



CATALOGUE DES PROBLÈMES DE SÉCURITÉ EN CONCEPTION ET DES MESURES CORRECTIVES DE L'AIPCR

PIARC CATALOGUE OF DESIGN SAFETY PROBLEMS AND POTENTIAL COUNTERMEASURES

Comité technique AIPCR 3.1 Sécurité routière

PIARC Technical Committee 3.1 Road safety



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A propos de l'AIPCR

L'Association mondiale de la Route (AIPCR) est une association à but non lucratif fondée en 1909 pour favoriser la coopération internationale et les progrès dans le domaine de la route et du transport routier.

L'étude faisant l'objet de ce rapport a été définie dans le Plan stratégique 2004-2007 approuvé par le Conseil de l'AIPCR dont les membres sont des représentants des gouvernements nationaux membres. Les membres du Comité technique responsable de ce rapport ont été nommés par les gouvernements nationaux membres pour leurs compétences spécifiques.

Les opinions, constatations, conclusions et recommandations exprimées dans cette publication sont celles des auteurs et ne sont pas nécessairement celles de la société/organisme auquel ils appartiennent.

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Statements

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2004 – 2007 approved by the Council of the World Road Association, whose members and representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organizations or agencies.

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Ce rapport technique a été préparé par le Comité technique C3.1 – Sécurité routière de l'Association mondiale de la route (AIPCR). Il a été approuvé par ce comité.

Le comité technique était présidé par Hans-Joachim VOLLPRACHT (Allemagne), les secrétaires étaient Beth ALICANDRI (USA), Patrick MALLEJACQ (France) et Roberto LLAMAS RUBIO (Espagne).

Références des diagrammes figurant dans le rapport

	Source	#Page dans ce rapport
[A]	German Guidelines for road design, edited by the Research Society for Roads and Transport (FGSV), German National PIARC Committee	35, 37, 49, 51, 58, 59, 60, 61, 62, 63, 64, 65, 71, 73, 151
[B]	Research Report of BAST (German Highway Research Institute 1992 about the accident severity of different cross sections for interurban roads	46
[C]	UK's Design Manual for Roads and Bridges volume 6. - TD 42/95 "Geometric Design of Major/Minor Priority Junctions"	53, 81, 83, 85, 87, 91, 113
[D]	Lutz Pfeiffer and Hans-Joachim Vollpracht U-Turns in narrow conditions for Romania	53
[E]	PIARC RS manual	57, 89
[F]	Diagram is from the UK's Design Manual for Roads and Bridges volume 6. - TD 16/93 "Geometric Design of Roundabouts"	74, 75, 85
[G]	Vietnamese auditors guidebook (Lutz Pfeiffer and Hans-Joachim Vollpracht), SIDA- Project	89, 117, 137
[H]	Austrian guidelines for service and rest areas	97, 105
[I]	Swedish /German recommendations for bus stops in Bukarest (European TA project)	107
[J]	Romanian auditors guidebook Rein Shenderson	125
[K]	UK's "Safety at Street Works and Road Works - A Code of Practice"	135
[L]	Dutch Road design guidelines	149

The report was edited by PIARC Technical Committee 3.1 Road Safety and was approved by the Committee.

TC3.1 was chaired by Hans-Joachim VOLLPRACHT (Germany) and the secretaries were: Beth ALICANDRI (USA), Patrick MALLEJACQ (France) and Roberto LLAMAS RUBIO (Spain).

References of the diagrams printed in this report

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[A]	German Guidelines for road design, edited by the Research Society for Roads and Transport (FGSV), German National PIARC Committee	35, 37, 49, 51, 58, 59, 60, 61, 62, 63, 64, 65, 71, 73, 151
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I N T R O D U C T I O N

Le Comité technique sur la sécurité routière de l'AIPCR (C3.1) a préparé un Catalogue des problèmes de sécurité en conception et des mesures correctives à l'intention des pays en développement, des pays émergents et des pays en transition. En plus de présenter de manière succincte et facile à comprendre des informations sur des erreurs de conception bien connues, accompagnées de représentations graphiques, le catalogue propose un éventail de méthodes permettant de remédier aux problèmes relevés et donne une indication des coûts comparés des mesures correctives afin de faciliter la priorisation des travaux. Le catalogue peut être employé soit comme outil proactif pour prévenir les erreurs de conception soit comme outil réactif d'aide à la conception de mesures correctives offrant un bon rapport coût-efficacité aux problèmes qui existent déjà dans un réseau routier donné.

STRUCTURE DU CATALOGUE

Le catalogue est divisé en 8 sections :

1. Fonction
2. Profil en travers
3. Tracé
4. Intersections
5. Services publics et privés
6. Usagers vulnérables de la route
7. Signalisation routière et marquages sur la chaussée
8. Caractéristiques des abords de la route

Chaque section est codée d'une couleur distincte au haut des pages afin que les lecteurs sachent à tout moment quelle section ils sont en train de consulter. Les sections se subdivisent en types de problèmes particuliers. Chaque page est organisée comme suit : le problème particulier considéré est décrit en haut à gauche, les solutions possibles au problème sont décrites du côté droit et des détails supplémentaires concernant les types de traitement et les coûts relatifs, les types d'accidents et les usagers de la route touchés par les accidents sont présentés dans la partie inférieure de la page à gauche. Compte tenu de la variabilité de coûts des matériaux et de la main-d'œuvre d'un pays à l'autre, le catalogue ne donne pas d'indications quant aux coûts précis mais plutôt les coûts relatifs de diverses mesures correctives sur une échelle allant de faibles (\$) à élevés (\$\$\$\$\$).

I N T R O D U C T I O N

The road safety Technical Committee of PIARC (TC3.1) has produced a Catalogue of Design Safety Problems and Countermeasures aimed at developing and emerging countries and countries in transition. The catalogue gives brief information, including pictorial representations, of well-known design errors in a readily understood way, suggests a range of methods to overcome these and gives an indication of the comparative countermeasure costs to facilitate prioritisation of the work. The catalogue can be used both as a proactive safety tool to ensure the design faults do not arise in the first place, or a reactive safety tool to assist in designing cost-effective countermeasures where problems already exist on the road network.

STRUCTURE OF THE CATALOGUE

The catalogue is divided into 8 sections:

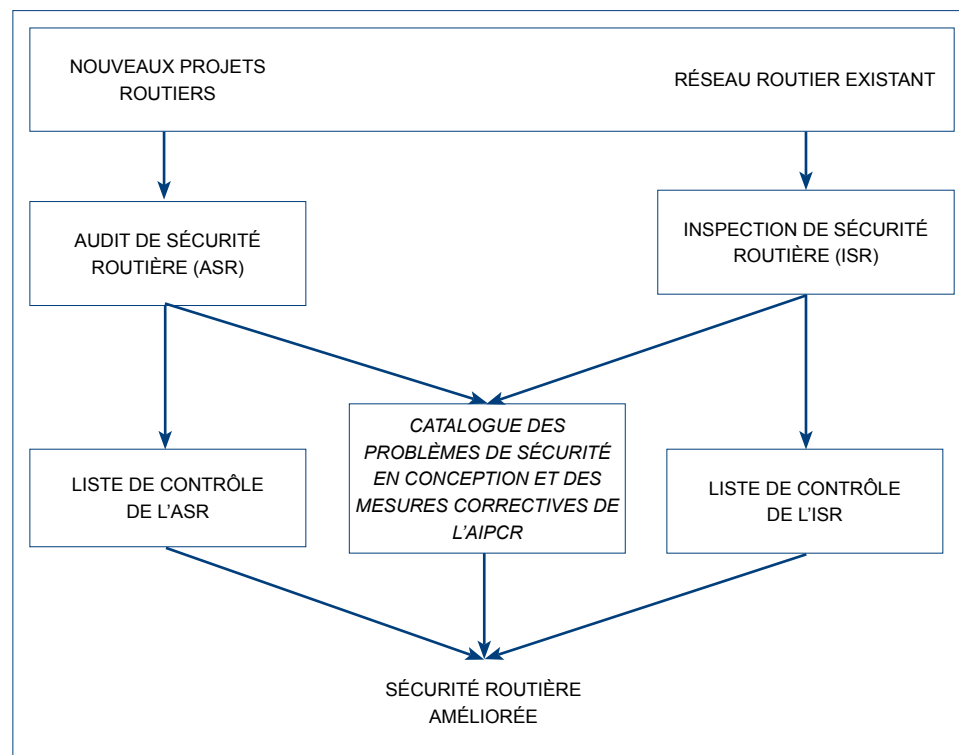
1. Function
2. Cross Section
3. Alignment
4. Intersections
5. Public and Private Services
6. Vulnerable Road Users
7. Traffic Signing and marking
8. Roadside Features

Each section is colour coded at the top of the page so that the reader will always know which section they are considering. The sections are further divided into specific problem areas. Each page is set out such that the particular problem under consideration is described in the top left hand side. Potential solutions to these problems are set out on the right hand side of the page with further details of the treatment types and relative costs, crash types and road users affected by the crashes on the lower half of the left hand side. Because of the difference in materials and labour costs in various countries, exact costs cannot be estimated, but relative costs of various countermeasures are included, ranging from low (\$) to high (\$\$\$\$\$).



Les huit sections du catalogue correspondent aux sections détaillées des publications complémentaires sur les audits de sécurité routière (ASR) et les inspections de sécurité routière (ISR). Elles correspondent aussi aux sections des listes de contrôle détaillées qui ont également été publiées pour aider à l'exécution des procédures d'ASR et d'ISR. Grâce à cette structure commune, il est facile de repérer les parties pertinentes d'un document à l'autre.

