CHARACTERISTICS OF DISABLED VEHICLES ON ENGLAND'S YORKSHIRE AND LANCASHIRE MOTORWAYS

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An analysis of the records of calls reporting breakdowns received from the emergency telephone system on 2 sections of the British motorway system has been carried out to determine the factors that influence the rate of vehicle disablement on British limited-access highways.

•EMERGENCY telephone calls received during a 7-month period on Yorkshire motorways and during summer weekends for a 3-month period on Lancashire motorways have been examined, and the hourly, weekly, and monthly patterns of reported disablements have been determined. The basic relationships between reported disablements and traffic flow for the mainly business and commercial flows in Yorkshire and the mainly recreational flows in Lancashire were determined. Similar rates were found for both situations. Hourly, daily, and monthly patterns of traffic flow and reported disablements were observed and compared. Distribution of age based on first registration for disabled vehicles has been investigated together with the suspected cause of the disablement. The proportion of disablements due to faults that could be corrected at the roadside was found.

An attempt has been made to correlate breakdown rate with climatic variation by using mean ambient temperature as an independent variable. Membership in the Automobile Association (AA) and the Royal Automobile Club (RAC), both of which give help to disabled vehicles, of occupants of disabled passenger cars was also noted to be a significant factor in the operation of the emergency telephone system.

The need for facilities to enable users of the British limited-access motorway system to summon aid in the event of accident or vehicle disablement has long been recognized. The British motorway system consists of 2 carriageways separated by a central reservation. Each carriageway is normally composed of 3 traffic lanes together with a hard shoulder or emergency lane. Emergency telephones are located in pairs on opposite sides of the motorway at 1-mile (1.6-km) intervals. Communication with the driver in the event of an emergency on the British motorway system is handled by the police. Information is received at the police traffic control room primarily from the emergency telephones and, less frequently, from police patrols. The objective of the emergency telephone system is to provide motorists with a communication link that reduces the time required to obtain aid. The telephone system also is believed to be effective in reducing hazards and congestion caused by disabled vehicles, which thus increases the safety of motorists and maximizes highway capacity.

Research is currently being carried out at the University of Bradford into the cost effectiveness of this system and into the likely benefits of other disabled vehicle location-and-aid systems that could be introduced as alternatives to emergency telephones.

As an initial step in evaluating any disabled vehicle location-and-aid system it is necessary to determine the nature and frequency of vehicle stoppages on the highway system that are caused by breakdowns. To obtain this information we have analyzed the motorway emergency telephone records on disabled vehicles on the West York-

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shire and Lancashire motorways. In West Yorkshire attention was focused on vehicle disablements throughout the whole week. In the analysis of the Lancashire records, however, Saturday and Sunday were studied because this is when most vehicles travel for leisure purposes. By selecting 2 differing study periods we hoped to determine the difference between the characteristics of vehicle disablements on a motorway carrying mainly commercial and business traffic and those on a motorway carrying recreational or holiday traffic.

The motorways selected for study, which are shown in Figure 1, are as follows:

1. M1 between junctions 30 and 43 [41 miles (66 km)],
2. M62 between junctions 27 and 42 [6 miles (9.6 km)] and junctions 13 and 22 [21 miles (33.8 km)],
3. M6 between junctions 21 and 35 [60 miles (96.6 km)],
4. M18 between junctions 32 and 2 on A1(M) [9 miles (14.5 km)], and
5. A1(M) in the West Riding of Yorkshire [14 miles (22.5 km)].

In West Yorkshire the study was from October 1971 to May 1972; in Lancashire the study period was from July to September 1971. Average daily traffic flows during 1971 are shown in Figure 1 (1).

TOTAL DISABLEMENTS

Because of the large volume of data available for the West Yorkshire motorways a sampling procedure was used and the data for the first 7 days of each month were analyzed. In Lancashire all records for each Saturday and Sunday between July 17 and September 26 were analyzed. The number of reports of disabled vehicles received during these periods is given in Table 1 for West Yorkshire motorways and Table 2 for Lancashire motorways.

