DEPARTMENT OF TOWN PLANNING

ADAPTING RESIDENTIAL ROADS FOR SAFETY AND AMENITY

Liz Beth and Tim Pharoah

OP 3/88

OCCASIONAL PAPER

SOUTH BANK POLYTECHNIC

FACULTY OF THE BUILT ENVIRONMENT

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ABSTRACT

The paper examines a range of problems associated with motor traffic in residential areas, and the use of physical street adaptations to tackle these problems. Practice in England and Wales is discussed in the context of a survey of local authorities. Amongst authorities who had implemented physical measures, there were wide variations in enthusiasm and approach, often depending on urban renewal policies rather than the benefits of street design per se. These differences are explored using case studies. Most authorities seemed unaware of practice in other European countries, where reconstruction of residential streets to achieve environmental and safety improvements has been standard practice for ten years or more. The paper argues for a major expansion of street adaptation activity, and suggests that this should be based on the experience of other European countries.

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PREFACE

The last ten years have seen many new ideas for the design and layout of residential roads implemented in new housing developments. Most highway authorities have issued design guidance for new residential roads, based on the national guidelines given in Design Bulletin 32 "Residential Roads and Footpaths". As a result, new residential layouts being built today often differ radically from those of ten years ago, both in their appearance and in their design objectives. Design Bulletin 32 (DB32) stated that:

> "The needs of pedestrians for safety and convenience should be given priority in design over the use of vehicles" (DOE 1977:5)

Most of the nation's housing stock, however, is served by roads built before 1977. The purpose of this paper is therefore to consider how these more traditional residential roads and streets may be adapted to meet the objective of pedestrian priority.

The DOE is reviewing DB 32, and may provide new guidance on adapting existing streets. Meanwhile the guidance on such adaptations is incomplete and spread amongst several sources.

The first two chapters of this paper look at the problems on existing residential streets in terms of safety and environment, and argues the need for changes in their design and layout to provide greater pedestrian safety and comfort. Treatments caried out by local authorities are considered in terms of their objectives and department of origin. In particular, schemes by highway authorities appear to be done on mainly road safety grounds, while schemes from housing and planning departments concentrate on environmental objectives.

Chapter 3 discusses the implementation of new safety and environmental criteria, and dismisses the notion that there is an inevitable conflict between these two objectives. Chapter 4 looks at some examples of adapted residential streets. European practice is briefly referred to, but collation of the vast range of European experience is beyond the scope of this paper, and is the subject of ongoing research at South Bank Polytechnic and elsewhere.

Chapter 5 contains the results of a survey of local authorities in England and Wales, which has enabled a clearer picture to emerge of the location and nature of adaptations made to residential roads up to 1986.

In chapter 6 conclusions are drawn about the present situation, and suggestions are made concerning the type and organisation of possible future adaptations.

Since this paper was written, some interesting developments have occurred: Several conferences have indicated a growing interest in the subject; road hump regulations have changed, and many more examples of this technique have now appeared on public roads; a manual on "Roads and Traffic in Urban Areas" has been published by the Institute of Highways and Transportation and the Department of Transport; and initial results from the Urban Road Safety Project have appeared. In addition, the Department of Transport's Traffic Advisory Unit has issued a series of leaflets aimed at informing

local authorities of the available techniques and regulations. For example leaflet 1/87 shows "Measures to Control Traffic for the Benefit of Residents, Pedestrians and Cyclists", while leaflet 3/87 describes the more flexible road hump regulations introduced in 1986. Meanwhile, an increasing number of local authorities have been experimenting and implementing street adaptations. It does appear that progress is now being made, though still not underpinned, as in other European countries, by any major programme of research or demonstration projects, or by any significant encouragement from central government.

CHAPTER 1

THE CASE FOR ENVIRONMENTAL IMPROVEMENT

THE PRESENT LEGACY

The two most common forms of traditional residential road design in Britain are firstly the By-law terraced housing on a basic "grid" or "broken grid" pattern, and secondly the suburban estates of the inter-war and post 1945 years. The earlier By-law housing, not surprisingly, is mostly nearer to the centre of towns and cities, while semi-detached and detached twentieth century suburbia occupies the outer parts of urban areas. Because of the radial character of the main road network of most towns and cities, with traffic focussed on the centre, it is the older, inner areas that suffer most traffic conflict and pressure. Changes to these streets have involved either meeting traffic pressure (one-way streets, road markings, high level lighting, parking meters and restrictions) or, more rarely, resticting traffic through various environmental schemes (closures, footway extensions, planting). As a rule, the former have been carried out under highway and traffic authorites, while the latter have been mostly connected with area improvement schemes under housing and planning legislation, namely General Improvement Areas and Housing Action Areas. But the layout and design of the vast majority of urban streets remains the same as on the day they were built. It is a simple economic fact that transport infrastructure is expensive and long lasting, while the vehicles that use it are relatively cheap and short lived.