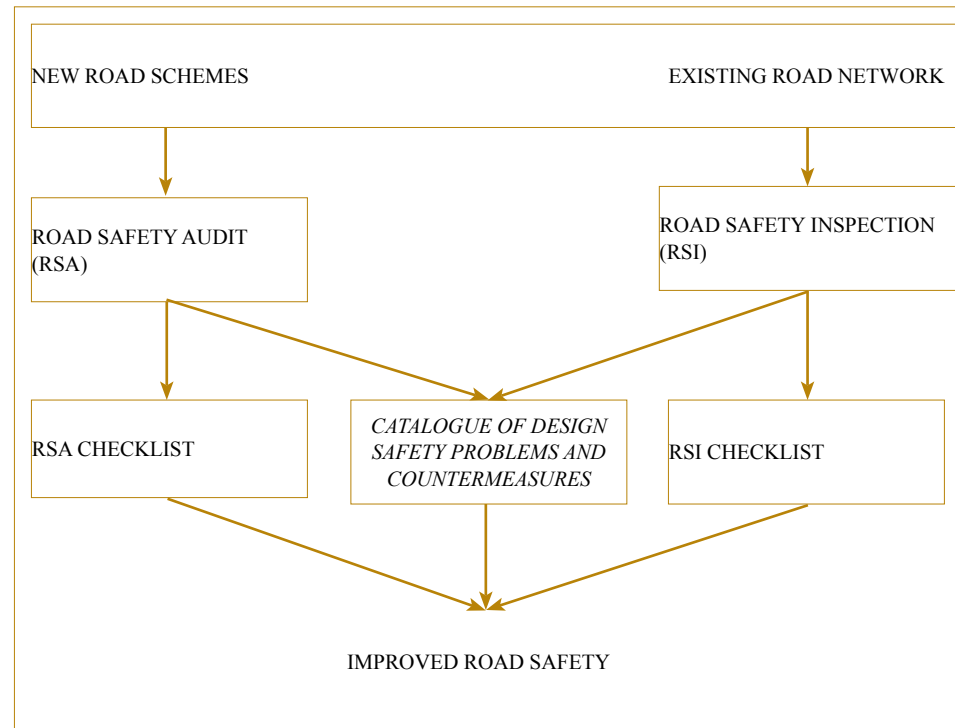
Le graphique qui suit illustre les relations entre les directives relatives à l'ASR et à l'ISR, les listes de contrôle qui s'y rapportent et le catalogue.



Il est à noter que ce catalogue ne se veut pas un manuel de conception détaillé en matière de sécurité routière; il s'agit plutôt d'un simple recueil des types d'erreurs de conception les plus courantes et de correctifs possibles. L'AIPCR a déjà publié un Manuel de sécurité routière détaillé que le lecteur est invité à consulter en complément de ces nouvelles directives.

These eight sections correspond to the sections detailed in the accompanying publications on Road Safety Audits (RSA) and Road Safety Inspections (RSI). They also conform to the sections in the detailed checklists which have also been published to assist both the RSA and RSI procedures. This format provides for a cohesive “read-across” between the various documents.

The following diagram explains the interaction between the RSA and RSI guidelines, the accompanying checklists and this catalogue.



It is important to note that this catalogue is not intended to be seen as a detailed road safety design manual. It is merely a collection of the most common types of design failures and ways to potentially overcome these. PIARC has already published a detailed Road Safety Manual and the reader is commended to consider this publication in conjunction with these new guidelines.



COMMENT EMPLOYER LE CATALOGUE DANS LE CADRE DE LA PROCÉDURE D'AUDIT DE SÉCURITÉ ROUTIÈRE

- Cerner le sujet (par ex., les intersections)
- Se servir des exemples d'erreurs possibles comme guide tout au long du processus de conception
- Se servir des coûts donnés à titre indicatif pour déterminer la solution qui offre le meilleur rapport coût-efficacité
- Appliquer le concept
- Évaluer la performance réelle (ceci est essentiel au processus d'apprentissage et d'amélioration continus)

COMMENT EMPLOYER LE CATALOGUE DANS LE CADRE DE LA PROCÉDURE D'INSPECTION DE SÉCURITÉ ROUTIÈRE

- Examiner le secteur/réseau qui pose problème
- Considérer les accidents qui pourraient se produire relativement à chacune des sections thématiques du catalogue (par exemple, les intersections)
- Passer en revue les diverses mesures correctives possibles
- Évaluer les économies potentielles attribuables aux accidents évités de même que les bienfaits économiques
- Choisir les mesures correctives
- Classer les travaux par ordre de priorité
- Appliquer les mesures correctives
- Contrôler la performance réelle (ceci est essentiel au processus d'apprentissage et d'amélioration continus)

ÉCONOMIES POTENTIELLES ATTRIBUABLES AUX ACCIDENTS ÉVITÉS

Le tableau qui suit est tiré d'une publication du Department for International Development/TRL intitulée « Overseas Road Note 5, A guide to road project appraisal ». À noter qu'il est question ici d'économies potentielles attribuables aux accidents évités. Comme les données proviennent d'études effectuées dans plusieurs pays, il est possible qu'on n'obtienne pas les mêmes résultats ailleurs. Cela dit, il y a manifestement des économies importantes à réaliser en termes d'accidents évités si les mesures correctives sont bien appliquées.

HOW TO USE THE CATALOGUE AS PART OF THE ROAD SAFETY AUDIT PROCEDURES

- consider the subject area (e.g. intersections),
- use examples of what can go wrong as a guide during the design process,
- use indicative costs to decide on most cost-effective solution,
- implement design,
- monitor actual performance (this is crucial to the continuous learning/improvement process).

HOW TO USE THE CATALOGUE AS PART OF THE ROAD SAFETY INSPECTION PROCEDURE

- review the area/network of concern,
- consider the potential accidents that could occur from the individual sections of the guidance e.g. intersections,
- look at the range of countermeasures,
- estimate accident savings and economic benefits,
- decide on remedial measures,
- prioritise work,
- implement remedial measures,
- monitor actual performance (this is crucial to the continuous learning/improvement process).

POTENTIAL CRASH SAVINGS

The following table has come from the Department for International Development/TRL Publication: "Overseas Road Note 5, A guide to road project appraisal". It is important to note that these are potential crash savings. The results have come from studies in a number of countries and it is possible that the same results might not be obtained elsewhere. That being said, there are clearly significant crash savings to be gained by proper implementation of these countermeasures.



ÉLÉMENT D'AMÉNAGEMENT ROUTIER	CATÉGORIE D'ACCIDENT*	RÉDUCTION DU NOMBRE D'ACCIDENTS (EN POURCENTAGE)
Norme routière		
Application d'une norme plus stricte	I	19-33
Augmentation du nombre de voies	I	22-32
Tracé horizontal		
Amélioration de la géométrie	T	20-80
Courbure : augmentation du rayon	I	33-50
Tracé vertical		
Gradient / élimination des sommets de côte	T	12-56
Amélioration/introduction des dévers	T	50
Voie de dépassement	I	11-43
Voie pour véhicules lents	T	10-40
Structure de route		
Élargissement des voies	T	12-47
Réduction de la glissance	T	18-74
Élargissement des accotements	T	10-40
Imperméabilisation des accotements	T	22-50
Élargissement des séparateurs	T	13-44
Conception des jonctions		
Réaménagement des carrefours à passage tout droit en carrefours à routes décalées	I	40-95
Réaménagement des intersections en Y en jonctions en T	T	15-50
Remplacement des intersections non contrôlées par des ronds-points	T	25-81
Remplacement des carrefours à feux de signalisation par des ronds-points	T	25-50
Utilisation de mini-rond-points à la place de carrefours non contrôlés	T	40-47
Voies de virage	T	10-60
Îlots directionnels	T	39
Contrôle de la circulation		
Panneaux de prescription aux intersections	T	22-48
Panneaux d'indication/orientation aux intersections	T	14-58
Panneaux de supersignalisation	T	15
Panneaux de signalisation latérale	T	19-24
Panneaux et marquages plus lumineux	T	24-92

*I = Accidents entraînant des blessures

T = Total des accidents

ROAD FEATURE	ACCIDENT CATEGORY*	PERCENTAGE REDUCTION IN ACCIDENTS
Road Standard		
Improve to higher standard	I	19-33
Increase number of lanes	I	22-32
Horizontal Alignment		
Improve geometry	T	20-80
Curvature: improving radius	I	33-50
Vertical Alignment		
Gradient / removing crest	T	12-56
Superelevation improvement/introduction	T	50
Passing lane	I	11-43
Climbing Lane	T	10-40
Road Structure		
Lane widening	T	12-47
Skid resistance improvement	T	18-74
Shoulder widening	T	10-40
Shoulder sealed	T	22-50
Road verge widening	T	13-44
Junction Design		
Staggered (from straight) crossroads	I	40-95
T-junctions (from Y-junctions)	T	15-50
Roundabouts (from uncontrolled)	T	25-81
Roundabouts (from traffic signals)	T	25-50
Mini roundabouts (from uncontrolled)	T	40-47
Turning lanes	T	10-60
Traffic islands	T	39
Traffic Control		
Regulatory signs at junctions	T	22-48
Guidance/directional signs at junction	T	14-58
Overhead lane signs	T	15
Side road signs	T	19-24
Brighter signs and markings	T	24-92

