Total Average Yearly Overlay Costs = $8,640,562 / 12.1 + $883,694 / 19.8

= $714,096 + $44,631

= <u>$758,727 per year</u>

Manhole Alignment Costs (Patched) = $2,500 per mile * 76.56 miles

= $191,400 per complete overlay

Manhole Costs (Non-Patched) = $2,500 per mile * 10.44 miles

= $26,100 per complete overlay

Total Average Yearly Manhole Costs = $191,400 / 12.1 + $26,100 / 19.8

= <u>$17,136 per year</u>

As before, the curbing will require replacement every third overlay resulting in an average service life of 36.3 years for patched pavements. The total curbing costs are therefore as follows:

Total Curbing Costs (Patched) = $147,840 per mile * 76.56 miles

= $11,318,630 per complete overlay

Total Curbing Costs (Non-Patched) = $147,840 per mile * 10.44 miles

= $1,543,450 per complete overlay

Total Average Yearly Curbing Costs = $11,318,630 / 36.3 + 1,543,450 / 59.4

= <u>$337,792 per year.</u>

The total average yearly costs to the city can then be computed as before as the summation of the overlay, manhole and sewer alignment, and curbing costs. This results in an average yearly cost equal to $758,727 - 17,136 - 337,792 = <u>$1,113,655</u>. This figure represents an additional cost to the city

<u>$1,113,655 - 599,443 = $514,212.</u>

It should be noted that these additional costs are for the paved portion of the streets only and do not include the following:

1. Administrative and planning costs associated with patching
2. Grinding or repatching as preparation for overlays
3. Costs associated with excavations in the sidewalk or greenbelt area.

CONCLUSIONS

Based on the analysis presented herein, it was concluded that pavement performance is significantly affected by utility cut patching. A pavement life reduction factor of 1.64 was computed based on the PCI survey results. This life reduction, combined with the increased overlay requirements as computed from the FWD deflection analysis, results in a significant increase in rehabilitation costs to the city. This increase was calculated at approximately $514,000 per year for the paved portion (curb to curb) of the street system in the city. It should be pointed out that these costs are based on a minimum acceptable PCI value of 70, thus avoiding excessive reconstruction costs at lower PCI values. It was also concluded that utility patching operations on streets with PCI values below 40 will produce no consequential damage.

References

1. M.Y. Shahin, S.D. Kohn, "Pavement Maintenance Management for Roads and Parking Lots," United States Army Corps of Engineers Construction Engineering Research Laboratory Technical Report M-294, October 1981.

2. American Public Works Association Reporter, November 1983, page 16.

3. Richard Weiss, "Nondestructive Vibratory Testing of Airport Pavements; Volumes I and II," FAA-RD-73-205-I&II, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

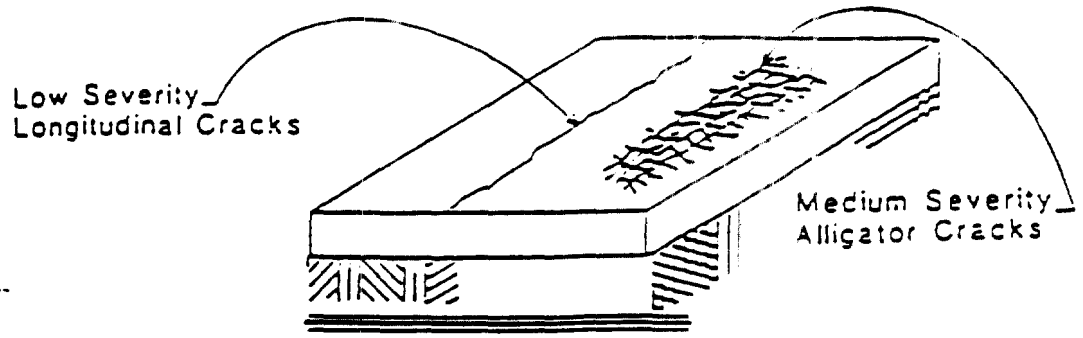
Table 1: PCI Results for Selected Streets

Street	Age (Yrs)	PCI Patch	PCI No Patch	Det. Rate Patched	Det. Rate Not Patched
1	2	100	84	0.00	8.00
2	2	100	91	0.00	4.50
3	19	95	57	0.26	2.26
4	12	95	77	0.42	1.92
5	5	92	76	1.60	4.80
6	20	91	87	0.45	0.65
7	10	89	78	1.10	2.20
8	14	89	80	0.79	1.43
9	5	88	86	2.40	2.80
10	17	88	77	0.71	1.35
11	8	86	79	1.75	2.63
12	21	86	77	0.67	1.10
13	22	84	82	0.73	0.82
14	12	84	80	1.33	1.67
15	14	84	65	1.14	2.50
16	22	82	82	0.82	0.82
17	10	82	79	1.80	2.10
18	10	80	59	2.00	4.10
19	11	80	70	1.82	2.73
20	17	80	75	1.18	1.47
21	8	80	78	2.50	2.75
22	8	80	83	2.50	2.13
23	29	80	30	0.69	2.41
24	18	78	48	1.22	2.89
25	17	78	62	1.29	2.24
26	20	78	79	1.10	1.05
27	11	78	73	2.00	2.45
28	8	77	74	2.88	3.25
29	10	73	79	2.70	2.10
30	28	73	52	0.96	1.71
31	11	73	57	2.45	3.91
32	10	73	60	2.70	4.00
33	13	72	47	2.15	4.08
34	11	72	55	2.55	4.09
35	8	71	75	3.63	3.13
36	21	70	74	1.43	1.24
37	11	68	72	2.91	2.55
38	4	68	59	8.00	10.25
39	25	67	58	1.32	1.68
40	22	66	62	1.55	1.73
41	20	65	75	1.75	1.25
42	28	63	65	1.32	1.25
43	11	62	75	3.45	2.27
44	13	60	33	3.08	5.15
45	21	56	56	2.10	2.10
46	8	55	60	5.63	5.00
47	16	43	33	3.56	4.19
48	13	39	80	4.69	1.54
49	27	29	42	2.63	2.15
50	36	27	28	2.03	2.00

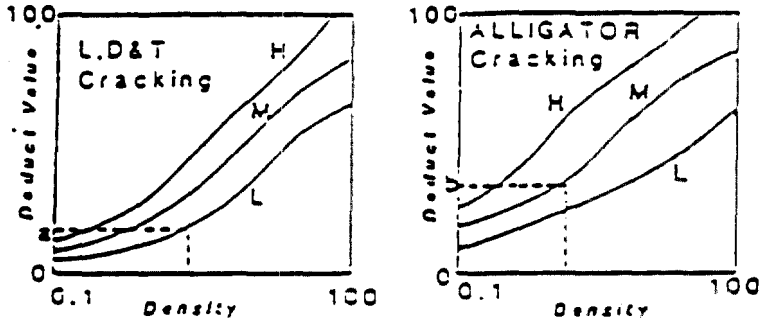
Table 2: Comparison of Average Pavement Lives for Patched and Non-Patched Pavements

Analysis Method	Average Life of Non-Patched Pavements	Average Life of Patched Pavements	Life Reduction Factor
Method 1: Rate of Deterioration	20.1 years	11.6 years	1.73
Method 2: Best-fit Line through data			
a: all data	19.8 years	12.1 years	1.64
b: PCI > 40	30.0+years	11.9 years	2.52
Method 3: Best-fit Curve through data			
a: all data	25.9 years	8.5 years	3.05
b: PCI > 40	28.9 years	7.8 years	3.71

* Step 1 Inspect sa[illegible] severity level of pavement distresses

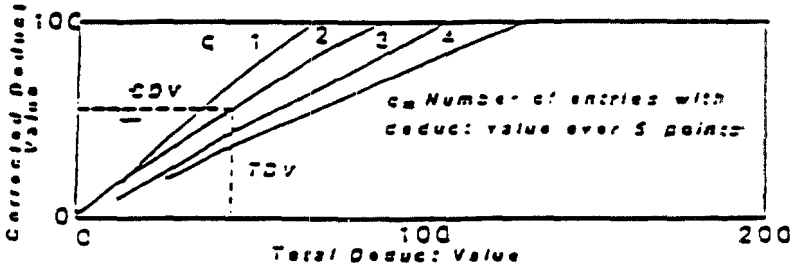


* Step 2 Determine deduct values.



* Step 3 Compute Total Deduct Value, TDV= a+b

* Step 4 Adjust Total Deduct Value.



* Step 5 Compute Pavement Condition Index, PCI=100-CDV, for each sample unit inspected.