Compared to medieval street layouts, the nineteenth century designs have been able to absorb large quantities of traffic and parking for which they were not designed, while from about 1918 onwards the design of streets reflected a conscious attempt to facilitate motor traffic. The 1946 report from the Ministry of War Transport "The Design and Layout of Roads in Built Up Areas" stipulated that residential roads should avoid restriction of traffic circulation, and, for example, gave minimum road curvature specifications to allow motor vehicle movement at reasonable speeds. The manual also stressed that through traffic should be taken out of residential areas, but said that this would happen automatically with the provision of better distributor roads. In the event through traffic often took advantage of the lack of restriction, and cut through residential areas in order to shorten journey times. This problem is now avoided only where the layout is irregular (through the use of culs-de-sac, crescents, circles etc.) or where deliberate counter measures have been introduced.

The growing perception of the environmental problems of traffic in the 1960's stimulated several Government publications on the subject of roads and traffic. The most influential, Buchanan's "Traffic in Towns" which was published in 1963, acknowledged the environmental problems due to traffic in residential areas. The main enemy of residential areas was seen as "through traffic", and a philosophy was advocated of a hierarchical road network design to confine major traffic flows on a distributor network, and to restrict the use of residential roads to traffic having business there. The design techniques to achieve this protection were referred to as "environmental traffic management". These were demonstrated in an example study of the Headingly area of Leeds, and involved road closures and pedestrianised streets.

A design guide published three years later by the Ministry of Housing proposed quite drastic new design criteria. This

publication, "Cars in Housing", called for a Radburn approach to new residential road design, involving the complete separation of vehicle and pedestrian traffic and access (Figure 1). This approach to residential layout was subsequently used in many places, especially the new towns, but has now lost favour. Although no explicit reasons have been offered for its rejection, Radburn layouts did not improve the carriageway in terms of aesthetics or road safety, and residents' privacy suffered by having access front and rear. The carriageway was often more popular than the traffic free areas for pedestrians and for children's play.

Also published in 1966 was the Ministry of Transport's manual on road design, "Roads in Urban Areas", which emphasised traffic segregation as the answer to conflict, but was equally concerned to ensure that motor vehicle movement was not impeded. This manual influenced the design of a whole generation of residential roads with dimensions and layouts capable of accommodating even the largest vehicles.

It was not until the late 1970's that changing the design of residential roads to suit pedestrian activities, and thus most home-based activities, was officially suggested. In 1977 the Department of the Environment issued "Residential Roads and Footpaths", commonly referred to as Design Bulletin 32, which although deservedly the subject of some adverse criticism (see for example Jenks, 1983), did mark a crucially important shift in the priorities of design, from vehicles to pedestrians, and from drivers to residents.