*I = Injury accidents

T = Total accidents



ÉLÉMENT D'AMÉNAGEMENT ROUTIER	CATÉGORIE D'ACCIDENT*	RÉDUCTION DU NOMBRE D'ACCIDENTS (EN POURCENTAGE)
Panneaux et dispositifs de délimitation	T	29-37
Panneaux de signalisation de virage	T	20-57
Panneaux de signalisation d'arrêt	T	47
Panneaux « Limite de vitesse »	T	23-36
Réduction de la limite de vitesse – avec panneaux	I	16-19
Panneaux « Cédez le passage »	T	59-80
Panneaux « Arrêt »	T	33-90
Contrôle de la circulation (suite)		
Signaux ajoutés aux intersections non contrôlées	T	15-32
Signaux modifiés	T	13-85
Canalisation de la circulation aux intersections	T	10-51
Visibilité		
Marquages de délimitation des voies	T	14-19
Marquages sur les bords de chaussée	T	8-35
Barres jaunes	T	24-52
Marques surélevées rétroréfléchissantes sur la chaussée	T	6-18
Délinéateurs	T	2-47
Balises clignotantes	T	5-75
Installation de systèmes d'éclairage	T	6-75
Augmentation de la distance de visibilité	T	28
Terre-pleins de canalisation	T	22-50
Dispositifs de retenue et de sécurité		
Glissières de sécurité médianes	T	14-27
Dispositifs de retenue latéraux	T	15-60
Supports de signalisation fragilisés	I	30
Éléments pour piétons		
Passages piétons	T	33-44
Passages piétons marqués	T	13-34
Passages piétons avec feux pour piétons	T	21-83
Refuges pour piétons	T	56-87
Passerelles	T	39-90
Éléments pour cyclistes		
Réseaux de pistes cyclables	T	35-56
Passages marqués pour cyclistes aux intersections	T	10-15
Ligne d'arrêt avancée pour cyclistes aux intersections	T	35

*I = Accidents entraînant des blessures

T = Total des accidents

ROAD FEATURE	ACCIDENT CATEGORY*	PERCENTAGE REDUCTION IN ACCIDENTS
Signs and delineation	T	29-37
Bend warning signs	T	20-57
Stop ahead sign	T	47
Speed advisory sign	T	23-36
Speed limit lowering - & sign	I	16-19
Yield/Give Way	T	59-80
Stop sign	T	33-90
Traffic Control (to be continued)		
Signals from uncontrolled	T	15-32
Signals - modified	T	13-85
Junction channelization	T	10-51
Visibility		
Lane markings	T	14-19
Edge markings	T	8-35
Yellow bar markings	T	24-52
Raised reflective pavement marking	T	6-18
Delineator posts	T	2-47
Flashing beacons	T	5-75
Lighting installations	T	6-75
Sightline distance improvement	T	28
Channelization medians	T	22-50
Crash Amelioration		
Median barrier	T	14-27
Side barriers	T	15-60
Frangible signs	I	30
Pedestrian Facilities		
Pedestrian walkways	T	33-44
Pedestrian zebra crossings	T	13-34
Pelican crossings	T	21-83
Pedestrian refuges	T	56-87
Footbridges	T	39-90
Cycling Facilities		
Cycle schemes	T	35-56
Marked cycle crossing at signals	T	10-15
Cyclist advanced stop line at junctions	T	35

*I = Injury accidents

T = Total accidents



ÉLÉMENT D'AMÉNAGEMENT ROUTIER	CATÉGORIE D'ACCIDENT*	RÉDUCTION DU NOMBRE D'ACCIDENTS (EN POURCENTAGE)
<i>Passages à niveau</i>		
Feux clignotants	I	73-91
Barrières automatiques	I	81-93
<i>Pacification du trafic</i>		
Bandes rugueuses	T	10-80
Zones où la vitesse est limitée à 30km/h (au moyen de dos d'âne, de chicanes, etc.)	T	27-50

*I = Accidents entraînant des blessures

T = Total des accidents

Source : DFID/TRL Overseas Road Note 5 - A guide to road project appraisal.

ROAD FEATURE	ACCIDENT CATEGORY*	PERCENTAGE REDUCTION IN ACCIDENTS
<i>Rail Crossings</i>		
Flashing signals	I	73-91
Automatic gates	I	81-93
<i>Traffic Calming</i>		
30km/h zones (incs. humps, chicanes etc.)	T	10-80
Rumble strips	T	27-50

*I = Injury accidents

T = Total accidents

Source: DFID/TRL Overseas Road Note 5 - A guide to road project appraisal.



1. FUNCTION

SPECIAL DESIGN POLICIES FOR INTER-URBAN ROADS

The separation of the fast traffic from the slow traffic and the use of 'dynamic design' in accordance with the legal speed are the most important design policies for interurban roads. The most critical situation in respect of road safety is the **mixture of functions** where there is no clear distinction between the interurban and urban area and where we find so called **linear settlements often with commercial activities** or road trading along the interurban roads.



In respect to road safety it is necessary to limit the use of properties along inter urban roads and especially to rigorously control the access to these properties from the main carriageway. Separate local distributor roads or agricultural ways alongside or running parallel to the highway are the best solution. Road legislation should strictly forbid accesses to private properties and the building of houses and other constructions for a distance of 40m back from carriageway edge of motorways and 20m from other roads. However, in order for these regulations to be effective, they must be enforced sometimes even against local authorities who often give permission for the construction of buildings and accesses, for a variety of reasons.

Examination of accident data reveals a high proportion of pedestrian fatal accidents in these circumstances. Potential improvements for existing linear settlements are contained in section 6 'Vulnerable Road Users'.

Dynamic design

Roads with speeds higher than 50 km/h require a 'dynamic design':

Traffic lanes need to be wider, radii and cross falls have to be calculated as a function of speed and skid resistance, the horizontal and vertical alignment have to be coordinated to be consistent with the hierarchy of the road and stopping sight distances have to be calculated.

In addition, traffic signs and signals have to be visible and comprehensible from a larger distance and a width of forgiving road sides commensurate with the legal speed should be provided. Passive safety and energy absorbing installations have to be strong enough to fulfil their primary function but flexible enough not to cause injury if struck.

A good design gives a clear orientation. **"Never mislead the driver"** is the most important rule for the designer.

Often overlooked but none the less important for road safety are **Transitions** to prepare the driver for any new section of road that requires a change in driving behaviour. **"Never surprise the driver"** is our second important rule. **Drivers need time to plan, check and correct their reaction whilst driving.** This distance is known as the "Transition Area".

There should be a consistency of sight distances along the horizontal and vertical alignment within these minimum and maximum distances depending on the legal speed.

See table 1 **Principle design features for interurban Roads**

SPECIAL DESIGN POLICIES FOR URBAN ROADS

Roads inside built-up areas must fulfil different functions:

- mixed composition of road users with cars trucks, buses, motorcycles and vulnerable users such as pedestrians and cyclists;
- a variety of different functions such as connection, distribution, access and stopover;
- different activities along the roads such as public and private transport of goods and people, shopping, road business, parking and loading, children's playground, etc.



However the legal speed is reduced to 50km/h or even lower by regulations.

The urban road network too has to be structured in a hierarchy of different categories according to their main functions. These are urban motorways for a large metropolis with some million inhabitants, the connection of urban centres by a system of urban main roads, the distribution by distributor roads and the residential roads in the residential areas. Normally there is access to properties from all urban roads.

The separation of the most vulnerable road users, pedestrians and cyclists, from the motorized traffic is most important along urban main roads. Here we need safe facilities for pedestrians such as sidewalks and raised pedestrian refuge islands in the middle of the roads, traffic signals and underpasses for crossing.

In many countries this hierarchy conforms with the hierarchy of legal speed reductions to 50 km/h along the urban main and distributor roads and 30 km/h in residential areas. Urban planning itself has a significant influence on road safety. Shopping areas along the urban trunk roads with direct accesses are not the safest solution but we find them in many cities.

The geometric Design

Below urban motorways the geometric needs of vehicles, cyclists and pedestrian are essential for urban roads. We speak of **geometric design policy**. Smaller radii of curves and carriageways with narrow lanes help to reduce speed and to enhance road safety. Not the lane width but the number of lanes and the design of junctions are decisive for the traffic capacity.

Dynamic issues such as transition curves, large radii, and super elevation in curves are less important than a slow but smooth flow of traffic.

See table 2 **Principle design features for urban roads**



1. FUNCTION

Special types of accidents along interurban roads

On interurban roads, single vehicle accidents dominate the figures; in developed countries these can account for up to 46% of all accident costs. The accidents are also above average in their severity. A balanced horizontal alignment (balanced relation of radii: “relation alignment”) and a good combination of horizontal and vertical alignment, good drainage of the road surface and good surface skid resistance are therefore important. Shunt accidents, overtaking accidents, and head-on accidents lead to about a quarter of accident costs (23%) in developed countries. Accidents involving vehicles leaving the road to the near side (21% of accident costs) and to the far side (17% of accident costs) have above average accident severity. Accidents of these types are particularly severe where they involve collisions with trees and other immovable objects (80%). Consequently, collisions with trees result in almost one quarter (23%) of the entire accident costs on interurban roads in Germany.

A safe and, where possible, obstacle-free roadside design, ‘forgiving’ road sides, are therefore most important. Where roadside obstacles cannot be avoided, passive safety installations or traffic management measures, in particular enforcement of the speed limit and, if necessary, a reduction of the speed limit is required. All these measures, especially speed reduction, will reduce the severity of accidents.

