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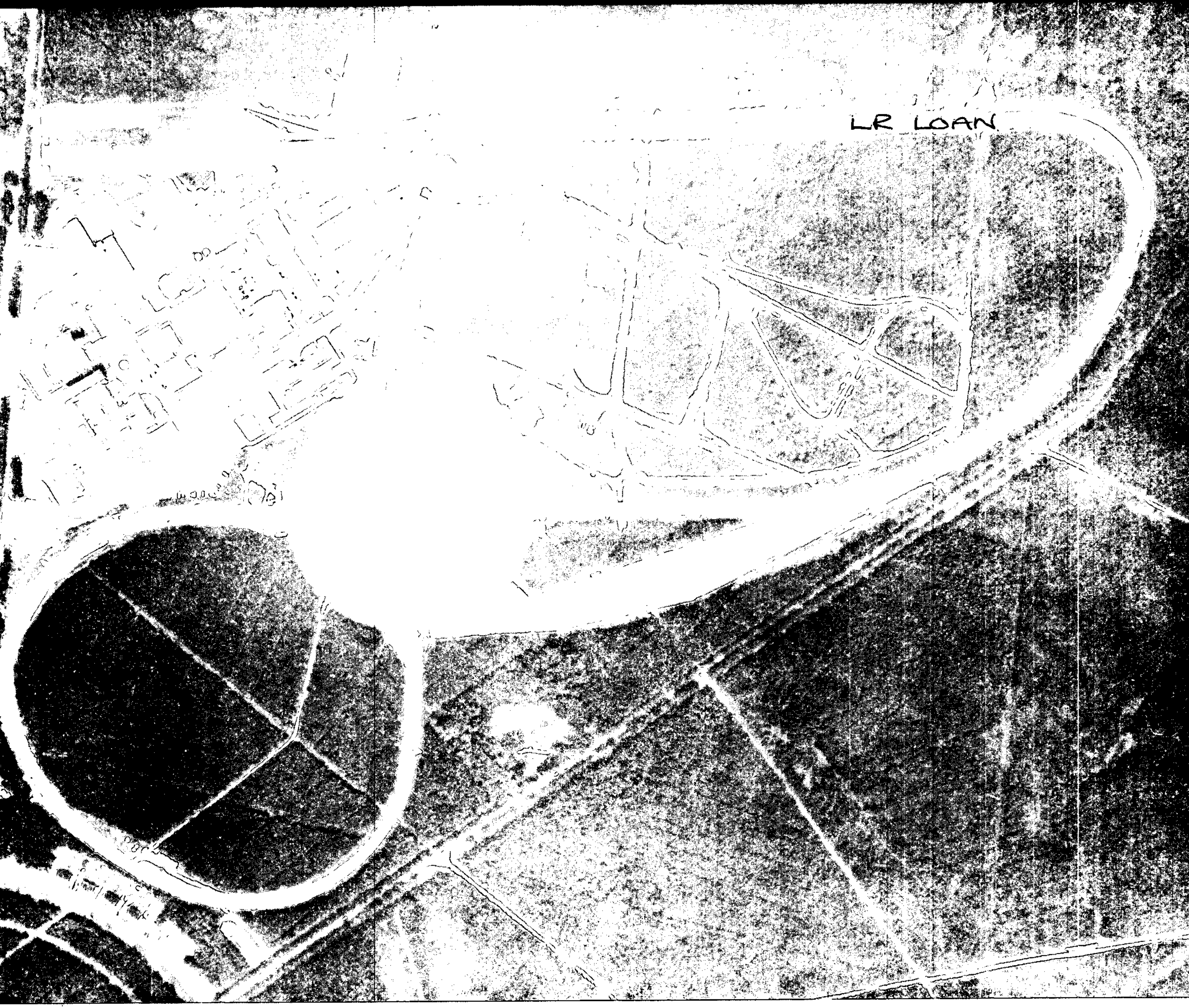
TRANSPORT and ROAD RESEARCH LABORATORY

DEPARTMENT of the ENVIRONMENT



A study of accident rates on rural roads in developing countries

by

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ABSTRACT

The purpose of the study described in this report was to investigate relationships between personal injury accident rates on rural roads in Kenya and Jamaica and factors such as vehicle flow and road geometry.

Regression analysis was used to derive equations which can be used to estimate changes in accident rates following improvements to the geometric design of the road.

The accident rate per kilometre per annum was found to be significantly related to the vehicle flow whilst the rate per million vehicle-kilometres was found to be significantly related to the physical characteristics of the road tested, such as junctions per kilometre, surface irregularity and road width.

Comparisons were made with similar relationships derived in a number of developed countries; the accident rates in Kenya and Jamaica were found to be consistently greater for similar values of vehicle flow and geometric design.

1. INTRODUCTION

Studies of road accidents in developing countries have indicated that accident rates tend to be particularly high on rural roads[1,2]. An analysis of road accidents involving personal injury in Kenya[1], showed that single-vehicle accidents were particularly prevalent on rural roads, being almost 50 per cent of the total number of accidents occurring. In this situation it is probable that design features of the road are a significant factor. Even in Great Britain where the standard of road construction is high compared with most developing countries, the road layout, surface or furniture was found to be a contributory factor in almost 30 per cent of all accidents occurring on mainly rural roads within a defined study area[3]. Work carried out in Oxfordshire[4] in 1937 (when vehicle flows were probably in the order of those in some developing countries at present) concluded that 75 per cent of the accidents would not have occurred had the road conformed to the (then) current Ministry of Transport Memorandum 575 on the Layout and Construction of Roads.

In order to study the relationships between personal injury accident rates and geometric design of the road, data have been collected from Kenya and Jamaica. The primary objective of the investigation was to attempt to correlate the number of accidents per million vehicle-kilometres on a length of road with the design characteristics of the road in order to obtain information which would be of use in formulating principles for the design of safer roads in developing countries. However, relationships derived in this investigation need to be verified by studies on roads in other countries. In particular it is hoped that the relationships derived here and in other countries could eventually be incorporated into the Road Transport Investment Model[5] developed by the Overseas Unit. This Model attempts to minimise the total transport cost of a given project by devising the optimum standard of road construction and design.

2. DATA COLLECTION

In order to correlate accident rates with road design it is necessary to have, for each section of road, the precise location of each personal injury accident taking place over a given period of time, an accurate measurement of traffic flow throughout the year and measurement of factors such as road width, horizontal and vertical curvature, surface irregularity etc. There were very few developing countries where such data were available but it proved possible, by using data from various research studies, to obtain the required information for Kenya and Jamaica.

