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TRIALS OF RURAL ROAD SAFETY ENGINEERING MEASURES

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EXECUTIVE SUMMARY

During the last decade the number of reported injury accidents has been gradually falling, despite an increase in road traffic. The number of resulting fatalities has also been falling and at a far greater rate than that for all casualties. These encouraging trends are thought, in part, to be attributable to a raised road safety profile and the effects of improved vehicle design, road user training and education, publicity, government policies and road engineering. However, some road user types and road classes have fared better than others and so it is important to monitor individual trends so that resources are targeted effectively.

In particular, it has been noted that currently more than half of all fatal casualties are found on rural roads (speed limit ≥ 50mph) and that the proportion of fatalities on rural roads has steadily increased over the past decade, from 0.48 in 1985 to 0.59 in 1995. Although the number of fatalities has decreased on both rural and urban roads over this period, the rate of decrease on rural roads has been slower than on urban roads. Since the proportion of all traffic on rural roads has not increased over the past decade, this almost certainly reflects the emphasis that has been placed in recent years on developing improved road safety measures for the urban situation. It is important, therefore, that more safety engineering research is now being directed at tackling the rural road safety problem.

This report concerns work carried out under a project for the Road Safety Division of the Department of Transport. The project was set up to develop and trial suitable low-cost engineering measures to tackle rural road safety problems. The nature of rural roads often encourages drivers to travel at high speeds and past research has shown that if vehicle speeds can be reduced, accident frequencies and severities will also fall. Consequently, many measures have been designed specifically to slow drivers down, and to alert them to the presence of a particular hazard ahead. The engineering measures under consideration have been innovative with respect to either the type of measure or the type of application.

Another important function of the project has been to build and maintain working relationships between the Local Highway Authorities (LHAs), TRL and the Department of Transport (DOT) so that ideas and experience could be shared. Thus, LHAs could have the freedom to try out new ideas and to participate in multi-county, co-ordinated trials to enable objective assessments of the engineering measures to be made. Departmental policies could then be shaped to promote the most successful engineering measures and give guidelines for their maximum cost-effective benefit.

Many different types of engineering measure have been investigated and trialled during the project. Some trials have included only a single site; others have included a large number of sites. In general, installation costs of measures in small trials were met by the LHAs while those for the larger trials were at least partly funded by the DOT. Monitoring was undertaken for all trials, before and after scheme installation. Data were most often collected by the LHAs and the analyses of data carried out and reported by TRL. The type of monitoring and analysis performed was dependent on the trial type but, in most cases, changes in vehicle speeds and injury accident frequencies were examined.

The report considers national rural accident patterns and summarises the trials of the different engineering measures that have been, or are being, undertaken within each of the following rural site types:

- Motorways - *Chevrons,* Third lane coach ban
- Junctions - *Yellow bar markings on motorway off-slips, Bar markings on minor road approaches*
- Bends - *Rumble areas,* Bar markings, Channelisation
- Villages - *Riblines, Speed limit Count-down signs and Roundel markings,* Vehicle-activated speed warning signs, 30mph speed limits, *traffic calming.*

Trials of the engineering measures in italics above have been completed. Except for 30mph Roundel markings, these trials all achieved reductions in either mean vehicle speeds (up to -6mph), or accident frequencies (up to -60%), or both. The speed reductions were always statistically significant, but except in the Chevron trial, the numbers of accidents were too small for the reductions in frequency to be declared statistically significant.

Trials of the other engineering measures above are continuing and will be reported by TRL as they are completed. Additionally, new ideas will be developed and trialled as appropriate.

(Statistical sources: Road accidents Great Britain - The casualty report. Department of Transport, 1985-1995.)

TRIALS OF RURAL ROAD SAFETY ENGINEERING MEASURES

ABSTRACT

This report summarises progress on work carried out under a project for the Road Safety Division of the Department of Transport. The project was set up to develop and trial engineering measures to address the rural road safety problem. The engineering measures under consideration were low-cost and innovative with respect to either the type of measure or the type of application. Some trials included only a single site; others included a large number of sites.

The report gives a summary of national rural accident patterns and details past and present trials on rural motorways (Chevrons, Third lane coach ban), bends (Rumble areas, Bar markings, Channelisation), junctions (Yellow bar markings on motorway off-slips, Bar markings on minor road approaches), and villages (Riblines, Speed limit Count-down signs and Roundel markings, Vehicle-activated speed warning signs, 30mph speed limits, traffic calming).

