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Effect of Utility Cut Patching on Pavement Deterioration

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Abstract. Utility Cut Patching (UCP) is a major cause of pavement deterioration in city streets. The streets of the city of Riyadh are no exception. A study was undertaken to investigate factors related to UCP and possibly contributing to pavement deterioration. Existing pavement condition, materials properties of patch and pavement, and geometry of trench were among factors investigated. Pavement deterioration was evaluated by deflection measurements at various points on the patch and existing pavement using falling weight deflectometer. Analysis of the results indicated that deflection at center of patch is the most critical one. Furthermore, deflection readings at various points on the patch indicated the dependency of patch deflection on trench geometry and existing pavement structural conditions. Investigation of patching effects on pavement roughness suggested an increase in roughness of pavement due to UCP.

Introduction

Patching of city streets is frequently required as a result of utility cuts. In Riyadh, there are nearly 180 million square meters of paved roadways [1]. The cumulative area for patched sewage network were approximately 2,925,000 square meters until 1408 H (1988). The patched area for the water network for the two years 1407, 1408 was nearly 240,640 square meters, in addition to nearly 47,300 square meters for the year 1408 for the telephone network [2].

The use of road for utility services is a long established practice and there is a need to study the influence of utility cut restorations on the performance of pavements.

The impact of discontinuities resulting from vertical cuts in existing pavements is widely recognized as one of the main causes of deterioration. The pavement deterioration resulting from UCP results in a noticeable nuisance to road users due to pavement roughness and due to traffic flow interruptions caused by closing the road for repair of pavement failures.

The utility cut patching has an effect on the service life of pavement. It was found that utility cut patching has a significant detrimental effect on pavement performance as measured by pavement condition surveys and non-destructive deflection testing. The magnitude of this effect was found to be a function of climate, traffic loadings, pavement patching procedure and pavement condition at the time of patching [3].

Most of the studies reviewed with respect to structural evaluation of streets with utility cut patching use Falling Weight Defelectometer (FWD) [3,4].

In examining the pavement cost impact of utility cut restoration it was found that there were many qualitative statements in the technical literature on the negative impact of restoration [4]. These statements often indicate a resotration impact that can significantly reduce the pavement service life.

The objectives of this research include the following:

1) To determine the various factors affecting pavement deterioration as a result of utility cut patching and;

2) To establish the effect of utility cut patching on pavement roughness.

Field and Laboratory Evaluation

In order to determine various factors related to utilities cut patching, it was necessary to select utility cut locations with various dimensions and characteristics. Several laboratorty and field tests were used to meet the objectives of this study.

In this study, an extensive field survey of utility cut patching in the city of Riyadh was conducted to study the effect of various cut parameters on the performance of pavements. Initially, more than 250 locations in seven different zones were randomly selected on streets having a width of 25 m or more. The selection of these locations was partially based on records obtained from the Coordination Department of Riyadh Municipality which is in charge of issueing utility cut permits. However, due to difficulties in obtaining complete records of some of these utility cuts, only 75 locations for various utility types were finally selected.

Initial information collected for each trench included width, depth, and its distance from the nearest pavement edge. Table 1 present these data for each location included in the study.

Table 1. Dimensions and relative locations of surveyed utility trenches

Location #	Width (CM)	Depth (CM)	Distance from sidewalk (M)	Location #	Width (CM)	Depth (CM)	Distance from sidewalk (M)
1	80	80	2.4	39	105	100	9.5
2	80	80	2.4	40	100	150	9.55
3	80	80	2.4	41	100	150	2.25
4	120	80	4.6	42	130	150	1.90
5	100	120	0.7	43	200	150	3.35
6	40	60	1.2	44	107	150	1.50
7	40	60	0.4	45	104	100	4.2
8	40	65	1.0	46	120	150	2.8
9	40	80	1.2	47	120	150	2.85
10	40	60	2.7	48	105	150	2.0
11	80	80	2.4	49	100	150	2.5
12	120	140	4.6	50	110	150	2.35
13	120	100	2.6	51	100	150	5.0
14	80	80	1.9	52	110	120	4.10
15	80	80	2.4	53	80	100	4.0
16	60	80	-	54	140	150	5.6
17	120	180	5.1	55	100	150	7.3
18	50	60	0.65	56	100	150	1.9
19	80	60	6.4	57	110	150	9.3
20	60	60	0.5	58	100	150	2.4
21	60	60	3.3	59	80	100	5.7
22	80	60	-	60	40	60	0.4
23	40	50	–	61	100	150	4.5
24	80	60	-	62	80	80	0.5
25	105	150	3.1	63	100	150	0.5
26	110	150	3.7	64	90	100	0.5
27	190	150	1.7	65	110	100	6.6
28	100	150	3.5	66	40	80	7.3
29	110	150	5.0	67	50	60	0.6
30	110	150	3.15	68	120	150	0.85
31	100	150	4.0	69	90	150	0.7
32	105	150	3.1	70	50	80	0.7
33	100	80	1.8	71	105	100	8.9
34	110	80	2.1	72	45	80	1.08
35	110	80	1.65	73	100	150	0.7
36	100	80	3.56	74	100	150	0.5
37	100	80	5.5	75	40	50	0.5
38	70	80	1.25				

For the purpose of laboratory evaluation of pavement materials, a total of four cores were obtained from each location; two cores from the patched pavement (p) and the other two from the existing (uncut) pavement (c).