In developing countries, pedestrian, cyclist and motorcycle accidents are particularly frequent in linear settlements and small markets along the national roads. Pedestrian accidents are the most severe accidents with more than double the average severity. Careful and specific consideration should therefore be given to pedestrians and cyclists; Special routes for pedestrians and cyclists and other slow traffic are the safest solutions, both along the road and at junctions. Children, elderly people, and disabled people are particularly exposed.

Typical safety deficits affecting the design of **interurban roads** are:

- mixed functions with fast and slow traffic,
- inappropriate access control,
- lack of transitions when entering built up areas, such as traffic islands or other gateway treatments,
- inconsistent radius sequence,
- “hidden-dips”,
- no correlation of alignment and junction type,
- lack of protection for vehicles turning across oncoming traffic,
- missing/insufficiently separated pedestrian and cyclist facilities,
- insufficient cross fall in curves,
- lack of strong and stable verges,
- errors in centre markings on crests and in curves with insufficient overtaking sight distances,
- missing, insufficient or incorrect passive safety installations,
- lack of “forgiving roadsides” i.e. without dangerous obstacles,
- deep ditches of the drainage system are a linear obstacle themselves.

In addition, safety can also be positively influenced by the selection of a comparatively safe cross section or a comparatively safe junction type.

Special types of accidents along urban roads

Main roads

Inside built-up areas, the safe design of junctions is of considerable importance: in most developed countries approximately half of the accidents occur at junctions. The protection of more vulnerable road users is particularly important inside built-up areas: in Germany, 38% of accident costs result on major urban roads from accidents involving pedestrians and cyclists; on residential roads, the percentage is even higher (54%).

Due to the particularly high severity of accidents, considerable attention must be paid to safeguarding railway level crossings.

Collisions with trees on high-speed major urban roads are also significant (these accidents have twice the severity of all other accidents inside built-up areas).

Children, elderly people, and disabled people are particularly exposed in built-up areas. Careful consideration should therefore be given to pedestrians and cyclists; safe sidewalks for pedestrians and special tracks for cyclists are required along the major urban roads and facilities for safe crossing of the carriageway, especially at junctions.

In developing countries it is very common for there to be a lack of passable sidewalks in most of the villages and towns, safe pedestrian crossings with refuge islands and strong regulations against the parking on the sidewalks and pedestrian ways. Consequently pedestrians are forced to use the carriageway.

Typical safety deficits affecting the design of **major urban roads and through roads** are:

- unsafe routing of pedestrians and cyclists at junctions
- conflict-sensitive signal control (lack of protection for offside-turning movements, excessive delays for pedestrians and cyclists as well as insufficient co-ordination with design).
- lack of protection for crossing pedestrians and cyclists on open sections of road
- combination of minimum width in cross section
- unfavourable allocation of areas for parking/loading

Residential Roads

Typical safety deficits affecting the design of residential roads are:

- ineffective speed control or traffic calming,
- unfavourable parking area allocations,
- lack of visual contact between motorists and pedestrians,
- poor recognition of junctions and the right of way.



1. FUNCTION

PRINCIPLE DESIGN FEATURES FOR INTERURBAN ROADS											
Design category	Cross Section m	1,000 Vehicle/day	Legal speed Km/h	Alignment	Maxi Long fall %	Horizontal Radii (R) Transition (A) Superelevation %	Vertical. Radius at crests m	Range of Sight distance m	Junction Type	Traffic Composition	Environment
Main arterial Motorway	36 31	> 90 20 - 70	≥ 120	Very wide	≤ 4*	R>700 m A>240 m 7-8%	16,000	≥ 600	Different levels (Grade separated)	Motor vehicles only. No agriculture traffic	No access to properties, Forgiving road side : 12 m
Main arterial Express Roads	4lane-road: 21 2+1lane 15,5	15- 30 10- 25	100	Very wide	≤ 4*	R≥ 500 m A≥ 150 m 7-8%	8,000	300 - 600	Different levels (Grade separated)	Motor vehicles only. No agriculture traffic	No accesses to properties, forgiving road side 9 m
Main distributor roads, Highways Outside	11 + Z Overtaking sections 11	10- 20	80	Wide	≤ 5.5*	R = 300-900 A ≥ 80 m 7-8%	5,000	200 - 450	Partly on different levels + signalization	No bicycles no light motor-bikes No agriculture traffic	Outside build up areas. No accesses to properties Forgiving road side 6 m
Main distributor roads inside	Lane width 3.25m Pedestrian islands	10- 20	40 to 50	Adapted to geography	≤ 8	2,5% cross fall	2,400	100 - 200	Partly on different levels + signalization	Strict separation of bicycles and pedestrians by curb stones	Inside build up areas. Access to private properties Forgiving road side 1.5 m
distributor roads, regional outside	10	5 - 20	80	Adapted to geography	≤ 7*	R= 250-600 A ≥ 80 m 7-8%	3,000	200 - 450	One level (At grade) +signalization or round about	Separation of light motorbikes and bicycles	Limited access to agriculture properties Forgiving road side 6 m
Distributor roads, inside	Lane width 3.00 m Pedestrian Islands	5 - 20	40 to 50	Adapted to geography	≤ 8	2,5% cross fall	2,400	100 - 200	One level (At grade) +signalization or round about**	separation of bicycles and pedestrians by curb stones	Inside build up areas Access to private properties Forgiving road side 1.5 m
Community connection roads	Single lane 8.5	0 - 15	60	Very adapted	≤ 8	150-300 2.5% cross fall	2,400	150 - 300	Simple junction, no roundabout	Mixed traffic	No road trading outside build up areas
Mountain roads	2 lanes 2x 3.00 m	5 - 15	60	Adapted	≤ 8	150 -300	2,400	150 - 300	Simple junction	Mixed traffic	Access to agriculture possible



1. FUNCTION

PRINCIPLE DESIGN FEATURES FOR INTERURBAN ROADS										
Design category	Lane width m	Legal speed Km/h	Alignment	Maxi Long fall %		Horizontal Radii (R) Transition (A) Superelevation %	Vertical. Radius at crests m	Junction Type	Traffic Composition	Environment
Main arteries Urban motorway	Lane width 3,25 to 3,50 m	80	wide	≤ 4		$R > 300$ m ----- $A > 150$ m ----- 7-8 %	8,000	Different levels (Grade separated)	Motor vehicles only.	No access to properties, forgiving road side : 6 m or barrier
Main arteries Urban main roads	Lane width 3,00 to 3,25 m Safe pedestrian crossings	50	wide	≤ 5.5		$R \geq 200$ m ----- 2.5% cross fall	2,400	Partly on different levels + signalization	Motor vehicles only. Separation of none motorized traffic	Accesses to properties Forgiving road side 2.0 m or curb stone
Distributor roads	Lane width 3.00 m Traffic calming by design	50	Adapted to urban geography	≤ 8		$R \geq 150$ ----- 2.5% cross fall	1,200	Signalization and roundabouts	All kinds of road users, Separation of none motorized traffic	Accesses to properties Forgiving road side 1.5 m or curb stone
Residential roads	Lane width 3.00 m Traffic calming by design	30	Adapted to urban geography	≤ 8		2.5% cross fall	1,200	Signalization and Roundabouts	All kinds of road users, separate side walks no heavy trucks	Access to properties Forgiving road side 1.0 m or curb stone
Traffic calming areas	$\geq 4,50$ m	10	Adapted to urban geography	≤ 8		2.5% cross fall		One level (At grade)	No separation of traffic, No heavy trucks	Access to properties Forgiving road side 0.5 m
Pedestrian areas		5	Adapted to urban geography			2.5% cross fall		Simple junction, no roundabout	Pedestrians only, no bicycle ride	No road trading outside build up areas



1. FUNCTION

1.01. LINEAR SETTLEMENTS



Problem: Linear settlements with a mixture of through and local slow traffic and non motorized road users. This is a major road safety problem especially in developing countries.

Treatment Types & Costs

T1: Access control	\$
Low cost solution with reasonable expectation of accident savings but strong legal enforcement	
T2: Separation of the shoulder by barriers	\$\$
Medium cost solution with good expectation of accident savings	
T3: Separate system of Motorways and express roads completely access controlled	\$\$\$
High cost solution with excellent potential for accident savings.	

Crash Types

- Mainly severe accidents with pedestrians and cyclists
- Side collisions
- Head on collisions where crash barriers are missing

Affected Users

- All users but especially pedestrian, cyclists and motorcyclists

Treatments & Their Benefits, Road functions and categories

General Principles

Road design is determined by the desired travelling and transport time and transport capacity. Similar to a body's blood system road networks are organized in a hierarchy of main arteries for high capacity and fast movement of blood:

- distributors to spread the blood to organs and muscles,
- arterioles and capillaries to access the single cells in the muscles and organs.

Transforming this model to our road network we can see that we have different types of roads for different functions:

- express roads for high capacity transport to shorten the travelling time for long **distance transport** or between strategically important economic centres like airports, ports and cities;
- various classifications of secondary roads for **distribution** of passengers and goods;
- **access** roads to reach private and public properties and for local communication.

This model has shown over millions of years of evolution to be the most successful way of transporting blood around the body and we may derive from this the following general design principles for our road networks:

1. make a clear distinction and separation between interurban roads for high speeds and urban roads for low speeds but smooth transport;
2. design hierarchies of both function and different legal speeds within these two categories;
3. take the legal speed limit as a consistent design speed;
4. design each category and function specifically to facilitate safe movement. The safest roads are single functional roads;
5. avoid mixed functions along interurban roads and, as far as possible, on urban roads;
6. to improve road safety it is obviously necessary to limit the number of properties along inter urban roads and especially to rigorously control the access to these properties from the main carriageway. Separate local distributor roads or agricultural ways along or separate from highways are the only sustainable solution.