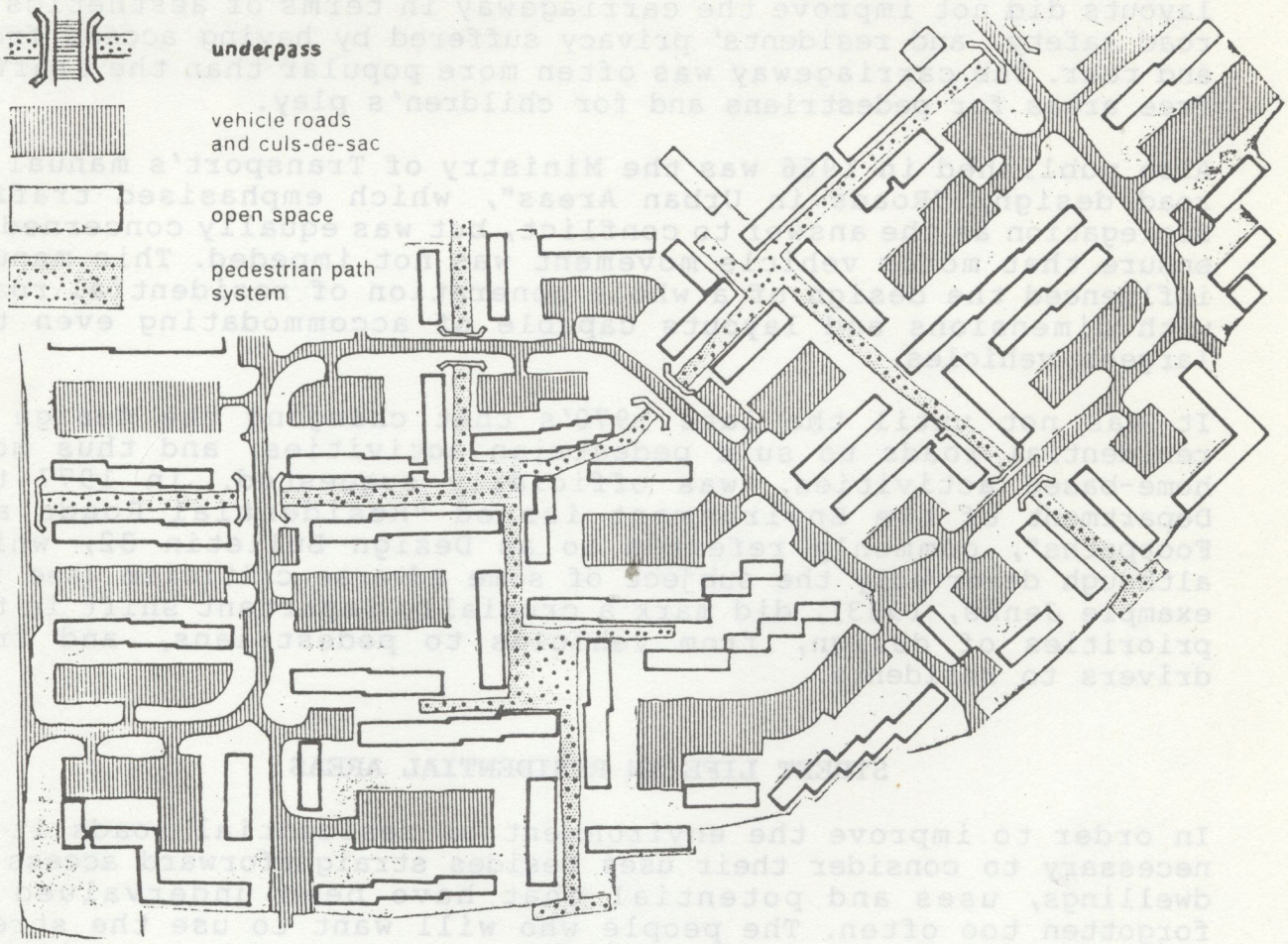
STREET LIFE IN RESIDENTIAL AREAS

In order to improve the environment of residential roads it is necessary to consider their uses besides straightforward access to dwellings, uses and potential that have been undervalued or forgotten too often. The people who will want to use the street most are those who spend most time at home, for example the elderly, children, the unemployed and women at home. They will want to use it for access to nearby areas and facilities as pedestrians, for casual strolling, for visiting and talking with neighbours. Children will use the street for playing, learning to ride a bike, watching, and as neutral ground on which to meet others. The street often offers children more space than the family home, and a convenient hard surface for games. Provided the neighbourhood is safe, children can gain their first taste of independence in the street outside their home.

The increasing levels of motor traffic have severely restricted the possibilities for residential roads to be used for anything other than access. Appleyard argues that a new concept of the street as sanctuary rather than as a social centre has developed. But despite a lessening of intensity, residential streets still serve a social and play function when the traffic environment permits.

The call for greater pedestrian priority in DB 32 would seem to acknowledge the right of residents to use the street for more than just access, and that motor vehicle traffic, unless restrained, will destroy the environment in which such use can take place.

FIGURE 1. Typical Radburn layout with separate footpath and road networks serving dwellings (after Ministry of Housing & Local Government, Design Bulletin 10, 1966)



A PLEASING ENVIRONMENT FOR RESIDENTIAL ROADS

A "pleasing" environment is not entirely a subjective matter. People respond with near unanimity to the aesthetic value, or lack of it, in many surroundings. Some authors have attempted to define what makes a pleasing urban environment (eg. Lynch 1960 and 1972, Rapoport 1977). Lynch argued that an urban area should be comprehensible if it was to be enjoyed, and identified five elements used in urban comprehension: paths, edges, districts, nodes and landmarks (Lynch 1960, 46). Rapoport explains the importance of this comprehensibility by reference to psychological stress caused by both sensory deprivation and information overload. An undifferentiated urban environment can, he argues, cause both sorts of stress, with a lack of sensory stimulation in immediate surroundings, yet at the same time a large number of similar objects to be comprehended at the macro level. Complexity of environmental elements without confusion seems to be needed, and contrasts are required within an urban environment to claim

attention and stimulate perception. By these criteria, many of our residential areas are undifferentiated, unstimulating and thus not pleasing, though people would probably be reluctant to describe their own street in this way.

An indication of the sort of features people respond to is given in Table 1.

TABLE 1: Cues that people use to differentiate their physical environment (based on Rapoport 1977, 229)

VISION

Objects: Shape, size, height, colour, materials, texture, details.
Space quality: Size, shape, barriers and links.
Light and shade: light levels and quality
Greenery
New vs old
Order vs variety
Well maintained vs neglected
Scale and form
Road pattern
Topography
Location : prominence, at decision points, on hills etc.
Movement: speed, quantity of traffic

TACTILE

Mainly texture underfoot (but more than this for children)

SOUND

Noise vs quiet
Human sounds: industry, traffic, music, talk, feet.
Natural sounds: wind, trees, birds, water etc.
Temporal changes in sound

SMELLS

Foods and shops, plants, flowers, sea etc.

