rolled shapes generally require a vee heat in combination with a rectangular heat. The rectangular heats are necessary because of the perpendicular planes of the plate elements forming the shape. A set of typical heating patterns (32) are shown in Figure 7. By using the proper pattern of vee and rectangular heats, sweep, camber, or twisting type of movements can be obtained resulting in repair for a wide variety of damage conditions. While there is general agreement on the vee pattern, there have been no published studies directed toward quantifying the optimum heating patterns for rectangular heats in combination with the vee.

RESTRAINING FORCES

Fable.--Internal and external restraining forces are unimportant in heat straightening.

Fact.--Of equal importance to temperature are the constraints and forces acting on the member during the heat-straightening process. Practitioners have recognized this fact and usually employ some type of jacking or constraining force. The basic principle is that an applied force in the direction of the desired movement will impede the reverse expansion during the heating phase, increase the plastic strain, and thus produce more contraction during the cooling phase. Experiments show that the application of external forces can have a significant effect on the amount of plastic rotation that occurs in a plate. A series of tests was conducted by the writers in which various levels of external force were applied to a plate. The force applied produced a bending moment about the major axis, tending to close the angle of the vee. For comparison purposes, the moment is non-dimensionalized by computing the load ratio, which is the ratio of the moment at the vee due to the applied load to the plastic moment capacity of the section, M/M_p. Nicholls and Weerth (45,60) and Roeder (50,52) also measured the behavior of vee-heated plates for various load ratios. Their results, along with those of the writers, are plotted in Figure 8. A second order parabolic regression analysis for each vee angle and load ratio producing a least squares curve fit is also plotted. The curves are nearly linear with respect to vee angle and reflect that the plastic rotation is proportional to the load ratio and is fairly linear.

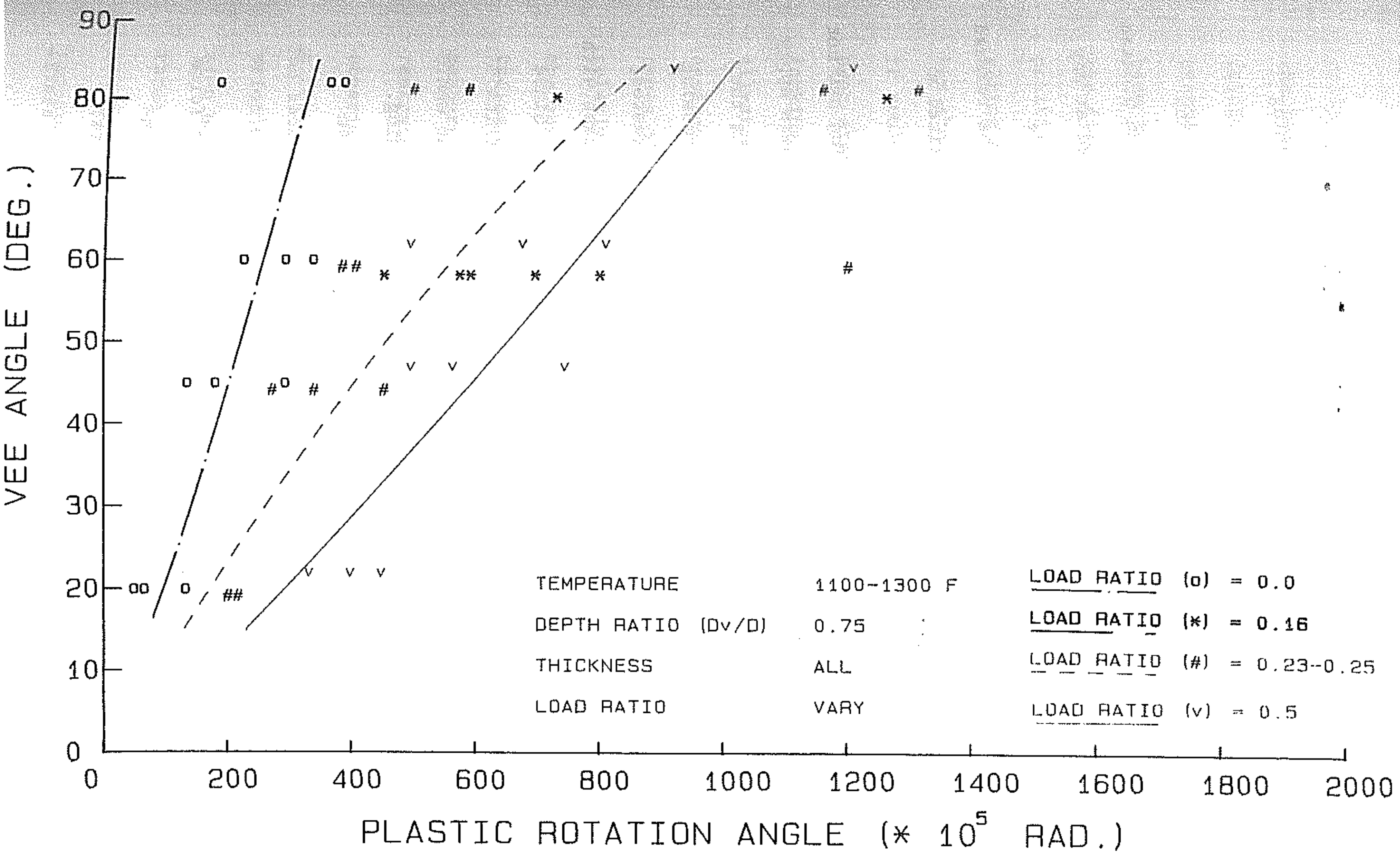


Figure 8. Vee heat angle vs. plastic rotation for vee-heated plates with variations in the load ratio (8,45,52).

It can be seen from these results that there is a distinct advantage to using an external force during the heat-straightening process. However, the constraining force should be used as a passive force rather than an active force once the heating has begun. The standard procedure is to apply the external force first and then proceed with the vee heats. The external force should not be increased at any time during the heating and cooling process. However, it can be adjusted to maintain the original level, since the force will be relaxed as contraction takes place. All the test data shown here utilized a constant force during the entire process.

The level of the constraining force for a given application has not been addressed in the literature. Apparently, most practitioners apply the force by "feel." The primary limit on the external force is the buckling capacity of the vee area during the heating or overstressing when the yield stress is reduced by the heat. For the plates tested, some buckling difficulties have been encountered only for the case with a combination of the largest vee angle and largest load ratio. Since the yield stress is typically reduced to approximately one-half its original value when heated to 1200°F, a load ratio of 50 percent would be a theoretical upper limit to avoid hot mechanical straightening.

Fable.--Heat straightening is unlikely to be developed as an engineering process because sometimes a properly heated member does not straighten.

Fact.--In addition to external restraints, a second type of force must also be considered in many structures, that is, internal constraints. These constraints are a result of structures which are: (1) carrying some load (e.g., dead load) during heating, and (2) statically indeterminate. Since many structures are partially loaded during the heat-straightening process, a structural evaluation is required to determine whether the loading will be beneficial or harmful. For example, three types of damage are shown in Figure 9 for a wide flange beam subjected to a gravity loading. For case (a) the loading acts in the direction of the desired straightening and therefore will have a positive effect during heat straightening. For case (b) the loading is acting in the opposite sense of the desired movement. Roeder (50,52) has shown that not only will the straightening process be impeded, but it could well be reversed such that the damage gets worse. Successful heat straightening on such members would require an upward external jacking force to overcome the negative gravity load influence. Case (c) illustrates an example where the loading effect is neutral since the desired movement is perpendicular to the direction of loading. Other types of internal constraints are more subtle in their effects, particularly those associated with static indeterminancy. A good example is the case where a damaged member is restrained axially against longitudinal expansion, as typified by indeterminate frames or compression members in trusses. In order to evaluate the effect of an axial restraint, a series of tests was conducted on plate elements (8). A superimposed axial load was applied through a hydraulic jack to produce a ratio of axial load to yield load of 56 percent. The load was applied prior to heating and the jack acted to prevent any longitudinal expansion but not contraction. The resulting curves (based on averaging three single vee heats) are shown in Figure 10 for a 60° vee. The axial constraints produce a significant increase in the plastic rotation when compared to an identical plate without the axial restraint.

complained of vibration from trucks, and the fact that the street was frequently used as a "gangway" for cars and motorcycles at night.

Both owners of the Valentine comparables said their homes were in excellent condition at time of sale. 2420 Valentine is on a corner and 2721 Valentine is exceptionally well landscaped.

The average variance in the actual sales prices of this limited sample was nill, and with the lot adjustment was 1.2%. But, the sales were an average of 5.7 months before the sale of the Holiday Drive house. Values were increasing at an average monthly rate of .81% according to our research; therefore, there would have been 4.62% difference in addition to the 1.2% or 5.82% less sale price for the house on Holiday Drive, or a probable variance of approximately 6%.

The sale of 2542 Prancer in November, 1977, for $75,900.00 was not considered because it had a swimming pool.

INDIVIDUAL SALES PRICE COMPARISON BY HOUSES

MODEL C - 2524 HOLIDAY DRIVE

SALE, OCTOBER, 1977 - $58,500.00 - LOT 86' x 110'

DATE	ADDRESS	PRICE	ABSOLUTE VARIANCE %	LOT SIZE	EST. PRICE W/LOT ADJ.	ADJUSTED VARIANCE %
10-76	2136 Comet	$52,400	-10.4	65 x 100	$55,500	- 5.7
11-76	2613 Valentine	$53,000	- 9.4	65 x 100	$56,100	- 4.1
11-76	2110 Valentine	$47,046	-19.6	65 x 100	$50,146	-12.6
11-76	2608 Comet	$53,000	- 9.4	60 x 100	$56,900	- 2.7
3-77	2310 Beck	$56,000	- 4.3	62 x 99	$62,100	+ 6.2
3-77	2728 Valentine	$60,500	+ 3.4	65 x 100	$63,650	+ 8.8
4-77	2220 Beck	$52,500	-10.3	64 x 97	$55,900	- 4.4
5-77	2133 Easter	$48,500	-17.9	86 x 104	$48,500	-17.9
5-77	2253 Beck	$52,500	-10.3	60 x 100	$56,400	- 3.6
6-77	2100 Beck	$53,600	- 8.4	64 x 94	$57,000	- 2.6
7-77	2201 Valentine	$53,000	- 9.4	79 x 100	$54,100	- 7.5
7-77	2701 Valentine	$54,000	- 7.7	64 x 100	$57,300	- 2.1
7-77	2640 Comet	$54,000	- 7.7	60 x 100	$57,900	- 1.0
7-77	2634 Prancer	$52,000	-11.1	60 x 100	$55,900	- 4.4
11-77	2476 Prancer	$60,000	+ 2.6	61 x 117	$63,750	+ 9.0
11-77	2145 Beck	$52,000	-11.1	63 x 100	$55,400	- 5.3
11-77	2545 St. Nick	$50,235	-14.3	60 x 102	$54,100	- 7.5
12-77	2101 Valentine	$58,500	0.0	65 x 100	$61,650	+ 5.4
AVERAGE		$53,488	- 8.6	64 x 100	$56,794	- 2.9

In spite of the fact that the absolute variance in price of the comparables is 8.6% under the price of 2524 Holiday Drive, approximately 5.7% of this is explained by the larger lot of the Holiday Drive house. (The lot width differences are considerable, about twenty-two feet average.) With lot adjustments, the variance is but 2.9% lower for the comparables. Interestingly, the sales took place an average of 4.8 months prior to subject, and the monthly price increase factor is calculated to be .71% or 3.4% for the period. Therefore, the comparables sold for .5% more than the subject after the adjustments which really reflects no significant difference.

The condition of 2524 Holiday Drive at the time of sale was excellent.

INDIVIDUAL SALES PRICE COMPARISON BY HOUSES

MODEL C - 2600 HOLIDAY DRIVE

SALE, NOVEMBER, 1977 - $60,500.00 - LOT 70' x 100'

DATE	ADDRESS	PRICE	ABSOLUTE VARIANCE %	LOT SIZE	EST. PRICE W/LOT ADJ.	ADJUSTED VARIANCE %
11-76	2613 Valentine	$53,000	i2.4	65 x 100	$53,750	-11.2
11-76	2110 Valentine	$47,046	-22.2	66 x 100	$47,646	-21.2
11-76	2608 Comet	$53,000	-12.4	60 x 100	$54,500	-11.6
3-77	2310 Beck	$56,000	- 7.4	62 x 99	$57,200	- 5.5
3-77	2728 Valentine	$60,500	0.0	65 x 100	$61,250	+ 1.2
4-77	2220 Beck	$52,500	-13.2	64 x 97	$53,500	-11.6
5-77	2133 Easter	$48,500	-19.8	86/vd x 104	$48,500	-19.8
5-77	2253 Beck	$52,500	-13.2	60 x 100	$54,000	-10.7
6-77	2100 Beck	$53,600	-11.4	64 x 94	$54,700	- 9.6
7-77	2201 Valentine	$53,000	-12.4	81/73 x 94	$52,400	-13.4
7-77	2701 Valentine	$54,000	-10.7	64 x 100	$54,900	- 9.3
7-77	2640 Comet	$54,000	-10.7	60 x 100	$55,500	- 8.3
7-77	2634 Prancer	$52,000	-14.0	60 x 100	$53,500	-11.6
11-77	2476 Prancer	$60,000	- 0.8	58/68 x 117	$61,200	+ 1.2
11-77	2145 Beck	$52,000	-14.0	63 x 100	$53,100	-12.2
11-77	2545 Beck	$50,235	-17.0	59/62 x 102	$52,000	-14.0
12-77	2101 Valentine	$58,500	- 3.3	65 x 100	$59,250	- 2.1
AVERAGE		$53,552	-11.5	63.5x100	$54,523	- 9.9

The owner of 2600 Holiday Drive reported that the house was very clean and needed no repainting or repairs at the time of purchase. Additionally, there was a wet bar in the den and the patio was covered, which partially accounts for the 11.5% higher sales price of this house over the comparables. The lot value differential (figured at 50% of retail due to the fact that the added width is considered excess) accounts for an average of 1.6%. The market for this house indicates at that time, a monthly average resale price increase of .71% and the average time of sale is 5.35 months prior to the sale on Holiday Drive. Therefore, time accounts for another 3.8% of the difference. The lot size and time adjustments total 5.4% before consideration of the wet bar and patio cover. Probably, the Holiday Drive house actually sold after all adjustments at about 3% above the comparables.

INDIVIDUAL SALES PRICE COMPARISON BY HOUSES

MODEL C - 1940 HOLIDAY DRIVE

SALE, SEPTEMBER, 1975 - $47,000.00 - LOT 76' x 100'

DATE	ADDRESS	PRICE	ABSOLUTE VARIANCE %	LOT SIZE	EST. PRICE W/LOT ADJ.	ADJUSTED VARIANCE %
9-74	2613 Valentine	$51,996	+10.6	65 x 100	$53,650	+14.1
10-74	2575 Valentine	$49,000	+ 4.3	62 x 100	$51,100	+ 8.7
10-75	2318 Comet	$44,000	- 6.4	62 x 100	$46,100	- 1.9
3-75	2711 Prancer	$43,943	- 6.5	60 x 100	$46,350	- 1.4
6-75	2563 Prancer	$46,345	- 1.4	60 x 100	$48,750	+ 3.7
6-75	2546 St. Nick	$41,904	-10.8	60 x 100	$44,000	- 6.4
7-75	2601 St. Nick	$45,978	- 2.2	60 x 100	$48,400	+ 3.0
7-75	2220 Beck	$44,753	- 4.8	64 x 97	$46,550	- 1.0
7-75	4400 Copernicus	$43,462	- 7.5	75 x 100	$43,600	- 7.2
8-75	2100 Comet	$43,000	- 8.5	65 x 100	$44,650	- 5.0
9-75	2371 Beck	$44,000	- 6.4	96 x 118	$41,000	-12.8
10-75	2129 Beck	$44,700	- 4.9	63 x 100	$46,650	- 0.7
10-75	2145 Beck	$42,750	- 9.0	63 x 100	$44,700	- 4.9
10-75	2701 Valentine	$46,000	- 2.0	64 x 100	$47,800	+ 1.7
11-75	2010 St. Nick	$43,000	- 8.5	60 x 100	$45,400	- 3.4
1-76	2035 Comet	$44,000	- 6.4	63 x 100	$45,950	- 2.2
3-76	2591 Valentine	$50,000	+ 6.4	62 x 100	$52,100	+10.5
3-76	2240 St. Nick	$44,650	- 5.0	63 x 101	$46,600	- 0.9
4-76	2522 Prancer	$46,250	- 1.6	69 x 120	$47,300	+ 0.6
4-76	2401 St. Nick	$50,500	+ 6.4	63 x 114	$52,450	+11.6
6-76	2253 Beck	$48,000	+ 2.1	60 x 100	$50,400	+ 7.2
7-76	2129 Comet	$49,500	+ 5.3	63 x 100	$51,450	+ 9.5
8-76	4134 Copernicus	$50,000	+ 7.5	57 x 100	$52,850	+12.4
8-76	2139 Mediamolle	$51,500	+ 9.6	64 x 96	$53,300	+13.4
AVERAGE		$46,218	- 1.7	64.4x100	$47,963	+ 2.0

The twenty-four houses in the sample show that the house at 1940 Holiday Drive sold for 1.7% more than the average of the comparables. After adjusting for the difference in lot size at 50% of the retail lot value, the comparables on the average sold for 2% more. The time spread is such that the average house sold for two-thirds of a month later than the property on Holiday Drive which would liquidate about 0.5% of this 2% leaving a resultant 1.5% lower price for the Holiday Drive house. Some of the comparables are known to have been in excellent condition at the time of sale and the subject house was apparently only in fair condition. Since the purchase, the buyers repainted the inside and replaced the garbage disposal. The outside presently needs paint.

Any conclusion as low as 1.5% can hardly be considered a reliable indication of the adverse effect of noise based upon this sample. The market and the individual conditions of the properties could easily account for even more than this difference.

The following sales were eliminated from the sample for the reasons indicated:

1. 4128 Fiesta sold in July, 1975 for $55,251 with lot 77/96' x 100' because it had a finished garage.

2. 2661 Gallinghouse sold in June, 1976 for $55,923 on lot 60' x 100' because it had an addition built thereon.

INDIVIDUAL SALES PRICE COMPARISON BY HOUSES

MODEL D - 2576 HOLIDAY DRIVE

SALE, NOVEMBER, 1976 - $53,000.00 - LOT 70' x 100'

DATE	ADDRESS	PRICE	ABSOLUTE VARIANCE %	LOT SIZE	EST. PRICE W/LOT ADJ.	ADJUSTED VARIANCE %
11-75	2642 St. Nick	$47,500	-10.4	60 x 100	$49,000	- 7.5
6-76	2732 Valentine	$48,800	- 7.9	60 x 100	$50,300	- 5.1
6-76	2554 St. Nick	$51,300	- 3.2	60 x 100	$52,800	- 0.4
6-76	2642 St. Nick	$52,367	- 1.2	60 x 100	$53,867	+ 1.6
2-77	2643 Prancer	$50,000	- 5.7	60 x 100	$51,500	- 2.8
5-77	2709 Comet	$58,350	+10.1	60 x 100	$59,850	+12.9
5-77	2599 Valentine	$53,500	- 0.9	62 x 100	$54,700	+ 3.2
7-77	2428 Prancer	$59,000	0.0	65 x 121	$59,750	+12.7
7-77	2624 Comet	$58,000	+ 9.4	60 x 100	$59,500	+12.3
AVERAGE		$53,202	+ 0.4	61.5x100	$54,474	+ 2.8

The pattern formed by the sales used for comparison with 2576 Holiday Drive is interesting in that it clearly reflects the great rate of inflation of 1977. The spread of the sales is such that the average sale took place .5 months after the Holiday Drive sale. The average percentage of resale increase for all Model D houses resold since 1973 was 8.15% however, those sold from June of 1976 through the end of 1977 averaged 10.96% annual resale increase. Therefore, the time adjustment would be -.46% on the comparables, produci a variance after lot size and time adjustments of 2.3% higher sales price for the comparables than for the subject house.

This is hardly significant because of the condition of 2576 Holiday Drive at the time of The owner indicated that, at the time of purchase, the house needed exterior paint new carpet upstairs. Both the air conditioner and dishwasher needed replacement. The n and stove needed repairs. Also, the yard had little landscaping. Because the sale was de by owner, there was no real estate commission involved. The owner was a naval icer who had been transferred, and there was probably some pressure to hurry the sale.

The property at 2374 Beck Street on lot 60' x 100', which sold for $61,500 in June, 1977, eliminated because it had a swimming pool.

Considering the condition of the Holiday Drive house at time of sale, the conclusion that the comparables sold at about the same figure as the Holiday Drive house, indicating diminution due to noise.

INDIVIDUAL SALES PRICE COMPARISON BY HOUSES

HOLIDAY DRIVE HOUSES ELIMINATED

MODEL A - 2700 Holiday Drive sold in February 1973, for $55,500 on lot 80' x 100'. attempt was made to compare this with interior comparables because this property had a mming pool.

MODEL A - 2544 Holiday Drive sold in September 1974, for $41,319 on lot 70' x 100'. was a sale from a succession, and the executor indicated that the sale was not a normal 's length sale, but rather was a "give away".

C. Frequency of Resales On and Off Boulevard

The rate of turnovers for 1973 – 1977 was determined for the twelve streets in the study area in addition to Holiday Drive. Holiday Drive, with a 65% turnover (10.83% per annum), ranked with the fifth lowest street in the area. There were seven streets with higher rates of transfer, one as high as 97% (16.17% per annum).

STREET	NO. OF LOTS	NO. OF TRANSFERS	TOTAL TURNOVER RATE	TURNOVER RATE PER ANNUM
Holiday (east side excluding four new homes)	40	26	65%	10.83%
Mediamolle	31	30	97%	16.17%
Beck	66	59	89%	14.83%
Copernicus	21	18	86%	14.33%
Comet	76	60	79%	13.17%
St. Nick	100	72	72%	12.00%
Valentine	99	69	70%	11.67%
Gallinghouse	30	20	67%	11.17%
Fiesta	20	13	65%	10.83%
Prancer	69	43	62%	10.33%
Easter	48	25	52%	8.67%
Vixen	25	11	44%	7.33%
Cupid	34	14	41%	6.83%
AVERAGE OFF HOLIDAY DRIVE				11.44%

D. Resale Percentage Increases

There were three long term resales in the group of subject houses on Holiday Drive and one short swing resale of three months. They are:

ADDRESS	SALES DATE	INCREASE PER ANNUM	
2544 Holiday Drive	9/74 to 12/77	+15.77% *	(1)
2576 Holiday Drive	2/72 to 11/76	+ 5.51%	(2)
2600 Holiday Drive	8/72 to 11/77	+14.35% *	(3)
2700 Holiday Drive	2/73 to 5/73	+10.26%	(4)
AVERAGE		+ 7.89%	

The average annual resale increase for all houses resold in the interior of this subdivision since 1973 was 8.22%. (In arriving at this average, resales showing less than an average annual increase of 2.4% or more than 12.5% have been eliminated on the theory that extremes such as this indicate that there had been a change in the condition of the house, unusual circumstances surrounding the sale, or some other extenuating factors.)* As is shown above, of the four resales on Holiday Drive, two were eliminated because they were over 12.5% annual increase. The other two sales average 7.89% increase, or .33% less than the average for all houses in the interior, which is not a significant difference. It should be noted that resales (1) (2) and (3) occurred in the high inflation period after June of 1976, and if they had not been eliminated the average of the four sales would have been 11.47%; and that sale (2) was precipitated by a military transfer. Therefore, this sample is really not large enough to give any meaningful results. However, it cannot be deducted from the resale data that houses on Holiday Drive appreciated in value any less than those in the interior of the subdivision.

Following are the percentages of resale increase tables for each model of the comparables.

PERCENTAGE OF RESALE INCREASE

MODEL A

ADDRESS	DATE	PURCHASE PRICE	DATE	SALE PRICE	AVERAGE PERCENTAGE INCREASE	
					MONTHLY	YEARLY
2358 Beck	8-74	$47,750	3-73	$44,000	.50	6.02
2642 Prancer	5-77	$60,000	3-76	$51,000	1.26	15.13 *
2562 St. Nick	8-77	$63,500	9-75 1-73	$52,000 $43,000	.96 .65	11.54 7.85
2567 St. Nick	5-77	$60,000	7-74 7-72	$43,500 $38,500	1.12 .54	13.39 * 6.49
2732 St. Nick	8-73	$45,502	6-72	$40,500	.88	10.59
4118 Fiesta	5-77	$58,000	3-74	$42,000	1.00	12.03
2539 Comet	1-74	$42,600	7-72	$38,500	.59	7.10

AVERAGE INCREASE

Prior to 6-76		6-76 through 1977	
MONTHLY	YEARLY	MONTHLY	YEARLY
.63	7.61	.98	11.78

* Increases over 1.04% monthly (12.5% annually) and under .20% monthly (2.4% annually) have been eliminated from the averages as being unreasonable, probably caused by extenuating factors.

PERCENTAGE OF RESALE INCREASE

MODEL B

DRESS	DATE -	PURCHASE PRICE	DATE -	SALE PRICE	AVERAGE PERCENTAGE INCREASE MONTHLY	YEARLY
3 Cupid	5-75	$53,400	6-74	$48,500	.92	11.02
1 Valentine	4-77	$62,000	9-75	$46,000	1.83	21.96 *
0 Valentine	2-77	$61,000	3-76	$56,000	.81	9.74
0 Beck	7-77	$63,000	3-76	$49,000	1.79	21.43 *

AVERAGE INCREASE

Prior to 6-76 MONTHLY	Prior to 6-76 YEARLY	6-76 through 1977 MONTHLY	6-76 through 1977 YEARLY
.92	11.02	.81	9.74

* Estimated as unreasonable, probably caused by extenuating factors.

PERCENTAGE OF RESALE INCREASE

MODEL C

ADDRESS	DATE	PURCHASE PRICE	DATE	SALE PRICE	AVERAGE PERCENTAGE INCREASE	
					MONTHLY	YEARLY
2401 St. Nick	4-76	$50,500	6-74	$42,000	.92	11.04
2545 St. Nick	11-77	$50,235	12-72	$38,500	.52	6.20
2601 St. Nick	7-75	$45,978	5-73	$37,723	.84	10.10
2133 Easter	5-77	$48,500	10-73	$38,500	.60	7.25
2100 Easter	9-76	$49,500	3-74	$40,500	.74	8.89
2145 Beck	10-77	$52,000	10-75	$42,750	.90	10.82
			3-74	$40,500	.29	3.51
2100 Beck	6-77	$53,600	10-73	$40,700	.72	8.64
2220 Beck	4-77	$52,500	7-75	$44,753	.82	9.89
			10-73	$42,500	.25	3.03
2129 Beck	10-75	$44,700	8-73	$37,500	.74	8.86
2253 Beck	5-77	$52,500	6-76	$48,000	.85	10.23
			3-73	$37,500	.72	8.62
2101 Valentine	12-77	$58,500	8-73	$39,000	.96	11.54
			2-73	$35,298	1.75	20.98
2201 Valentine	7-77	$53,000	8-72	$39,300	.59	7.09
2613 Valentine	11-76	$53,000	9-74	$51,996	.07	.89
			7-73	$46,900	.78	9.31
2701 Valentine	7-77	$54,000	10-75	$46,000	.83	9.94
			8-72	$37,500	.60	7.16
2575 Valentine	10-74	$49,000	9-72	$41,500	.72	8.67
2110 Valentine	11-76	$47,046	6-74	$44,517	.20	2.35
			6-73	$39,500	1.06	12.70

- continued -

PERCENTAGE OF RESALE INCREASE

MODEL C (continued)

DRESS	DATE	PURCHASE PRICE	DATE	SALE PRICE	AVERAGE PERCENTAGE INCREASE MONTHLY	AVERAGE PERCENTAGE INCREASE YEARLY
Gallinghouse	6-76	$55,923	6-74	$52,073	.31	3.70
			9-73	$47,000	1.20	14.39 *
Copernicus	7-75	$43,462	8-72	$38,312	.38	4.61
			1-72	$34,025	1.80	21.60 *
Fiesta	7-75	$55,251	10-72	$46,500	.57	6.84
36 Comet	10-76	$52,400	8-73	$41,900	.66	7.91
Comet	5-74	$40,945	9-72	$37,500	.46	5.51

AVERAGE INCREASE

Prior to 6-76 MONTHLY	Prior to 6-76 YEARLY	6-76 through 1977 MONTHLY	6-76 through 1977 YEARLY
.60	7.15	.71	8.52

* Eliminated as unreasonable, probably caused by extenuating factors.