T1: Access control

Unconstrained access to roads allows an unsustainable mix of fast-moving, heavy and dangerous traffic together with slower, vulnerable users, pedestrians, old people, cyclists etc. It is crucial to strictly control access to roads ensure that these incompatible mixes do not occur.

T2: Separation of the shoulder by barriers

A vehicle barrier separating the moving traffic from vulnerable users gives protection and facilitates efficient throughput of traffic.

T3: Separate system of motorways and express roads completely access controlled

The safest solution of all is to completely separate the different classes of road users and to rigidly control access to these roads.



1. FUNCTION

1.02. ROAD FUNCTION



Problem: For economic reasons, many countries try to improve their arterials by widening their existing national roads both inside and outside built up areas. As a result their problems increase and the widened carriageways get more and more occupied by local activities. This mixture of functions results in the decrease of road safety and high accident figures with fatalities and injuries.

Treatment Types & Costs

T1: Construction of bypasses \$\$\$

This is a solution for single cities but it results in serious alignment and safety problems if one bypass is followed by the other.

T2: Construction of road system outside built up areas \$\$\$

The safer and cheaper solution is the construction of a motorway and express road system outside built up areas with distributor roads into the different parts of the cities.

T3: Construction of express road \$\$\$\$

When the widening of roads is coming to an end, the next step is the construction of an elevated express road.

Crash Types

- Accident with pedestrians, cyclists and motorcycles are the worst

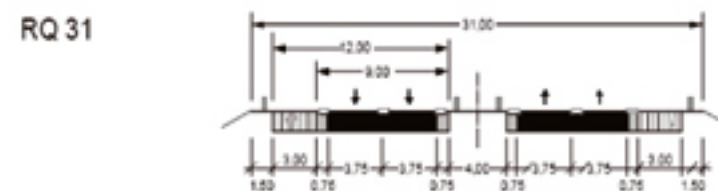
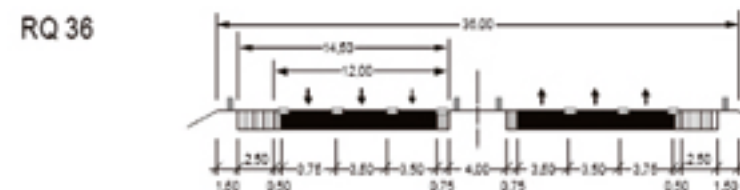
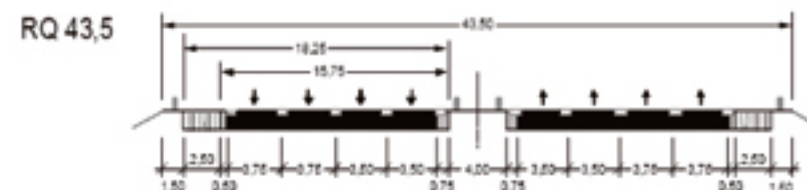
Affected Users

- The local citizens and businesses

Treatments & Their Benefits: Function and Road categories

T1, T2, T3: Construction of bypasses, express roads and road systems outside built up areas. Roads should be designed such that it is clear to road users what is the function of the road they are using and how they should behave.

Example of design for 4-8 lanes. Legal and design speed 120 km/h, for example Intersections should be on different levels for the higher speeds.



[A]



1. FUNCTION

1.03. ROAD FUNCTION 2



Problem: Highways and distributor roads are often used by vulnerable non motorized users, for example schoolchildren, who are exposed to extremely dangerous conditions. See also Vulnerable Road Users, Section 7.

Treatment Types & Costs

- | | |
|---|--------|
| T1 : Road marking | \$ |
| If the carriageway is wide enough, separate a shoulder by marking it for pedestrian and bicyclists. Low cost solution with good expectation of accident savings | |
| T2: Use safer cross section | \$\$ |
| Use of safer cross section in the design phase with complete separation of bicycles and pedestrians. Excellent potential for accident savings | |
| T3: Add a hard shoulder | \$\$ |
| Add a narrow ($\leq 1,5\text{m}$) hard shoulder for pedestrian and bicyclists. Medium cost solution with good expectation of accident savings. | |
| T4: Build a separate way | \$\$\$ |
| Build a separate way for non motorized users. Medium cost solution with excellent potential for accident savings. | |

Crash Types

- Severe accidents with pedestrians and bicyclists

Affected Users

- Non motorized users, especially children

Treatments & Their Benefits Cross sections

T1: Road marking

Marking can be enhanced by providing a wide marking, double-line marking or even hatched areas to denote separation.



T2: For Highways, distributor roads and rural roads use smaller cross sections and separate slow traffic

The design and legal speed on highways and distributor roads should be 80 km/h.

They have green verges made by stabilized gravel and grass instead of wide hard shoulders. Non motorized traffic has a separate way for some distance.

Intersections between the same or lower categories are on the same level (more see chapter on intersections).

Rural and community connection roads have design and legal speed of 60 km/h and two hard shoulders for non motorized traffic but only one 4.5m lane for vehicles.

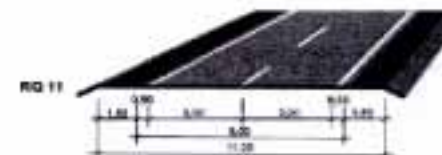
T3: Addition of a hard shoulder $\leq 1,5\text{m}$ wide

An unbroken marking forbids the use of the shoulder by trucks and vehicles. But if the shoulder is used for emergency cases the non motorized road users have to move into the carriageway where they are in great danger.

T4: Non motorized and slow traffic is separated on a special way for light traffic

A small hard shoulder may be necessary for climate conditions when green verges will not grow. Since there is a separate way for non motorized and light traffic this hard shoulder is only likely to be used in an emergency.

(Separate way shown on the right of the photo.)



[A]





1. FUNCTION

1.04. TRAFFIC CALMING (T1) - SIGNS



Problem: On many roads, the speed and also the volume of traffic is sufficiently high that the safety of all road users – pedestrians, cyclists, motorcyclists and even those in larger vehicles in the main traffic flow – is threatened.

Treatment Types & Costs

Rather than installing barriers and other measures to protect vulnerable road users from fast moving vehicles, traffic calming measures specifically aim to reduce the speed of the vehicles so that all road users can mix more safely in the same space. In most cases, a reduction in speed also serves to reduce the number of vehicles using the road. Other outcomes of traffic calming include an improved quality of life and reduced pollution.

Traffic calming measures can be divided into four categories according to the nature of the measure and how it is constructed, Signs, physical obstruction, road surface and larger schemes. It is difficult to divide them in any other way, such as rural/urban or link/junction since most measures can be used in a variety of locations.

T1. Signs – this page - 1.04(T1)	\$
T2. Physical obstruction – 1.04(2)	\$\$
T3. Road surface – 1.04(3)	\$\$
T4. Larger schemes – 1.04(4)	\$\$\$

Each measure can have several variants and can be used either in combination with others or in isolation.

Crash types

- The close proximity of fast moving vehicles to each other and to vulnerable road users can result in head-on, side impact and rear-end accidents.
- All crash types.

Affected Users

- All road users are at risk from fast moving vehicles.

Treatments & Their Benefits – (T1) Signs

All the solutions on this page entail signs or other indicators alongside the road. These signs and indicators focus the driver's attention onto the road and their own driving and warn the driver of any change in condition ahead. The solutions do not force the driver to slow down, but merely suggest that a lower speed would be more appropriate.

T1.1 Side marker posts

These posts indicate the line of the road edge and are particularly effective at night if reflective and if used only where the road follows an unpredictable alignment.



T1.2 Advance warning signs

Advance warning signs inform drivers of what is ahead and allow them to slow down before reaching the hazard.

T1.3 Vehicle activated signs

These signs are triggered by speed (in the case of a sharp bend) or height (in the case of a low bridge) and are timed to flash on as the triggering vehicle is close and in so doing it attracts the attention of the driver.



T1.4 Accident history signs

These signs, either official or unofficial, attempt to use the historical record of fatalities and injuries at the site to encourage drivers to assess and adjust their own driving behaviour.

T1.5 Traffic light timers

Traffic light timers, which indicate the remaining time before the lights turn to green, attempt to reduce the impatience of waiting drivers and, in so doing, achieve a calmer traffic flow beyond the junction.



T1.6 Site specific signs

Sometimes a site- or problem-specific sign, provided it is well chosen, is more effective at persuading a driver that his or her behaviour may be dangerous than is a standard sign.



1. FUNCTION

1.04. TRAFFIC CALMING (T2) - PHYSICAL OBSTRUCTION



Problem: On many roads, the speed and also the volume of traffic is sufficiently high that the safety of all road users – pedestrians, cyclists, motorcyclists and even those in larger vehicles in the main traffic flow – is threatened.

Treatment Types & Costs

Rather than installing barriers and other measures to protect vulnerable road users from fast moving vehicles, traffic calming measures specifically aim to reduce the speed of the vehicles so that all road users can mix more safely in the same space. In most cases, a reduction in speed also serves to reduce the number of vehicles using the road. Other outcomes of traffic calming include an improved quality of life and reduced pollution.

Traffic calming measures can be divided into four categories according to the nature of the measure and how it is constructed, Signs, physical obstruction, road surface and larger schemes. It is difficult to divide them in any other way, such as rural/urban or link/junction since most measures can be used in a variety of locations.