DAILY AND HOURLY VARIATIONS IN DISABLEMENTS

Table 2 also gives the effect of the day of the week on disablements on Lancashire motorways. In the early part of the summer-vacation period more disablements occurred on Saturdays than on Sundays mainly because of higher traffic volumes on Saturdays. For the West Yorkshire motorways, where leisure traffic is a very small portion of total flow, the average proportion of disablements occurring on any given day is as follows:

Day	Percentage
Sunday	11.48
Monday	14.83
Tuesday	15.38
Wednesday	14.31
Thursday	14.20
Friday	17.77
Saturday	12.03

In evaluating any disabled vehicle location-and-aid system, one must know the distribution of vehicle disablements throughout the day, and Table 3 gives this distribution for weekday traffic on M1 in West Yorkshire and for Saturday and Sunday traffic on Lancashire motorways. These hourly variations in reported disablements are shown in Figures 2, 3, and 4. It is interesting to note the dual peaks in the M1 weekday pattern (Fig. 2), which is characteristic of a highway where flow is influenced by commuting. For Saturday and Sunday flow (Figs. 3 and 4), the peaks are those that would be expected on a highway carrying a large proportion of weekend holiday traffic.

Figure 1. Motorway sections studied.

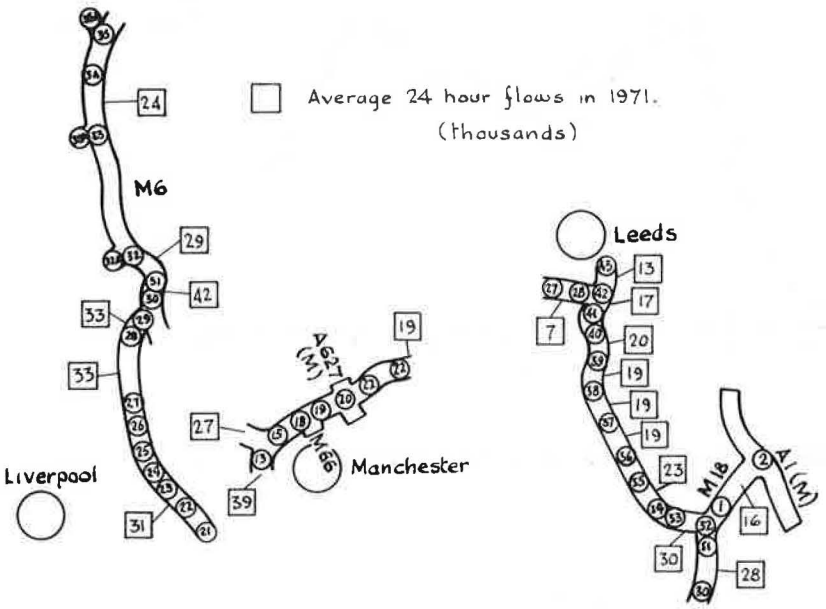


Table 1. Reported disabled vehicles on West Yorkshire motorways.

Time	M1	M18	M62	A1(M)
1971				
October	1,071	264	193	242
November	1,138	198	203	167
December	1,034	164	198	170
1972				
January	1,135	195	210	198
February	1,059	175	205	193
March	1,135	198	217	216
April	1,018	197	223	198

Table 2. Reported disabled vehicles on Lancashire motorways, 1971.

Date	Disablements	Date	Disablements
July 17[a]	177	August 22[b]	144
July 18[b]	147	August 28[a]	179
July 24[a]	183	August 29[b]	152
July 25[b]	147	September 4[a]	178
July 31[a]	174	September 5[b]	167
August 1[b]	142	September 11[a]	150
August 7[a]	178	September 12[b]	169
August 8[b]	171	September 18[a]	142
August 14[a]	150	September 19[b]	151
August 15[b]	142	September 25[a]	133
August 21[a]	158	September 26[b]	114

[a]Saturday. [b]Sunday.

Table 3. Hourly distribution of disablements for the entire study period.