PERCENTAGE OF RESALE INCREASE

MODEL D

ADDRESS	DATE -	PURCHASE PRICE	DATE -	SALE PRICE	AVERAGE PERCENTAGE INCREASE MONTHLY	YEARLY
2599 Valentine	5-77	$53,500	7-75	$44,482	.92	11.06
2732 Valentine	6-76	$48,800	7-74	$40,700	.87	10.3[illegible]
2374 Beck	6-77	$61,500	7-75	$48,850	1.13	13.51
2325 Beck	5-75	$45,700	12-73	$43,500	.30	3.57
2428 Prancer	7-77	$59,900	10-75	$49,000	1.06	12.71
2401 Prancer	9-74	$53,000	10-73	$50,087	.53	6.34
2554 Prancer	6-76	$51,300	4-74	$39,900	1.10	13.19
2642 St. Nick	7-76	$52,367	11-75	$47,500	1.28	15.37
			10-72	$37,000	.77	9.20
2538 St. Nick	12-74	$47,223	12-73	$40,000	1.50	18.06
2611 St. Nick	8-74	$44,858	8-72	$40,721	.42	5.08
2624 Comet	7-77	$58,000	12-73	$40,000	1.05	12.56
2709 Comet	5-77	$58,350	10-73	$41,400	.95	11.43

AVERAGE INCREASE

Prior to 6-76 MONTHLY	Prior to 6-76 YEARLY	6-76 through 1977 MONTHLY	6-76 through 1977 YEARLY
.51	6.05	.91	10.96

* Estimated as unreasonable, probably caused by extenuating factors.

IV. Conclusion

A. The study of individual sales tends to indicate a maximum deficiency of value of 2.5% on Holiday Drive due to numerous factors, such as danger from speeding vehicles, unattractiveness of view, fewer trees on Holiday than on interior streets and vibrations, with noise being merely one of these factors. Even so, because of the potential for error in the adjustment factor, because of the poor condition of one of the houses on Holiday Drive and because of the imperfect real estate market, the average deficiency is believed to be closer to 1.5%.

B. The study reveals that Holiday Drive falls midway in the frequency of sale during a six-year period. Therefore, people do not find enough discomfort on Holiday Drive to sell more frequently than on the interior streets.

C. The average rate of value increase on resale of the same houses on Holiday Drive is above the resale percentage average annual increase on the interior houses. Therefore, houses on Holiday Drive apparently do not increase in value at any less a rate than do the houses in the interior. Unfortunately, this is a very limited sample of four houses.

RECAPITULATION

DATE	MODEL	ADDRESS	PRICE	ABSOLUTE VARIANCE %	W/LOT ADJ. VARIANCE %	W/LOT AND TIME ADJ. VARIANCE %	PROBABLE VARIANCE %
12-77	A	2544 Holiday	$62,500	- 2.3	- .2	+ 4.7	+ 2.7
2-75	A	2336 Holiday	$50,000	- 7.3	- 2.8	- 2.8	0.0
2-75	A	2754 Holiday	$45,000	+ 3.0	+ 9.9	+ 9.9	+ 6.0
10-77	B	2534 Holiday	$62,000	0.0	+ 1.2	+ 5.8	+ 6.0
10-77	C	2524 Holiday	$58,500	- 8.6	- 2.9	+ .5	0.0
11-77	C	2600 Holiday	$60,500	-11.5	- 9.9	- 5.4	- 3.0
9-75	C	1940 Holiday	$47,000	- 1.7	+ 2.0	+ 1.5	0.0
11-76	D	2576 Holiday	$53,000	+ 0.4	+ 2.8	+ 2.3	0.0
AVERAGES			$54,938	- 3.5	- 0.1	+ 2.1	+ 1.5

NOTE: -3.5% would indicate interior house sold for an average of $53,015.00 or $1,923.00 less than the Holiday Drive house.

+1.5% would indicate that after taking into consideration lot size, time and condition differentials, the interior houses sales prices are adjusted to an average of $55,762.00, or $824.00 more than houses on Holiday Drive.

The Recapitulation of the findings of the eight houses compared with interior houses indicates that the absolute variance before any adjustments would indicate that the houses on Holiday Drive with the noise sell for 3.5% more than the interior houses. They should have, since Holiday Drive houses have larger lots. After adjustment for one-half of the retail value of the excess land, the houses in the interior still sold for approximately the same price. After the adjustment for time of the sales of the interior lots, however, the houses to the interior sold for 2.1% more. After some adjustment for extremes of the adjustments, plus the condition of one of the properties, it is estimated that the houses to the interior sold, on the average, at 1.5% more than the Holiday Drive houses.

Most interesting about this comparison is that the probable variances of four of the eight houses indicate the same price. Three indicate that the Holiday Drive houses would be worth 4.9% less. One indicates the Holiday Drive house is worth 3% more. The imperfection of the market, along with the potential of error in the adjustments, could easily account for the differential variances.

Therefore, while the absolute variance before adjustments and even the variance after the adjustment for lot size differentials tend to indicate that the Holiday Drive houses are worth more than the interior comparables, nonetheless, after time adjustment, the interior houses would, on the average, be worth 2.5% more than Holiday Drive. With further adjustment for condition, etc., the probable difference is but 1.4%, an amount hardly indicating any significant difference in value.

Even assuming the diminution in value of the Holiday Drive houses at 2.1%, this would be caused by all of the following:

1. Danger from traffic and speeding vehicles
2. View of Holiday as compared to interior streets
3. Noise
4. Vibrations
5. Lack of trees on Holiday Drive as compared to the interior streets.

How much of this diminution is caused by each of the above factors which is different for the interior houses is impossible to measure. The personal interviews tend to point to the speeding and danger factor as paramount, although noise from racing vehicles during the P.M. hours was mentioned. Backing of the cars out of the driveways into heavy traffic is included in the danger factor.

Had the speed limits, and particularly laws prohibiting drag racing during the middle of the night, been properly enforced, the environmental impact of the street probably would have been less. Even the noise levels would have been reduced for ordinary traffic operating at proper speed limits.

Considering all factors, it is our belief that the differences in sales prices do not tend to indicate any appreciable diminution in value in this subdivision as a result of noise; although there may be a slight difference in value due to a combination of noise and the other factors stated above, particularly danger from traffic and speeding vehicles.

3.4 Sherwood Forest Subdivision

I. Background Information

A. Location of Subdivision

1. Area Description

Sherwood Forest Subdivision is located in the city of Baton Rouge, capitol of Louisiana, with a population of 219,462 in 1977. It is in East Baton Rouge Parish and is approximately 80 miles up the Mississippi River from New Orleans. Additional general information about the city is included in the Introduction to this report.

Besides the impact of a hugh petrochemical industrial complex, many wholesale and retail firms serve South Louisiana, South Mississippi and some Southwestern states from Baton Rouge. The city is the center of a retail and wholesale trade area which radiates approximately 40 miles from the city, covering 10 Louisiana Parishes.

Louisiana State University and Agricultural and Mechanical College is located in Baton Rouge. It is a 300 acre campus with an enrollment of about 25,000 students. Industry in the area promotes education by offering scholarships to L.S.U. in related fields. Southern University in Baton Rouge is one of the largest predominantly negro universities in the United States with an enrollment of about 8,500.

Interstate 10 approaches East Baton Rouge Parish from the Southeast whereas Interstate 12 enters the parish from an east-northeast direction. The two Interstate Highways converge at a point just outside the city limits and continue westward across the Mississippi River as Interstate 10. Two other major arteries through the city are Florida Boulevard which runs east-west and Airline Highway which runs northwest-southeast. These highways are components of U.S. Highway 61 and 190, and Bypass 61 and 190. Another important road is State Highway 37, known locally as Greenwell Springs Road, which runs northeast-southwest.

The subject of study is Sherwood Forest Boulevard. It is a north-south artery which varies in width from 2 lanes to four lanes. It runs from Florida Boulevard on the north to Airline Highway on the south. Sherwood Forest Boulevard passes beneath Interstate 12 which has an interchange at that point. Sherwood Forest Boulevard is also traversed by Harrell's Ferry Road and the Old Hammond Highway, which are heavily traveled local roads. Since Sherwood Forest Boulevard connects several major roads, it is a heavily traveled thoroughfare.

2. Neighborhood Description

Sherwood Forest Boulevard has both commercial areas and residential areas. Between Airline Highway and I-12, the street is still being developed as commercial; however, there are some apartment complexes in this area also. From I-12 to the Old Hammond Highway is also commercial, with small shopping centers and several fast-food establishments. North of the Old Hammond Highway, up to Florida Boulevard, the area is entirely single family residential. It is this area of homes fronting on Sherwood Forest Boulevard that is the subject of study.

The northern section of Sherwood Forest Boulevard, and much area to the east and west has experienced heavy population increase since 1970. The area has the second highest median income level in the city of Baton Rouge.

3. Study Area Description

The study area includes Sherwood Forest, North Sherwood Forest and West Sherwood Forest. Generally the boundaries of the study area are Little John Drive and Westbrook Drive to the east, and the Sherwood Forest Golf Club to the south, on the east side of the boulevard. The southern border of the study area on the west side is Sheraton Drive, western borders are Marlbrook and Voohries streets. The study area west of the boulevard was limited to homes south of Mollylea Drive although on the eastern side it extends to Florida Boulevard to the north.

B. Description of Subdivision

In this report Sherwood Forest is meant to include Sherwood Forest Park and North Sherwood Forest. Both subdivisions border Sherwood Forest Boulevard.

It is generally an upper middle class area with well kept homes and lawns. Lots along Sherwood Forest Boulevard range in width from 90 to 100 feet. Lots off the boulevard vary from 80 to 100 front feet, some streets having been developed with larger lots than others. The streets are asphalt paved and there are no sidewalks except along some parts of Sherwood Forest Boulevard.

The homes are all brick veneer, most with asphalt shingle roofs. However, the homes do vary in age, size and style. Prices along Sherwood Forest Boulevard have ranged from the mid $40's to mid $80's during 1976 and 1977. Some were custom built by individuals, while others apparently were constructed by developers. Among the individually built homes are houses with 5 and 6 bedrooms and one with a "mother-in-law" apartment. These homes were much larger and higher priced than other homes in the subdivision, consequently no attempt at comparison was made. However, the sales are set out in the study.

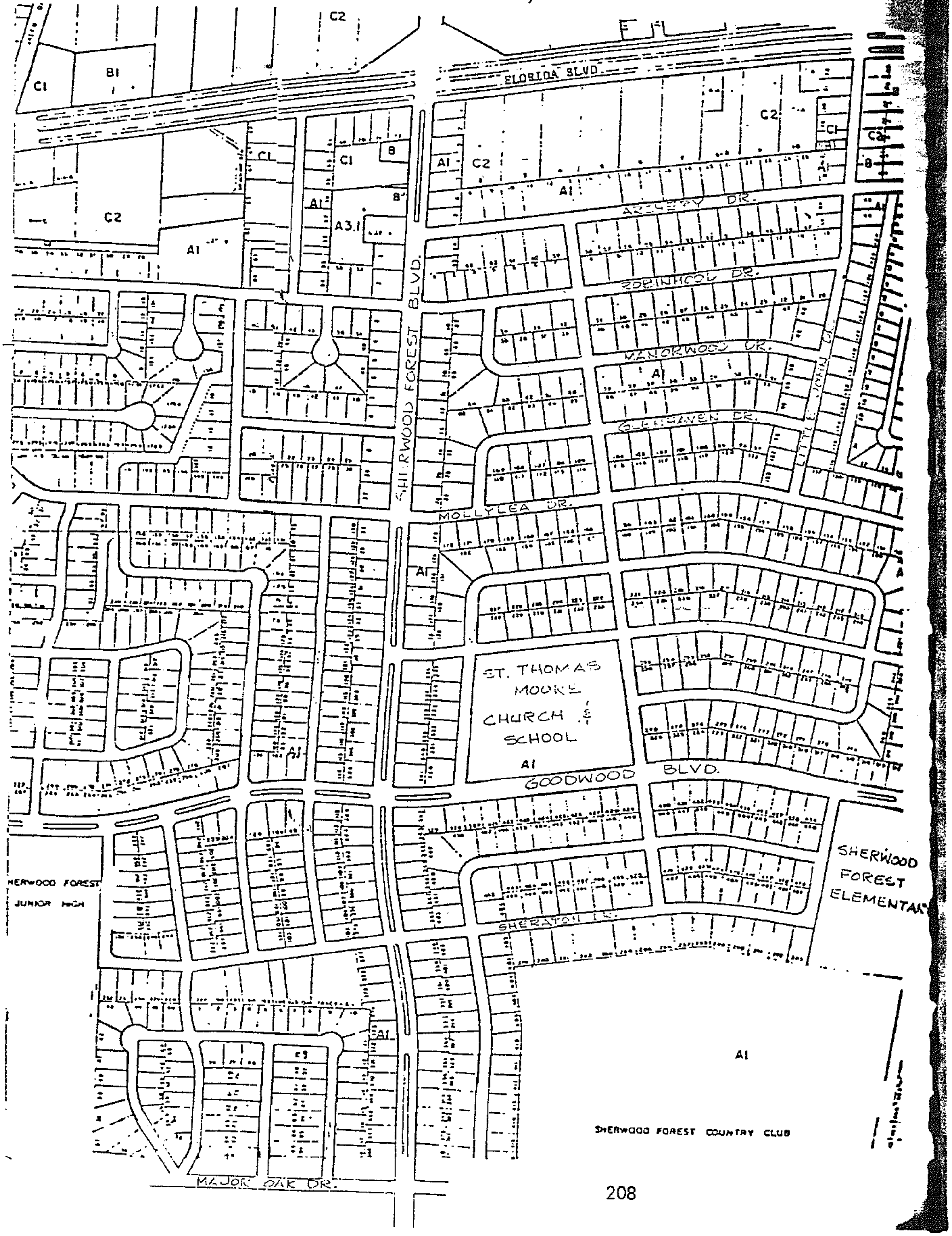
C. Orientation of Subject Houses to Boulevard

All subject homes front on Sherwood Forest Boulevard. The distance of the houses from the street varies, but mose are about 20 feet from the right-of-way.

D. Comparison Houses Studied

The homes used for comparison are to the east of Sherwood Forest Boulevard. Sales research and some field study was done in West Sherwood Forest on the west side of the boulevard but it was found that this area contained mostly smaller lots and smaller houses and therefore was omitted.

MAP OF SHERWOOD FOREST SUBDIVISION
BATON ROUGE, LA.



As in other subdivisions, sales during the same time period and in the same general price range were used as comparables. The study was limited to sales since the middle of 1975 ince traffic along Sherwood Forest Boulevard has greatly increased in recent years due to the growth of the City of Baton Rouge toward the east.

E. Noise Analysis

Sherwood Forest Boulevard is a major arterial collector on the east side of Baton Rouge, connecting most of the major east-west thoroughfares of the city. It has two lanes with a 3 meter (10 foot) median and bicycle lanes on the outside. The residences are set back bout 10 meters (30 feet) from the travel lane.

The results of the noise analysis are shown in Table 11. Because of a malfunction in he precision level recorder, only the A-weighted L_{10} was measured at Site 1. It is apparent rom the readings that there is a great deal of vehicular traffic on the boulevard during all he time periods studied. The difference between the peak noise level and the late night eading is only 6 dBA, whereas the average difference for the other areas studied was 8 or dBA. Peak hour traffic therefore represents about 8% of the Average Daily Traffic. A light difference exists between the morning peak and evening peak noise levels, however, nlike the interstate highways where the directional split is the cause, this is accounted for y a difference in total traffic between morning and evening.

The measurements at Site 2 indicate a mean reduction of 11 dBA, with a maximum of 4 dBA and a minimum of 7 dBA. The reduction at the second row of houses is high compared o other areas, and is attributable to the large size of the houses and the extensive use of rick or wood fences. The readings at Site 3 vary considerably, fluctuating in conjunction ith interior subdivision activity.

Traffic counts along Sherwood Forest Boulevard were obtained from the East Baton Rouge City/Parish Department of Public Works. A 1978 count of vehicles per day indicated 9450 were going north and 9569 were going south. Because this area is one of the fastest growing in the city, a 10% per year figure was used to calculate historic traffic data. Observations made during the noise monitoring period indicated a small number of heavy trucks on the boulevard. Since the L_{10} prediction method can not use a figure less than 30, other than zero, heavy trucks were not included in the calculations. This omission is not expected to significantly effect the calculations shown in Table 12.

TABLE 11

SHERWOOD FOREST

TIME	dBA/LOCATION			ACTUAL TRAFFIC COUNT (10 minutes)	
	Site 1	Site 2	Site 3	North	South
1600	68	58	54	143	110
1630	68	59	50	147	104
1700	69	59	50		
1730	69	58	59		
1800	69	57	51		
2000	65	55	46	90	77
2300	66	59	51	46	30
0630	69	58	54		
0700	70	56	54		
0730	71	58	56	154	164
0800	72	60	60	159	171

TABLE 12

SHERWOOD FOREST BOULEVARD NOISE LEVELS

Peak Hour Traffic*

Year	Automobiles *	Trucks	Calculated ** L_{10} (dBA)
1978	1520	-	72
1977	1365	-	72
1976	1230	-	72
1975	1105	-	71
1974	1000	-	71
1973	900	-	71
1972	800	-	70

* Calculated from 1978 traffic count, East Baton Rouge City/Parish Department of Public Works.

** Calculated using prediction method in NCHRP 174.

These figures indicate that the noise level along Sherwood Forest Boulevard has exceeded FHWA recommended guidelines during the peak traffic hour since 1973.

II. Study Objectives

A. On and Off Boulevard Sales Price Comparisons

1. Total Sample Studied

There were 12 subject houses along Sherwood Forest Boulevard sold from the middle of 75 to the middle of 1978. Four were above average in price at the time they were sold, so y the remaining eight were studied in depth. There were twenty-two sales off the boulevard d for comparison. An attempt was made to use only similar size lots and houses of comparable and size, there being great diversity within the subdivision.

2. Analysis of Sales

Sales were compared on the basis of price per square foot (i.e., total price divided by square footage of the house). The basic facts on the subject house are shown under the individual comparison section with the information on the comparables following it. Where explanation is necessary it follows the basic information.

B. Frequency of Resale Comparison

Because of the relatively few resales in the short period of the study (mid '75 to mid '78) and the relatively large number of lots included in the subdivision, frequency of resale comparison could not be used to infer any conclusions. Therefore, in this subdivision, this analysis is omitted.

C. Resale Percentage Increases

Unlike some of the subdivisions in New Orleans where there is frequent turnover in ownership, Sherwood Forest appears to be more stable. Where there has been a resale of a subject or comparable in recent years, it is shown in the individual comparisons.

Also, it is difficult to compare resale percentage increases on custom built houses. It is obvious from some of the resale prices that considerable improvements and/or additions had been made in the interim. Because of this and because there was a limited amount of resales on Sherwood Forest Boulevard the resale percentage increases were not compared.

III. Results of Study

A Total House Sales Reported

Our study covers a group of 34 houses which were selected from 145 sales. As mentioned, sales from other stages of development of the subdivisions were considered and eliminated, thereby decreasing the quantity of comparisons but increasing the similarity of subject and comparables.

B. Individual Sale Comparisons

1. Eliminations

All of the sales listed below were above average in price for the subdivision during the time period in which they occurred, and therefore have been eliminated from the study.

1231 Sherwood Forest	April, 1978	$80,000
1277 Sherwood Forest	March, 1977	$79,900
1351 Sherwood Forest	February, 1977	$65,000
1388 Sherwood Forest	August, 1976	$85,000
1265 Sherwood Forest	June, 1976	$62,500

2. Subject Houses

Individual comparison of sales on and off of Sherwood Forest Boulevard are shown below.

Subject a)

1) 422 Sherwood Forest Blvd. - March 1978 - $58,000.00

1,860 S.F. - $31.18 per sq. ft.

Lot: 96' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Double Carport

This house was purchased for $45,979 in May of 1977. The absolute price variance was 26% for ten months or the equivalent of 31% annual rate.

Comparables

1233 Ashbourne - March 1978 - $58,000.00

2,033 S.F. - $28.53 per sq. ft.

Lot: 100' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, On Golf Course

12342 Mollylea - May 1978 - $57,000.00

1,801 S.F. - $31.65 per sq. ft.

Lot: 92' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Double Carport

11820 Mollylea - December 1977 - $56,900

1,926 S.F. - $29.54 per sq. ft.

Lot: 100' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry

Subject House	$31.18 per sq. ft.
Average of Three Comparables	$29.91 per sq. ft.

The subject house, 422 Sherwood Forest Boulevard, had a double carport at the time of the sale which has been made into a double garage by the latest purchaser. The subject's per square foot is the highest in the group when the time of the 12342 Mollylea sale is taken into consideration.

2) 422 Sherwood Forest Blvd. - May 1977 - $45,979.00

1,860 S.F. - $24.72 per sq. ft.

Lot: 96' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Double Carport, No Fireplace

Comparables

11724 Mollylea - March 1977 - $45,000.00

1,965 S.F. - $22.90 per sq. ft.

Lot: 100' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry Area, Double Carport, Fireplace

11834 Sherbrook Dr. - May 1977 - $44,500.00

1,699 S.F. - $26.19 per sq. ft.

Lot: 100' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Utility Room (2), Double Carport, Wet Bar

11824 Archery - June 1977 - $47,158

1,936 S.F. - $24.36 per sq. ft.

Lot: 91' x 154' Corner Lot

4 Bedrooms, 2 Baths, Living Room, Kitchen, Den, Utility Room, Double Carport, Covered Patio (10' x 20')

Subject House	$24.72 per sq. ft.
Average of Comparables	$24.48 per sq. ft.

The sale of the subject falls about the middle of the group as far as price per square foot is concerned. The greatest discrepancy is with the 11834 Sherbrook Drive sale. The price was lower for the Sherbrook Drive sale but the square foot price is higher because it is a smaller house. However, it has a wet bar and two large storage rooms 6' x 15' off of the carport. One is located behind the other with a covered walkway 15' in length between them. This extra area accounts for the small price difference.

The owners of the Sherbrook Drive house said it was in very good condition. The subject has resold so we have no knowledge of its condition at the time of this sale.

Subject b)

1) 425 Sherwood Forest Blvd. - April 1977 - $58,500.00

1,963 S.F. - $29.80 per sq. ft.

Lot: 100' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport

This house was purchased for $45,900 in September of 1976. The absolute price variance was 27% for seven months or the equivalent of 47% annual rate.

Comparables

11821 Parkwood - July 1977 - $56,800.00

1,952 S.F. - $29.10 per sq. ft.

Lot: 100' x 154'

3 Bedrooms, 2 Baths, Living Room, Kitchen, Den, Laundry, Double Carport, Covered Patio (12' x 20')

This house was purchased for $41,000 in October of 1976. The absolute price variance was 39% for nine months or the equivalent of 51% annual rate.

11563 Millburn - March 1977 - $57,500.00

2,288 S.F. - $25.13 per sq. ft.

Lot: 92' x 150'

3 Bedrooms, 3 Baths, Living and Dining Area, Kitchen, Den, Study or Sewing Room, Double Carport, Fireplace

Subject House	$29.80 per sq. ft.
Average of Comparables	$27.11 per sq. ft.

The subject compares closely with the comparables. Note that both the subject house and 11821 Parkwood sold at very high resale prices, which would tend to indicate that both had been considerably improved since the last sale.

2) 425 Sherwood Forest Blvd. - September 1976 - $45,900.00

1,963 S.F. - $23.38 per sq. ft.

Lot: 100' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport

Comparables

11755 Glenhaven - August 1976 - $46,900.00

2,173 S.F. - $21.58 per sq. ft.

Lot: 112' x 167' (Larger Lot)

4 Bedrooms, 3 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Wet Bar

11825 Mollylea - October 1976 - $45,100.00

1,707 S.F. - $26.42 per sq. ft.

Lot: 125' x 150' (Wider Lot)

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Covered Patio

11720 Archery - November 1976 - $46,500.00

1,667 S.F. - $27.89 per sq. ft.

Lot: 100' x 174' (Deeper Lot)

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Sewing Room, Laundry Room, Double Carport

Subject House	$23.38 per sq. ft.
Average of Comparables	$25.30 per sq. ft.

The sale of 425 Sherwood Forest Boulevard compares well with the comparables when all factors are taken into consideration. All three comparables are on significantly larger lots, one 12' wider and 17' deeper, one 25' wider, and the other 24' deeper. The house at 11720 Archery also has an additional room. Therefore, the sale on the boulevard is not out of line with the comparables.

Subject c)

755 Sherwood Forest Blvd. - April 1976 - $48,000.00

1,906 S.F. - $25.18 per sq. ft.

Lot: 105' x 150'

3 Bedrooms, 2 Baths, Living Area, Kitchen, Den, Utility Room (outside built on back), Double Carport, Older house (1957) with kitchen remodeled, Covered Patio (39' x 13')

Comparables

11841 Parkwood Dr. - April 1976 - $48,400.00

1,650 S.F. - $29.33 per sq. ft.

Lot: 110' x 155'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace, Pool in back yard with covered patio and brick barbeque pit

11755 Glenhaven - August 1976 - $46,900.00

2,173 S.F. - $21.58 per sq. ft.

Lot: 112' x 167'

4 Bedrooms, 3 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, No Fireplace, Wet Bar, Older house (1958)

Subject House	$25.18 per sq. ft.
Average of Comparables	$25.46 per sq. ft.

The house at 755 Sherwood Forest Boulevard is older than the average house in the area. It was built in 1957 whereas most homes in the area were built in the mid 1960's or later. The house at 11755 Glenhaven is of similar age, built in 1958. Its price is probably below the subject because the subject had a recently remodeled kitchen. The house at 11841 Parkwood was much smaller but had a swimming pool which increased its value. These differences account for the wide range in price per square foot.

Subject d)

1293 Sherwood Forest Blvd. - January 1978 - $55,000.00

1,850 S.F. - $29.73 per sq. ft.