T1. Signs – 1.04(T1) \$

T2. Physical obstruction - this page - 1.04(2) \$\$

T3. Road surface – 1.04(3) \$\$\$

T4. Larger schemes – 1.04(4) \$\$\$\$

Each measure can have several variants and can be used either in combination with others or in isolation.

Crash types

- The close proximity of fast moving vehicles to each other and to vulnerable road users can result in head-on, side impact and rear-end accidents.
- All crash types.

Affected Users

- All road users are at risk from fast moving vehicles.

Design/Treatments & Their Benefits – (T2) Physical Obstruction

All the solutions on this page entail changes to the road which cause vehicles to deflect to follow a different and safer route. Unlike road markings and signs, these solutions force drivers to slow down and travel more carefully.

T2.1 Narrowing maybe of two narrow lanes or a single lane, depending upon traffic flow. They may be located centrally or on one side and used on urban or rural roads.



T2.2 Islands constrict traffic flow and protect crossing pedestrians, although traffic may be displaced laterally into a cycle lane.



T2.3 Restricted junctions discourage certain traffic movements and encourage vehicles to follow a safer route.



T2.4 Separated lanes can be used to isolate local traffic from through traffic and encourage the former to travel more slowly.



T2.5 Short medians force vehicles along a given alignment and can also be used to prevent a vehicle turning across traffic and into the far lane of a major road.





1. FUNCTION

1.04. TRAFFIC CALMING (T3) - ROAD SURFACE



Problem: On many roads, the speed and also the volume of traffic is sufficiently high that the safety of all road users – pedestrians, cyclists, motorcyclists and even those in larger vehicles in the main traffic flow – is threatened.

Treatment Types & Costs

Rather than installing barriers and other measures to protect vulnerable road users from fast moving vehicles, traffic calming measures specifically aim to reduce the speed of the vehicles so that all road users can mix more safely in the same space. In most cases, a reduction in speed also serves to reduce the number of vehicles using the road. Other outcomes of traffic calming include an improved quality of life and reduced pollution.

Traffic calming measures can be divided into four categories according to the nature of the measure and how it is constructed, Signs, physical obstruction, road surface and larger schemes. It is difficult to divide them in any other way, such as rural/urban or link/junction since most measures can be used in a variety of locations.

T1. Signs – 1.04(T1)	\$
T2. Physical obstruction 1.04(2)	\$\$
T3. Road surface – This page - 1.04(3)	\$\$
T4. Larger schemes – 1.04(4)	\$\$\$

Each measure can have several variants and can be used either in combination with others or in isolation.

Crash types

- The close proximity of fast moving vehicles to each other and to vulnerable road users can result in head-on, side impact and rear-end accidents.
- All crash types.

Affected Users

- All road users are at risk from fast moving vehicles.

Treatments & Their Benefits – (T3) Road surface

The solutions on this page entail treatments to the road surface. The first three solutions, unlike road markings and signs, force drivers to slow down and travel more carefully. Anti-skid surfacing reduces the risk of accidents on bends and shunt accidents at junctions.

T3.1 Rumble strips extend across the carriageway and force drivers to slow down. Note however that rumble strips cause noise and vibration. Also, some problems with snow clearing can be caused if the strips are proud of the road as apposed to being indented.



T3.2 Cushions are raised areas of sufficient width to force cars to slow down but permit buses to pass without deflection



T3.3 Raised crossings combine pedestrian facilities with a flat topped hump





1. FUNCTION

1.04. TRAFFIC CALMING (T4) - LARGER SCHEMES



Problem: On many roads, the speed and also the volume of traffic is sufficiently high that the safety of all road users – pedestrians, cyclists, motorcyclists and even those in larger vehicles in the main traffic flow – is threatened.

Treatment Types & Costs

Rather than installing barriers and other measures to protect vulnerable road users from fast moving vehicles, traffic calming measures specifically aim to reduce the speed of the vehicles so that all road users can mix more safely in the same space. In most cases, a reduction in speed also serves to reduce the number of vehicles using the road. Other outcomes of traffic calming include an improved quality of life and reduced pollution.

Traffic calming measures can be divided into four categories according to the nature of the measure and how it is constructed, Signs, physical obstruction, road surface and larger schemes. It is difficult to divide them in any other way, such as rural/urban or link/junction since most measures can be used in a variety of locations.

T1. Signs – 1.04(T1)	\$
T2. Physical obstruction 1.04(2)	\$\$
T3. Road surface – 1.04(3)	\$\$
T4. Larger schemes – this page – 1.04(4)	\$\$\$

Each measure can have several variants and can be used either in combination with others or in isolation.

Crash types

- The close proximity of fast moving vehicles to each other and to vulnerable road users can result in head-on, side impact and rear-end accidents.
- All crash types.

Affected Users

- All road users are at risk from fast moving vehicles.

Treatments & Their Benefits – T(4) Larger schemes

All the solutions on this page are more complex than single isolated measures. They are either larger schemes that require more substantial works to complete or solutions which enforce significant changes to the traffic flow pattern in an area.

T4.1 Width restrictors permit narrow vehicles, sometimes only bicycles and motorcycles, to pass



T4.2 Amended junctions change the permitted movements into and out of a junction



T4.3 Bus-only accesses permit buses (and emergency vehicles) to pass, but block other vehicles, using restriction signs or high cushions



T4.4 Gateways combine a variety of measures to indicate that the driver has entered an area where slower speeds are expected



T4.5 Roundabouts are a junction type which, when traffic flows are low or balanced, calm traffic in all directions



T4.6 Home zones use a wide variety of traffic calming and safety measures over an extensive residential area



T4.7 One-way streets change travel patterns by restricting movement along a road to a single direction



T4.9 Closed roads have a great impact upon traffic patterns and can prevent residential roads being used as short cuts



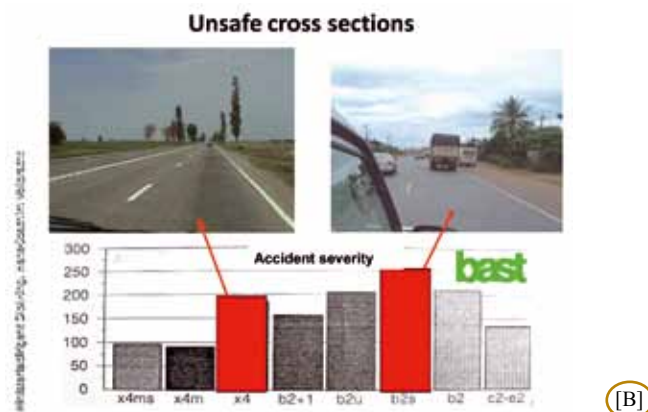
T4.8 Speed limit zones force vehicles to travel at or below a defined speed





2. FUNCTION

PRINCIPLE DESIGN POLICIES FOR CROSS SECTIONS



The right choice of cross sections is most crucial for road safety. In the history of road standards and design the following types have been built and operated: Four (and more) lane cross sections with and without separation of the directions by a medium

- **X4ms** = 4x (3,00 to 3,75) metre wide lanes + medium + 1,5 emergency lane
- **X4m** = 4x (3,00 to 3,75) metre wide lanes + medium
- **X4** = 4x (3,00 to 3,75) metre wide lanes No medium!
- **b2** = 2 x 3,50 metre wide lanes
- **C2** = 2x 3,25 metre wide lanes + speed limit
- **b2s** = 2x 3,50 metre wide lanes + 2,5m emergency lane: used as four lane roads
- **b2+1** = 2x 3,50 metre wide lanes + an overtaking lane alternatively used (regulated by markings, plastic poles or barriers).

Problems:

1. Heavy accidents on roads without separation of vulnerable road users
2. On four (and more) lane roads without a medium (X4) the number of head on accidents and side accidents from left turning is extremely high.
3. 2-lane roads with wide lanes (b2ü) or wide hard shoulders (b2s) are regularly used as very narrow four lane roads and the number of heavy accidents is even higher **These two cross sections are the most dangerous at all.**

These cross sections have been built and operated for some decades in western European countries. Based on their accident statistics it was possible to compare the different cross sections in respect of their accident severity expressed by the accident cost rates in independent research projects of several countries.

Treatments & Their Benefits

T1: separate the slow and non- motorized traffic from the fast and heavy traffic.

T2: For 4- lane roads separate the directions by a central medium

In most cases this is possible by a reduction of the lane width.

There is little relationship between the lane width and the traffic capacity of a road. The most significant relationship is between the lane width and the speed. So we need wider lanes for interurban roads with high speeds (dynamic design) than for urban roads with low speeds (geometric design).

- Main arterial, Motorway : 3,50 to 3,75 m lane width ,
- Main arterial , Express Roads: 3,25 to 3,50 m lane width
- Main distributor roads, Highways: 3,25 to 3,50 m lane width
- Regional distributor roads: 3,00 to 3,25 m lane width

T3: Remark the b2ü and b2s cross section and create the 2+1 cross section with regulated overtaking possibilities on the middle lane (see 2.02)

T4: Reduce the lane width In build up areas

- Main arteries, Urban Motorway 3,25 to 3,50 m lane width
- Urban Main Roads 3,00 to 3,25 m lane width
- Distributor roads, and 3,00 m lane width
- Residential roads 2,75 to 3,00 m lane width with traffic calming
- Traffic calming areas 4,50 m for both directions

Remarks: the reduction of lane width in urban and other build up is also to be seen in connection with the design of intersections. Their capacity and safety will increase the more narrow they are.



