NINE YEAR EVALUATION
of
RECYCLED RUBBER IN ROADS
Final Report, Project 86-8

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The contents of this report reflect the views of the author(s) who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the University of Connecticut or the Connecticut Department of Transportation. This report does not constitute a standard, specification, or regulation.

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Introduction

An extensive rubber/asphalt experimental program was undertaken by the State of Connecticut in 1977-78 with Federal Department of Transportation support. This program was carried out by the Civil Engineering Department of the University of Connecticut. Reclaimed tire rubber was incorporated into five different forms of pavement rehabilitation:

1. Thick overlays (4 centimeters)
2. Thin overlays (1.5 centimeters)
3. Chip seals
4. Crack and joint sealing
5. Stress relieving interlayers

A three year evaluation of all test sections was included in the final report of the project. A summary of the three year performance of the thick overlays was presented at the 1982 Annual TRB meeting. A four year evaluation of the thick overlay sections was presented at the 1983 annual meeting of the Rubber Division of the American Chemical Society.

As the roadways containing the test sections grow older, realistic maintenance will result in loss of the sections. Tapered transitions to save the short sections would cause changes in loading conditions sufficient to destroy the usefulness of continuing observations. A small number of sections were lost prior to the nine year survey.

THICK OVERLAYS

The thick overlay sections were originally selected to create a matrix of three levels of surface condition at three levels of traffic. This matrix is presented in table I. At each location, sections with both one and two percent rubber and controls were evaluated. The minus 30 mesh rubber was added to the mix in the pug mill. Evaluation has been made on the basis of visible cracking. For nine year old overlays, the cracking present is largely reflective cracking from the layers below. All cracking is age related but transverse tends to be related additionally to temperature and longitudinal to loading. The two forms of cracking have been tallied separately.

For ease of presenting the survey results, plots of cracking have been prepared for both columns and rows of the table 1 matrix. Figure one represents the variation in amount of longitudinal cracking with distress for different levels of traffic at nine years. As the sections were of different widths, all data has been converted to an equivalent three meter lane. Absolute values of cracking are of less importance than relative values for controls and test sections. At a constant level of traffic, there is an inverse correlation of the effect of one percent rubber with distress. That is, as the level of distress increases, the benefit of rubber decreases and becomes negative. Figure 2 represents data for transverse cracks and distress level again at nine years. There is no distinct trend of transverse cracking that relates to the addition of one percent rubber.

Figure 3 depicts longitudinal cracking versus traffic. The one percent rubber sections over highly distressed pavement suffered more longitudinal cracking than the controls at all levels of traffic. Over medium distressed pavement, the controls had more cracks at all traffic levels than the overlays with one percent rubber, however the difference was small. The rubber and controls performed about equally when over lowly distressed pavements.

The extent of transverse cracking shows very little correlation with traffic, figure 4. Four curves show an initial increase then a decrease, one was constant with traffic and one had decreasing cracking with increasing traffic. The form of pavement structure was not standardized between the sections and it is very possible that those currently carrying high traffic have more strength in proportion to the loads carried than those carrying low traffic. Traditionally, transverse cracking has been thought of as more pointed toward environmental factors than toward loading. These curves support that thesis.

With survey data at four ages, it is possible to make some projections of future performance. Figures 5, 6 and 7 presents cracking versus age. In figures 5 and 6 for low and medium distress, at five of the six sites the rate of increase of longitudinal cracking in the one percent rubber sections has slowed over the last five years. The cracking of five of the control sections has continued at a constant rate for the nine year period. For all high distress sections regardless of traffic level, both the amount and rate of increase is greater in the one percent rubber sections.

Transverse cracking versus age for one percent rubber makes up the data for figures 8, 9 and 10. Over low level of distress there is a trend for rubber to be more effective at high traffic levels. At low traffic, the control has less cracking with the difference increasing with time. At high traffic, the one percent rubber has less cracking with the difference again increasing with time. At mid-level traffic, the two are the same and are increasing at the same rate. For medium distress, low and medium traffic show less cracking in the one percent rubber with the rate of increase the same or lower for rubber. At high traffic the situation has changed with the cracking of the one percent and controls about the same at nine years but with the rate of increase much greater for the one percent. At high distress, the one percent rubber is effective only at low traffic. Reflection cracks came through early for the Barkhamsted concrete pavement and for the deep Marlbough bituminous concrete.

Although the one percent rubber sections are performing better than the controls at five of the nine sites, the average longitudinal cracking of all sections using one percent rubber is greater than that of the corresponding controls, figure 11a. The extreme amount of cracking at two sites causes this unbalance. Figure 12 is a simpler presentation of the differences found in the preceding figures. Locations where one percent rubber and control are performing equally would plot on the 1:1 line with areas of better performance for the rubber below the line. One percent rubber is performing from modestly better to sharply poorer than the controls when judgement is based on longitudinal cracking.

Although the average of all rubber sections fall above the 1:1 line, the medium and low distress locations are performing as well or slightly better than the controls.

Similar plots for transverse cracking, figures 11, 12 and 13, show only one location where rubber is performing measurably poorer than the control. At the other eight sites, the rubber is performing equal to or better than the control.

A higher level of rubber performs differently. Of the nine locations in the matrix, two percent rubber bettered the performance for longitudinal cracking at one site, that with low distress and medium traffic, figures 14 and 16. Transverse cracking was also bettered by two percent rubber at one site, medium distress and low traffic, figures 15 and 17.

At six locations aging as measured by longitudinal cracking is occurring faster for the two percent rubber than for the controls, figures 18, 19 and 20. Transverse cracking is developing at a faster rate in all the two percent sections over high distress, figure 23, than in the controls. The two percent rubber and the controls are performing at about the same rate over medium distressed pavements, figure 22. Both average longitudinal and average transverse cracking for the two percent rubber sections are increasing faster than the average of the controls, figure 24.

Correlation plots for two percent rubber, figures 25 and 26, show clearly that two percent rubber is doing little to reduce cracking at the sites chosen. At best, points fall along the 1:1 line indicating equal performance. Any benefit occurring is in that part of the matrix around low traffic-low distress.

SUMMARY OF THICK OVERLAYS

One percent rubber reduced the amount and rate of longitudinal cracking of overlays placed over low to medium distressed pavement. In contrast, over high distressed pavements regardless of traffic level, the amount of cracking is greater and increasing in the rubber section. No clear pattern is apparent for transverse cracking at one percent rubber. Whether rubber or the control performed better seems to be random rather than related to distress or traffic.

Longitudinal cracking increased with two percent rubber. At all levels of traffic over high distress, two percent rubber overlays developed longitudinal cracking at least twice as fast as the controls. At only one site, medium distress-low traffic, the two percent is performing better.

THIN OVERLAYS

Thin overlays, intended to be 1.5 centimeters thick, were placed at four locations and served different purposes. That on route 32 in Franklin was used to level a rough Portland cement concrete pavement which has now received a thick overlay. Two routes, 151 and 12, were placed to gain a few years time until a more permanent surface could be applied. Both were over badly cracked surfaces which consisted of many seal coats. The last, placed on route 32 in Stafford Springs, was used to minimize curb loss. All rubber was minus #8 and was added at the pug mill.

Data from route 12 is inconclusive as the thickness was not well controlled. The rubberized mix flowed more smoothly under the strike off of the paving box than the normal mix. As a consequence, the operator had little feel for the thickness being placed and some loads covered nearly twice the calculated lengths Subsequent investigations found that the combination of thin lift and the roughness of the badly deteriorated pavement resulted in frequent areas of zero thickness. The inability to define the thickness destroys the usefulness of crack counts. Most cracks reappeared in weeks.

Along route 151, the level of rubber ranged from 0 to three percent. The average thickness was 1.5 centimeters. Cracks were and are very frequent in this pavement and no attempt was made to discriminate between longitudinal and transverse cracks. Comparisons of total cracking per meter of lane are shown in figure 27. One percent reduced the cracking by two thirds, but further increases in rubber were detrimental with cracks three times more extensive in the three percent sections than in the control.

The last thin overlay, route 32 in Stafford Springs, was placed in two passes on the travel portion of the roadway. The gutter areas were not covered, the northbound lane contains 1.8 percent and the southbound 3.1. Transverse cracking in the 1.8 percent lane is 0.59 meters per meter of lane and in the 3.1 percent lane only 0.31 percent. The difference in longitudinal cracking is greater with 1.10 per meter of lane for the 1.8 lane and a mere 0.05 in the 3.1 lane.

Most cracks in thin overlays are reflections of old cracks in the surface below. The boundaries of the old surface treatments did not coincide with those of this treatment. Some insight into the effect of modifying the binder can be gained from the extent to which cracks running in one material stop when encountering a different material. This is especially apparent at the route 32 site. Twelve of the transverse cracks in the east gutter strip did not reflect through the 1.8 material and eleven in the west gutter did not reflect through the 3.1. Fifteen of the transverse cracks did not penetrate into the adjacent 3.1 material. All transverse cracks running in the 3.1 percent material crossed into the 1.8 material.

Unfortunately, this difference can not be clearly credited to the effect of the rubber level as the thickness also varied. Comparing the total of 1.69 (1.10 longitudinal + 0.59 transverse) meter per meter of lane for the 1.5 centimeter thick 1.8 percent rubber lane to the curve of figure 27 shows some agreement. However, the total cracking in the 3.1 percent rubber section 0.36 (0.31 longitudinal + 0.05 transverse) meters per meter of lane does not fit the curve. This total is less than predicted by figure 27, indicating that the better performance of the 3.1 percent material is probably due to its greater thickness of 2.5 centimeters.

SUMMARY OF THIN OVERLAYS

For the limited data available, the addition of one percent rubber reduced the amount of cracking two thirds. Further increases in the amount of rubber resulted in more cracking. Increasing the thickness of the layer increased the effectiveness of the rubber.

CHIP SEALS

The original research plan called for two chip seal sites. As the original sections were sand sealed a few months after construction, two additional sites were selected. At the completion of the experimental construction, there were then four chip seal sites two of which were topped with an emulsion-sand seal. At nine years, the two which were sand sealed were still exposed but the two replacement chip seals had been covered with overlays.

At the seal site on route 14, the rubber modified section and the control to the west were overlaid with 5 centimeters of bituminous concrete in 1984. The control to the east was covered in 1985.At nine years, no transverse cracks had appeared over the rubber sections, 0.007 meters per meter of lane had appeared over the control to the west, and 0.02 in the 85 overlay to the east. Longitudinal cracks are appearing faster with 0.045 m/m over the rubber seal, 0.18 in the 84 material and 0.33 in the 85 material over the controls, If these trends continue, the rubber seal must be acting as a stress relieving layer.

The rubberized seal and controls on route 203 were chip sealed again in 1984 using an asphalt emulsion and one centimeter chips. As on route 14, cracking over the old rubberized seal far less than over the controls. Transverse cracks amount to 0.02 m/m over the rubber and 0.07 over the old control. Longitudinal cracks are 0.38 m/m over the rubber and 1.12 over the old control.

Possibly the most spectacular success of the program was the result of the unintentional sand seal over the rubberized chip seals on routes 31 and 32. One contractor placed the short experimental test seals on roadways which were to be routinely treated in the annual maintenance program. A second contractor doing the maintenance then sand sealed over the test sections. The construction evolved as a spray of 1.9 liters per square meter and 16 kilos of 1 centimeter gravel followed a month later by 1.2 liters of emulsion and 12 kilos of sand. As completed the appearance was much as the sand seals to either end of the test. After a few month, the sand disappeared from the road and the 1 centimeter stone reappeared. The sand worked down into the rubber\emulsion binder forming a mortar that embedded the stone some ninety percent. As the stone rested on the old surface, traffic could not compact the material farther and bleeding has not occurred yet the space between the stone is filled with a soft plastic material in which cracks can not develope

The pavement prior to the treatment was an accumulation of seals and had cracked longitudinally along the spray pattern at 12 to 15 centimeter intervals. The sand seal at either end of the rubberized seal reflected all cracks during the first season. At the nine year survey, the cracking in the non rubber area is to frequent to make length of cracking per length of lane a meaningful quantity. The rubber sections with no treatment beyond the sand seal at the time of construction had one-two meters of crack per meter of lane.

SUMMARY OF CHIP SEALS

At the three and four year evaluations, all rubberized seals were in better condition than the controls. At nine years, all sections have been covered. Cracking in the new surfaces show less cracking when over the rubberized seals implying that the material is relieving stresses in the new surface. Cracking in the two seals that were sand sealed when new is many times less than that in the regular sand-emulsion seals.

STRESS RELIEVING INTERLAYER

Stress Relieving Interlayers (SRI) theoretically can reduce the concentration of stresses in a new overlay. The pliable interlayer allows relative motion between the old hardened pavement and the new overlay, thus relieving the sharp changes above the edges of an old crack. The interlayer used in this work was similar to a chip seal in that a layer of rubber/asphalt binder was sprayed on the old pavement and chips spread.

At the time of construction, it was assumed that the addition of rubber to the overlay would make major differences in the stiffness of the mix and would in turn affect the amount of cracking. Due to support variations that occur along the roadway, a new control section was designated for each level of rubber test section. Comparisons can then be made for each level of overlay rubber with and without SRI. The length of some sections was very small and with a limited number of sections and no replica sections available, a true statistical analysis is not possible. A number of major trends can be noted.

The (a) portion of figure 28 plots the longitudinal cracking of overlays with and without a SRI. The diagonal line represents equivalent performance, with and without a SRI. Points 1, 3, 5 and 7 are for 0% overlays and are respectively the controls for the 2 and 1 percent rubber overlays on St Rte 30 and the 1 and 2 percent on Rte 44A. The scatter of these points indicates the degree to which the physical condition at the sites differ. The SRI under the overlay at 3 reduced the amount of longitudinal cracking .4 meters per lane meter but at 5 and 7 increased the cracking .5 meters. The average of these four falls very near the 1:1 correlation line. 2, 4 and 6 are in the same cluster and the addition of rubber to the overlay did not reduce the amount of cracking.

In figure 28b, the cluster of 1, 3, 5 and 7 is much tighter. This could be anticipated as transverse cracking is related more directly to temperature than support conditions. The last portion of figure 28 portrays alligator cracking which is usually due to soft areas in the base, often caused by poor internal drainage. Several of the short test sections contained no alligatored areas. A single alligator area can then throw a test section into the extreme portions of the figure. If truly random, an equal number would occur above and below the correlation line (8 and 4).

An over view of all three portions of figure may be significant. There are 12 points plotted for 0 percent rubber (points 1, 3, 5, 7 in each of three plots) which fall equally above and below the correlation line, implying that the SRI did little to benefit the pavement. Of the six plotted points for 1% rubber (4 and 6), five are below the line and indicate that SRI improved the performance of 1% overlays. Five of the six points plotted for 2% rubber (2 and 8) fall above the line. Three are substantially above indicating that the performance of 2% rubber was significantly reduced by the inclusion of a SRI.

The poor response of overlays over SRI may be explained by the construction procedure used. In order to place the overlay with a standard paver, substantial amounts of stone were spread on the interlayer. The overlay rested on this stone. Compaction of the hot overlay could force the chips down through the SRI layer to the old surface. The stone/rubber/asphalt layer would no longer function as a stress relieving layer as shear stresses could develope at both interfaces. That the effect was different for longitudinal and transverse cracking is probably explained by the rate of loading. Longitudinal cracking is related to wheel loading which would be rapid. Transverse is related to temperature which is a slow loading.

The newly construdted SRI/overlay differed from the chip seal/overlay in that the amount of cover chips was greater for the chip seals and the rubberized binder was aged when the overlay was placed. Both are factors that would prevent the overlay from reaching the old surface.

SUMMARY OF STRESS RELIEF INTERLAYERS

For the combinations considered, the use of a SRI did not improve performance. Within the construction methods used the average performance with or without SRI was nearly the same. It is possible that the rubber/asphalt layer as constructed could not act as a stress reliever.

RUBBER/ASPHALT JOINT SEALS

Substantial effort was expended during the original work on the comparison of summer/winter joint and crack filling. The first set of experimental joints in Portland cement concrete was lost when only a few months old as a contract joint sealer resealed the test joints. Only one quarter of the site mixed crack sealer remained in the bituminous concrete section by the fourth year. The commercial material was pulled out by traffic. The site compounded material never got hard and appeared to drain out of the joint/crack into the base. Original and resealing could not be reliably separated after nine years for the bituminous concrete sections. No further discussion will be attempted for the bituminous sections.

At the four year survey, a major difference in the action of the two sealers used to fill the joints in the concrete test sections became apparent. The premixed material did not adhere to the concrete. When cured, the filler could be pulled from the joint. Six and eight foot lengths were found along the roadside. The site mixed material adhered well but gradually flowed down into the lower part of the joint. Before the nine year survey, the joints were resealed with a large portion of the joint length now having new sealer at the top face.