1. INTRODUCTION

During the last decade the number of reported injury accidents has been gradually falling, despite an increase in road traffic. The number of resulting fatalities has also been falling and at a far greater rate than that for all casualties. These encouraging trends are thought, in part, to be attributable to a raised road safety profile and the effects of improved vehicle design, road user training and education, publicity, government policies and road engineering. Most effort has been directed at the urban situation where about half of all traffic and 74% of all accidents are currently concentrated. Consequently, the potential for treating urban roads is now much reduced and recently more attention has been focused on rural roads.

During 1995, in Great Britain, 26% (60,646) of all accidents occurred on rural roads (speed limit ≥ 50mph) which are estimated to carry 55% of all traffic. These accidents accounted for 31% (95,518) of all resulting casualties and 59% (2121) of all resulting fatalities. Twelve per cent of the rural road accidents occurred on motorways, 55% on 'A' class roads and 33% on other road classes.

Table 1 shows that the percentage of all fatalities occurring on rural roads has gradually increased over the past decade. However, the proportion of all traffic on rural roads has not increased over the same period (Table 2). Although the number of fatalities has decreased on both rural and urban roads over the past decade, the rate of decrease on rural roads has been slower than on urban roads. However, the rate of increase of traffic levels has been similar on rural and urban roads (Department of Transport, 1985-95).

This report concerns work carried out under a project for the Road Safety Division of the Department of Transport. The project was set up to develop and trial suitable engineering measures to tackle rural road safety problems. The nature of rural roads often encourages drivers to travel at high speeds and past research has shown that if vehicle speeds can be reduced, accident frequencies and severities will also fall (see for example 'Speed, speed limits and accidents' - Finch et al, 1994). Consequently, many measures have been designed specifically to slow drivers down, and to alert them to the presence of a particular hazard ahead. Accidents on rural roads also tend to be widely scattered, geographically. Comparing rural roads with urban roads, rural junctions are less frequent, pedestrian activity is lower, and land use is less concentrated. Therefore, to be effective, safety engineering treatments must be low-cost and widely applicable. Thus, the measures trialled have generally been chosen to treat particular types of accidents occurring at common site types, rather than at specific sites.

Another important function of the project has been to build and maintain working relationships between the Local Highway Authorities (LHAs), TRL and the Department of Transport (DOT) so that ideas and experience could be

TABLE 1

Percentage of all casualties that were on rural roads (including all motorways), by injury severity (1985-1995)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Casualties	28%	29%	30%	30%	31%	31%	31%	31%	31%	31%	31%
KSI	35%	36%	36%	37%	38%	38%	38%	38%	39%	39%	39%
Killed	48%	51%	50%	52%	54%	54%	52%	55%	55%	56%	59%

(KSI = Killed or Seriously Injured)

TABLE 2

Estimated traffic (100 million vehicle kilometres) by road type (1985-1995)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Urban roads	1285	1353	1370	1663	1882	1867	1868	1848	1866	1938	1961
Rural roads (excluding motorways)	1560	1665	1314	1499	1635	1678	1690	1694	1649	1658	1683
% of all traffic: on rural roads (excluding motorways)	55%	55%	49%	47%	46%	47%	47%	48%	47%	46%	46%
on rural roads (including motorways)	n/k	n/k	n/k	55%	54%	55%	55%	55%	55%	55%	55%

(n/k = not known)

shared. Thus, LHAs could have the freedom to try out new ideas and to participate in multi-county, co-ordinated trials to enable objective assessments of the engineering measures to be made. Departmental policies could then be shaped to promote the most successful engineering measures and give guidelines for their maximum cost-effective benefit.

Many different types of engineering measure have been investigated and trialled during the project. The engineering measures under consideration were innovative with respect to either the type of measure or the type of application. Some trials have included only a single site; others have included a large number of sites. In general, installation costs of measures in small trials were met by the LHAs while those for the larger trials were at least partly funded by the DOT. Monitoring was undertaken for all trials, before and after scheme installation. Data were most often collected by the LHAs and the analyses of data carried out and reported by TRL. The type of monitoring and analysis performed was dependent on the trial type but, in most cases, changes in vehicle speeds and injury accident frequencies were examined.

The next section of the report considers national rural accident patterns. Following sections detail the different engineering measures that have been, or are being, studied.

Full details of completed trials can be found in the relevant referenced reports. Published reports are available from the TRL library. For information on unpublished reports apply directly to the author. Results concerning trials currently in progress will be reported, in due course.

2. ACCIDENT CHARACTERISTICS

National statistics concerning the detailed characteristics of accidents are not readily available. Therefore, as a precursor to the present project, TRL undertook a detailed examination of all the reported injury accidents occurring in 1988/89 on rural, single-carriageway roads in Great Britain. (Single-carriageway roads were selected as those most likely to have accident reduction potential.) STATS19 data (92630 accidents involving 170666 vehicles and 146634 casualties) were analysed to identify the most common scenarios and any particular causes for concern.