Hour of Day	Disablement Percentage			Hour of Day	Disablement Percentage		
	M1	Lancashire Motorways			M1	Lancashire Motorways	
	Weekdays	Saturdays	Sundays		Weekdays	Saturdays	Sundays
1	1.14	2.50	2.23	13	5.23	8.02	6.42
2	1.21	1.86	1.35	14	6.06	7.12	6.49
3	0.53	1.03	1.01	15	6.52	7.76	6.35
4	0.61	0.58	0.74	16	6.67	7.76	8.18
5	0.53	0.90	0.47	17	7.42	7.18	7.03
6	0.68	0.71	0.47	18	8.41	7.12	7.23
7	1.67	1.60	0.95	19	6.59	5.58	6.76
8	3.94	1.54	0.95	20	4.47	4.68	7.64
9	7.80	3.40	1.55	21	3.26	4.11	5.81
10	8.41	3.85	2.36	22	2.27	3.34	6.22
11	7.05	7.31	5.00	23	2.50	2.68	4.19
12	5.53	7.25	6.89	24	1.52	2.12	3.72

Figure 2. Distribution of vehicle disablements and traffic flow on M1 on weekdays.

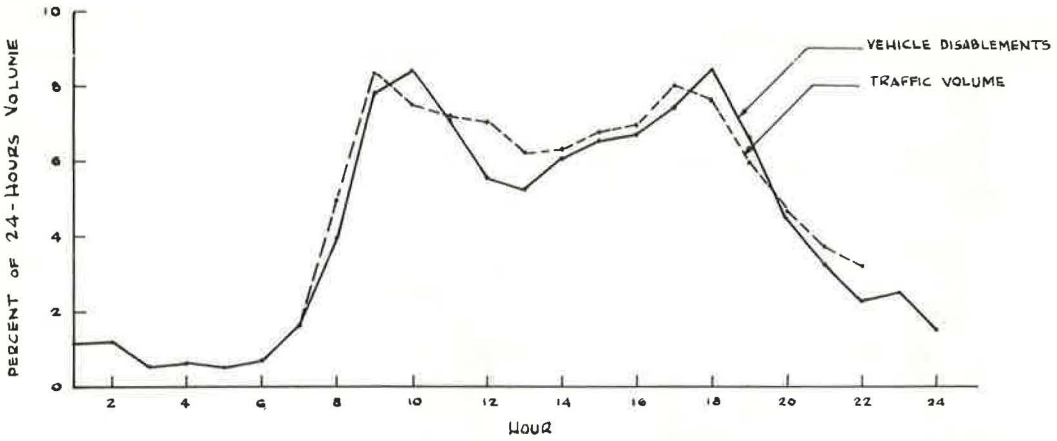


Figure 3. Comparison of disablements and traffic volume on M6 on Saturdays.

