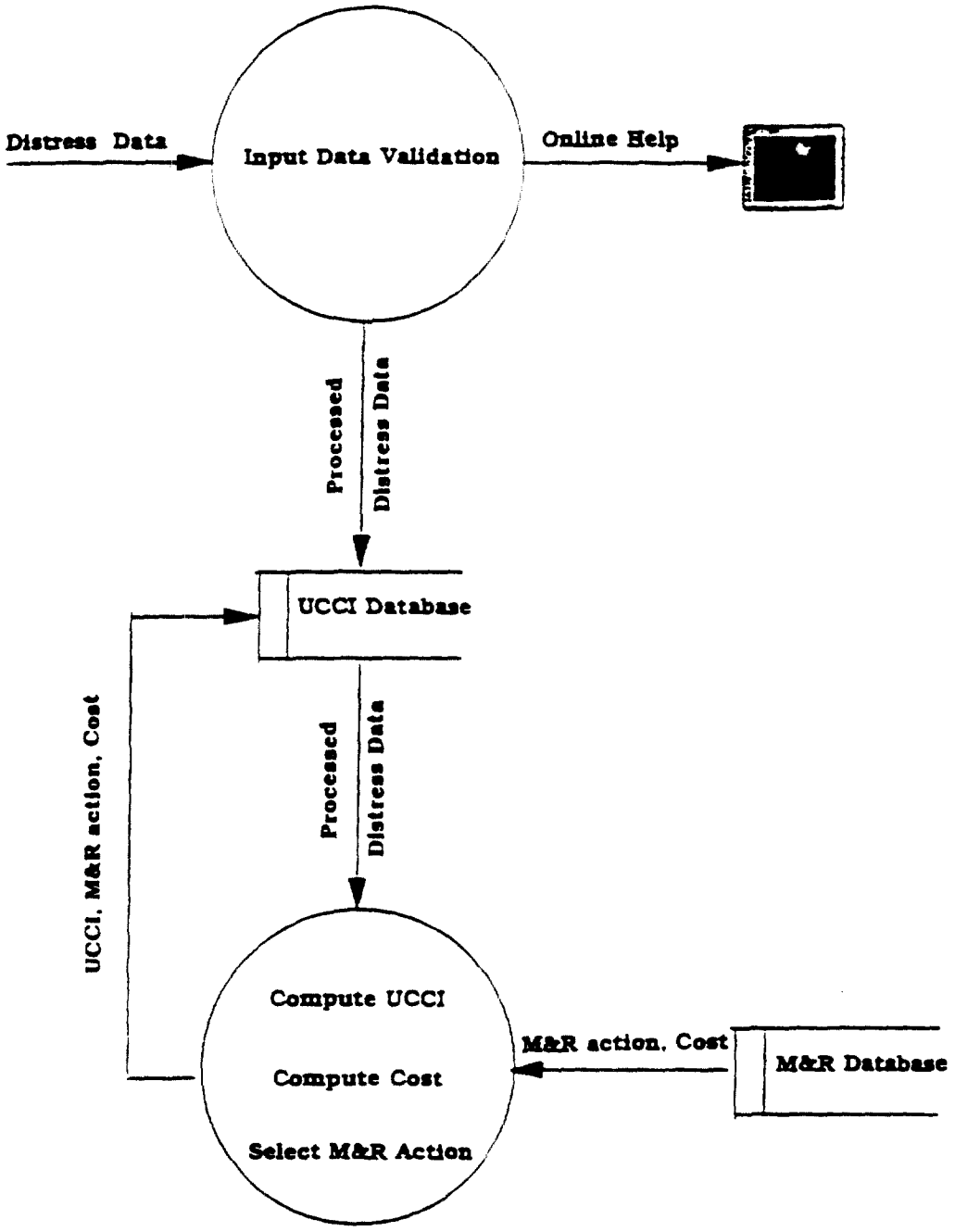


FIG. 6.2.b. Distress Data Sub-system

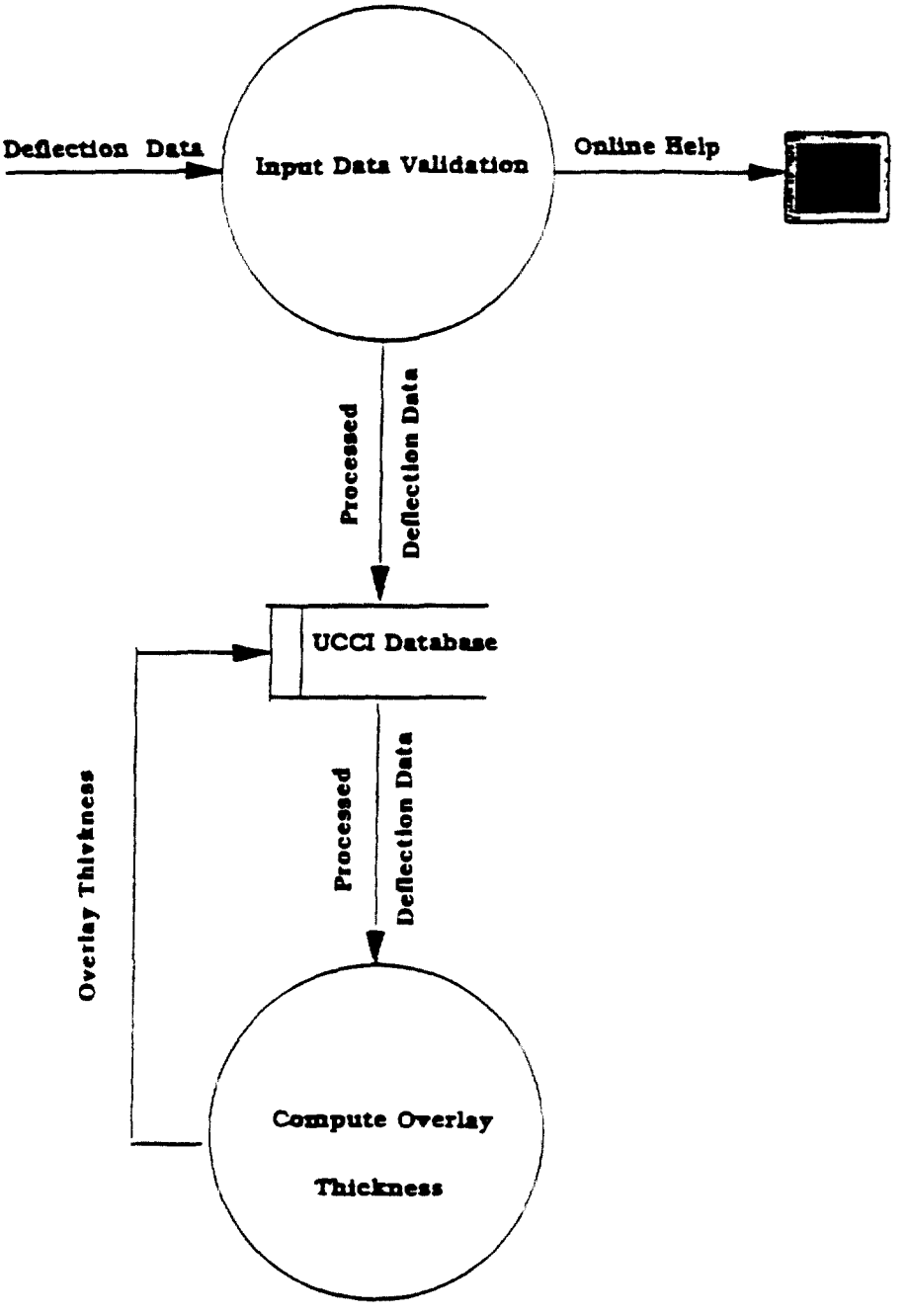


FIG. 6.2.c. Deflection Data Sub-system

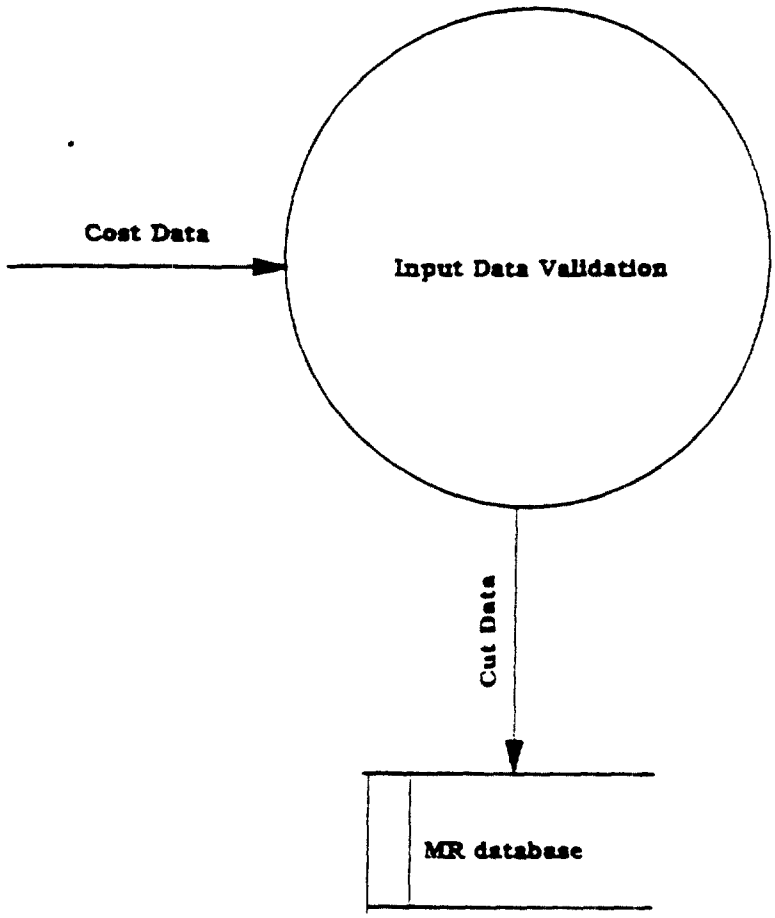


FIG. 6.2.d. Cost Data Sub-system

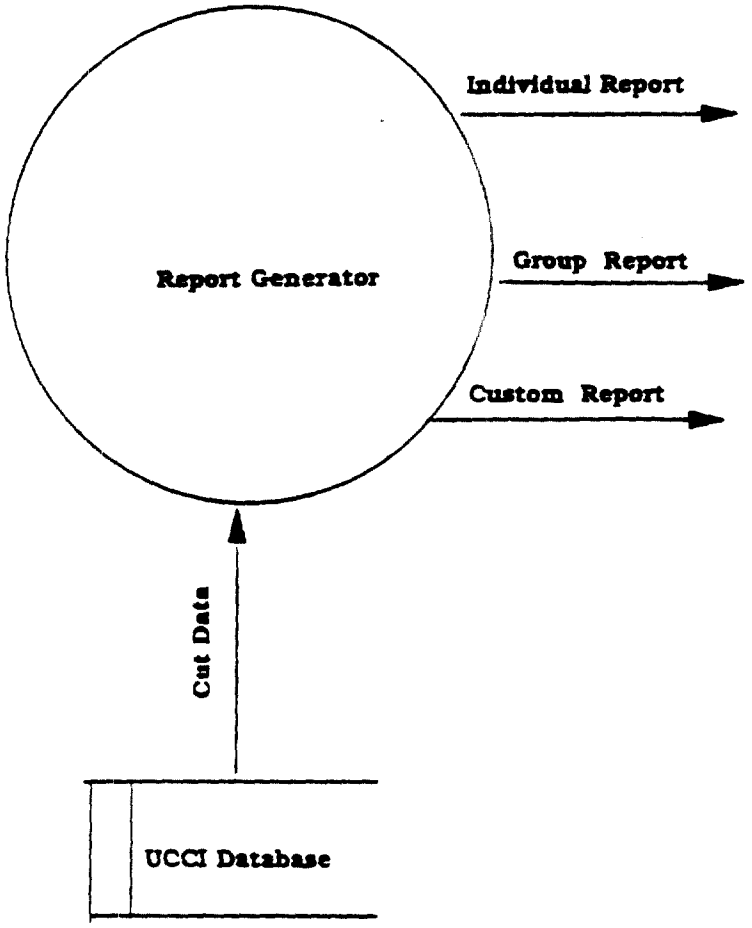


FIG. 6.2.e. Report Generator Sub-system

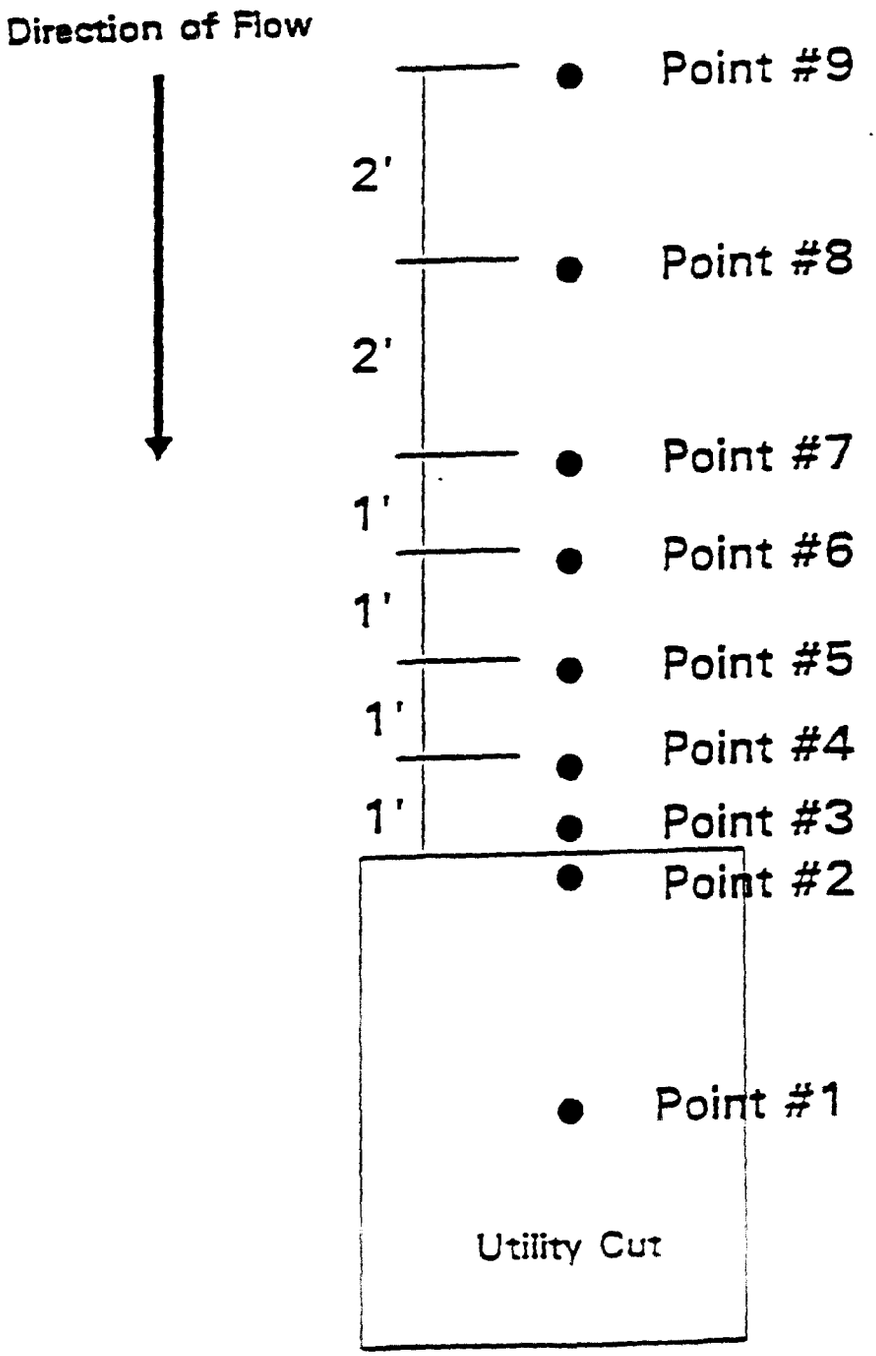


FIG. 6.3. Location of Deflection Observation Points

FIG. 6.4. Typical Measured and Computed Deflections at a Site

TITLE: UCMACOBS2881-1