Each test section consisted of 25 transverse joints twelve feet long for a total length of 300 feet. Considering the summer filled joints, 124 feet of commercial blended material remained visible and 98 feet of the site blended material. For the winter filled sections, 2 feet of the commercial material and 19 feet of the site prepared material could be seen. For the 25 transverse joints adjacent to the test section, none of the old material could be seen.

SUMMARY OF JOINT SEALING

After nine years there is no difference in the apparent amount of joint sealant remaining in the pavement. As the site prepared material has shown a tendency to flow down into the joint with time, there is a strong possibility that a substantial footage of newer sealant is over old site prepared material. Significantly more material placed in the summer remains than that placed in the winter.

CONCLUSIONS

The addition of ground tire rubber to class 1 or 2 bituminous concrete in the pug mill changes the character of the mix. The inclusion of 1% rubber in overlays over low distressed pavements may improve performance. Increasing the rubber level to 2% will not improve and may reduce performance.

The addition of ground tire rubber to class 12 bituminous concrete in the pug mill improves the performance if the thickness of the layer is adequate.

The addition of ground tire rubber to asphalt cement to be used as chip seal binder increases the adhesion and general performance of the seal. For this use, the asphalt was soaked in the hot asphalt sufficiently long to soften the rubber.

An effective Stress Relieving Interlayer can not be made by the simple use of an asphalt/rubber binder with cover chips.

The sealing of concrete pavement joints in winter as carried out in this study was not as effective as summer sealing.

RECOMMENDATIONS

Disposal of discarded tires remains a major waste problem. The combination of rubber and asphalt as carried out in this study did not prove greatly effective except in the case of the seal coats. The major difference was the conditioning of the asphalt/rubber blend accomplished by soaking the rubber in the hot asphalt for several hours before use. The incorporation of the rubber into the mix at the pug mill was a logistic necessity. Adding the rubber to the asphalt ahead would reduce the delays at the pug mill and provide the soaking time desired. The resulting asphalt/rubber binder would reduce the sensitivity of the mix to asphalt content, permit thicker films to extend life yet resist rutting and flushing under load. Approval and use of such a second generation of rubber/asphalt binders should be considered.

Table 1. Thick Overlay Test Section Matrix

Pavement Distress Level \ Traffic Level	Low	Medium	High
Low	354 (Colchester) 1,300	66 (Marlborough) 7,600	44A (Coventry) 9,500
Medium	85 (Bolton) 3,700	2 (Preston) 4,600	44 (Barkhamsted) 9,600
High	354 (Salem) 1,300	69 (Woodbridge) 5,000	101 (Dayville) 10,400

Note: State Route Number
(Location)
1987 ADT

Table 2. Crack Summary, One Percent Rubber and Controls
(meters/meter of three meter lane)

Site	Length (mters)	1979 Long.	1979 Trans.	1980 Long.	1980 Trans.	1981 Long.	1981 Trans.	1986 Long.	1986 Trans.
2 Preston									
1 %	149	.0102	.0918	.0408	.1748	.1130	.2918	.1880	.3827
0 %	65	.0053	.1790	.3075	.3312	.4183	.4512	.7673	.7263
44 Barkhamsted									
1 %	117	.2283	.2783	.2633	.3000	,3698	.2916	.6755	.3798
0 %	73	.2983	.3892	.4367	.3532	.4457	.4074	1.045	.3732
44A Coventry									
1 %	185	0	0	.0047	0	.1408	.0434	.5123	.1621
0 %	183	0	0	.0835	0	.2319	.0045	.5608	.2877
66 Marlborough									
1 %	241	.2250	.2392	.2492	.2475	.3641	.3183	.4105	.3486
0 %	197	0	0	0	.2267	.0091	.2911	.2993	.3401
69 Woodbridge									
1 %	123	.0620	.2060	.0597	.2114	.2054	.4455	0.933	1.047
0 %	123	.2800	.3648	.2761	.3781	.8614	.4901	.9212	.6248
85 Bolton									
1 %	133	.0123	.0705	.0282	.0741	.3501	.2122	.5019	.3759
0 %	133	.0547	.0071	.1765	0	.3128	.3026	.5879	.4819
101 Dayville									
1 %	192	.0127	.0063	.0127	.0412	.1415	.1336	.6249	.4353
0 %	202	0	.0618	0	.0769	.0235	.1525	.2381	.4040
354 Colchester									
1 %	157	.0447	.2000	.1984	.2043	.4531	.2468	.4877	.3807
0 %	130	.2188	.1247	.2822	.1225	.3194	.1546	.7382	.2388
354 Salem									
1 %	165	.1708	.0285	.3077	.0369	.3867	.0754	2.695	.3338
0 %	91	.0975	.0333	.1031	.0908	.2108	.1123	.7370	.4157
Average									
1 %		.0851	.1246	.1294	.1434	.2805	.2287	.8958	.4271
0 %		.1061	.1289	.1851	.1754	.3036	.2629	.6550	.4325

Table 3. Crack Summary, Two Percent Rubber and Controls (meters/meter of three meter lane)

Site	Length (mters)	1979 Long.	1979 Trans.	1980 Long.	1980 Trans.	1981 Long.	1981 Trans.	1986 Long.	1986 Trans.
2 Preston									
2 %	152	0.0838	.0718	.1408	.2224	.1455	.3460	.7872	.4547
0 %	152	0	.1163	.1069	.1612	.2259	.2947	.3702	.3841
44 Barkhamsted									
2 %	139	.4833	.2617	.4100	.2617	.6214	.3085	.9047	.3508
0 %	122	.6667	.2792	.7125	.2967	.7676	.3134	.9368	.3621
44A Coventry									
2 %	207	.0900	.0259	.0988	.0441	.1529	.0967	.5624	.3550
0 %	207	.0018	.0129	.0059	.0371	.0279	.0690	.1881	.1115
66 Marlborough									
2 %	188	0	.1692	0	.1958	.0250	.2972	.1162	.3253
0 %	91	0	.1917	0	.2267	.0091	.2911	.2993	.3403
69 Woodbridge									
2 %	126	.0121	.2233	.0510	.2937	.1626	.5534	1.379	1.174
0 %	126	.0510	.2573	.1141	.4126	.3544	.5655	.6302	.7558
85 Bolton									
2 %	179	.2237	.1037	.2999	.0711	.5806	.1847	1.508	.3397
0 %	179	.2405	.1037	.2999	.0711	.5806	.1847	1.508	.3397
101 Dayville									
2 %	210	0	0	.0406	,0145	.0860	.0392	.7851	.2924
0 %	91	0	.0270	0	.0330	.0020	.0540	.3232	.2049
354 Colchester									
2 %	176	.2247	.3685	.2820	.3927	.2808	.3646	.4990	.4295
0 %	107	0	.2029	.0182	.2342	.0502	.2405	.2916	.3799
354 Salem									
2 %	161	.3482	,0248	.5055	.0932	.5813	.1471	4.797	.4547
0 %	300	.0975	.0333	.1031	.0908	.2108	.1123	.6494	.3208
Average									
2 %		.1640	.1387	.2032	.1766	.2584	.2597	1.260	.4640
0 %		.1175	.1416	.1552	.1831	.1849	.2328	.5649	.3806

Table 4. Thin Overlays
Crack Units, meters per meter of 3 meter lane
%, rubber percent as percent of dry aggregate

Site	Length (meters)	Total Cracks	
12 Thompson			
0 %	168	1.203	
1 %	181	1.174	
2 %	252	1.886	
3 %	280	1.199	
4 %	217	0.99	
32 Franklin (Overlaid)			
151 East Haddam			
0 %	189	3.25	
1 %	189	1.05	
2 %	198	4.29	
3 %	195	8.51	
32 Stafford Springs		Transverse	Longitudinal
0 %	85	0.89	1.00
1.8 %	85	0.61	1.15
3.1 %	86	0.31	0.05
0 %	87	0.45	2.08

Table 5. Chip Seals (constructed 1977)
Crack units, meters per meter of 3 meter lane
Rubber level, 20% of binder

Site	Length (meters)	Transverse	Longitudinal	Alligator Sq. meters/meter of 3 meter lane	Patching
14 Scotland					
Rubber (overlaid 1984)	205	0	0.049		
Control (overlaid 1984)	91	0.007	0.117		
Control (overlaid 1985)	91	0.002	0.33		
203 Chaplin (Chip sealed, 1 cm stone 1985)					
Rubber	152	0.02	0.38		
Control	150	0.07	1.12		
32 Mansfield (Sand sealed 1 month after construction)					
Rubber	139	0.65	1.36	0	0
Control	123	1.03	1.28	0.49	0.06
31 Coventry (Sand sealed 1 month after construction)					
Rubber	102	0	0.146		0.447
Control	76	0	0		0.963

TABLE 6. CRACKING OVER SRI Year Nine

Section	Overlay Rubber Content	Longitudinal (meters/meter of 3 meter lane) No Overlay	Longitudinal SRI	Transverse No Overlay	Transverse SRI	Alligator (Sq meters/meter of 3 meter lane) No Overlay	Alligator SRI
State Route #30							
1	0	.41	.23	.39	.74	0	.09
2	2	.34	.49	0	1.31	.93	.48
3	0	.47	.11	.59	.4	0	0
4	1	.37	.33	1.31	1.99	3.32	.45
State Route #44A							
5	0	.46	1	.59	.45	0	1.07
6	1	.7	.34	.88	.41	.11	.13
7	0	.08	.55	.49	.41	0	0
8	2	.01	1.12	.58	.82	1.07	3.81

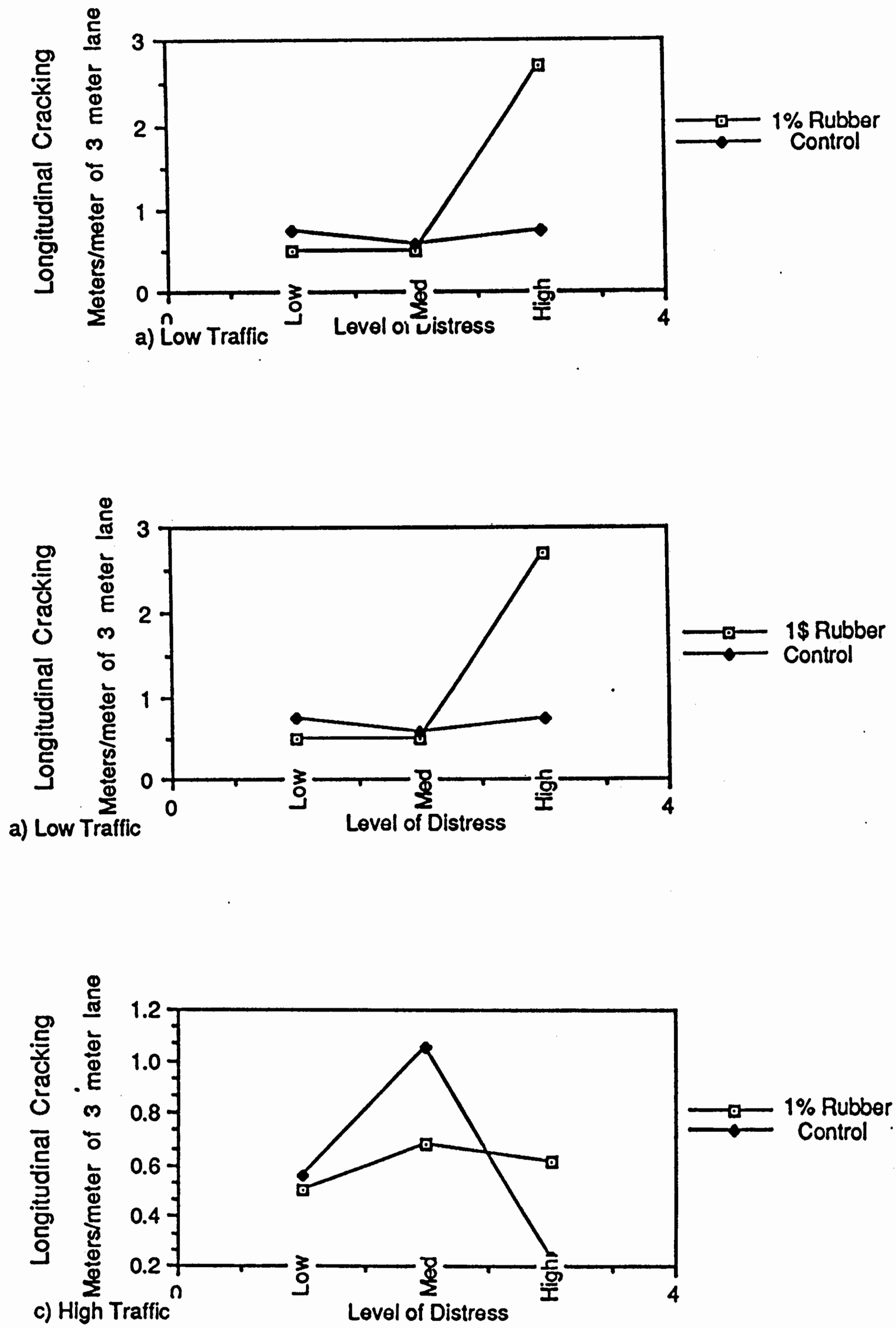


Figure 1. Longitudinal Cracking versus Distress Level Prior to Overlay, 1% Rubber, 9 Years

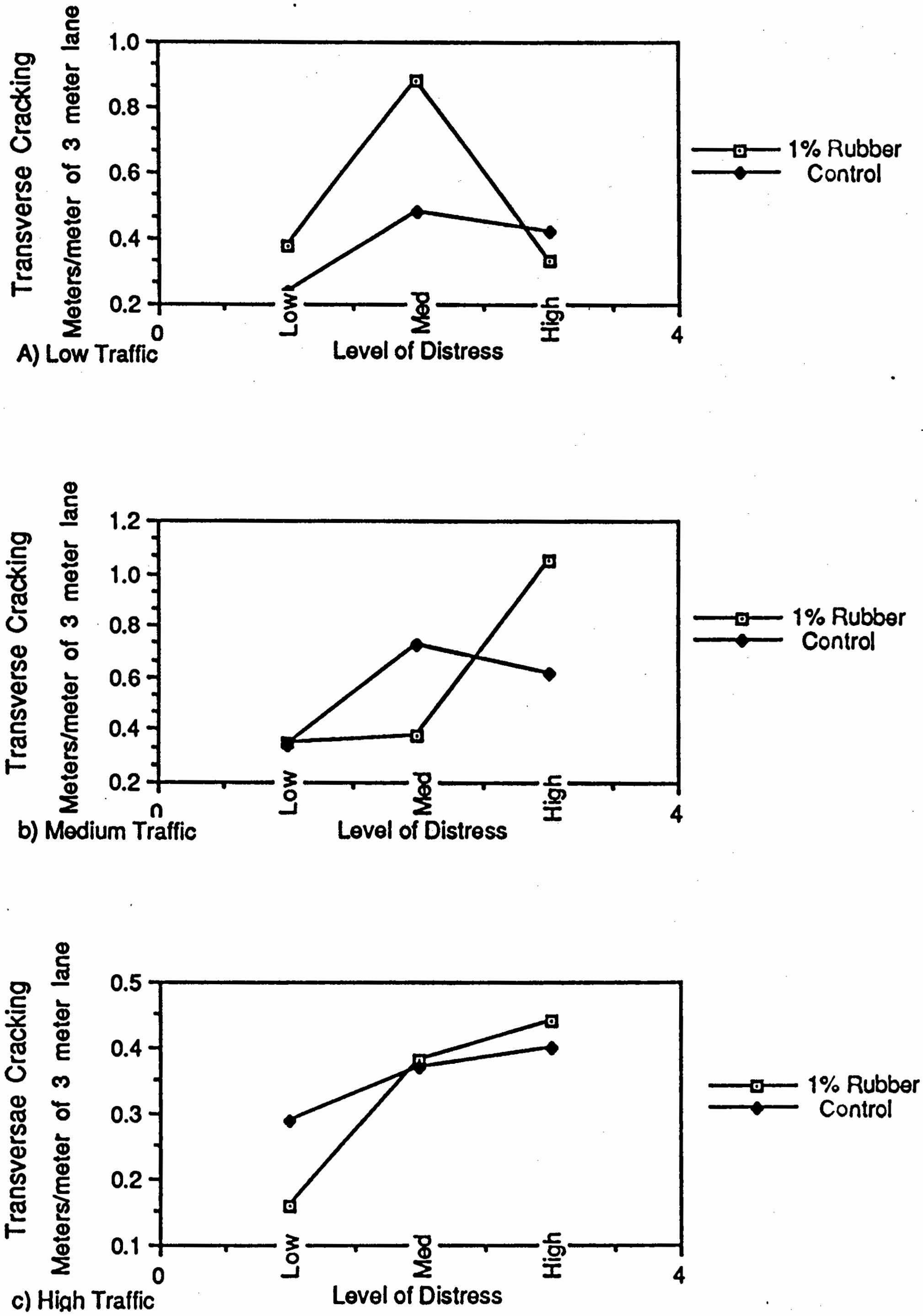


Figure 2. Transverse Cracking versus Distress Level Prior to Overlay, 1% Rubber, 9 Years