Lot: 90' x 153'

4 Bedrooms, 2 Baths, Living Area, Kitchen, Den, Laundry, Double Garage, No Fireplace, Repainted whole interior and replaced living room carpet.

Comparables

436 Little John - February 1978 - $52,500.00

1,523 S.F. - $34.47 per sq. ft.

Lot: 100' x 150' (Wider Lot)

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, No Den, Laundry-Storage Area, Double Carport, No Fireplace, Covered Patio (30' x 11'), Owner Financed

11820 Mollylea - December 1977 - $56,900.00

1,926 S.F. - $29.54 per sq. ft.

Lot: 100' x 150' (Wider Lot)

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, No Fireplace

12686 Robin Hood - November 1977 - $53,750.00

1,880 S.F. - $28.59 per sq. ft.

Lot: 85' x 139' (Smaller Lot)

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, No Fireplace

11000 Sheraton Drive - October 1977 - $54,500.00

1,822 S.F. - $29.91 per sq. ft.

Lot: 95' x 197' (Larger Lot)

3 Bedrooms, 1 1/2 Baths, Living Area, Kitchen, Den, Laundry, Double Carport, Fireplace, Covered Patio

12762 Robin Hood - October 1977 - $55,450.00

2,069 S.F. - $26.80 per sq. ft.

Lot: 85' x 139' (Smaller Lot)

4 Bedrooms, 2 1/2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, No Fireplace

Subject House	$29.73 per sq. ft.
Average of Comparables	$29.86 per sq. ft.

The subject, 1293 Sherwood Forest Boulevard is almost identical in price per square foot to two out of the comparables, 11820 Mollylea and 11000 Sheraton Drive. The house at 436 Little John is unusually small for the neighborhood. However, it has a large covered patio, 30' x 11', with fruit trees in the back yard, plus a lot that is 10' wider than the subject. The 436 Little John sale was also owner financed, which at the prevailing interest rates was an important consideration. The house at 12762 Robin Hood was reported to have been in poor condition at the time of the sale, and was on a smaller lot than the subject, as was the house at 12686 Robin Hood. The house at 11000 Sheraton Drive was on a lot 5' wider and 44' wider.

Considering the fact that the present owner of the subject house repainted the whole interior and replaced some carpeting, and after lot size adjustments, the price is just about the same as the average of the comparables.

Subject e)

1173 Sherwood Forest Blvd. - October 1975 - $53,491.00

2,200 S.F. - $24.31 per sq. ft.

Lot: 110' x 150'

4 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Garage, Fireplace, Wet Bar, Corner Lot.

This house was purchased in November of 1974 for $45,389, and sold in October of 1975 for $53,491. The absolute price variance was 18% for eleven months or the equivalent of 19% per annum.

Comparables

11555 Parkwood Dr. - August 1975 - $54,000.00

2,336 S.F. - $23.12 per sq. ft.

Lot: 100' x 150' (Narrower Lot)

4 Bedrooms, 3 1/2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace. Has one sunken tub, and brick around built in appliances in kitchen.

This house was resold in March of 1976 for $57,000, an increase of 5.56% in seven months or an annual rate of 9.52%.

1209 Ashbourne - August 1975 - $50,750.00

2,318 S.F. - $21.89 per sq. ft.

Lot: 125' x 150' (Wider Lot)

3 Bedrooms, 2 1/2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace, Corner Lot adjacent to golf course.

11335 Archer - September 1975 - $52,000.00

2,042 S.F. - $25.47 per sq. ft.

Lot: 100' x 175' (Deeper Lot)

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace

This house sold again in February of 1978 for $59,900.00, an increase of 15% for 29 months or 6.3% per annum.

Subject House	$24.31 per sq. ft.
Average of Comparables	$23.49 per sq. ft.

The house at 11555 Parkwood Drive was on a lot 10' narrower than the subject, but it had 1 1/2 baths more, plus other attractive features which probably compensated in price for the smaller lot.

The house at 1209 Ashbourne was on a lot 15' wider, had 1/2 bath more, and overlooked the golf course, however had one less bedroom, and still the price was less per square foot than any of the others. The house at 11335 Archer was on a lot 25' deeper than the subject, and since it sold only one month prior to the subject house, the higher price per square foot probably reflected the much deeper lot.

The subject house at 1173 Sherwood Forest Boulevard was reported to be in poor condition at the time of its last sale. Repainting was required inside and out, and a new central air system had to be installed. The 18% resale increase probably reflected the beginning of the big upswing in the real estate market in late 1975.

In spite of its poor condition, the per-square-foot price was above the average of the comparables.

Subject f)

466 Sherwood Forest Blvd. - June 1975 - $45,500

1,860 S.F. - $24.46 per sq. ft.

Lot: 110' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace, Corner Lot

Comparables

11612 Glenhaven - June 1975 - $45,900

2,457 S.F. - $18.68 per sq. ft.

Lot: 100' x 150'

4 Bedrooms, 3 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace, Poor Condition

664 Westbrook - October 1975 - $45,500

1,869 S.F. - $24.34 per sq. ft.

Lot: 101' x 150'

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den - Breakfast Room, Laundry, Double Carport, No Fireplace, Built in barbecue grill in den.

Subject House	$24.46 per sq. ft.
Average of Comparables	$21.51 per sq. ft.

The subject house at 466 Sherwood Forest Boulevard was reported to be in fair condition at the time of sale. Some interior painting was required. The house at 11612 Glenhaven had to be completely repainted inside and some floors were replaced, which apparently accounts for its low price. Also, it is on a lot which is 10' narrower than the subject.

The other comparable at 664 Westbrook is likewise on a lot 9' narrower than the subject, however, since the sale was four months later, the lot size and time adjustments probably counteracted each other.

Again, the subject sold for a higher per-square-foot price than the comparables.

IV. Conclusion

Many houses on Sherwood Forest Boulevard were custom built and have more space or unusual features which cuased them to sell for prices above average in the subdivision. The more typical houses along Sherwood Forest Boulevard have sold for prices which are average among similar types of houses on similar size lots in the subdivision.

RECAPITULATION

			Overall Price Per S.F.	Percent Price Difference	Area	Percent Area Difference
	Subject a)					
1)	Mar 78	422 Sherwood Forest	$31.18	- 4.2	1,860	
		3 Comparables	$29.91		1,920	+ 3.2
2)	May 77	422 Sherwood Forest	$24.72	- 1.0	1,860	
		3 Comparables	$24.48		1,867	+ .4
	Subject b)					
1)	Apr 77	425 Sherwood Forest	$29.80	- 9.9	1,963	
		2 Comparables	$27.11		2,120	+ 8.0
2)	Sept 76	425 Sherwood Forest	$23.38		1,963	+ 6.2
		3 Comparables	$25.30	+ 7.6	1,849	
	Subject c)					
	Apr 76	755 Sherwood Forest	$25.18	+ 1.1	1,906	
		2 Comparables	$25.46		1,912	+ .3
	Subject d)					
	Jan 78	1293 Sherwood Forest	$29.73		1,850	+ .3
		5 Comparables	$29.86	+ .4	1,844	
	Subject e)					
	Oct 75	1173 Sherwood Forest	$24.31	- 3.5	2,200	
		3 Comparables	$23.49		2,232	+ 1.5
	Subject f)					
	June 75	466 Sherwood Forest	$24.46	-13.7	1,860	
		2 Comparables	$21.51		2,163	+16.3
		AVERAGE PRICE DIFFERENCE		- 2.9%		

The data above would indicate not only that noise does not affect the value, but also that there is apparently a very true market in the Sherwood Forest subdivision in Baton Rouge. In each case, the price differential could be explained by lot size and/or time adjustments, or by the varying conditions of the houses. In the above recapitulation, it is also interesting to note that part of the price differential could be reflected in area differentials with an inverse effect on price per unit.

What is most interesting about the findings on Sherwood Forest Boulevard is that with about the same quantity and type of traffic, the noise levels are considerably below the 76 dBA of Holiday Drive in Algiers, New Orleans. While the speed limits are strictly enforced on Sherwood Boulevard, there is evidence that this is lacking on Holiday Drive even though the speed limit is the same.

In our opinion, the type and quality of market demand on both streets is similar. Yet, because of the control of the speed limit, variations in price "on" and "off" the boulevard are absent in Sherwood Forest subdivision.

3.5 Slidell Country Club Estates

I. Background Information

A. Location of Subdivision

1. Area Description

The City of Slidell is located in southeastern Louisiana, St. Tammany Parish, on the north shore of Lake Pontchartrain. The City has road access to New Orleans (about 28 miles to the CBD) via I-10 which runs from Florida to California. I-10 runs on the east side of Slidell with two major access interchanges, the south one at Old Spanish Trail (or Salt Bayou Road) and the north one at Gause Road. For almost the length of Slidell, I-10 runs in a north-south direction.

In the northeast part of the city there is a large non-access interchange. I-10 turns easterly toward the Mississippi Gulf Coast. That part of the Interstate system which was I-10 up to the major interchange becomes I-59 and proceeds northerly toward Birmingham, Alabama, and northeasterly from there. That part of the system which continues westerly from this major interchange becomes I-12, a bypass of New Orleans which goes from Slidell westerly to Baton Rouge, Louisiana.

The first major street north of Gause Road which parallels the Interstate system (both I-10 and I-59) is called Robert Road. The subject area is primarily residential on both sides of Robert Road and south of I-12. This would be in the southwest quadrant of the totally limited access interchange of I-10 (south and east), I-12 (west) and I-59 (north). The residential area extends westerly to the Southern Railroad and adjacent to U.S. Highway 11.

2. Neighborhood Description

The subject subdivision, Country Club Estates is located in the north part of Slidell on the west side of Robert Road and adjacent and south of I-12. Robert Road itself borders commercial and residential properties but the adjacent areas to the east and west are single family residential developments. They include homes of all sizes and price ranges. The area is still in the process of development.

3. Study Area Description

The study area lies adjacent to the junction of the interstate highways described above. It is bordered by I-12 to the north. The subdivision additions are still developing across Robert Road eastward toward I-10. Much of the area south of the subdivision remains wooded and undeveloped. To the southwest and west are more single family residences in Country Manor and Brookwood Estates, respectively. There are homes currently under construction in both of these subdivisions. Both of these subdivisions adjoin Country Club Estates but do not have the quality of construction or the large lots that are found in the subject study area.

The original filings of the subdivision lie west of Robert Road. The subject area under study is this group of homes. The newest development is east of Robert Road. The entrance and first street of the new development east of Robert Road have lots the same size and homes comparable to those in the western part of the subdivision. However, the streets which were developed later and those currently under construction are made up of much smaller lots and smaller houses. Since, this newer development could have an effect on the prestige and prices in the area, even the homes on the larger lots in this newer section of the subdivision have been excluded.

B. Description of Subdivision

Slidell Country Club Estates is an upper middle class area with large tree-strewn lots. Development of the subdivision was begun approximately 14 years ago on the sides of the Pinewood Country Club Golf Course. The area along Interstate 12 was developed next. West

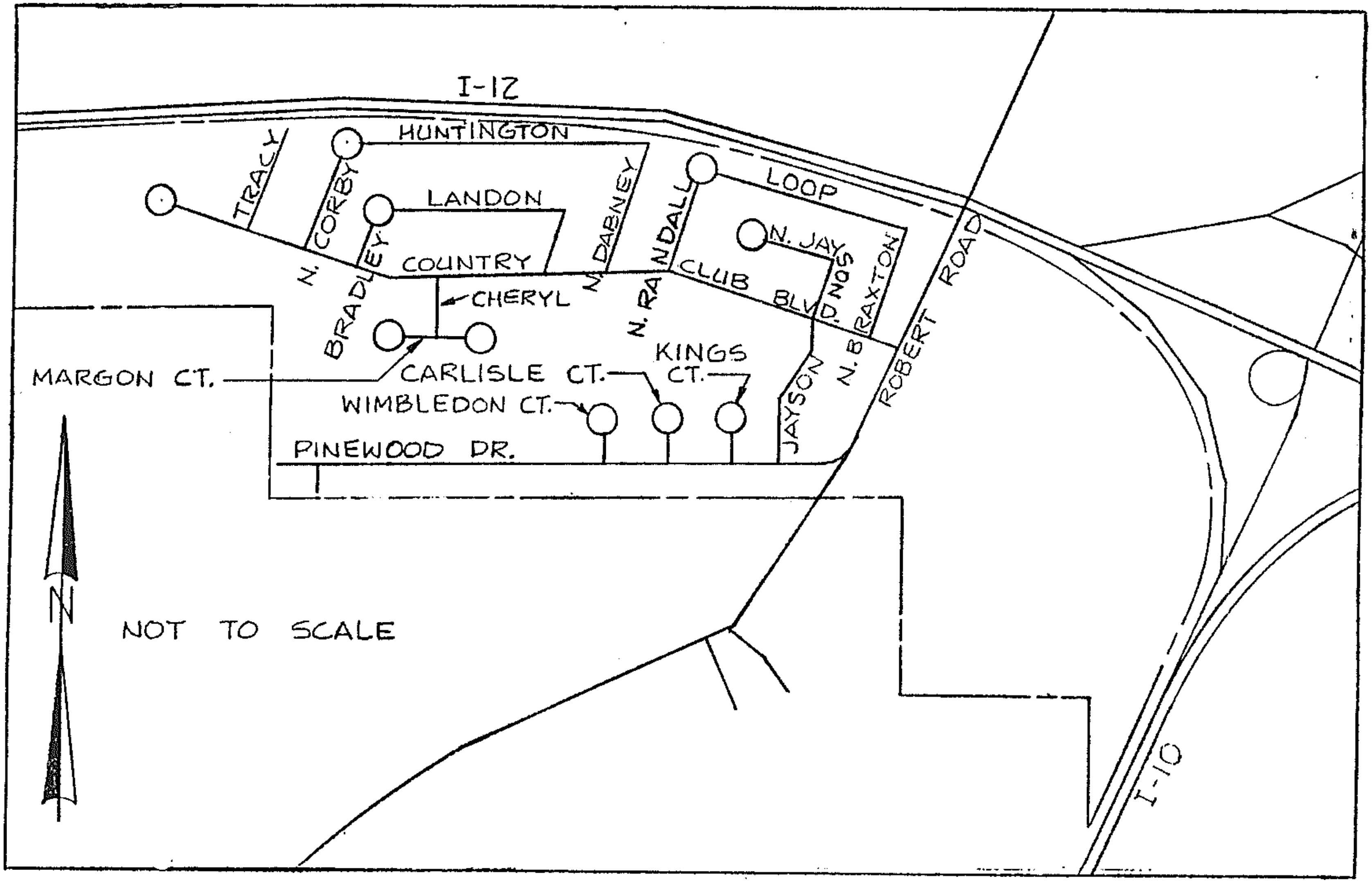
Pinewood Drive and the adjoining courts on the south side of the golf course followed. Subsequently, the extension of the subdivision was opened on the east side of Robert Road. East Pinewood Drive and Grafton Drive were developed with homes on 100' lots similar to those in the west side of the subdivision. However, the streets which have been developed eastward from Grafton have lots which average 80' in width and are developed with smaller houses. As mentioned above, this newer area has been excluded from the study.

All houses in the subdivision are brick veneer with asphalt shingle roofs. There are some one and a half and two story houses in the subdivision, but only one story homes were considered because all but one of the subject houses on the highway were single story. The average home studied had approximately 2,000 square feet of living space. They generally had three, or more often, four bedrooms, with 2 or 2 1/2 baths, living room, dining room and kitchen. Most had a den and the majority of homes had a fireplace. Most of the homes had a laundry room and many also had a storage room. All homes used in the study have a double garage or a double carport built on the house.

The lots are generally 100' x 150'. However, the lots on Huntington Drive are an exception, being 100' x 143' on the average. They front on asphalt surfaced streets. Unlike the subdivisions studied in New Orleans, there are no sidewalks in this subdivision.

Most of the homes on the north side of West Pinewood and the south side of Country Club Boulevard back up to Pinewood Country Club golf course. The golf course continues around the circle at the end of Country Club Boulevard and borders some lots on the north side of Country Club Drive. The Club House for the Country Club is located on the south side of Country Club Boulevard, and there is also a children's playground.

Nearly all of the homes in Country Club Estates appear to be in good condition and are nicely landscaped. The spacious lots and well kept homes give the subdivision an attractive



MAP OF

SLIDELL COUNTRY CLUB ESTATES

appearance with a rather serene effect. There is a neighborhood association for the subdivision which posts announcements and holds occasional meetings. This is another reflection of the pride in ownership which is evident throughout Slidell Country Club Estates.

C. Orientation of Study Houses to Interstate Highway

The subject houses front on two streets which run parallel to Interstate 12, Huntington Drive and Loop Drive. The back of the lots on which the subject houses are built abutt the Interstate right-of-way. The lots on Loop Drive are 100' x 150' like most of those in the subdivision. However, as mentioned previously, the lots on Huntington Drive are only 143' in depth which happens to bring the houses closer to the highway.

D. Noise Levels

The Interstate 12 through Slidell was chosen for study due to its low traffic volume, high truck percent (17%) and suburban setting. In Country Club Estates, the homes back up to the interstate and are screened from it either by thin rows of plantings or board fences. Site 1 was located in a vacant lot in line with the back of the first row of houses, while Site 2 was situated in line with the front of the second row of houses. Site 3 was placed to the side of the main boulevard of the subdivision.

The results of the noise measurements are summarized in Table 13. The evening peak is slightly higher than the morning peak however, due to the high truck noise, to which all four lanes contribute, there is no significant difference. The readings at Site 2 indicate a mean reduction of 5 dBA due to the first row of houses and increased distance. The maximum reduction was 7 dBA and the minimum was 2 dBA. The measurements at Site 3 indicate a further reduction of about 10 dBA depending upon the traffic volume on the boulevard.

The traffic data in Table 14 show two trends. There was a reduction in the volume in 1975 probably due to gasoline shortages, and a large growth in 1977 and 1978 primarily due to the completion of Interstate 12. While the segment studied was open prior to that date, traffic was forced to travel a more circuitous route, and therefore the volume was not as great as after completion.

As shown by the table, noise levels from the interstate have exceeded the FHWA guidelines since the highway completion in late 1976.

TABLE 13

NOISE MEASUREMENTS

SLIDELL COUNTRY CLUB ESTATES

TIME	L_{10} SITE (dBA)			TRAFFIC			
				(West)		(East)	
	I	II	III	Auto	Truck	Auto	Truck
1600 - 10	69	65	54	48	9	41	5
1630 - 40	70	64	54	73	10	42	14
1700 - 10	71	64	54	91	15	36	12
1730 - 40	68	62	54	59	13	28	13
1800 - 10	68	65	51	77	8	24	11
2000 - 10	66	62	53	13	5	11	6
2300 - 10	64	60	51	16	9	6	5
0700 - 10	69	65	56	25	9	76	5
0730 - 40	69	62	54	30	11	86	6
0800 - 10	68	66	55	36	28	42	12
0830 - 40	70	64	53	58	16	52	8
0900 - 10	69	65	56	60	14	47	10

Site I - Only I-10 noise

Site II - Both I-10 & (minor-negligible) subdivision noise

Site III - Both I-10 & (minor-negligible) subdivision noise

TABLE 13 (continued)

FREQ. ANALYZED SITE I

SLIDELL COUNTRY CLUB ESTATES

Freq. L_{10}							
Time	125	250	500	1K	2K	4K	8K
1630	68	70	73	74	74	66	50
2000	58	56	61	63	60	54	44
2300	55	54	58	60	59	52	42
0800	60	64	64	68	66	57	41

TABLE 14

PEAK HOUR TRAFFIC LEVELS

SLIDELL COUNTRY CLUB ESTATES

Year	Automobiles*	Trucks	Calculated** L_{10} (dBA)
1973	159	33	65
1974	214	44	66
1975	192	39	66
1976	352	72	69
1977	595	122	70
1978	726	153	71

* Louisiana Department of Transportation and Development, Office of Highways yearly traffic counts.

** Calculated from prediction method in NCHRP 174.

E. Comparison Houses Studied

The comparison houses are located throughout the subdivision. However, as noted above, none of the homes which were built on the east side of Robert Road have been included.

II. Study Objectives

A. On and Off Highway Sales Price Comparisons

Slidell Country Club Estates, unlike the subdivisions discussed earlier in this report, was developed with homes which were primarily individually built, as opposed to identical tract housing models. In order to avoid having to make many adjustments for the differences in the houses which would lead to very subjective results, a different approach was taken to the comparison of this group of houses. The subject houses on the highway were matched with other homes which sold about the same time for a similar price. An attempt was made to select homes which sold within three months before or after the sale on the highway and with a sale price within $2,000-$3,000 of the subject house.

A subject house was used only if two or more price and time matches for that house could be found. Where, after inspection, it was found that there was a substantial difference between the subject, and a comparison house, the comparison was dropped. For example, one and a half and two story houses were dropped from the study, as were homes which had additions or converted garage areas which existed at the time of the sale.

The owners of the subject house and all comparison houses were interviewed to obtain general information about the interior, such as the number of rooms, special features, and condition at the time of purchase. All homes were measured in order to determine the square foot area. In some cases, the area of a home was to a small degree estimated because measurement was difficult due to shrubbery, outbuildings, or the inability to get access to the back yard. It was also difficult in a few cases to determine how much of a house was garage and storage area as opposed to living area. Consequently, the square foot area and square foot value should not be strictly interpreted. However, considering the price of most of the sales, a minor variation in area should not have a substantial effect upon price per square foot.

All pertinent information obtained about each house is set out below for comparison. A discussion of how the homes and prices "on" and "off" of the highway relate to each other follows the basic information.

Because of the great similarity in the lots, the criteria used to make the comparison in prices obtained was the square foot area of the house divided into the price paid. This is sometimes referred to as "the price per square foot overall".

B. Differences in Resale Percentage Increases

Where a home on the highway sold more than once since 1972, an average monthly increase for the resale of the subject house and its comparables is shown with the other information outlined in Section A. A comparison of resale increases is made in the discussion following that information.

C. Frequency of Resales Comparisons

Slidell Country Club Estates was developed in stages over a period of time which encompasses the five-year sales study. Therefore, the period for resales comparison has been limited to 1975 through 1977 when most of the study area should have been developed. Streets which were still being developed and had new home sales during that period were omitted. Unless noted otherwise, only fully developed streets where all sales were resales in this time period have been used for comparison.

As in other subdivisions, sales from a succession were excluded and transfers to and from a corporate entity were counted as one transfer. The number of transfers was divided by the number of lots on the street. Lots which sold with new houses during the 1975 to 1977 period were omitted from the lot count.

III. Results of Study

A. Total Sales Reported

Including lot sales there were 54 sales backing into I-12 and 341 off the highway, for a total of 395.

B. On and Off Highway Sales Price Comparisons

The subject house on the highway is listed first, followed by the comparison house. A discussion of how they compare follows.

Slidell Country Club Estates - 1

Backing Into I-12:

1a. 228 Loop Drive - July 1977 - $61,000.00

1,952 S.F. - $31.25 per sq. ft.

Lot: 100' x 150' Lot No. 240

4 Bedrooms, 2 1/2 Baths, Living and Dining Area, Kitchen, Den, Laundry Room, Double Garage. No fireplace

Prior Acquisition: October 1974 - $47,500 - 10.3% Per Year Increase

Away From I-12:

1b. 102 N. Dabney Drive - June 1977 - $61,000.00

2,466 S.F. - $24.74 per sq. ft.

Lot: 108'/151' x 85'/102' - Corner Lot. Lot No. 98

4 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Detached

Double Garage with Flat Roof. Older House.

Prior Acquisition: May 1976 - $51,000 Increase 16.8% Per Year

1c. 102 S. Jayson Drive - April 1977 - $61,000.00

2,070 S.F. - $29.47 per sq. ft.

Lot: 91'/80' x 159'/158' Lot No. 190

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport. Wet Bar in Den. Fireplace.

Prior Acquisition: October 1975 - $54,400 - 8.09% Increase Per Annum.

1d. 202 Country Club Boulevard - June 1977 - $62,000.00

2,077 S.F. - $29.85 per sq. ft.

Lot: 110' x 150'. Corner Lot. Lot 195

3 Bedrooms, 2 Baths, Living and Dining, Kitchen, Den, Laundry, Double Carport

Prior Acquisition: February 1974 - $43,973 - Increase 12.0% per annum.

1e. 334 Country Club Boulevard - June 1977 - $62,500.00

2,495 S.F. - $25.05 per sq. ft.

Lot: 100' x 150'. Corner Lot. Lot No. 129

4 Bedrooms, 2 1/2 Baths, Living and Dining, Kitchen, Den, Laundry, Fireplace, Double Garage. House needed exterior paint, recarpeting and a new roof.

Prior Acquisition: August 1973 - $49,500 - 6.85% per annum.

Conclusion - Slidell Country Club Estates - 1

The price per square foot obtained for the house backing into I-12 was greater than all the other houses. The owner of 228 Loop Drive said the condition at time of purchase was excellent and no work has been done on the house. All the other houses except 334 Country

Club Boulevard (which required repainting, recarpeting, and reroofing) were also in good condition. The resale increase of the comparables averages 10.9% per annum while that of 228 Loop Drive was 10.3%. The 1976 sale of "1b" is from sellers who had a low cost basis.

Slidell Country Club Estates - 2

Backing Into I-12:

2a. 326 Huntington - July 1977 - $62,500.00

2,156.14 S.F. - $28.99 per sq. ft.

Lot: 100' x 127'/135' Lot 87

4 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace

Prior Acquisition: December 1974 - $49,526.00 - 10.14% per year

Away From I-12:

1b. 102 N. Dabney - July 1977 - $61,000.00

2,466 S.F. - $24.74 per sq. ft.

Lot: 151'/150' x 106'/87' - Lot 98

4 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Detached double garage with flat roof, no fireplace, Older House.

Prior Acquisition: May 1976 - $51,000 - 16.8% per annum increase

1c. 102 S. Jayson Drive - April 1977 - $61,000.00

2,070 S.F. - $29.47 per sq. ft.

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace, Wet Bar in Den

Prior Acquisition: $54,500 - October 1975 - 8.09% per annum

1d. 202 Country Club Boulevard - July 1977 - $62,000.00

2,077 S.F. - $29.85 per sq. ft.

Lot: 110' x 150' - Lot 195

3 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Carport, Fireplace

Prior Acquisition: $43,973 - February 1974 - 12.0% per annum

1e. 334 Country Club Boulevard - July 1977 - $62,500.00

2,495 S.F. - $25.05 per sq. ft.

Lot: 100' x 150' - Lot 129

4 Bedrooms, 2 1/2 Baths, Living and Dining Area, Kitchen, Den, Laundry, Double Garage, Fireplace, Corner Lot, Needed outside paint, recarpeting and new roof.

Prior Acquisition: $49,500 - August 1973 - 6.85% per annum

Conclusion - Slidell Country Club Estates - 2

The house at 326 Huntington sold at a price equal to if not above other homes in the subdivision. It also compares favorably on a per square foot value basis. The average resale increase of the houses off the highway is 10.9%, which is very close to the increase of 10.14% for the subject house.

The owner of 326 Huntington said that it was in perfect condition at the time it was purchased and has required no repairs. All of the comparison houses, excluding 334 Country Club Boulevard, were in good condition at the time of sale.