Point No	Intermediate Deflection (1/1000 in)	Final Deflection (1/1000 in)	Ave Interm Deflection (1/1000 in)	Ave Final Deflection (1/1000 in)	Corrected Deflection (in)	Temp Corrected Deflection (Cor = 0.93)	Seasonal Correction	Final True Deflection
1	8.8 9.7	9.7 9.9	18.5	18.8	0.0227	0.0211	1.00	0.021
2	15.8 14.0	16.2 14.9	29.8	31.1	0.0345	0.0321	1.00	0.032
3	18.2 16.6	18.3 17.8	32.8	35.9	0.0447	0.0416	1.00	0.042
4	12.6 12.2	13.1 13.1	24.8	26.2	0.0302	0.0281	1.00	0.028
5	10.8 11.1	11.1 12.1	21.8	23.2	0.0268	0.0250	1.00	0.025
6	10.1 10.1	10.8 11.0	20.2	21.8	0.0264	0.0245	1.00	0.025
7	10.0 10.2	10.5 11.3	20.2	21.8	0.0264	0.0245	1.00	0.025
8	9.2 10.4	10.1 11.2	19.6	21.3	0.0261	0.0243	1.00	0.024
9	10.0 10.2	10.7 10.9	20.2	21.8	0.0258	0.0238	1.00	0.024

Individual Report

Cut location 1712 Antique | Between _____ and _____

Applicant 1 | Area 10.65

Purpose _____

Pavement _____ | Base restored by _____

Surface restored by _____

Survey date 12/07/93 | Date of Restoration 04/15/83

Distress Information

	Cut	Vicinity		Cut	Vicinity
Alligator Cr	3	3	Raveling	2	
Edge Cr	0	0	Drop-Off	3	3
Transverse Cr	0	0	Edge Seperation	2	
Potholes	0	0	Corner Breaks	0	
Rutting	0	0			