* Step 6 Determine Pavement Condition Rating

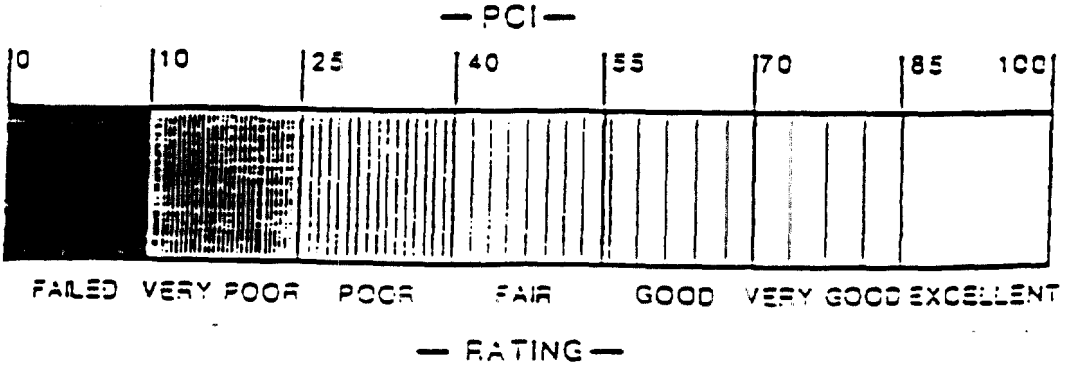


Figure 1: Pavement Condition Index Computation Procedure

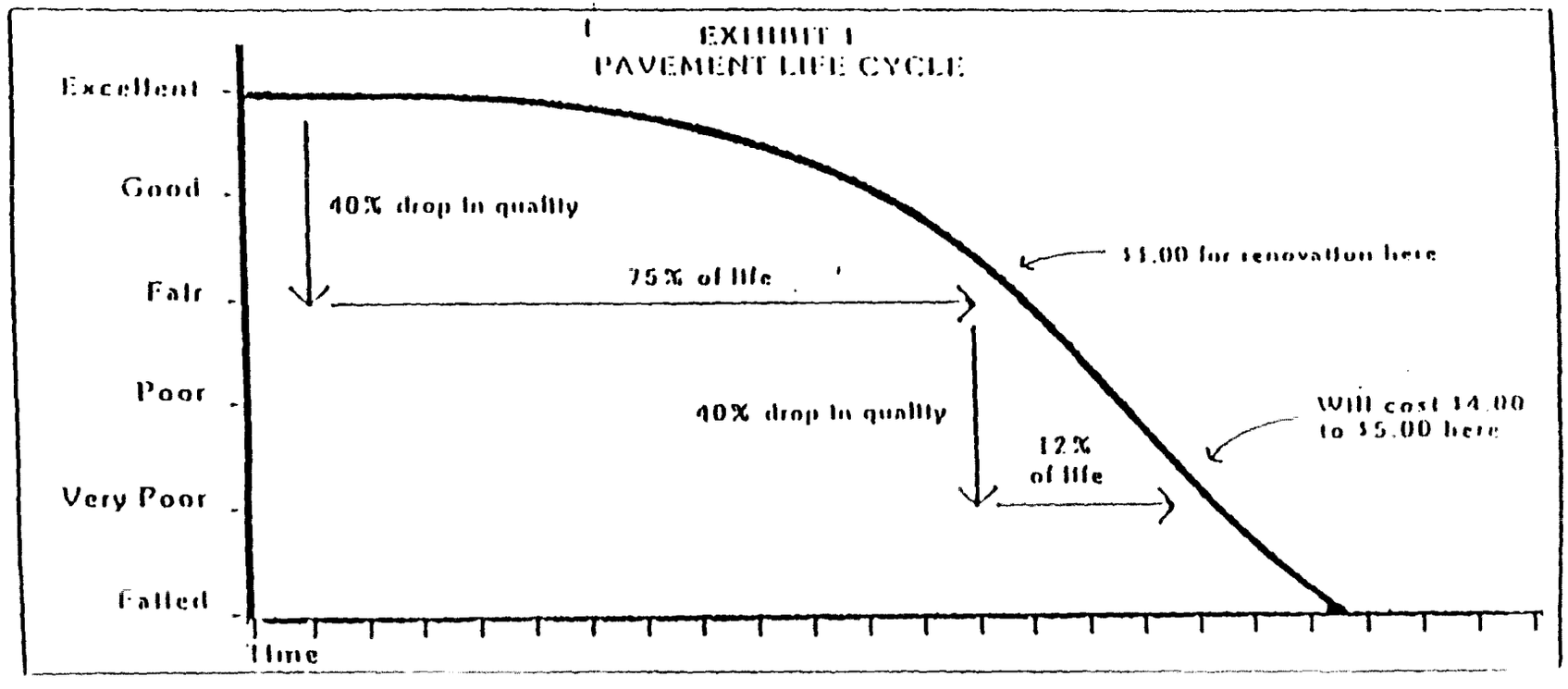


Figure 2: Renovation costs vs. pavement condition (Reprinted from APWA Reporter, November, 1981).