2.1 Kenya data

During 1974 a visit was made to Kenya by the author to collect information on all personal injury accidents taking place in 1972. In 1975, following collaboration with the Kenya Ministry of Works, details of all injury accidents taking place in 1973 on the Nairobi-Mombasa Road (see Figure 1) were obtained. With this extra road accident data and with accurate traffic flow data available, it was decided to use this road for detailed study.

The Road Transport Investment Model[5], designed by the Overseas Unit to minimise total transportation costs on a given road project, was based on data collected in Kenya over the period 1969-1974. Test sections were set up throughout Kenya, particularly on the Nairobi-Mombasa Road, and the traffic flow and geometric design data collected during that period have been used for this investigation of road accident rates. The road in question was divided into various sections (see Figure 1) with the following information available for each road length:

1) personal injury accidents occurring in 1972 and 1973
2) the length of each section
3) the average annual daily traffic flow
4) the average road width (metres)
5) the number of junctions (per kilometre)
6) the average horizontal curvature (degrees per km)
7) the average vertical curvature (metres per km)
8) surface irregularity (millimetres per km).

From 1) and 2) personal injury accidents per kilometre per annum were obtained, and from 1), 2) and 3) accidents per million vehicle-kilometres were obtained.

2.1.1 Geometric design parameters The road width was the width of the surfaced section of the road excluding the gravel shoulders.

The vertical curvature of a road can be described most easily by its 'average gradient' or its total vertical 'rise and fall'. Neither measure is fully satisfactory but rise and fall was preferred. A method of measuring it from a specially designed and instrumented moving vehicle was developed for the study in Kenya. The development of this technique allowed a high degree of accuracy to be obtained even on roads with irregular surfaces.

Horizontal curvature is simply the 'bendiness' of a road. A particular bend can be defined either by the radius of curvature measured in metres or by the degree of curvature, defined as the angle in degrees between the straight sections of road which are joined by the curve. Althought the latter definition does not differentiate between bends of different radii, it is the most suitable for evaluating the overall effect of a series of bends on accident rates because it is additive and easier to measure. In developed countries where similar studies have been carried out[6,7,8], the accident rate has frequently been correlated with the existing radius of curvature. On busy roads where numerous accidents occur and where high levels of vehicle flow exist, this is probably the most convenient dimension to use.

Surface irregularity is sometimes called the 'riding quality' of the road. A method of measuring surface irregularity was developed from the principles of the 'bump integrator'[9] in which the vertical movements of the axle of a single-wheel trailer are summed over a test section by an integrating clutch. Though necessarily arbitrary, the system that was developed provided an index of the irregularity which was useful for comparing the surface conditions of the test sections.

The parameters obtained for the sections of road used in the analysis are given in Table 1.

2.2 Jamaica data

In 1962 a team was sent by the Laboratory to carry out urban and rural research work in Jamaica. During this period an unpublished report was produced[10] which gave details of accident rates and 'black spots' on rural 'A' and 'B' roads on the island. The accident rates (per million vehicle-miles) were calculated for almost the entire 'A' road network on the island (see Figure 2) and have been used in this present report after converting the rates into metric units. A detailed investigation was also carried out on the deficiencies of the rural road network in Jamaica[11], with detailed inventories being made of the existing rural road system. For each section of rural 'A' road the following parameters were obtained:

1) average width (feet)
2) profile and gradients (per cent)
3) average vertical curvature (ft/mile)
4) average horizontal curvature (degrees/mile)
5) average surface irregularity (in/mile)
6) average sight distance (ft)
7) the number of junctions (per mile)

2.2.1 Geometric design parameters Average road width was obtained by taking five measurements at equal intervals every mile.

The vertical curvature was obtained by measuring the elevation at every crest and hollow and accurately measuring the distances in between. Thus, as in Kenya, the 'rise and fall' per unit length of road was obtained. The gradient was obtained by using an Abney level mounted in a survey car and modified to read grade directly.

As in Kenya, the horizontal curvature was measured in terms of degree of curvature or 'bendiness' per unit length of road, but in this case was obtained by taking measurements from 1 : 12,500 scale land valuation maps.

The average surface irregularity (see above) for each section of road was obtained by using a towed bump integrator where, as described above, the vertical movement of a wheel relative to its mounting was measured, thus providing a measure of the unevenness of the road surface.

The average sight distance of each section was obtained by measuring how far ahead a driver could see an obstruction on the road. Measurements were made by putting down markers at 100 ft intervals along the road and, at each marker, counting how many markers could be seen on the road ahead. Twelve-inch high rubber cones were used as markers. This method has the advantage of simplicity and speed. The average sight distance was calculated from the total of the numbers of cones counted in the section and the number of observations made within the section.

The parameters obtained for the sections of road used in this analysis are given in Table 2.

3. ANALYSIS PROCEDURE

Regression analysis was used to establish and quantify relationships between one dependent variable and one or more independent variables. (The first variable, which is the quantity under study, is known as the dependent variable and the others are defined as the independent variables.)

In this investigation four dependent variables were studied separately.

1) personal injury accidents per kilometre per annum Kenya
2) personal injury accidents per kilometre per annum Jamaica
3) personal injury accidents per million vehicle-kilometres Kenya
4) personal injury accidents per million vehicle-kilometres Jamaica.

The choice of independent variables implied that they were 'sensibly' related to the dependent variable. In this study, a further condition in choosing independent variables was that they should be simple to define and, for an engineer working in the field, reasonably easy to measure.

As a preliminary investigation of which variables were most closely correlated with accident rate, simple regressions of accident rate on each of the road features individually, were performed. Equations derived were of the form:

$$y = a + b_1 x_1$$

where

y = independent variable
x_1 = dependent variable
a = regression constant
b_1 = regression coefficient

However because many of the road design features are inter-related simple regression analysis may give a misleading impression of the relationships that they have with accident rate. Multiple regression, in which the accident rate is expressed as a function of several 'independent' variables simultaneously, is likely to be a better guide.

Equations derived were then of the form:

$$y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 \ldots\ldots b_n x_n$$

where $y, x_1, x_2, x_n, b_1, b_2, b_n$ were as above.