UCCI 37

Deflection Information

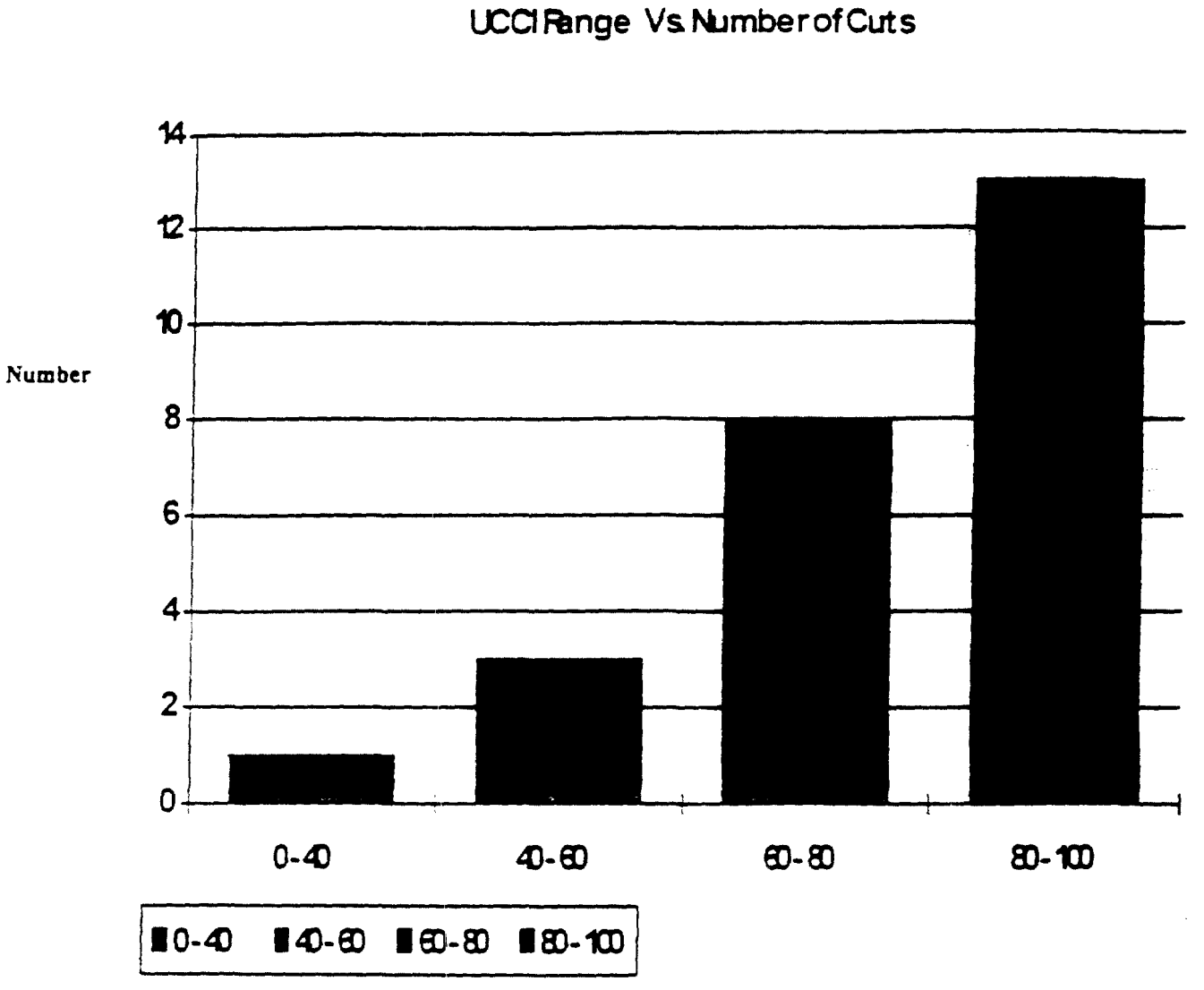
D1	0.00	D2	0.00	ADT	0
D3	0.00	D4	0.00	Trucks	0.0
D5	0.00	D6	0.00	Growth	0.0
D7	0.00	D8	0.0	Temp	0.0

Overlay 0

Recommended Action Reconstruct | Cost 1278.00

FIG. 6.5. Individual Report

Utility Cut Histogram Report



The total number of cuts is: 25

The total cost to rehabilitate the cuts is: $6220.44

FIG. 6.6. Utility Cut Histogram Report

Report on rehabilitation of Utility Cuts

Cut location	UCCI	Recommended Action	Cost
1712 Antique	37	Reconstruct	1278.00
704 Glenwood	42	Overlay	984.75
626 Greenwood	57	Overlay	623.25
3526 Akron	60	Overlay	1399.50
120 W 14th st	63	Surface Treatment	328.10
115 W 14th St.	65	Surface Treatment	367.54
3435 Duncan	69	Surface Treatment	219.64
2927 De Breck	75	Surface Treatment	122.74
2642 Park Ave	75	Surface Treatment	146.54
1034 Academy Av	76	Surface Treatment	405.96
3726 Davenant	78	Surface Treatment	54.74

FIG. 6.7. Report on rehabilitation of Utility Cuts

CHAPTER 7

SPECIAL TOPICS

MULTIPLE UTILITY CUTS

IN ASPHALTIC CONCRETE AND MACADAM PAVEMENTS

Introduction

In the preceding chapters of this study, through the use of objective measurements of strength (deflection) and by subjective assessment (visual inspection of distresses), it was shown rather clearly that a single utility cut in asphaltic concrete or macadam pavement most often has an adverse impact on the pavement surrounding the cut. This commonly is recognized by increased deflections in the pavement, or signs of distress. The data presented in Chapter 2 indicated a weakening of the pavement near the edge of the cut with the stiffness of the pavement progressively increasing away from the cut. As a general rule, it was found that flexible pavements of Cincinnati, having an average size of 4 feet by 5 feet, may be expected to show measurable weakening beyond the cut edges for an average distance of 3.0 feet.

The lateral extent of damage having been demonstrated for single utility cuts, the question remains regarding the impact that these utility cuts may have on the pavement when they are in close proximity.

With multiple cuts, for example, as the distance increases from the edge of the cut, will the pavement deflections become progressively smaller but at some point reverse and become larger again as the adjacent cut is approached? Specifically, when two cuts are made with a distance between their edges equal 2.0 x 3.0 = 6.0 feet will the Benkelman Beam deflection of the point midway between the cuts be equal to the deflection of the undisturbed pavement, the control point, or will an interaction between the two cuts cause the point to deflect more? If the latter is the case,

one could conclude that two adjacent cuts have an amplified weakening effect on the pavement between them, and it would be prudent to place the cuts at an edge-to-edge distance greater than 6.0 feet. The questions is, how far apart must cuts be placed to prevent extended pavement weakening?

Investigative Approach

In this phase of the study, fifteen sets of multiple cuts, five in each of the three traffic categories, were tested for deflections using the Benkelman Beam. The cuts selected were in a row, in multiples of from two to five, and with edge-to-edge distances that ranged from 2 feet and 9 inches to 21 feet and 8 inches. A typical utility cut arrangement with the plot of deflection in the surrounding pavement is shown in Figure 7.1; the plots of all 15 sites are included in Appendix B.

Analysis and Results

The deflection data were analyzed visually. At each test site, the deflection at the control point (or points) was determined. Then, the deflections of the pavement between the utility cuts were compared to that at the control point. If the deflections anywhere between two cuts were equal or less than the control point deflections, it was concluded that the two cuts had no effect on each other, that is, there was no interaction between the two cuts. Conversely, if the deflections between these cuts were all greater than at the control point, the cuts were considered to be interacting with each other.

To illustrate the analytical procedure, consider the cuts on Euclid Avenue in Figure 7.1. As shown, the pavement at this site had a series of five multiple cuts, with edge-to-edge spacings of 9 feet 2 inches, 5 feet 9 inches, 4 feet 9 inches, and 7 feet 5 inches, respectively. The control point deflection is 0.037 inches, as observed on the right side of the plot. The deflections between the first two cuts on the left are less than the control point deflections, therefore, one can conclude that these two cuts do not interact in weakening the pavement. Thus, the 9 feet 2 inches edge-to-

edge spacing is large enough to exclude interaction. The deflections between the last two cuts on the right side come up to about 75% of the maximum differential deflections thus the interaction is minimal. The interaction may be considered to be borderline. The two other edge-to-edge spacings between the Euclid Ave cuts are 5 feet 9 inches and 4 feet 9 inches, respectively. At these distances, the cuts clearly interact, that is, all deflections between the cuts are greater than at the control point.

