According to the 2001 Edition of Transport Statistics – Great Britain (DTLR, 2001), motor vehicle traffic carried by motorways in the 10 year period between 1990 and 2000 has increased from 61.6 to 94.1 billion vehicle kilometres. The fact that most sections of the motorway network have reached their design life and are operating at their full capacity (with heavy goods vehicles increasingly using them) suggests that there will always be a serious need for maintenance. As a result, major prolonged motorway roadworks are becoming a feature of those busy sections leading to excessive delays, higher operational costs to road users as well as higher risks of traffic accidents.

Motorway roadworks: effects on traffic operations

This paper examines traffic operations at the approaches to motorway roadwork sites in the North West of England and focuses on some of the parameters affecting both safety and capacity.

The trade–off between capacity and safety at motorway roadworks represents a dilemma for the traffic engineer. Capacity is reduced with the closure of one or more lanes to traffic. Lower operating speeds may be observed due to the substandard layout and to the lower speed limits imposed on site. Speed cameras are sometimes introduced to enforce the posted speed limits. Observations suggest that traffic behaviour at the approach to a roadwork section differs in terms of drivers' operating speeds and their choice of lanes. Speed differentials close to the merge section could be a contributory cause of flow breakdowns and are a danger to road–users and workers alike. In addition, some drivers force themselves into the path of others on adjacent lanes by accepting smaller gaps to merge into especially when they are getting closer to the taper section. Previous work suggests that higher accident rates are usually associated with roadwork sections compared with normal motorway ones.

Data collection

For this study, camcorders fitted onto tripods were used to collect the necessary data. Unobtrusive locations were chosen to minimise disturbance to drivers and other road users. The duration of filming was for a period of three to four hours for each of the visited sites. The chosen sites were the M6 motorway between Junctions 14 and 15 with a full contra-flow (primary stream); and the M61 between Junctions 8 and 9 with a lane closure (two lanes open, including the hardshoulder as a running lane). For further details on data extraction and the method used in measuring traffic flows and speeds, see Kazzaz (1998).

All flow and speed data were based on five–minute intervals and were averaged and then converted to hourly flows for each interval. Flow data were also converted into passenger car units per hour (pcu/hr). Each light vehicle (ie, cars, motorcycles, car towing trailer, pick–ups, mini vans and any other four wheeled vehicles) is regarded as equivalent to 1 pcu and each heavy vehicle (ie, public service vehicles and all other commercial vehicles) is equivalent to 2 pcu's.

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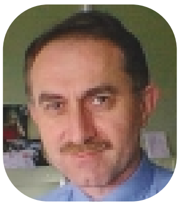

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Data analysis

Traffic flows and maximum throughputs

Table 1 shows the maximum observed throughputs with different traffic management schemes based on a study by Mathews (1984) for a typical traffic composition of 15–20% heavy goods vehicles. These values formed the basis for the expected maximum throughputs on motorway roadworks.

Table 1: Maximum observed throughputs with different traffic management schemes

Type of traffic management scheme at roadworks	Maximum throughput pcu/hr	Maximum throughput pcu/hr/lane
Lane closure – 1 lane open	1900	1900
Lane closure – 2 lanes open	3770	1890
Two – way traffic (one lane each way)	1770	1770
Segregated contra–flow (primary stream)	3420	1710
Full contra–flow (primary stream)	3500	1750
Contra–flow sites (secondary stream)	3540	1770

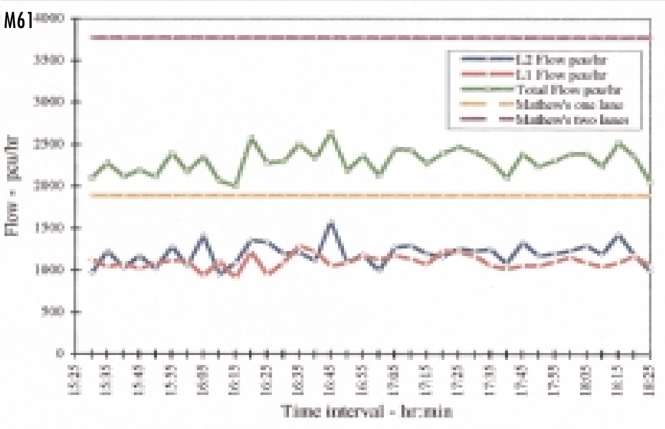
Apart from the effects of traffic composition, number of open lanes, and the type of layout and traffic management schemes, there are other factors which could influence throughputs. Observations suggest that higher throughputs have been recorded when a substantial number of commuting cars is present. In addition, the layout at the merge section is believed to be the main factor limiting capacity.