A further factor in design is the different scale necessary if the environment is to be pleasing to pedestrians rather than to drivers. Figure 2 shows how the level of complexity needed in a street, and the degree of differentiation appreciated, varies with the speed of travel of the observer. Streets designed for motor traffic travelling at 50 km/h or more which deliberately lack differentiation and have long unobstructed sightlines, tend to create a monotonous environment for pedestrians.

This difference between the ideal environment for drivers and pedestrians makes the two travel modes as incompatible in design terms as they are in traffic terms. Rapoport (1977, 243) argues that motorists will suffer information overload in a pedestrian environment. If this is so then this may encourage greater care and

less speed where a street is designed with priority for pedestrians.

One of the easiest ways to introduce variety and contrast in an urban street is by the provision of soft landscaping. Trees and other plants provide irregular forms and new colours to counter the regularity of built forms. Vegetation also changes with the seasons and the weather, and adds movement to an urban scene. A well-landscaped street may also look less like a route for traffic and more like an extension of house and garden. The care and maintenance of soft landscaping in residential streets can be costly, but residents themselves may be willing to tend planted areas, provided that theyare in favour of the planting scheme, and are involved in the design and implementation process.

On older streets, the lack of off-street parking often means that parking places have to be accommodated as well. But parking can, with imaginative layout, contribute to safety by narrowing and twisting the carriageway, while at the same time being aesthetically more pleasing than unregulated kerbside parking.

The street designer has other tools, including street furniture and lighting, seating and children's play space. Such features can, together with soft landscaping, help to increase the richness of detail necessary for a pleasing residential environment.

FIGURE 2: Speed and noticeable differences (from Rapoport 1977, 241)

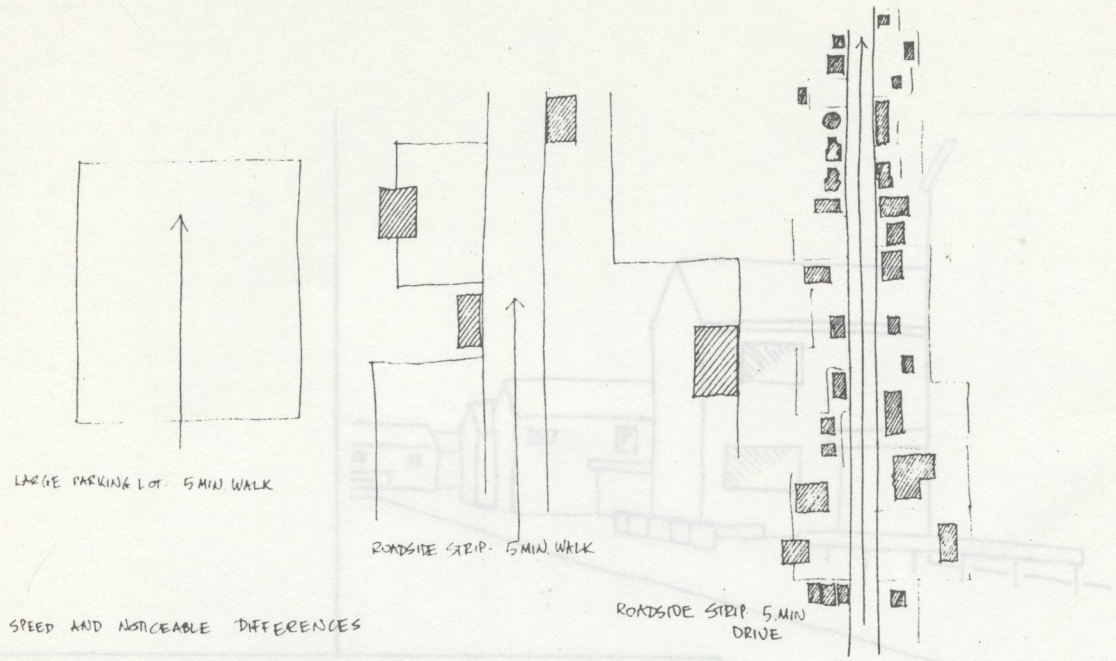


FIGURE 3: The differing environmental requirements of motorists and pedestrians (from Rapoport 1977, 244)