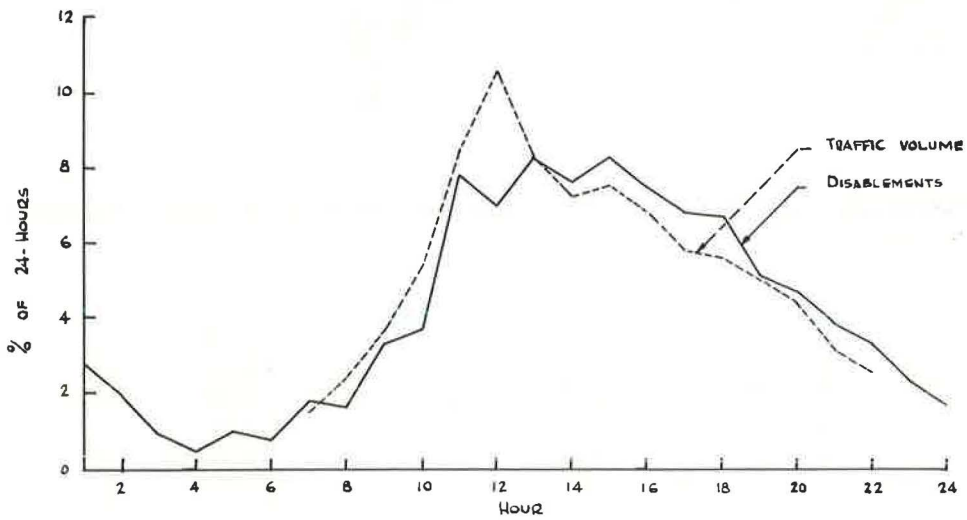
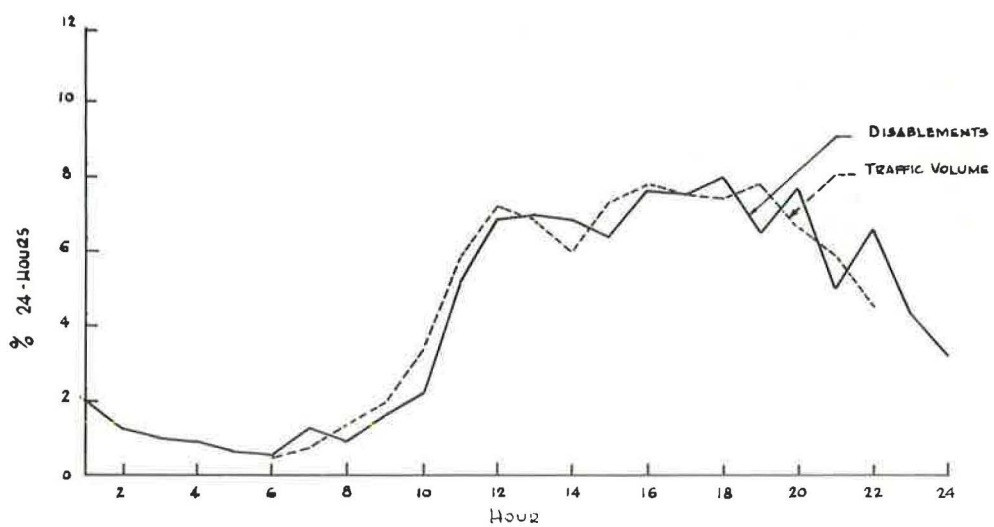


Figure 4. Comparison of disablements and traffic volume on M6 on Sundays.



DISABLEMENTS AND TRAFFIC VOLUME

The number of reported disablements is a function of the number of vehicles on the road. The factor of interest is the disablement rate expressed as disablements per vehicle unit of length. It was thus necessary to relate the reported disablements to traffic flow by using expanded 16-hour traffic counts. Variations in mean hourly traffic flow for the 2 motorway networks selected for study are shown in Figures 2, 3, and 4, and the close correlation between disablements and flow is apparent.

DISABLEMENT RATE

Disablement rate, expressed as reported disablements per million vehicle miles (vehicle kilometers), is an important factor in the design or evaluation of any disabled vehicle location-and-aid system for limited-access highways. Using data from M1 in Yorkshire for weekdays and Lancashire motorways for weekends, we found the following:

Time	Rate	r
Weekday	0.00005	0.78
Saturday	0.00004	0.73
Sunday	0.00004	0.85

The slightly lower values for recreational flows can be explained by the better climatic conditions that prevailed from July through September 1971. Kuprijanow (2) reported comparable rates.

AGE OF DISABLED VEHICLES

Disabled vehicle age was extracted from the emergency telephone call records. The age of the vehicle was assumed to be the date of first registration of the vehicle. The percentages of disabled passenger cars and commercial vehicles in each age group are given in Table 4. Although no conclusions can be drawn about the relative disablement rates of vehicles of different ages because age distribution of vehicles on motorways is not known, it can be seen that vehicles reported as being disabled during the weekend period in Lancashire are older than those reported disabled in Yorkshire. For commercial vehicles the difference is approximately 1 year. This difference in age can be expected when one motorway system carries mainly business and commercial traffic and the other carries mainly recreational traffic. It is interesting to note that commercial vehicles also had an older age distribution because of the number of vans and light trucks that are used for private purposes.

CAUSES OF VEHICLE DISABLEMENT

Callers on the emergency telephone system are asked to try to identify the cause of the disablement, and, although it has not proved possible to check either the accuracy of the diagnosis or whether repairs on the emergency lane were possible, these initial reports are an indication of the faults that do occur. Table 5 gives the suspected causes of disablement and their distribution. The relative similarity between suspected faults on both Yorkshire and Lancashire motorways is clearly shown.