A similar analysis was conducted for all 15 sites and a summary of the results are presented in Table 7.1. This shows the test site designation, traffic level, edge-to-edge distance between cuts and whether or not the adjacent cuts interacted with each other or, whether they represented borderline cases.

The data from the 15 sites, as presented in Table 7.1, were rearranged to summarize the results in three columns, Table 7.2. In column one, those edge-to-edge distances are listed which resulted in significant interaction between adjacent cuts. Column two lists borderline cases and column three lists those which resulted in no interaction. The listings show that there was perceptible interaction between all cuts that were closer than 5 feet 6 inches. Further, interaction can extend to an edge-to-edge distance as much as 7 feet 4 inches (somewhat higher than 2 * 3.0 = 6.0 feet). It was noted that traffic level appeared to have no effect on the results.

In conclusion, this limited study suggests that multiple cuts result in a zone of weakened pavement between cuts that is somewhat larger than what would be expected around two single cuts, 7 feet 6 inches versus 6.0 feet. Therefore, it is recommended that multiple cuts in flexible pavements not be placed closer than 7 feet 6 inches apart.

Although it has not been studied in detail and quantified, it is suspected that close cuts not only extend the pavement damage zone laterally, but also increase the magnitude of deflections. As a result, the thickness of the required overlay for repair, and consequently the cost of repair, may be

expected to increase. Further research is needed to determine the extent of cost increase

CORRELATION BETWEEN BENKELMAN BEAM DEFLECTIONS AND DEFLECTIONS MEASURED BY DYNAFLECT AND FALLING WEIGHT DEFLECTOMETER ON FLEXIBLE PAVEMENTS

Introduction

To evaluate the strength of a flexible pavement by the Asphalt Institute Method, or to design the required overlay for it, the Benkelman Beam Deflections should be obtained. However, this is a complex and rather time consuming process, especially when compared to using either the Dynaflect or the Falling Weight Deflectometer (FWD). Therefore, a deflection study of flexible pavements with cuts was conducted to compare the Benkelman Beam deflections with those from the Dynaflect, and the FWD.

Correlations Between Benkelman Beam And Dynaflect Deflections

Method: Six randomly selected utility cuts and the pavements around them were tested using the Benkelman Beam and Dynaflect, three in asphaltic concrete and three in macadam. At each cut the following five points were tested: the control point, one foot from the edge of cut, at the edge of cut in the pavement, at the edge and at the center of the cut. At each point the Benkelman Beam Deflection was compared to the Dynaflect deflection.

Results and Analysis: The results are summarized in T B.1*. The data points are plotted in Figure 7.2. Also plotted are a best fit line from regression analysis, a best fit curve, and the correlation curve given by AASHTO. As seen, the curved Cincinnati correlation agrees well with the AASHTO curve, except for the data points for the large deflections. These large deflections were obtained on cuts and pavements that were subjected to light residential traffic loads only, not

*See Appendix B

typical for AASHTO type deflection measurements. It is recognized that more tests are needed on residential streets to establish a reliable correlation for pavements with light traffic.

Correlations Between Benkelman Beam And Falling Weight Deflectometer Deflections

Method: Thirteen randomly selected pavement locations adjacent to utility cuts were tested (six in asphalt concrete and seven in macadam pavements) by both the Benkelman Beam and the Falling Weight Deflectometer (FWD). At each location, five points were tested, all in the pavement: the control point, edge of cut, one foot, two feet and four feet from edge. The FWD tests were conducted at three different load levels, 9, 12 and 15 kips.

Results: The results are plotted in T. B.2,B.3, B.4(App).Figure 7.3 shows the plot of data points from the comparison of Benkelman Beam deflections with those from FWD with the 9 kip loading. The best fit line from regression analysis also is shown. Figure 7.4 shows the regression lines for all three level of loads, 9, 12 and 15 kips. There was no AASHTO correlation available for comparison with the Cincinnati results.

Conclusions

The correlations presented should be considered preliminary, especially when used outside Cincinnati where there may be different pavement compositions, subgrade soils, water tables, and climate conditions. Even in the City of Cincinnati, more tests are needed to increase the reliability of the correlations. In all cases, however, the Dynaflect and FWD equipment can be used effectively to explore the existence and lateral extent of damage to asphaltic concrete and macadam pavements around cuts.

TABLE 7.1. Interaction Between Multiple Cuts in Flexible Pavements

Address	Traffic	Spacing (ft.)	Interaction Exists
UCMULINTRED-1	H	6' 8"	yes
UCMULRED3161-1	H	2' 9"	yes
		5' 6"	yes
		6' 1"	no
		6' 8"	no
UCMULMAD3215-1	H	5' 6"	no
UCMULOBS2741-1	H	6' 0"	?
UCMULMAD2724-1	H	6' 4"	no
		10' 5"	no
UCMULMRK2723-1	M	6' 10"	no
UCMULMRK2901-1	M	21' 8"	no
UCMULEUC3016-1	M	9' 2"	no
		5' 9"	yes
		4' 9"	yes
		7' 5"	?
UCMULWFD3357-1	M	7' 4"	yes
UCMULSET822-1	M	5' 10"	no
UCMULHEL321-1	L	11' 0"	no
UCMULTER346-1	L	6' 1"	yes
UCMULHAR3228-1	L	6' 4"	yes
		5' 8"	yes
		6' 7"	yes
UCMULMCH3648-1	L	6' 9"	yes
UCMULMOR3363-1	L	12' 0"	no

TABLE 7.2. Effect of Utility Cut Spacing on Interaction

Cut Interaction

Yes	Borderline	No
2'-9"		
4'-9"		
5'-6"		5'-6"
5'-8"		
5'-9"		
		5'-10"
	6'-0"	
6'-1"		6'-1"
6'-4"		6'-4"
6'-7"		
6'-8"		6'-8"
6'-9"		
		6'-10"
7'-4"		
	7'-5"	
		9'-2"
		10'-5"
		11'-0"
		12'-0"
		21'-8"