2. FUNCTION



Problem: Dangerous cross sections of express roads and highways, for example, four lane road without a crash barrier and two lane road with wide hard shoulder. A road with a wide hard shoulder can sometimes be used as a very narrow four lane road, with disastrous results.

Treatment Types & Costs

T1: Use safer cross section in the design phase with complete separation between fast and slow traffic. Excellent potential for accident savings.

\$

T2: Median separation by plastic poles or barriers and reduction of shoulder width $\leq 1,5$ m.

Low cost solution with reasonable expectation of accident savings.

\$

T3: Median crash barrier and separation of the shoulder by barriers or remarking to 2+1 cross section. Medium cost solution with good expectation of accident savings.

\$\$

T4: Reconstruction to a safer cross section

High cost solution with excellent potential for accident savings.

\$\$\$

Crash types

- Mainly severe head-on accidents
- Side collisions in the same direction
- Run off the road accidents to avoid collisions with another vehicle or obstacle on the hard shoulder

Affected Users

- Occupants of all motorized and non motorized vehicles, agriculture vehicles, cyclists and pedestrians

Treatments & Their Benefits

T1: For express roads use safe cross sections and separate slow traffic completely. For 4-lane and 2+1 cross section roads the legal and design speed is 100 km/h, the minimum speed is 40 km/h and intersections are on different levels.

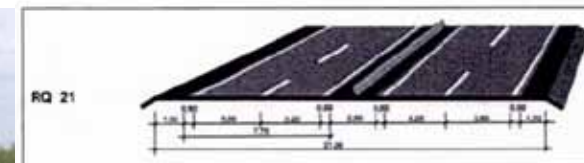


Bild 6: Verstreifter Regelquerschnitt (RQ)

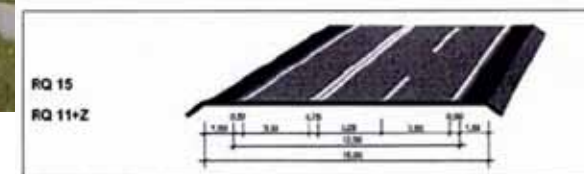


Bild 7: Dreistreifige Regelquerschnitte (RQ)



Bild 8: Gegenüberstellung System RQ 15 – System RQ 11+Z

T2: Use of plastic poles



or barriers for separation



T3: Median crash barrier and separation of the shoulder

Like motorways, express roads should be free of built up areas. In cases of reconstruction, parallel separate local roads and over- or under- passes for pedestrian should be constructed.

(See section 6, Vulnerable Road Users)





2. FUNCTION

LANE CONVERGING



Problem: At the end of a four lane cross section, a climbing lane or an overtaking lane, the correct principles is for fast moving traffic to be slowed down and made to merge with slow traffic rather than the other way around. Otherwise, fast traffic will be pushed into the oncoming traffic. Black spots with side and head on collisions are the result.

Treatment Types & Costs

T: Signing and marking

\$

Without extra costs in cases of new roads and low costs in cases of remedies.

Excellent results and removal of black spots

Crash types

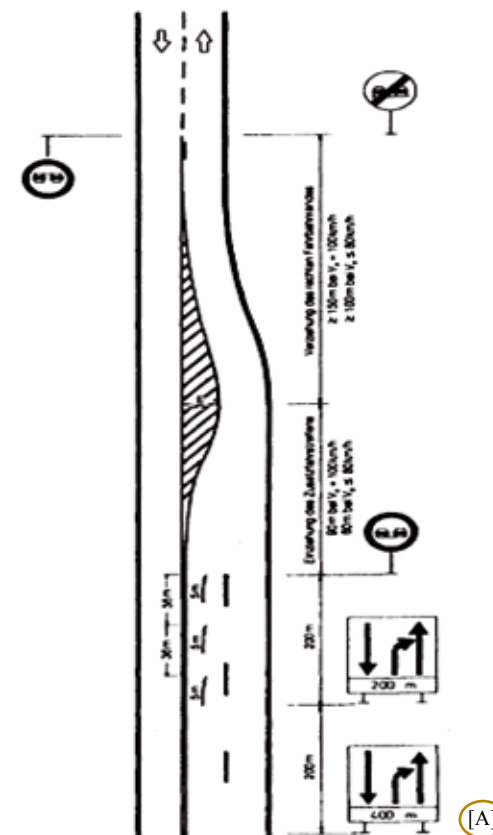
- Side and heavy head on collisions are the worst

Affected Users

- Trucks, buses, passenger cars and motorcyclists

Treatments & Their Benefits: Cross sections with lane reductions

T: Signing and marking



The reduction from 4 to 2 lanes, the end of climbing and overtaking lanes demands the same driving manoeuvre: Overtaking. The fast traffic has to merge into the slow traffic after passing.

This has to be clarified by signing and marking.





2. FUNCTION

UNCONTROLLED MEDIAN CROSSING



Problem: Medians reduce accidents by eliminating conflict between opposing traffic. However, unless median crossings are provided to allow vehicles to turn across oncoming traffic, they require drivers to travel further to a major junction where they can make an unsafe U turn or they encourage drivers to travel short distances against the oncoming traffic. Median gaps are therefore useful, but if poorly designed, they can expose turning vehicles to danger from high speed vehicles. Poor design includes lack of deceleration lane, lack of protection when waiting to turn and unprotected entry into high speed traffic.

Treatment Types & Costs

T1: Prevent vehicles making a U turn	\$
T2: Close the median gap	\$
T3: Provide a deceleration/acceleration lane	\$\$
T4: Protect waiting vehicles	\$\$
T5: U-turn	\$\$

Crash types

- Rear end accidents when decelerating and waiting
- Side accidents when pulling out

Affected Users

- Trucks, buses, passenger cars and motorcyclists

Treatments & Their Benefits

T1: Prevent vehicles making a U turn

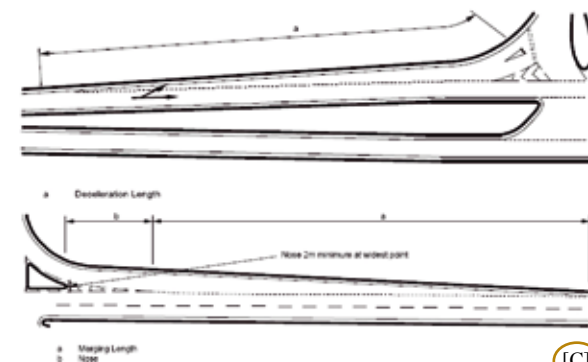
In most cases, vehicles take longer to find a traffic gap into which to make a U turn than to find a traffic gap through which to turn into a minor road. In addition, due to the nature of the manoeuvre, U turns can only be carried out at a low speed leading to large speed differentials between vehicles making the turn and through vehicles on the main carriageway. Preventing U turns will therefore reduce the number of vehicles which use a median gap and reduce the potential for vehicle conflict. This solution should only be used if prohibition signs are complied with by road users and enforced by traffic police.

T2: Close the median gap

If the gap does not lead to a major road and the road authority is trying to discourage U turns along the road (a manoeuvre which is often not absolutely necessary) or if there is a safer site nearby at which to make a turn, the median gap may be closed.

T3: Provide a deceleration/acceleration lane

The outside lanes next to a median are normally used by fast moving and overtaking traffic. Slowing down in these lanes can lead to accidents as other vehicles stop suddenly or swerve into another lane. Providing a sufficiently long deceleration lane within the median allows vehicles to slow down in greater safety. Emerging from a median gap at slow speed traffic into an outside lane with high speed traffic is unsafe. Vehicles can be protected by providing an acceleration lane within the median and ensuring that the two lanes merge in a safe manner.

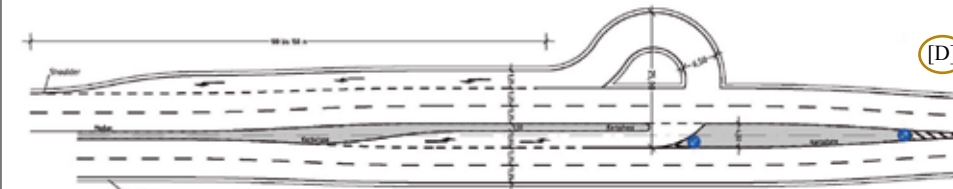


[C]

T4: Protect waiting vehicles

If a median is narrower than the length of a vehicle or if several vehicles are waiting to turn, these vehicles may protrude into the outside lane. They can be protected in a number of ways, including widening the median and closing the outside lane with markings, cones or barriers for a distance suitable for the speed of traffic on the road in advance of the gap.

T5: provision for U-Turn for one direction, if roundabouts are not possible



[D]



2. FUNCTION

MEDIAN DIVIDER

Problem: On roads without a physical median divider, head-on collisions and rear-end collisions with cars waiting to turn right and with cars making a U-turn easily occur.



Treatment Types & Costs

T1: Centre poles	\$
T2: Guard fence	\$\$
T3: Green central reserve	\$\$

Crash types

- Head-on collisions
- Rear-end collisions

Affected Users

- Trucks, buses, passenger cars and motorcyclists

Treatments & Their Benefits

T1: Centre poles

Centre poles are erected on a centre line to prevent right turns and U-turns.

However, they are not effective in preventing head-on collisions caused by cars leaving their lanes.



T2: Guard fence

Installing a guard fence on the centre line effectively prevents head-on collisions.



T3: Green central reserve

A green central reserve used as a median divider to improve the environment prevents U-turns but is much less likely to prevent head-on collisions than a guard fence. Note however that maintenance of such a central reserve can be expensive, time consuming and a danger to the workforce.