The published report of this work (Taylor and Barker, 1992) contains:

i) tabulations of key STATS19 variables for accidents, vehicles and casualties compared to corresponding urban statistics;

ii) cross tabulations between factors such as accident severity, junction type, road type, carriageway type, vehicle involvement, time of day, conditions at time of accident, vehicle location, vehicle manoeuvre, alcohol involvement, pedestrian involvement, driver sex and age, vehicle model and vehicle ownership;

iii) detailed examinations of several important accident sub-groups identified, such as non-junction accidents involving the vehicle manoeuvres 'going ahead on a left (or right) hand bend' and 'going ahead - other', single-vehicle accidents and two-vehicle accidents.

Some of the main findings of the statistical analyses were that:

Compared with accidents in built-up areas, those on rural single-carriageway roads were more severe; only half as likely to be at a junction; only one seventh as likely to involve a pedestrian and half as likely to involve a two-wheeled vehicle; but they were three times as likely to involve a single vehicle (with no pedestrian).

The most frequently-involved vehicle manoeuvre was 'going ahead - other' (43% of accident-involved vehicles at junctions and 44% away from junctions). Away from junctions 'going ahead on a left/right hand bend' featured next most frequently (35%) while at junctions, 'turning right' did so (21%).

Single-vehicle accidents accounted for one third of all accidents. They were more likely than other accidents to be associated with B/C class roads, night-time, the youngest drivers and with 'going ahead on a bend'.

Accidents involving vehicles doing the faster manoeuvres ('going ahead', 'overtaking') were more likely than other accidents to involve young drivers, male drivers, two-wheeled motor vehicles, a pedestrian, skidding, leaving the carriageway, hitting objects on or off the carriageway, and to be more severe.

27% of all accidents involved a single vehicle 'going ahead', not at a junction. Just under half of these involved a male driver/rider under the age of 25 and just over half occurred on a bend. 20% of all accidents involved a single vehicle leaving the carriageway while 'going ahead', not at a junction.

4% of all accidents involved a pedestrian. More than half of these involved a single vehicle, 'going ahead', not at a junction.

9% of all accidents involved two (non-overtaking) vehicles travelling in opposite directions on bends, not at a junction, and 8% involved two (non-overtaking) vehicles travelling in opposite directions, not at a bend or at a junction.

12% of all accidents involved two vehicles at a junction, with at least one vehicle 'turning right'. The other vehicle was usually 'going ahead'. At T/Y junctions, about 60% of the right-turners were entering the main road and about 40% were leaving it.

Up to about 1% of all accidents could have been junction 'overrun' accidents - ie where a vehicle failed to stop to give way.

A number of the measures trialled were suggested as practical solutions to these findings - in particular, to treat the problems associated with high vehicle speeds and specific types of hazard (such as bends). The next four sections describe the trials undertaken relating to motorways and rural bends, junctions and villages.

3. MOTORWAYS

The vast majority of British motorways are rural, 2 or 3 lane, dual-carriageway roads with speed limits of 70mph. Although the accident rates on motorways are lower than on other road classes, one consequence of the high vehicle speeds is that motorway accidents often involve many vehicles and severe injuries, resulting in high average accident costs and increased publicity. The following two measures have been assessed to establish their potential for reducing such accidents.

3.1 CHEVRONS

In 1990 trials of French-designed Chevron markings were carried out at two sites on the M1 motorway, one in Leicestershire and one in Northamptonshire (Webster et al, 1992; Helliar-Symons and Butler, 1995; Helliar-Symons et al, 1995a). The Chevrons are inverted 'V'-shaped markings, laid at 40m intervals on the nearside and centre lanes for a distance of 4 or 5km. Roadside signs advise drivers to 'Keep apart, 2 chevrons' (Figure 1). The main objective of the markings was to improve close-following behaviour and hence safety.

Inter-vehicle gaps, vehicle speeds and injury accidents were examined before and after each scheme was installed. Drivers' opinions of the markings were also sought after the schemes were installed.

Following implementation of the schemes, improvements in inter-vehicle gaps were observed in all three lanes, with vehicle speeds changing little. (The exception was one Leicestershire monitoring position, downstream of the Chevrons, where speeds increased by about 10%.) Reductions of about 15% in the percentage of drivers following with a gap of less than one second, and of about 5% in the percentage of drivers following with a gap of less than two seconds, were achieved in the two lanes where Chevrons were laid.