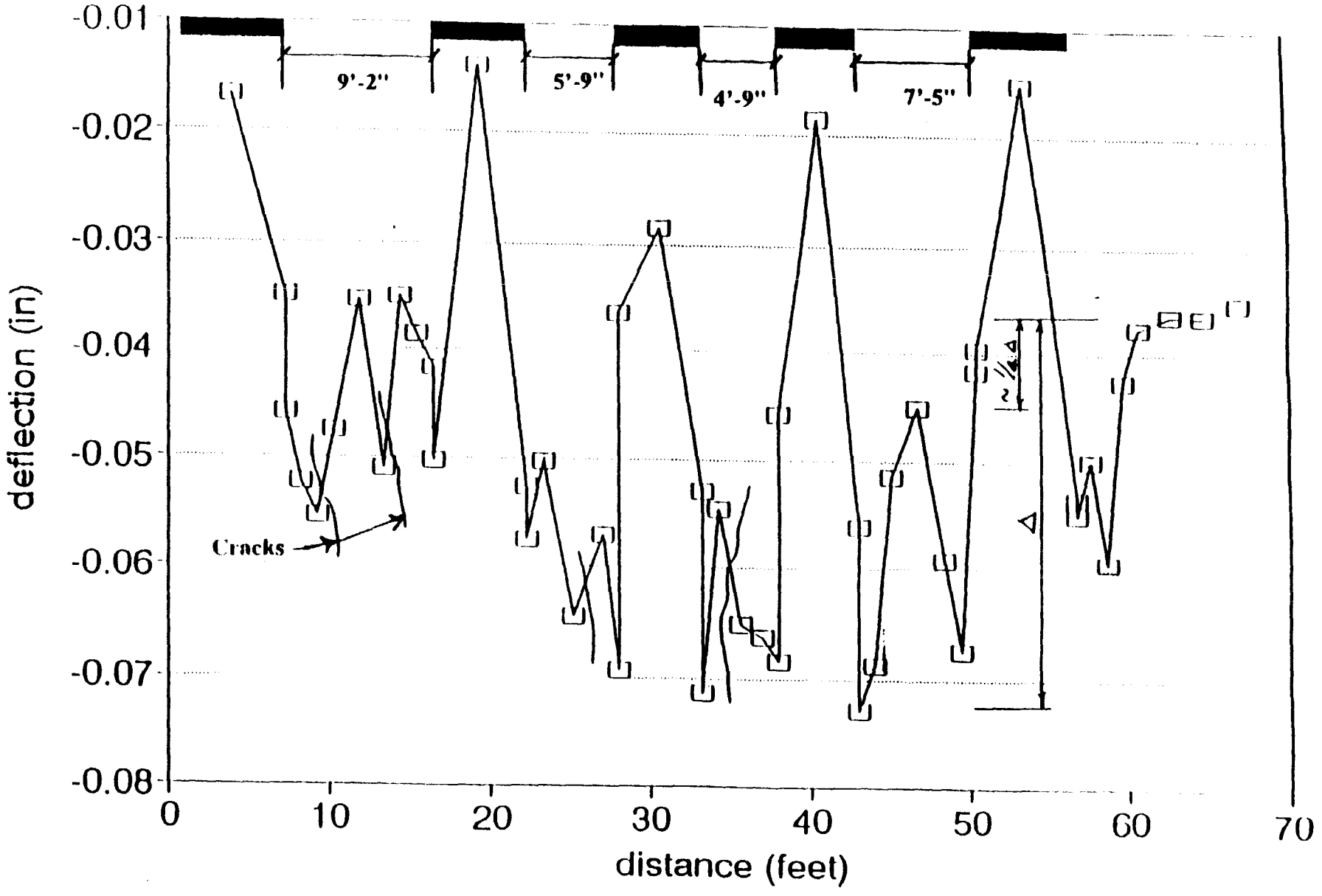


FIG. 7.1. Deflections between Multiple Cuts at 3016 Euclid

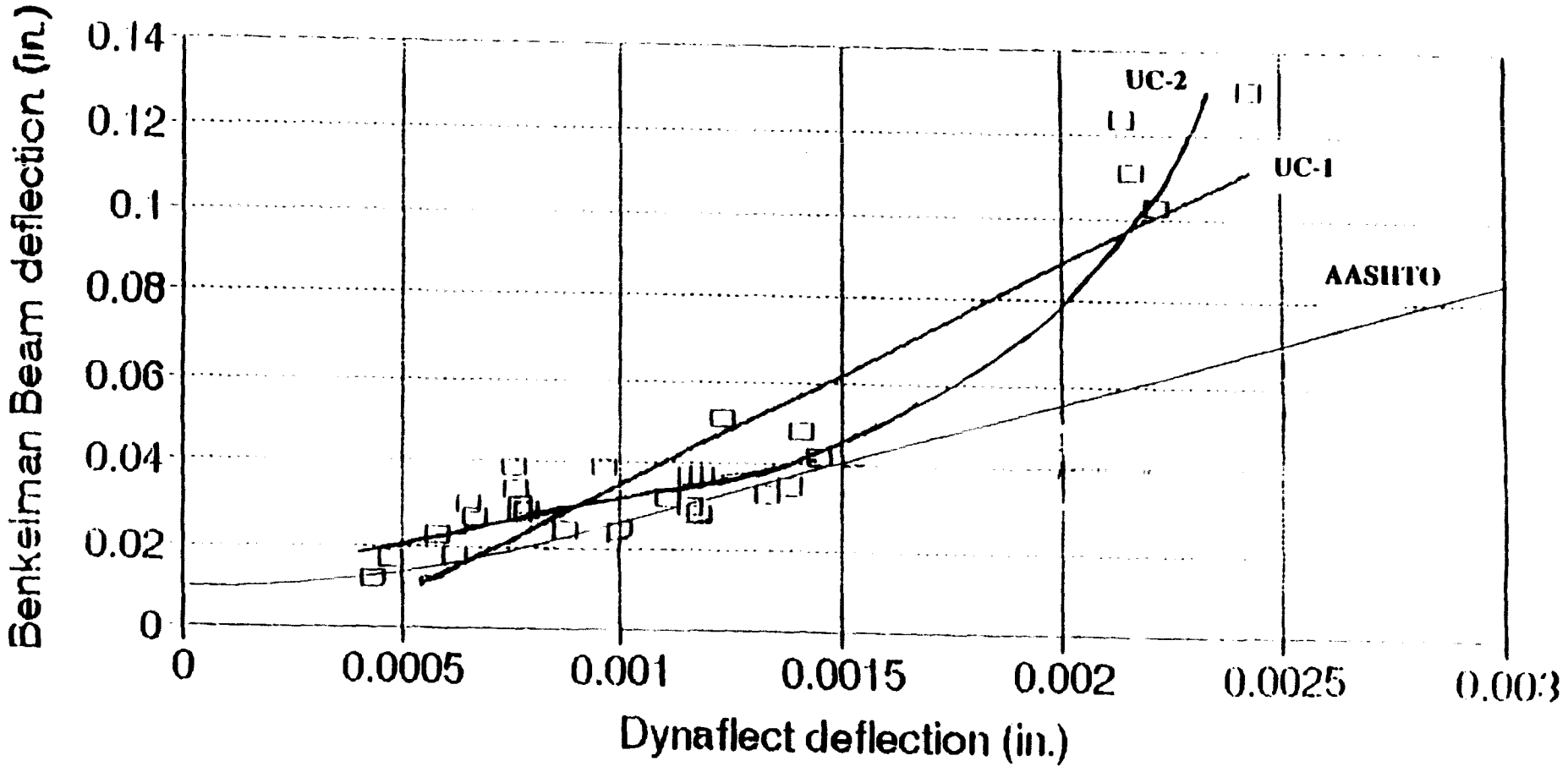


FIG. 7.2. Correlation between Dynaflect and Benkelman Beam Deflections for Light, Medium and Heavy Traffic.