For these estimates to be acceptable it was necessary to test the hypothesis that the value computed for each regression coefficient was unlikely to have arisen by chance. To check this, the standard error of each regression coefficient was computed and tested for significance; variables with non-significant co-efficients were eliminated from the analysis.

The computer program used was part of a statistical package and had an automatic procedure for eliminating non-significant variables and for testing such variables with other combinations and replacing them where necessary. This technique is known as 'stepwise' regression analysis.

Data obtained on rural roads in Kenya and Jamaica were analysed separately.

4. RESULTS

From the analysis, equations were derived which related accidents per kilometre per annum to vehicle flow and accidents per million vehicle-kilometres to the geometric parameters. Table 3 gives the maximum, minimum and means of the parameters obtained on the rural roads studied. The standard deviation, which measures the variance about the mean, is also given.

4.1 The relationships between accident rate and vehicle flow

The number of injury-accidents per kilometre of road per annum occurring on rural roads in Kenya and Jamaica were regressed against the vehicle flow per hour occurring on each test section of road (averaged over a 12-hour 7am – 7pm period). In both cases the accident rate was found to be related to the vehicle flow (with results being statistically significant at the 5 per cent level). The equations derived were as follows:

For Kenya $y = 0.116 + 0.0091x$
For Jamaica $y = 0.158 + 0.0126x$

where y = personal injury accidents per km per annum
x = average vehicle flow/hour.

Figure 3 illustrates how the accident rate in both countries increases with increasing flow. (Figure 3 also shows a relationship derived for a number of developed countries; this is discussed later). It can be seen from Fig 3 that, for a similar rate of vehicle flow, Jamaica has a higher accident rate than Kenya.

In order to investigate relationships between geometric design and accident rates, the number of accidents per kilometre of road per annum were divided by the vehicle flow per annum on each section of road, to obtain the number of personal-injury accidents per million vehicle-kilometres. In this way the relationship between vehicle flow and the accident rate is taken into account.

4.2 The results of the simple regression analysis

The results of the simple regression analysis are given in Table 4. The 't' value is the ratio of the regression coefficient to the standard error and was used to test whether the relationship was statistically significant (ie were unlikely to have occurred by chance). The tables indicate the relationships which were found to be significant at the 5 or 10 per cent level. (Note: 5 per cent is the level usually accepted in statistical analysis, ie there is only a 5 per cent probability that the relationship could have occurred by chance. Bearing in mind the many factors affecting accident rates, a relationship found significant at the

10 per cent level in this study could be considered satisfactory). The correlation coefficient r is also given. The value r^2 provides a measure of the proportion of variability in y that is accounted for by variability in the appropriate x value. Thus, for example in Kenya, junctions per kilometre was found to be the most significant independent variable. The r^2 value of 0.49 indicates that 49 per cent of the variation in accident rate is 'explained' by variation in the number of junctions per kilometre alone.

In both countries the most significant parameter of those considered in this study was found to be the number of junctions per kilometre. The correlation between the junctions and the accident rate was greater on the Nairobi-Mombasa road, Kenya, than in Jamaica but as can be seen from Figure 4, the ranges were quite different in the two countries. In Kenya where there were never more than two junctions per kilometre an addition of one junction per kilometre was associated with an increase in the accident rate of over one accident per million vehicle-kilometres. In Jamaica, where there were often as many as eight junctions per kilometre, an increase of three junctions per kilometre would increase the accident rate by one accident per million vehicle-kilometres.

On the Jamaican 'A' roads, road width was also a very significant factor, the wider the road the lower the accident rate (see Figure 5). On the Nairobi-Mombasa road, there was very little variation in the road width and the small amount of variation (see Table 3) has not provided a significant relationship with accident rate.

In both countries the surface irregularity was related to the accident rate: the rougher the road the higher the number of accidents per million vehicle-kilometres. In Jamaica the relationship was statistically significant at the 5 per cent level whilst in Kenya it was significant at the 10 per cent level. (Again, in Jamaica, the range was greater than in Kenya). The effect of surface irregularity was very similar in both countries; an improvement in roughness of 2000 millimetres per kilometre was associated with a reduction in the accident rate of 0.8 accidents per million vehicle-kilometres per annum.

In Kenya the horizontal curvature was found to be significantly related to the accident rate, a decrease of 35 degrees per kilometre reducing the accident rate by one accident per million vehicle-kilometres. In Jamaica neither horizontal curvature nor sight distance was found to be a significant factor. This is a somewhat surprising result since the range of horizontal curvature is much greater in Jamaica than in Kenya.

4.3 Multiple regression analysis

The results obtained in the previous section show how various features of the road considered separately were related to the accident rate. In order to determine how the combined factors are associated with the accident rate, multiple regression analyses as described in Section 3 were carried out.

Parameters were given the following notation

y = accident rate per million vehicle-kilometres

x_1 = road width (metres)

x_2 = vertical curvature (m/km)

x_3 = horizontal curvature (deg/km)

x_4 = surface irregulatiry (mm/km)

x_5 = junctions per kilometre

x_6 = sight distance (metres)

The regression equation of factors related to the accident rate (significant at the 5 per cent level) in Kenya was as follows:

$$y = 1.45 + 1.02x_5 + 0.017x_3$$

(Note: The independent variables in this equation and those below are listed in order of significance; thus, in Kenya, junctions per kilometre was found to be the variable which had greatest 'effect' on the accident rate).

Other parameters were not significant at the 5 per cent level but were at the 10 per cent level. Although 5 per cent is the level normally accepted in statistical analysis, in this case, taking into account the limitations of the data, the 10 per cent level might be considered acceptable. The equation for Kenya then becomes

$$y = 1.09 + 0.031x_3 + 0.62x_5 + 0.0003x_4 + 0.062x_2$$

The 'effects' of surface irregularity and vertical curvature are considerably less than those of junctions per kilometre and horizontal curvature. Nevertheless they are worth including, particularly surface irregularity where, for example, the improvement under consideration is the upgrading of a gravel road to a bituminous-surfaced road and the change in riding quality may be considerable.

The multiple regression equation for Jamaica (with parameters significant at the 5 per cent level) was as follows

$$y = 5.77 - 0.755x_1 + 0.275x_5$$

In this equation, road width was the variable most closely associated with the accident rate. In section 4.2 it was seen that, in Jamaica, the accident rate was related separately to road width, junctions per kilometre and surface irregularity (all at the 5 per cent level). In the multiple regression analysis however, it was found that surface irregularity was not significant (even at the 10 per cent level). The reason for this is that surface irregularity and road width were themselves related, the correlation between the two variables being significant at the 5 per cent level. The most significant factor (road width) enters the equation first and since this is closely related to surface irregularity, it aslo 'explains' most of the variation associated with surface irregularity, which was therefore found to be non-significant.