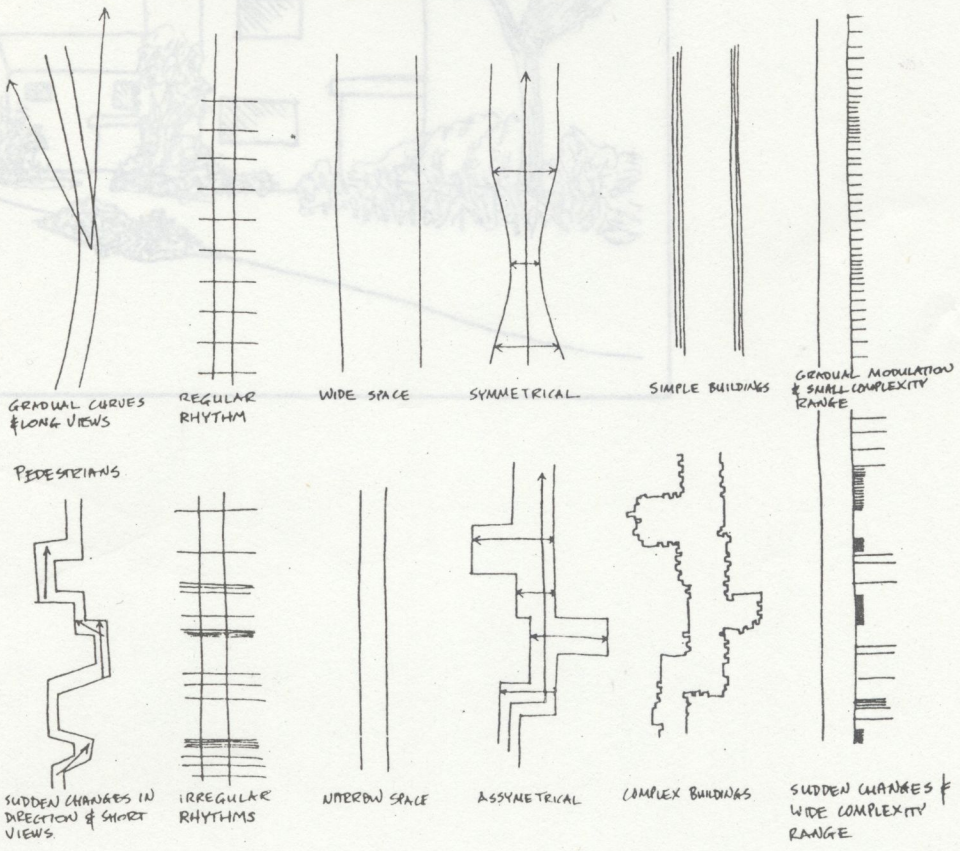
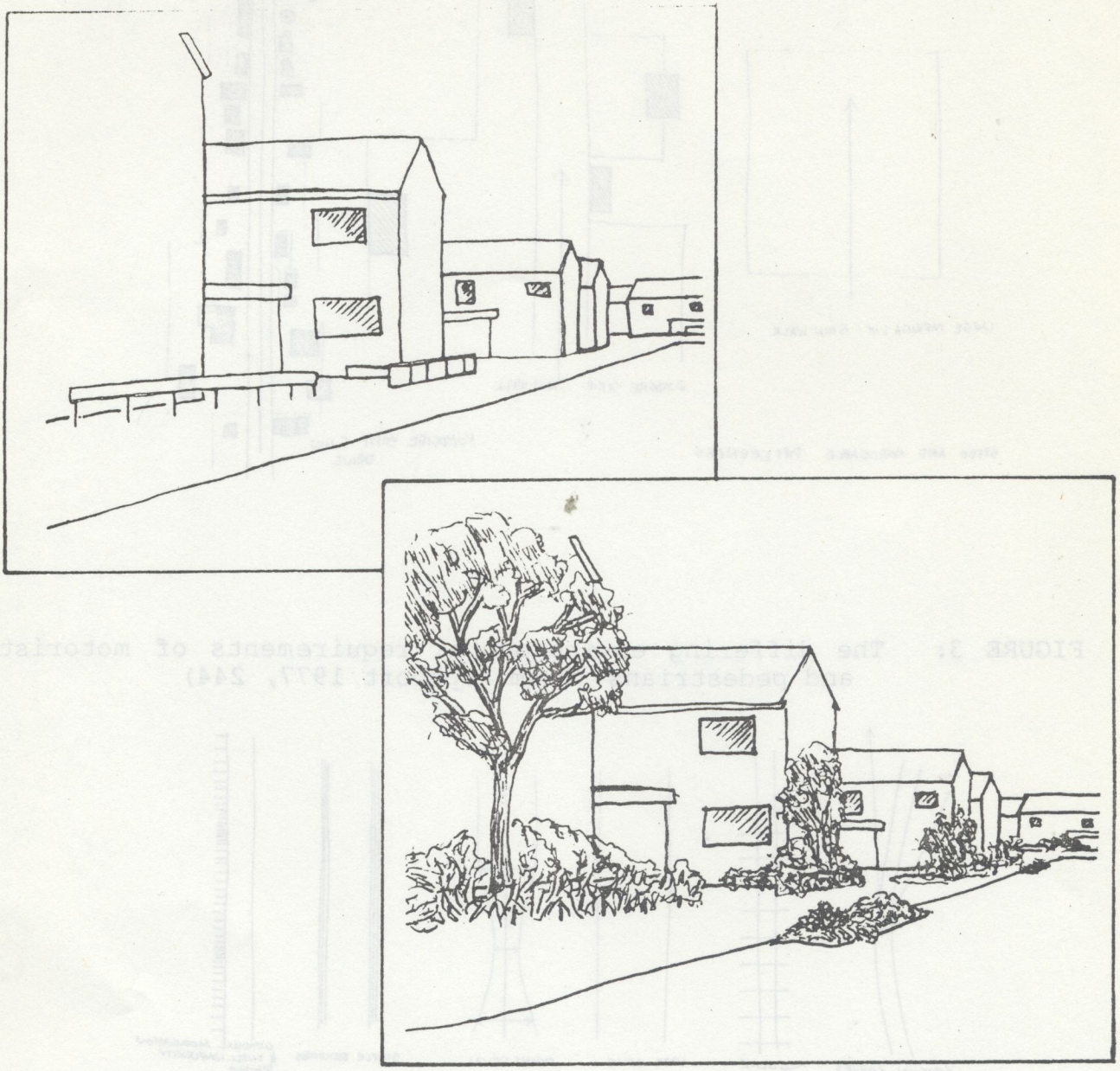