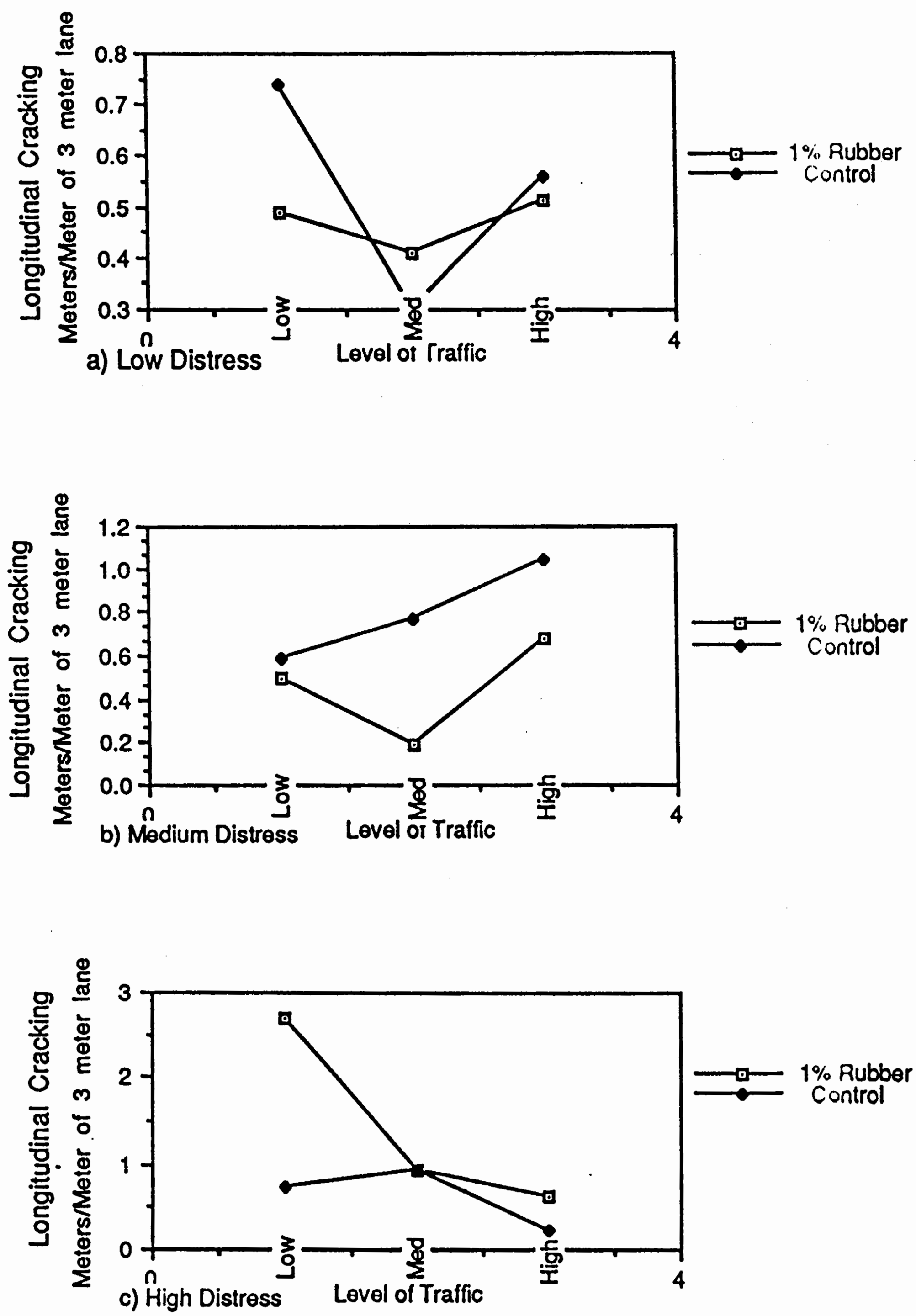


Figure 3. Longitudinal Cracking versus Traffic, 1% Rubber, 9 Years

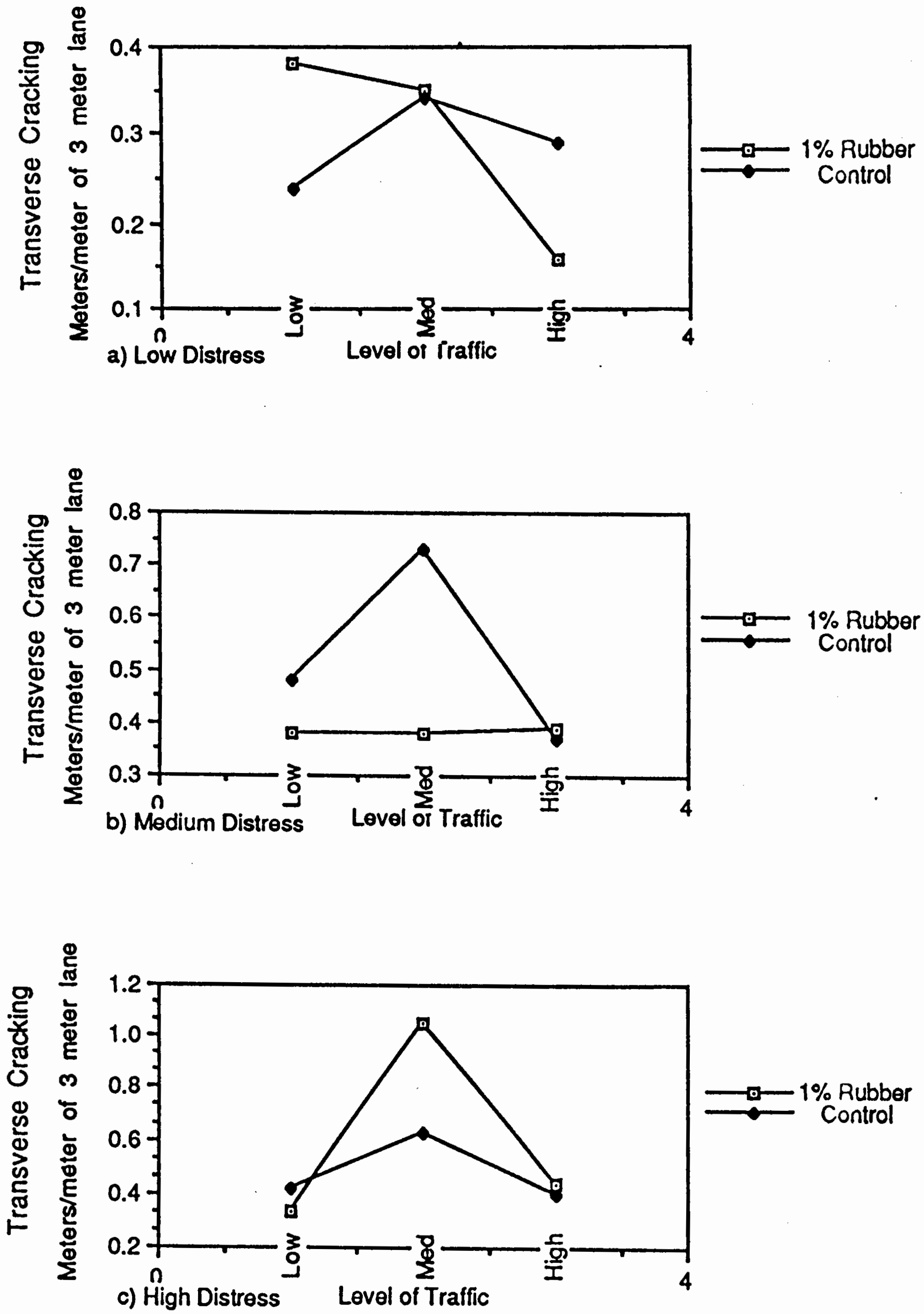
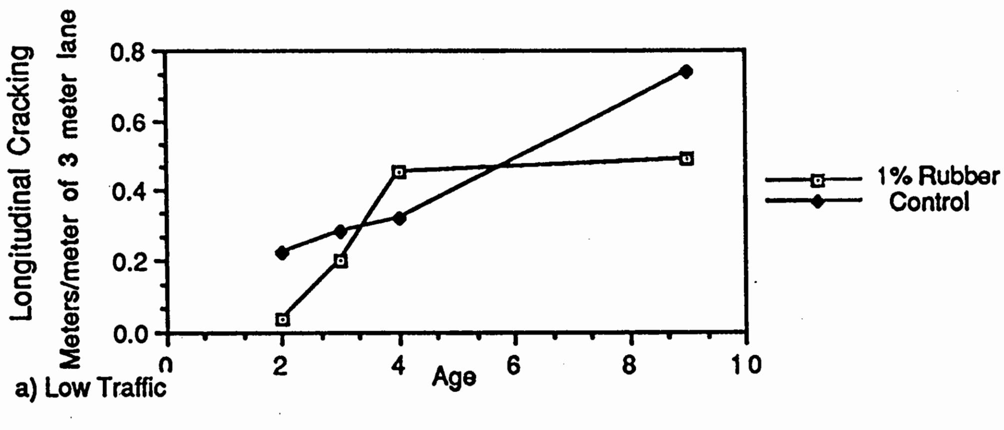
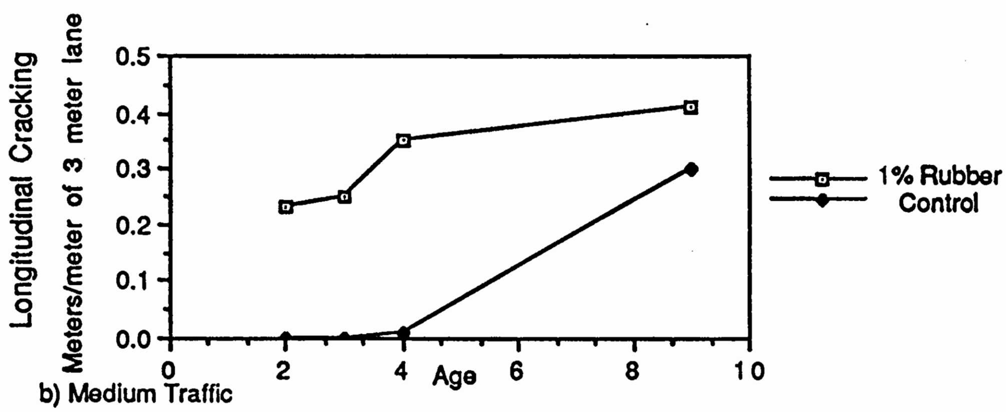


Figure 4. Transverse Cracking versus Traffic, 1% Rubber, 9 Years





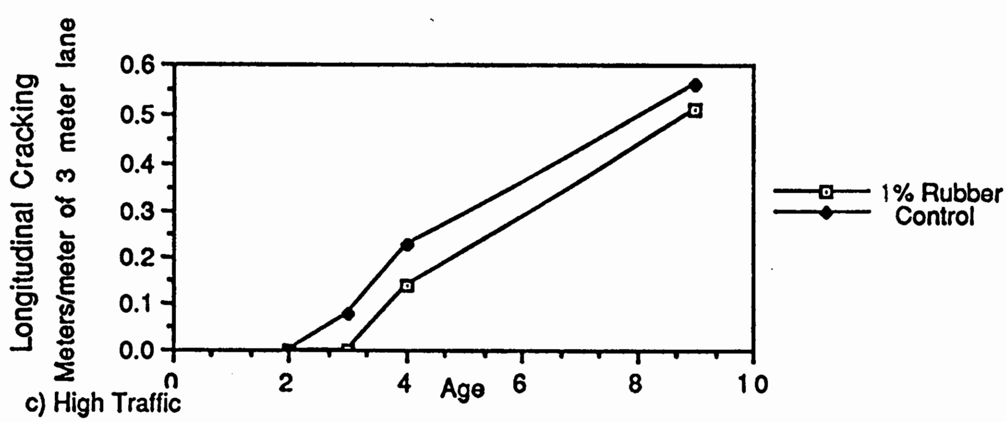


Figure 5. Longitudinal Cracking versus Age, 1% Rubber, Low Distress

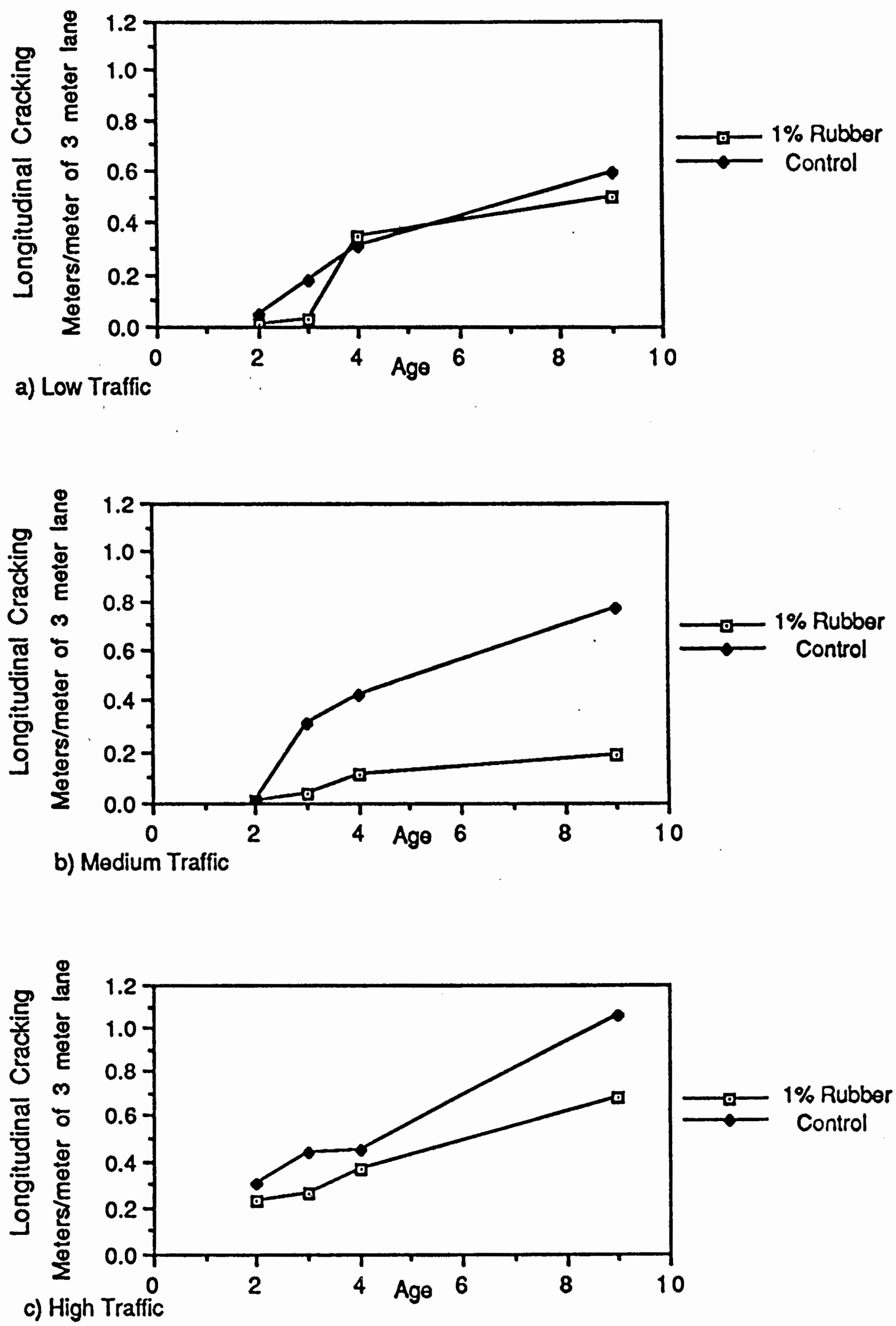
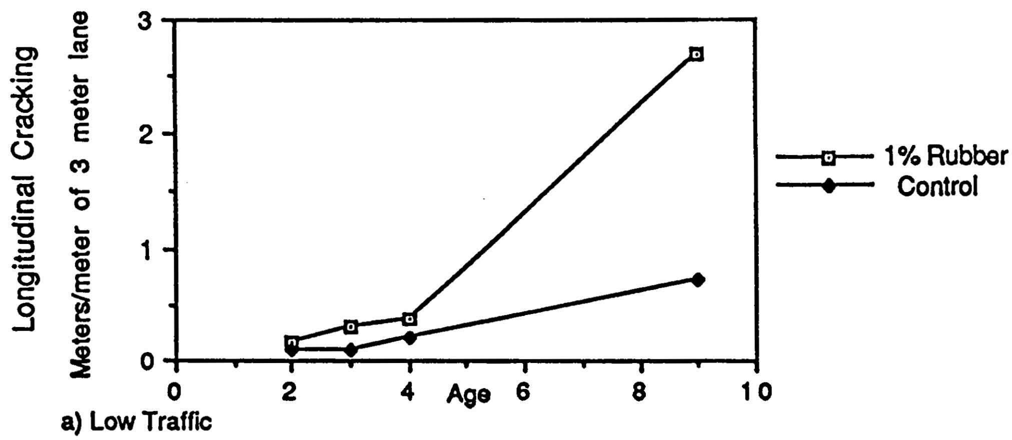
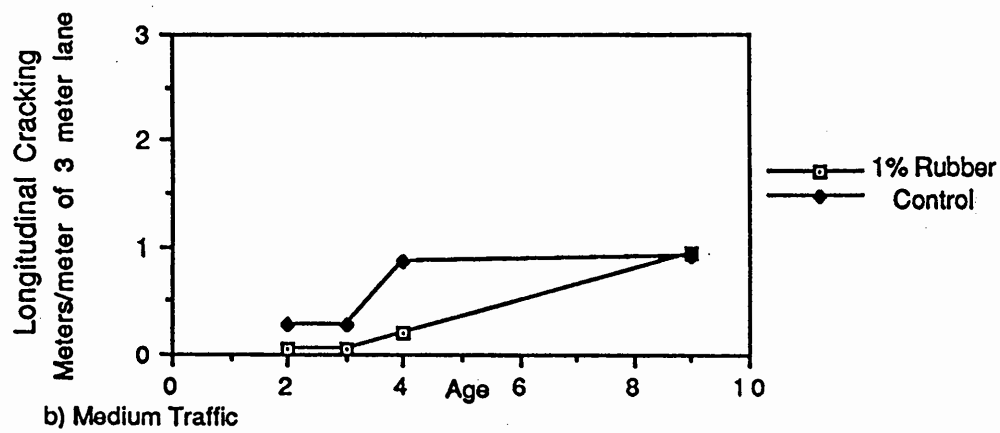