4.4 Comparison of the Kenya and Jamaica results with those from other countries

In January 1973 Silyanov published the results of a comparison of accident rates on roads of different countries[12]. This work has enabled a comparison to be made between the relationships derived in Kenya and Jamaica with those obtained on rural roads in developed countries.

Silyanov examined the relationships between accidents per kilometre of road per annum and traffic flow derived by workers in Russia[13], Sweden[14] and Australia[15] and, grouping the results from the different countries together, found that the relationship between accidents and vehicle flow could be expressed by the formula:

$$y = 0.256 + 0.000408N + 1.36(10^{-7})N^2$$

$$\text{for } 40 < N < 1600$$

where y = number of personal injury accidends per km/pa

N = vehicle flow/hour

This equation has been plotted on Figure 3 and, as can be seen, the accident rate in Kenya and Jamaica is very much greater than in the above developed countries for a similar level of vehicle flow. (This comparison should be treated with caution because there were few instances where Silyanov found flow levels below 200 vehicles per hour). For example, at a flow level of 100 vehicles/hour, the accident rate in Kenya is over three times greater than in the developed countries and the rate in Jamaica is almost five times greater. These greater accident rates could be due to the quality and condition of the road or possibly to driver behaviour.

The number of junctions per kilometre was found to be significantly related to accident rates in Kenya and Jamaica and this has been compared with results of early work carried out in Great Britain in 1946-48[16]. The result of this work has been plotted on Figure 4 and it shows that for the same number of junctions per kilometre the accident rate per million vehicle-kilometres was similar in Great Briatin and in Jamaica. (The accident rate in Kenya, however, was very much higher than in either Jamaica or Great Britain but the range of the number of junctions per kilometre is obviously different from that in the other two countries and comparisons are not really valid).

In Jamaica the road width was an important factor and, by combining results from Great Britain, France[17], Hungary[18], West Germany[19] and the United States[20], Silyanov also related accidents to road width according to the formula:

$$y = 1/(0.173B - 0.21)$$

where y = number of accidents per million vehicle-kilometres

B = road width in metres ($4 < B < 9$)

This relationship has been plotted on Figure 5 and it can be seen that, for the same road width, the accident rate is greater in Jamaica than in the developed countries. This difference is greatest at low road widths; for example with a road width of 5 metres, the accident rate in Jamaica is over twice that of the developed countries.

Although sight distance was not found to be a significant factor in Jamaica it is interesting to compare the accident rates in Jamaica for different levels of sight distance with those found by Silyanov. According to Silyanov the sight distance can be related to accidents by the formula:

$$y = 1/(0.20 + 0.0011d + 0.0000009d^2) \quad \text{for } 25 < d < 800$$

where y = accident rates per million vehicle-kilometres

d = sight distance (metres)

According to the formula, at sight distances of 100 and 200 metres, the accident rates would be about 3.0 and 2.0 per million vehicle-kilometres per annum respectively. Over this range of sight distance in Jamaica, most of the sections had accident rates of between 3.0 and 4.0 accidents per million vehicle-kilometres.

Thus from this comparison it would seem that the accident rates in Kenya and Jamaica are considerably greater than in developed countries for similar levels of geometric design.

5. CONCLUSIONS

From data obtained from various sources in Kenya and Jamaica, it has proved possible, using multiple regression analysis to relate the accident rates on rural roads in these countries to certain design characteristics of the road. In Kenya, the accident rate per million vehicle-kilometres was significantly related to the number of junctions per kilometre, the horizontal curvature, the vertical curvature and the surface irregularity. In Jamaica, it was found to be related to road width, and, again, junctions per kilometre.

Engineers and planners may wish to use these regression equations in other developing countries to obtain estimates of changes in accident rate following given road improvements where traffic and road conditions are similar to those described here. However since the equations derived are different in Kenya and Jamaica it would be difficult to decide which equation to use. Where conditions were similar to those on the Nairobi-Mombasa road, the equation derived from the Kenya data would appear the more appropriate. Similarly, where there were greater extremes of horizontal and vertical curvature and surface irregularity the equation derived for Jamaica may be more appropriate. However there was little variation in road width on the Nairobi-Mombasa road and this did not appear to be a significant parameter, whereas in Jamaica it was the most important parameter. Thus where a road was being widened it might be difficult to decide which was the most sensible equation to use particularly if conditions were similar to those on the Nairobi-Mombasa road.

Before the equations can be used with certainty and, for example built into the Road Transport Investment Model, they need to be verified and adjusted by carrying out similar analyses on other roads in other countries.

It would appear from the comparison of results obtained in Kenya and Jamaica with those from developed countries that the accident rate in the two developing countries was considerably higher than in the developed ones for similar levels of vehicle flow and geometric design. It is quite likely therefore that other factors are involved, such as road user behaviour and vehicle condition and maintenance. It is intended that these factors will be the subject for future research.

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TABLE 1

Data for sections on Nairobi-Mombasa Road, Kenya

Section Number	Personal Injury Accidents/ Million Veh-km/ annum	Average Road Width (metres)	Vertical Curvature (m/km)	Horizontal Curvature (deg/km)	Surface irreg (mm/km)	Junctions/ km
1	2.93	6.1	10.02	19.42	2300	0.66
2	2.17	6.1	1.36	4.59	2300	0.39
3	2.32	6.1	0	0.73	3030	1.43
4	2.82	6.1	5.40	12.54	3264	0.67
5	3.54	6.1	5.40	35.53	3086	0.43
6	1.67	6.1	14.6	40.72	3086	0.56
7	2.83	6.1	14.6	49.74	3308	0.32
8	2.67	6.1	14.6	16.98	3308	0.35
9	1.08	6.1	15.0	2.08	3308	0.12
10	2.11	6.1	15.0	31.5	3308	0.43
11	2.42	6.1	1.41	1.19	3308	0.32
12	1.88	7.0	2.62	5.07	3308	0.17
13	4.60	7.0	8.88	53.79	3308	1.94
14	1.96	7.0	5.59	12.73	1633	0.14
15	1.33	7.0	4.45	4.78	1633	0.12
16	1.54	7.0	5.04	7.22	1633	0.26
17	1.91	7.0	13.02	38.90	1633	0.21
18	1.67	7.0	1.91	10.42	1633	0.31
19	2.29	7.5	11.12	30.44	1488	0.56