Non-Destructive Testing

In this study, the FWD was used to evaluate the pavement at four different points: at the center (C), along the inner edge (I), and along the outer edge of utility

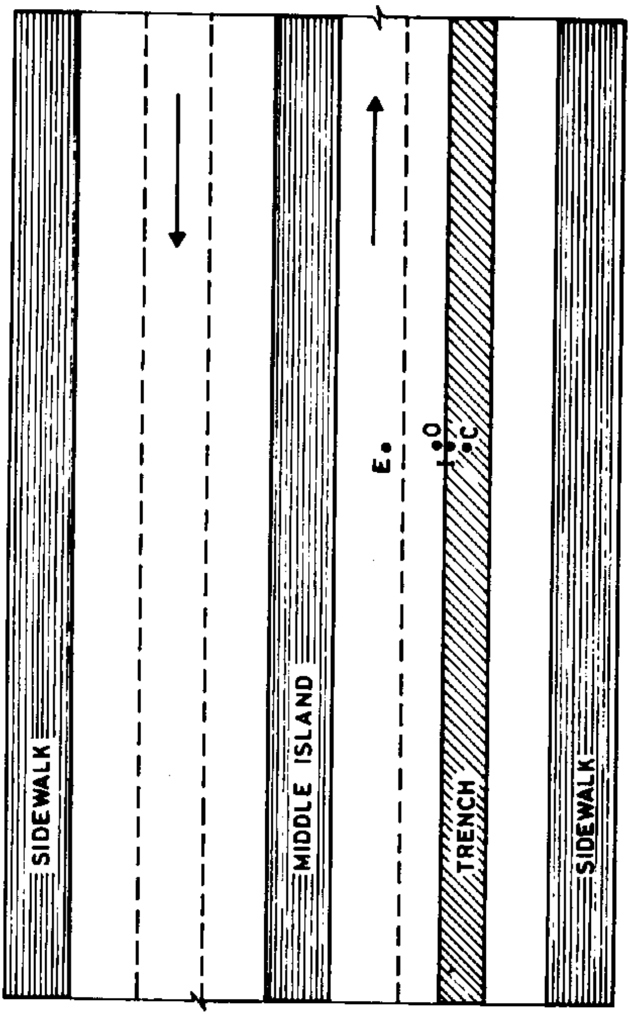

Fig. 1. Trench plan showing location of deflection measurements

cut patching (O), and at the original uncut pavement away from patch (E). Fig. 1 is a layout of a patched trench showing the location of the points C,I,O, and E.

Before any analysis of deflection data can be performed, it is essential that all deflections measurement be corrected to standardized load and temperature. Deflections were first corrected for a load of 18,000 lbs (80 KN), then were corrected for temperature.

For temperature correction, linear regression was used to establish the following relationship between deflection and temperature:

$$D = 0.26543\,T + 100.434 \qquad (R^2 = 0.97)$$

where

D is deflection in (microns) (10^{-3} mm) and
T is pavement surface temperature (°C)

To obtain correction factors for temperature, it was necessary to define a standard temperature to which all deflections will be corrected. The 40°C temperature was believed to be a resonable approximation of the average surface temperature for Riyadh pavements. Therefore, it was selected as the standard temperature.

Table 2 shows the maximum corrected deflection at the four locations indicated above, where DC, DI, DO and DE represents deflection at center, inner edge, outer edge and existing pavement respeetively. Due to difficulties in measuring deflection on some of the patches only 49 locations were considered in this part.

The maximum, the minimum and the average of these corrected deflections are shown in Fig. 2. From the average values of the corrected deflections it is clear that deflection at point C has the largest value and is approximately twice the average deflection at point E. This indicates that the structural integrity of a pavement is effected to a large degree by the construction of utility cuts. Fig. 3 shows the relationship between deflections at point E versus deflection at point C, I and O and indicates that deflections at point O have always the smallest value. The critical deflections occur in either point C or I depending on the patch location. However, for most locations, the deflection at the center of patch (C) is the critical one.

Material Properties

Material properties constitute an important factor which affect the strength of the pavement. Quality of construction is another factor. Marshall stability and modulus of resilience are two measures which indicate the strength of asphalt mixes. High

Table 2. Maximum deflection at various points on patch

Location #	Deflection C	I	Micron O	E
1	422.00	493.00	–	210.00
2	480.00	451.00	–	416.00
3	394.00	257.00	–	244.00
4	679.00	345.00	–	206.00
5	840.00	664.00	–	441.00
6	1303.00	361.00	–	272.00
7	1560.00	640.00	–	479.00
8	562.00	405.00	–	277.00
9	640.00	457.00	–	284.00
10	513.00	460.00		353.00
11	1469.00	307.00	–	199.00
12	515.00	223.00	–	164.00
13	427.00	664.00	–	154.00
14	580.00	500.00	–	382.00
15	345.00	344.00	–	258.00
16	336.00	440.00	–	235.00
17	289.00	249.00	–	225.00
18	1151.00	1190.00	–	587.00
19	281.00	–	–	124.00
20	463.00	332.00	–	196.00
21	548.00	595.00	–	481.00
22	482.00	455.00		343.00
23	623.00	–	-	572.00
24	821.00	1139.00	–	305.00
25	411.00	409.00	348.00	105.00
26	410.00	141.00	596.00	106.00
27	460.00	374.00	340.00	280.00
28	1020.00	935.00	472.00	702.00
29	724.00	523.00	223.00	161.00
30	525.00	324.00	229.00	159.00
31	680.00	510.00	541.00	265.00
32	1320.00	1306.00	506.00	260.00
33	416.00	390.00	265.00	245.00
36	286.00	309.00	371.00	251.00
38	627.00	–	643.00	371.00
40	1749.00	1928.00	1647.00	1500.00
42	705.00	605.00	345.00	219.00
43	361.00	360.00	338.00	330.00
46	358.00	423.00	562.00	450.00
47	425.00	626.00	333.00	225.00
48	1118.00	1194.00	494.00	466.00
49	760.00	874.00	453.00	270.00
58	753.00	1119.00	770.00	595.00
59	1004.00	709.00	793.00	619.00
60	828.00	–	592.00	330.00
67	–	–	–	–
69	–	–	–	–
70	953.00		503.00	385.00
71	487.00	1138.00	511.00	212.00
74	1291.00	1242.00	1347.00	1053.00
75	1118.00	–	567.00	552.00