The Leicestershire markings were temporary ones which, after about six months, almost completely disintegrated, making long term accident analyses impossible. Comparing accident frequencies for the 3 years before the (permanent) Northamptonshire scheme installation with those occurring over a two year period after installation, and with Control data, a statistically significant overall accident reduction of 56% was observed. Multi-vehicle accidents

were reduced by over 40%. A large proportion of these were likely to have been rear-shunt accidents and a consequence of close-following. However, a surprising result was that single-vehicle accident reductions observed were even greater. It was suggested that the Chevrons may have acted as an alerting device to drivers travelling in an otherwise fairly stimulation-free environment or that the result might be due to the novelty effect of the signs and markings. There was also evidence to suggest that the beneficial effect of the presence of the Chevrons persisted for at least 18km beyond the start of the pattern.

The opinion surveys of 1061 drivers established that 95% understood the purpose of the markings and 90% felt that the Chevrons were helpful, or very helpful. Ninety per cent of those who had the opportunity to do so tried to use the Chevrons, and 70% of these drivers reported that they had done so without difficulty. For those who did experience difficulty, the main problem cited was of other drivers moving into 'their' gap.

3.2 THIRD LANE COACH BAN

Under a European Community directive, coaches have been limited to travelling at a maximum speed of 65mph since 1st January 1996. The Department of Transport decided, therefore, to prohibit coach traffic from using the 3rd (offside) lane of all 3-lane motorways in Great Britain, for a two year experimental period from the same date. This option was considered preferable to that of allowing vehicles unable to travel at the motorway speed limit to use the third lane, on road safety grounds.

TRL are monitoring compliance with the third lane ban. Automatic vehicle classifier data collected at eight core census sites, on selected motorways, will be analysed to identify any changes in lane usage over the trial period. 'Before' data for two two-week periods, one in February 1995 and one in August 1995, have shown that of 966825 vehicles:

* 0.5% were coaches/buses;
* 36%, 41% and 23% were in lanes 1, 2 and 3, respectively;

and that:

* 62.8%, 34.6% and 2.6% of coaches/buses were in lanes 1, 2, and 3, respectively;
* 0.06% of vehicles travelling in the 3rd lane were coaches/buses.

'After' data will relate to lane usage at the same sites. Data for February/August 1996 and 1997 will be analysed each year, as they become available.

4. JUNCTIONS

The large number of rural junctions which carry relatively low volumes of traffic make it difficult to design cost-effective accident remedial treatments. The two measures described in this section were primarily designed to tackle junctions with high speed approaches where vehicles were most likely to fail to stop and give way. Although only about 1% of accidents on rural single-carriageway roads are estimated to involve 'junction-overrunning', the low cost of the measures means that widespread application might be worthwhile.

4.1 YELLOW BAR MARKINGS ON MOTORWAY OFF-SLIPS

In the 1970's, transverse bar markings with an irregular (approximately logarithmically decreasing) spacing pattern were suggested as a possible solution to the effect known as 'speed adaptation' where, when a driver has been driving at high speed for a considerable distance and then reduces speed (from 70mph to 30mph, for example), the driver feels as if s/he is travelling much slower than s/he actually is. The spacing pattern, therefore, was designed to manipulate a driver's visual field so that, as a driver travelled over the markings, perceived speed was greater than actual speed. The objective of the markings was, therefore, to slow drivers on the approach to a hazard, such as a junction.

A previous trial of Yellow bar markings on 42 dual-carriageway approaches to UK, at-grade roundabout junctions (Helliar-Symons, 1981) achieved overall accident reductions of 57% (with respect to Control accidents). Thus, it was decided to trial similar markings on 44 UK motorway off-slip, junction approaches with the aim of reducing 'junction-overrun' accident frequencies (Haynes et al, 1993). The pattern used differed from those found on dual-carriageways only in the pattern length which was shortened to 45 bars (Figure 2). Traffic flows and accident data were studied for 3 years before, and 4 years after, the schemes were installed in 1986. Geometric data and information concerning motorway roadwork schedules were also collected for analysis. The results indicated a reduction in injury accident frequency of about 15% (with respect to Control sites) which was not statistically significant.

4.2 BAR MARKINGS ON MINOR ROAD APPROACHES

In 1994, bar markings, similar to those described in section 4.1, were installed at ten rural single-carriageway crossroad junctions in Bedfordshire, Cambridgeshire, Cheshire and Lincolnshire (Barker and Nicholls, 1995). Each junction had a history of accidents and was situated within a derestricted speed limit, away from residential properties, on lightly trafficked roads.

At each site the bar markings were laid across a minor arm approach to the junction, in one of two colours - 'Sea Green' or 'Primrose'. (These colours were chosen to be more in keeping with the rural environment than the traditional Yellow markings.) The bar markings were laid across *both* carriageways. Although this meant that vehicles leaving the junction would also pass over the markings, it was felt that had the markings been laid on only the approach carriageway, some drivers might choose to approach the junction on the wrong side of the carriageway, either to avoid their slight vibrational effect or believing them to be hatching. Forty-five bars were laid, each 0.6m wide, in a hot, screed applied, thermoplastic material at right angles to the direction of travel. The bar pattern was positioned between 50m and 250m from the junction mouth, the spacing between consecutive bars decreasing in an approximately logarithmic fashion towards the junction.