TABLE 2

Data for sections of rural A roads, Jamaica

Section	Total Injury Accidents per million veh-km	Average width (metres)	Vertical Curvature (metres/km)	Horizontal Curvature (deg/km)	Surface irreg. (mm/km)	Sight Distance (metres)	Junctions per kilometre
1	2.16	7.32	2.43	25.40	2822.8	237.29	4.80
2a	3.05	6.92	3.27	47.70	3879.4	209.54	6.64
2b	1.96	6.10	12.41	134.41	4904.5	126.58	6.81
3a	3.70	6.13	9.29	102.86	4809.9	146.40	7.73
3b	3.71	5.89	35.93	274.16	5109.5	96.38	8.32
4a	2.47	6.25	51.36	322.42	4557.5	106.75	4.84
4b	1.37	6.68	19.10	130.62	4368.3	139.69	5.88
5a	1.04	6.34	8.93	111.12	3122.5	168.67	2.51
5b	3.01	5.64	7.56	124.66	4604.8	133.29	3.18
6	6.17	5.43	8.09	184.66	4967.6	127.80	8.19
8	2.78	6.22	11.23	199.63	4257.9	122.00	5.40
9	1.61	6.41	1.77	97.95	3800.6	163.79	3.76
10a	1.95	6.50	14.73	148.32	4872.9	134.81	3.12
10b	2.25	6.59	6.08	106.71	3311.7	169.58	4.61
11a	1.85	5.86	11.31	133.04	4683.7	131.76	4.49
11b	3.37	5.22	20.94	249.63	4967.6	110.41	7.17
12	1.52	5.09	12.79	273.04	6103.0	110.41	3.27
13a	1.88	5.37	11.50	243.48	5850.7	105.84	6.50
13b	4.06	5.09	15.68	339.57	6039.9	95.47	4.53
14a	3.02	4.97	18.89	250.75	4731.0	92.11	5.75
14b	3.19	5.34	13.36	180.62	4857.2	118.34	4.24
15a	5.00	5.43	15.58	138.32	5456.4	135.73	4.42
15b	3.31	5.76	17.21	219.13	6087.2	111.63	6.37
16	2.25	5.55	29.79	368.32	4936.0	80.52	8.01
17a	1.73	6.65	8.87	161.18	4321.0	117.73	2.83
17c	0.95	7.59	22.31	38.32	2192.0	149.45	4.35
17d	1.17	5.98	39.56	423.60	6087.2	68.63	1.17
17e	3.40	5.43	29.62	346.34	6986	71.98	3.88
18	2.61	5.40	40.87	232.42	5945.3	96.99	2.61

TABLE 3

Variation in Parameter values

Parameter	Maximum	Minimum	Mean	Standard Deviation
KENYA				
Average width (metres)	7.50	6.10	6.50	0.500
Vertical curvature (m/km)	15.00	0	7.91	5.41
Horizontal curvature (deg/km)	53.80	0.73	20.0	17.33
Surface irregularity (mm/km)	3308	1488	2625	770.5
Junctions/km	1.94	0.12	0.49	0.460
JAMAICA				
Average width (metres)	7.6	4.97	6.00	0.68
Vertical curvature (m/km)	51.35	1.77	17.26	12.33
Horizontal curvature (deg/km)	423.6	25.4	193.4	102.86
Surface irregularity (mm/km)	6991.1	2193.0	4783.0	1081.7
Junctions/km	8.32	1.17	5.01	1.89
Average sight distance (metres)	237.3	68.6	126.9	37.60

TABLE 4

Results of simple regression analysis

a) Kenya

Independent Variable	Regression Constant a	Regression Coefficient b	Correlation Coefficient r	t value	Level of Statistical Significance
Av width (m)	3.9166	-0.2482	0.1507	-0.6287	not sig at 10%
Vertical curvature (m/km)	2.2846	0.0022	0.0145	0.0601	not sig at 10%
Horizontal curvature (deg/km)	1.7674	0.0268	0.5645	2.8201	sig at 5%
Surface irregularity (mm/km)	1.1837	0.0004	0.3984	1.7907	sig at 10%
Junctions per kilometre	1.6855	1.2476	0.6968	4.0061	sig at 5%

b) Jamaica

Independent Variable	Regression Constant a	Regression Coefficient b	Correlation Coefficient r	t value	Level of Statistical Significance
Av width (m)	7.6658	-0.8418	0.4802	-2.8445	sig at 5%
Vertical curvature (m/km)	2.6969	-0.0033	0.0346	-0.1798	not sig at 10%
Horizontal curvature (deg/km)	2.3654	0.0014	0.1224	0.6407	not sig at 10%
Surface irregularity (mm/km)	0.7750	0.00039	0.3643	2.10	sig at 5%
Av sight distance (metres)	3.1711	-0.0042	0.1324	-0.6941	not sig at 10%
Junctions per kilometre	1.1082	0.3054	0.4847	2.8797	sig at 5%