As mentioned in the discussion of 228 Loop, the home at 334 Country Club Drive required repainting outside, recarpeting, and a new roof. These condition defects were apparently offset by the additional living area.

Slidell Country Club Estates - 3

Backing Into I-12:

3a. 216 Loop Drive - March 1977 - $61,400.00

2,100 S.F. - $29.24 per sq. ft.

Lot: 100' x 150' - Lot 246

4 Bedrooms, 2 Baths, Living and Dining, Kitchen, Den, Laundry, Double Garage, Fireplace

Prior Acquisition: $53,750 - July 1975 - 8.54% per annum

Away From I-12:

1c. 102 S. Jayson Drive - April 1977 - $61,000.00

2,070 S.F. - $29.47 per sq. ft.

Lot: 91'/80' x 159'/158' - Lot 190

3 Bedrooms, 2 Baths, Living and Dining, Kitchen, Den, Laundry, Double Carport, Fireplace, Wet Bar in Den

Prior Acquisition: $54,400 - October 1975 - +8.09% per annum

3b. 211 Loop Drive - January 1977 - $62,000.00

2,150 S.F. - $28.84 per sq. ft.

Lot: 100' x 150' - Lot No. 265

4 Bedrooms, 2 Baths, Living and Dining, Kitchen, Den, Laundry, Double Garage, Roughly across Loop Drive from Test House.

Prior Acquisition: $37,750 - August 1972 - 14.5% per year

Conclusion - Slidell Country Club Estates - 3

The price per square foot of 216 Loop compares closely with the comparables. The high resale percentage per annum increase on 211 Loop may be attributable to the fact that it is the first resale since the house was first sold in 1972, whereas 216 Loop and 102 S. Jayson show more recent acquisitions. The resale percentage increase of the comparables was 11.3% while "3a" on the highway showed but 8.54%.

Slidell Country Club Estates - 4

Backing Into I-12:

4a. 346 Huntington - October 1976 - $53,000.00

1,761 S.F. - $30.09 per sq. ft.

Lot: 100' x 143' - Lot 77

4 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Den, Double Garage, Fireplace

Prior Acquisition: Purchase price unknown; no sale since 1972

Away From I-12:

4b. 109 Pinewood - April 1976 - $51,500.00

1,951 S.F. - $26.40 per sq. ft.

Lot: 100' x 161' - Lot No. 360

4 Bedrooms, 2 Baths, Living and Dining Area, Kitchen, Laundry, No Den, Double Garage, Fireplace

Prior Acquisition: $49,475 - November 1974 - 2.89% per year

PLANTATION ESTATES-HOLIDAY PARK

SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1973	1974	1975	1976	1977	COB/Folio
EASTER LANE										
X 3	469	2001	54x105	W. J. Lannes III-Anna D. Reese					6/58,500	745/241
				R. Radakovich-W. J. Lannes III	1/38,000h					715/81
X 3	467	2019	63x100	P.W. Richardson-A.M. Harrison					5/48,500h	748/61
X 4	472	2020	65x100	J.T. Hobbs-Thos. J. Ingersoll			12/47,000h			737/31
X 3	465	2035	63x100	R.M. Herman-H.J. Lovekamp		5/44,500a				720/566
X 4	570	2056	65x100	J.D. Libiez-C.T. Fair					6/53,000v	744/189
X 3	462	2061	63x100	Employee Transfer-T.L. Levy			11/43,500			729/588
				F.L. Heuler-Employee Transfer Corp.			7/20,177			731/320
C 4	571	2100	65x100	R.M. McCormic-L.F. Kenny				9/49,500		741/86
				W.L. Green-R.M. McCormic		3/40,500				723/542
X 4	572	2110	65x100	J.C. Bugg, Jr.-N.T. Cowley		6/38,500				728/36
X 3	460	2111	72x110	R.L. Hill- T.R. Bulloch				3/43,874		734/331
				B.G. Altman-R.L. Hill	1/36,000v					714/54
C 3	458	2133	86x104	S.A. Tace-M.L. Rachelson					5/48,500h	747/188
				L.J. Sarber, Jr.-S.A. Tace	10/38,500v					719/154
X 4	575	2134	57/62x 100/104	J.S. Janik-B.J. Martin					6/53,500v	746/194
				J.J. Mann-J.S. Janik		4/35,000				719/632
X 11	561	2200	65/73x 100	K.M. Savage-C.H. Corliss					1/56,000h	743/571
X 28	497	2227	50/60x 165	J.H. Adams-S.D. Qubty					2/56,000h	739/439
				Potere Inc.-J.H. Adams		2/44,900h				721/509
X 28	498	2235	63/64x 141	R.P. Harper-E.D. Faulk			7/46,500			732/181
X 11	5B	2244	62x100	E. Rloskat, Jr.-C.W. Richardson		3/40,545a				723/491
X 28	501	2311	61/71x 115/102	D.O. Cole, Jr.-C.D. Crowe				6/48,500h		737/374
X 11	568	2312	79/55x 98/100	R.T. Hazell-V.M. Richardson, Jr.					10/53,900v	745/547
D 28	506	2349	61x100	K.E. Arnold-B.T. Starkey, Jr.			7/46,000			730/371
FIESTA DRIVE										
A 28	954	4118	60/74x 140	J.J. Koeppel-K.C. Court					5/58,000	747/196
				L.A. Vondy-J.J. Koeppel		3/42,000				7723/510
C 28	955	4126	60/81x 122	E.T. Salathe, Jr.-R.V. Collins		3/9,500h				720/280
C 28	508	4128	77/96x 100	W.M. Jones-S.N. Neel			7/55,251a			731/398
C 16B	71B	4400	65/66x 100	R.V. Tedesco-E.W. Shallin	9/35,500h					719/49
D 16B	73B	4418	69x100	E.A. Hendricks-F.J. Schulte			8/44,000h			732-248
X 23	80	4419	68/65x 105	H.R. Messinger-L.R. McCrocklin, Jr.	7/41,500h					714/627
A 16B	74C	4426	68/61x 100	S.E. Anderson-G.L. Mabney				11/66,132a		740/191
				J.A. Good-S.E. Anderson		10/56,000				726/353
				G.H. Troxell, Jr.-J.A. Good	1/45,000h					714/35
B 16B	76B	4446	54x100	C.O. Morrison-J.W. Beasley			11/49,000h			732/605
X 16B	78A	4508	54/49x 100	L.T. Nesbitt, Jr.-T.B. Davisson		7/34,300				719/49

PLANTATION ESTATES- HOLIDAY PARK

MAC ARTHUR BLVD.

	SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB/ FOLIO
X	25	123	4118	65x90/94	E. Canulette-Ruben E. Villagram					6/32,000		736-386
X	25	124	4126	65x99	B.F. Davis-Amos C. Smith Jr. John C. Mitchel-Benj. F. Davis		4/33,000v	11/36,453a				727-323 718-300
X	25	125	4134	65x100	Altha A. Manes-M.P. Schwarzenbach, Jr.		2/18,225					714-146
X	25	128	4218	65x100	H.H. Brock-Wm. W. Johnson Jr.	9/37,000						712-495
X	25	129	4226	65x100	C.V. Booth-Thos. J. Wood						12/61,500cs	753-114
X	25	40	4334	69x100	F.P. Dunn--Clark L. Fox F.J. Shick-Francis P. Dunn		9/29,204	2/30,000a				722-488 719-58
X	13	2A	4341	67/68x104/100	L.S. Salvador-Richard Alfred Carr		3/41,500					717-220
X	25	35	4434	70x102/104	V.E. Holland-Jas. D. Estopinal			3/35,370a				723-509

MEDIAMOLLE DRIVE

	SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB/ FOLIO
X	2	432A	1915	64x100	D.L. Forney-D.A. Anderson R.G. Martin-D.L. Forney P.E. Schumacher-C.A. Burk D.H. Edgington-P.E. Schumacher C.A. Burk-R.G. Martin		2/37,090a 2/36,125 8/37,240a	12/42,000a			6/54,800v	746-272 724-533 716-138 709-468 723-39
C	2	434A	1927	53x116xvd	R.A. Meyer-A. Bisso		5/39,000h					714-423
X	3	435A	1933	53/91/95 x118/222	A.C. Greig-R.L. Scott Wm. Fulton-A.C. Grieg				5/44,000		5/55,000	744-178 732-95
X	2	436	1935	41/13/89 x100/118	M.E. Sharp-H.C. Choate	8/35,500h						710-346
X	3	443	1942	63x100	J.A. Niemeyer-C.E. Thayer C.E. Thayer-Wm.C. McClaughry					6/51,500h	1/53,276	734-579 743-587
X	2	438	1955	65x100	D.L. McMullen-Wm. H. Glung, Jr. G.A. McCleland-D.L. McMullen			10/39,357a		2/43,000h		735-198 724-410
X	3	444	2000	65x100	D.K. Byrd-C.J. Kennington T.J. Burnett, Jr.-D.K. Byrd	9/71/35,900					6/54,000h	748-140 707-186
X	2	439	2001	65x100	A.C. Lyles, Sr.-D.C. Sansom				10/42,000h			731-577
X	3	445A	2010	62x100	M.K. Gilbertson-G.T. Neal D.E. Lidke-M.K. Gilbertson R.H. Koerner-D.E. Lidke		11/39,000h		9/44,900h		1/53,920a	740-376 732-370 721-206
X	2	483	2021	61x110	C.W. Boyd-V.G. Shaver						1/51,000	743-609
X	2	484	2029	65x100	Wm. B. Manson-E.W. Emmons		3/36,500h					715-213
X	3	447	2030	65x100	J.M. Morris,Sr.-B.J. Morris			9/39,500h				733-472
X	3	450	2110	56/70x 104/100	J.M. Mayfield, Jr.-K.J. Anderson S.L. King-J.B. Mayfield, Jr.			3/39,000			6/53,200	745-261 722-551
C	2	487	2111	63x98/110	F.G. Dinoto-J.G. Schmidt J.G. Schmidt-T.N. Lennox T.N. Lennox-W.L. Copening		11/40,500	7/39,000 7/39,000				721-267 728-123 728-123
X	3	453	2134	62x100	C.L. Bowers-C.A. Harman J.D. Boyett-C.L. Bowers A.L. Leslie-J.D. Boyett			7/40,000	5/41,700h	9/47,000v		741-58 730-156 724-96
C	2	490	2139	68/58x96	Robt. M. Rice-J.F. Moore					8/51,500h		743-43

PLANTATION ESTATES-HOLIDAY PARK

PRANCER STREET

	SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB/ FOLIO
C	13	177	2301	65x100	H.A. Bergman-Richard H. German	3/39,900v						704-632
X	13	172	2343	60/77x100/126	J.C. Smith-Seymour Marx	10/44,000						709-514
X	13	169A	2363	51x123	Robt. Bezigian-Lynn C. Shannon				7/55,000h			732-232
C	13	168A	2371	63/79x104/100	Shirley Hayes-Bobby R. Harris		5/40,750h					716-390
D	13	167A	2401	67x109/104	D.T. O'Brien-Burton S. Stewart			9/53,000				724-326
					Paul L. Keyes-Dennis T.O'Brien		10/50,087					723-161
X	13	166A	2411	65x113	H.E. Holcombe, Sr.-Billy J. Briscoe						4/60,000	740-643
					Wm. B. Bean-Hosea E. Holcombe, Sr.	9/45,000						713-451
X	14	235A	2412	65x100/105	J.E. Call-Edw. F. Miesch						8/51,930	748-467
					R.D. Luker-Jack E. Call				7/43,500v			731-350
					Succ. Fred Dyjhuizer-Ronald D. Luker		9/40,000h					723-114
A	14	236A	2420	65x116	C.R. Blomberg-Billy R. Poole					10/55,000h		741-232
D	14	237A	2428	65x121	T.A. Brown-Mark B. Puckett						7/59,900h	748-304
					R.W. Donaldson-Thos. A. Brown				10/49,000h			730-612
X	13	164A	2431	65x123	Chas Majors-Michael B. Tepovich		6/48,750h					718-505
D	13	159A	2465	64x134	John Lowe-Dudley L. Mann					8/52,500h		739-54
C	14	244	2476	58/68x119/116	C.R. Peterson-Thomas P. Lang et al						10/60,000	746-517
C	21	245	2500	70/50x117/125	Chas. R. Turner-Chas. M. Thames			7/41,500a				726-176
A	20	157	2501	59/121/66x108	J.C. Berry-Michl Brechtel				6/45,000h			729-155
X	21	246A	2510	70/69x125	Richard L. Brown-Ronald Bifani				8/52,000h			733-394
C	21	247A	2522	73/55x120x127	Roy S. Reed-Raymond K. Whelan					4/46,250h		736-324
X	21	249A	2532	73x104	Edw. L. Weitz-Roy I. Swanson		6/44,000h					714-514
X	20	152A	2537	67x105	Potere, Inc.-Edw. D. McCarthy		7/47,700h					714/618
B	21	250A	2542	66x100	M.R. Smith-Bhagway Gupta						11/75,900h	748-658
					David Majors-Malcolm R. Smith					9/62,500v		743-80
D	21	251A	2552	68x100	B.F. Heinrick-Louis Sanchez-Navarro			8/43,500h				724-201
C	20	149	2563	60x100	Paul E. Pilkington-Wm. F. Rachal	9/38,500v						711-432
X	21	255	2618	60x100	C.E. Bollinged-Jas. J. Jaubert	11/1-34,112a						708-291
C	20	146	2619	60x100	H.M. Penton-Arthur S. Cramer,Jr.	4/39,000						705-647
X	20	145	2627	60x100	J.E. Spaulding-Kenneth C. Mabley					7/47,500		736-484
					A.A. Kancher-Jas. E. Spaulding		6/37,000a					718-513
C	21	257	2634	60x100	G.S. Smith, Jr.-Stuart Hirsch						7/52,000h	748-303
A	21	258	2642	60x100	R.A. Jardine-Chas. E. Davis						5/60,000h	746-183
					W.E. Aeschbach-Robt. A. Jardine					3/51,000h		737-135
D	20	143	2643	60x100	J.K. Callaway-Kenneth D. Norton						2/50,000h	742-471
C	21	259	2700	60x100	S.J. Black-Kenneth C. Marley						8/52,500	745-432
					L.R. Nott, Jr.-Sloan J. Black	4/32,500						707-676
X	20	142	2701	60x100	John W. Ault-Jacob W. Lehman			12/37636a				726-527
C	20	141	2711	60x100	John E. Carr-Hubert A. Wiechert				3/43,943a			724-687
X	21	261	2716	50x100	J.B. Atterbury-Lloyd Breaux						3/53,474a	740-622
					Albert T. Shukas-Joe. B. Atterbury			1/35,000				721-443
X	21	263	2730	50x100	Geo. Lewis-Charles S. Voorhies	12/34,000						711-692
A	21	264	2738	68x100	L.C. Powell-Gregory L. Duffy						9/68,900	744-538

HOLIDAY PARK

ST. NICK DRIVE

	SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB/ FOLIO
X	5	357	1933	61 /72x103 /113	J.P. Higman, Jr.-Lawrence A. Boston	8/42,032a						615/648
C	6	350A	2010	60x100	Geo. W. Stoehl-Robt. F. Kiesling				11/43,000h			731-663
X	5	359	2011	63x110	M.E. Ruebush-Douglas G. Mitchell						9/49,840h	747-510
					J.M. Jones-Milton E. Ruebush		2/38,000h					716-167
X	5	362	2035	66x100	G.D. Jackson-Thos. S. Ballard						10/59,200v	746-587
C	6	347A	2036	60x100	L.B. Williams-Guy W. Smith		3/39,200a					714-207
X	5	364A	2051	62x100	J.W. Hughes-Phillip A. Garrett				2/36,417-			724-630
X	6	345A	2052	66x100	Theo. Miles-Troy W. Michie, Jr.					5/49,160a		738-424
					E.C. Arnold-Theo. T. Miles		8/43,748a					717-646
					B.M. Sanderson-Eilon C. Arnold	7/40,000v						712-331
X	5	365	2101	65/63x99/100	John Snyder-Cary M. Becker					8/51,000h		736-667
C	6	343	2110	62/69x104/100	Equit. Life Ass.-John R. Krail	4/36,500-						713A-8
					Richd. A. Turner-Equitable Life	4/36,000-						708E-131
X	5	369	2139	70/61x114/109	D.G. Gurley-Henry W. Kemmerly, Jr.					7/50,000h		736-409
X	5	370	2149	70x115	A.O. Sherick, Jr.-Jos. Q. Cipiano				8/43,600a			732-252
X	12	372	2213	63x114	W.F. Leruth-Coerte A. Voorhies					10/60,000h		742-173
X	13	390	2216	65x100	Dale D. Lindholm-Wm. B. Goss			5/47,200-				720-521
X	13	389	2224	63x100	Chas. E. Chadwick-Francis A. Wilson	9/39,900h						709-427
X	12	374	2229	63x114	D.W. Martin-John G. Koch		5/40,000h					717-357
					M.T. Jenkins, Jr.-David W. Martin	10/38,500						713-553
X	13	388	2232	63x100	T.B. Price-Edw. C. Tyson						6/56,000h	747-239
C	13	387	2240	63x102/100	J. Bruskotter-John J. Sodenstrom					3/44,650h		735-239
X	12	376	2247	63x114	Joe C. Greer-Jos. A. McQueen			7/45,600v				726-106
X	13	386	2250	63x102/104	J.G. Bryant-Jos. M. Mullen				8/41,900v			731-423
X	13	384	2310	62/63x109	Chas W. Walker-Algiers United Meth.Ch	2/37,000a						707-487
X	12	378	2311	63x114	B. Waldrop-Adam W. Arizmendi						6/55,500a	746-294
X	13	554	2320	63x111	E.J. Le Ruth-Earl R. Schultz					6/3,000h		734-642
A	13	924	2400	63x118/116	W. Cunningham-Richard B. Meyer						10/70,000c	746-523
C	12	926	2401	63x114	H. Patterson-David W. Kennedy					4/50,500h		734-360
					Jas. R. Moffett, Jr.-Harrell EugenePatterson			6/42,000h				725-78
X	26	929	2501	69/90x116/115	A.G. Andrews-Edw. P. Strassel						7/84,000-	747-381
D	20	920	2510	65/55x122/125	D.S. Crosbie-Jack R. Cochran		6/39.900h					718-508
C	26	930	2511	59/61x115/108	Louis V. Sierra-Iranklis E. Liokis			4/40,000h				721-617
X	20	919	2520		N.B. Gallagher-Fredrick W. KraemerIII		1/36,607a					716-47
D	26	931	2521	59/66x106/108	J.C. Denney-Henry J. Ahydel	8/40,500h						712-395
X	26	932	2529	59/78x106/110	Jas. Erler-Benj. G. Cuoto	9/40,000h						713-431
A	20	918	2330	65/55x123/114	Jas. Crosbie-Robt. D. Winston, Jr.					5/52,000a		738-493
D	20	917	2538	65/55x100/114	H.L. Widener-Edw. L. Thomae			12/47,223a				725-455
					Peter Perani-Harrell L. Widener		12/40,000v					723-330
C	26	935	2545	59/62x102	A.C. Hayes-Wayne H. Grimes						11/50,235h	744-669
					A.E. Hill-Aubrey Hayes	12/38,500h						711-675
C	20	916	2546	60x100	Max N. Langston-Harry G. Thrailkill				6/41,904a			733-188
D	20	915	2554	60x100	E. Donaldson, Jr.-Robt. W. Hindle					6/51,300v		735-600
					Oto C. Sims, Jr.-Edw. L. Donaldson, Jr.			4/39,900v				720-306
A	20	914	2562	60x100	C.T. Dean, Jr.-Dennis R. Miers						8/63,500c	747-413
					A. Bohannon, Jr.-Claire T. Dean				9/52,000h			729-451
					Frank Ber-Avril R. Bohannon, Jr.		1/43,000h					717-81
A	26	938	2567	60x100	R.L. Nichols-Ray Cochran						5 /60,000-	747-167
					M.W. Entrekin-Robt. L. Nichols			7/43,500h				724-107
					Mrs. D.G.Brocks-Edw. A. Kunz	7/38,500h						711-231
D	20	913	2570	60x100	R.J. Bork-Howard Murphy		7/44,159a					716-522
A	26	939	2575	60x100	J. Goffredo-Stephen T. Day						3/50,500h	734-259

HOLIDAY PARK

ST. NICK DRIVE

SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB/ FOLIO
20	911	2600	60x100	Lovick P. Thomas-Margaret C. Thomas				½ int		10/25,430a	746-459
26	941	2601	60x100	J.E. Curtis-Ernest R. Brooks				7/45,978a			730-391
				C.R. Crowley-Jon E. Curtis		5/37,723a					715-393
20	910	2610	60x100	Red J. Jerron-Jas. L. Hingle, Jr.	3/42,000-						705-534
26	942	2611	60x100	Jackie E. Ricker-Wm. H. Murphy			8/44,858a				726-250
				W.S. Allen-Jackie E. Ricker	8/40,721a						709-343
20	908	2626	60x100	Sam Katz-Don C. Miller		12/41,500a					722-307
				David L. Goren-Sam Katz		10/12,095a(deed to extinguish debt)					720-71
				H.D. Wilson- David L. Goren	6/41,000a						712-212
20	906	2642	60x100	Jos. Hart-Roy L. Dooley					7/52,367a		736-480
				P. McKinnon-Jos. F. Hart				11/47,500h			733-639
				Richd. Risley-Philip S. McKinnons	10/37,000h						712-559
26	946	2643	60x100	E. Hoffman-Basil B. Aumiller					5/48,771a		735-391
20	905	2700	60x100	Jesse S. Edwards-Sharion W. Shumock		12/44,798a					723-352
20	904	2710	60x100	J.M. Speers III-John A. Van Pelt						11/62,700h	751-50
26	948	2711	60x100	S.P. Johnson-Wayne E. McNeely	8/40,000h						712-399
26	949	2717	51x100	Earl Bates-Orville C. McDaniel					8/53,500		741-27
				K.N. Foerster-Earl F. Bates				6/44,006a			733-255
				Fred E. Davis-Kent N. Foerster	8/36,500	8/36,500					710-305
20	902	2724	60x100	R.E. Tredinnick-Billy C. Davis				9/46,500h			729-433
26	950	2725	60x100	Ewell F. Hartzog-David A. Myers			6/46,000a				725-43
20	901	2732	60x100	J.M. Morrison-Wm. Burges		8/45,502a					717-638
				R.T. Halfacre-John M. Morrison	6/40,500-						713-198

HOLIDAY PARK

VALENTINE COURT

	SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB/ FOLIO
X	5	423	1920	66x100	Mrs. J.M. Fontenot-Carl O. Hartwell					11/23,114a		741-345
X	4	420	2000	65x100	H.J. Holley, Jr.-Earl L. Bahnmaier						11/54,000v	747-669
X	4	591	2001	43/28/92/103x100	P.A. Morris,Jr.-Garland R. Cain		6/40,500-					714-501
X	4	589	2019		N.W. Layfield-Richd. W. Armstrong, Jr.	2/37,900-						705-484
X	5	416	2040	65x100	C.H. Cole, Jr.-Jas. G. Gooding	9/37,500v						712-445
X	4	586	2045	64x100	L.C. Lehmann-Wm. H. Reardon			2/41,000-				719-486
C	5	415	2050		M.P. Ramber-Percy D. Bagwell	5/36,166a						711-66
X	5	414	2060	65x100	G.W. Acklin-Philip J. Straug						6/55,000h	746-271
X	5	413	2100	65x100	L.S. Kincl,Jr.-Terren D. Bass						6/54,000h	744-287
C	4	584	2101	65x100	J.S. Stewart,Jr.-Kaye E. Stabler						12/58,500h	751-154
					Ms. J.V. Ory-Jas. S. Stewart,Jr.		8/39,000h					721-15
					E.C. Kimball-Randall J. Ory		2/35,298a					717-159
C	5	412	2110	62/72x100/103	J.W. Frederick-Kenneth C. Marley					11/47,046a		740-207
					R.I. McArron, Jr.-John W. Frederick, Jr.			6/44,517				728-41
					R.F. Travaglio Russell T. McArron		6/39,500h					717-505
X	4	582	2121	70/59x93/99	R. Witherspoon-Jackie M. Shall						7/53,203a	748-376
					John C. Yeager-Ronnie Withenspoon, Sr.					8/50,900-		739-17
X	4	581A	2131	70/34/19x95/93	D.G. Stephens-Neil F. Anderson					12/50,000-		741-370
					L.H. Edmond III-Daniel G. Stephens				10/40,000h			731-634
C	5	408	2144	17/65x114/116	James C. Hilton-David E. Manning	7/37,000-						709-272
X	5	407	2152	74/65x115/114	G.H. Trosclair-Arthur D. Young	3/38,500						705-623
C	11	560	2201	81/73x100	C.J. Pusateri-Lee E. Haskin						7/53,000h	746-411
					W.M. Chappelle-Cosmo J. Pusateri	8/39,300						713-303
X	11	539	2213	65x100	Glenn P. Carson-Goldoni E. Flack			6/43,076a				726-61
					A.R. Brown-G.P. Carson		1/41,000h					717-58
X	12	404	2220	67x114	Equitable Life Ass.-A.C. Herbert				12/46,000			732-574
					Dennis D. Allen-Equitable Life				12/48,000h			729-648
X	12	401	2246	67x114	D.M. Miller-Gareth E. Allenone		8/40,700h					716-654
C	12	33	2312	67x114	L.A. Mac Pherson,Jr.-Jas.F.Kirklighter	11/40,000v						713-604
X	12	397	2330	67x114	T. Conger, Jr.-Robt. H. Turner						1/55,000a	741-486
					C.D. McMillin-Thurston Conger,Jr.				11/46,000h			732-607
B	12	393	2420	62/72x114/115	W.L. Yeckley-Dan'l. R. Aldridge						2/61,000h	742-522
					T.L. Recker-Wayne L. Yeckley					3/56,000		736-227
X	26	548	2522		S.S. Hoffman-M. Eug. Wright,Jr.				6/46,900			733-170
X	27	511	2525	62/13x59/118	G.T. Wierzbicki-Tom Gibbons					12/60,000a		741-432
					S.D. Bichler-Gregory T.Wierzbicki				2/48,000v			727-531
X	27	512	2533	62/71x106	L.M. Hendricks-Randall J. Parrish	3/42,994						707-651
X	27	514	2551	66x100	F.E. Hopkins-George D. Madsen					1/56,000h		736-25
X	27	515	2559	65x100	R.O. Campbell-Chas. G. Sauls						12/64,450h	749-151
					Jos. A. Roy-Roy O. Campbell			6/44,250				725-93
					B.M. Shepard-Jos. A. Roy		3/40,000					718-239
X	27	516	2567	62x100	H.L. Johnston-Thomas M. McGraw						12/66,500v	750-145
					Robt. E. Burns-Howard L. Johnston			1/47,000a				722-436
C	27	517	2575	62x100	Chas A. Shaw-Wilbur S. Williams			10/49,000a				725-335
					E.V. Weaver-Chas. A. Shaw	9/41,500v						711-495
X	26	542	2580	68x100	A.M. Rubenstein-Luther F. RogersJr.		9/52,000					722-6
B	26	541	2590	68x100	Benj L. Goepfert-Geo. O. Fergurson, Jr.			7/49,500-				726-91
C	27	519	2591	62x100	Don P. Meltzer-Wayne M. Johnson					3/50,000-		734-317
A	26	540	2598	68x100	J.A. Wanamaker-John H. McCandless				5/46,900			729-110
D	27	529	2599	62x100	R. Davis-Jos. P. Tynan						5,53,500h	748-118
					G.C. Scott-Robt. Davis				7/44,482a			732-201
C	27	522	2613	65x100	W.D. Blalock-Jos. E. Warner					11/53,000h		742-234
					Jos. E. Warner-Wm D. Blalock			9/51,996a				726-318
					M.A. Chaudoin-Eleanor T. Warner		7/46,900h					714-601
X	26	537	2620	70x100	A.C. Marshall-David J. McMurchie						4/58,500a	745-37
					Rolland E. Smith-Alice C. Marshall				10/51,500h			731-584
X	27	524	2629	65x100	J.A. Lawrence-Clifton R. Heuay		5/44,000h					714-425
C	27	526	2701	64x100	P.F. Constantine-Diego V. Martinez						7/54,000h	747-298
					Chas. P. Menard-Dr. Patrick J. Constantine				10.46,000h			730-627
					K. Arnold-Chas. P. Menard	8/37,500h						711-419