The bar markings were designed to slow drivers down, to alert them to the junction which was generally not clearly visible on the approach (Figures 3 and 4) and, thus, reduce the frequency of 'junction-overrun' accidents. Speed measurements were recorded using radar guns on several occasions before and after the schemes were installed.

Before the bar markings were installed, the mean and 85th percentile speeds of light vehicles (100m away from, and approaching the junctions) averaged 37mph and 42mph, respectively. During the year after the bar markings were installed, the mean speeds of vehicles fell by an average 1.2mph, and the 85th percentile speeds by an average 1.0mph. In general, the greatest speed reductions were achieved at the sites with the highest approach speeds.

Accident frequencies at the junctions were very low with the frequency of all accidents (including 'junction-overruns') averaging 1.3 per site year, before the schemes were implemented. The frequency of accidents involving vehicles entering the junctions from the treated arms fell by (a statistically non-significant) 10%, with respect to all other accident types, over a 12 month period after the bar markings were installed.

There was not sufficient evidence to favour the use of any particular site-approach layout or bar marking colour. However, it has been observed that the 'Sea Green' markings tend to fade significantly after only a few months.

5. BENDS

The degree to which a particular bend poses a hazard to a driver is dependent on many factors. Road layout factors (such as visibility, road width, curvature of bend, curvature of preceding road sections and camber) and other factors (such as the weather, vehicle type, vehicle speed, driver alertness and whether the driver is familiar with the road) can vary so widely from site to site that there is no one convention for signing and marking bends in terms of severity. The measures described in this section have been investigated for possible future use as low-cost treatments at selected bends that appear especially hazardous.

5.1 RUMBLE AREAS

In 1993, a rumble area was laid on each approach to a very sharp bend on the A581 at Shaw Green, Lancashire (Farmer, 1995). The site had a history of 'loss of control' accidents and the aim of the measures was to slow drivers down and alert them to the proximity of the bend ahead. Each rumble area consisted of 18 strips of a red thermoplastic material containing 3-6mm chippings (Figure 5). Speed measurements were recorded using radar guns on several occasions before and after the scheme was installed. Over the year following installation of the scheme, reductions in the mean speed of light vehicles at the apex of the bend averaged 3mph.

5.2 BAR MARKINGS

In 1995, transverse bar markings, similar to those described in section 4.2 but red in colour, were installed on both approaches to a severe bend on a 60mph speed-limited stretch of the A646 near Burnley, Lancashire. The site had a history of accidents and the aim of the scheme was to encourage drivers to approach the bend at lower speeds. Prior to the scheme being installed, mean light vehicle speeds of 41 and 46mph were recorded on the approaches to the bend, using a radar gun. TRL anticipate monitoring '12 months After' speeds at the site in late 1996.

5.3 CHANNELISATION

An experiment is currently in progress to develop and test channelisation markings on bends which are designed to encourage drivers to slow down and guide them in their choice of path through the bend. The aim of using such markings is to reduce the numbers of head-on collisions and 'loss of control' accidents on rural bends. A feasibility trial on the TRL driving simulator has been carried out, during which the speeds and lateral displacements of 36 subjects were recorded as they drove along a simulated, 10m wide, 6km long rural route. After the drive, subjects were asked to fill in a short questionnaire to record their observations and comments. The whole of the route was level and contained several left- and right-hand bends, each 200m long with a constant radius of curvature of either 300m or 800m. The bendy sections were linked together by 600m long straight road sections.

The bends were marked in one of three ways (Figure 6). The first type of bend marking comprised edge-lining with dashed centre-lining. The second type comprised edge-lining with solid centre-lines 2.5m apart and filled with standard, straight hatching with 2m spacing. The third type of bend marking trialled was the same as the second except