A further investigation was made into the relationship between reported type of fault and the vehicle age for the Lancashire motorway. The resulting percentage of reported faults and disabled vehicle age are given in Table 6.

Although it is not possible to comment on how liable vehicles of certain ages are to become disabled with certain faults (because the age distribution of all vehicles on the

Table 4. Percentage distribution of ages of disabled vehicles.

Years Since First Registration	Yorkshire Motorways		Lancashire Motorways	
	Passenger Cars	Commercial Vehicles	Passenger Cars	Commercial Vehicles
0 to 1	6.8	6.2	1.0	0.7
1 to 2	13.9	15.3	6.0	8.3
2 to 3	12.7	16.7	7.3	15.4
3 to 4	12.2	14.4	9.4	10.5
4 to 5	7.6	9.6	12.5	14.7
5 to 6	9.9	13.6	9.9	11.5
6 to 7	9.2	9.0	9.6	6.6
7 to 8	5.2	4.1	10.4	7.6
8 to 9	8.9	6.3	7.4	5.4
9 or more	13.6	4.8	26.5	19.3

Table 5. Distribution of suspected causes of disablements.

Suspected Fault	Yorkshire, All Vehicles		Lancashire Cars		Lancashire Goods	
	Number	Percent	Number	Percent	Number	Percent
Lack of fuel	383	14.08	304	11.56	57	13.94
Flat tire or wheel trouble	289	10.63	263	10.00	56	13.69
Water required	81	2.98	38	1.44	5	1.23
Mechanical failure	1,079	39.70	1,232	46.88	181	44.01
Mechanical-electrical failure	444	16.34	416	15.82	43	10.51
Electrical failure	213	7.84	186	7.07	23	5.62
Fuel-mechanical or fuel-electrical problems	171	6.29	119	4.53	35	8.56
Brake failure	17	0.63	22	0.84	3	0.73
Lack of oil	40	1.47	47	1.78	7	1.71
Driver illness	1	0.04	2	0.08	0	0

Table 6. Percentage distribution of causes of disablements on Lancashire motorways by vehicle age.

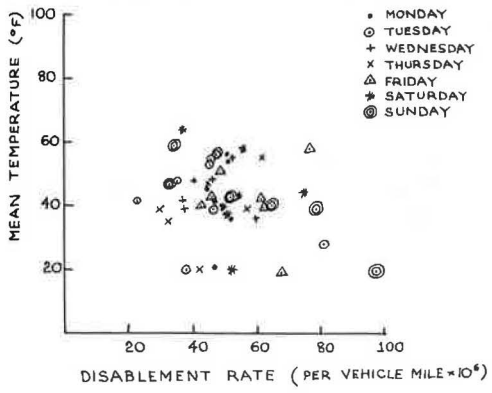
Vehicle Age (years)	Lack of Fuel	Flat Tire	Water Required	Mechanical Failure	Mechanical-Electrical Failure	Electrical Failure	Fuel-Mechanical or Fuel-Electrical Problems	Brake Failure	Lack of Oil	Driver Illness
0 to 1	10.0	6.7	0	23.3	23.3	13.3	20.0	0	0	3.4
1 to 2	20.9	8.4	0.5	41.4	13.1	4.7	7.9	1.0	2.1	0
2 to 3	18.4	10.2	0.8	37.9	18.4	5.5	7.4	0.8	0.6	0
3 to 4	8.2	11.7	2.1	52.9	12.7	6.9	3.4	0.7	1.4	0
4 to 5	17.7	11.0	1.5	41.0	15.4	7.2	4.6	0.3	1.0	0.3
5 to 6	15.7	9.5	1.3	48.0	13.4	4.9	4.2	0.7	2.0	0.3
6 to 7	7.2	8.6	2.5	51.4	15.8	7.2	5.0	1.1	1.2	0
7 to 8	8.9	10.6	1.0	48.2	14.5	8.3	4.0	1.3	3.2	0
8 to 9	6.5	9.7	1.4	52.2	13.0	7.9	4.6	0.5	4.2	0
9 or more	8.9	11.8	1.4	47.1	16.3	7.3	4.7	1.0	1.5	0

Table 7. Ranking of reported disablement causes on the Lancashire motorways.