HOLIDAY PARK

VALENTINE COURT

	SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB/ FOLIO
X	26	532	2720	66x100	Henry Dolson-Don A. Navarro			7/49,000h				725-128
B	27	526	2721	65x100	J.L. Hepkin-Jas. H. Baskett						4/62,000v	747-42
					J.P. Lawson-John L. Hepkin				9/46,000h			730-523
C	26	531	2728	65x100	H.V. Pazos-Ralph F. Primerano						3/60,500h	739-643
D	26	826	2732	60x100	Jas. C. Kiefer-Jas. B. Humphrey					6/48,800h		734-615
					W.S. Taylor,Jr.-Jas. C. Kiefer			7/40,700h				724-46
A	26	825	2740	60x100	V.F. Alletto-Karl D.Erbacher					10/59,000-		740-162
X	27	824	2744	65x100	J P Dimmerling-Barbara P. Ellis					12/53,304a		739-298
					Edw. F. Sayehg-Jas. P. Dimmerling			1/39,622a				722-446
					G.R. Foster, Sr.-Edw.F.Sayegh		2/40,984a					716-173
					A.B. Develschoward-Gerald R. Foster	7/38,702a						710-229

PLANTATION ESTATES-HOLIDAY PARK

VIXEN STREET

	SQ.	LOT	HOUSE NO.	SIZE	SELLER-PURCHASER	1972	1973	1974	1975	1976	1977	COB, FOLIO
D	25	478	4211	60x100	I.T. Strenge, Jr.-Jas. O. StanleyJr.	12/40,840v						711-692
X	25	134	4329	50x100	L.A. Rogers-Louis I. Reinach, Jr.	8/36,500h						712-403
X	25	51A	4343	59/60x101	P.G. Pizzeck-Chas. D. Smith					6/52,584a		728-563
					J.A. Alvenus-Patricia G. Stinchcomb		5/42,000a					715-413
X	25	49B	4401	59/60x100	Theodore Scott-Kenneth Randall					1/40,400v		734-71
X	25	47B	4417	50x101	G. Frederick-Frank J. BeninateIII						11/47,700cr	753-14
X	25	46C	4423	60/61x102/101	Eugene H. Winder-Everett Kastler			4/36,955				722-630
X	25	45C	4439	51x104	Frank S. Peace-Gerard J. Noonan				2/40,500h			738-33
X	25	44B	4447	62/61x103	D.W. KennamerII-David B. Anderson			5/38,500v				720-632
X	25	43B	4455	63x103/101	Equitable LAS-Theron H. Pace						2/50,500	742-470
					E.R. Jones of U.S.-NY Corp.-Equitable LAS					10/49,250-		743-197
					Wm. F. Goodwin-Edw. R. Jones	6/37,584a						710-194

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SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
SOUTH BRADLEY DRIVE											
1	201			L.S. Prokop-Wm. G. Counts						11/56,000v	850/451
	212			W.DeBosier-So.Standard Homes	2/6,300						654/317
				R.L. Frost-Harvey E. Johnson	7/35,300(h)						674/29
NORTH BRAXTON DRIVE											
	10		108 x 150	C.B. Cooper-Paul L. Landry	12/47,000						694/23
	253			Circle R., Inc.-Raymond C. Whedon		8/44,500					710/935
	254		100 x 150	N. Fortenberry-Palmer L. Click		10/46,000(a)					715/737
				J.H. Jenkins-Norman W. Fortenberry	10/6,750						689/239
				C.B.S. Builders-Norman Fortenberry		4/41,550(h)					702/247
	255		100 x 147	D.T. Greer, Jr.-Allen J. McKean			8/46,916(a)				736/275
				G.H. Taylor-Dewitt T. Greer, Jr.		1/38,000(h)					696/491
	256			H.W. Poque-Saml. R. Steele, Sr.	6/51,900						671/211
2	257		100 x 147	N.V. Abernathy-Eugene J. Bourgeois						11/54,000cs	848/347
2	258			B.I. Duke-Ozro E. Ewers				5/55,500(a)			[illegible]/317
				J.H. Jenkins-Jos. Braud Bldrs,Inc.	4/6,750						662/114
				Jos. Braud Bldrs.-Baprett I. Duke	8/41,633						683/83
2	259	103	100 x 150	R.J. Vinson-Daniel T. Sullivan, Jr.				10/56,500(v)			769/67
				G. Guidry - R.J. Vinson		1/46,400(h)					696/968
	260	105	100 x 150	R.T. Pike-John N. Chanceilor, Jr.					12/52,103(a)		808/581
	261		100 x 150	W.H. Halsey-Lester G. Harmon			6/53,500(a)				732/804
	263		100 x 150	Marris, Inc.-Milton Soulier	9/6,890						632/88
CARLISLE COURT											
	323			So.Standard Homes-J.F. Wilkinson	4/39,360(h)						661/190
	324		vd x 195	Circle R., Inc.-Jas.W. McCaron		12/78,690					717/40
				R.J. Richardson-Circle R., Inc.		6/14,200					707/678
	325		vd x 190	W.R. Schelihase#-Ralph H. Boisblanc			1/77,000				723/45
				P.D. Fountain, Jr.-Walter R. Schellhase		1/13,000					695/866
NORTH CORBY DRIVE											
1	66		100 x 150	H.R. VanBrunt, Jr.-Jean G. VanBrunt						11/21,205	680/3[illegible]3
	67		100 x 150	E.R. Hicks-Edw.A. Vajmar	8/42,300						
	70			D.R. Culpeper-Martin A. Smith, Jr.					11/5,600(s)		804/304
1	123	164	115/75 x 150/155	W.F. Pohlman-R.J. Stuckart						(1978)-1/65,500	856/109
				A.V.Vinding-Kenneth E. Krzyzek		10/49,500(a)					715/634
				K.E. Krzyzek-W.F. Pohlman			8/52,000(a)				737/546
				R.W. Winters-J.V. Vinding	4/40,923(a)						663/85
	125	167	100 x 150	M.J. Poretto-Eugene A. Pilon					7/54,900		793/17
				P.R. Lalumiere, Jr.-Mario J. Poretto				5/50,500(a)			755/588
COUNTRY CLUB BOULEVARD											
1	5		86/20 x 174/106	W.E. Chaney Const.Co.,Inc.-Edw. J. Rupert				9/60,800			766/100
				E.J. Rupert-W.E. Chaney Const.Co.,Inc.				5/12,500			753/227
	6			W.M. Arnold-Jeff T. Holman					3/16,500(h)		780/601
	14	214	90/110 x 151	S.S. Tucker-Jos. E. Brown						1/52,500	810/787
1	15		100 x 150	P.W. Cain-Geo.W. MacArthur				6/45,500(h)			756/630
	16		100 x 130	K.G. Atkinson-Ray D. Marrs					3/48,500		778/773
	20	441	100 x 130	J.H. Meaux, Sr.-Eugene Migotsky				10/52,500(h)			768/662
	23	435	100 x 130	C.F. Claxton-Patrick T. Taylor						5/65,000(h)	823/758
	27		105 x 130	J.F. Dobbs-Myrtle R.M. Nuber					11/58,000(a)		804/739
	28		150 x 130	S.Hitchcock-Arthur A. Caire					7/52,500(v)		794/606
	36	409	100 x 140	R.P. Dickey-Chas.M. Easterling					8/67,500(h)		796/719

SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
COUNTRY CLUB BOULEVARD - (Contd.)											
	39		100 x 130	J.W. Hill-W.T. Gansert						9/52,900cs	842/666
				F.W. Pfaff-Jimmy W. Hill				11/47,500			770/281
	45	424	105 x 130	R.J. Dinjar-John H. Hall					9/68,000(h)		799/563
	46	422	150 x 130	J.N. Fowler-Julius A. Mire, Jr.					7/56,248(a)		793/516
1	63		100 x 150	R.E. Stanton-Jas.A. Ruff			2/54,000(a)				723/411
	64		100 x 150	L.E. Byrd-Wm.B.Doan		4/36,624(a)					703/613
1	65		100 x 150	P.C. Little-Jerry D. Scoggins				6/42,000			757/761
				J.A. Brown-Paul C. Little		1/34,737					696/313
	129	334	100 x 150	D.F. Peterson-John B. Delaha						7/62,500(h)	832/6
				J.J. Eckle-Dale F. Peterson		8/49,500					712/68
	131		100 x 150	J.E. Barber-Jack Hocutt		7/40,000(h)					707/916
	132		46/80 x 150	H.L. Lavender-Ramon Sperandeo						8/52,000(a)	835/518
				A. Swede, Jr.-Harold L. Lavender		1/34,907(a)					969/677
	134		100 x 150	Pollard Estates Dev. Corp.- So. Standard Homes	10/6,350						636/109
				So. Standard Homes- Daniel P. Bauer	7/38,800						676/275
1	135	324	100 x 150	D.P. Bauer-Kenneth P. Simon				9/52,000(h)			764/759
				Kenneth P. Simon-Robt. Fellman						(1978) 2/62000(h)	862/115
	136	318	100 x 150	C.W. Krieger-Philip R. Brock						8/60,500(a)	841/165
				W.F. Toler-Chas. W. Kreiger, Jr.		11/55,332(a)					719/295
				W.J. Hewitt-Wm.F. Toler	7/44,825(a)						711/611
				J.N. Chancellor-W.J. Hewitt	7/44,825(a)						678/224
	138		100 x 150	L.P. Ramirez-Albert A. Lovell		4/41,300(h)					701/338
1	139		100 x 150	C. Sparkman-Herman A. Trosclair				4/27,000			753/345
	140	310	113 x 150	E.W. Sanders-Johnnie W. Bennett						8/57,500(h)	834/271
				B.A. McArdle-Emmett W. Sanders				6/50,500			758/723
	145		105 x 150	S.A. Fahrion-David A. Larson					9/49,200(v)		799/738
				J.C. New-John J. Meehan	12/36,465(a)						647/375
				J.J. Meehan-Sam A. Fahrion	5/37,206(a)						667/376
	149		120 x 150	W.J. Pastorick-Raymond R. Duane	5/40,560(a)						682/102
1	169		100 x 150	P.M. Dollar-S.L. Dollar(Same Name)			12/23,600				745/592
	171		100 x 150	J.M. Carlin-So.Standard Homes	9/7,000						633/54
				So. Standard Homes-A.E. West	1/42,200(h)						651/318
	172		100 x 150	Marquette Co.-John R. Richardson						5/43,000(a)	823/374
				K.E. Parks-Marquette Inv.Corp.				10/44,000(a)			767/147
1	173		100 x 150	W.E. Langan-Jesse J. Loving		9/41,000(h)					714/70
1	175		100 x 150	C.A. Hanson-Carroll R. Gray			2/47,000				724/322
1	177		100 x 150	F. Arnold, Jr.-Geo.W. Thompson,Jr.			4/50,000(a)				727/815
	179		100 x 150	J.M. Clemens-Geo.E. Severs		6/19,700(a)					705/725
	180		100 x 150	J.L. Laslie-Vincent B. Faxhia		3/49,500					699/187
1	183		100 x 150	J.E. Becker-Robt. G. Devine			7/19,943				734/431
	185			A.T. Terry, Jr.-John F. Galvin					10/50,000(a)		802/777
1	188		100 x 150	J.E. Queen-Benj.V. Groninger		10/55,000(a)					716/99
	189		90/140 x 158/150	W.J. Evers-Bobby G. Redd					3/65,000		778/380
	190		91/80 x 159	Falcon Homes, Inc.-Billy D. Swafford		1/42,500(h)					696/374
1	193		100 x 150	G.P. Hars-Harvey L. Morgan		11/35,036(a)					719/567
	194		111 x 150	W. Clements-Manis, Inc.	2/8,000						687/300
				Manis, Inc.-Jerry Williams		4/48,500(h)					703/212

SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
COUNTRY CLUB BOULEVARD - (Contd.)											
	195	202	110 x 150	D.C. Bailey-Ivan M. Jones						7/62,000(h)	831/205
				L.S. Smith-Delbert C. Bailey			2/43,973(a)				724/137
				S.M. Sakwa-Lee Stanley Smith		3/39,750					
	197		100 x 150	C.J. & G.L. Fritchie-Lorne W. Hicks						3/30,000(v)	817/868
	198		100 x 150	R.C. Irons-Jos. A. Stephany				11/49,000			771/188
NORTH DABNEY DRIVE											
1	93	114	73 x 150	V.R. Smith-Burnham Josselyn			9/49,650(a)				738/626
				D. Murphy-Virgil R. Smith	9/38,000(h)						687/268
				J. Norwood, Jr.-Denis Murphy	10/33,524(a)						637/221
	95		100 x 150	W.J. Gugler-Jerry V. Cochran	10/51,500(h)						689/39
	96		100 x 150	D.H. Minzell-Gordon R. Gain						8/49,000(a)	836/37
				E.H. Youngblood-David H. Minzell		5/35,496(a)					703/945
				D.C. Blitz-Earnest H. Youngblood	4/32,500						660/35
	97	106	100 x 150	W.R. Hamer-Jas. B. Noble						6/56,500(h)	826/570
	98	102	108/151 x 85/102	D. & R.E. Groat-John D. Davis & C.R. Fox, Jr.						6/61,000(a)	830/90
				P.L. Landry-Ronald E. Groat					5/51,000(h)		787/34
				M.Burns-Rodney M. Hornor					1/42,000		774/883
	100	103	100 x 150	D. Dugas, Jr.-Theodore A. McLeod					6/66,200(h)		790/575-587
1	101		100 x 150	S.G. Martin, Jr.-Huey D. Clark			10/46,000				742/321
	103		100 x 150	R.P. Ewing-Elmary A. Morgan	8/41,676						683/380
1	104		100 x 150	R. H. Kramer-Donald G. Levy			8/40,000				738/294
HUNTINGTON DRIVE - ADJACENT TO I-12											
	71	358	53 x vd	G.E. Hinton-B.E. McDaniels	2/5,000						652/39
				B.G.H. Dev., Inc.-J.G. Irwin, Jr.	6/45,000						668/368
	72	356	110 x 143	Falcon Homes, Inc.-Ronald W. Tweedel		6/44,300					705/514
				Polland Estates-Falcon Homes, Inc.	11/13,500(includes Lot 73)						692/623
	73	354	100 x 143	Falcon Homes, Inc.-Jos.H. Miller		11/61,000					717/814
				Polland Estates-Falcon Homes, Inc.	11/13,500(Includes Lot 72)						691/623
	74	352	100 x 143	Polland Dev.Corp.-Jas. J. Braud	12/6,750						694/669
				J.J. Braud-Daryl VaWarner		6/42,000					705/186
	75	350	100 x 143	R.J. Sweeney-Han Tai						(1978) 2/43,500cs	858/113
	77	346	100 x 143	J.C. Kelley-Jack P. Harrison					10/53,000		802/56
	78	344	100 x 143	G.I.Lindah III-Employee Transfer Corp.					3/19,177		781/492
				Employee Transfer Corp.-Jos. R. Armstrong					7/43,000		794/726
	79	342	100 x 143	Neal Const. Co., Inc.- Hanson Const. Co., Inc.	9/6,000						688/259
				F.C. Treadway-Chas.E. Fields, Jr.			6/51,000 (h)				731/479
	80	340	100 x 143	T.W. Alley-Elegant Homes, Inc.		7/10,600(Includes Lot 81)					678/311
				Elegant Homes, Inc.-Jos. C. Glake, Jr.			9/38,000				715/433
				J.C. Blake, Jr.-Peter J. Grieff					6/47,973(a)		791/169
	81	338	100 x 143	T.W. Alley-Elegant Homes, Inc.		7/10,600(Includes Lot 80)					678/311
	82	336	100 x 143	B. Allen Const. Co.-Robt.A. Carter, Jr.		3/39,500(h)					699/917
				T.W. Alley Dev.Corp.- B. Allen Const. Co.	7/13,500(Includes Lots 834 & 245)						675/17
	83	334	100 x 143	B.Allen Const. Co.- Kenneth T. Corey	12/42,500(h)						694/26
				T. W. Alley Dev. Co.- B. Allen Const. Co.	7/13,500(Includes Lots 82 & 245)						675/17
	85	330	100 x 143	R. L. Ashby-John C.Holmes, Jr.						6/56,473	828/550
				J.H. Parsley-Robt. L. Ashby				1/53,000(a)			747/398
				Polland Estates-Falcon Homes,Inc.	10/15,850(Includes Lot 190)						672/279
				Falcon Homes, Inc.-James H. Parsley	11/41,000						692/9
	87	326	100 x 127/135	H.R. Monneyahn-Otis M Polland, Sr.			11/47,276(a)				743/310
				O.M. Polland, Jr.-Robt. V. Weiss, Jr.			12/49,526(a)				746/259
				R.V. Weiss, Jr.-Jimmie A. Juliana						7/62,500(h)	831/152
				Falcon Homes, Inc.-H.P. Monneyahn		5/43,500(h)					705/89
	88	324	100 x 143	Falcon Homes, Inc.-Terry M. Davis		4/39,900(h)					701/483
				T.M. Davis-R.L. Hinshaw				5/51,000(a)			755/685

SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
HUNTINGTON DRIVE - ADJACENT TO I-12 - (Contd.)											
	89	322	100 x 117	Falcon Homes, Inc-Bernie L. Pittman		5/35,000(h)					704/255
	90	320		Polland Estates Dev.Corp.- Joseph Braud Bldrs., Inc.			7/7,500(Includes Lot 91)				736/33
				J. Breaud Bldrs., Inc.-I.B. Buckles, Jr.				9/49,600(Includes Lot91)			766/98
				"Same as For Lot 90"							
HUNTINGTON DRIVE - OFF OF INTERSTATE											
1	105			H.F. Donnes, Jr.-Vernon C. Cory			4/37,415(a)				727/84
	109		100 x 150	H.E. Hilkes-Chas. W. O'Neill, Jr.						8/51,000cr	835/478
	110		100 x 150	D.R. Ekberg-Kendall G. Hinman, Jr.					8/58,500(v)		796/196
	113		100 x 150	J.M. Braud-Han Tai	7/38,000(h)						674/183
	116		100 x 150	W.Otto-Gerald W. Gay				7/42,500			760/188
1	117	345	100 x 150	R.T. Jones-Jos. L. Francis		9/41,000					714/356
	118	347	100 x 150	M.H. Payne-Dwight E. Arnold					5/54,000		785/688
	119	349	100 x 150	B.Allen Const. Co.-Carl L.Wild		5/42,500(h)					704/423
	121	353	100 x 150	J.F. Bowski-Louis J. James						10/51,500cs	847/457
				S.A. Holditch-J.F. Bowski			3/40,904(a)				724/925
NORTH JAYSON DRIVE											
	279		100 x 150	R.J. Kearney-Chas. E. Couvillion			3/35,500(s)				725/748
2	282	217		W.E. Chaney Const.-John W. Scelfo					7/68,000(h)		794/138
				R.F. Morrow-W.E. Channey Const. Co.				8/14,000			762/624
	284		80 x vd	Goldway Trans., Inc.-S.N. Morrill	9/38,000(h)						632/255
	285			B.G.H. Corp.-Geo.E.Bisbee, Jr.		1/47,000					696/394
	286		36 x vd	B.E. McDaniel-F.H. Goodson	9/45,000						686/17
2	288	214		W.L. Lively-Michl A. Havert					8/52,500(h)		796/451
				M.B. Tuttle-W.L. Lively		9/45,000(a)					713/688
	290	210	100 x vd	R.S. McQuincy-Edw.G. Ganezak			8/49,900(a)				736/652
				McDaniel Homes, Inc.- Raul S. McQuivey	12/37,475(h)						644/205
2	291		52 x vd	J.P. Bennett-Geo. T. Onega			10/54,910				742/182
				So. Standard Homes-J.T. Bennett	12/42,319						694/4
2	292	206	50 x 134 x vd	A.P. Calarusso, Jr.-Jos. W. McCaffery, Jr.						9/68,500	842/123
				E.A. Sullivan-Anthony P.Calarusso, Jr.			10/54,518				741/544
2	293	204	33/99 x 134/146	S.R. Helfer-Robt. G. Sanders					9/56,500(h)		799/527
	294		80 x 146	C.E. Love-Geo. W. Piper		11/30,000					717/121
SOUTH JAYSON DRIVE											
3	190	102	91/80 x 159/158	C.E. Shipp-Wm. A. Wacher						4/61,000cr	822/256
				B. D. Swafford-Chas. E. Shipp				10/54,500			766/630
				Falcon Homes, Inc.-Billy D. Swafford		1/42,500(h)					696/374
	337	114	100 x 164	J.G. Glenn-Jas.G. Sell		9/43,975					714/149
				J.G. Sell-Lorin W. Good			4/46,000				
				Marco Land, Inc.-Jerry L. Glenn	9/40,000(h)						687/146
3	338			Sticker Const.Co-R.N. Henegan				9/60,500			764/519
				F.G. Spiess, Jr.-Sticker Const.Co., Inc.			6/14,500				
3	339			M.L. Hamilton-Theodore B. Miller				5/70,000(a)			785/803
				E.P. Robert-Melvin L. Hamilton				6/65,000			757/253
	341		100 x 158	E.P. Robert-Conway B. Benson						4/85,000(h)	821/33
3	342			N.J. Rogers, Jr.-Wm.A. Swansburg					7/57,500		791/589
	343	101		C.G. Calongne-Edward G. Fisher,Jr.						9/79,000(h)	841/628
				Jos. Braud Bldrs.-Geo.C. Calongne				5/60,630			755/617
				J.A. Davis-Jos. Braud Bldrs., Inc.			6/10,500				732/465
	344		100 x 201	Marco Land, Inc.-Chas.D. Burks	2/39,800(h)						652/153
	345		100 x 201	Coldway Trans., Inc.-W.R. Wilcox	2/38,500(h)						652/213

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SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
SOUTH JAYSON DRIVE - (Contd.)											
3	346	107	100 x 201	J.R. Lynch-Bernard J. Helmke, Jr.					1/57,000		775/421
				Coldway Trans., Inc.-Jos.R.Lynch	8/45,500(h)						
	347		76 x vd	Marco Land, Inc.-Murray D. Poller		8/49,500(h)					711/833
	348		100 x vd	Empire Homes, Inc.-R.C. Weber	9/42,500						686/350
LANDON DRIVE											
2	204		95 x 203	T.A. Templet-Jas. H. Brannon			10/54,044(a)				741/552
	205		95 x 203	1st Bank Slidell-Roberta C. Crellin					6/42,500		790/515
2	209	328	95 x 204	L. L. McCarthy, Jr.-Terry Affolter				8/51.951(a)			762/110
	210		95 x vd	So. Standard Homes-Frank G. Swarr	11/38,000						642/164
	213		100 x 204	J.M. Trapani, Jr.-Kegham T. Tachijian					1/47,500		775/429
				D.E. Chunn-John M. Trapani, Jr.				4/47,500			752/584
	214		100 x 204	E.V. Triplett-Edw. L. Donaldson,Jr.					6/57,500		790/107
				E.B. Fdeeman-David W. Hubbell	6/42,186(a)						669/334
	216		46 x 216	L.B. Reuther-Herbert H. Stevens,Jr.	7/35,445(a)						675/34
1	223		95 x 210	R.E. Jaskot-Geo.C. Pfaff, Jr.		11/52,000					719/111
	224		95 x 210	E. Magnus-C.B. Almond, Jr.	8/36,500(h)						682/158
	229		95 x 210	V.Kall-Michael J. Egli						9/56,000(v)	842/271
				J. Staut-Victor Koll			4/37,908				738/424
2	230		95 x 210	T.B. Fowler-Richard R. Foll				7/51,500			760/ 26
	231		65 x 210	R. Jensen#-Arnold L. King	4/31,404						663/170
LOOP DRIVE - ADJACENT TO I-10											
	240	228	95/150 x 265/240	A.T. Hesby-Joseph L. Odom						7/61,000	832/206
				H.W. Hickman-Allen T. Hesby			10/47,500(a)				741/718
	242	224	100 x 150	Werner H. Keidel-Terrell E. Harbun						(1978) 2/64,500	860/617
				Builders Comp, Inc.-Werner H. Keidel		7/45,000					708/308
	243		100 x 150	J.H. Jenkins-Jerry A. Brown	6/36,000(h)						673/394
	244	220	100 x 150	J. Braud Builders-Jos.L.LaJaunie,Sr	11/39,500(h)						692/824
	245	218	100 x 150	B. Allen Const.Co.-Robt. J. Hyde		4/44,500					701/656
	246	216	100 x 150	W.D. Gardner-Daniel D. Johnson						3/61,400	818/319
				C.M. Cornelius-Willis D. Gardner				7/53,750(h)			759/403
				C.F. Rauthier-Chas.M. Cornelius			7/49,000				734/289
				Mans, Inc.-Chas. F. Rauthier		8/45,000					712/254
	247		100 x 150	Bill Allen Const.Co.-T.W. Alley	2/49,000						655/69
				B. Allen Const.Co.-J.E. Bearden, Jr	7/36,100(h)						674/285
	248	212	100 x 150	Circle R., Inc.-John R. Richardson	10/39,500(v)						689/127
				John R. Richardson-L.H. Blakely				12/57,800			771/813
	249	210	100 x 150	Neal Const.Co., Inc.-Thos.F. Landreth, Jr.		4/45,000(L)					702/250
	252	204	53 x vd	Q.T. Hinton, Jr.-John L. DeLee						2/57,006(a)	813/500
				J.H. Jenkins Cost.Co.-R.A. Beran	9/6,750						688/270
				R.A. Beran-Quincy T. Hinton, Jr.		7/41,750					708/811
LOOP DRIVE - OFF OF INTERSTATE											
	265	211	100 x 150	J.C. Carlisle-Bruce J. Bienvenu						1/62,000(h)	811/241
				W. E. Chaney Const.-J. C. Carlisle	8/37,750						682/89
	266			W.E. Chaney Const.-J.J. Foster	11/40,800 (v)						692/425
	267		100 x 150	D.M. Gerwin-Robt. A. Baker		12/50,000					721/176
				So. Std. Homes-D.M. Gerwin	10/30,925(h)						690/191
	268		100 x 150	D.M. Demuth-Fletcher W. Cochran					5/57,000(v)		787/619
	270	221	100 x 150	G.R. McNickle-Terrel A. Barrios						12/68,450	852/42
				Edw.C. Hanson-G.R. McNickle			10/37,500(a)				742/629
				Manis, Inc.-Edw. C. HansonIII	8/46,900(h)						683/30
	271			R.C. Orr-Alex M. Sturrock, Jr.	7/35,500						675/21

SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
MARGON COURT											
	151		103 x 150/143	J.E. Richardson-Bob L. Van Tuyl		1/42,881					696/547
	152		108 x vd	C.S. Weber#-Othiel Alsop		8/17,821(a)					711/753
	153		52 x vd	W.W. Watson-Marion Gampp		2/43,459					798/754
	155		55 x vd	R.W. Winters-W.W. Cunningham					1/42,000(h)		775/770
				P.L. Schrock-R.W. Winters	3/35,000(a)						656/314
	160	311	100 x 150	W.T. Lawrey-Raymond C. Hammond, Jr.					3/57,500(h)		781/602
				L.H. Dunham#-W.T. Lawry			1/43,500				722/414
	161			R.A. Morgan-Circle R., Inc.				10/44,812(a)			767/621
				Circle R., Inc.-Viola D. Elken					3/48,800(a)		779/603
	162		61 x vd	C.M. Quigley, Jr.-Louis E. Brucksieck						5/67,500(h)	823/751
				Hanson Const.Co.-C.M. Quigley,Jr.	7/46,260(h)						674/189
	167	318	115 x 150	M.B.H. Jetton-David P. Barnes, Jr.					5/59,500		788/451
				M.C. MacMurrough-Elden V.Jetton				4/54,000			752/399
				R.W. Weir-M.C. MacMurrough	2/47,484						
NORTH RANDALL DRIVE											
	233		100 x 150	J.S. Checkan-John J.Dingler,Jr.		10/52,500(a)					715/658
	234		100 x 150	L.A. Pitt-Thos.R. Hicks	11/42,156(a)						691/917
	235		100 x 150	A.Whittington-W.K. Strange					3/44,728(a)		779/101
				R.D. Hilton-Alex Whittington	1/34,455(a)						681/41
	237			So. Std. Homes-R.E. Rathbun	7/39,860(h)						674/278
	273		105/91 x 150	N.J.A.Parons-Russell Sutton, Jr.						7/71,500(a)	830/92
				W.E. Chaney Con.Co.-W.D. Parsons			12/60,000				745/642
	274	112	90 x 150	E.L. Berg-Jos. W. Hackett						4/56,700(v)	817/629
				R.G. Meyers-Eric L. Berg		8/42,500					712/84
	276		90 x 150	D.Q. Smith-Paul M. Borgatti		11/45,000(v)					717/403
	277		119 x 150	R.L. Nix-Nicholas A. Daniloff					11/82,000(cr)		806/300
SOUTH RICKFORD DRIVE											
1	216		46 x vd	H.H. Stevens-Mingyang See		9/38,744(a)					714/573
1	219		150 x 150	M.J. Duffy-Stephen W. David				9/45,386(a)			765/335
				M.R. Simmons-Michl J. Duffy			8/43,900				736/622
1	220			Anthony H. Lasseigne-A.H. Lasseigne, Jr.						11/57,000(a)	848/287
PINEWOOD DRIVE											
	295		100 x 150	Hanson Const. Co.-Walter P. Halse		12/45,500					693/724
	296		100 x 150	Pro.Const., Inc.-Roland Decrevel	12/53,000(h)						695/347
2	297		100 x 150	R.L. Smith-Anthony J. Vrana					11/64,460(v)		805/777
				J.R. King-Richard L. Smith			12/59,000				745/884
				E.A. Broden-Jas. R. King		9/51,000					713/291
				McDaniel Homes-Elissa A. Bowen	8/47,000						683/242
	299	182	100 x 150	W.S. Ezell-Alan M.Norton		10/50,900(a)					715/667
				J. E. Sticker, Inc.-W.S. Ezell		4/45,500(h)					701/814
2	298	184	100 x 150	M.J. Mayell-J.Peter Johnson			10/58,200				743/192
				Sticker Const. Co.-Michael J. Mayell		4/46,250					702/289
	300	180	100 x 150	Robt. T. Hastings-Wm.James Costas						7/67,500	837/488
				Sticker Const. Co.-Robt.T. Hastings		4/45,900					701/972
2	301			B.O.Cox-Don W. Barry					8/89,500(h)		795/299
				Slidell Bldrs.-Bobby O. Cox		6/65,000					705/827
	305		100 x 150	J.R.Fitzgerald-Wm.F. Barrett			6/62,500(a)				732/786
	307		100 x 150	P.N. Fuller-Gordon R. Hamilton						8/87,500(a)	833/311
				D.R. Durden-Paul N. Fuller			6/67,000(a)				733/344
	309		100 x 150	S.B.O. Lippert-August J. Penkava		8/51,969(a)					711/310
	310		100 x 150	D.R. Nolan-John Jos. Gunther			1/48,152(a)				722/425
	311		100 x 150	W.F. Hakes-Wm. E.King, Jr.		10/50,510(a)					716/738
2	312		100 x 150	P.J. Greene-Kenneth J. Guffey				5/48,000			755/191

SLIDELL COUNTRY CLUB ESTATES

PINEWOOD DRIVE - (Contd.)

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
	313		100 x 150	T.F. McNamara-Hugh E. Meyer			1/51,500				723/37
	315		105 x 99	Bldrs.Components, Inc.- Jos. J. Schnodelback	8/44,000(h)						679/184
	321		vd x 150	Bldrs.Comp., Inc.-Ralph Parker		8/52,000(h)					712/950
	322		110 x 99	Bldrs. Comp.-Jas.C. Parker,Jr.	8/44,000(h)						679/187
3	327	126	110/74 x 180	T.M. McCluskey-Russell C. Pickett					8/61,000		797/396
				James G. Schmidt#TR-Thos. N. Lennox				8/53,000			763/753
				T.N. Lennox-Thomas M.McCluskey				8/53,000			763/260
				Coldway Trans.,Inc.-W.S. Brasher	2/46,000(h)						655/71
	328		110 x vd	So.Std.Homes-Robt. D. Murphy	3/40,700(h)						658/338
3	329		115 x 130	E.C. Crain, Jr.-Leroy C. Pool					8/61,800(a)		797/448
	334		121 x vd	F.Hughey-Douglas D. Angele			5/61,000(a)				732/597
				Bldrs. Comp., Inc.-Fred Hughey	9/48,000						685/361
	335			J.W. Weldon, Jr.-John D. Smith		8/50,969(a)					713/103
	336		100 x 130	Marco Land Co.-Paul J.Enochson	5/41,000						664/12
	349		100 x 150	D. Haman-Employee Transfer Corp.						11/30,268	848/858
				R.F. Morrow-Drew Haman		4/49,500(h)					
	350		100 x 150	Delightful Homes, Inc.-N.H. Sather	5/42,450(h)						665/41
3	351	102	85 x vd	J.Dubbs-Chas. Schimmel, Jr.					1/58,500		774/631
				So. Travel Hms. Corp.-John A. Dubbs			3/54,000				724/842
3	358			R.T. Dunn-Eldridge Dugas, Jr.					6/64,000		790/224
				J.W. Buttrey-Robt. T. Dunn		7/53,100					709/746
3	360	109		J.E. Douglass-Howard H. Russell					4/51,500(a)		784/753
				T.L. Tedrow-John E. Douglass			11/49,475(a)				744/668
				J.B. Peterson-Thos.L. Tedrow			7/47,331(a)				735/599
				Marco Land, Inc.-J.B. Peterson	7/40,000(h)						674/23
3	361		100 x 161	J.L. Matter#-Edwin L. Kippler, Jr.				6/67,500(a)			758/478
				Bill Allen Const.-Verdell W. Matter	3/50,800						658/331
	363		100 x 161	D.R. Christiansen-P.L. Greenwood		11/50,318(a)					719/569
	365	123		R.J. May-Jas. M. McKisic						4/65,250	821/652
				D.L. Starr-Robt.J. May			7/59,470(a)				
3	366	125	100 x 160	K.W. Embry-John D. Vetter				12/58,500			772/602
				C.E. Schauss-Kenneth W. Embry			7/54,000(a)				734/90
	367		100 x 180	L.F. Abbotts-Gladys K. Menard		10/65,000					716/446
3	368		100 x 160	J.W. Klerk-Herman J. Byrnes					9/66,500		799/234
3	369			S.C. Johnson-Waldo H. Schock				3/49,500(a)			750/807
	370		111 x 140	M.G. Campbell, Jr.-Wm. C.Probst		11/65,000(a)					718/938
3	371		120 x 140	J.H. Munger-Henry C. Townsend, Jr.				7/59,637(a)			759/637
				Bldrs. Comp., Inc.-John H. Munger	8/45,000(h)						682/153
	373	153	110 x 140	So. Std. Homes-Wm.P. Ewig		11/45,500					717/668
				Polland Estates Dev., Inc.- So. Std. Homes, Inc.	4/27,750						659/195
	375		100 x 140	So. Standard Homes - Edw. Priestas			2/48,400				724/408
	376		95 x 140	R.L. Frost#-Walter Krzymowski			6/55,883				733/346
3	377		100 x 140	W.P. Daniels-Otis E. Sanford				6/59,000			757/663
				J. Buttrey, Inc.-Wm.P. Daniels		4/51,800(h)					702/98
5	378		100 x 140	C.F. Lennon-Johnny L. Reeves						9/66,500cs	840/69
				J.W. Buttrey-Clifford F. Lennon	7/48,000(h)						674/32
	379		100 x 140	J.W. Buttrey-Earl M. DeRouen, Jr.			2/45,000				724/111
	380		100 x 140	B. Allen Cosnt.-Frank A. Bailey	10/52,800(h)						690/491
3	381		100 x 140	L. Makosky#-Howard A. Perez				5/53,000			753/259
				B. Allen Co., Inc.-Frank Makosky	11/50,000(h)						692/170
	382			B. Allen Const. Co.-Geo.M. Brooks	10/50,600(h)						691/191
	383		100 x 140	Bill Allen Const. Co.- Eugene Zetka	5/42,450(h)						663/238
	384		100 x 140	A.E. Hawkins-Martin Marietta Corp.						5/69,000	824/646
				M. Marietta Corp.-David A. Cardot						5/69,000	824/658
				G.J. Bodenhamer-Albert E. Hawkins				3/58,500(a)			751/417
				Distinctive Homes, Inc.-Geo.J. Bodenhamer		1/46,000					596/240

SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
PINEWOOD DRIVE - (Contd.)											
3	385	179	100 x 140	F.H. Ugolini-Loyd J. Fischer					8/60,915(a)		797/253
				W.G. Perry-Jimmy W. Carpernter		10/51,000(a)					715/662
				J.W. Carpenter-Francis Henry Ugolini			1/54,000				
				Stickler Const.Co.-Wm.G. Perry	9/43,950(v)						685/288
	386		100 x 140	Sticker Const. Co.- Stonewall J. Craft	11/42,000(h)						692/396
	387		100 x 140	B.Allen Const.-H.W. Copeland	7/42,116						676/1
	388		140 x 140	W. Hanson-John B. Winch	10/63,000(a)						691/637
	389		119 x 140	J.J. Denson-Walter L. Oulliver		6/46,000					705/368
				Hanson Const.-Jas.J. Denson	7/45,354(h)						674/180
	390		125 x 140	Pro Const., Inc.-E.F. Stasney	10/46,000(h)						691/574

SLIDELL COUNTRY CLUB ESTATES

SEC.	LOT	HOUSE NO.	SIZE	SELLER - PURCHASER	1972	1973	1974	1975	1976	1977	COB-FOLIO
PINEWOOD DRIVE - (Contd.)											
3	385	179	100 x 140	F.H. Ugolini-Loyd J. Fischer					8/60,915(a)		797/253
				W.G. Perry-Jimmy W. Carpernter		10/51,000(a)					715/662
				J.W. Carpenter-Francis Henry Ugolini			1/54,000				
				Stickler Const.Co.-Wm.G. Perry	9/43,950(v)						685/288
	386		100 x 140	Sticker Const. Co.- Stonewall J. Craft	11/42,000(h)						692/396
	387		100 x 140	B.Allen Const.-H.W. Copeland	7/42,116						676/1
	388		140 x 140	W. Hanson-John B. Winch	10/63,000(a)						691/637
	389		119 x 140	J.J. Denson-Walter L. Oulliver		6/46,000					705/368
				Hanson Const.-Jas.J. Denson	7/45,354(h)						674/180
	390		125 x 140	Pro Const., Inc.-E.F. Stasney	10/46,000(h)						691/574

SHERWOOD FOREST

SHERATON DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
3	487	11610	100 x 150	Henry N. Bretz	Jon Wave Morar	1-78	$84,000c	2618-132
1	495	11445	90 x 150	Wm. D. McCharen	Ms. C. I. Kelleher	5-78	$70,000	2573-095
4	480	11935	50 x 150	Howard S. Billings	N. S. Desmarais	6-76	$60,000h	2505-274
2	494	11467	90 x 150	John F. Reilley	Hugh Holderith	10-75	$74,000c	5453-516
		11000	95 x 197			10-77	$54,500	

SHERWOOD FOREST

SHERBROOK DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
2	249	11834	100 x 150	R. B. Holloway	S. W. Critchfield	5-77	$44,500h	2573-899
3	240	11841	100 x 150	Chas. G. Hoover	Wm. A. Lewis	4-76	$40,570a	2488-315
				E. J. Jeansonne	Chas. G. Hoover, Jr.	3-74	$35,800c	2352-311
1	253	11650	100 x 150	Wm. A. Belding	Hollie M. Carter	2-76	$43,900h	2475-649
4	243	11955	100 x 150	Jos. J. Sqwyer	George D. Stack	6-75	$38,500v	2428-221

SHERWOOD FOREST

SHERWOOD FOREST BOULEVARD

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
	5	388	96 x 150	T. V. Bagwell	R. Chambers	8-76	$85,000h	2517-663
	6	422	96 x 150	D. S. Russell	K. A. Hammock	5-77	$45,979a	2568-805
				K. A. Hammock	G. R. Fowler	3-78	$58,000h	2633-894
	71	425	100 x 150	G. R. Cannon	E. C. Bacon	4-77	$58,500	2568-080
				E. H. Jordan	G. R. Cannon	9-76	$45,900	2521-214
	8	466	110 x 150	D. C. Antrobus, Jr.	F. H. Spend	6-75	$45,500v	2428-206
	28	626	106 x 160	W. J. Mayeux	E. E. Lear	11-74	$67,450a	2395-152
	32	740	95 x 160	Amer. Investment	J. B. Hilkena	4-75	$39,000c	2417-043
	177	755	105 x 150	D. M. Guynn	S. J. Culotta	4-76	$$48,000a	2485-044
	390	820	100 x 150	R. K. Pratt	W. S. Wright	4-75	$38,827	2417-587
	348	1173	110 x 150	M. P. Mock	N. Lang, Jr.	10-75	$53,491a	2455-564
				E. E. Lear	M. P. Mock	11-74	$45,389a	2396-012
	352	1265	95 x 150	R. A. Beckman	Noah L. Falgout	7-76	$62,500h	2511-497
	353	1277	92 x 153	R. H. Maughan	J. R. Pope	3-77	$49,900	2556-717
	354	1293	90 x 153	D. B. Robertson	J. B. Rogers	1-78	$55,000h	2620-113
	370	1336	90 x 150	B. Chaumont	C. J. Washispack	6-74	$40,937	2367-374
				National Residence	B. W. Chaumont	1-74	$38,000	2343-079
	358	1351	95 x 150	H. C. Carney	M. P. Mock	2-77	$65,000	2552-427
	361	1423	115 x 150	Runnymede, Inc.	M. G. Robinson	3-75	$73,000a	2410-588
				M. R. Downs	Runnymede, Inc.	9-74	$80,000a	2384-231

SHERWOOD FOREST

WESTBROOK DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
4	305	919	85 x 150	O. J. Blanco	R. A. Champion	7-77	$45,500h	2585-296
2	206	744	100 x 150	John S. Nelson	Arthur J. Young	6-77	$54,000c	2579-101
1	209	664	101 x 150	John W. Brophy	Mary J. L. Smith	10-75	$45,500h	2450-449
3	309	846	95 x 150	Mack J. Alonzo	J. F.O. Reinne	2-75	$54,200c	2405-333
5	307	955	85 x 150	A. T. Abadie	Robert H. Finlay	3-78	$62,300c	2636-152

SHERWOOD FOREST

ASHBOURNE DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
3	405	1209	125 x 150	Louis Golden	Wm. S. Fairbanks	8-75	$50,750c	2444-183
7	415	1367	100 x 150	M. J. Felps, Jr.	G. E. Rooney	4-75	$64,050c	2414-363
1	459	1110	67 x 215	R. C. Beecher	Lars G. Lund	4-74 1-78	$54,128 $80,000	2354-414
5	400	1232	95 x 150	Albert C. Doyle	Guy B. Wirth	8-78	$76,500c	2589-108
2	403	1180	125 x 150	Wendl Shiflett	Clinton C. Aubert	5-76	$23,500c	2494-402
4	406	1221	100 x 150	J. G. Terhoeve	Cornelia UnHal	7-76	$55,000a	2511-250
6	407	1233	100 x 150	Nora R. Hodges	David B. Pitzer	3-78	$58,000c	2633-011

SHERWOOD FOREST

FAIRHAVEN DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
3	275	11734	120 x 148	C. M. McCarstle	Jose Lima	9-77	$58,000c	2594-483
5	262	11865	100 x 150	Ms. R. E. Aucock	Mabel J. Armer	6-77	$55,250c	2576-542
				Maxine J. McKay	Rodney R. Litke	10-76	$49,500	2529-236
2	258	11725	125 x 162	Ken J. Daspit	Ed Kaltenbacher	1-77	$77,500c	2546-792
6	269	11976	101 x 257	David Eberback	Jack R. Goldberg	9-75	$57,240	2445-445
				Mary S. Bergeron	David Eberback	7-74	$50,000c	2374-218
1	257	11665	77 x 150	A. S. Heroman	Rich G. Barras	3-74	$35,800c	2352-311
4	274	11820	125 x 150	P. T. Bernard	Mark R. Haik	5-74	$33,000c	2360-726

SHERWOOD FOREST

GLENHAVEN DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
10	929	12763	85 x 139	J. M. Wacehr	A. R. Crech, Jr.	2-78	$64,000	2630-072
9	919	12666	88 x 140	John D. Payner	D. Mike Downing	10-77	$62,900h	2603-409
8	917	12640	88 x 140	Chas. R. Marin	Chas. Jos. Curtis	4-77	$47,000c	2567-660
2	77	11333	125 x 157	Robt. Sweasingen	F. B. Casanova	5-76	$36,600a	2496-403
3	81	11433		Emanuel Longo Richard H. Delatt	Thurst Woodward Emanuel Longo	10-76 4-76	$73,322a $70,000h	2530-268 2487-619
5	89	11635	100 x 150	Gil S. Parker, Jr.	Ferrol Fuselier	8-76	$43,500h	2518-385
7	93	11755	112 x 167	Robt. E. Waltman	Terry R. Jones	8-76	$46,900v	2518-085
4	101	11612	100 x 150	A. B. Wiggins	Gary R. Gregory	6-75	$45,900c	2428-172
6	24	11666	100 x 164	Robert Clifford	D. A. Breechen	7-75	$34,000c	2374-038
1 West	15	1125	120 x 160	Robt. D. Litt	Walt A. Grisham	5-77	$58,000c	2573-679

SHERWOOD FOREST

LITTLE JOHN DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
7	94	436	100 x 150	K. W. Davis, Sr.	John H. Tabony, Jr.	2-78	$52,500a	2528-314
8	133	463	100 x 150	Eric E. Crake	Nancy P. Mills	2-78	$58,500h	2630-432
9	122	536	100 x 150	Wm. W. Sabbagh	J. A. Koty	12-77	$45,000c	2616-776
5	130	365	156 x 139	Chas. B. Redman	M. J. Guillory, Jr.	10-77	$65,585a	2604-538
1	44	305	85 x 189	Dav. J. Gardner	Alice M. Pace	8-77	$44,500	2591-606
6	95	426	110 x 150	Glen Wakerfield Ed. L. James	John H. Tabony A. H. Johansson	7-76 5-74	$59,613a $49,739a	2512-538 2364-688
2	127	335	100 x 150	Walter R. Watson Joel L. Thomas	John N. Bankston Walter R. Watson	10-76 2-74	$34,900c $26,390a	2530-257 2348-720
10	46	10896	91 x 154	B. S. Gerald, Jr.	Robt. K. Kinderer	4-76	$41,000c	2488-540
4	44	350	85 x 189	Wm. E. Coleman	D. J. Gardner	10-74	$32,500v	2388-531
3	48	340	141 x 158	R. H. Charlton	K. M. Elmore	3-78	$69,900v	2636-289
11	26	12020	90 x 143	R. M. Millburn	J. M. Yglesias	4-78	$42,000c	2643-374

SHERWOOD FOREST

MILLBURN DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
1	459	1110	67 x 215	Arthur J. Nash Lars G. Lund	Peter R. Mansur Arthur J. Nash	2-78 5-77	$80,000a $73,000	2627-258 2573-899
3	450	11563	92 x 150	Wm. G. Robinson	Chas. J. Inzenga	3-77	$57,500	2558-736
5	446	11719	86 x 160	Jon W. Morar Wm. H. Gallmann	Steven R. Ward Jon. W. Morar	12-76 6-76	$72,000a $65,000c	2545-186 2497-563
4	468	11552	90 x 150	Francis Gebhart	Friedrich Puls	7-76	$57,800a	2507-124
6	441	11943	85 x 150	R. H. Maughan	F. Wm. Stewart	6-75	$48,900a	2433-103
2	453	11517	92 x 150	K. N. Robertson	Robt. N. Box, et al	6-74	$49,000c	2371-652
7	479	11970	100 x 150	Carol T. Pettey	J. A. Hoffpauis	3-78	$69,900a	2636-747

SHERWOOD FOREST

MOLLYLEA DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
7	121	11725	110 x 170	Glenn F. Gresens	Yang Hua Hu	2-78	$47,472	2625-341
9	155	11820	100 x 150	F. A. Cangelosi	Ed Leon Coen, Jr.	12-77	$56,900c	2612-519
3	113	11463	100 x 150	Art L. Magee	P.V. Ponthier	6-77	$44,000c	2574-428
16	143	11945	106 x 150	Peter R. Aube	John L. Carbo	5-77	$38,500c	2570-415
15	150	11934	100 x 150	Dean M. Wallis Wm. S. Fairbanks	Marc J. Scher Dean M. Wallis	5-77 9-75	$45,000c $35,800c	2572-765 2448-055
8	157	11754	125 x 150	Jos. N. O'Keefe	Daryl N. Burke	5-77	$58,000m	2571-050
6	158	11724	100 x 150	T. Paul McDevitt	Gary L. Black	3-77	$45,000c	2556-721
13	262	118651	100 x 150	Rodney R. Utke	Rebecca Aycock	3-77	$49,422	2562-274
4	117	11565	100 x 150	M. Hohenberger F. B. Casanova	Man'l E. Knight M. Hohenberger	8-76 11-74	$44,934a $36,206c	2519-737 2395-040
10	137	11825	125 x 150	Jeff D. Williams	Daryl R. Foushee	10-76	$45,100a	2535-073
2	168	11454	100 x 150	Wm. Ray Harris James R.Adams	Wm. R. Tindall, Jr. Wm. R. Harris	5-76 10-74	$32,684 $29,824a	2491-301 2387-725
14	151	11924	100 x 150	Don L. Britt	Artin B. Haymon	9-75	$36,953a	2447-308
5	159	11680	100 x 146	J. Myers, Pump, Sr.	Jesse Waldroup	9-75	$24,700a	2449-387
1	172	11350		R. T. Bahlinger	Judith M. Baker	7-75	$32,250h	2437-005
12	153	11840	100 x 150	Sam N. Lee	Ralph W. Butler	2-74	$32,464a	2347-363
11	154	11836	100 x 150	Ronnie Thaxton	Ballard, Jr.	9-74	$32,000c	2387-090
17	590	12342	92 x 150	Joseph I. Junks	L. D. Mouch	5-78	$57,000	2652-224

SHERWOOD FOREST

PARKWOOD DRIVE

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
3	195	11821	100 x 154	Jim C. Thompson	C. H. Mandell	7-77	$56,800	2586-767
				Chas. R. Bergeron	Jim C. Thompson	10-76	$41,000a	2532-082
1	186	11555	100 x 150	Fount Smothers	Weldon L. Smith	3-76	$57,000a	2477-500
				Eugene R. Schultz	F. T. Smothers	8-75	$54,000c	2444-132
5	196	11841	110 x 155	Stuart Graham	Chas. M. Stanton	4-76	$45,000h	2490-642
6	213	11860	100 x 150	John H. Lease	Harvey Wm. Pryor	7-76	$46,903a	2507-039
2	194	11775	97 x 152	Ken J. Smith	Robt. S. Cary	9-74	$34,357a	2383-149
8	198	11930	100 x 150	Chas. E. Graham	John H. Lease	7-74	$39,000a	2373-380
7	198	11925	100 x 158	Norton L. Golden	Ken W. Streeter	9-74	$36,960a	2385-095
4	214	11840	100 x 150	L. Phillip Reiss	Milham S. Howie	2-74	$64,958a	2345-275