Figure 6. Longitudinal Cracking versus Age, 1% Rubber, Medium Distress





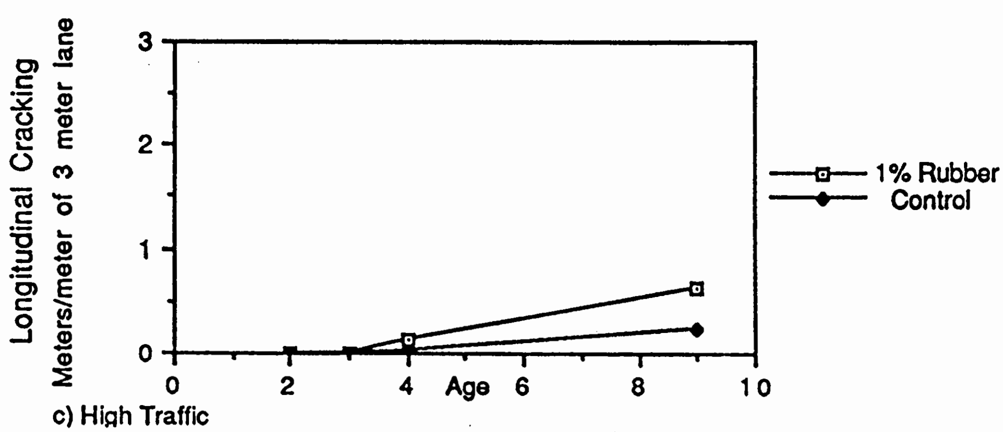
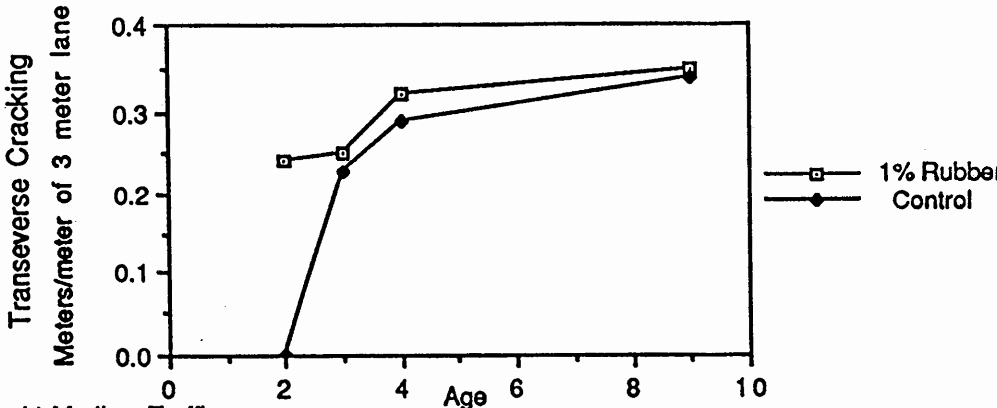
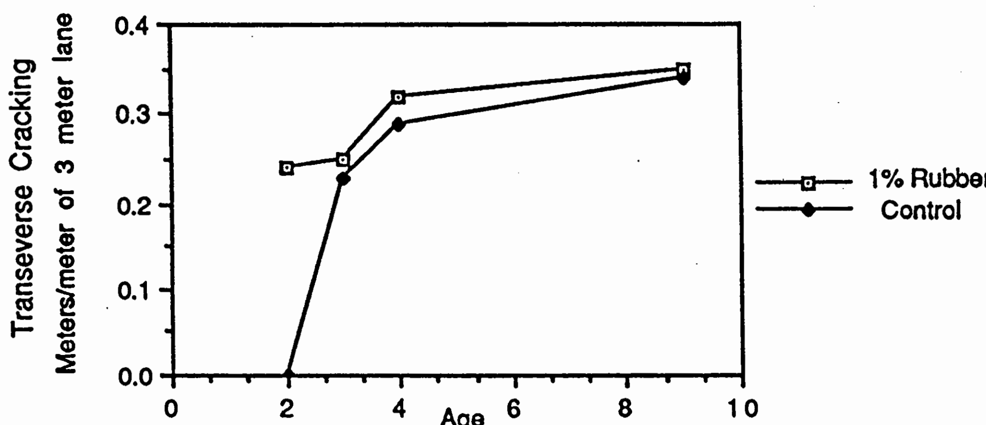


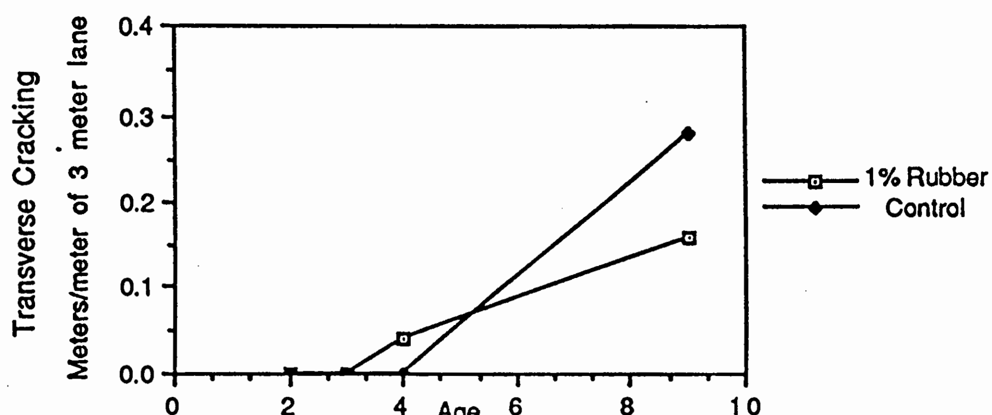
Figure 7. Longitudinal Cracking versus Age,
1% Rubber, High Distress



b) Medium Traffic



b) Medium Traffic



c) High Traffic

Figure 8. Transverse Cracking versus Age,
1% Rubber, Low Distress

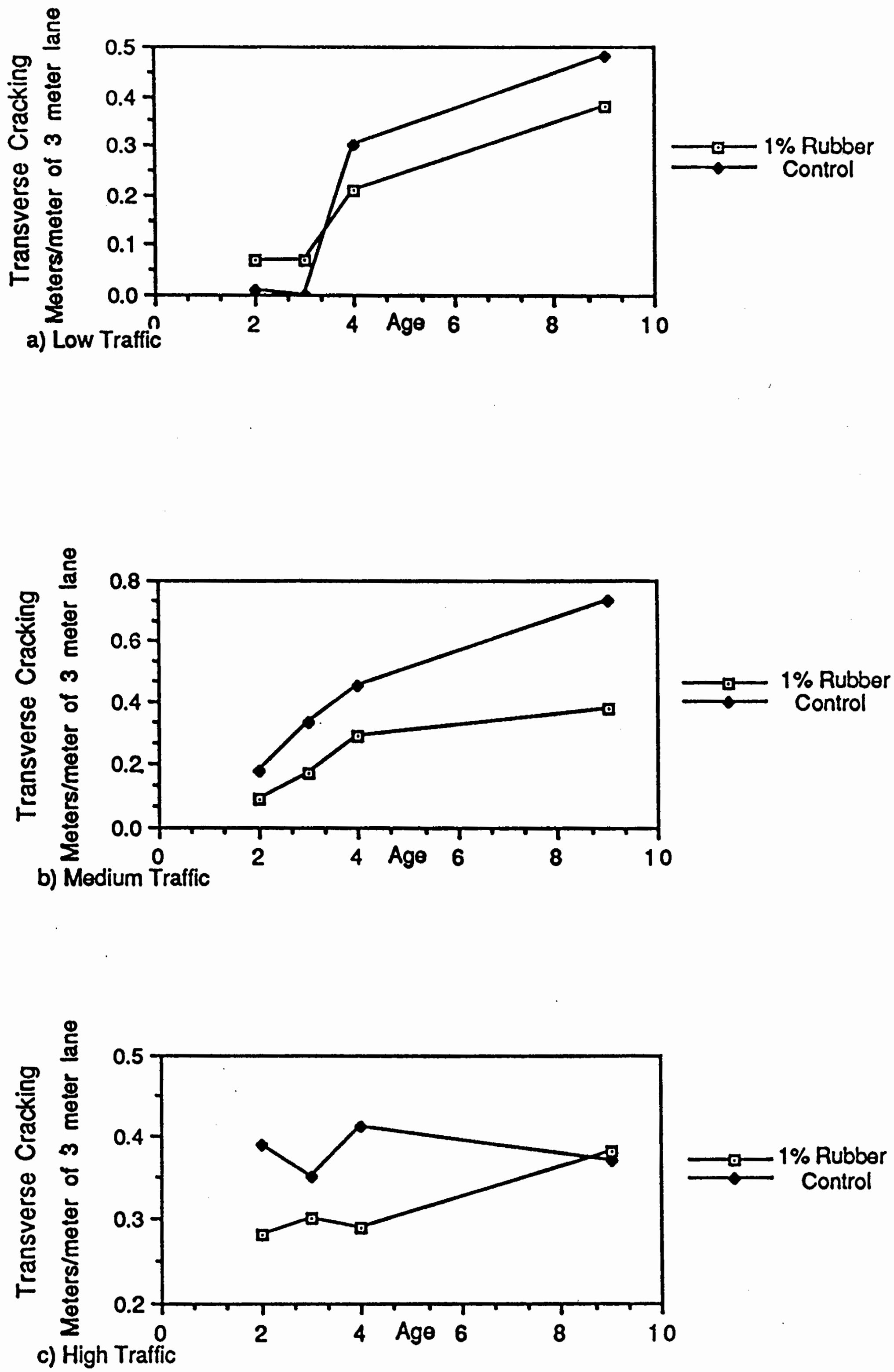
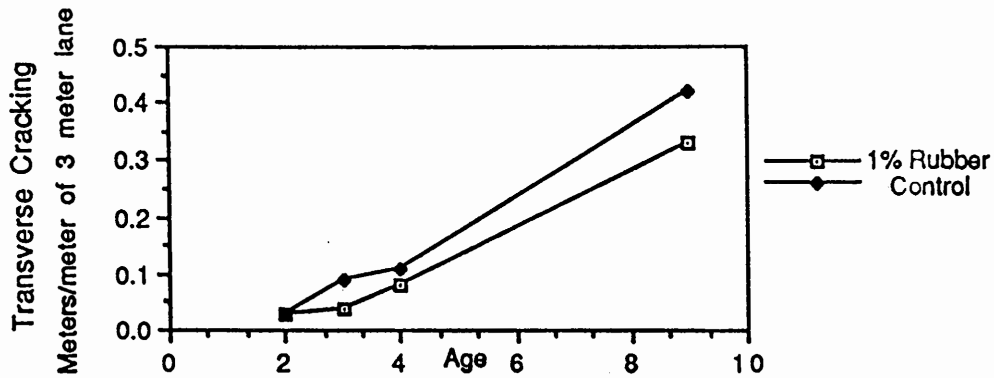
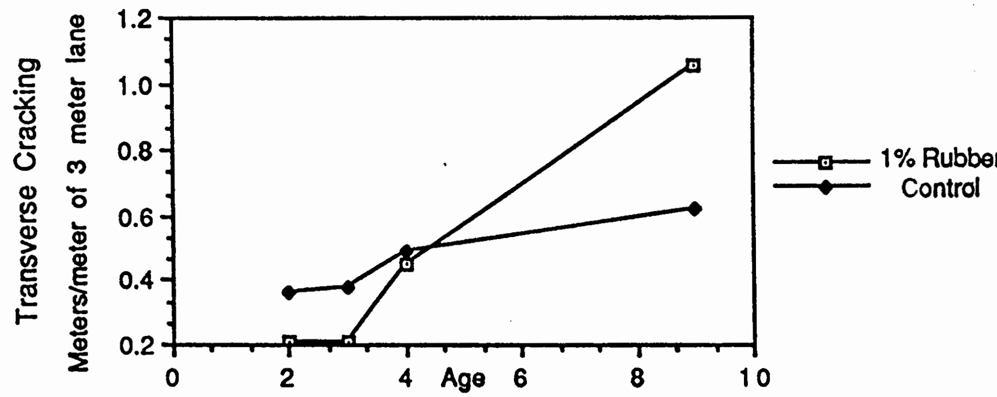