Fig 1 shows flow fluctuations on the M6 and M61 in each lane, together with the total flow. Lane 1 (L1) represents the nearside lane (ie, the lane adjacent to the hardshoulder) and Lane 2 (L2) is the other running lane. The recorded flows on both sites were of a very different nature. Flows on the M61 motorway were well below the maximum expected throughputs for normal lane closures (as reported by Mathews, 1984), whereas flows on the M6 were near the maximum expected throughputs for full contra–flows for most of the survey period.

For the M61, fluctuations in the total traffic were minimal, ranging between 2000 and 2500 pcu/hr. Traffic could be considered as operating in free flowing conditions. On the M6, traffic was operating near the maximum expected throughput for most of the time. Although traffic was relatively dense, it was still moving. However, as the demand increased, traffic became more restricted and congested situations occurred. Traffic flow as high as 2250 pcu/hr was observed in Lane 2 during the pre-congested conditions.

Fig 1 also shows that as the demand flow increases Lane 2 starts to operate at its capacity. At such conditions, there is a continuous movement of vehicles from Lane 2 to Lane 1 filling all available gaps in Lane 1. This behaviour continues until all gaps are filled in and

Motorway roadworks.



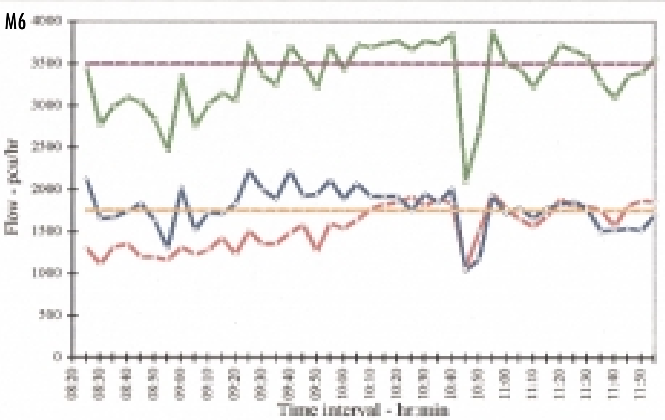


Fig 1: Flow fluctuations on the M6 and M61 roadwork sections.

both lanes carry similar flows. At such situations, drivers are travelling too close to each other in any one lane which could result in flow breakdowns. Traffic operation under close following conditions could explain the two minor shunts (nose to tail) which occurred at 10:34 and 10:55. Vehicles involved in both of these minor accidents were moved quickly to the hardshoulder. As a result of these accidents, a prolonged flow breakdown occurred causing a decrease in the overall throughput coupled with a reduction in average speed.

Traffic Speeds

At motorway roadworks, speed restrictions are normally in operation. A mandatory 50mph speed limit (equivalent to 80km/hr) is normally used together with other traffic signs and control devices to warn drivers of the changes in the road layout facing them. The aim is to have safer operations by reducing speed differentials between vehicles travelling in the same lane and in adjacent lanes. This will consequently assist the merging process occurring within a relatively short distance from the taper section. In addition, maximum throughputs could be achieved when traffic is operating below or close to a 50mph speed (Hunt and Yousif, 1993).

Fig 2 shows the average speeds for the 5-minute intervals for both sites at the approach to roadworks. Recorded speeds from the M61 showed a steady pattern with minimal fluctuations. On the M6, average speeds were at high levels at the beginning of the survey and as the demand flow increased and approached the maximum expected throughputs, speeds started to drop sharply. Speed turbulence was observed in both lanes and flow breakdowns were unavoidable. The average speed dropped to about 20 km/hr at around 10:45. Thereafter, there was a marginal speed recovery for the rest of the survey period.

Table 2: Compliance with speed limits for Lanes 1 and 2 at roadworks.