FIG 3: AVERAGE DETERIORATION RATES FOR THE CITY

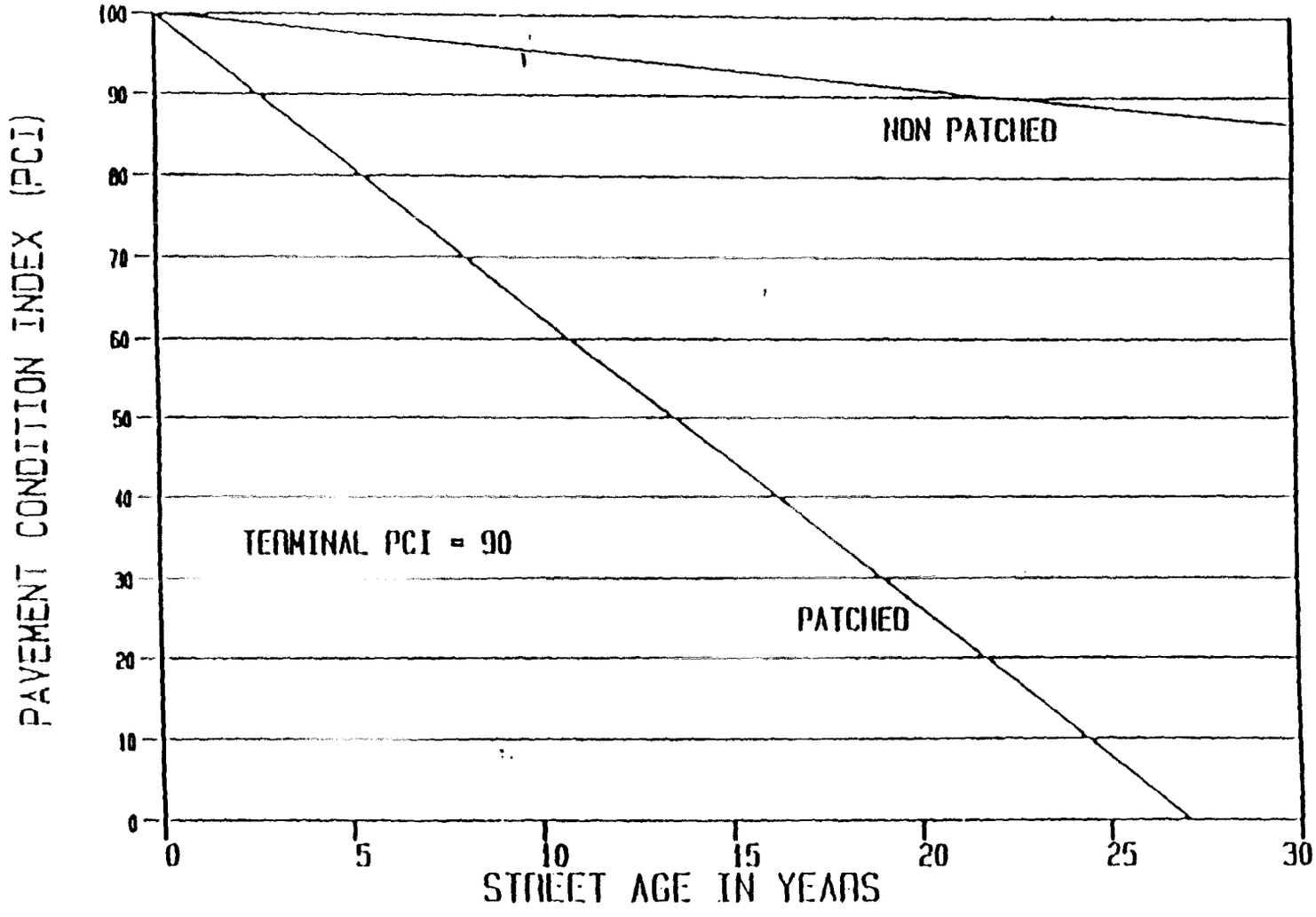


FIG 4: AVERAGE DETERIORATION RATES FOR THE CITY

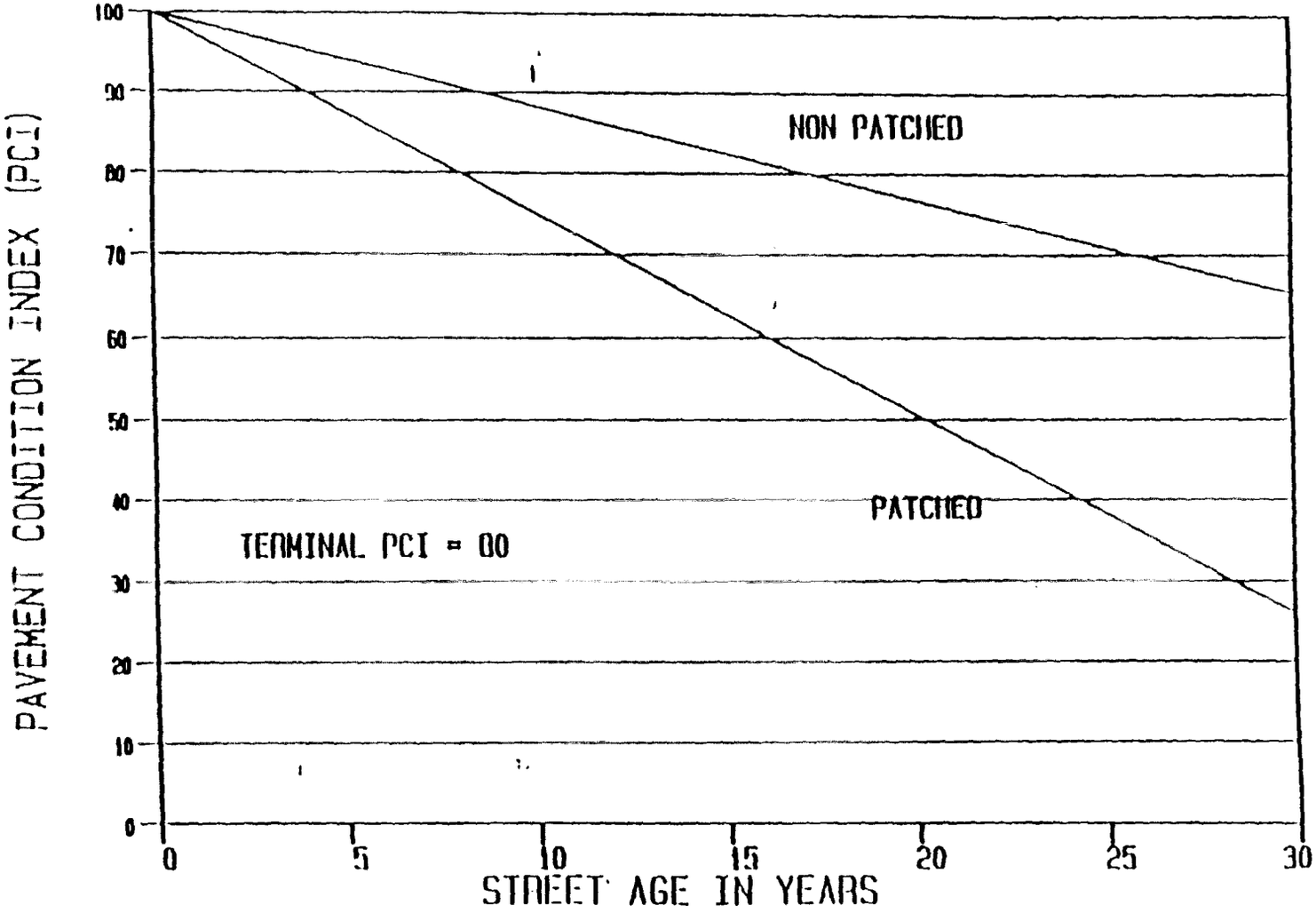


FIG 5: AVERAGE DETERIORATION RATES FOR THE CITY