Fig. 1 Chevron markings on the M1

Fig. 2 Yellow bar markings on a motorway off-slip

Fig. 3 Primrose bar markings on hill approach to junction at Ufford, Cambs

Fig. 4 Sea Green bar markings on bend approach to junction at Hyde, Beds

Fig. 5 Rumble strips at Shaw Green, Lancashire

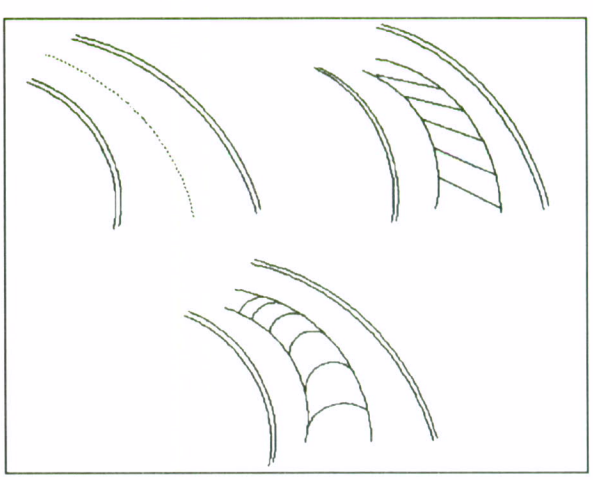

Fig. 6 Sketch of the three bend marking types under test (not to scale)

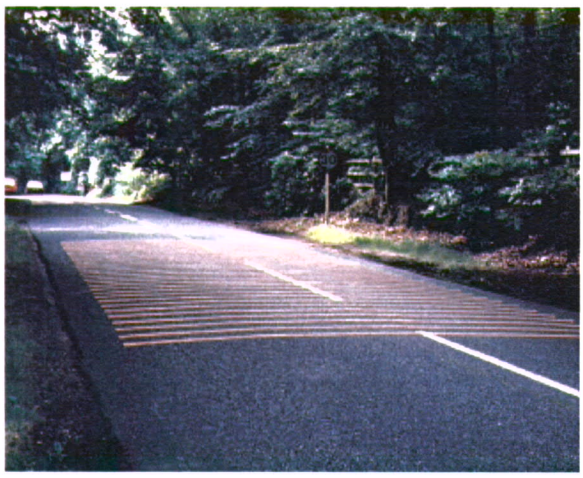

Fig. 7 Riblines

Fig. 8 30 mph Count-down signs

Fig. 9 40 mph Roundel marking

Fig. 10 A vehicle-activated sign at Long Compton, Warwickshire

Fig. 11 The vehicle-activated sign at Scole, Norfolk

that the centre-hatching comprised curved lines. The curved hatching is an innovative approach which has been designed to make the centre of the road appear humped (or troughed, depending on the direction of travel). It is postulated that drivers may be less likely to impinge on such markings if they believe the road is not flat. The three types of marking were linked in six different orders along the route and 6 subjects drove through each route combination.

The trial data will be analysed to identify any differences in the behaviour of drivers as they encountered each type of marking. Depending on the outcome of the analyses, further on-road trials may be carried out.

6. VILLAGES

It is often the case that, on entering an area with a lower speed limit, drivers do not slow down to comply with the speed limit. There may be many reasons why drivers behave like this, including, perhaps, being unaware of the lower limit, being unaware of their own speed and responding late to the presence of the lower limit. These factors can be of particular concern in villages in rural areas: the differential between the speed limits inside and outside the village can be large, and so speeds observed through such villages can be particularly high compared to what is appropriate for the conditions. Thus, the potential for conflict between pedestrians, cyclists and motor vehicles can be great, leading to an adverse effect on road safety and the quality of life for residents.

This section concerns measures thought likely to have the potential to encourage drivers to reduce their speed at the boundaries of rural residential areas in preparation for the conditions ahead. Measures of this type were the subject of the earlier VISP (VIllage SPeed control initiative) study (Wheeler et al, 1994; Wheeler and Taylor, 1995). However, that study involved the application of *combinations* of measures and was not designed to test the effectiveness of each individual component. In contrast, the trials in the present project have generally been of single measures in isolation.

6.1 RIBLINES

Riblines (Figure 7) are thermoplastic, transverse road markings, with a higher, narrower profile and shorter pattern length than the bar markings described in section 4.

In 1988, riblines were trialled at three sites in Hampshire - Basing, Sway and Hawley (Butler and Helliar-Symons, 1993; Helliar-Symons et al, 1995b). The objective of the trials was to slow drivers down and alert them to the presence of the village ahead not only visually, but also through the noise and vibration generated when travelling over the riblines. Speed measurements were made using radar guns at each site on several occasions before and after the schemes were installed. One disadvantage of riblines is that the noise generated by vehicles driving over them can disturb residents up to about half a mile away, particularly at night. Due to complaints about the noise at Basing and Sway, the riblines were removed after only one week and two months, respectively.

At the three trial sites, reductions of up to 6mph in the mean speed of light vehicles were achieved immediately after the riblines were installed but at Hawley the reduction was found to decay exponentially over time. This was possibly due to a 'novelty' effect of the markings and some drivers may have discovered that (as with cattle grids) the faster one drives over riblines, the less the discomfort. At Hawley, accidents recorded over 3 years before and 4 years after ribline implementation showed a reduction in accident frequency of 60%. Although encouraging, this reduction was not statistically significant.