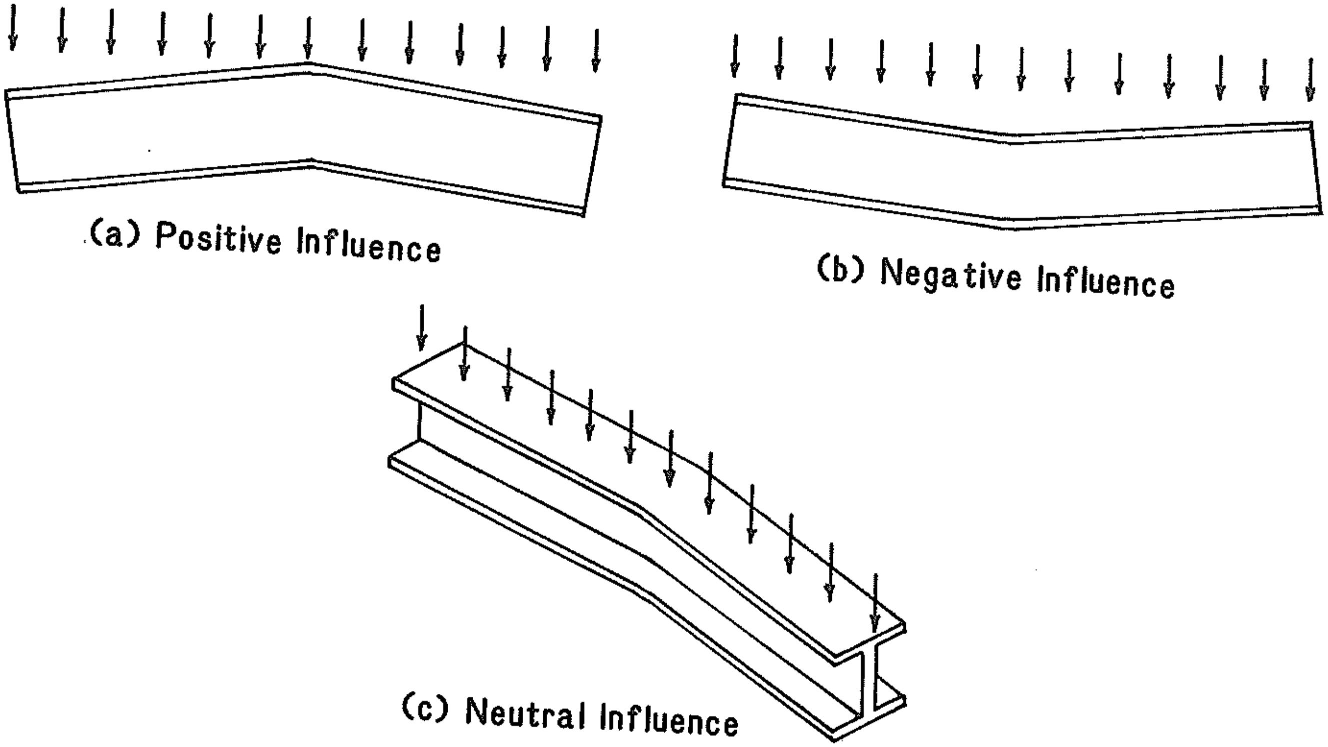
SHERWOOD FOREST

ROBIN HOOD

SECTION	LOT	HOUSE NO.	LOT SIZE	SELLER	PURCHASER	DATE	PRICE	COB/FOLIO
11	967	12628	100 x 139	Allan K. Gistedt	B. P. Savant	2-78	$65,000a	2628-762
12	973	12686	85 x 139	Stephen E. Vise	Jack B. Wilhite	11-77	$53,750a	2608-012
13	977	12762	85 x 139	Ray J. Gaillard	Audis C. Hill	10-77	$55,450v	2600-533
4	7	11465	125 x 150	Julia G. Young	Harry W. Crute	8-77	$46,500c	2590-540
10	25	11646	100 x 150	Wm. M. Sleigh	Jane H. Berlin	8-77	$52,000	2589-094
9	14	11645	100 x 150	Bob Swearington Beny Bouser	Lester Lemoine R. E. Swearington	2-77 4-76	$42,390a $35,190b	2551-822 2489-540
6	10	11555	75452	Walt R. Bankston	Lewis Edw. Jones	1-77	$42,000c	2550-441
7	27	11620	100 x 150	Jimmie Hammond D. M. Gilland	James A. Shelton J. G. Hammond	11-76 5-76	$39,000a $34,000c	2538-154 2425-044
2	4	11425	100 x 150	R. H. Patience, Jr.	J. A. Carter, III	1-76	$21,059a	2404-307
3	6	11455	100 x 150	Frances S. Honea	Wm. E. Cooley	12-76	$39,500c	2463-730
5	9	11545	125 x 150	John P. Elliott	W. J. McClanahan	9-76	$40,000c	2447-091
	22	11736	100 x 150	C. C. Speller, Jr.	Jack E. Dismukes	5-75	$27,149a	2362-111
1	40	11122		Dell B. Tribble	W. E. Berthelot	4-75	$29,500a	2418-157
8	12	11623	100 x 150	Harold E. Amos	Peter H. Lattu	3-78	$51,000v	2637-545

NORTH SHERWOOD FOREST - ARCHERY

SEC.	LOT	STREET NO.	LOT SIZE	SELLER PURCHASER	1973	1974	1975	1976	1977	1978	COB FOLIO
5	9	11335	100 x 175	M. J. Lanasa - J. A. Panson						2/2/59,900(h)	2624-754
				R. G. Thevenot - M. J. Lanasa			9/25-52,000(c)				2449-447
9	46	11824	91 x 154	R. Hinderer - W. T. Mott					6/21-47,158(a)		2578-463
10	55	12023	100 x 174	V. H. Roppolo - C. J. Remondet, Jr.					4/25-42,750(v)		2567-084
8	49	11720	100 x 174	R. Revuelta - M. Nassar				11/2-46,500(h)			2536-626
				M. B. Price - M. T. Cole						5/57,306	2651-566
7	54	11610	100 x 174	M. L. G. Newell - L. Wm. Reissener				12/6-47,000(c)			2451-553
2	57	1890	100 x 174	D. A. Pepe - D. D. Harlow				3/11-41,800(v)			2479-421
6	58	11516	100 x 174	W. B. Day - B. H. Miles				11/30-48,000(c)			2540-477
4	63	11320	105 x 176	C. L. Hill - J. E. McClary				7/16-64,900(c)			2510-431
				B. J. Murphy, Jr. - C. L. Hull		10/3-56,621(a)					2388-188
1	8	1879	116 x 178	J. B. McClary - Wm. C. Baker			11/25-39,500(c)				2460-243
11	25	12024	100 x 175	W. Tessier - R. Neugent			7/7-38,234(h)				2434-193
3	60	1896	105 x 174	J. V. Dustefano - P. Stepfenhart		1/29-40,400(v)					2344-308



(a) Positive Influence

(b) Negative Influence

(c) Neutral Influence

Figure 9. Typical dead load conditions and their influence as a constraint to aid heat straightening.

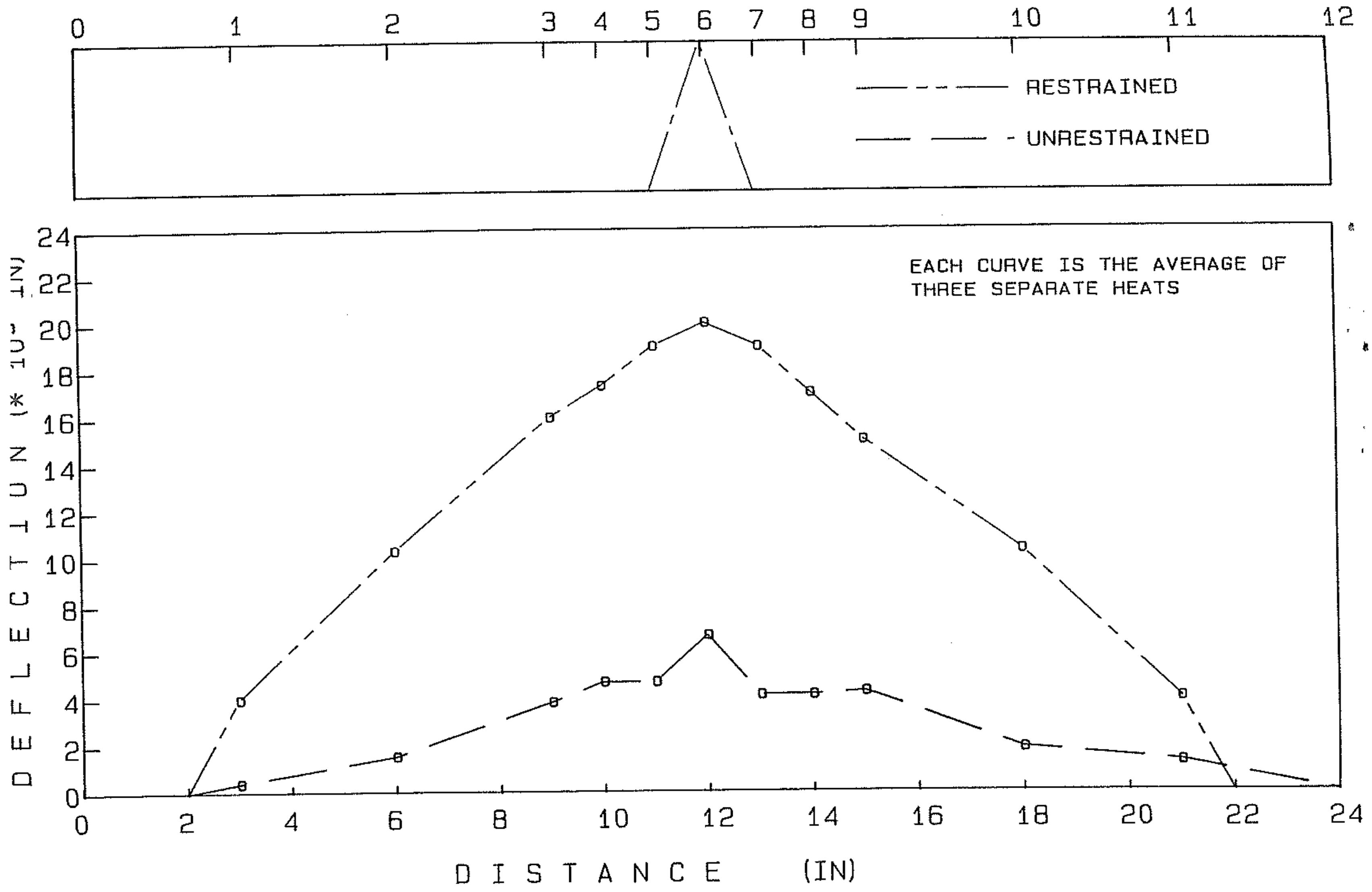


Figure 10. Comparison of deflections for full-depth 60 degree vee heats on 1/4 x 4 x 24 inch plates with axial or unrestrained conditions.

In summary, restraining forces are very important in the heat-straightening process and the effects may be either harmful or beneficial. Relatively little research has been directed toward this aspect of heat straightening. In practice, jacks are usually used to provide external constraints. However, often the level of such jacking forces are not measured. Caution should be exercised whenever jacking is used in heat straightening.

ANALYSIS OF BEHAVIOR DURING HEAT STRAIGHTENING

Fable.--Heat straightening is an art and the actual magnitude of movements cannot be predicted.

Fact.--Several analytical methods have been developed for applications to plates. One approach (32,33,41), generally referred to as the Holt formula, is a formula based on the assumptions of: ideal single axis confinement, linear strain variation across the width of the plate, and a uniformly distributed temperature of 1200°F. This formula was modified by Moberg (41) to include partial depth vees, giving an equation

$$\phi = 2 \frac{S_p d_v}{w} \tan \frac{\alpha}{2} \qquad (1)$$

where as shown in Figure 5, ϕ = the angle of plastic rotation, S_p = plastic strain associated with perfect single axis confinement, d_v = the depth of the vee, α = the vee angle, and w = the width of the plate. For A36 steel, Shanafelt and Horn (55) give a value of $S_p = 0.00864$. Equation 1 is quite approximate in nature, since typical vee heat behavior is not a perfect single axis confinement case and since the effect of restraining forces is neglected. However, these two effects sometimes cancel each other, resulting in fairly good agreement with actual measurements (41) in a few cases. The principle weakness of this formula is its neglect of the effect of constraining forces. At present, no simple formulation exists which accounts for this effect.

The alternative approaches offered in the literature (12,24,35,50, 51,52,60) all basically combine a thermal analysis with an inelastic finite element or finite strip stress analysis. These methods require excessive computer time and have only been applied to a few simple plate cases. Thus, while some analytical formulations exist, they are limited to plates and cannot be conveniently used in general design applications for rolled shapes. Because of these limitations, emphasis has been placed on the art of heat-straightening rather than the science.

Fable.--A vee heat over the full depth of the member is always better than a partial depth vee heat.

Fact.--The depth of the vee in comparison to the depth of the plate element influences the plastic rotation. Both Nicholls and Weerth (45) and Roeder (50,52) have stated that the plastic rotation is proportional to the vee depth. However, an examination of their test data, as shown in Figure 11 for a specific heating temperature and load ratio, indicates that there is little discernable difference for ratios of vee depth to plate width greater than 2/3. All data was compared using least squares curve fits. Only for the ratio of 50 percent does the plastic rotation show a significantly lower value. The number of experimental data points is small; thus additional study is needed to determine how the vee depth influences behavior. It should be noted that full-depth vees usually produce member shortening. Such member shortening can be minimized with the partial-depth vee. Full-depth vee

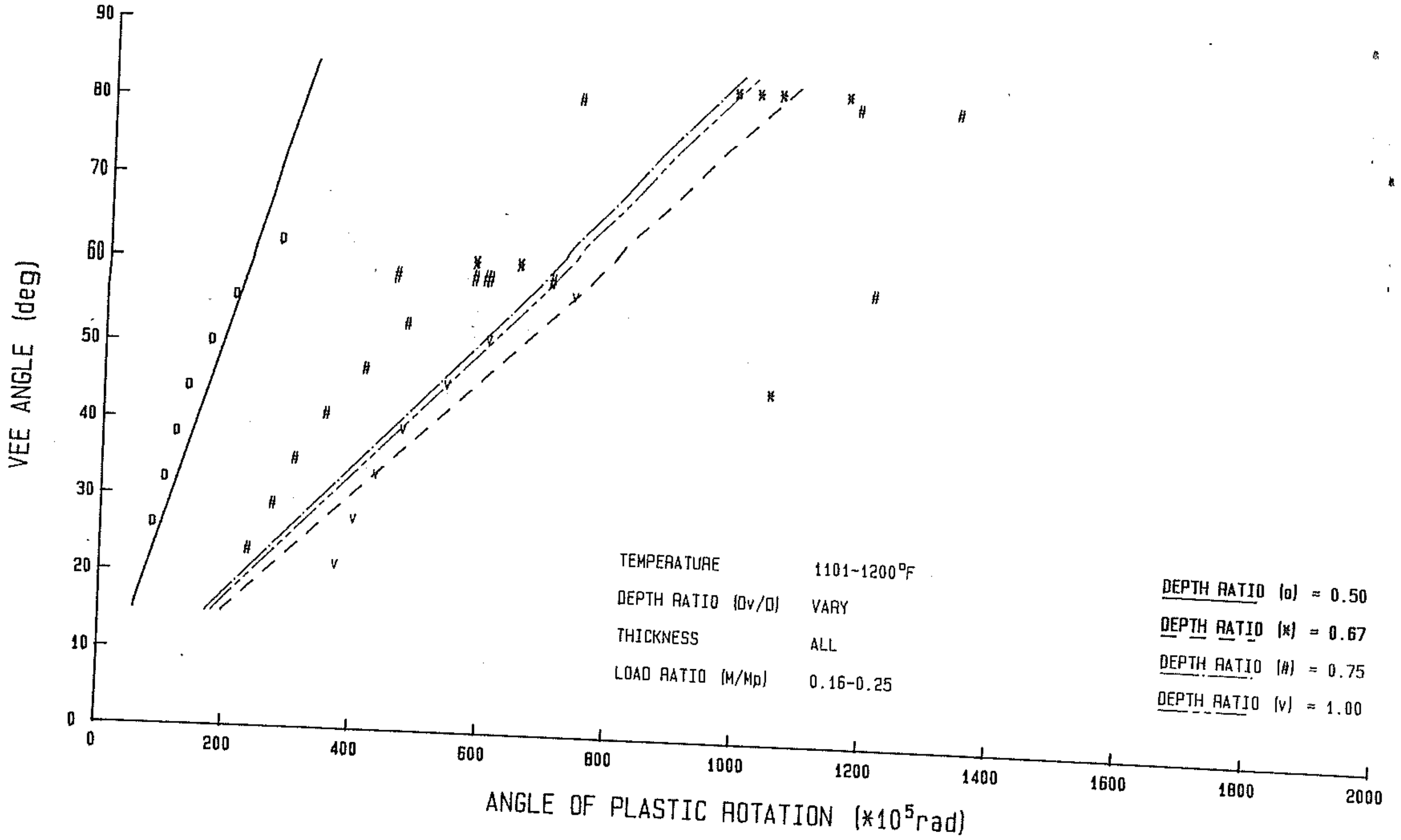


Figure 11. Vee heat angle vs. Plastic rotation for vee-heated plates with various ratios of vee depth to plate width (45,52).

heats should not be used in situations where member shortening would be detrimental to the structure.

Fable.--The angle of a vee heat is unimportant.

Fact.--A number of authors (32,41,45,50,52,60) have concluded the amount of plastic rotation resulting from a vee heat is directly proportional to the angle of the vee. The test results in Figure 6 illustrate this effect. A parabolic regression curve shows that the relationship between vee angle and plastic rotation is nearly linear. Several researchers (32,41) have developed simplified analytical models which account for this effect. Others have developed finite element models (12,50,52). However, large angle vee heats may produce out-of-plane distortions (50,52) or buckling (55). Caution should be used to minimize such effects. Holt (32) and Shanafelt and Horn (55) recommend that the maximum width of the base of the vee be limited to 10 inches.

SECONDARY EFFECTS

Fable.--Residual stresses are not a serious concern in heat straightening.

Fact.--At this time, the magnitude and effects of residual stresses in the heat-straightening process are not well understood (36,38,39,40). Although Roeder (50,52) has measured residual strains, these cannot be extrapolated into stresses because of the plastic flow that occurs during heat straightening. Brockenbrough and Ives (14) measured residual stresses by the sectioning method for a heat-curved girder in which line heats were used. He later developed criteria for heat curving based on this work (13). The residual stresses were characterized by yield-point tensile stresses along the heated flange and smaller tensile stresses in the opposite flange. Compressive stresses dominated the web. In a companion paper, Brockenbrough (12) developed a theoretical approach for computing the same residual stresses, as did Roeder (50,52) and Nicholls and Weerth (45,60) for the vee-heated plate. These researchers concluded that, as in welding, the residual stresses caused by heat straightening may be high. Since residual stresses primarily cause strength reductions in compressive members, these stresses should not be ignored in such cases. It is also suspected, but as yet unproved, that residual stresses may influence the degree of movement during heat straightening by acting as either a positive or negative constaining force. Harrison and Mills (27) found that light hammering (peening) on the transverse face of a stressed plate produces plastic elongation. By applying peening during the cooling cycle of the heat-straightening process, residual stresses may be reduced and the level of contraction increased. Although recommended by some researchers (55), there is no research data on peening related specifically to heat straightening. It is therefore premature to make a recommendation on its effectiveness. Until additional research evidence becomes available, caution should be used when contemplating a heat-straightening repair of compression elements, since residual stresses are related to buckling strength.

Fable.--No matter how light or severe the damage, heat straightening can be used if no fractures have occurred.

Fact.--Surprisingly little information is available on the effect of damage level (strain history). It is known that cold bending into the yield range reduces the ductility of steel in general (15). However, the application of heat tends to restore the original material characteristics. Shanafelt and Horn (55) recommended that the maximum allowable strain be limited to 15 times the yield strain and/or 5 percent nominal strain for repair of tension members. The limit approximately defines the delineation between the plastic region and the strain hardening region. No limits are suggested for compression members. The specific limits given for tension members in two categories are as follows:

Primary--Straighten if strain is less than 5 percent

For F_y = 36 ksi, the strain must be less than 40.3 x yield

For F_y = 50 ksi, the strain must be less than 29 x yield

For F_y = 100 ksi, the strain must be less than 14.5 x yield

Primary with severe fatigue--Straighten if strain is less than 15 x yield or less than 5 percent

However, these recommendations are not backed by specific research data. Until additional data become available, judgment should be exercised for tension members and particularly fatigue-sensitive members.

Shanafelt and Horn (55) also suggested limits on the maximum radius of curvature for which heat straightening should be applied. The logic is that if the radius of curvature exceeds that which produces material yielding, heat straightening will be ineffective. Curvature in the non-yielded portions will be elastic and will be restored when the plastic zones are straightened. The radius of curvature at yield is given by

$$R_y = wE/(2F_y) \tag{2}$$

where w = plate width, E = modulus, and F_y = yield stress. Heat straightening should not be applied for regions with larger radii of curvature than this limiting value, or in general, to the portion of the member which has not plastically deformed.

SUMMARY AND CONCLUSIONS

Research results as reported in the literature show near unanimous agreement that temperature-controlled heat straightening will not have a deleterious effect on the mechanical properties of steel. The general consensus is that a heating temperature of 1200°F is appropriate for carbon steel with somewhat lower temperatures recommended for high strength steels. Within these limits, researchers have found no permanent harmful effects associated with modulus of elasticity, yield stress, tensile strength, brittleness or fracture. A slight reduction in ductility (10-20 percent) has been noted, but this reduction is considered small because there is no problem with fatigue.

Some data is available on the behavior of plates subjected to vee heats, although there is a need for additional research. Relatively little experimental data is available for rolled shapes. Measurements of actual bridge behavior are nearly nonexistent.

An area of particular importance is the need to develop simple yet accurate analytical models to predict behavior during heat straightening which includes not only angle and depth of vee, temperature, and steel grade, but also includes constraint conditions and residual stress patterns. Another area of research need relates to the effect of damage loading rate and strain history on repair effectiveness. Little hard evidence is available as to limits beyond which repairs will not be acceptable. Data on possible material degradation is also scarce for cases of repair followed by future damage and successive repairs. A final area involves the development of guidelines for the proper application of constraining forces including their number, location and magnitude.

To date, heat straightening has been used on a relatively limited basis to repair damaged steel structures. That limited use has produced a good track record and illustrates the potential of the method for providing safe and economical repairs.

3. BEHAVIOR OF PLATES SUBJECTED TO HEAT STRAIGHTENING

INTRODUCTION

Although the heat-straightening repair process is relatively simple, it has not been widely used. There are two main factors responsible. First, the practitioners who currently use heat straightening practice it as an art form as much as a technique based on engineering principles. These practitioners rely on their experience to guide them through a heat-straightening repair. The second reason is that many engineers have the notion that any application of heat to steel will permanently weaken it. Since there are no engineering design criteria for using heat straightening, engineers are often hesitant to use it. In recent years, research studies have led to greater understanding of this phenomena. The purpose of this chapter is to describe an experimental and analytical study of heat straightening as applied to plates and to present related engineering design criteria for its use.

Previous laboratory studies have been concerned with identifying the member behavior associated with curving slender members. Two types of heats are associated with member curving, edge heats and vee heats. Edge heats are simply line heats applied along the edge of a plate element which produce smooth, continuous curves, as in fabricating curved members. Vee heats produce small but sharp curves at the vee location. By varying the spacing of the vee heats, a smooth curve of changing radius can be produced. Since damage is usually of varying curvature, vee heats are the most suitable for structural repairs.

Several detailed studies have been conducted for vee heats applied to plates. These studies have attempted to identify parameters which influence vee heats and to develop predictive models based on this data. Weerth (60) and Nicholson and Weerth (45) describe the bends produced by 21 vee heats whose apex angle varied from 24° to 60° in 6° increments applied to 3/8 in. thick ASTM A36 steel plate. The vee depth was also varied over full depth, 3/4 depth, and 1/2 depth. No attempt was made to evaluate the effect of these parameters other than the general observation that the greater the vee angle and depth, the greater the bend produced. Roeder (52) also conducted a study on plates. He employed sophisticated monitoring equipment such as thermocouples, contact pyrometers, and strain gauges, as well as more conventional tools such as a vernier caliper and a steel ruler. Roeder considered a wide range of parameters which included vee geometry, specimen geometry, heating temperature and time, steel grade, restraining force, initial residual stresses, and quenching. This was by far the most extensive study done to date. These two studies provide a reference base and starting point for the current study. The specific findings of these studies will be evaluated in connection with the results of the current investigation.

The actual method of heat straightening is easily learned; however, the handful of practitioners currently using the method rely extensively on their many years of experience to guide them through a repair. An engineer lacking this wealth of experience needs a set of analytical procedures to determine how best to apply the heat-straightening process to a particular repair. These analytical tools, for reasons of economy, should be relatively fast, easy to apply and allow for such considerations as different vee geometries, temperature ranges, external loadings, and support restraints. At present there are the two extremes of overly simplistic models (32,33,41) which cannot take into account the effect of either temperature variations or internal and external restraint and comprehensive computer models (2,24,35,50,51,52,60) based on elastic-plastic finite element or finite strip stress analysis combined with a similar thermal analysis. However, there is as yet unavailable an analytical model that offers both practicality and a comprehensive inclusion of all important variables to accurately predict behavior.

Of interest here are the currently available simplistic models. Holt (33) developed one of the first and simplest methods for predicting plastic rotations from vee heats. Moberg (41) modified the Holt equation to account for the depth of vee by considering the experimental work of Weerth (60). In addition to Holt's assumptions, he assumed that the plastic rotation is proportional to the depth ratio d_v/w, where d_v = the depth of the vee heat. The resultant equation was Equation 1 of the previous chapter (page 40).

An important consideration not included in these formulations is the influence of external and internal restraining forces. The external forces producing compression in the vee during heating will increase the available confinement and therefore increase the rotation produced per heat. The field applications cited by both Holt and Moberg involved the use of restraining forces. Since in most cases the material restraint alone will be less than perfect, it seems likely that the good correlation between the predicted and actual movement in the structures being repaired as noted by both Holt and Moberg was due to the influence of the external forces. An improved analytical model should include the effects of both internal and external restraints.

This portion of the study is devoted to the development of simple yet efficient procedures for predicting the response of deformed steel plates during the heat-straightening process. The approach chosen was to first identify all parameters which have an important influence on the heat-straightening process. This phase was accomplished by studying the experimental data available from previous research as well as by conducting an extensive experimental program to provide additional data. After synthesizing this experimental data, an analytical procedure for predicting member response was developed.

Vee-shaped heats are used to repair plate elements with bends about their strong axis while line and spot heats are used to remove weak axis plate bends. Since the majority of damage is in the form of strong axis plate bends, the vee heat can be considered the fundamental heating pattern for heat straightening. Thus only the behavior of vee heats on plates is considered in this study.

EXPERIMENTAL PROGRAM

The tests conducted in the experimental program consisted of applying vee heats to straight specimens and measuring the resulting change in geometry. By using straight specimens as opposed to deformed ones, a larger variety and number of tests could be conducted in the least possible time. A total of 255 individual heating cycles were performed during this study. While this data will be presented graphically here, specific results of all tests are given in Appendix I.

Several supporting frames were used during the course of this study. The specimens were mounted as either cantilevers or simply supported members. All plates were hot-rolled A36 grade steel, and the majority of them had dimensions of 1/4 in. x 4 in. x 24 in. The only exceptions to these dimensions were associated with tests on variations in plate thickness and geometry. Plate deformation measurements consisted of measuring the offsets between the plate edge and a reference frame to the nearest 0.001 in.

It has been shown (52) that the plastic deformation developed by a vee heat occurs primarily within the vee area. Thus a very sharp but small curvature is obtained, which can be expressed in terms of plastic rotation as shown in Figure 5. For initially straight specimens, the portion of the plate from the ends to just outside the vee heat remains straight. This fact was used to compute the plastic rotation based on the straight line tangents. To reduce the influence of possible errors in the measured deflection, a straight line was first fitted through the four points on either side of the vee heat within the straight portion outside the yield zone using the least squares method. The acute angle formed between these two lines is the angle of plastic rotation, ϕ.

Practically all of the existing experimental data on vee heated plate behavior is found in two studies (45,50,52,60). The basic parameters studied were: angle of the vee; ratio of the vee depth to the plate depth; level of external constraining force; and heating temperature. The number of data points were in general relatively small and the variation fairly large. As a result, only general conclusions could be drawn and unanswered questions remained. Therefore, additional experimental data related to these basic parameters were obtained in the current study. In addition, several other variables were evaluated including: plate thickness, plate depth, and heating technique.

EVALUATION OF RESULTS OF EXPERIMENTAL PROGRAM

The available data on plate behavior can be found in three studies: Nicholls and Weerth (45), Roeder (52), and the current study. Indicated on plots presented here is the type or source of the data. The data type "current" indicates that only the results of the current study are used, while reference numbers are given for other data. An evaluation of each parameter is considered separately in the following sections.