FIGURE 4: Sketch showing the softening and contrasting effect of trees and other vegetation in a residential street.



CHAPTER 2

THE ACCIDENT PROBLEM ON RESIDENTIAL ROADS

THE ACCIDENT PROBLEM ON RESIDENTIAL ROADS

Close inspection of road accident figures shows that not all members of society suffer the same threat of death or injury on the road, and that some groups are particularly vulnerable. Inner city dwellers are more likely to suffer a road accident as pedestrians, cyclists and motorcyclists. The American joke that "a pedestrian is just a car driver who found a parking space" may be amusing, but it isn't true. Pedestrians are disproportionately formed from the young, the elderly, women the poor, and others with the least access to private cars. There are inequalities in exposure to road accident risk and, although ill-defined, two distinct interest groups can be identified, pedestrian and driver. Conflict between these two groups is not, however, necessarily severe or inevitable. If measures that inconvenience drivers are needed to alleviate the dangers to pedestrians, then several surveys have shown that the majority of drivers would accept them (Plowden and Hillman 1984, 89).

It has been argued that a residential street should be, as far as possible, a public extension of residents' living space, rather than a highway. And yet the extent and nature of the road accident problem on traditional residential streets indicates that it is not a safe environment for residential activities, and especially not safe for children.

The following analysis of road accident statistics follows the usual practice of using the national injury-only accident figures collected by local police forces.

Distribution of Accidents Throughout the Road Network

The pattern of road accidents in residential areas differs from that on the principal or arterial road network. Accidents on residential roads tend to be scattered thinly throughout the network while those on the principal roads are clustered, often at or near junctions (Faulkner 1975, 15). Road accident prevention has traditionally been concerned with improving accident "blackspots" or clusters by engineering solutions at the blackspot location. In recent years, however, there has been a move towards an area-wide approach that aims to improve safety generally, and to reduce the incidence of the diffuse (scattered) accidents of residential roads (see Dalby 1979). This change of emphasis in accident prevention has social implications, for cluster accident locations usually involve mainly motor vehicle occupants, whereas accidents involving pedestrians have a more diffuse location pattern.

There is evidence that an area-wide approach will be more effective in reducing the overall accident toll. Accident prevention measures at blackspots have a tendency to improve the situation at the site treated, but to have less impact on the general acident rate of the area (Faulkner 1975, 29).

Road Users at Risk

In residential areas, about one half of injury accidents involve a pedestrian, but the fatality rate is twice as high as the non-pedestrian fatality rate (Bennett and Marland 1978, 6). On the principal road network less than a quarter of all accidents involve

pedestrians. The most alarming aspect of the pedestrian accident rate on residential roads is the high percentage of young pedestrians and cyclists involved. Their vulnerability is illustrated in data from Swindon reproduced in Table 2, in which children (14 and under) are shown to comprise almost half (48%) of the diffuse injury accident rate.

TABLE 2: The relative vulnerability of children and adults on residential roads (source: Dalby 1979, 2).

	PERCENTAGE OF TOTAL INJURY ACCIDENTS	
	in clusters on arterial network	diffuse on residential streets
PEDESTRIANS		
Child	9	36
Adult	9	7
CYCLISTS		
Child	3	12
Adult	16	4
MOTORCYCLISTS	24	19
VEHICLE OCCUPANT	39	22
	100*	100

TABLE 3: Accidents to pedestrians and cyclists on residential roads in South Yorkshire by age group, 1982-84.

Age Group	Number of Accidents	Percentage of Total Accidents
0 - 11	791	42.2
12 - 15	344	18.3
16 - 19	167	8.9
20 - 29	164	8.7
30 - 39	90	4.8
40 - 49	61	3.3
50 - 59	78	4.2
> 60	480	9.6
TOTAL	1875	100 %

NB. All data for South Yorkshire provided by South Yorkshire County Council, and post-abolition by Sheffield City Council Road Safety Unit.