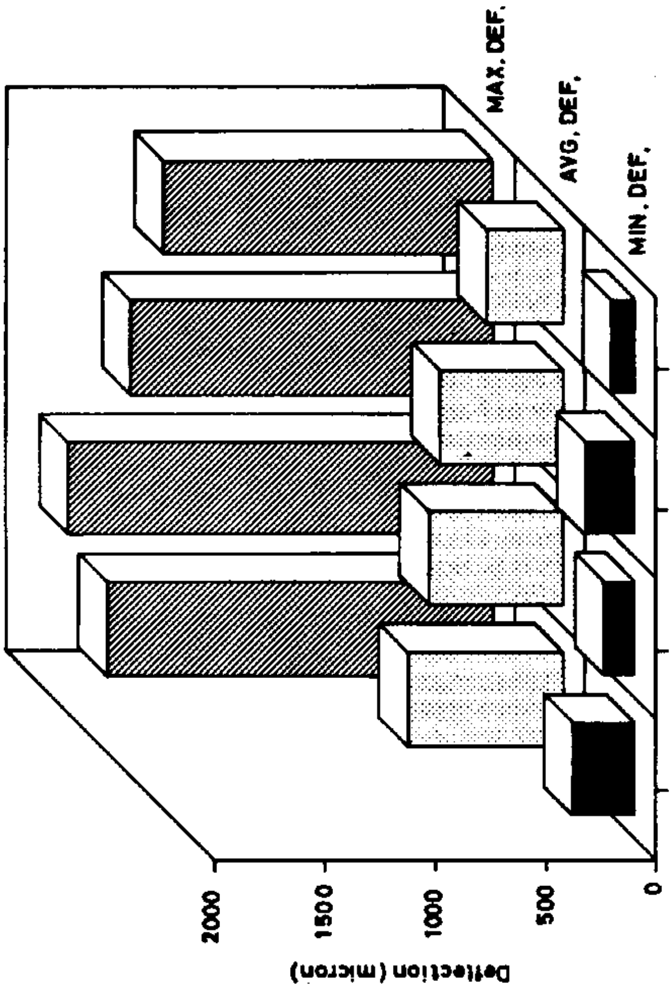

Fig. 2. Comparison of deflections at various patch oints

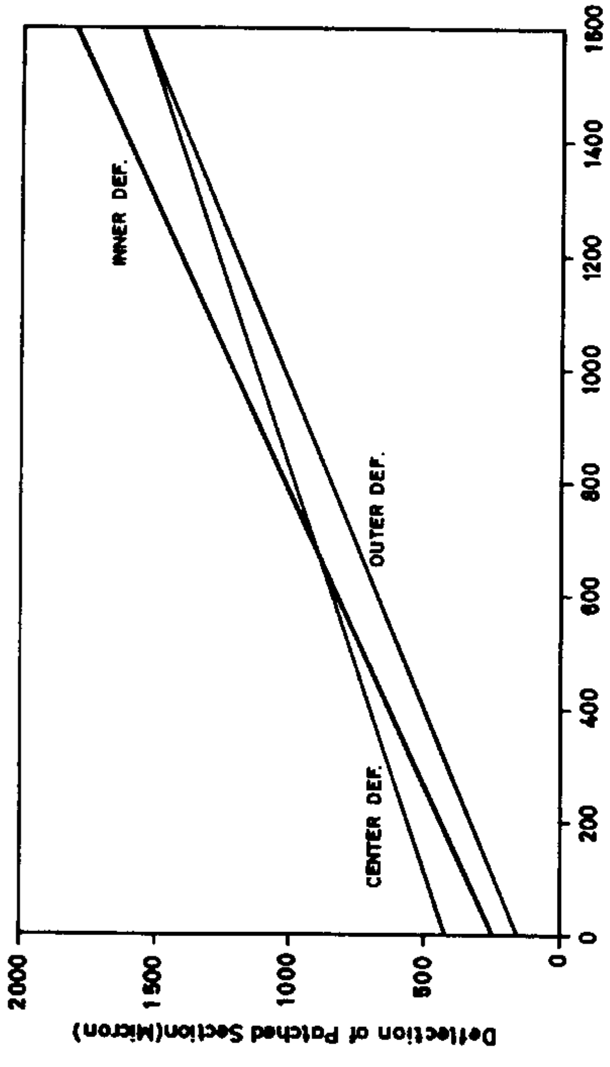

Fig. 3. Relationship between patch and deflection of existing pavement (Micron)

variations in these variables in both patched and existing uncut pavement sections will definitely result in variation of deflection measurements. Other pertinent mix variables that might affect deflection are bulk specific gravity (Gmb) and flow. Fig. 4 shows the plots for MR, stability, and Gmb for patches *vs.* existing uncut sections. The figure indicates that MR for existing sections has consistently higher values. This is also true for the majority of observed stabilities and Gmb. This suggests that these variables might contribute considerably to deflection differences observed for patches and existing pavements. Fig. 4 also shows a similar relationship for flow. Although, there is a large scatter of data points, a more even distribution of points around the equality line is observed for this property indicating comparable deformation properties for patches and existing uncut sections.