Vee Angle.--Researchers agree that one of the most fundamental parameters influencing the plastic rotation of a plate is the vee angle. The data shows a fairly linear relationship between plastic rotation and vee angle. For this reason, all data will be plotted with the vee angle as the ordinate, and plastic rotation, ϕ, as the abscissa. A first-order least squares curve fit will also be shown. Plots in succeeding sections show a consistent proportional relationship between these variables.

Of particular interest is the scatter of the experimental results. In both the current study involving 255 plate tests and in Roeder's research (52) involving 99 plate tests, a similar level of scatter was observed. In both cases, special efforts were made to control the heating temperature using not only temperature-sensing crayons, but also thermocouples or calibrated contact pyrometers. In spite of such efforts, a significant amount of variation occurred in identical repetitive tests. Surprisingly, the smaller scale study by Nicholls and

Weerth (45) which included 21 tests showed no evidence of random scatter. The consistency of data points was such that smooth curves were produced with no curve fitting necessary. This pattern is even more remarkable when apparently the only temperature control was temperature-sensing crayons. The writers therefore view these data points with some suspicion and have omitted them from most of the comparative studies.

Since a significant level of scatter does exist, an evaluation was conducted of data samples. The coefficients of variation for typical cases were on the order of 50 percent. Since the coefficient of variation is quite high, possible causes must be addressed. The most obvious source of the scatter would be the relative degree of control exerted over the parameters of the heating process, in particular, the restraining force and heating temperature. For the available equipment of the current study, the accuracy of measurements could vary by 10-15 percent. Similarly, the control of the heating temperature could introduce an error of 10-15 percent. A third possible cause is the development of residual stresses. Both Holt (32) and Roeder (52) suggest that residual stress is not significant in the heat-straightening process. However, a small number of tests conducted as part of this study indicates that very large residual stresses are possible as a result of the heating process. Thus, due to the difficulty in controlling the restraining forces and heating temperatures and the possible development of large residual stresses, a relatively large scatter in the data is not surprising.

Depth of Vee.--Past researchers (52,60) have concluded that the plastic rotation is proportional to the ratio of vee heat depth to plate width. Figure 11 shows the data which is available from past studies. From this plot it is apparent that past data does not support this conclusion. The trend is that depth ratios greater than 1/2 will produce only slightly larger rotations, but not proportional to the vee depth. Rather, the plate rotations are all approximately the same when using the curve fit. A similar situation exists when considering the data from the current study (Figure 12). Therefore, even though it would seem intuitive that increasing the vee depth would increase the plastic rotation, there appears to be no justification for such a general statement. While additional research is needed, it can be tentatively concluded that the variation for vee depths greater than 50 percent of the plate depth have little influence on plastic rotation.

Plate Thickness and Geometry.--The results from tests involving different plate thicknesses are plotted in Figure 6 and were discussed previously in Chapter 2. It is concluded that plate thickness will not have an important influence on heat straightening.

Roeder (52) considered the effect of plate geometry by varying the ratio of plate depth to thickness in a group of experiments while superimposing various load ratios. His findings suggested that the geometry as defined had some influence on rotation, but the exact nature was unclear. In the current study, the influence of plate depth for a series of tests in plates with equal thicknesses, vee angles, and zero load ratios was investigated. These results show similar rotation for each case; thus, plate depth under these conditions is not deemed an important factor.

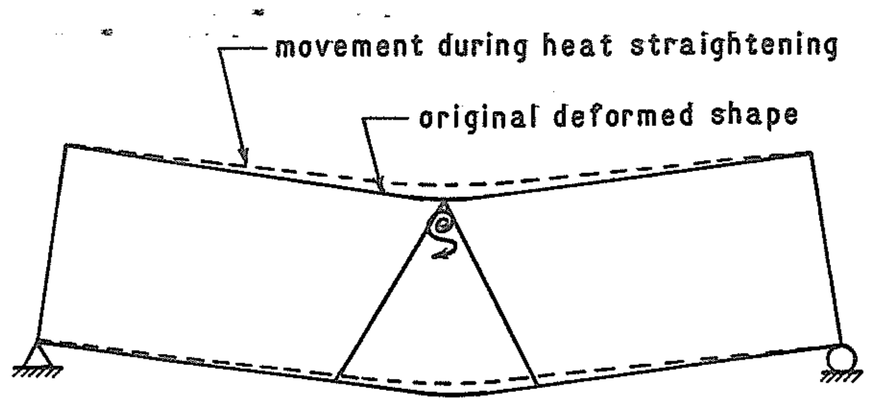
Temperature.--One of the most important and yet difficult-to-control parameters of heat straightening is the temperature of the heated metal. Factors affecting the temperature include: size of torch orifice, intensity of the flame, speed of torch movement, and thickness of the plate.

Assuming adequate control is maintained over the applied temperature, the question arises as to what temperature produces the best results in heat straightening without altering the material properties. Previous investigators have differed in answering this question. For example, Shanafelt and Horn (55) state that heats above 1200°F on carbon and low alloy steels will not increase plastic rotation. Rothman and Monroe (54) concluded that reheating areas where previous spot heats were performed will not produce any useful movements. However, the comprehensive testing program by Roeder (52) has shown that the resulting plastic rotation is directly proportional to the heating temperature up to at least 1600°F. These results were verified in the current research. Plots of vee angle versus plastic rotation for the data from the current study are shown in Figure 13. These results are combined with Roeder's in Figure 14. Both figures indicate that the plastic rotation generally increased with increasing temperature. The most important difference between these two plots is that the increased plastic rotation is nearly linear with temperature for the data of the current study, while the composite data shows the same trend although somewhat more irregular.

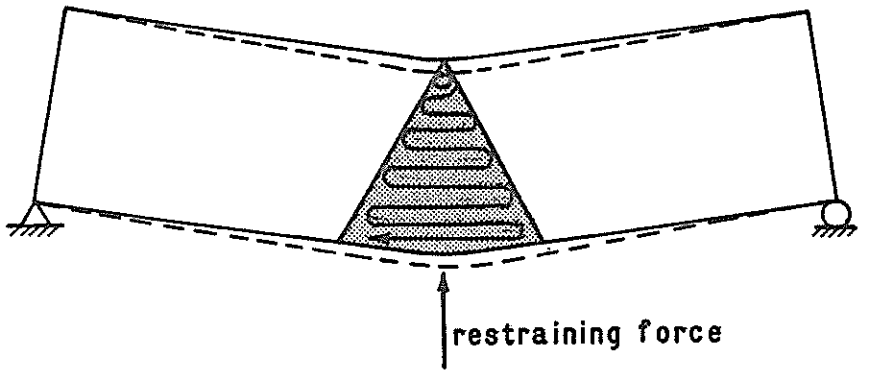
The maximum temperature recommended by most researchers is 1200°F for all but the heat-treated high strength steels. Higher temperatures may result in greater rotation; however, out-of-plane distortion becomes likely and surface damage such as pitting (52) will occur at 1400°-1600°F. Also, temperatures in excess of 1600°F may cause molecular composition changes (54) which could result in changes in material properties after cooling. The limiting temperature of 1200°F allows for several hundred degrees of temperature variation which was common among experienced practitioners. For the heat-treated constructional alloy steels (F_y = 100 ksi), the heat-straightening process can be used but temperatures should be limited to 1050°F to ensure that no metallurgical transformations occur (54). The conclusion that heat-treated constructional alloy steels can be heat-straightened is contrary to that of Shanafelt and Horn (55); however, Roeder (52) concurs with this recommendation.

To control the temperature, the speed of the torch movement and the size of the orifice must be adjusted for different thicknesses of material. However, as long as the temperature is maintained at the appropriate level, the contraction effect will be similar. This conclusion was verified by two test series on plates in which the intensity of the torch was varied. In one set, a low intensity torch moved slowly to maintain a 1200°F temperature, while in the other a high intensity torch was moved more quickly while again maintaining the same temperature. The rotations in either case were similar.

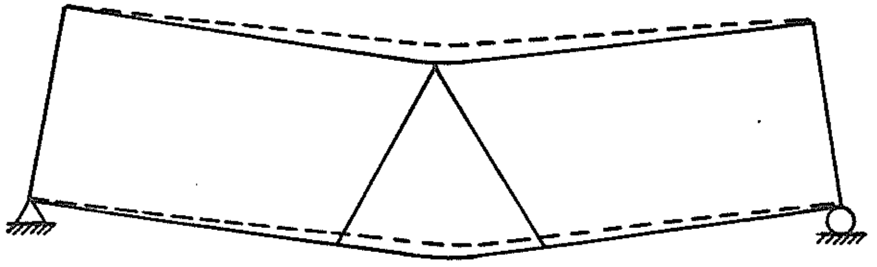
Restraining Forces.--The term "restraining forces" can refer to either externally applied forces or internal redundancy. These forces, when properly utilized, can expedite the straightening process. However, if improperly understood, restraining forces can hinder or even prevent straightening. In its simplest terms, the effect of restraining forces can be explained by considering a plate element, such as that shown in Figure 15. The basic mechanism of heat straightening is to create plastic flow, causing expansion through the thickness (upsetting)



(a) Plate Movement during Early Heating Phase



(b) Plate Movement near the Completion of Heating



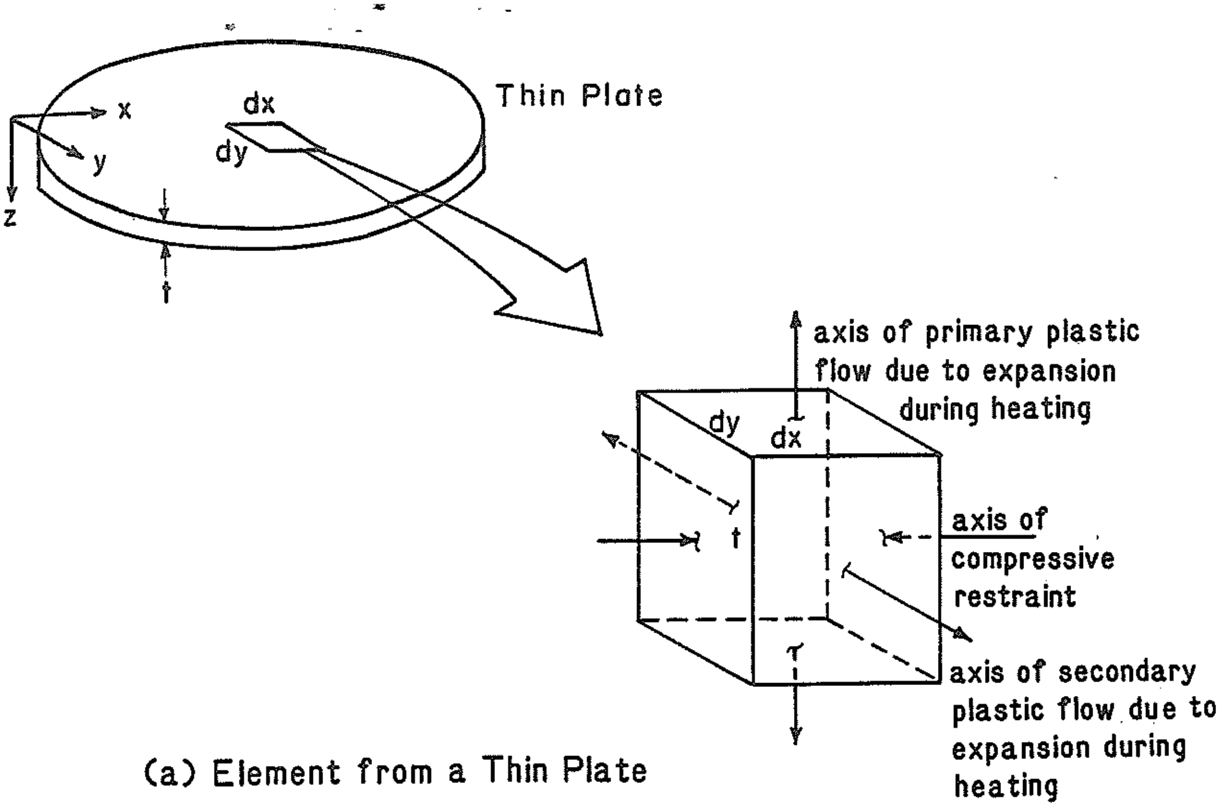
(c) Final Position after Cooling

Figure 15. Progression of movement for a plate during heat-straightening process.

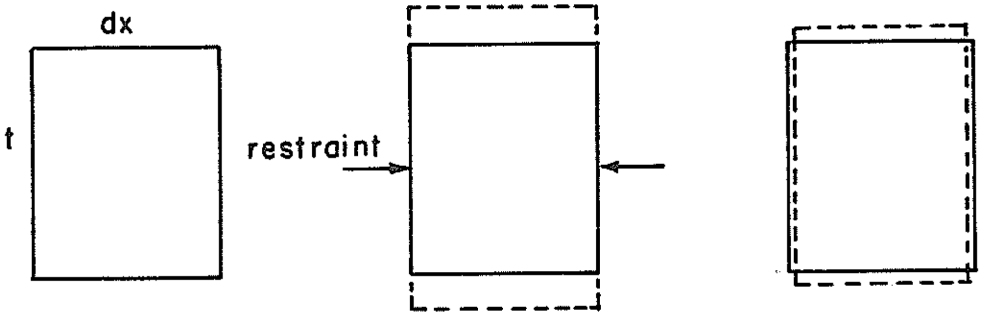
during the heating phase, followed by elastic longitudinal contraction during the cooling phase. This upsetting can be accomplished in two ways. First, as the heat progresses toward the base of the vee, the cool material ahead of the torch prevents complete longitudinal expansion of the heated material, thus forcing upsetting through the thickness. However, as illustrated in Figures 15a and 15b, some longitudinal expansion does occur because the surrounding cool material does not offer perfect confinement. After cooling, the degree of damage is reduced in proportion to the confinement level from the internal restraints.

A second method of producing the desired upsetting (usually used in conjunction with the vee heat) is to provide a restraining force. The role of the restraining force is to reduce or prevent plate movements associated with longitudinal expansion during the heating phase. For example, if a restraining force is applied as shown in Figure 15b, the upsetting effect will be increased through the flexural constriction of free longitudinal expansion at the open end of the vee. A restraining force is usually applied externally, but sometimes the structure itself provides restraint through internal redundancy.

In essence, a restraining force acts in an identical manner to that of the vee heat concept itself. The material behavior can be viewed as illustrated in Figure 16. A small element from a plate, when constrained in the x-direction and heated, will expand and flow plastically primarily through the thickness (Figure 16c). Secondary plastic flow will occur in the y-direction. However, this movement will be small in comparison to that of the z-direction, since the plate is much thinner than its y dimension and offers less restraint to plastic flow. Upon



(a) Element from a Thin Plate



(b) Original Element

(c) Plastic Flow during Heating with Full Restraint in x Direction

(d) Final Configuration of Element after Cooling

Figure 16. Characteristics of plastic flow and restraint during heat straightening.

cooling with unrestrained contraction, the final configuration of the element will be smaller in the x-direction and thicker in the z-direction, Figure 16d. The material itself cannot distinguish the cause of the constraint: either cooler adjacent material in the case of the vee heat, or an external force in the case of a jacking force. In either case, the plastic flow occurs in an identical manner.

In light of this discussion, a set of criteria for constraining forces can be developed. This criteria applies for internal as well as external constraints.

1. Constraints should be passive during the heating phase; i.e., they should be applied prior to heating and not increased by external means during heating or cooling.
2. Constraints should not prohibit contraction during the cooling phase.
3. Constraints should not produce local buckling of the compression element during the heating phase.
4. Constraints should not produce an unstable structure by either the formation of plastic hinges or member instability during the heating phase.

From a practical viewpoint, this criteria means that: (1) the vee angle should be kept small enough that local buckling is avoided; (2) the jacking forces must be applied prior to heating and be self-relieving as contraction occurs; and (3) the maximum level of any external jacking forces must be based on a structural analysis which includes the reduced strength and stiffness due to the heating effects.

While practitioners have long recognized the importance of applying jacking forces during the heat-straightening process, little research has been conducted to quantify its effect. A series of tests designed to evaluate this parameter involved applying a jacking force to a plate such that a moment is created about the strong axis in a direction tending to close the vee. This moment is non-dimensionalized for comparison purposes by forming a ratio of the applied moment at the vee to the plastic moment of the cross section, M/M_p. This term is referred to as the load ratio. The tests included load ratios of 0, 0.16, 0.25 and 0.50 with four different vee angles and vees extending over 3/4 the depth of the plate. The results are shown in Figure 17 (the theoretical curve will be discussed later). Roeder (52) also studied the effect of load ratio variation, and his results along with those of this study are plotted in Figure 18. Both plots indicate that the variation is generally proportional to the load ratios and that using external loads can greatly expedite the heat-straightening process.

A second type of constraint which may exert external forces on a member is axial restraint. A series of tests were conducted using a superimposed axial load on plates for various vee angles. The load created a 20 ksi axial stress or an actual stress to yield stress ratio of 56 percent. These results are shown in Figure 19 in comparison to the results from the bending load ratios of 0 percent and 50 percent. The axial load does increase the plastic rotation but to a lesser extent than the 50 percent bending load ratio.

In summary, the parameters which were found to have an important influence on the plastic rotations produced by vee heats are: (1) vee angle; (2) heating temperature; and (3) external restraining force. While the influence of the depth of the vee requires more evaluation, it appears to have a small effect in the practical range of greater than

50 percent of the plate width. Likewise, plate thickness and geometry are not important in the range of practicality.

Residual Stresses in Heat-Straightened Members.--A study was initiated to evaluate the magnitude and distribution of residual stresses due to heat straightening. The basic procedure was to take representative samples from heat-straightened members during the course of this project and measure the residual stresses.

The procedure used here to measure residual stresses was the sectioning method. Initial extensometer readings were taken in the zone of heating. Then the section was cut into thin longitudinal strips, which relieves the residual stresses. Finally, the extensometer measurements were repeated and both residual strains and stresses are calculated.

Eight plates have been tested to date. A plot of a typical residual stress distribution is shown in Figure 20. The trend of the results is that the edges are in tension, with compression near the midsection. More tests are needed to establish a clear pattern of the residual stress characteristics.

ANALYTICAL DEVELOPMENT

Two general approaches to developing an analytical procedure for predicting member response during a heat-straightening repair have been used. One approach involves finite element/finite strip thermal and stress analyses including inelastic behavior. The stress and strain equilibrium is evaluated over small time steps and takes into account the influence of the non-uniform temperature distribution. This approach is a lengthy computational task which is only possible using computer techniques. Even so, a typical analysis for a single vee heat can require several hours of computer time.

The other approach considers the global action of the vee. The Holt equation, Equation 1, which is based on such an approach, assumes that perfect confinement is provided at all times during the heating phase and that the resulting longitudinal displacements through the vee are linear. With this equation the number of vee heats required to remove a bend in a steel member can be simply calculated. Since an analytical procedure must be simple and easy to apply in order for it to be practical in design applications, this second approach was used in the current study.

The goal of the analytical development was to develop an equation which could be used to predict the angle of plastic rotation produced by a vee heat. The most common assumptions previously used in this type of development have been that: (1) longitudinal plastic strain occurs only in the vee heat zone (and in a similar vee area reflected about the apex for partial depth vees); (2) these strains are constant in the longitudinal direction over the width of the vee; (3) the planes defined by the sides of the vee remain planes after heating and rotate about the apex of the vee; and (4) confinement during heating is perfect single axis in the longitudinal direction. Roeder (50,52) has been the only researcher to experimentally investigate the validity of these assumptions. He found that the statistical correlation of plane sections remaining plane was typically less than 0.5, although the apex of the vee was close to the center of rotation. While he found that most of the plastic strain occurred in the vee zone, the strain was not constant in the longitudinal direction. Rather than the strain variation through the plate depth being constant, he found it to be fairly linear except possibly near the open face of the vee (for which no data points were given). While it is recognized that the assumptions listed above are approximate, the poorest is that of perfect single axis confinement. This assumption can be improved using the results of the experimental program as a guide. Figure 5 illustrates the geometry of a plate, before and after heating, based on the first three assumptions listed previously. The change in the width of the open end of the vee, δ, can be writen as

$$\delta = 2d_v \left[\tan \frac{\theta}{2} - \tan \left(\frac{\theta}{2} - \frac{\phi}{2}\right)\right] \tag{3}$$

If $\varepsilon_p'(T)$ is defined as the final plastic strain at the specified heating temperature, T, in the longitudinal direction after a heating/cooling cycle, then

$$\varepsilon_p'(T) = \frac{\delta}{w_v} \tag{4}$$

or using trigonometric relations from Figure 5

$$\delta = 2d_v \varepsilon_p'(T) \tan \frac{\theta}{2} \tag{5}$$

Equating Equations 3 and 5 gives

$$d_v \varepsilon_p'(T) \tan \frac{\theta}{2} = d_v\left[\tan \frac{\theta}{2} - \frac{\tan \frac{\theta}{2} - \tan \frac{\phi}{2}}{1 + \tan \frac{\theta}{2} \tan \frac{\phi}{2}}\right] \tag{6}$$

Since the experimental data shows that both ϕ and $\varepsilon_p'(T)$ are small, it is assumed that $\tan(\phi/2) \cong \phi/2$ and $\varepsilon_p'(T) << 1$. Equation 6 can then be solved for ϕ:

$$\phi = 2\varepsilon_p'(T) \sin \frac{\theta}{2} \tag{7}$$

The actual plastic strain, $\varepsilon_p'(T)$, depends on the heating temperature (which is usually known) and degree of confinement (usually unknown). If the restraint is perfect single axis confinement with the strain designated as $\varepsilon_p(T)$, then $\varepsilon_p' = \varepsilon_p$. In terms of the total unconfined thermal strain, $\varepsilon_t(T)$, and the elastic strain, $\varepsilon_e(T)$

$$\varepsilon_p(T) = \varepsilon_t(T) - \varepsilon_e(T) \tag{8}$$

where

$$\varepsilon_t(T) = \int \alpha(T)dT \tag{9}$$

$$\varepsilon_e(T) = \frac{F_y(T)}{E(T)} \tag{10}$$

and $F_y(T)$ is the yield stress at temperature T, E(T) is the modulus of elasticity at temperature T, and $\alpha(T)$ is the coefficient of thermal expansion. In order to obtain values for ε_t and ε_e, equations are needed for F_y, E, and α as a function of temperature. Weerth (<u>60</u>) and later Roeder (<u>52</u>) used the same equations to approximate these parameters in their analytical work. For temperature between 800°-1200°F, Weerth's equations substituted into Equations. 9 and 10 and then used in Eq. 8 yields

$$\varepsilon_p(T) = (.001\ T^2 + 6.1\ T - 415)\ 10^{-6}$$

$$- \left[\frac{(-720000 + 4200\ T - 2.75T^2)}{806(500000 + 1333T - 1.111T^2)}\right] \tag{11}$$

It should be noted that in all references reviewed, $\varepsilon_t(T)$ was computed as

$$\varepsilon_t(T) = \alpha(T)(T - T_{room}) \tag{12}$$

which is an approximate formulation. As an example of the difference between these two methods, the approximate formula gives an $\varepsilon_t(T)$ =

initial yield load although an exact value cannot be found because of the complex interaction of the flanges and web of the composite girder system. Based on the curves themselves, initial yield corresponded to a load ratio of about 3. Based on the degree of elastic rebound, the yield load ratio was in the range of 2 to 2.7. However, residual forces in the system would likely reduce the elastic rebound effect. The determination of this initial yield is important because during heat straightening at 1200°F, the yield stress of the steel is reduced by 1/2 to 2/3 its room temperature value (4). Should the yield strength of the system be reduced to values below that produced by the external restraining force, then hot mechanical straightening would occur. While expediting the straightening process, the effects of such procedures on the properties of steels are largely unknown. If a load ratio value of 3 is used to define initial yield of the laterally loaded W 10 x 39 at room temperatures, then the initial yield load ratio could be reduced by 2/3 to a value of 1.0 during heat straightening. The load ratios used during sequences 9 and 3 were 1.0 and 1.12, respectively. It is therefore believed that the large increase in plastic rotation which occurred during sequence 3 can, to some degree, be attributed to hot mechanical straightening. This conclusion is reinforced by comparing the similarity of sequences 1 and 2 to 4 and 9 as indicated in Figure 35. Similar comparisons cannot be made for the W 24 x 76 because only one load ratio was used.

A final geometric effect to be considered is the girder depth. Both girders have somewhat similar flanges: 7.985 x 0.53 in. for the plastic rotation occurred on the deeper beam, even though the load ratio was much smaller. The implication here is that interaction of web and flange reduces the straightening effect per cycle for shallow beams. The lateral load-deflection curves for both beam sizes verified this behavior. The level of flange web interaction was twice as great for the W 10 x 39 as the W 24 x 76.

SUMMARY AND CONCLUSIONS

A comprehensive testing program has been conducted in which two beams were repetitively damaged and repaired using the heat straightening process. The beams were supported in a frame to simulate a bridge girder-slab system. A W 10 x 39 and a W 24 x 76 were damaged and repaired twice each.

Ten different heating sequences were applied to plastically deformed areas of the damaged girders in order to study the effect of the external jacking forces and the heating patterns on the behavior of the heat-straightened members. This study verified many of the trends found in earlier laboratory testing but also has shown that additional study of large systems is needed. General conclusions drawn from this research are:

1. A distinct advantage is obtained by applying an external jacking force to the heat-straightened girder. Increasing the jacking force increased the plastic rotation proportionally.
2. Another distinct advantage is obtained by heating all of the plastically deformed zones in the girder. The addition of the web line heat along the yield line greatly increases the

amount of plastic rotation. Heating the yield line in the web reduces the counter-productive action of the yield stresses acting at this yield line. Therefore, all subsequent vee heats in the flange become more effective.

The line heat is most effective when the middle portion of the web is heated.

Heat straightening should only be applied to regions where plastic deformation has taken place. Heating elastic portions of the girder could cause an over-straightening in those regions.

There is evidence that the plastic rotation angle is proportional to the number of vee heats applied during a single cycle.

Deep girders require less constraining force to achieve the same level of plastic rotation as shallow members.

Repetitive damaging and straightening of moderately damaged girders did not change the load-deflection characteristics of the system.

6. IMPLEMENTATION OF HEAT-STRAIGHTENING REPAIRS IN PRACTICE: AN ENGINEERING GUIDE

The use of heat straightening has not gained wide acceptance because of the lack of an engineering guide for its use. The purpose of this chapter is to provide such a guide in preliminary form. There are still knowledge gaps which need to be filled through additional research. The outline of this guide is comprehensive in nature to illustrate the required scope of a finalized guide. Those sections with little or no content reflect the current lack of a research base. It is anticipated that a comprehensive version can be completed after another year of additional research, as has been submitted in a separate proposal.

Section 1. General

1.1 Purpose

The purpose of this manual is to provide an engineering guide for the heat-straightening repair of damaged steel structures. Included will be damage assessment, analytical considerations, design of the repair, and field supervision of the repair.

1.2 Scope

This manual addresses engineering issues related to the analysis and design of heat-straightening repairs for damaged structural steel. Details associated with contractor implementation of heat-straightening repairs are included only to the extent necessary for engineering considerations. The intention is to provide the structural engineer with analysis and design procedures for heat-straightening repairs of a similar form to procedures associated with traditional structural design