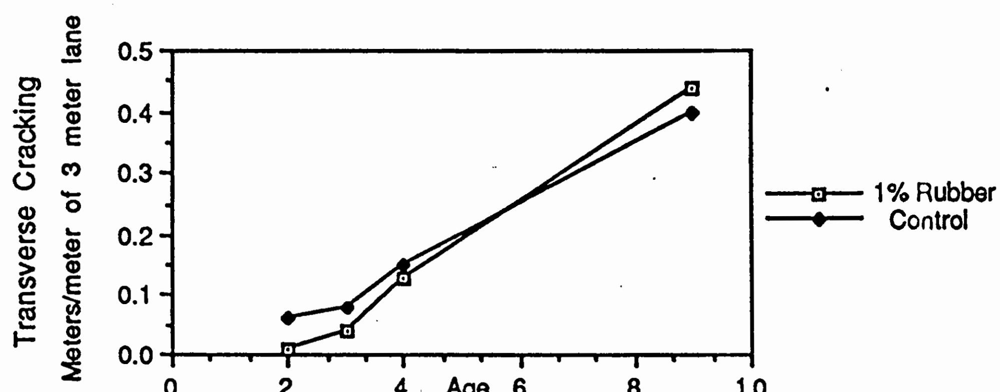
Figure 9. Transverse Cracking versus Age,
1% Rubber, Medium Distress



a) Low Traffic

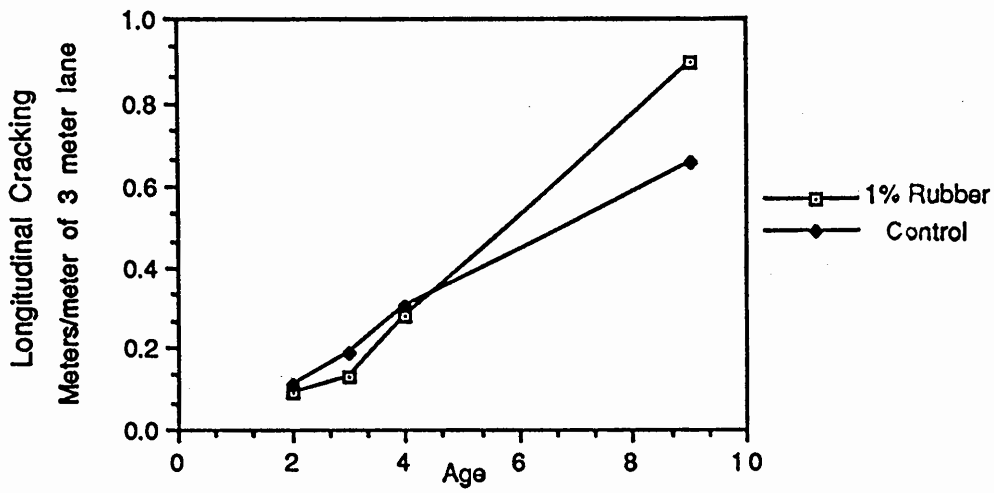


b) Medium Traffic

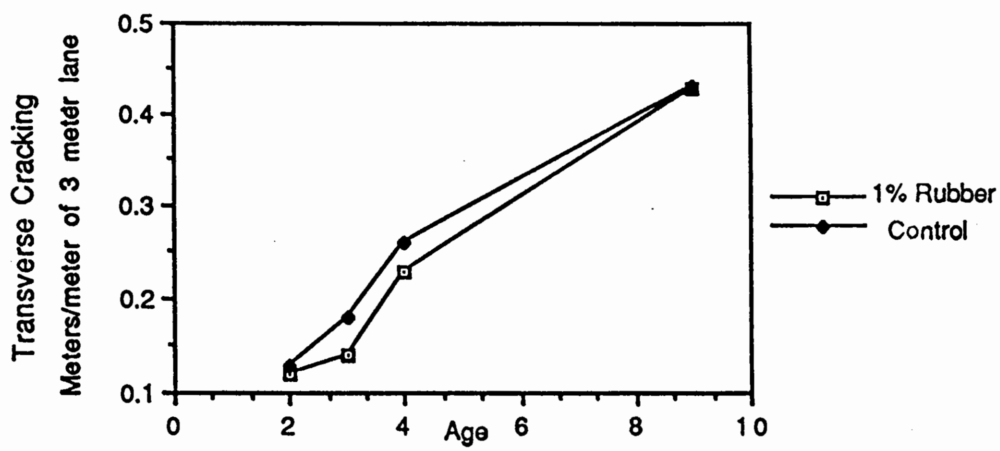


b)High Traffic

Figure 10. Transverse Cracking versus Age, 1% Rubber, High Distress



a) All Longitudinal



b) All Transverse

Figure 11. Cracking versus Age, 1% Rubber, Average of All Levels

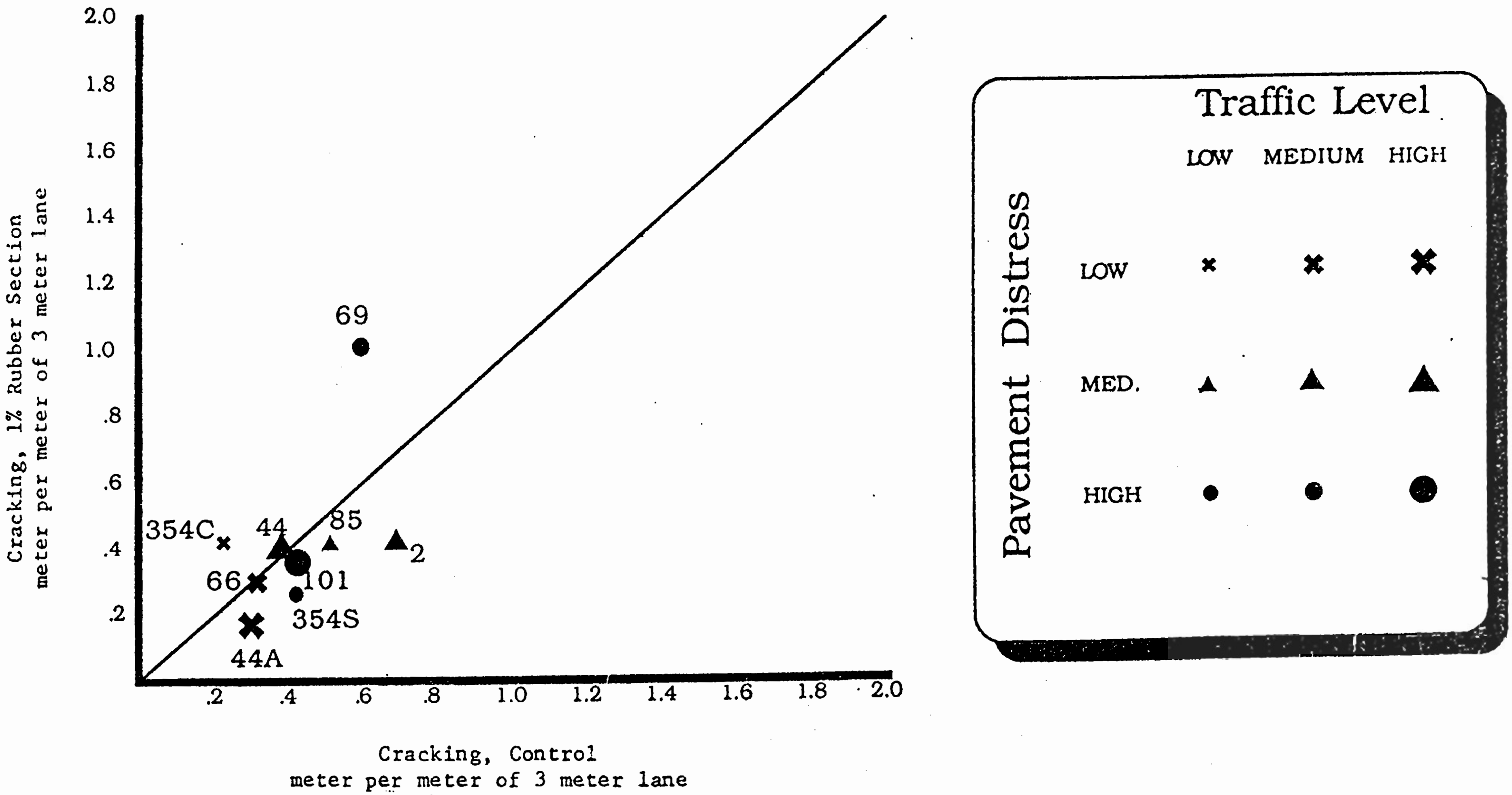


Figure 12. Longitudinal Crack Summary, 1% Rubber

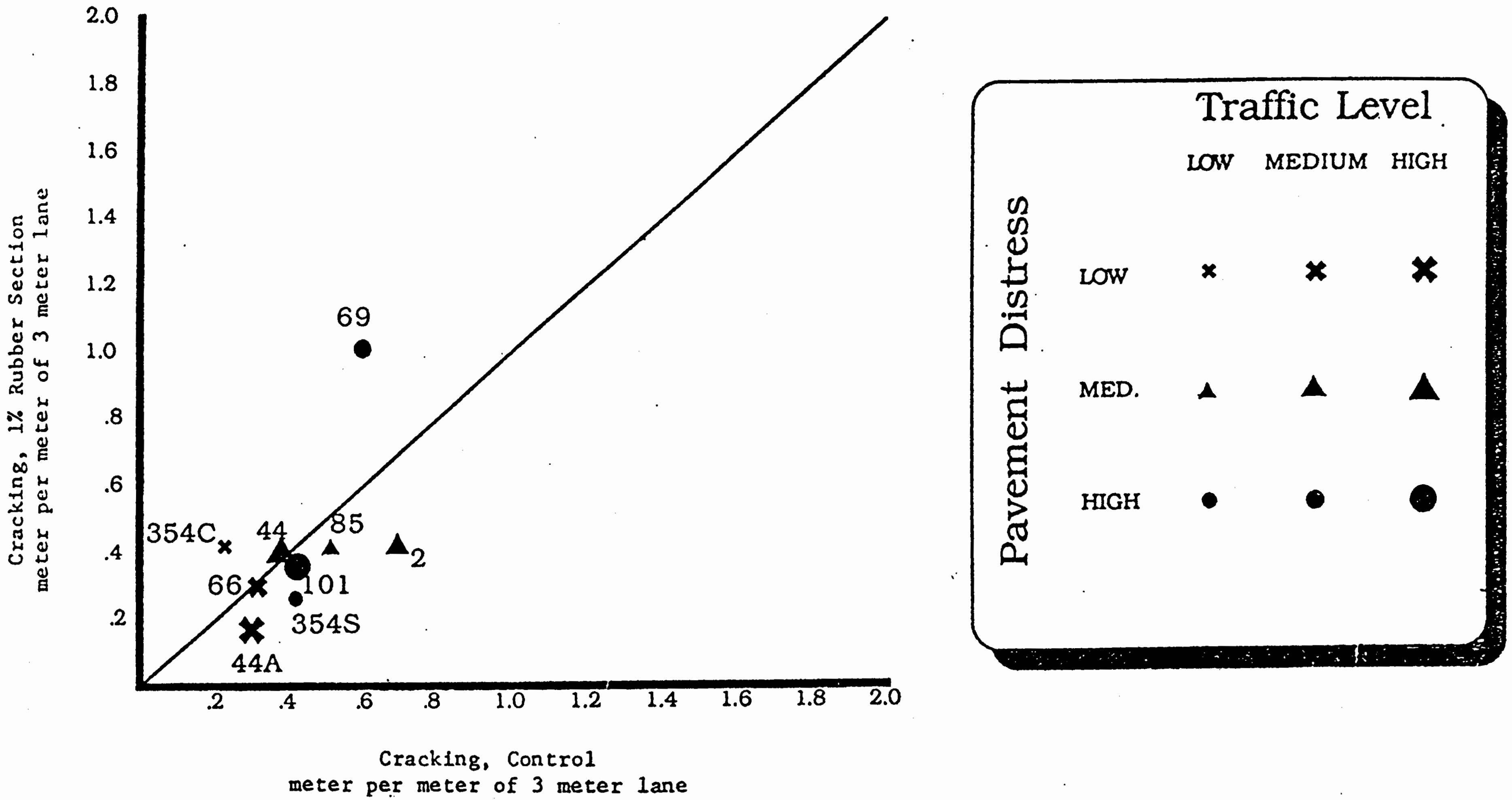


Figure 13. Transverse Crack Summary, 1% Rubber

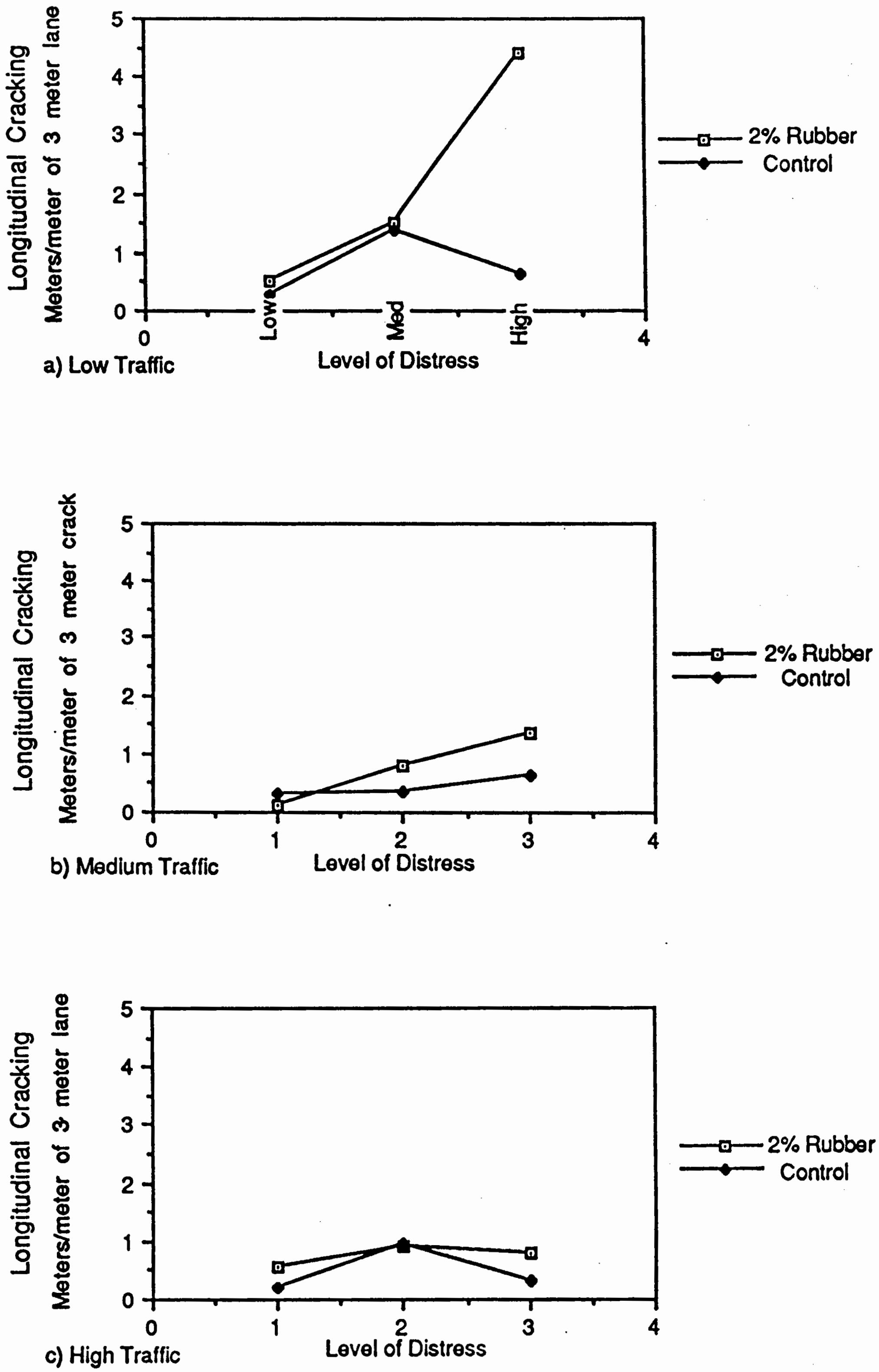


Figure 14. Longitudinal Cracking versus Distress Level Prior to Overlay, 2% Rubber, 9 Years

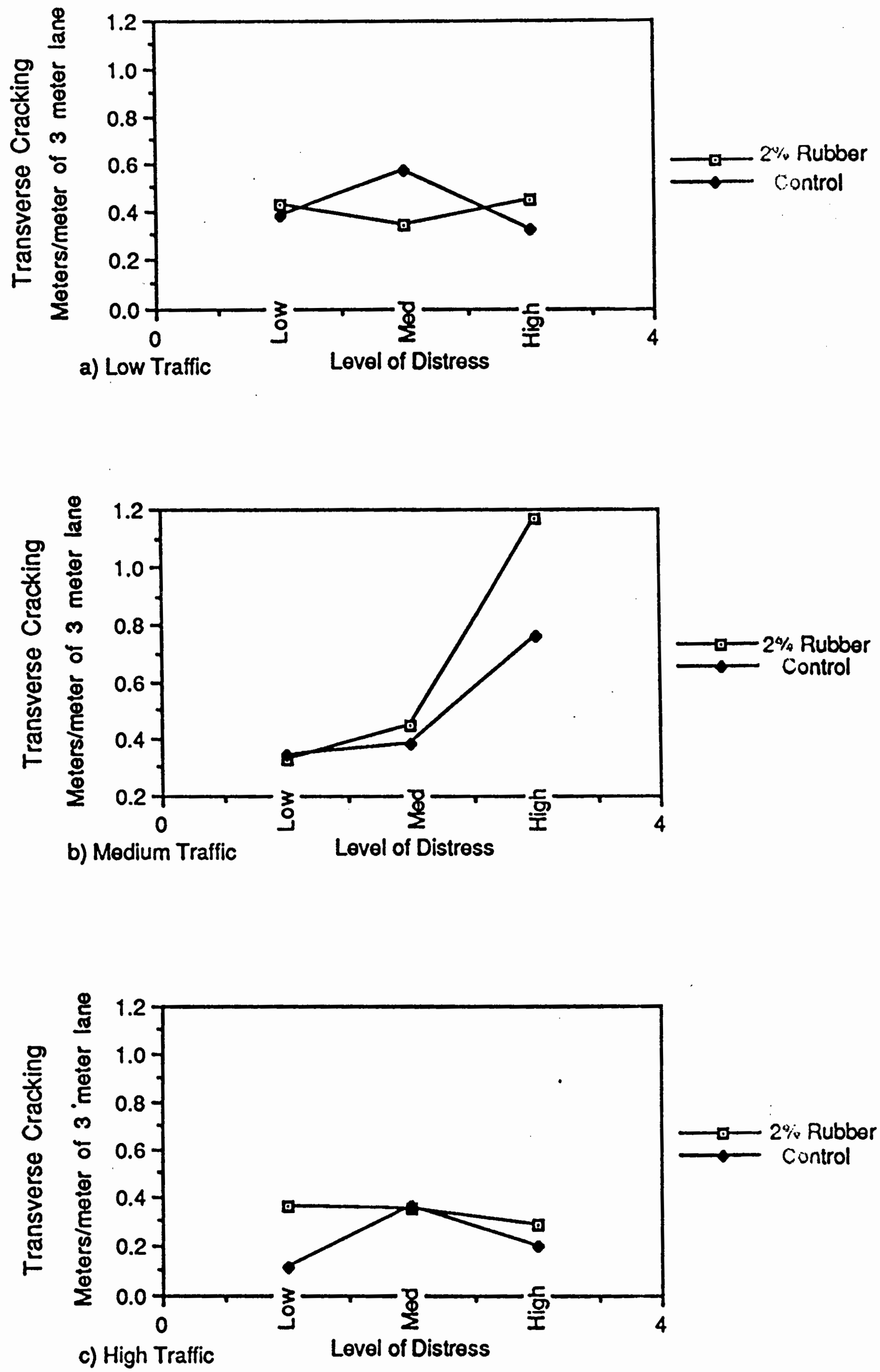


Figure 15. Transverse Cracking versus Distress Level
Prior to Overlay, 2% Rubber, 9 Years