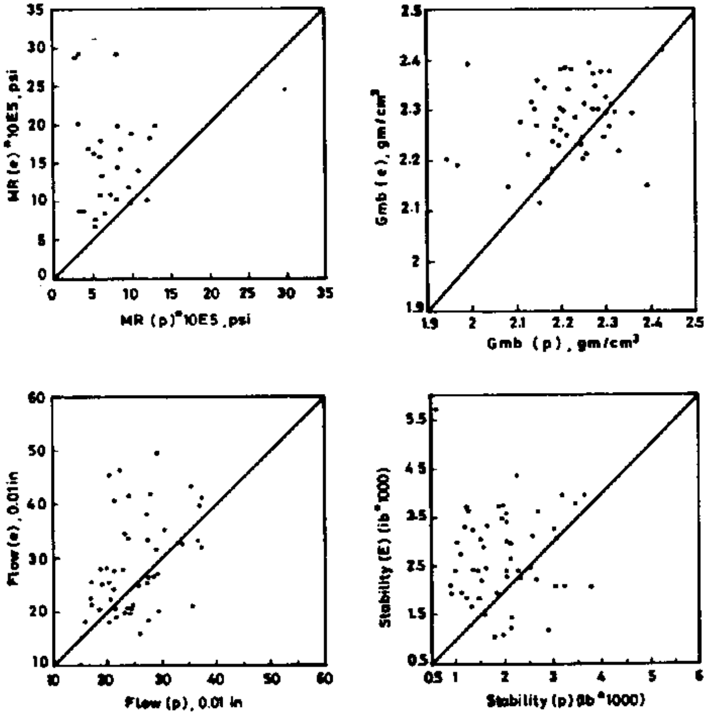

Fig. 4. Relationship between material properties of patch and existing pavement

Thickness of Asphalt Layer

One of the most important factors that might contribute to the relative performance of a patched section with respect to the existing pavement is the ratio of asphalt concrete layer thickness of the patch to that of the existing pavement. Cores obtained for patched and uncut sections were used to established the thickness ratios. Current specifications require that thickness ratio should be one. Table 3 gives results of these thickness measurements and ratios for the selected locations.

Trench Geometry

It was hypothesized that the geometry of trench might have an effect on patch performance. Therefore, data concerning trench depth and width and distance from trench edge to the nearest sidewalk were collected for each trench.

The effect of trench width on center of patch deflection is shown in Fig. 5. In this Fig. trench widths were divided into five separate groups; namely, less than 60 cm, 60 to 80 cm, 80 to 100 cm, 100 to 130 cm, and more than 130 cm. This figure indicates that deflection at center of patch decreases with a decreasing rate as trench width increases.

The other two variables, location of trench with respect to sidewalk and depth of trench, have little effect, if any, on the deflection at center of patch. Fig. 6 shows a plot of these two variables with deflection. More discussion of the effect of the above factors is given elesewhere [5].

Analysis of Test Results

In order to identify factors significantly affecting deflection at various points of patch, a correlation matrix was first formed. Based on these correlations, factors having high correlctions with patch deflections were then selected. Some of these factors were found to be correlated with each other, so screening was made to select the most important factors. These factors, however, are different for various points on the patch. Finally, a stepwise regression analysis was conducted between patch deflections as dependent variables and other factors as independent variables. However, since the stepwise technique may not give the highest coefficient of determination (R^2), those factors which were found to be significant were again entered into the model using another regression technique (PROC REG) [8]. The resulting models were as follows:

$$DC = 819.8 + 0.85\,DE - 354.53\,W - 0.696\,THP$$

$$R^2 = 0.69$$

Table 3. Thickness and asphalt layer for patch and existing pavement

Location #	Thickness (CM)		Thick Ratio	Th. diff. (CM)
	p	e	p/e	p-e
1.00	13.30	12.00	1.11	1.30
2.00	10.80	15.30	0.71	–4.50
3.00	12.90	13.50	0.96	–0.60
4.00	9.20	20.80	0.44	–11.60
5.00	8.20	12.70	0.65	–4.50
6.00	8.10	11.70	0.69	–3.60
7.00	10.50	14.90	0.70	–4.40
8.00	12.40	17.50	0.71	–5.10
9.00	12.80	19.50	0.66	6.70
10.00	14.80	15.30	0.97	–0.50
11.00	14.70	14.50	1.01	0.20
12.00	14.10	13.80	1.02	0.30
13.00	13.90	13.50	1.03	0.40
14.00	15.00	15.50	0.97	–0.50
15.00	12.70	12.80	0.99	–0.10
16.00	15.60	13.30	1.17	2.30
17.00	14.10	13.80	1.02	0.30
18.00	9.30	14.80	0.63	5.50
19.00	15.70	13.40	1.17	–2.30
20.00	15.10	17.40	0.87	–2.30
21.00	17.40	14.20	1.23	3.20
22.00	17.10	14.10	1.21	3.00
23.00	7.90	18.00	0.44	–10.10
24.00	14.30	13.60	1.05	0.70
25.00	24.00	19.50	1.23	4.50
26.00	15.50	19.50	0.79	–4.00
27.00	12.50	15.00	0.83	–2.50
28.00	6.80	5.60	1.21	1.20
29.00	12.00	9.30	1.29	2.70
30.00	14.50	15.00	0.97	0.50
31.00	9.80	5.70	1.72	4.10
32.00	9.00	5.40	1.67	3.60
33.00	9.00	10.00	0.90	–1.00
36.00	10.50	9.50	1.11	1.00
38.00	12.50	9.50	1.32	3.00
40.00	10.50	5.50	1.91	5.00
42.00	15.80	15.00	0.98	–0.30
43.00	15.00	23.00	0.65	–8.00
46.00	9.00	6.00	1.50	3.00
47.00	10.50	5.50	1.91	5.00
48.00	14.70	15.50	0.95	–0.80
49.00	7.20	7.40	0.97	–0.20
58.00	5.80	10.10	0.57	4.30
59.00	11.00	10.30	1.07	0.70
60.00	9.80	11.50	0.85	–1.70
67.00	10.10	17.60	0.57	–7.50
69.00	9.40	20.70	0.45	11.30
70.00	9.30	14.10	0.66	–4.80
71.00	9.10	8.20	1.11	0.90
72.00	8.00	5.60	1.43	2.40
74.00	8.80	8.70	1.01	0.10
75.00	8.10	9.00	0.90	–0.90