	Current Study		**Previous Study(*)**	
% of vehicles travelling with speed	Lane 1	Lane 2	Lane 1	Lane 2
Below speed limit	23	11	26	3
less than (speed limit + 10mph)	84	63	82	29
less than (speed limit + 20mph)	99	96	99	78

(*)Source: Hunt and Yousif (1993)

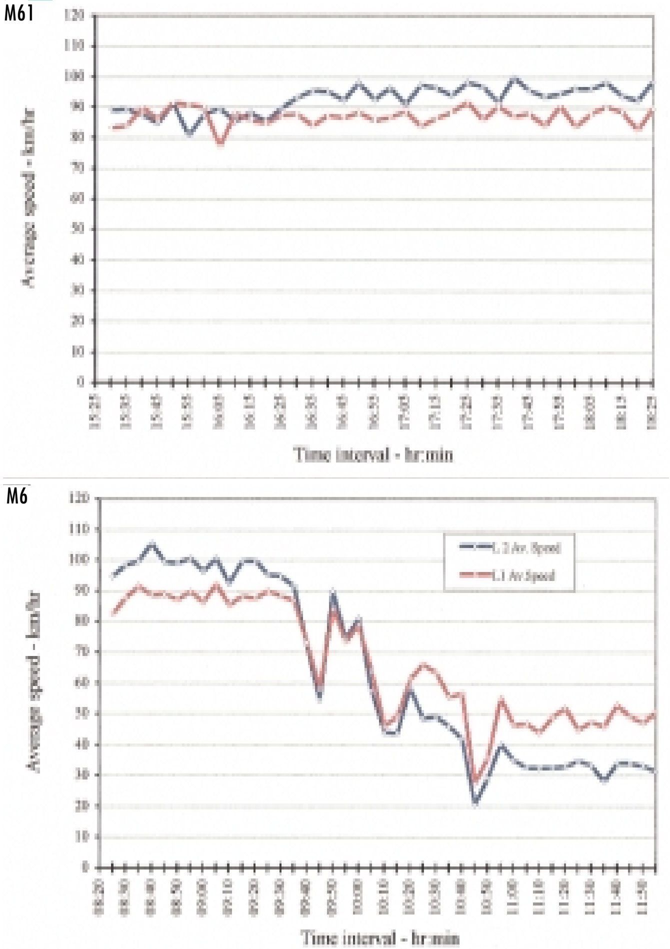


Fig 2: Average speeds at the approaches to roadworks.

Drivers' compliance with the 50mph mandatory speed limit was obtained and compared with results from a previous study based on data from other motorway roadwork sites in 1990 (Hunt and Yousif, 1993). Speed compliance measurements were only taken from the M61 site, since traffic was considered to be free flowing. Data from the M6 were ignored for this purpose. The findings are presented in Table 2 and are based on results obtained from cumulative speed distributions.

For the current study, only 23% and 11% of drivers in Lanes 1 and 2, respectively, complied with the speed limit of 50mph. These levels of compliance can be considered as poor and may reflect the absence of any speed monitoring systems on site, such as speed cameras at the time of the survey.

The comparison between these results and those obtained from the previous study suggests that for Lane 1, similar compliance with the 50mph speed limit has been obtained. The percentage of drivers travelling with speeds less than the speed limit plus 10mph (ie, 60mph) and the speed limit plus 20mph (ie, 70mph) were almost identical in both studies. These similarities in the levels of compliance throughout the different sites could be attributed to the fact that Lane 1 is mainly occupied by heavy goods vehicles and other "slower" moving vehicles.

For Lane 2, there is a lower level of compliance with the 50mph speed limit compared with that of Lane 1. However, nearly all drivers travelled with a speed of 70mph or lower for the current study (ie, 96%) whereas in the previous study, only 78% travelled with a speed of 70mph or lower. This may suggest an overall improvement in the level of drivers' compliance between the two periods (ie, 1990 and the current study). However, it is difficult to draw any conclusive evidence regarding these compliance levels since the data is limited to a small number of sites, as well as to other factors which could be site-specific. Further work in this field is therefore necessary to determine the levels of compliance and the effectiveness of using measures of enforcing speeds at roadworks.

Conclusion

Based on the data and analysis obtained from the two motorway roadwork sites, the following conclusions have been reached:

Flows as high as 2250 pcu/hr/lane can be observed in the pre–congested traffic conditions. However, this level of flow is considered to be at a critical stage and any slight increase in traffic flow demand or a slight disturbance in the operation could lead to flow breakdowns.

Drivers' compliance with the 50mph mandatory speed limit was found to be poor. Additional measures are required to control speeds at such sites. The use of speed cameras at motorway roadworks may have a positive effect. However, further work is necessary to assess the effectiveness of the use of such controls.

Safety levels are greatly reduced at the approach to roadwork sites due to close following and lane changing manoeuvres (caused by late merging and overtaking). There is a need to reduce the frequency of such undesirable and dangerous manoeuvres. Therefore, further work and trials are needed to use alternative controls and traffic management schemes, and test their effectiveness.

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