A detailed study of accident data from South Yorkshire reveals similar vulnerability of children. Here accident records for 1982-1984 have been examined, and the accident rate on residential roads deduced for pedestrians and cyclists aged eleven and under, (walking and cycling being the modes of travel most used by children on their own). Residential roads have been defined as closely as possible by including only unclassified roads with a speed limit of 30 mph. An age range of 0-11 rather than the more

usual 0-14 has been chosen because it is around eleven years of age that children become able to comprehend traffic and roads as adults do, and also the age at which more independence to travel is allowed by parents. Children are, nevertheless, still more vulnerable as pedestrians when older than eleven, as Table 3 demonstrates.

The approximate percentage of children aged 0-11 in the total population of South Yorkshire was 16.5% in 1981 (Census data for 0-4 plus 5-15 adjusted). Their 42.2% share of pedestrian and cycle accidents on residential roads shows their vulnerability. Table 4 shows South Yorkshire to have a concentration of child pedestrian and cycle accidents similar to that in Swindon shown in Table 2. The particularly high concentration of child cycle accidents on residential roads (58.4%) rather than arterial roads, has been suggested by Wright (1982) to show that accidents are occurring to child cyclists while they are playing rather than on a journey.

TABLE 4: Distribution of Pedestrian and Cycle accidents in South Yorkshire between residential roads and arterial/distributor roads, by age group, 1982-84.

	Residential roads	Arterial/ distributor roads	Total
PEDESTRIANS			
Aged 0 - 11	599	755	1,354
Aged 12 and over	810	2,315	3,125
Total	1,409	3,070	4,479
CYCLISTS			
Aged 0 - 11	192	137	329
Aged 12 and over	274	573	847
Total	466	710	1,176

Table significant at the 0.005% level.

The data above shows that children are particularly vulnerable on residential roads, but as a group children are generally more vulnerable as pedestrians than the older groups.

This general situation and the regional variations are shown in Table 5, in which a child is defined as younger than 15. Census data for the 0-15 age group has been adjusted to approximate to the 0-14 age group used in road accident statistics, while the standard English Regions are used rather than individual counties because this also makes easier the comparison of census and road accident data.

Children aged 14 and under account for 21% of the population in

England (col b), but 39.3% of all pedestrian injury accidents (col g). In every region for pedestrians the child casualty rate is at least double the adult rate. South Yorkshire has a slightly above average child pedestrian casualty rate, but it has the lowest rate of all the metropolitan county areas. The acknowledged (Department of Transport 1984, 23) greater vulnerability of all pedestrians in the conurbations is also evident (cols d and f).

Regional variation in the child pedestrian casualty rate (col f) is, however, particularly marked, with Greater London, Greater Manchester and Merseyside all being at least twice as dangerous for children as the "safer" regions of the South West, East Anglia and the South East (excluding London).

TABLE 5: Adult and child (0-14) pedestrian accident rates in the metroplitan counties and English regions for 1982-84.

	TOTAL POPn (m)	CHILD POPn 0-14 (% of total) #	ANNUAL INJURY ACCIDENTS FROM 3 YEAR AVERAGE (Rate per 100,000 popn shown in brackets)				CHILD PED ACCIDENTS AS % OF ALL PED ACCIDENTS
			ADULT		CHILD		
	a	b	c	d	e	f	g
MET. COUNTIES							
G.London	6.6	18.7	8,396	(156)	3,881	(315)	31.6
G.Manchester	2.6	21.5	2,255	(112)	1,745	(314)	43.6
Merseyside	1.5	21.3	1,071	(91)	996	(311)	48.2
W.Midlands	2.6	21.7	1,974	(96)	1,677	(293)	45.9
Tyne & Wear	1.1	20.3	837	(93)	661	(286)	44.1
W.Yorks	2.0	21.7	1,524	(96)	1,225	(279)	44.6
S.Yorks	1.3	21.1	846	(83)	650	(239)	43.4
ENGLISH REGIONS							
North West*	2.3	21.3	1,335	(74)	1,076	(221)	44.6
North*	1.9	21.3	1,006	(66)	846	(206)	45.7
E.Midlands	3.8	20.9	2,033	(68)	1,481	(187)	42.1
Yorks/Humb*	1.5	20.8	814	(69)	544	(175)	40.1
W.Midlands*	2.5	21.8	1,220	(63)	837	(155)	40.7
South West	4.3	19.8	2,284	(67)	1,240	(147)	35.2
South East*	9.9	22.3	5,144	(67)	3,090	(139)	37.5
E.Anglia	1.5	20.9	799	(55)	446	(116)	35.8
TOTAL ENGLAND	45.4	21.0	31,538	(87)	20,395	(212)	39.3

* minus the (former) metropolitan counties
\# Census data for 0-15 age group adjusted to approximate to 0-14

For adults, the pedestrian casualty rate in Greater London is more than twice the rate in the non-metropolitan regions, but otherwise regional variations are somewhat less extreme than for children. Adult rates also vary within a much lower national rate.