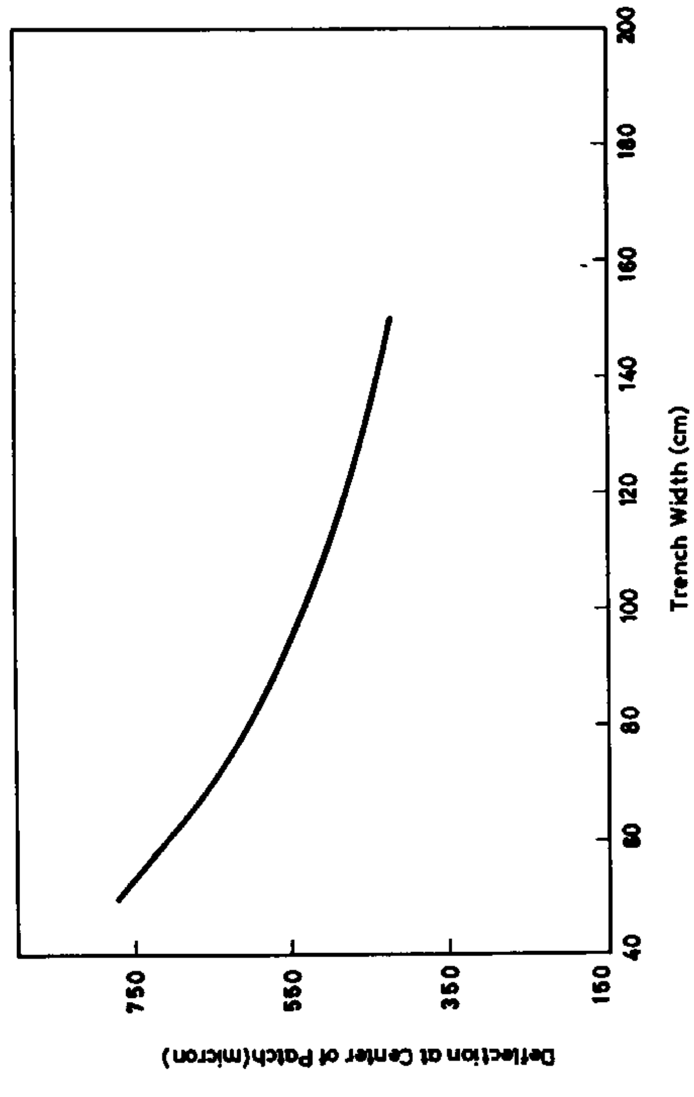

Fig. 5. Effect of trench width on deflection at center of patch

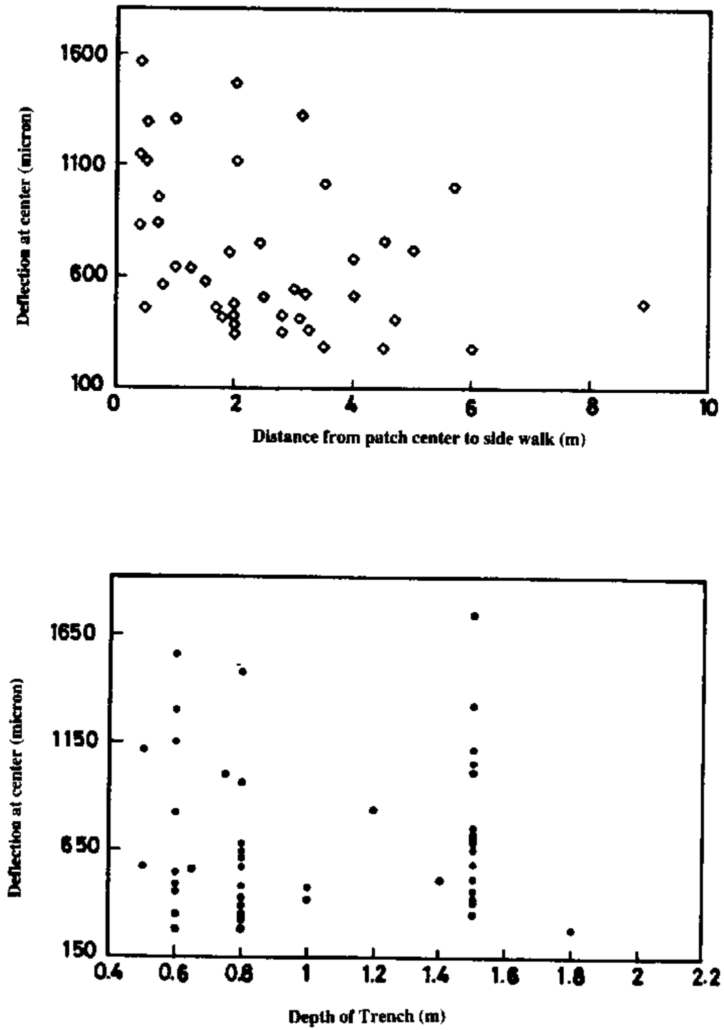

Fig. 6. Relationship between deflection at center of patch and each of distance from sidewalk and depth of trench.

$$DI = 157.4 + 0.82\ DE + 56.63\ SW$$

$$R^2 = 0.52$$

$$DO = 271.84 + 0.97\ DE - 64.98\ W^2$$

$$R^2 = 0.91$$

where

DC, DI, DO are deflections (Micron) at center, inner edge, and outer edge of patch respectively.