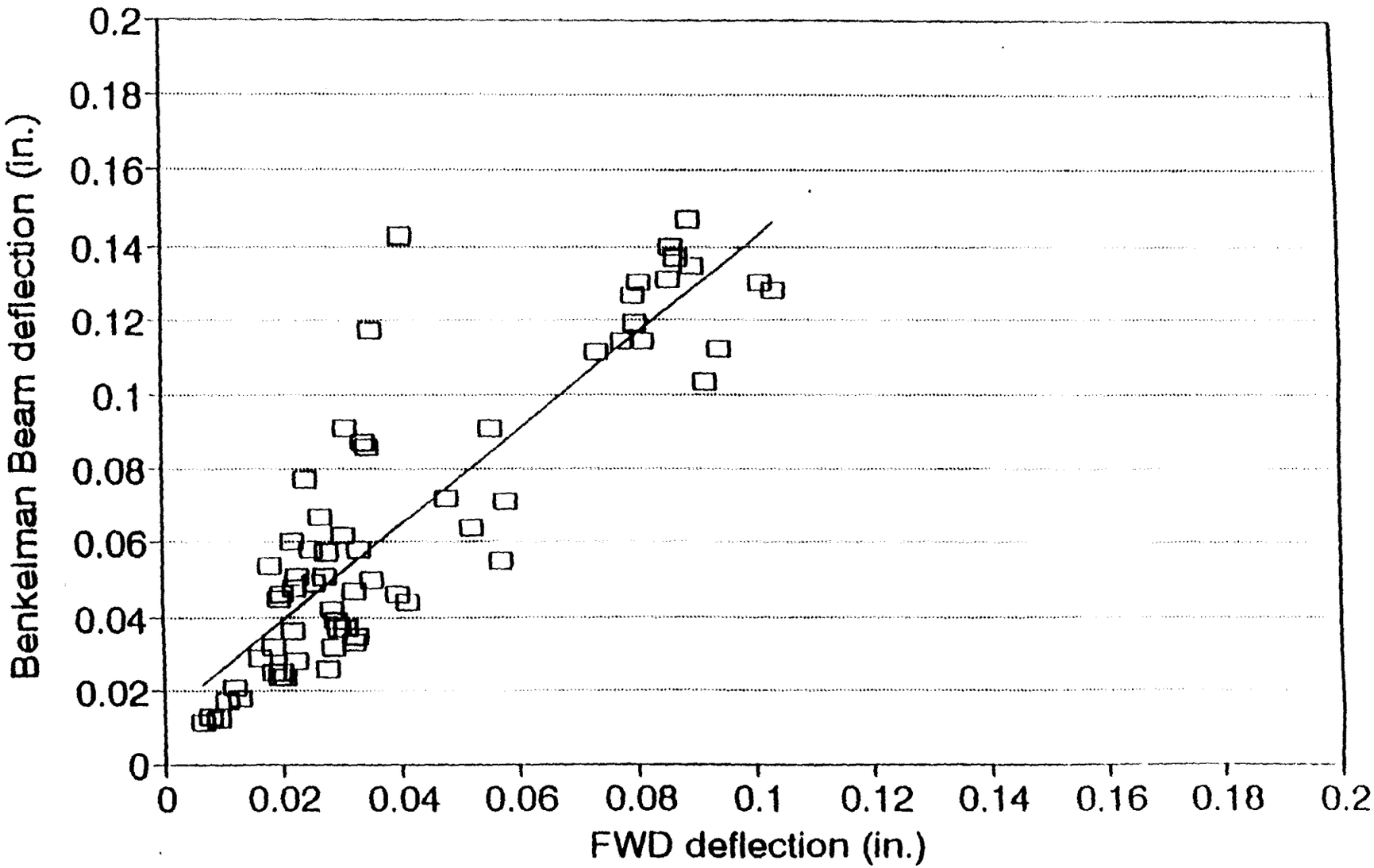


FIG. 7.3. Correlation between FWD and Benkelman Beam Deflections
(All Traffic ; 9 kip load)