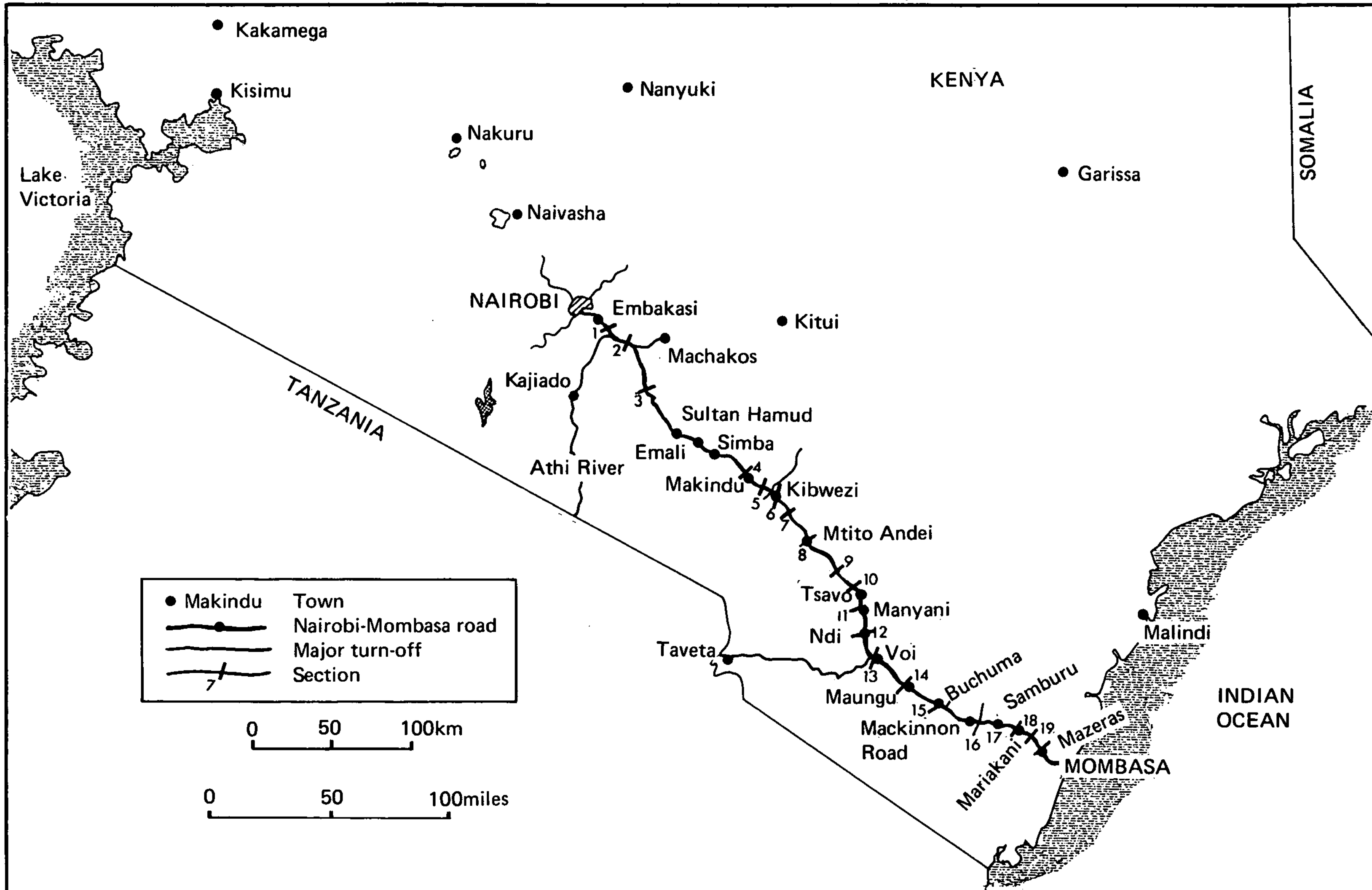

Fig. 1 MAP OF SOUTHERN KENYA (Showing Nairobi–Mombasa road and sections)

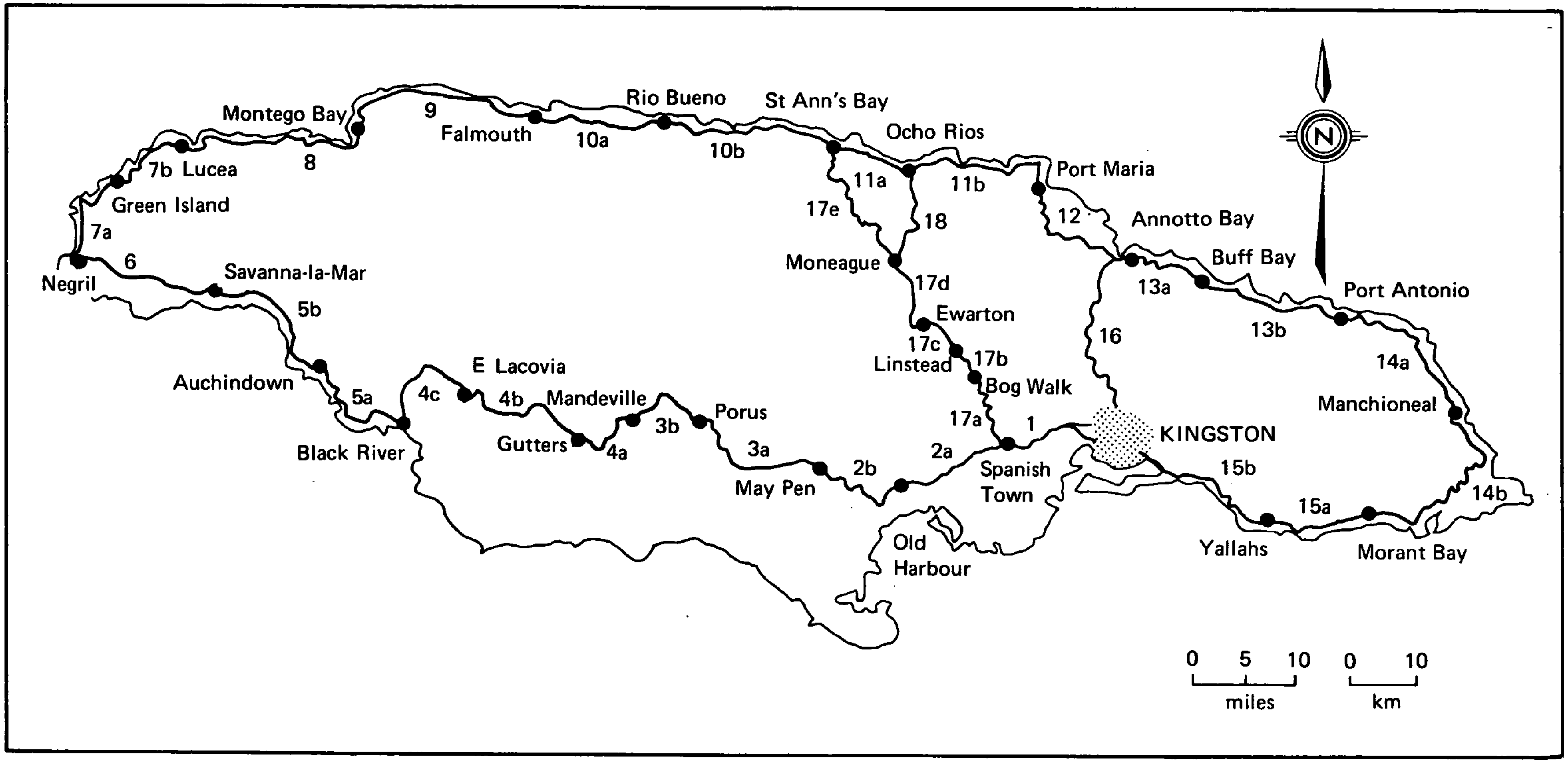

Fig. 2 MAP OF JAMAICA (Showing Class A roads and sections)