DE is deflection at the existing (uncut) pavement (Microns).

W, THP are width and thickness of patch respectively (cm).

SW is distance between the trench and the nearest sidewalk (meter).

These models clearly show that deflection at various points of patch is controlled mainly by width of trench, patch thickness and the structural condition of the existing pavement (DE) which accounts for most of the variation. The dependency of deflection at all three points (DC, DO, and DI) on the deflection of existing pavement (DE) emphasizes the point that a patch is just as bad as the existing pavement. From this, it stems that a patch constructed to a high standard will still perform badly if the already-existing pavement is in a bad condition. So, the existence of a good condition pavement is a prerequist for good patching.

The outer deflection model which relates DO to DE and W^2 has a very high determination coefficient ($R^2 = 0.91$) due to the fact that both DO and DE were taken at the same pavement. The dependency of DO on W^2 is probably because that compaction becomes easer and more effective as the trench gets wider, which in turn causes deflection to decrease.

Determination coefficient for the DC model is relatively high ($R^2 = 0.69$) indicating that the model could be used (with some caution) for deflection prediction with relatively good accuracy. However, DI model has a low coefficient ($R^2 = 0.52$), indicating unreliable model. The reason for this low R^2 value could be attributed to the fact that DI was measured on top of the "crack" where high variability is expected at this location. Despite of the low value of R^2, DI model shows that DI is not affected by either trench width or patch thickness, as was the case with DO and DC, but to some extent by how far is the trench from the sidewalk. This later effect could be related to the location of trench relative to the wheel path. This could mean that the farther the trench from the sidewalk the more it will be subjected to stresses from moving vehicles.

In conclusion, although these models cannot be generalized as they are based on limited field measurements, however, they highlight the important factors affecting patch deflection. This, of course, does not mean that other factors are not important. Indeed, factors such as mix properties may just be as important but, probably due to the large variation in these properties, (Fig. 3) they did not appear in the models. From this it follows that a more comprehensive study of UCP is needed to arrive at a concrete conclusion concerning factors affectng UCP deterioration.

Effect of UCP on Pavement Roughness and Performance

In order to establish the effect of utility cut patching on both pavement roughness and performance, the roughness and pavement condition as measured by PAVER's Pavement Condition Index (PCI) were determined for patched and uncut pavements. Road roughness was measured by a Mays Ride Meter (MRM) which is the most commonly used device among the response type road roughness measuring devices [6].

Pavement Roughness

In this study pavement roughness was measured by MRM for patched lanes of each location by letting one wheel pass on the patched pavement. Another roughness measurement was also taken for uncut pavement lanes.

Table 4 shows the variation of roughness between patched lanes and uncut pacment lanes. Roughness measurements were not taken for some of the locations due to uncontrolled circumstances.

The results clearly show that the roughness of uncut sections was observed to be always less than that of patched sections as shown in Fig. 7. The average value of roughness for uncut sections is 168 in/mile (267 cm/km) where it is 303 in/mile (481 cm/km) for patched sections. The average percentage of increase in roughness due to utility cut patching is 96.6 percent. This indicates that the roughness of a road section will nearly double after utility patching, resulting in a sharp increase in road user cost. Furthermore, the roughness of patched sections increases as trench width decreases as shown in Fig. 8.

Pavement Condition and Performance

The rating system of PAVER technique, which is a PMMS developed by the United State Army Corp of Engineers [7], was adopted for visual evaluation of pave-

Table 4. Roughness results for various test locations

Location #	Roughness		Increase in rough (p-e) cm/km	% Increase in rough due to UCP
	e cm/km	p cm/km		
25	144.46	276.22	131.76	91.21
26	142.88	269.88	127.00	88.89
27	227.01	268.29	41.28	18.18
28	187.33	508.00	320.68	171.19
29	244.48	439.74	195.26	79.87
30	279.40	639.76	360.36	128.98
31	176.21	423.86	247.65	140.54
32	153.99	463.55	309.56	201.03
33	101.60	400.05	298.45	293.75
34	239.71	327.03	87.31	36.42
35	471.49	711.20	239.71	50.84
36	304.80	609.60	304.80	100.00
37	309.56	444.50	134.94	43.59
38	301.63	606.43	304.80	101.05
39	257.18	576.26	319.09	124.07
40	466.72	803.28	336.55	72.11
41	304.80	498.47	193.67	63.54
42	180.98	466.72	285.75	157.89
43	269.88	368.30	98.43	36.47
44	198.44	579.44	381.00	192.00
45	193.67	508.00	314.33	162.30
46	160.34	407.99	247.65	154.46
47	228.60	439.74	211.14	92.36
48	263.53	415.92	152.40	57.83
49	646.11	701.68	55.56	8.60
51	212.73	363.54	150.81	70.90
53	203.20	304.80	101.60	50.00
56	376.24	508.00	131.76	35.02
58	396.88	701.68	304.80	76.80
59	203.20	600.07	396.88	195.31
61	290.51	368.30	77.79	26.78
65	498.47	690.56	192.09	38.54
71	142.88	182.56	39.69	27.78

ment distresses. It was selected for pavement evaluation since it deals with the subject most comprehensively and is based on sound statistical method of pavement sampling. Pavement Condition Index (PCI) is a combined measure of pavement structural integrity as well as surface operational condition. It is based on numerical rating of 0 to 100. In this study, the patched lane was taken as one unit and the uncut lane as another unit to be surveyed to find the reduction in pavement condition index due to cut patching.