The causes of this variation in pedestrian casualty rates may be more complex than the straightforward correlation of urban (and hence traffic) density and danger to pedestrians. Why, for example, are casualty rates lower in the more southerly regions (excluding Greater London of course)?

How do these figures compare with the situation in other countries? Although the accident record for motor vehicle occupants in Great Britain is relatively good, the injury accident rate for pedestrians generally compares unfavourably with other developed countries, for example the Netherlands and Japan. The pedestrian accident rate in Britain for children under fourteen also compares unfavourably with other countries having roughly similar traffic environments (Table 6), and this fact in particular is giving cause for concern at Government level (Department of Transport 1984, 21).

TABLE 6: Child pedestrian deaths per 100,000 population (from Department of Transport 1984, Table D1)

Sweden	0.8
Japan	1.6
Netherlands	2.2
Norway	2.3
France	2.6
West Germany	3.0
Great Britain	3.4
Switzerland	4.6
N. Ireland	5.4

MEASURES TO LESSEN CHILDREN'S VULNERABILITY

For many years the answer to children's vulnerability on roads was felt to be increased and improved road safety education. The Tufty Club, the Green Cross Code and other similar campaigns aimed to improve the ability of children to cross roads safely and become more aware of dangers on the road. For example, Grayson (1975, 6) argued that 90% of child injury accidents were "due" to partial or complete lack of attention on the part of the child - although this implies an unfair apportioning of blame to the child.

More recent work suggests that young children cannot be taught to cope safely with busy traffic conditions. Vinje (1981, 228) has estimated that it is not before the age of eleven that children are able to participate in traffic at an "adult" level, and even in their early teens they are still more vulnerable to the risks of pedestrian accident than adults. Children of ten years and younger have a limited ability to attend to two or more things at once, which makes them unreliable in traffic. They may for example be concentrating fully on the ice cream van and fail to attend to their road crossing technique on the way to it. Sandels (1979, 7) found that most adult pedestrians involved in accidents had behaved "correctly", but that only 17% of 0-6 year-olds and 3% of 7-10 year-olds had done so. Sandels (1975) also conducted experiments with children which suggested that their peripheral vision and

sound location faculties are not well developed until the age of 10-12. As she points out:

> "Perceiving objects in motion and judging their correct speed is something which requires training and experience even for adults."

Children have in any case a restricted field of vision due to their small stature and low eye-level. Parked cars are a particular problem and, of course, mask children from drivers. None of these arguments is intended to show that road safety education should not be given, only that it cannot be expected to be a complete answer to children's vulnerability.

If children cannot be educated to deal adequately with traffic, then there is clearly a case for educating drivers to the particular needs of children. A campaign might, for example, emphasise the need to anticipate children's unpredictable behaviour, or the increased likelihood of encountering children by taking short cuts through residential streets. The success of such a campaign could not, however, be expected to be very great. Drivers are often in a stressful situation and may have a real need to reduce journey time. Generally drivers will drive at a speed that appears safe for the road conditions; a natural response. Exhortations to alter natural responses may have some effect, but not in the long term.

A similar problem applies to lower speed limits and other measures that rely on exhortation rather than enforcement, as Norwegian experiments with 30 km per-hour speed limits in residential areas showed (Amundsen 1984, 95). Enforcement of speed limits in residential areas is practically impossible, so the speed limit signs in the Norwegian example would have been perceived by drivers as advisory rather than mandatory. Changes in driver behaviour are best achieved by measures that are self-enforcing. By and large this means ensuring that the road layout is appropriate to the desired traffic behaviour. The wisdom of this philosophy was recognised nearly half a century ago by Alker Tripp who said:

> "Nothing should ever be done by means of legal restrictions which is practical to effect by layout."

For most traditional roads that pre-date Design Bulletin 32 (and indeed many built since then), adaptations to the physical design will be necessary in order for them to become "child friendly".

There is a general acceptance that through traffic on residential streets must be discouraged wherever possible (though this is often not accepted by residents if the result impaires their own convenience of access by car). Buchanan's concept (1963, 44) of defining "environmental areas" and then excluding through traffic from them has been very influential in this respect. Quite apart from the considerable difficulties of implementing this approach (eg. see Collins and Pharoah, 1974) creating environmental areas can only be a starting point for improving the safety of residential roads, since it does little to modify the behaviour of the drivers remaining on the residential roads.

Bennett (1979, 269) has pointed out that child accident rates per vehicle kilometre do not vary much throughout the residential network. There is, whatever the volume of traffic, a basic incompatibility between these vulnerable pedestrians and any motor traffic, that can be reduced only if the motor vehicle is driven more slowly and in a less dangerous way. Making traffic on residential roads less dangerous has received less attention than measures to reduce traffic levels, but may well prove to be more effective in accident prevention. The next section explores strategies for implementing this change.