Vehicle Age (years)	Lack of Fuel	Flat Tire	Water Required	Mechanical Failure	Mechanical-Electrical Failure	Electrical Failure	Fuel-Mechanical or Fuel-Electrical Problems	Brake Failure	Lack of Oil	Driver Illness
0 to 1	5	6		1	1	4	3			7
1 to 2	2	4	9	1	3	6	5	8	7	
2 to 3	2	4	7	1	2	6	5	7	9	
3 to 4	4	3	8	1	2	5	6	7	9	
4 to 5	2	4	7	1	3	5	6	9	8	9
5 to 6	2	4	8	1	3	5	6	9	7	10
6 to 7	4	3	7	1	2	4	6	9	8	
7 to 8	3	2	8	1	2	4	5	7	6	
8 to 9	5	3	8	1	2	4	6	9	7	
9 or more	4	3	8	1	2	5	6	9	7	

Note: More than 1 cause can share the same ranking.

Figure 5. Comparison of mean temperature and breakdown rate on M1.



Note: 1 breakdown/vehicle mile = 0.62 breakdown/vehicle km.

motorways is not known), it is possible to comment on how liable vehicles of certain ages are to develop certain suspected disabling faults. To illustrate the relative importance of the various causes of disablements, we have prepared the rankings given in Table 7. It is interesting to note that vehicle age has little effect on the distribution of disabling faults. As expected, for vehicles of any given age, the primary suspected cause of disablement is mechanical failure. Mechanical-electrical failure and lack of fuel are the second most frequent causes.

MEMBERSHIP IN MOTORING ORGANIZATIONS

In Great Britain, membership in the AA and the RAC has many advantages when vehicle disablement occurs. These organizations will provide on-the-spot assistance to disabled vehicles and if necessary will tow the disabled vehicle from the motorway. When a disabled vehicle report is received by the police control room the disabled driver is asked if he or she is a member of either of these organizations. In this study, 42.57 percent of the drivers of disabled cars in Yorkshire were club members, and 62.9 percent in Lancashire were members. As expected, the percentage was found to be higher in the Lancashire motorway study because of the largely recreational nature of the traffic.

EFFECT OF WEATHER ON BREAKDOWN RATE

Climatic conditions can be expected to influence breakdown rate, but, in a temperate climate such as Great Britain's, climatic extremes rarely occur. Expected extreme conditions would most likely be heavy rainfall and snowfall, icing of the road surface, and high temperatures.

When precipitation rates are high, the area of rainfall usually is localized. Heavy snowfall and severe icing are infrequent problems on the motorways considered in this study, and under these conditions the incidence of disabled vehicles is a function of the highway maintenance operations of salting, sanding, and clearing. For these reasons vehicle disablements due to precipitation and severe icing are not considered in this paper. Temperature variations remain to be considered, and, because temperature records were available for the region of the Yorkshire motorway, an attempt was made to determine the correlation between temperature and breakdown rate. The results of the analysis are shown in Figure 5 where it can be seen that there is little relationship between ambient temperatures and the rate of disabled vehicle reports. This is not an unexpected result for the generally temperate climate of Great Britain.

CONCLUSIONS

This paper investigated some of the fundamental aspects of the disabled vehicle problem on limited-access highways. It was found that only a small difference existed between the rate of vehicles becoming disabled on Yorkshire motorways where a high proportion of the flow consisted of business and commercial traffic and the rate of those becoming disabled on Lancashire motorways where a high proportion of the flow was recreational.

Suspected causes of a vehicle becoming disabled were investigated. Mechanical-electrical problems and lack of fuel were found to be significant problems in causing

disablement. Climatic conditions as measured by ambient temperature were found not to have any significant effect on vehicle disablement.

This study is the first stage in the assessment of the benefits of disabled vehicle location-and-aid systems on limited-access highways.

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2. A. Kuprijanow. Communication With Stranded Motorists on California Urban Freeways. Airborne Instruments Laboratory, Rept. 3097-1.