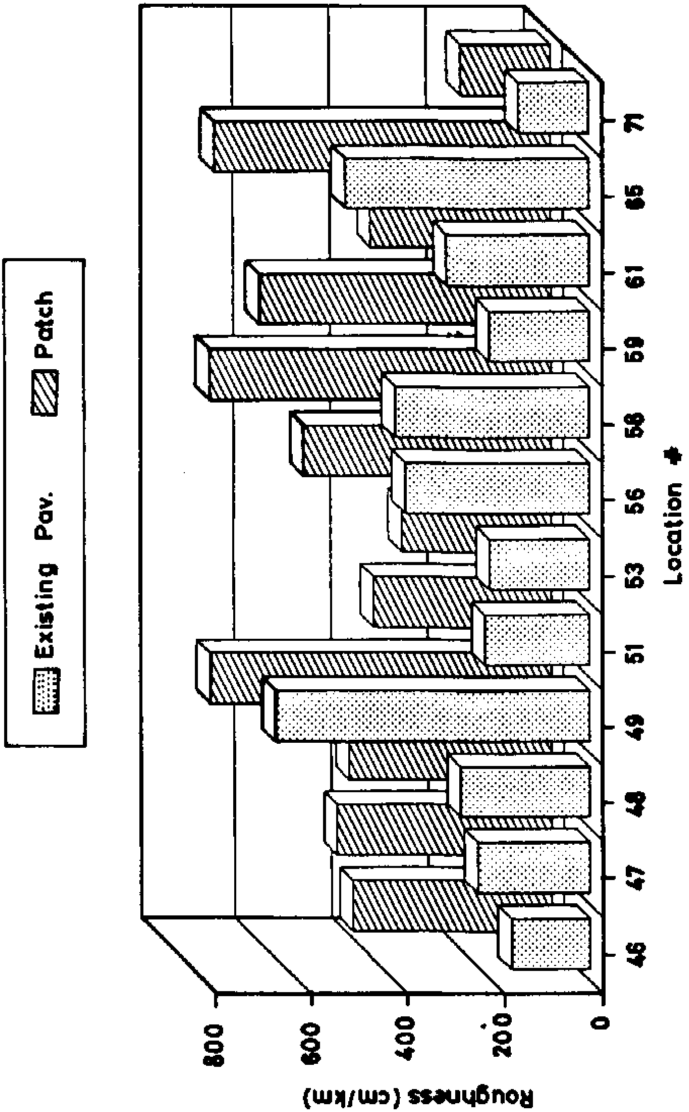

Fig. 7. Comparison of roughness of patch and existing pavement

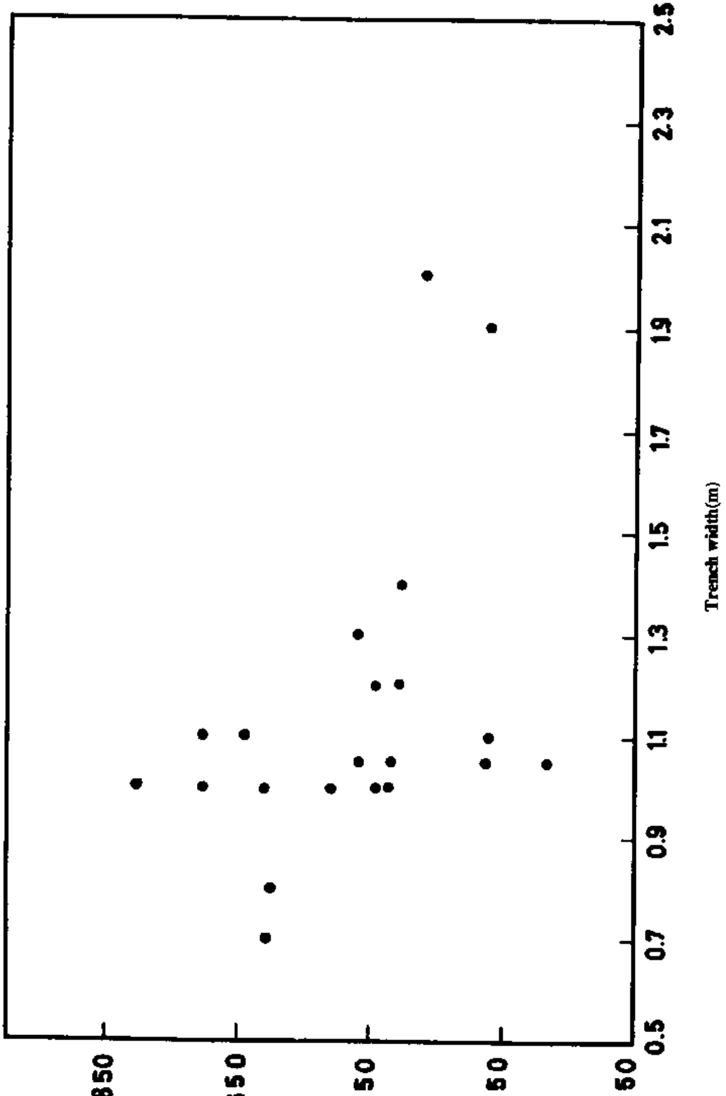

Fig. 8. Effect of trench width of roughness of patched sections

During the PCI survey , it was observed that weathering and raveling were the two major distress types on patched sections. Analysis of the PCI values shows large variations in PCI values between patched and uncut lanes. The PCI values of all locations are given in Table 5 which also gives the rating and percent reduction in PCI due to utility cut patching. Fig. 8 shows PCI for both patch (p) and existing pavement (e).