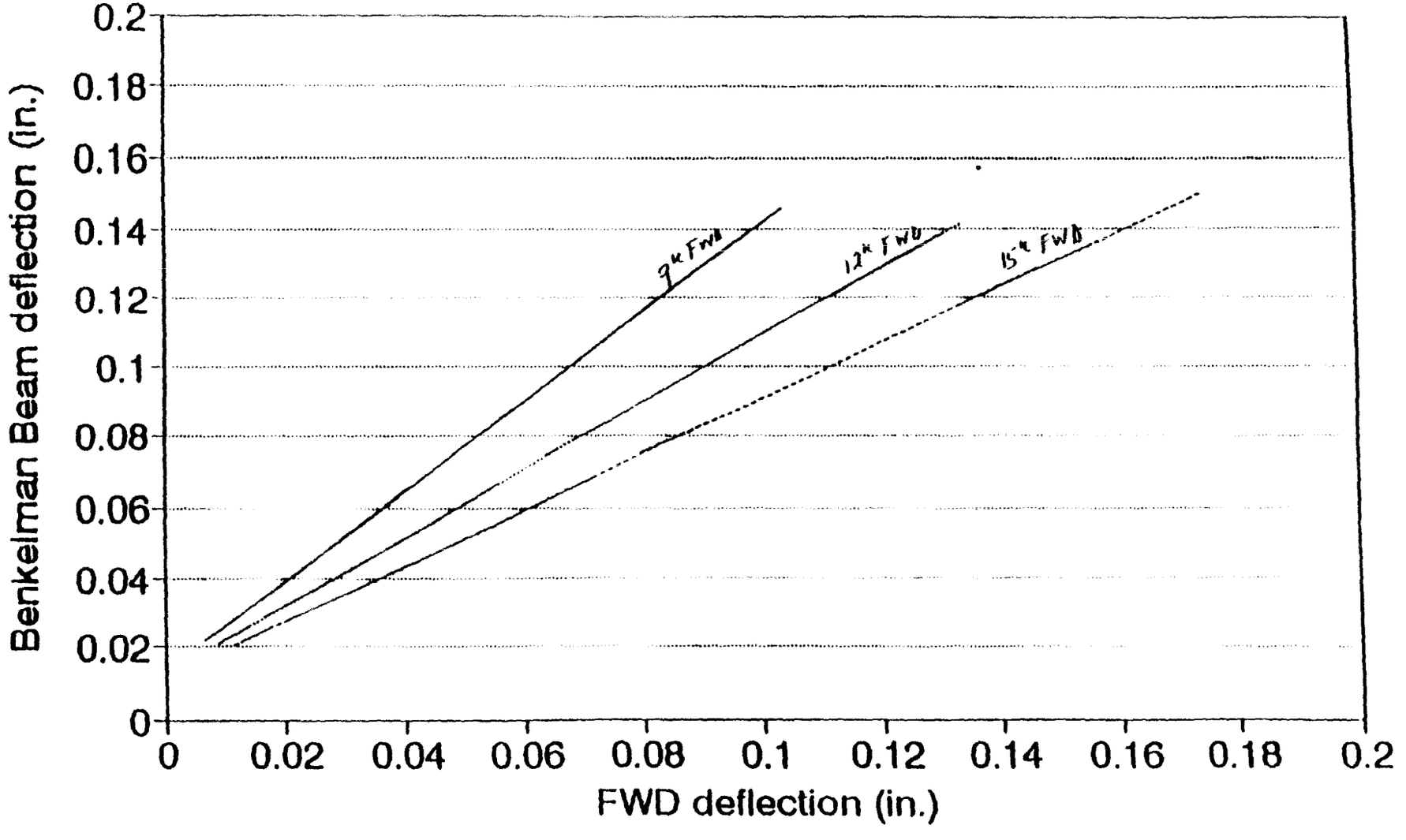


FIG. 7.4. Correlation between FWD and Benkelman Beam Deflections

CHAPTER 8

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study by the University of Cincinnati resulted in the development of an objective evaluation technique to assess the impact of utility cuts on flexible pavements. A practical field deflection testing methodology was established including the selection of appropriate points of testing at and around cuts. The study demonstrated that the Benkelman Beam can be used for the strength evaluation of pavements at utility cuts and to determine the lateral extent of area affected by the cuts. Results from testing thirty-six (36) cuts in the City of Cincinnati indicated that utility cuts in flexible pavements ordinarily damage the surrounding pavement. The lateral extent of damage beyond the edge of the cut ranged between 0 and 6 feet with an average extent of damage of 3 feet beyond the cut edge. To restore the pavement to its pre-utility cut strength required an addition to the original thickness of overlay up to 6 inches thick. The average added thickness required was 1.75 inches. The area of the average overlay covered 110 square feet.

It is recommended that more extensive deflection studies be conducted to increase the database on cuts in flexible pavements. Other cities should be included in the tests to determine the effects of different pavement structures, climates, soil conditions and workmanship of cut repair contractors. Typical deflection testing at a cut should be supplemented by tests on all sides of the cut, and measurement of deflection should be made at several control points outside the sphere of influence. This will improve the reliability of the reference deflection data.

Included in this study was an investigation of flexible pavements to determine what

effect there is on the pavement lying between multiple cuts. The limited study suggests that cuts in close proximity are likely to increase the extent of pavement damage. While the average lateral extent of damage in single cuts was found to be 3 feet, the lateral extent of deflection or pavement damage from adjacent cuts increased on the average to 3.75 feet. Therefore, it may be concluded that multiple cuts in flexible pavements should not be made closer than 7 feet 6 inches, edge-to-edge. It is recognized that further studies are needed to confirm these preliminary findings and to more precisely define the impact of multiple cuts in flexible pavements. If, as suspected, greater deflection and damage is associated with multiple cuts, the thickness of the required overlay and the cost of repair may be expected to increase.

As described above, the restoration of an average cut and the surrounding flexible pavement requires the additional thickness in the overlay section of 1.75 inches. This addition in thickness over a limited area of 110 square feet could cause an abrupt change or bump in pavement surface resulting in potential road hazard. To eliminate the rough transition, other strengthening schemes were considered and costed. It is recognized that proof of performance and economic feasibility of these repair schemes will require actual construction and field evaluation. From this study, it is estimated that the cost of the average repair will vary from $950 to $1,400. In the City of Cincinnati where 6,000 to 10,000 utility cuts are made each year, and 35 percent of these are in flexible pavements, the annual repair cost of the flexible pavement portion may range from $1,995,000 ($950 x 0.35 x 6,000) to $4,900,000 ($1,400 x 0.35 x 10,000).

To accelerate the deflection testing of flexible pavements around cuts, the potential

use of the Dynaflect and FWD devices was investigated in place of the Benkelman Beam. Correlations were established between the Benkelman Beam and Dynaflect deflections in flexible pavements. These agreed well with those given by AASHTO for highway pavements, except for the large deflections on residential streets. More tests, therefore, are needed on residential streets to establish a reliable correlation. Correlations also were established between the Benkelman Beam and FWD deflections in flexible pavements. Although the correlations are considered preliminary and are based exclusively on conditions in the Cincinnati area, the study does demonstrate that both the Dynaflect and the FWD can be used effectively to find the existence and lateral extent of damage in flexible pavements.

Approximately 30 percent of the pavements in the City of Cincinnati are of composite construction and were not studied. It is recommended that the effect of utility cuts on these pavements be investigated.

A Finite Element Model was successfully developed to model the behavior of PCC pavement slabs with or without cuts. The model was calibrated both with theoretical solutions and actual field cuts in the City of Cincinnati on 9 inches thick PCC pavements over thin base and silty clay subgrades. The model uses an $E = 6.5 \times 10^6$ psi modulus for the concrete and a $k = 250$ pci subgrade modulus.

The Finite Element Model was successfully used to conduct a parameter study on typical PCC pavements. The effect of the location of a cut and changes in subgrade stiffness were investigated. It was found than an average cut made in the average PCC pavement

does not create excessive stresses in that pavement, thus its effect is not critical. However, a utility cut placed against the curb could result in excessive stresses, even failure, if the repaired pavement and subgrade are weak. Also if the cut has to be made near an interior joint, it should be investigated how close its edge may be to the joint to avoid possible fatigue failure.

The above conclusions need not be modified for PCC pavements overlaid by asphalt, as the asphalt adds very little to the strength of the concrete pavement.

Further studies should include the modeling of PCC pavements of varying thicknesses, pavements with weakened subgrade support near the cuts, and pavements with varying sizes and shapes of cuts. The model should be improved and made more useful by using a calibration method based on strain measurements at critical locations in the pavement.

This study is a first attempt to visually evaluate distresses in and around utility cuts and, through a rational procedure, to develop a rating index for utility cuts. First, a distress manual for utility cuts was assembled. Then a rating index was developed using fourteen engineers and inspectors who evaluated 60 cuts with the Delphi Method. They were asked to judge the condition of each cut. Relationships were established between distresses and the general condition of the cuts by using a neural network software. This resulted in the definition of UCCI, the Utility Cut Condition Index. The model has been trained and tested for accuracy. The UCCI predicted by the neural network may be used as a management tool for identifying conditions of utility cuts in a city and assigning priorities for their maintenance. The UCCI may be used also to monitor the performance of newly repaired