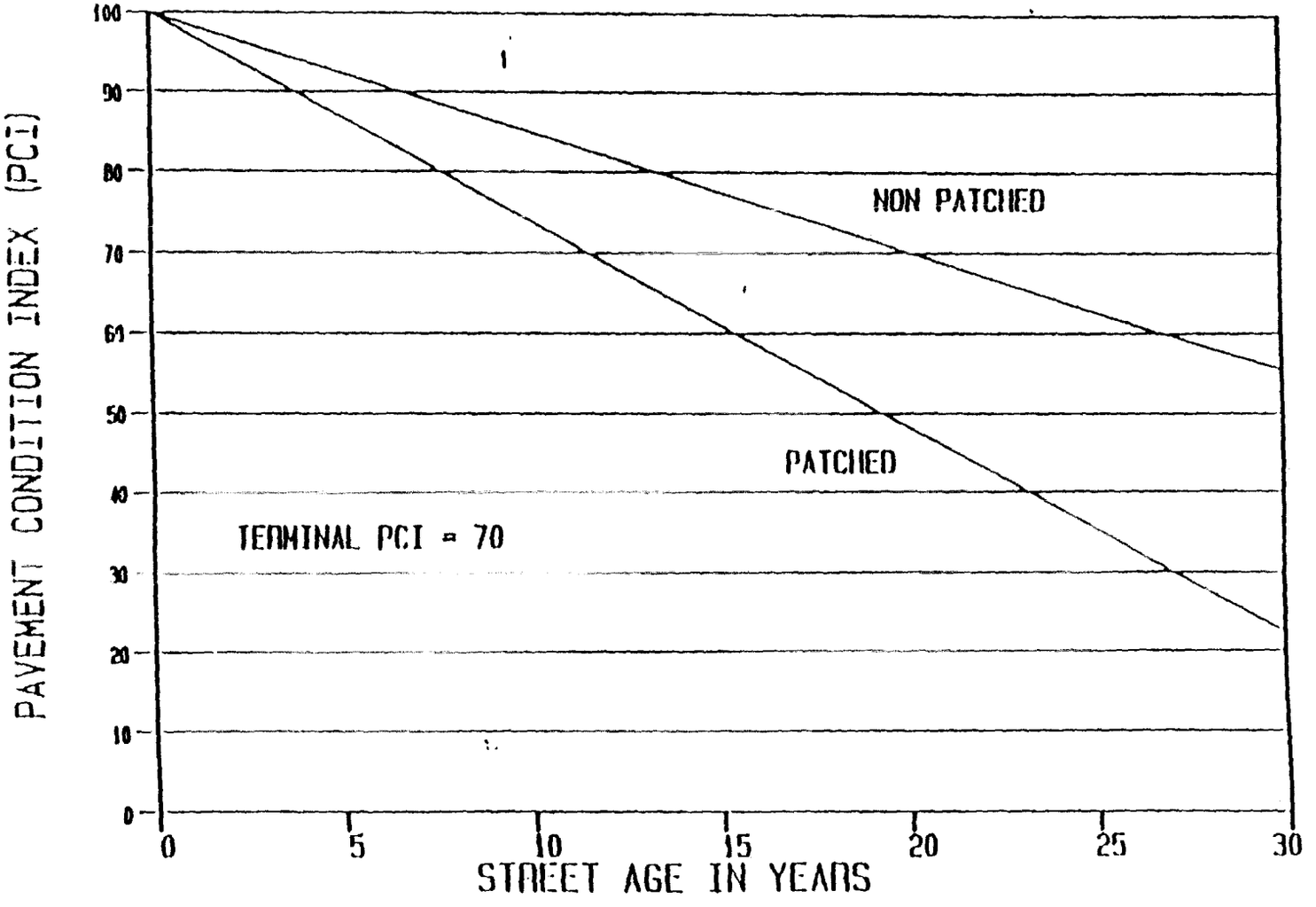


FIG 6: AVERAGE DETERIORATION RATES FOR THE CITY

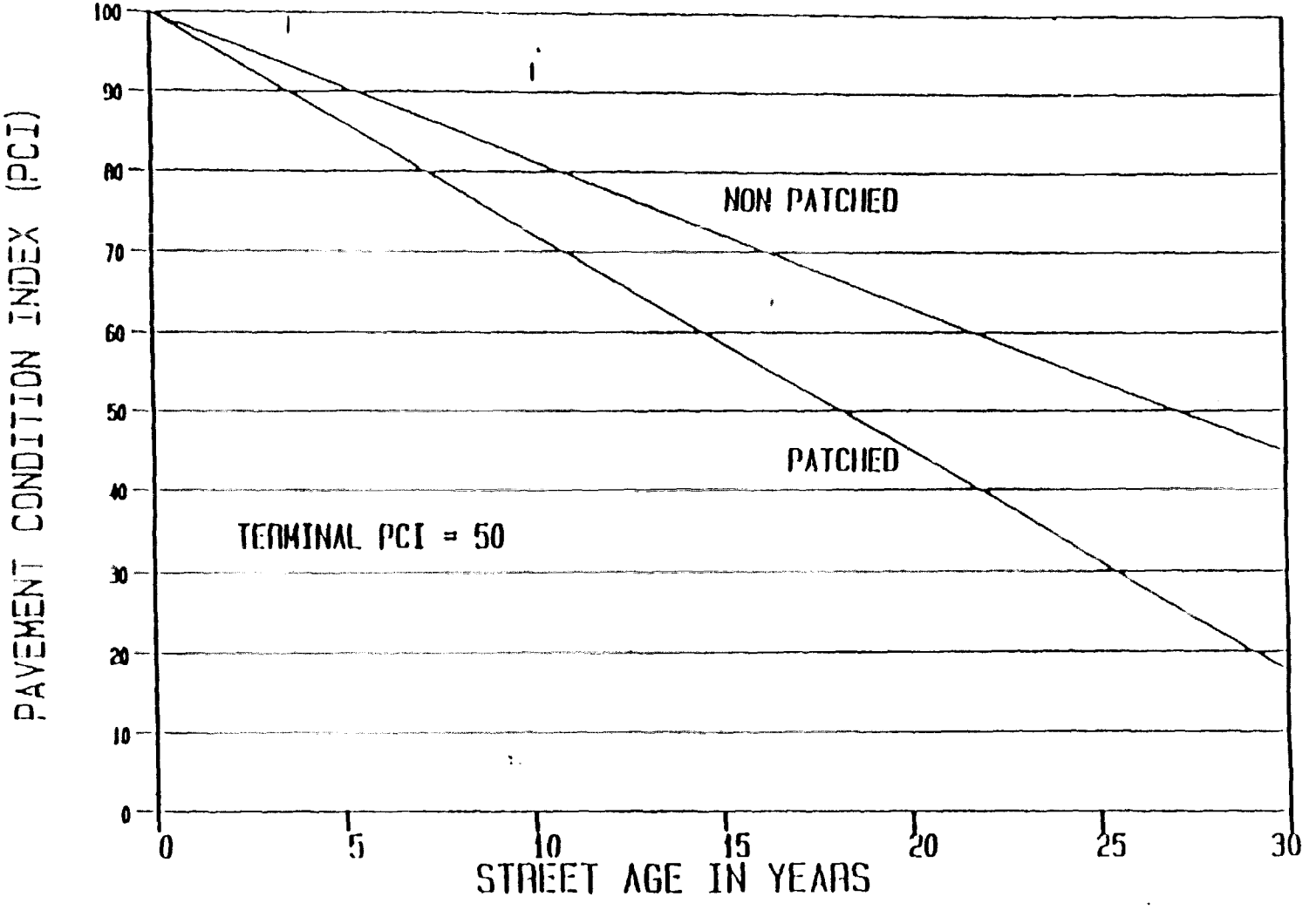


FIG 7: AVERAGE DETERIORATION RATES FOR THE CITY

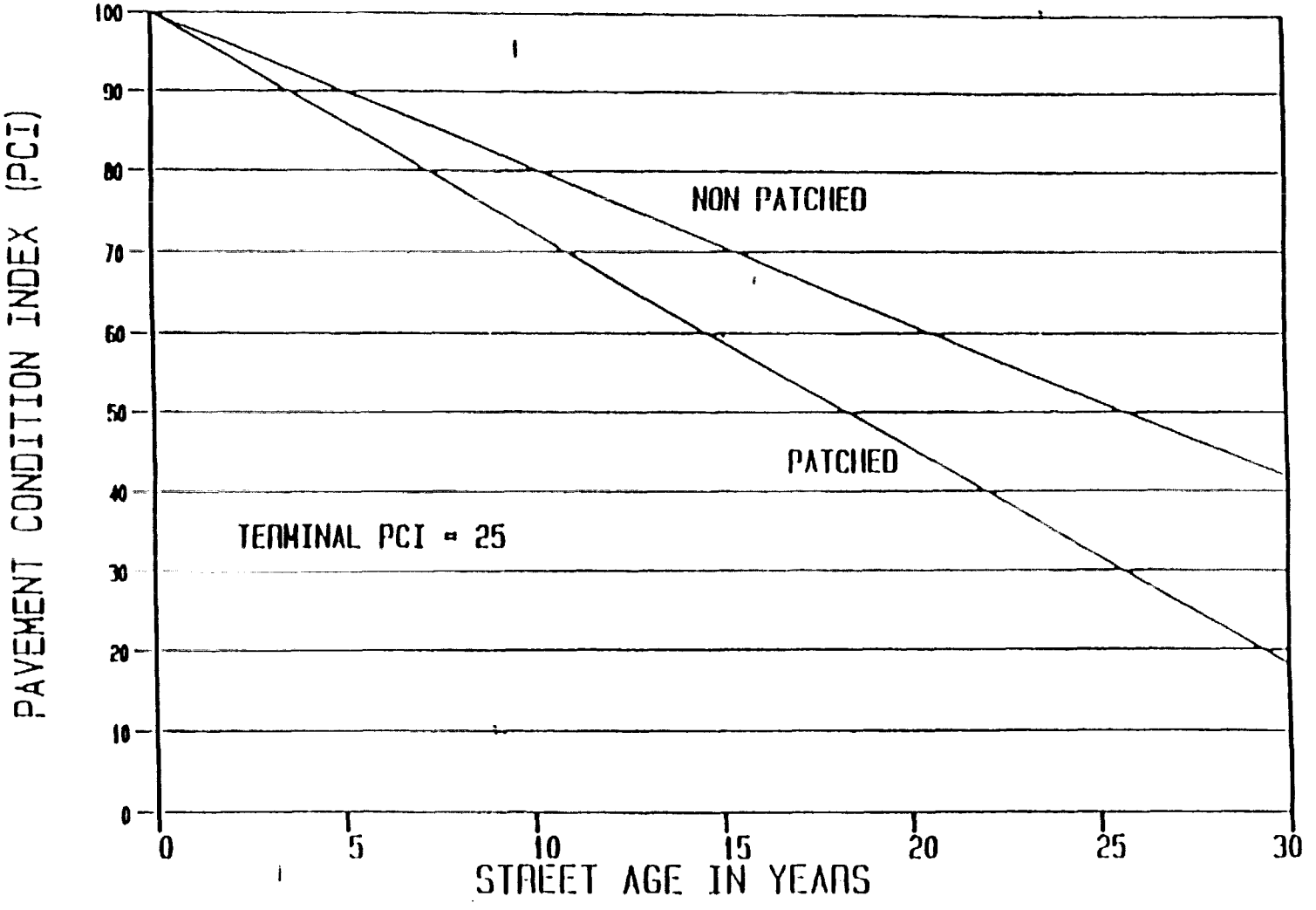