6.2 SPEED LIMIT COUNT-DOWN SIGNS AND ROUNDEL MARKINGS

Count-down signs show a black speed limit symbol together with three, two or one black diagonal bars on a white background, installed at 300, 200 and 100 metres respectively from the start of the speed limit (Figure 8). Roundels are elongated circles with the speed limit in their centre, laid in white thermoplastic on the road surface at one or more positions within a speed-limited area (Figure 9). Both engineering measures were designed to alert drivers to a change in speed limit and the presence of a residential environment (particularly if preceded by a long, fast section of road or poor forward visibility) and to encourage drivers to reduce their speed through rural villages.

Trials of speed limit Count-down signs and Roundel markings have been carried out at several rural villages in Great Britain (Barker and Helliar-Symons, 1996). In 1992, 30 mph Roundels, 40 mph Roundels or Count-down signs were installed at a total of twelve villages in the DOT Eastern Region and at one village in Buckinghamshire. During 1993, Count-down signs were installed at five locations in Northumberland. Also in 1993, Count-down signs and Roundel markings were installed at a village in Powys. Speed measurements of light vehicles were made using radar guns before, and at different times after, the schemes were installed.

Overall, the findings were that whilst the 40 mph Roundel markings produced a reduction in mean speed of about 3 mph which was statistically significant, the 30 mph Roundels and the Count-down signs did not have a significant effect on mean speeds. Due to the small size of the trials and the low accident frequencies involved, no firm conclusions could be drawn regarding the effect on accidents. In the main DOT Eastern Region and Northumberland trials, injury accident data indicated changes of -11%, +5%

and -25% (with respect to a Control) following the installation of the Count-down sign, 30mph Roundel and 40mph Roundel schemes, respectively, but the results were not statistically significant.

6.3 VEHICLE-ACTIVATED SPEED WARNING SIGNS

Vehicle-activated (or 'secret') signs are roadside signs which only target selected drivers. With speed warning signs, the speeds of vehicles travelling over a monitor loop on the road, or past a radar beacon, are measured. If this speed is in excess of a pre-set trigger speed, the 'secret' sign beside the road is activated. Hence, any driver travelling at a speed which is regarded as unsuitable for that particular stretch of road would activate the sign. When activated, the sign lights up and can, for example, display the speed of the offending driver, a simple written message (such as 'SLOW DOWN, 30'), or a speed limit roundel. In the trials reported here, the objective of using such signs was to alert drivers to a village ahead and to reduce the speeds of vehicles travelling through the villages.

Trials were carried out, one at each end of a Warwickshire village, in 1986 and 1990 respectively (Barker et al, 1995) - (Figure 10). In 1992, a separate trial took place in Scole, Norfolk where, for the first time, a red and white roundel, together with amber flashing lights, was used to enforce the speed limit (Figure 11). This latter type of sign design is currently being trialled in one Wiltshire village and six Norfolk villages with 30mph or 40mph speed limits.

In the Warwickshire trials, the mean speed of vehicles travelling into the 30mph speed-limited village was significantly reduced after the introduction of the automatic speed warning signs. Taking into account Control data, average reductions in the mean speed of cars at the first trial site were about 6mph near the signs and about 3mph in the village centre. At the second trial site (at the northern village entrance), the mean speed of cars was reduced by about 3mph at the single measurement position. Heavy goods vehicles were slightly less affected, probably due to their considerably lower Before speeds, showing an overall reduction of 2mph after sign installation. A similar pattern of reductions was observed for 85th percentile speeds. There was no conclusive evidence of reductions in the standard deviations of speed. The speed distribution results suggested that the signs affected the faster drivers most.

There was some evidence of a slight 'novelty' effect at the first trial site, with the largest reductions occurring soon after sign installation. Comparisons of the speed changes achieved at each monitoring position suggested that installing pairs of signs may be valuable. Slight differences in the 'trigger' speeds of the signs did not appear to have differing effects on drivers' behaviour. There was also some evidence to suggest that drivers were influenced by the signs whether or not they were triggered. The reductions in accident numbers and severities, although sizeable, were not statistically significant.

At Scole in Norfolk, over the 12 months after the sign was installed, a similar statistically significant reduction in mean speed of about 5mph was observed 200m after the sign. The current trials in Norfolk will show whether these reductions can be replicated with the more widespread use of the signs at other villages. Early results are promising.