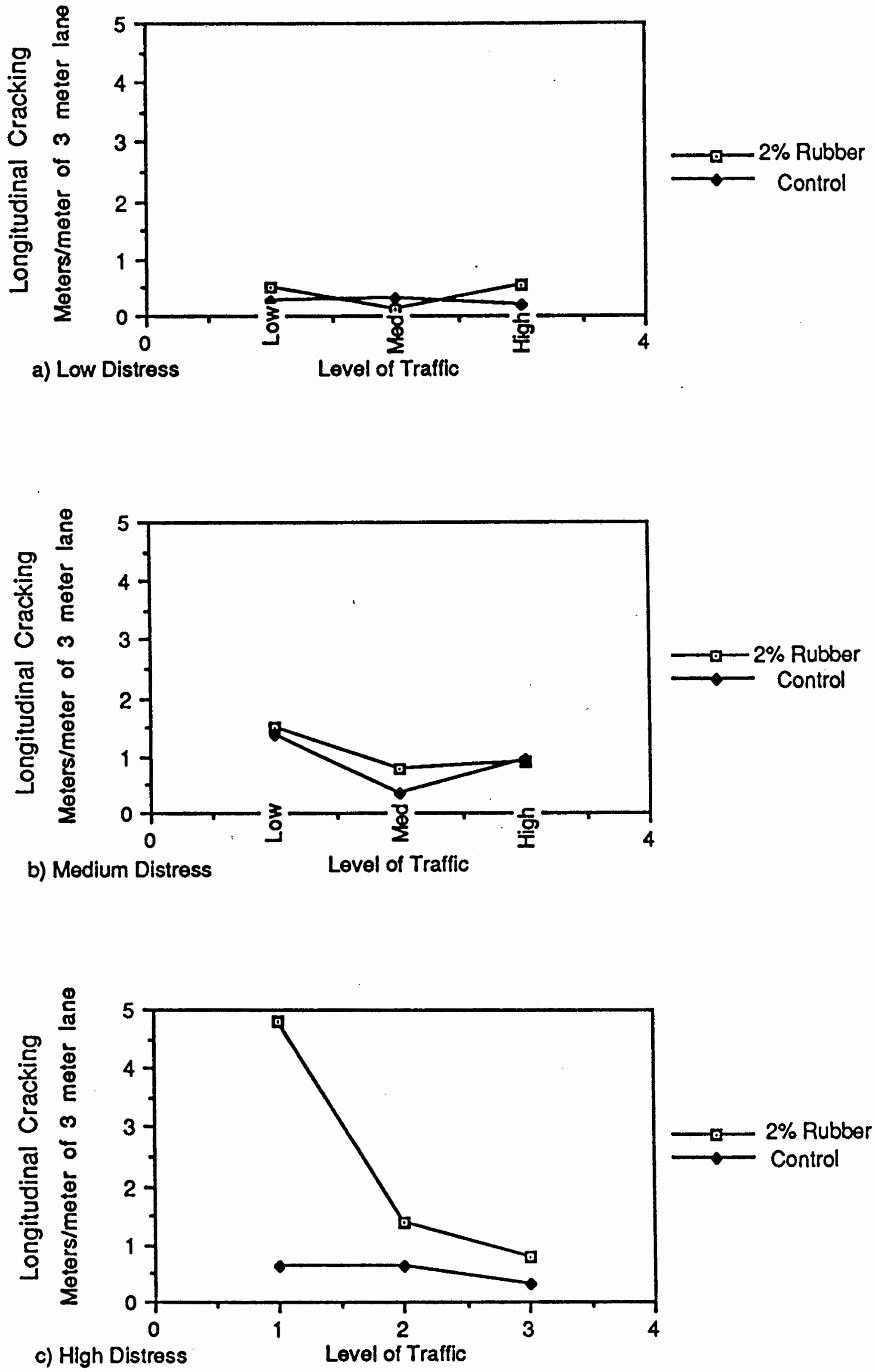


Figure 16. Longitudinal Cracking versus Traffic, 2% Rubber, 9 Years

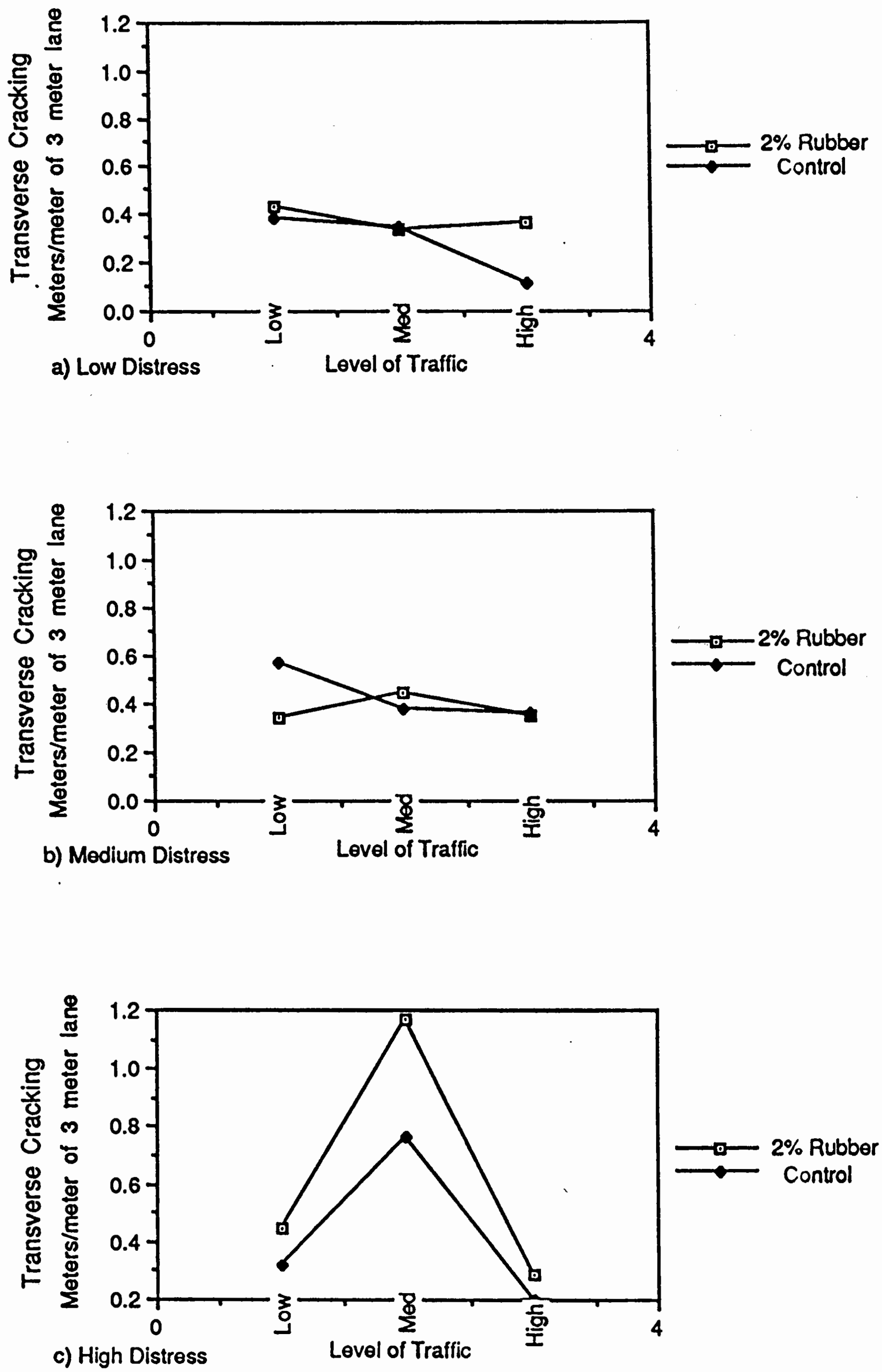


Figure 17. Transverse Cracking versus Traffic, 2% Rubber, 9 Years

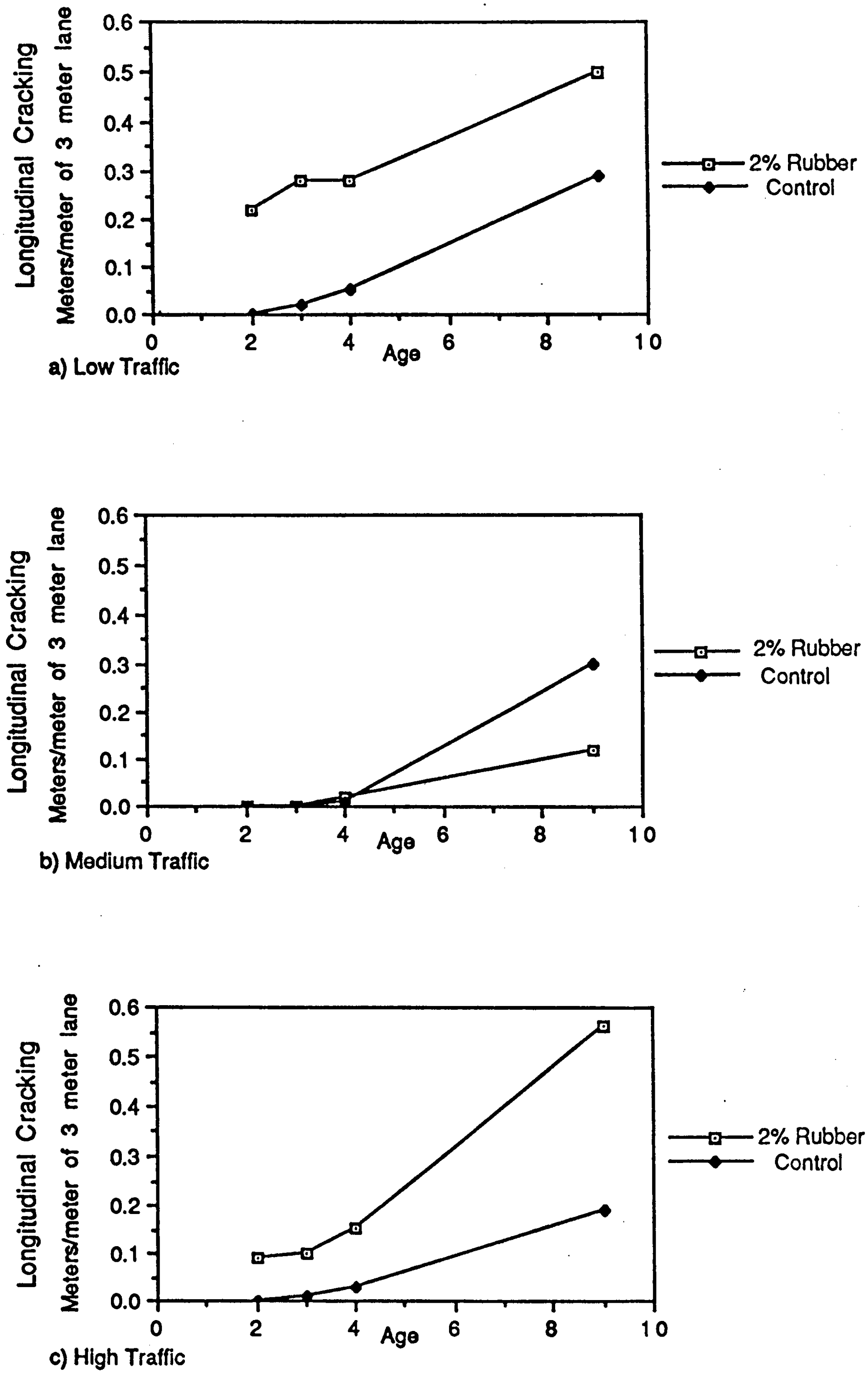
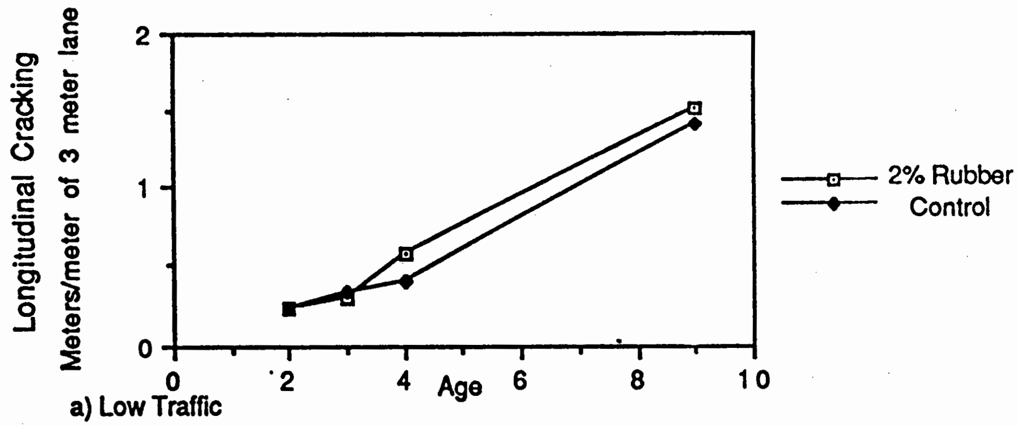
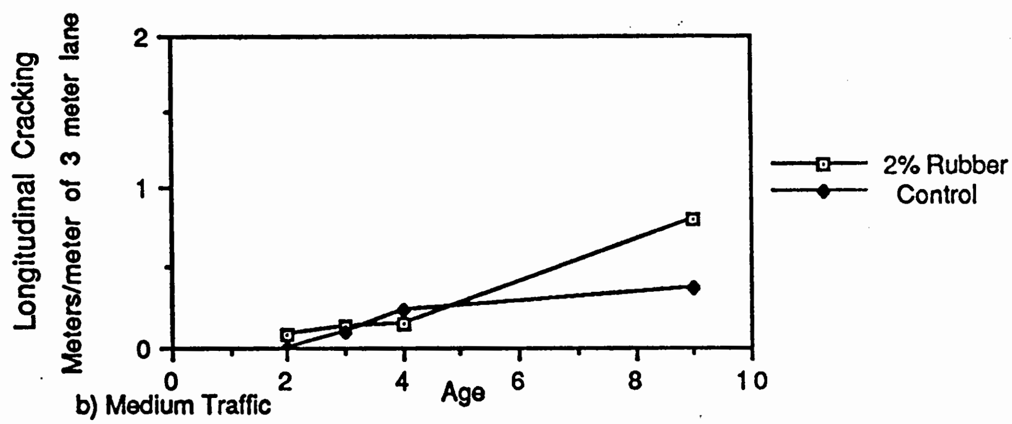