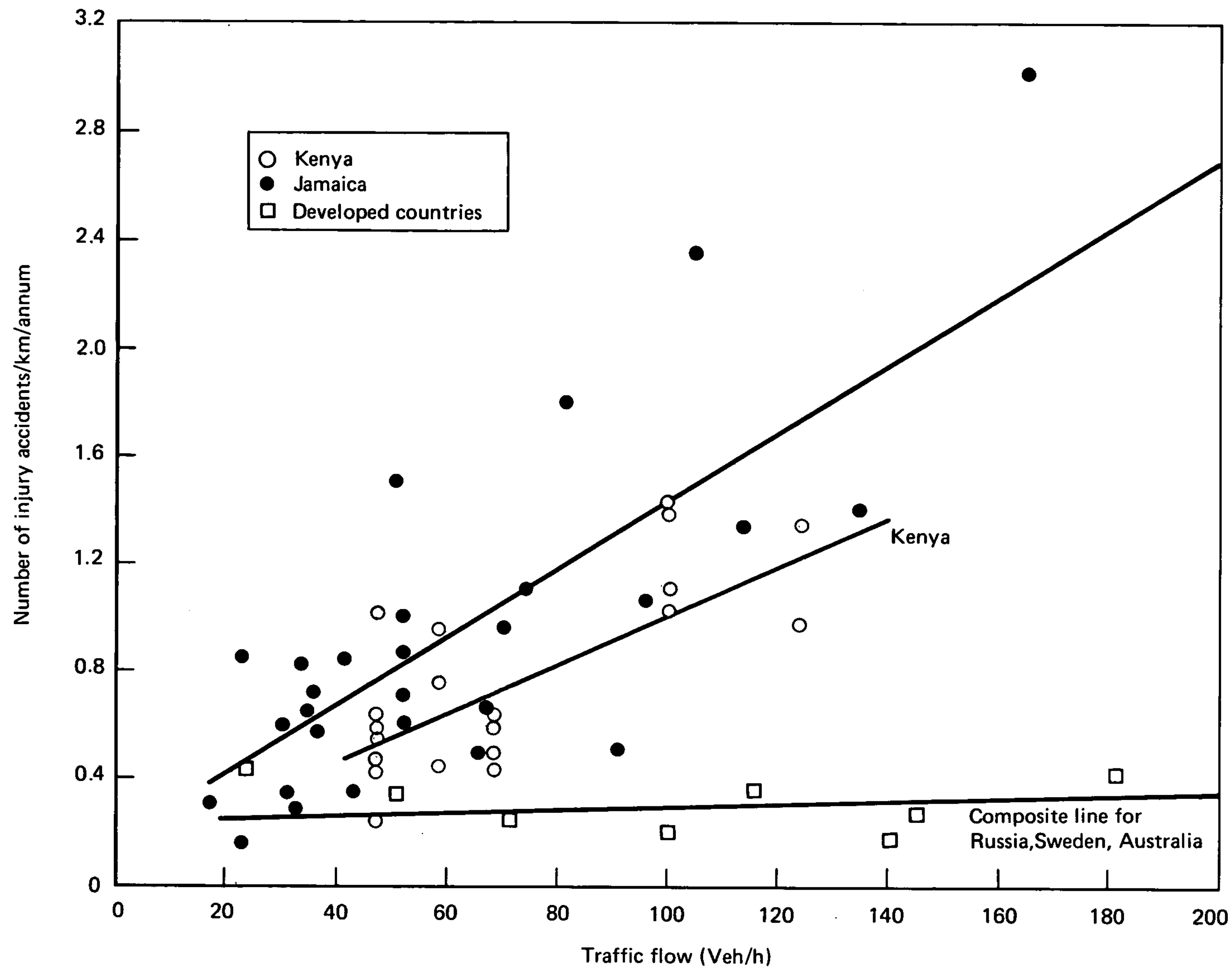

Fig. 3 COMPARISON OF ACCIDENT RATES AND VEHICLE FLOW FOR VARIOUS COUNTRIES

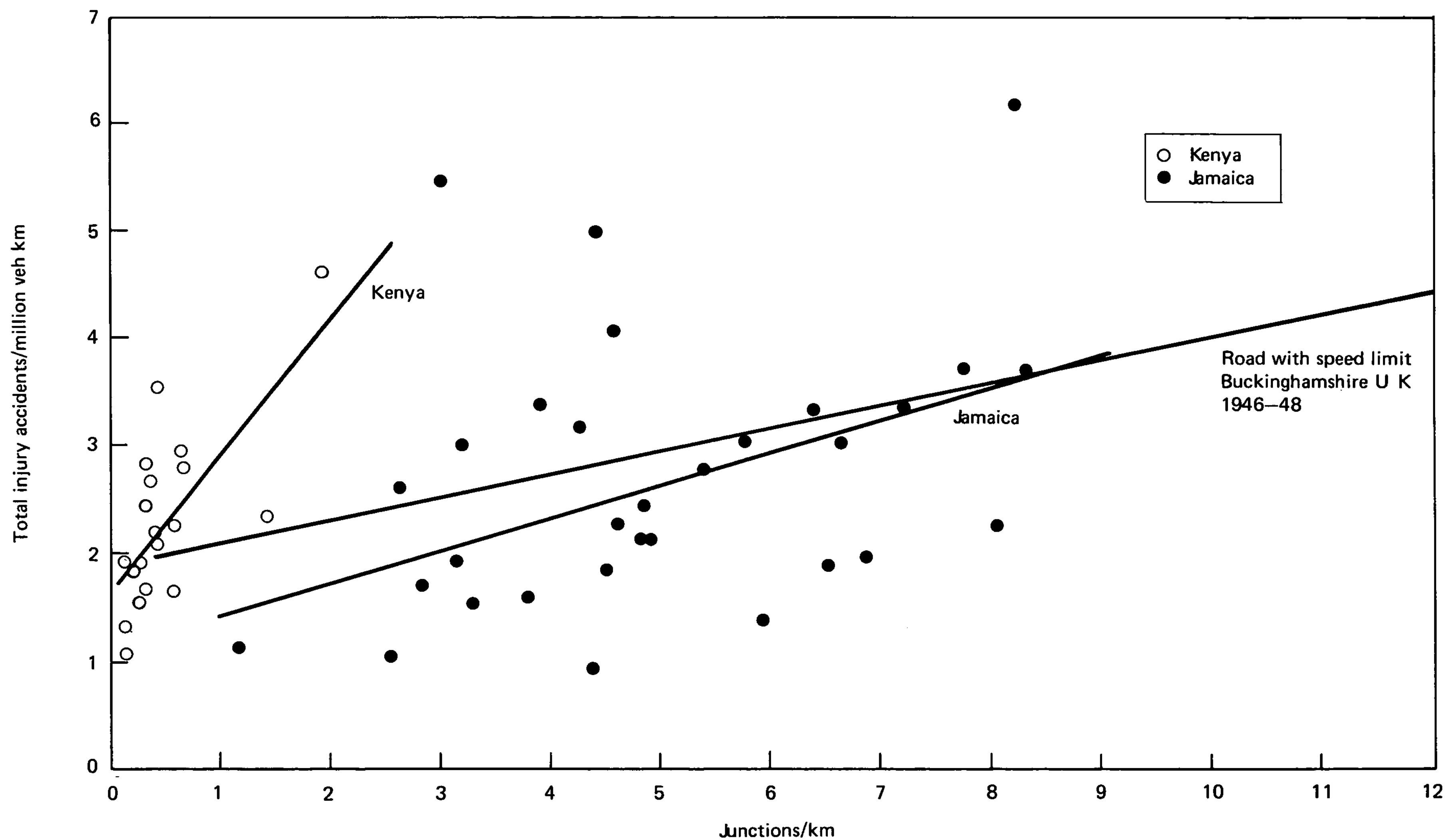

Fig. 4 COMPARISON OF ACCIDENT RATE AND FREQUENCY OF JUNCTIONS FOR KENYA JAMAICA AND BUCKINGHAMSHIRE, UK

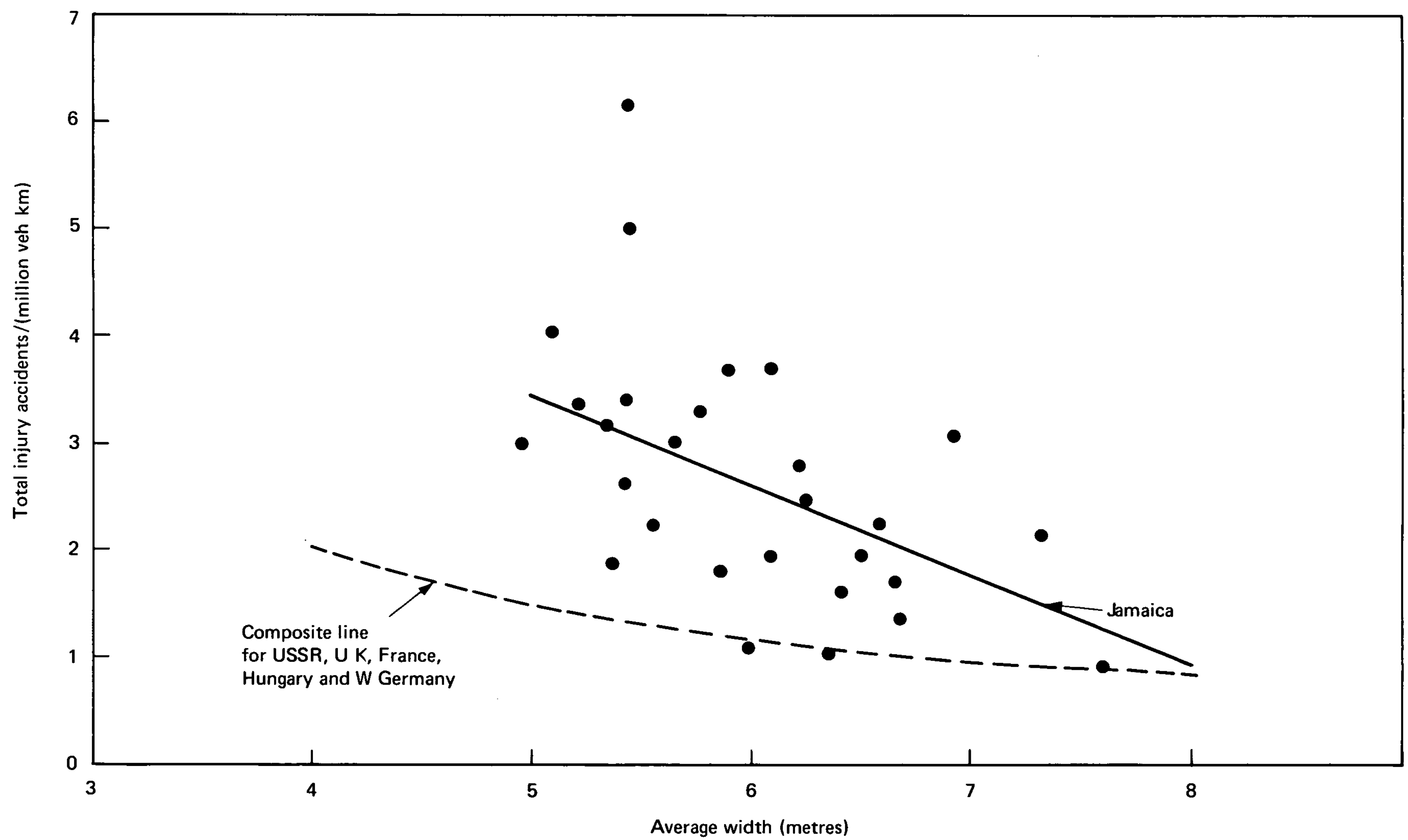

Fig. 5 ACCIDENT RATE/ROAD WIDTH

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ABSTRACT

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Regression analysis was used to derive equations which can be used to estimate changes in accident rates following improvements to the geometric design of the road.

The accident rate per kilometre per annum was found to be significantly related to the vehicle flow whilst the rate per million vehicle-kilometres was found to be significantly related to the physical characteristics of the road tested, such as junctions per kilometre, surface irregularity and road width.

Comparisons were made with similar relationships derived in a number of developed countries, the accident rates in Kenya and Jamaica were found to be consistently greater for similar values of vehicle flow and geometric design.

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