FIG 8: DETERIORATION RATES - PATCH VS NO PATCH

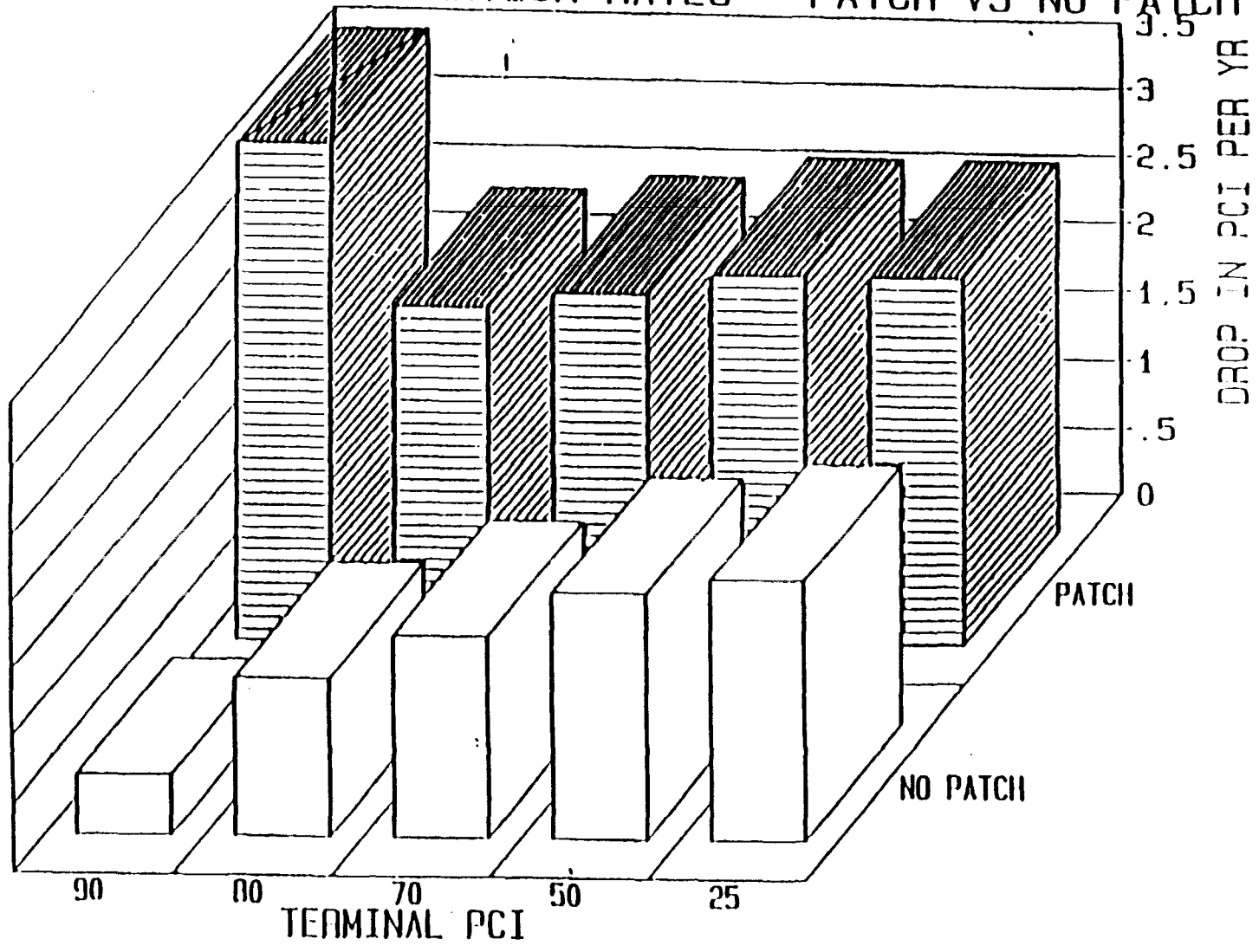


FIG 9: AVERAGE RATE OF DETERIORATION

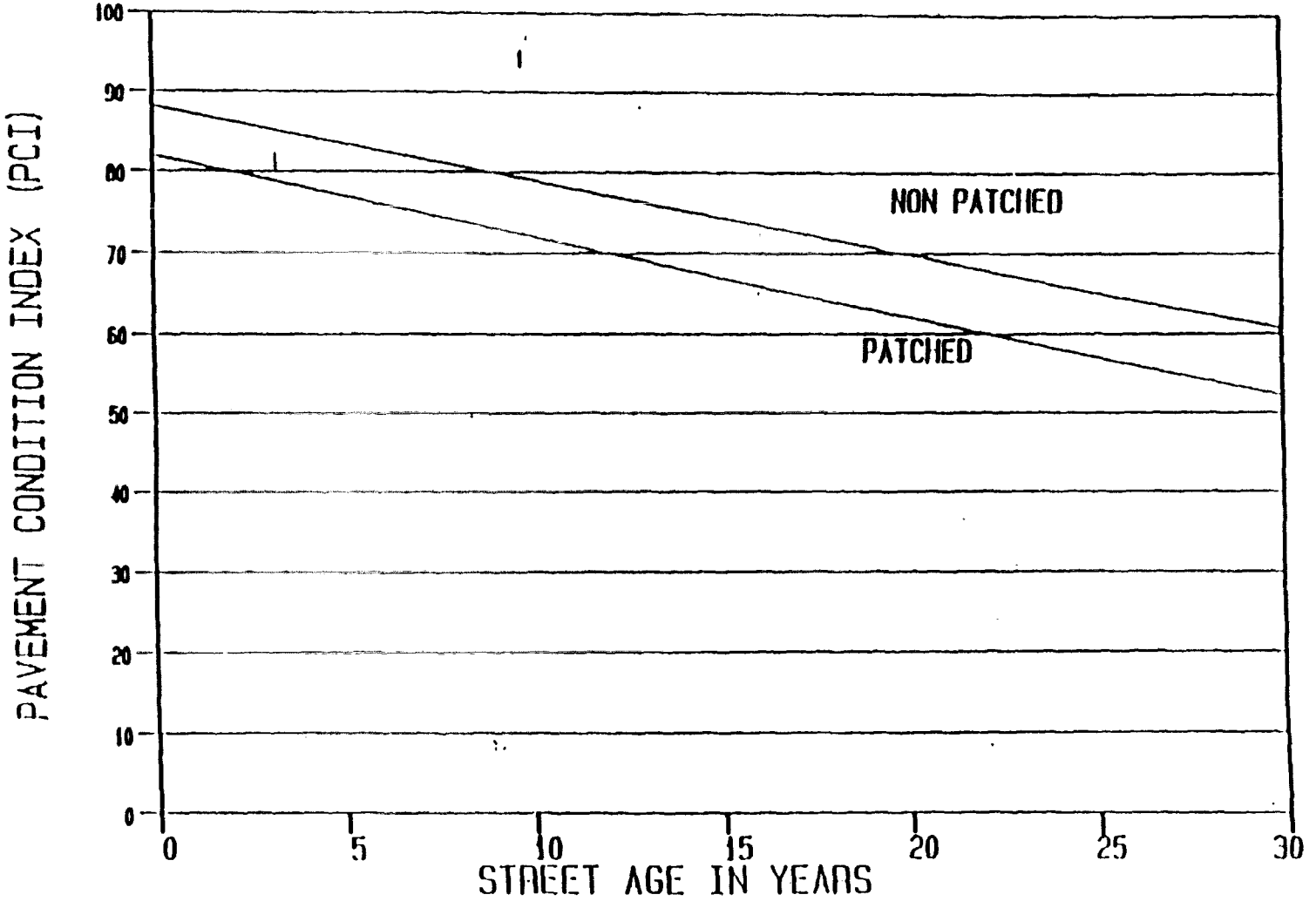


FIG 10: AVERAGE PCI - PATCH VS NO PATCH