Figure 18. Longitudinal Cracking versus Age, 2% Rubber, Low Distress





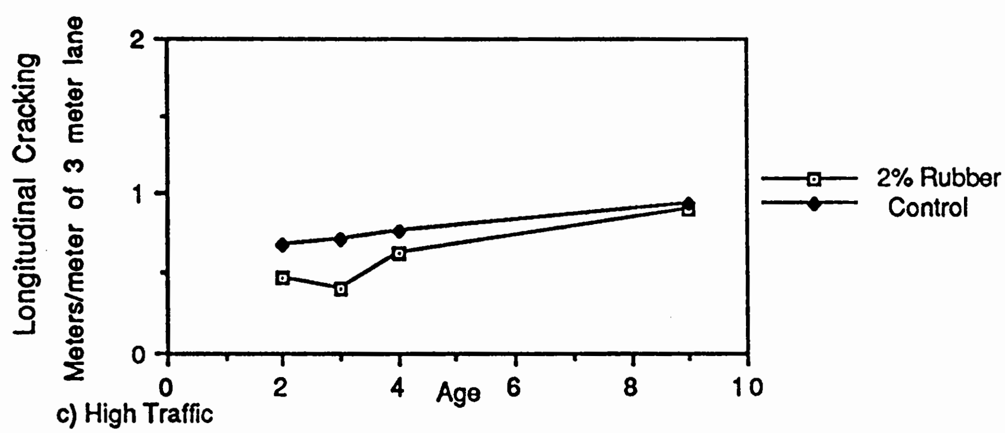


Figure 19. Longitudinal Cracking versus Age, 2% Rubber, Medium Distress

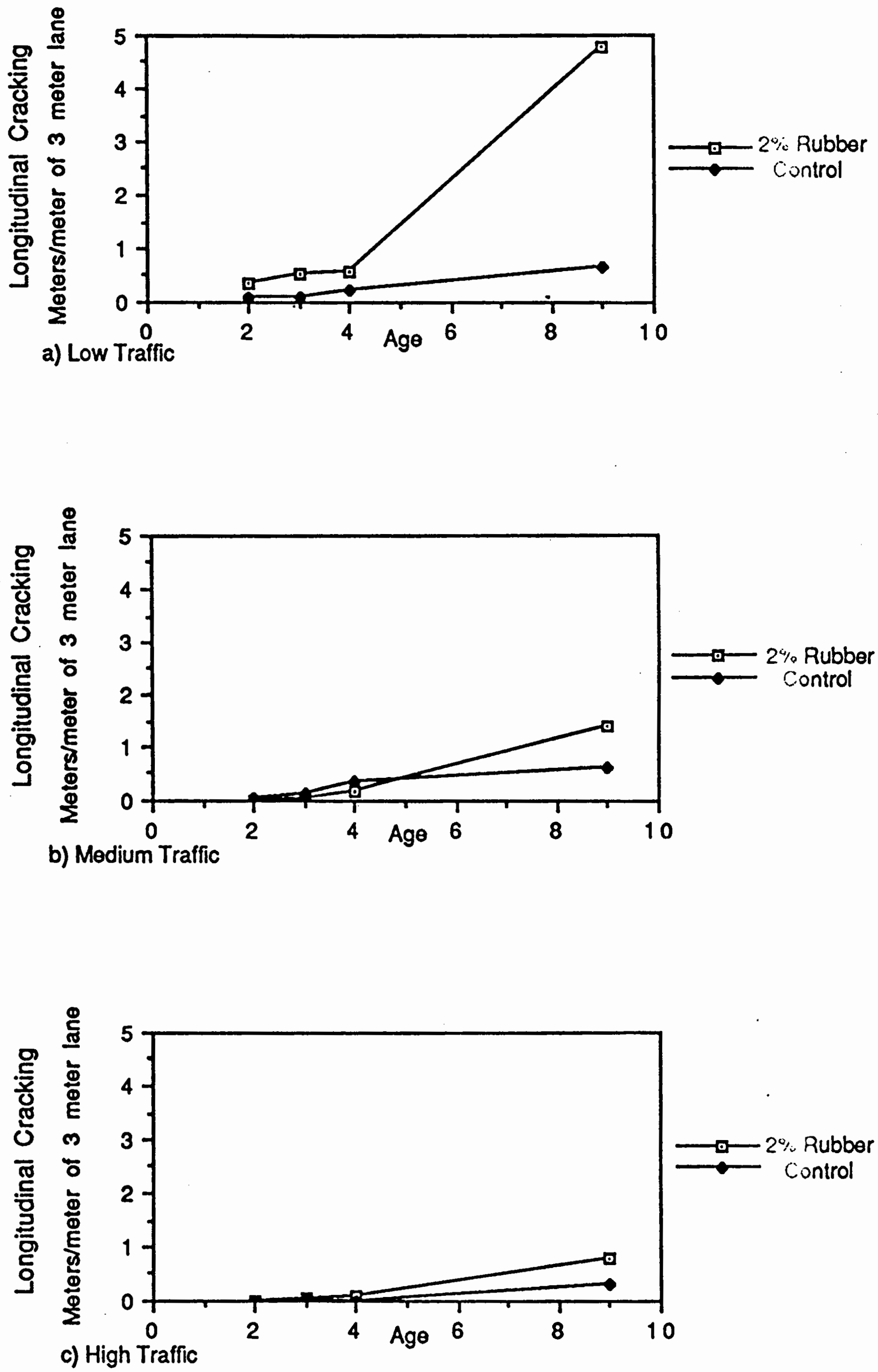


Figure 20. Longitudinal Cracking versus Age, 2% Rubber, High Distress

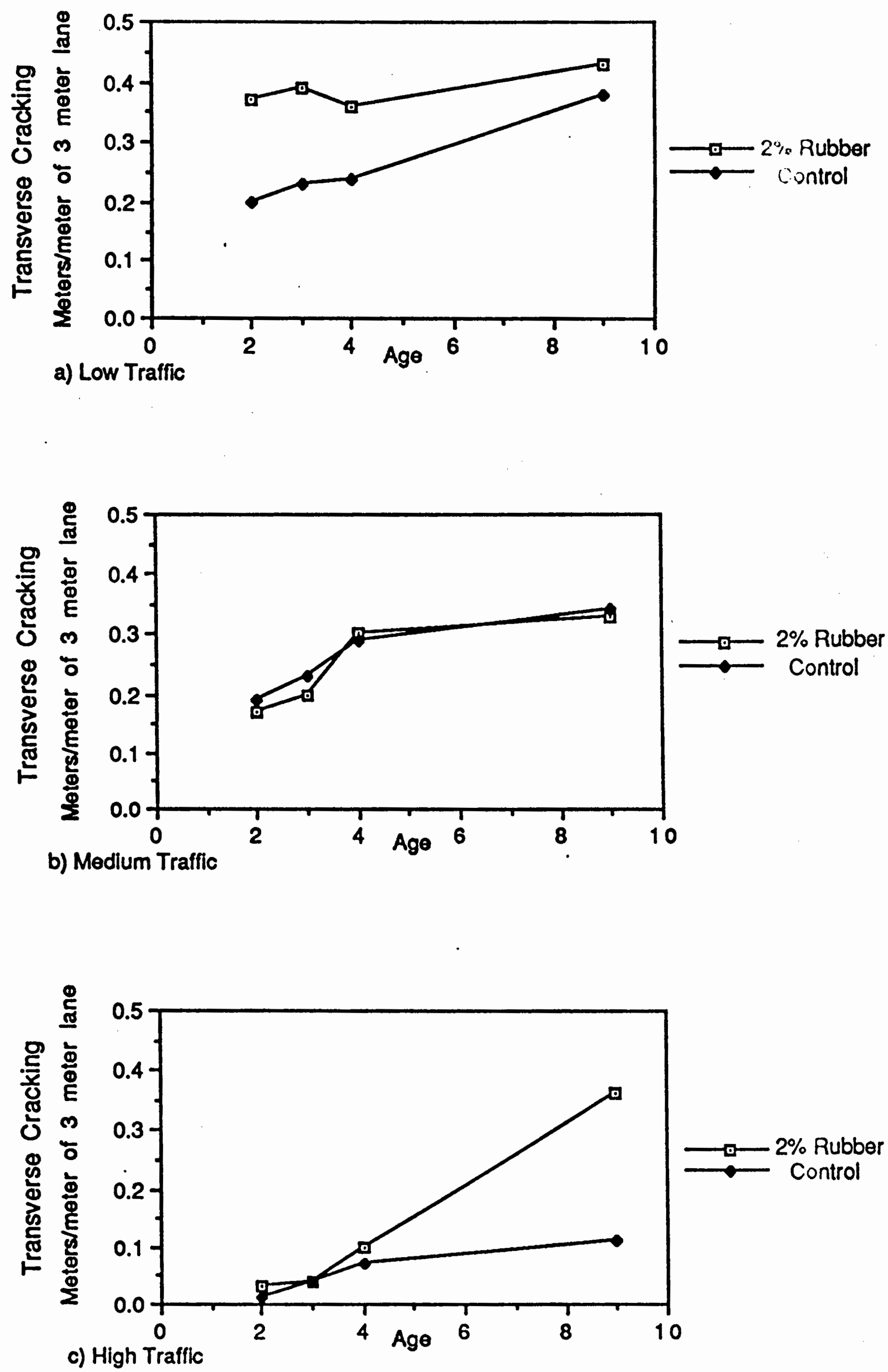
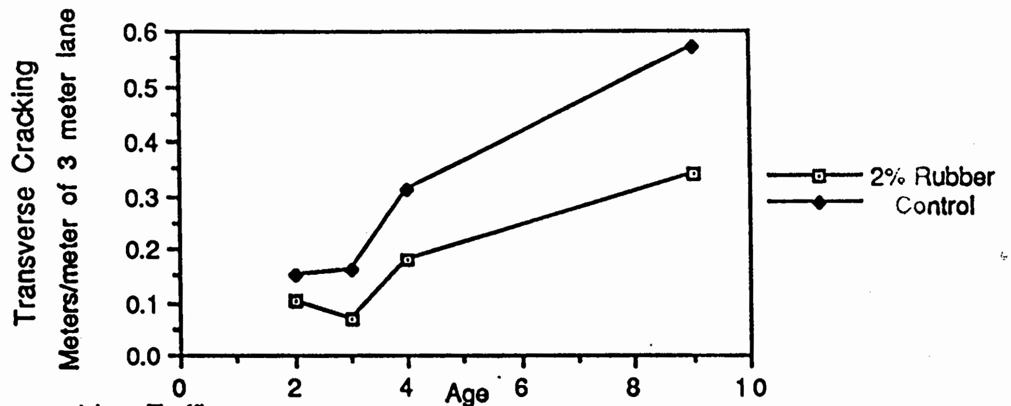
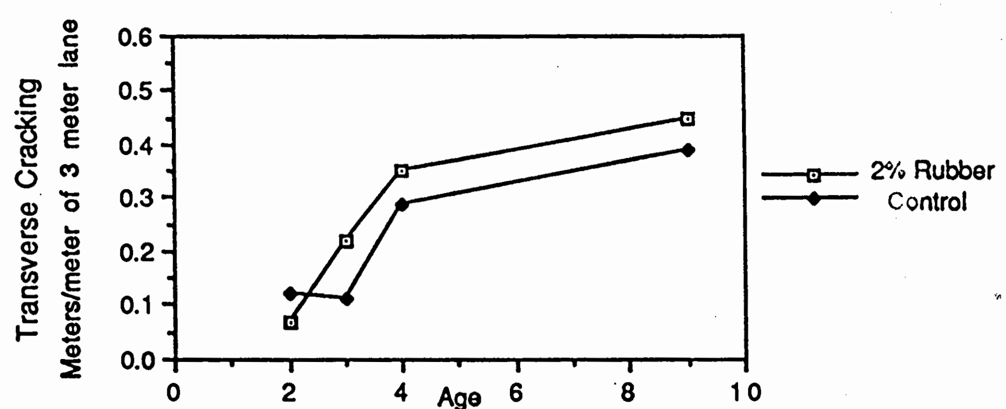


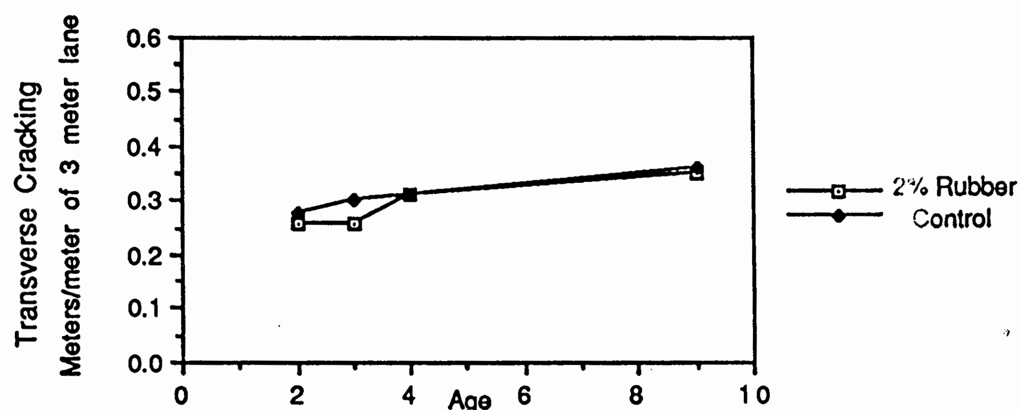
Figure 21. Transverse Cracking versus Age, 2% Rubber, Low Distress



a) Low Traffic



b) Medium Traffic



c) High Traffic

Figure 22. Transverse Cracking versus Age,
2% Rubber, Medium Distress

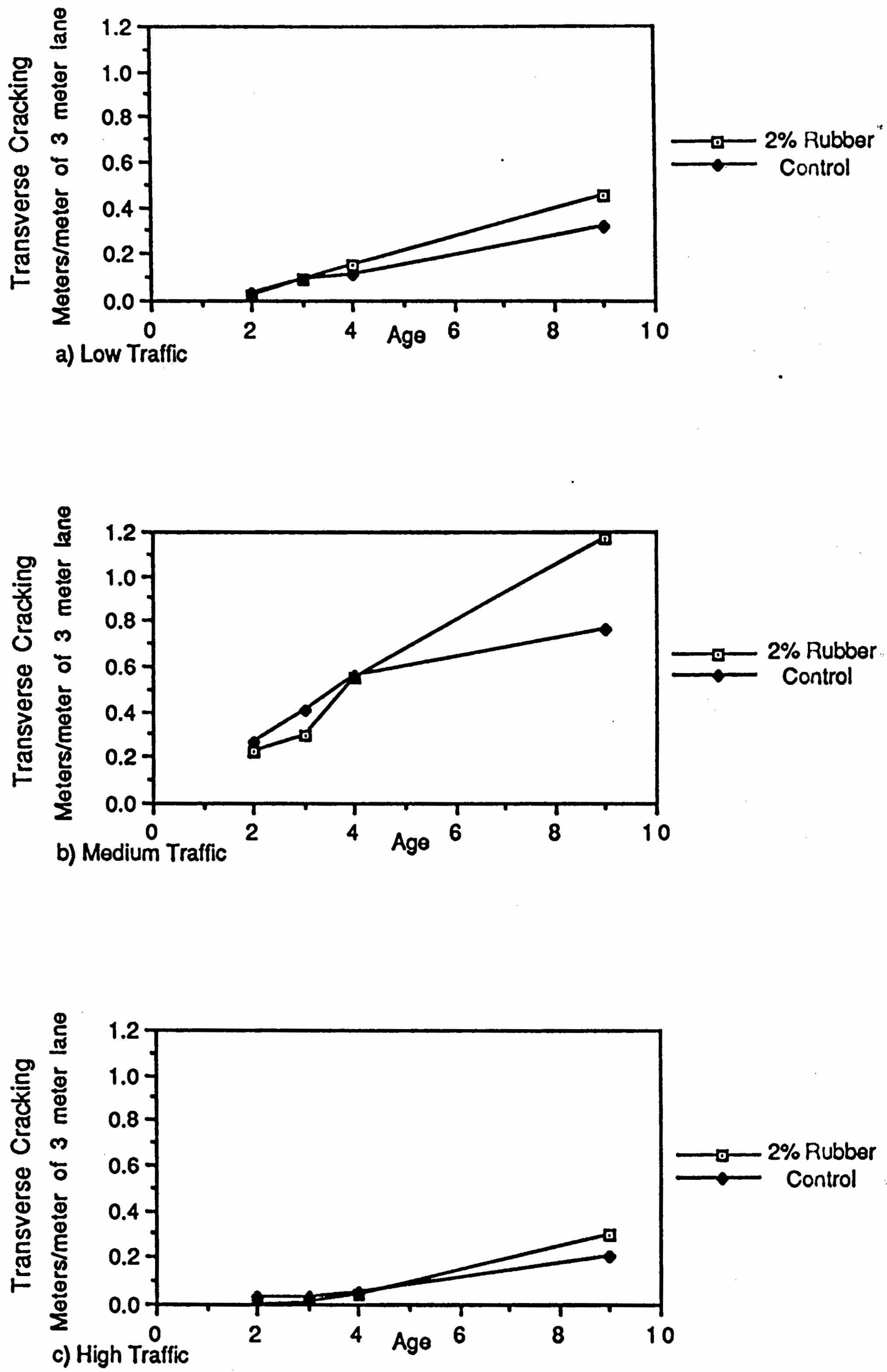
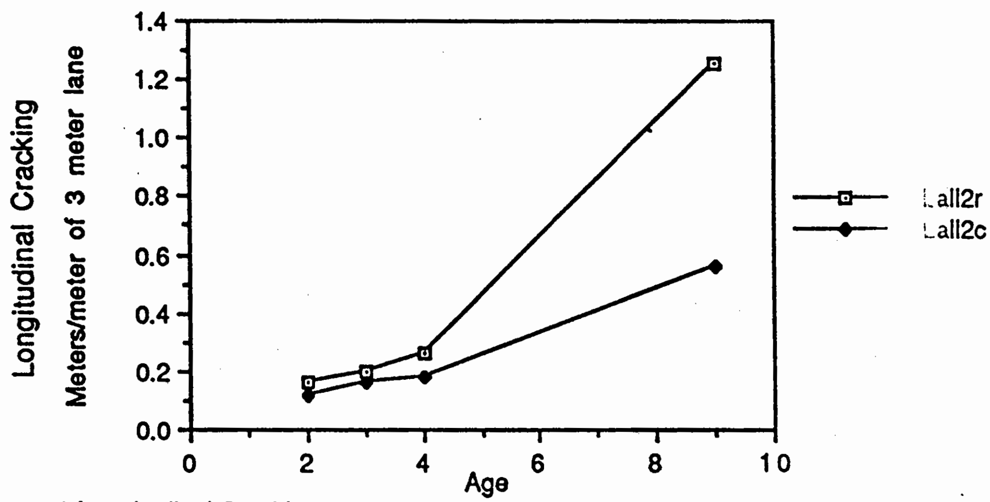
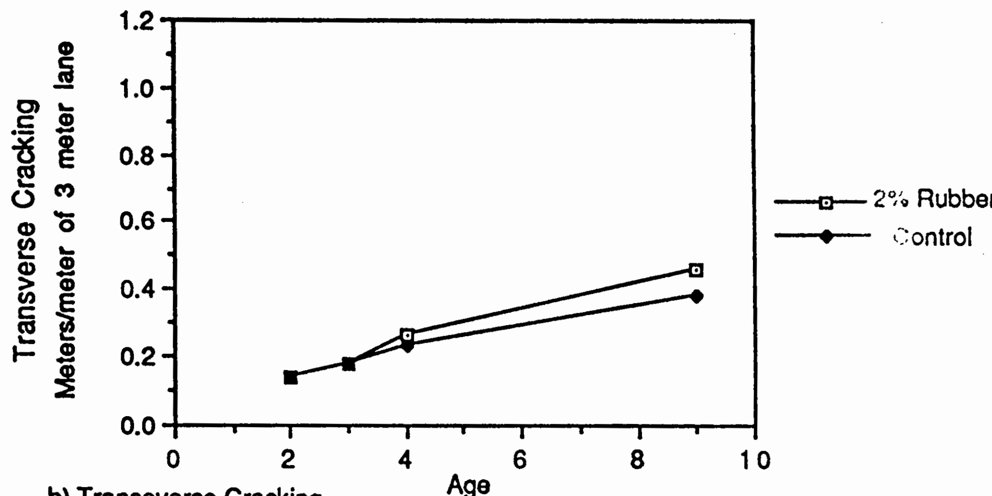