6.4 30MPH SPEED LIMITS

In 1995, Suffolk County Council started to implement their new policy of introducing 30mph speed limits in every village and hamlet in the county. The new speed limits are signed at the village boundaries and publicised widely but not enforced through additional police efforts or complementary engineering measures. The new speed limits are being introduced in 'batches' of about 30 villages. TRL and Suffolk County Council are collaborating in a trial to monitor the effects of the schemes. Suffolk are collecting speed data at selected villages on several occasions before and after the new speed limits come into force. TRL are monitoring residents' opinions of the new speed limits in four villages.

6.5 TRAFFIC CALMING

As already stated, the VISP study (Wheeler et al, 1994; Wheeler and Taylor, 1995) monitored the effects of various combinations of traffic calming measures installed in rural villages. North Frodingham, in Humberside, was one of the villages in the VISP study but, disappointed with the speed reductions achieved in the original scheme, the County decided to modify it in 1995. The results from further speed monitoring, carried out to assess the effectiveness of the modified scheme, were analysed by TRL under the present project (Wheeler, 1996).

The original scheme comprised kerb works narrowing the lane width of the main road through the village, centre hatching and edge markings. In 1995, a gateway (comprising prominent signing, surface changes and markings) was added at each end of the 40mph speed limit and build-outs within the village designed for one-way working were introduced.

To monitor the 1995 scheme, radar speed measurements of free-flowing light vehicles were taken outside the village, at the gateways and within the village. One gateway reduced mean and 85th percentile speeds by 4mph, but elsewhere speed reductions were small or absent.

7. SUMMARY, DISCUSSION AND FUTURE WORK

Table 3 summarises the results for each type of rural safety measure trialled during the project. As a consequence of the trials, the Department of Transport proposes to include motorway Chevron markings and village speed limit Roundel markings in the next issue of the Traffic Signs (Amendment) Regulations and General Directions, subject to consultation. (The proposals permit the use of Roundels in areas with speed limits of 40mph or greater and, on 30mph roads, permit the use of Roundels *next to* the speed limit terminal sign only.) The use of bar markings and other measures trialled will still require authorisation.

The trials described in this report have all tried to address the rural road safety problem. It is hard to find suitable, practical solutions to many of the accident types occurring on rural roads because of the length and variety of road and because of the difficulty in changing driver attitudes and behaviour. Nevertheless, overall, the results of the completed safety engineering trials reported here have been very encouraging. Although the vehicle speed reductions achieved have been small, it has been well-established that even small reductions in speed can lead to significant reductions in accidents (see for example 'Speed, speed limits and accidents' - Finch et al, 1994). In general, the schemes reported here have not yet been installed long enough for sufficient accident data to be collected to be able to confirm this statistically, but the early indications are promising. Given that the cost of installing schemes (except motorway Chevrons) was of the order of £3000-5000, it is likely that the widespread application of the measures could prove extremely cost-effective, even if only modest accident savings are realised. The one trial for which sufficient accident data were available (Northamptonshire motorway Chevrons) proved extremely cost-effective, giving estimated accident savings of about £1.6 million over a two year period, compared with the initial outlay of approximately £20,000 for scheme installation (1993 prices). However, it is not known to what extent any 'novelty' effect would be diminished with a more widespread use of the Chevrons.

The work undertaken in this project relies heavily upon the interest and cooperation of the LHAs and on their budgetary constraints. The precise timing and content of future

TABLE 3

Summary of measures trialled during the project

Site type	Measure trialled (and number of schemes)	Changes in mean speed	Changes in accident frequency	Other comments
Motorways	Chevrons (2 schemes)	none (1 exception)	-56% (1 scheme)	drivers close-following gaps of < 1s: -15%; < 2s: -5%
	Third lane coach ban	in progress		
Junctions	Yellow bar markings on motorway off-slips (44 schemes)	-	-15% (ns)	-
	Bar markings on minor road approaches (10 schemes)	-1.2mph	-10% (ns)	-
Bends	Rumble areas (1 scheme)	-3mph	-	at apex
	Bar markings (1 scheme)	in progress		
	Channelisation (simulator trial)	in progress		
Villages	Riblines (3 schemes)	up to -6mph	-60% (ns, 1 scheme)	noisy
	Speed limit: Count-down signs (17 schemes in main trial; 19 schemes overall)	none	-11% (ns)	-
	30mph Roundels	none	+5% (ns)	-
	40mph Roundels	-3mph	-25% (ns)	-
	Vehicle-activated speed warning signs (3 schemes complete; 7 in progress)	up to -6mph	-	at signs
	30mph speed limits	in progress		
	Traffic calming (1 scheme)	-4mph	-	at gateway

ns = not statistically significant

trials is therefore hard to define. However, TRL anticipate completing the trials currently in progress and continuing the development and trialling of new ideas generated within TRL, the Department of Transport, Local Highway Authorities and elsewhere.

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