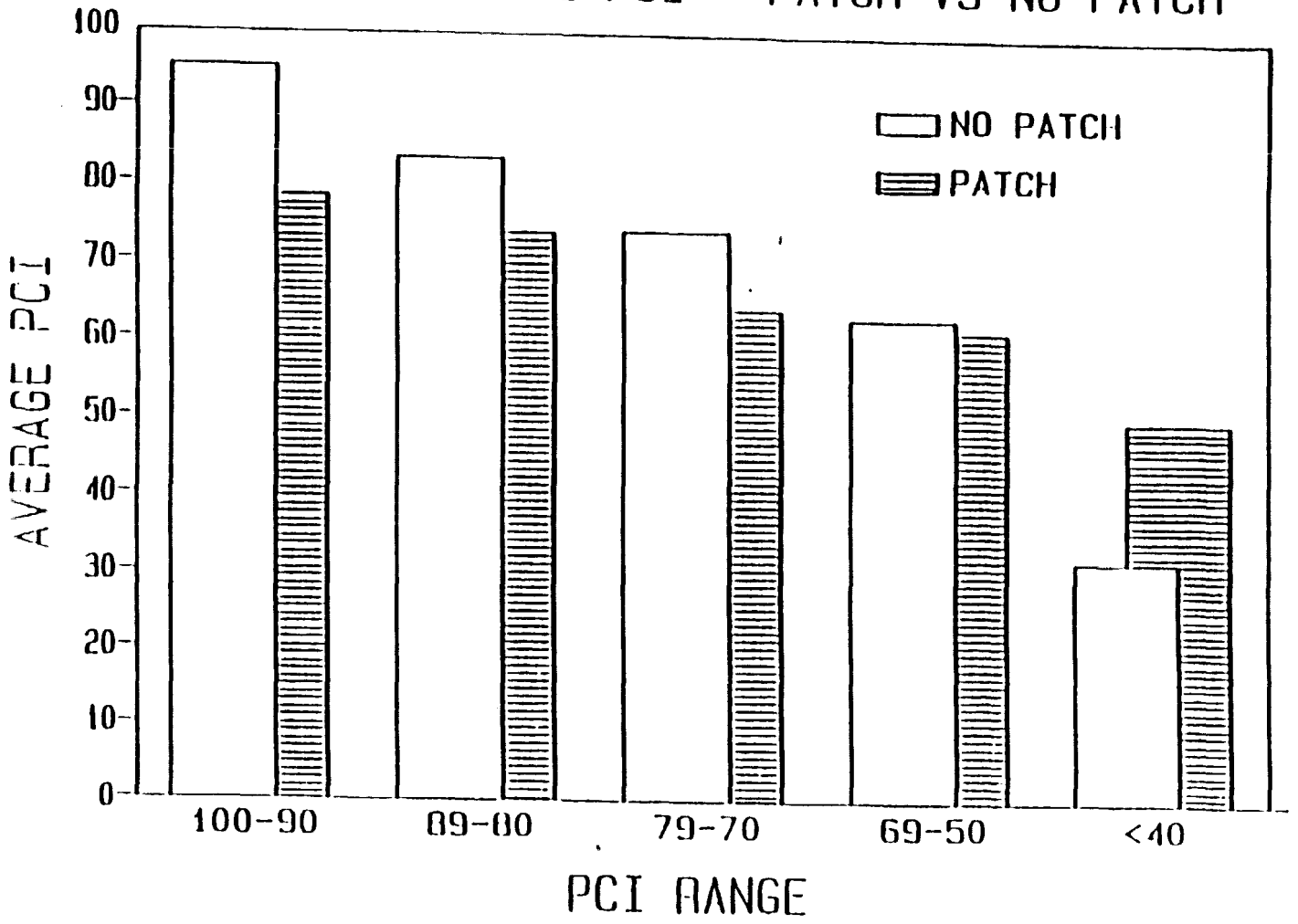


FIG 11: AVERAGE RATE OF DETERIORATION

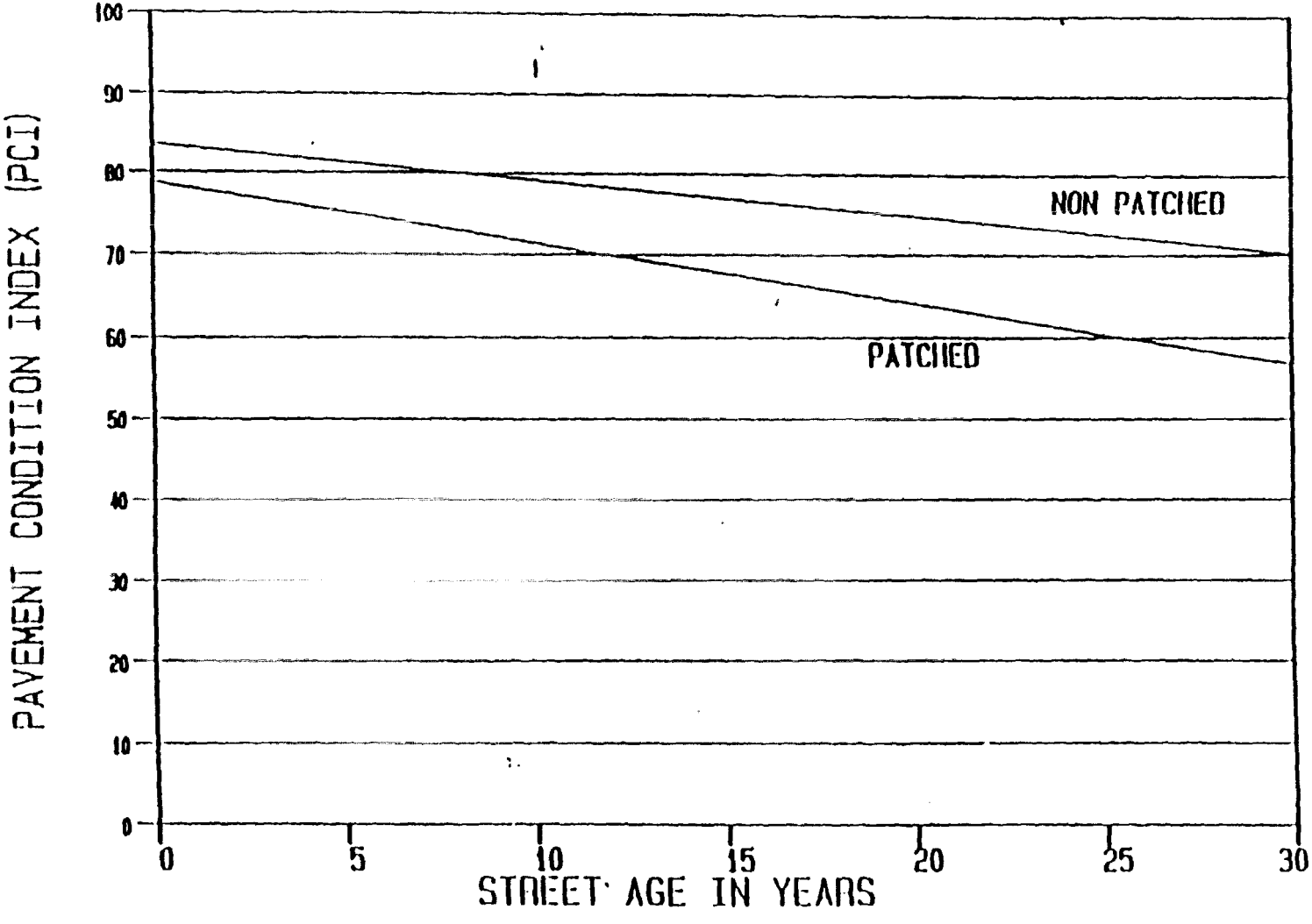


FIG 12: AVERAGE RATE OF DETERIORATION

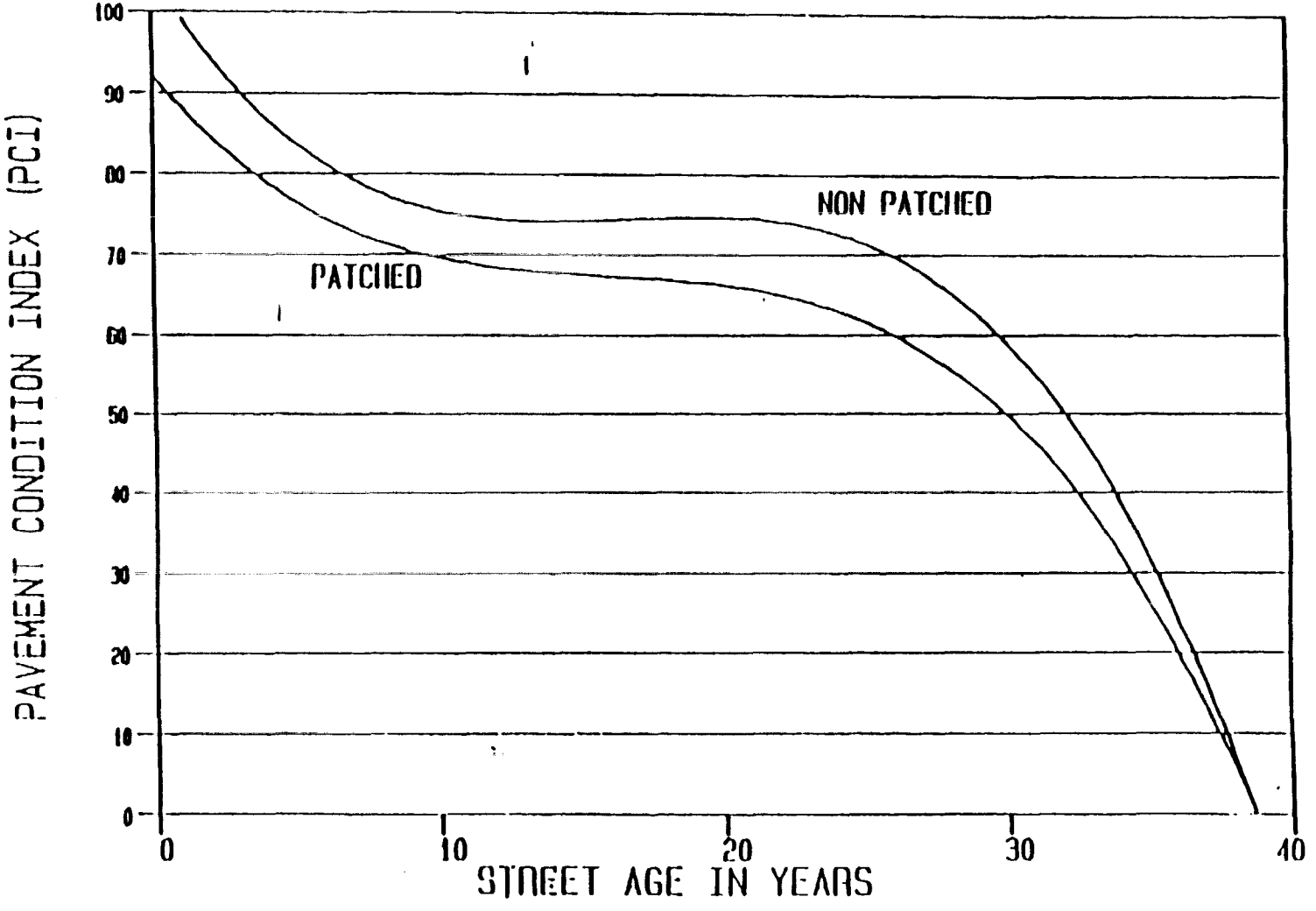
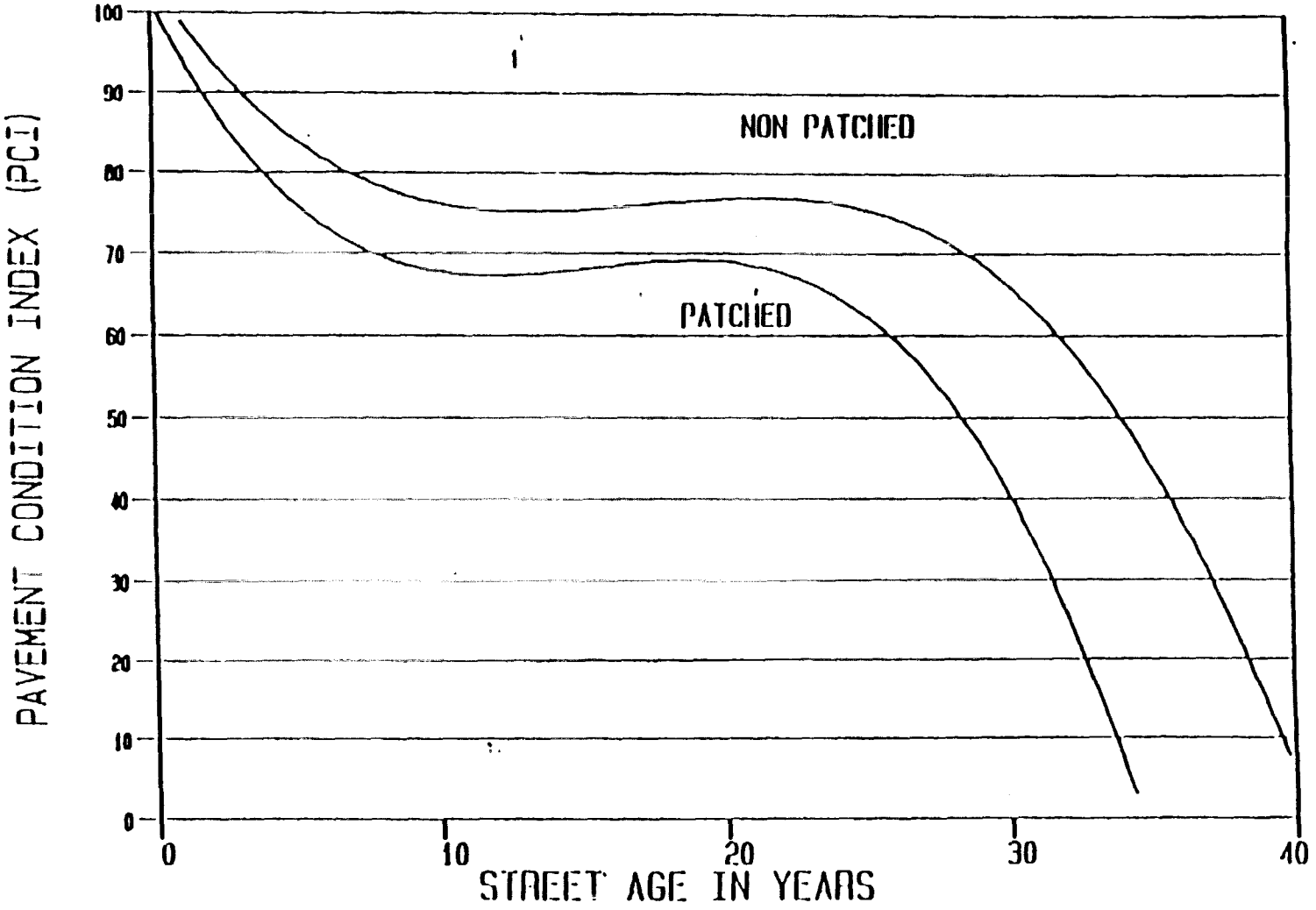