Table 5. Pavement condition index results for test locations

Location #	PCI (p)	Rating (p)	PCI (e)	Rating (e)	PCI (p - e)	% of Reduction
25	50.00	Fair	83.00	V. Good	- 33.00	39.76
26	53.00	Fair	80.00	V. Good	27.00	33.75
27	44.00	Fair	88.00	V. Good	44.00	50.00
29	75.00	V. Good	95.00	Excellent	20.00	21.05
30	45.00	Fair	88.00	V. Good	43.00	48.86
31	62.00	Good	90.00	Excellent	28.00	31.11
32	56.00	Good	90.00	Excellent	34.00	37.78
33	36.00	Poor	74.00	V. Good	38.00	51.35
34	58.00	Good	64.00	Good	6.00	9.38
35	20.00	V. Poor	22.00	V. Poor	2.00	9.09
36	38.00	Poor	65.00	Good	27.00	41.54
37	56.00	Good	66.00	Good	10.00	15.15
38	58.00	Good	68.00	Good	10.00	14.71
39	48.00	Fair	76.00	V. Good	28.00	36.84
42	45.00	Fair	69.00	Good	24.00	34.78
43	53.00	Fair	80.00	V. Good	27.00	33.75
44	17.00	V. Poor	57.00	Good	40.00	70.18
45	69.00	Good	91.00	Excellent	22.00	24.18
46	36.00	Poor	73.00	V. Good	37.00	50.68
47	54.00	Fair	69.00	Good	15.00	21.74
49	57.00	Good	84.00	V. Good	27.00	32.14
52	23.00	V. Poor	60.00	Good	37.00	61.67
53	68.00	Good	90.00	Excellent	22.00	24.44
58	19.00	V. Poor	36.00	Poor	17.00	47.22
60	65.00	Good	87.00	Excellent	22.00	25.29
61	42.00	Fair	58.00	Good	16.00	27.59
62	74.00	V. Good	90.00	Excellent	16.00	17.78
63	47.00	Fair	86.00	Excellent	39.00	45.35
67	77.00	V. Good	87.00	Excellent	10.00	11.49
71	68.00	Good	87.00	Excellent	19.00	21.84
74	32.00	Poor	48.00	Fair	16.00	33.33
75	58.00	Good	84.00	V. Good	26.00	30.95

The above results indicate that the average reduction in PCI values is 24.44 %. In addition, the average value of PCI for patched sections is 50.09 with standard deviation of 16.16 which gives a rating of fair. On the other hand, the average PCI value for uncut lane was 74.53 with standard deviation of 16.81 which has a rating of very good. This indicates that a patched section not only suffers from high deflection but also its performance as represented by PCI is lower.

Conclusions

Based on the field and laboratory test results, the following conclusions are drawn:

1) Utility cut patching results in faster deterioration of the pavement structure. FWD test results indicated that critical deflections occur at the center of patching in most of test locations and is approximately 1.8 times the average deflection at existing pavement.

2) The trench width has a definite effect on deflection at the center of patch. As width increases deflection decreases at a decreasing rate.

3) Models were estasblished from field and laboratory test results to predict deflection at various points on the trench. These models indicate that among all variables investigated, geometry of trench and existing structural condition of pavement have the highest effect on deflections.

4) Roughness of uncut lanes as measured by MRM are almost double those for utility cut patching. The PCI survey results indicated that utility cut patching caused an average reduction in PCI value of 24.4%.

Recommendations

Deterioration of pavements due to UCP is a major problem facing municipalities. However, certain actions could be taken to reduce or minimize the effect of UCP on pavement condition. For example, one provision could be increasing the thickness of the top layer of patch, above that of the existing pavements, and/or increasing its width to overlap existing pavement. In this later case, the patch top layer is extended beyond the trench. The feasibility of some of these measures in reducing pavement (deflection) deterioration is the subject of another study [5].

Furthermore, other measures such as the application of a more rigid quality control measures for both materials and construction techniques would help in minimizing the problem. Also, using unshrinkable fill instead of conventional types surely will reduce pavement deterioration.

Finally, the trench should be of sufficient width to eliminate or at least reduce problems associated with compacting a narrow trench. A study concerning the minimum practical width for utility trenches is warrented. The effect of the location of the trench relative to the wheel path also deserves some attention. More field as well as experimental investigation is necessary in order to reach a concrete conclusion concerning UCP construction.

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تأثير رقع أخاديد الخدمات على تدهور حالة الرصف

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ملخص البحث. تعتبر رقع أخاديد الخدمات من العوامل الرئيسة المؤدية إلى تدهور حالة الرصف في شوارع المدن، ولا تستثنى شوارع مدينة الرياض من هذه الظاهرة. ولدراسة هذه الظاهرة تم القيام ببحث لمعرفة العوامل التي لها علاقة بهذه الأخاديد والتي ربما تؤثر على تدهور حالة الرصف. ومن العوامل التي تمت دراستها حالة الرصف، خواص المواد المستخدمة في الترقيع والرصف وأبعاد الأخاديد. وقد تم تقويم مدى التدهور الحاصل بواسطة قياس الانحراف في عدة نقاط على كل من رقع الأخاديد والرصف وذلك باستخدام المطرقة الساقطة. وقد دلت النتائج بصورة عامة على أن الانحراف في منتصف رقع الأخاديد هو الأعلى. كذلك دلت النماذج الرياضية المستخرجة من النتائج على اعتماد انحراف رقع الأخاديد على كل من انحراف الرصف وأبعاد الأخاديد. وأخيراً وجد أن هناك علاقة وطيدة بين زيادة خشونة الرصف ووجود رقع الأخاديد.