Figure 23. Transverse Cracking versus Age, 2% Rubber, High Distress



a) Longitudinal Cracking



b) Transeverse Cracking

Figure 24. Cracking versus Age,
2% Rubber, All Levels

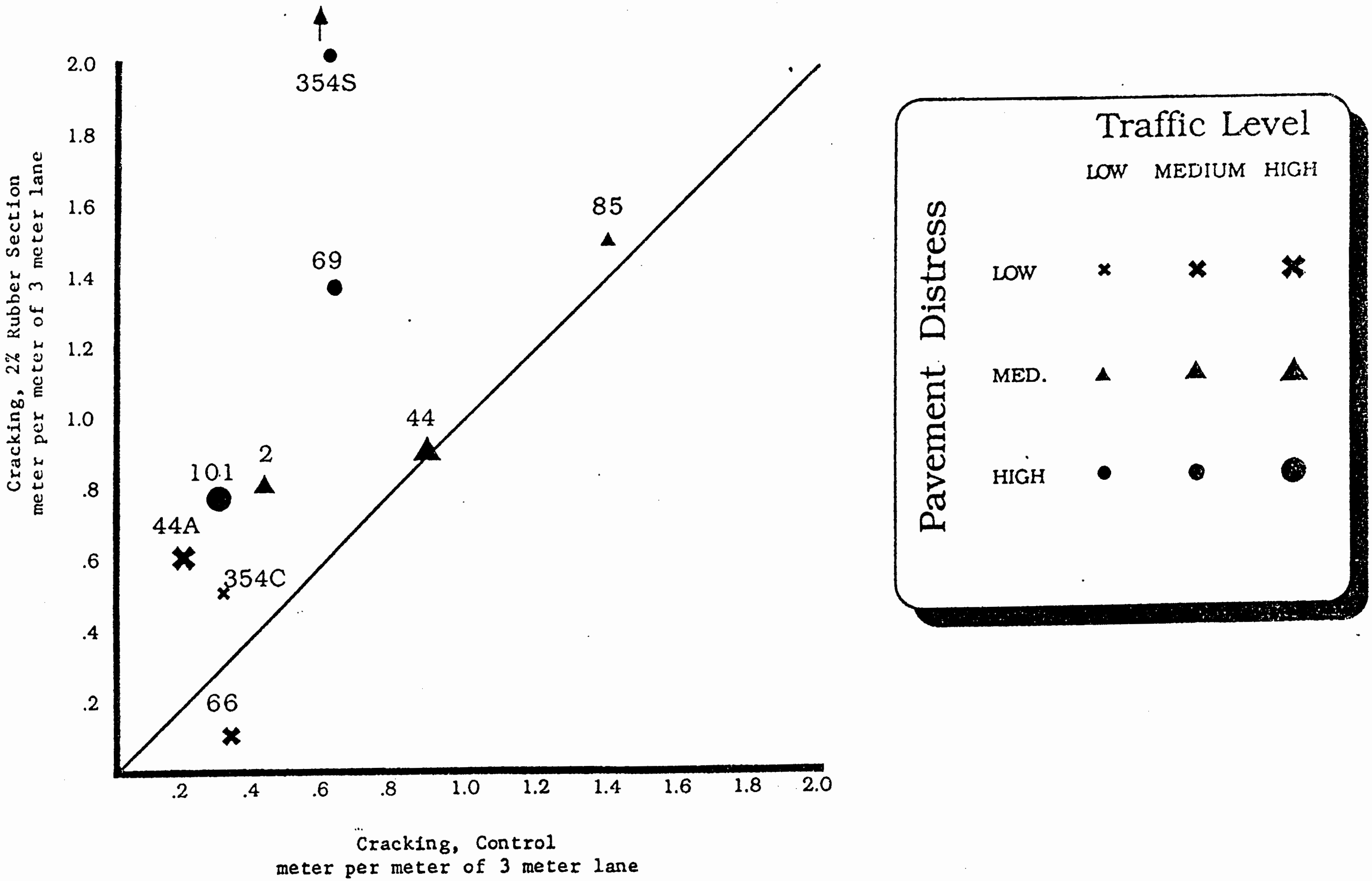


Figure 25. Longitudinal Crack Summary, 2% Rubber

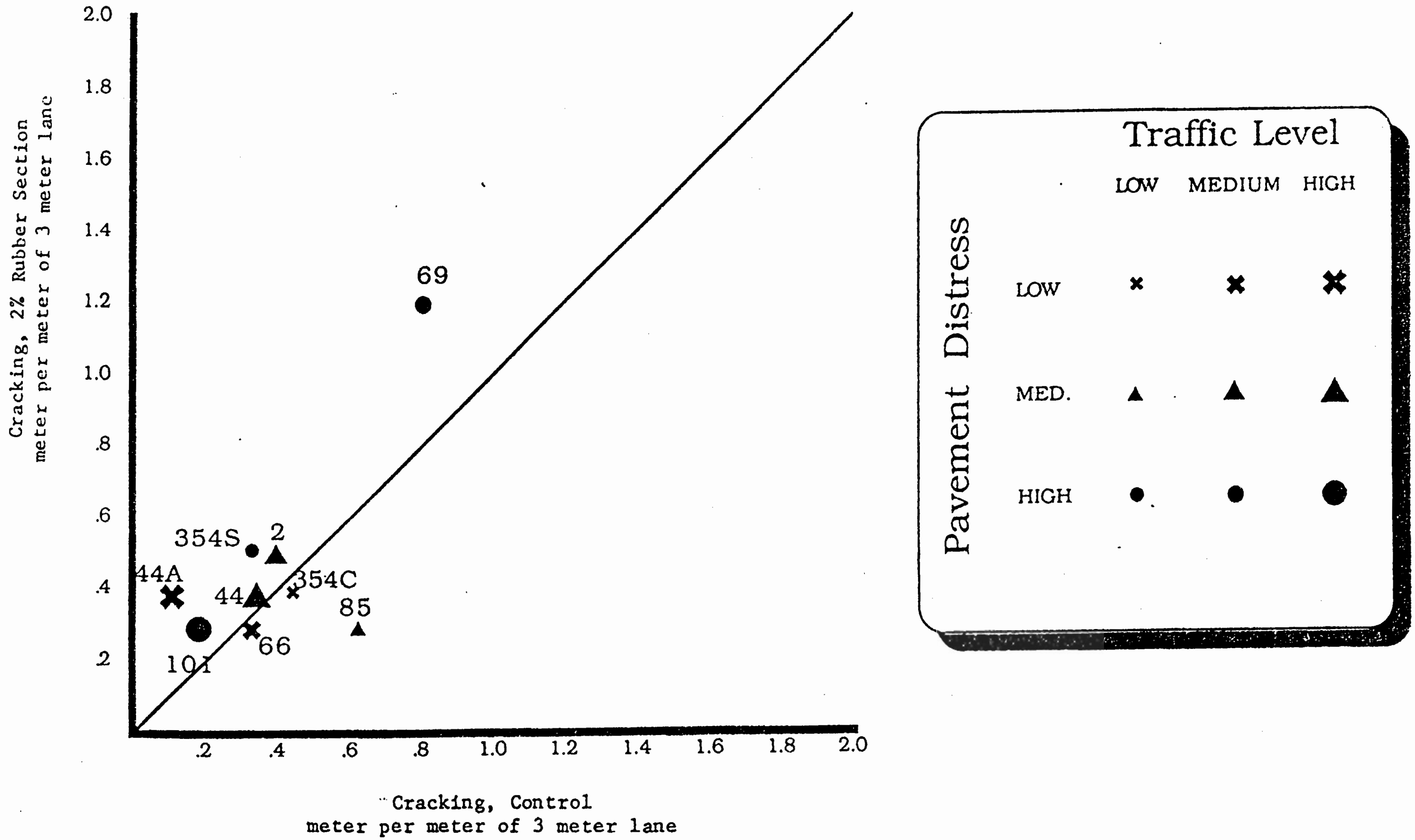


Figure 26. Transverse Crack Summary, 2% Rubber

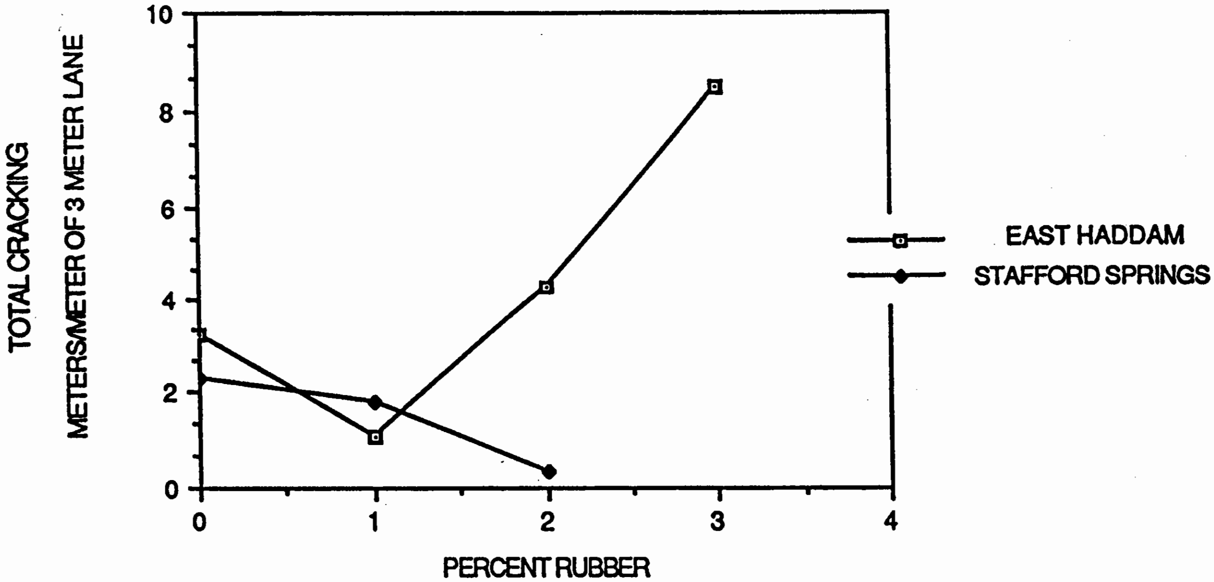


Figure 27. Cracking of Thin Overlays

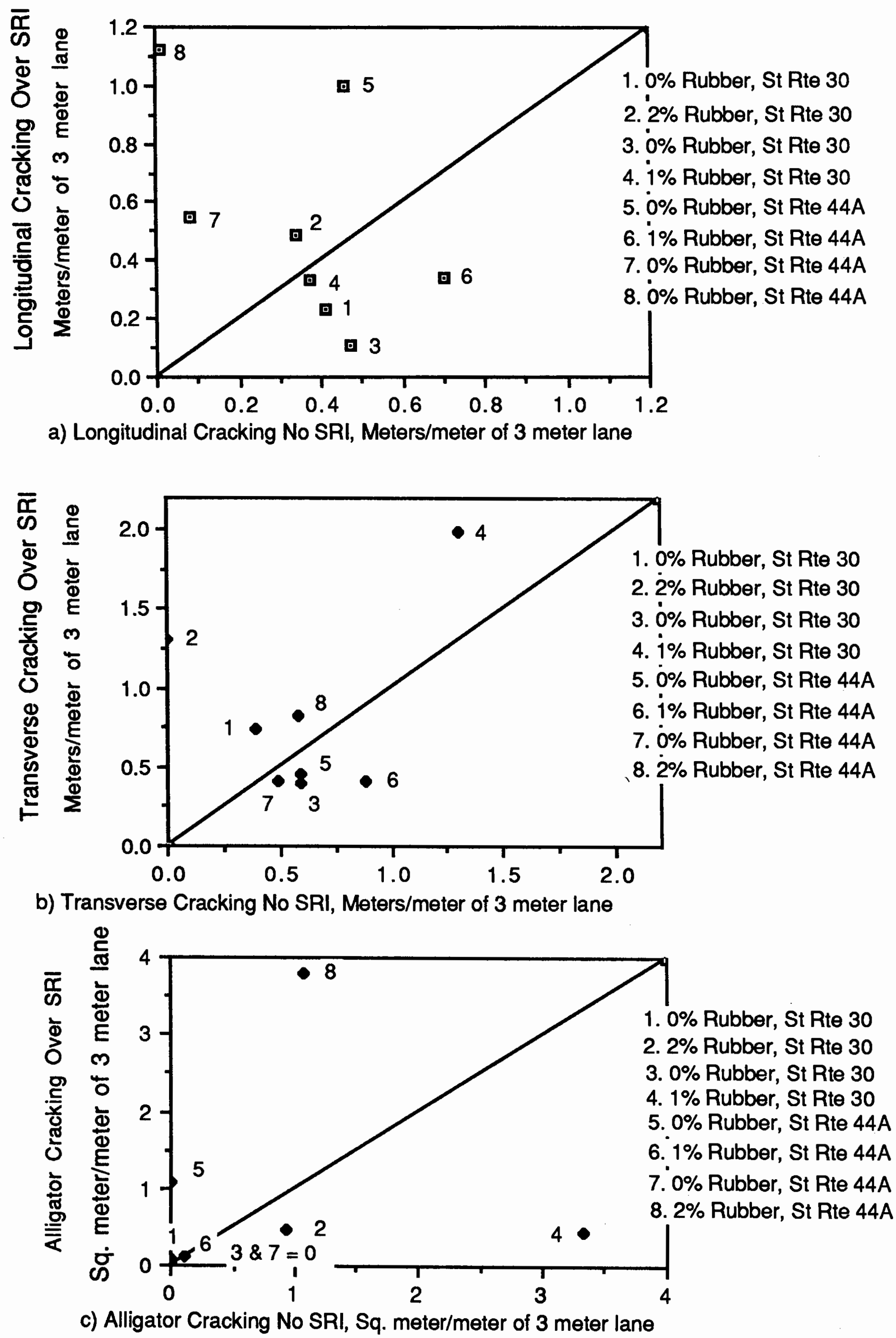


Figure 28. Comparison of Cracking With and Without Stress Relieving Interlayer