FIG 13: AVERAGE RATE OF DETERIORATION



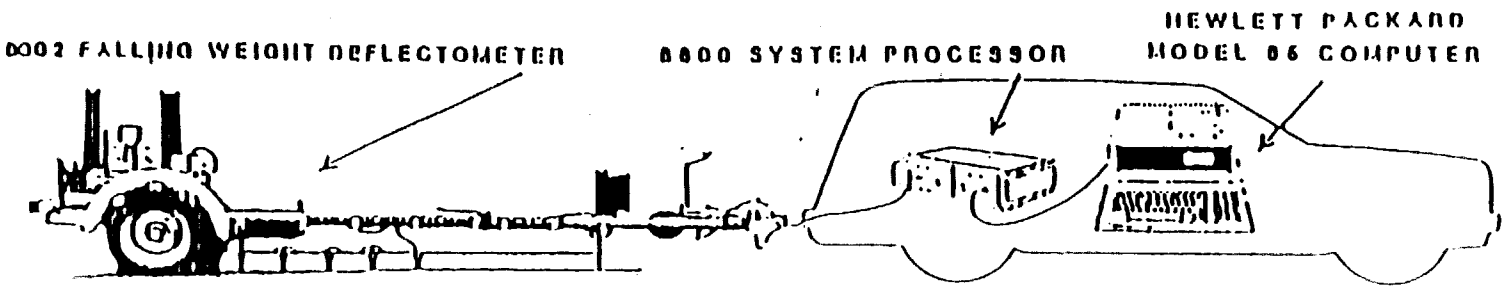


Figure 14: Schematic Drawing of the Falling Weight Deflectometer and Associated Hardware

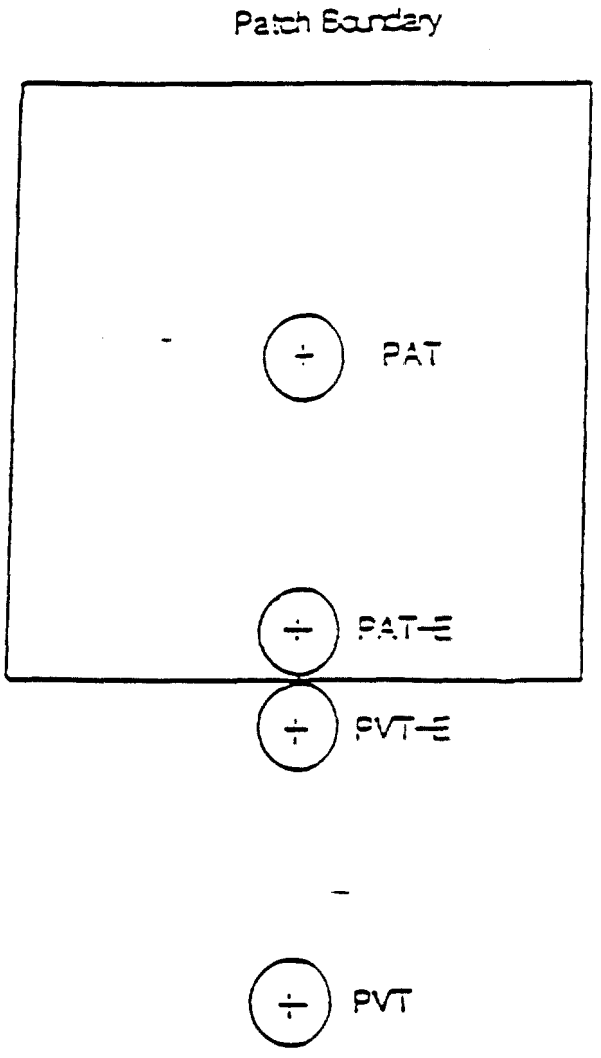


Figure 15: Test Location Designations

FIG 16: EFFECT OF PATCHING ON DSM

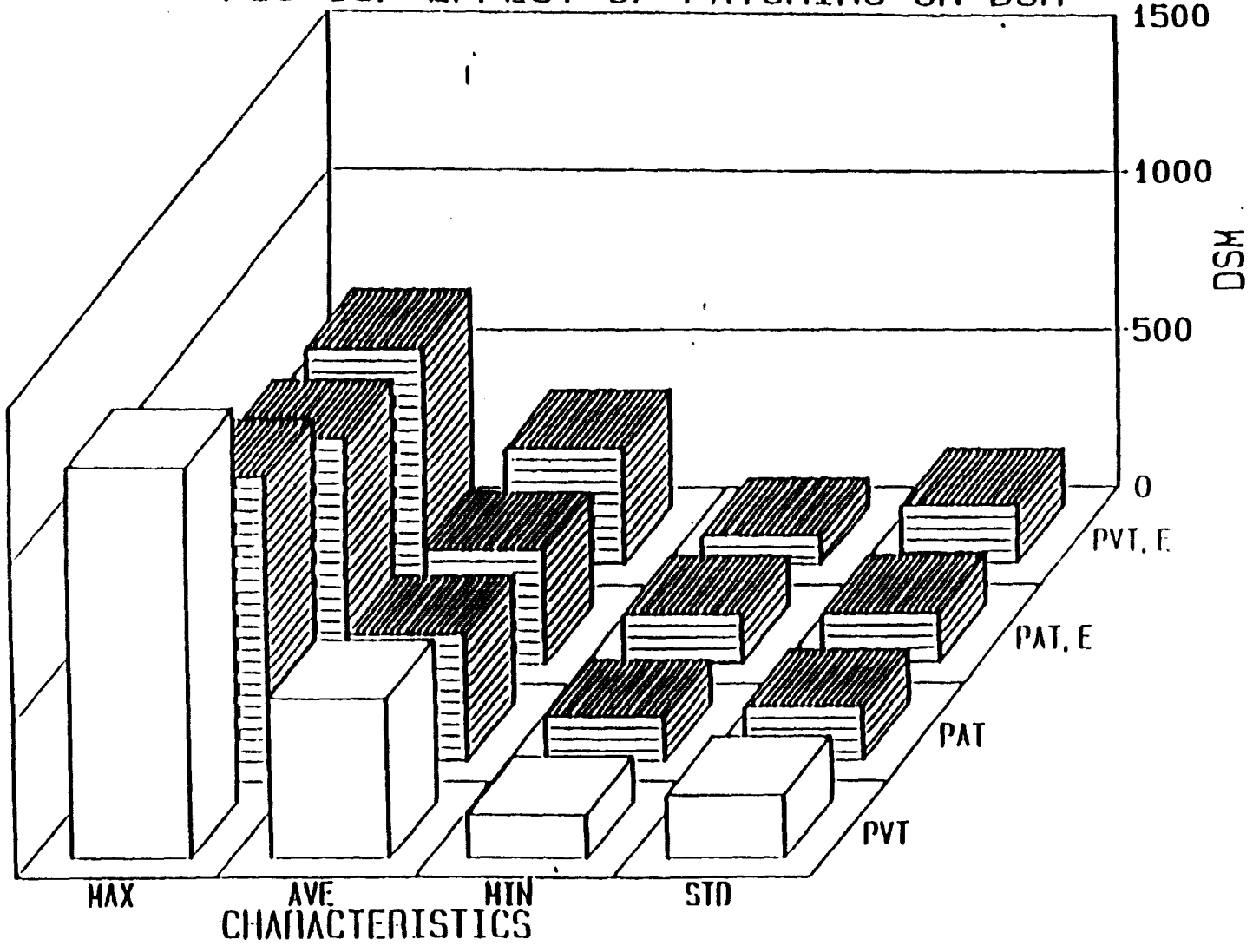


FIG 17: DSM - PATCHED VS NON PATCHED

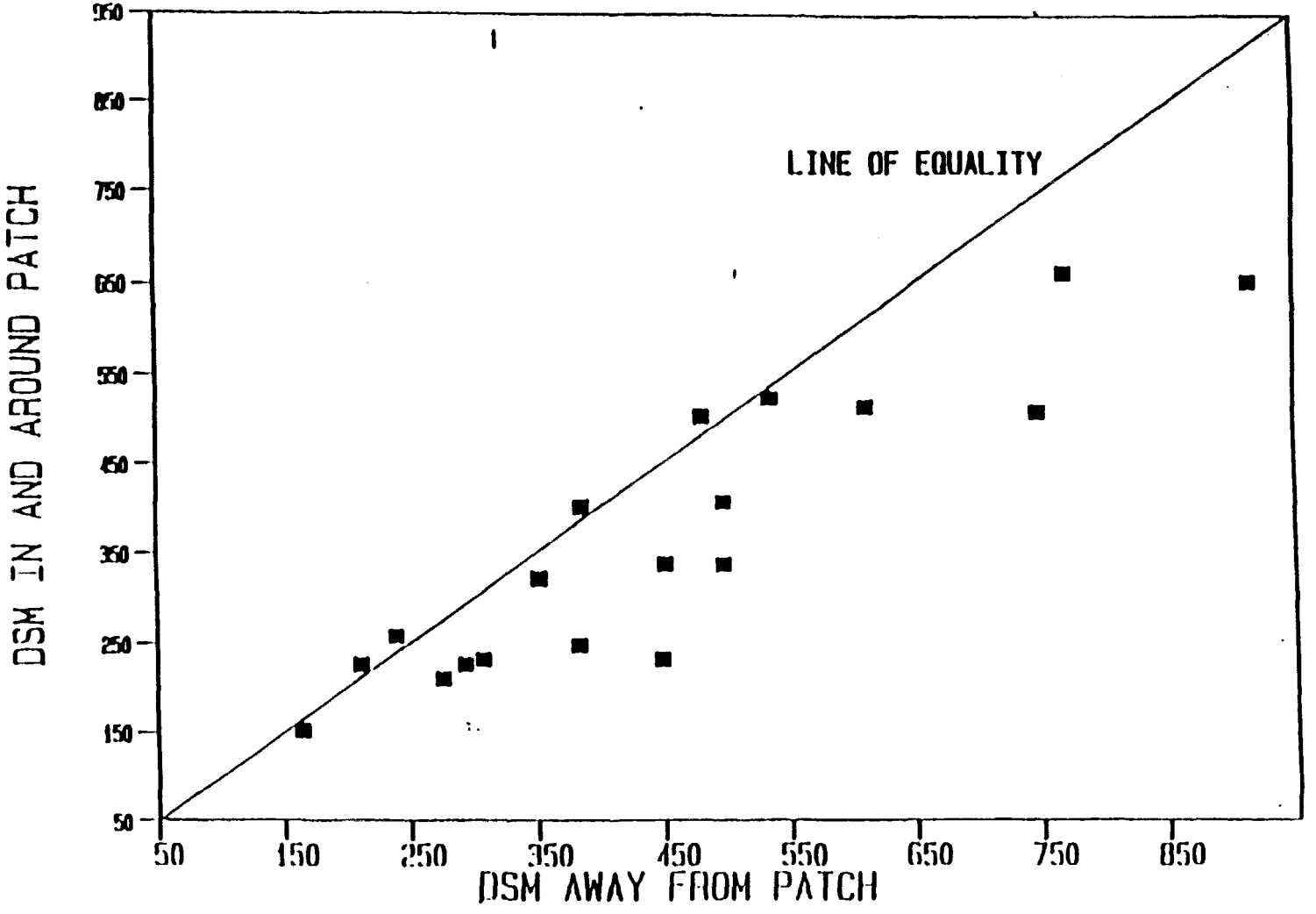


FIG 18: EFFECT OF PATCHING ON DEFLECTION

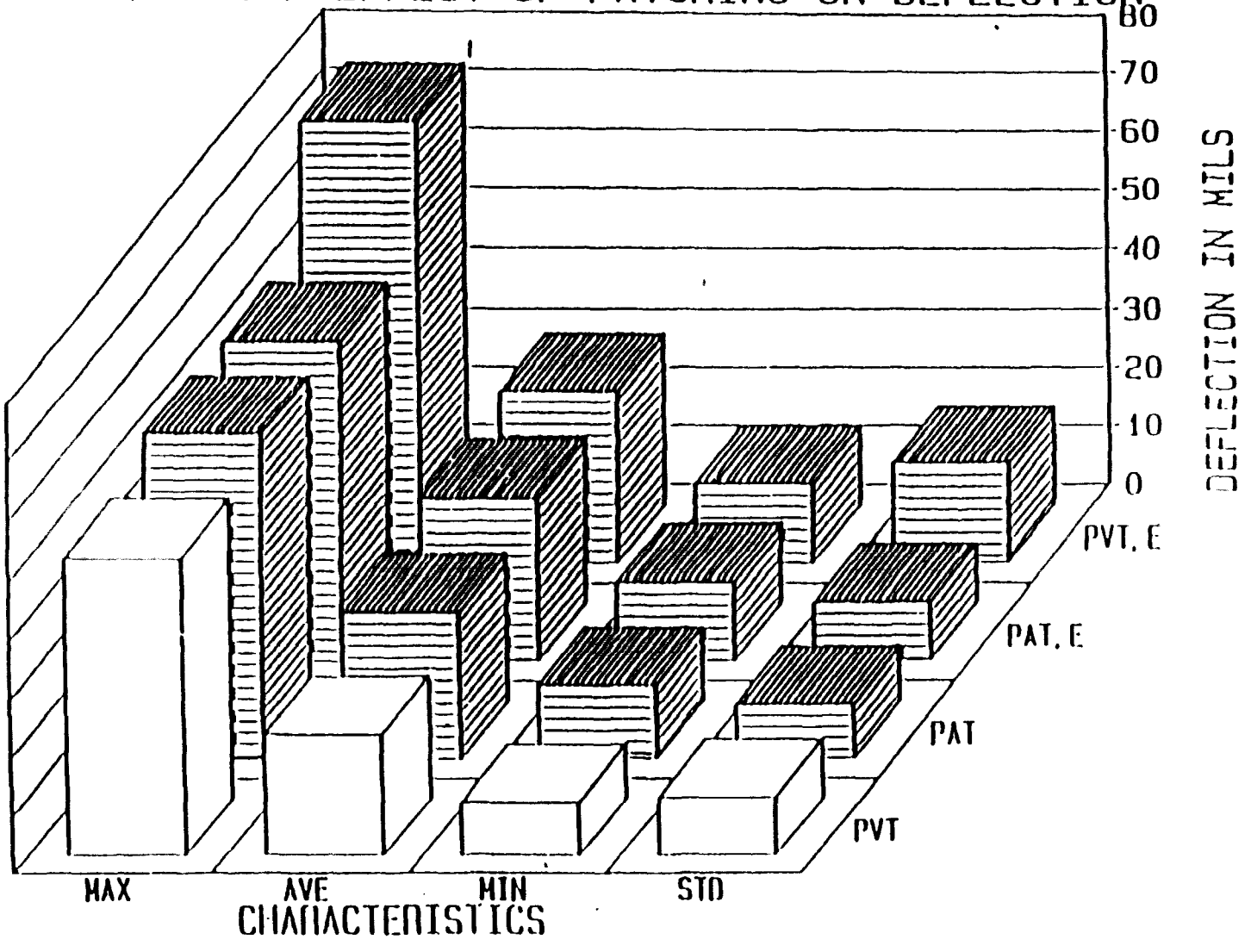
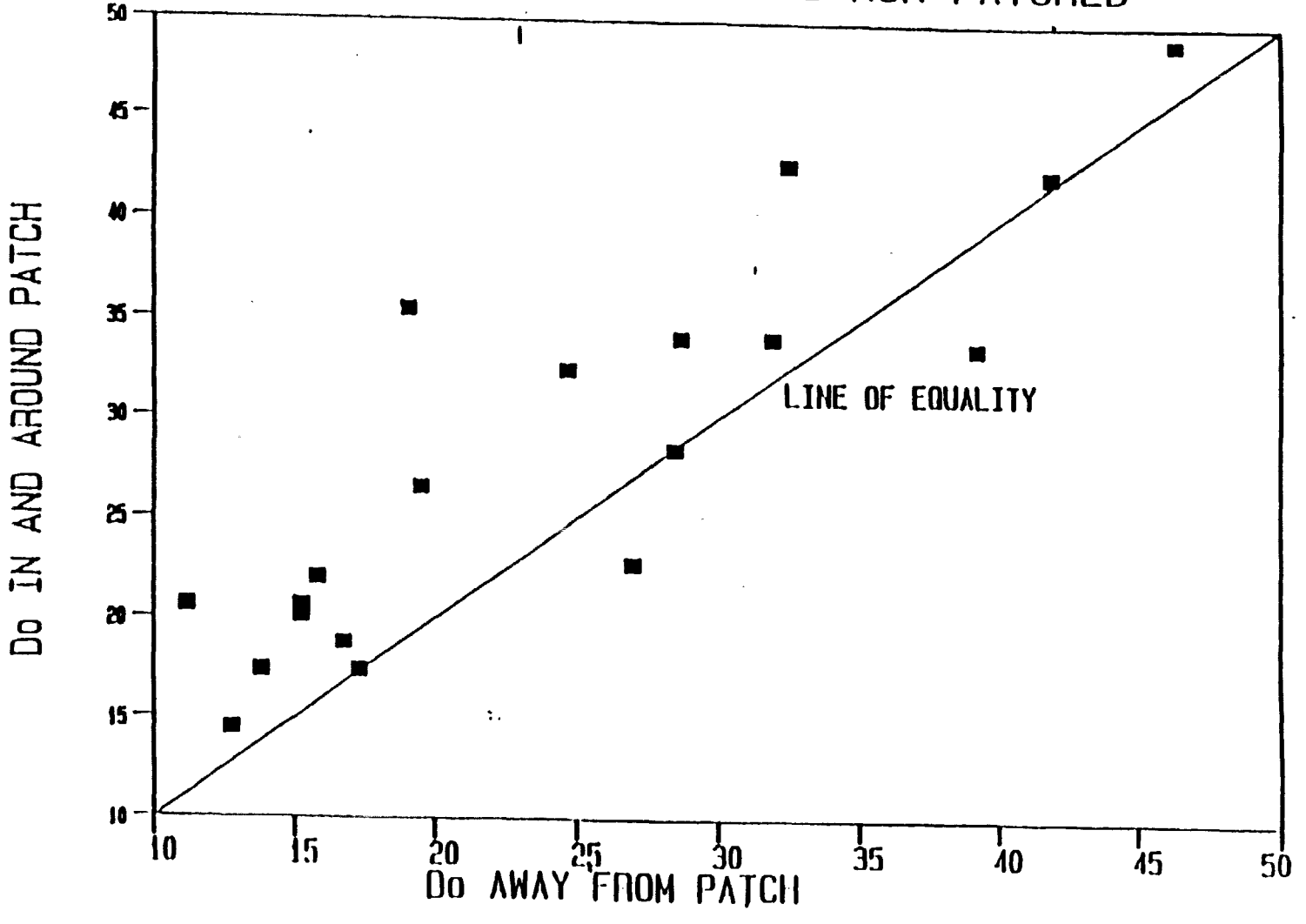



FIG 19: Do - PATCHED VS NON PATCHED