3. ALIGNMENT

PRINCIPLE DESIGN POLICIES FOR THE ALIGNMENT



Problems: The road course is not predictable and drivers react too late or are surprised by sudden changes of the curvature. The road gives no orientation in time and does not assist the drivers to keep the vehicles on the carriageway against the dynamic forces. The drainage of the road surface is poor and aquaplaning is the reason of heavy accidents in rain.

Treatment Types & Costs

T 1: Provide sufficient sight distances.

This is in most cases not a matter of costs but of intelligent engineering

T 2: Don't give too long sight distances

This is in most cases not a matter of costs but of intelligent engineering

Both treatments are most essential for accident prevention.

Crash Types

- Head-on collisions
- Run off accidents
- Side accidents

Affected Users

- Car, van, bus and truck occupants as well as motorcyclists

Principle Treatments & Their Benefits

T1: Provide sufficient sight distances

Drivers need a sufficient sight distance to stop in case of an obstacle laying on the road or a traffic event in front of him.

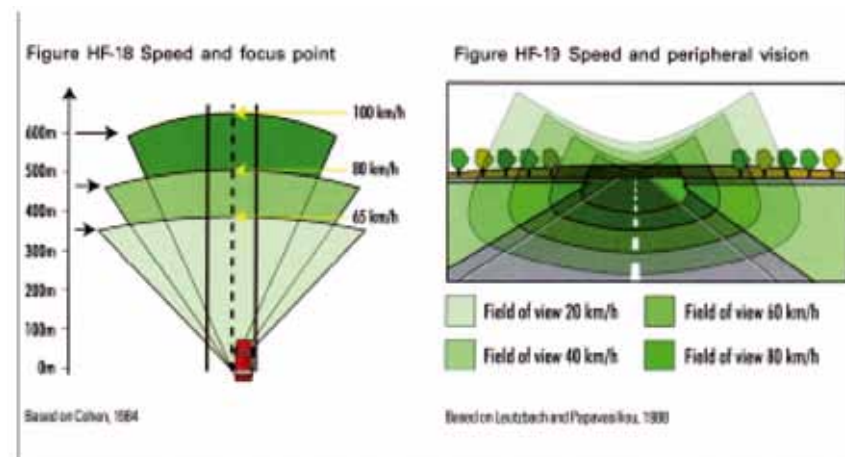
This Stopping Sight Distance is related to the design speed (compare the PIARC Road Safety Manual (RSM) page 339).

Drivers need time for orientation. In the case of an obstacle on the road there are only two options: break and stop or try to avoid to hit the obstacle. Drivers will manage this decision in 1 second. But in cases of other events such as intersections, curves, entrances of built up areas, changes of functions and so on they need much more time for orientation, decision making and reaction. 4-6 seconds are the average. They need an Orientation Sight Distance for example of 300 m when the design speed is 100 km/h (Compare the PIARC Human Factors guideline for road design).

Overtaking is one of the most critical decisions if there is not enough Overtaking sight Distance.

The most important design rules, standards and calculations for the horizontal and vertical alignment are based on these sight distances.

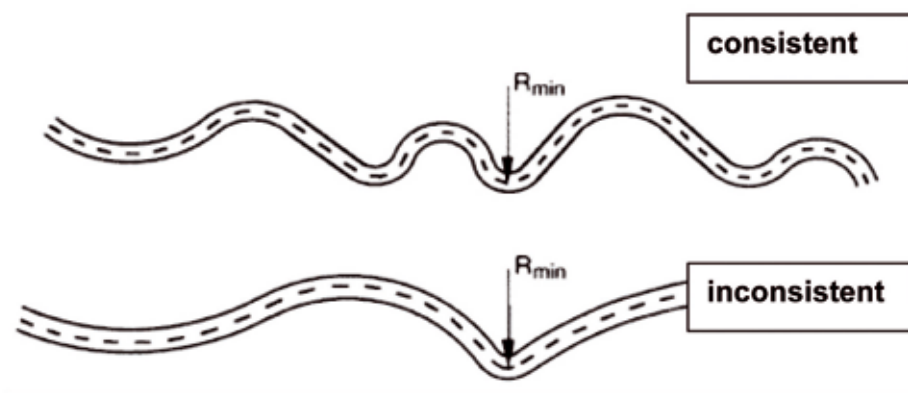
T2: Don't give too long sight distances



The faster we drive the further we look ahead. But reverse conclusion: The further we look ahead the faster we drive. So we have to adapt the maximum sight distance to the design speed or offer closer points of fixation. The range of sight distances in the table of Principle Design features for interurban roads in the chapter about Function is related to the orientation sight distance and this Speed controlling Sight Distance. (compare also the PIARC Human Factors guideline for road design).

3. ALIGNMENT

HORIZONTAL ALIGNMENT



[A]

Problem: An inconsistent alignment with a combination of large with small radius horizontal curves surprises the driver.

Treatment Types & Costs

T 1: Consistent design avoids treatment \$

This can be expensive if the road has to be rebuilt later. (\$\$\$\$)

T 2: Traffic signing and markings \$

Low cost solution with fairly good expectation of accident savings.

T3: Additional barriers \$\$

Medium cost solution with good expectation of accident savings.

T4: Reconstruction of curves \$\$\$

High cost solution with excellent potential for accident savings.

Crash Types

- Head-on collisions
- Run off accidents

Affected Users

- Car, van, bus and truck occupants as well as motorcyclist

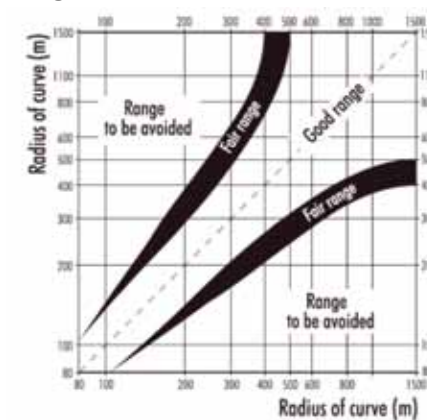
Treatments & Their Benefits, Horizontal alignment

T1: Consistent design

The differences of two radii in curve sequences should be in the good range. For example, first radius 400 m
► following radius between 250 m and 800m.

Range of horizontal radii for :

- Motorways: $R > 700$ m with spiral curves
 $A > 240$ m
- Express roads: $R \geq 500$ m with spiral curves
 $A \geq 150$ m
- Highways: $R = 300-900$ m with spiral curves
 $A \geq 80$ m
- Regional roads: $R = 250-600$ m with spiral curves
 $A \geq 80$ m
- Small rural roads: $R = 150-300$ m,
no transition curves



Source : German design guidelines, from Lamm et al. (1999)

T2: Traffic signing and markings

In existing cases, speed reduction, chevrons and rumble strips ahead.

T3: Additional crash barriers

Crash barriers on the outside of bends can drastically reduce the severity of accidents.

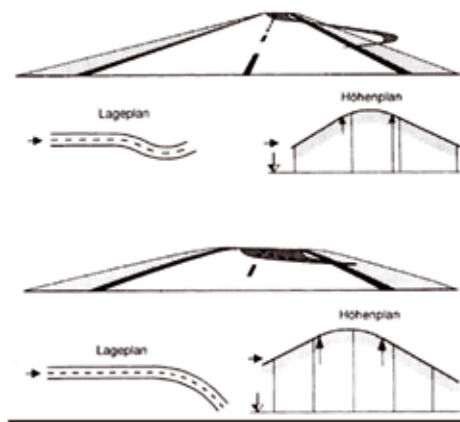
T4: Reconstruction of the curve

Reconstructing the bend with a more sympathetic radius and/or better super-elevation can drastically reduce the severity of accidents.



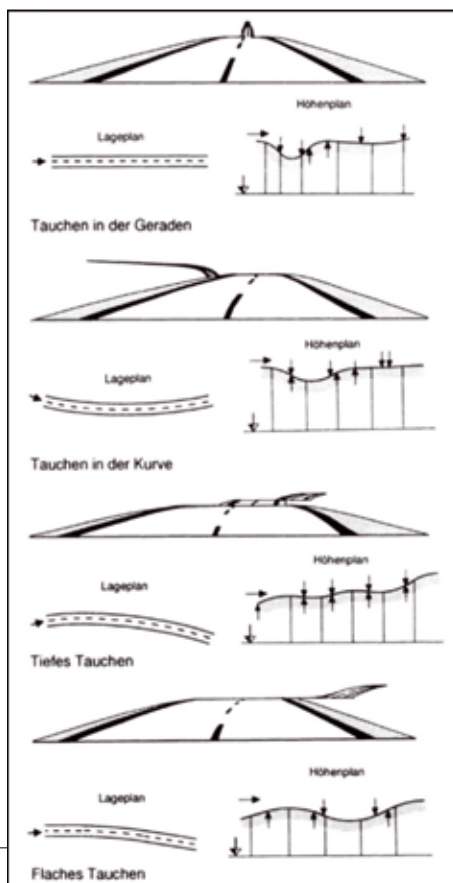
3. ALIGNMENT

VERTICAL ALIGNMENT



[A]

Problem: Hidden curves behind hill tops (above) and hidden dips in the alignment surprise the driver.



[A]

Treatment Types & Costs

T1: Consistent design avoids treatment

This is expensive if the road has to be rebuilt later.

T2: Traffic signing and markings

\$

Low cost solution with fairly good expectation of accident savings

T3: Reconstruction of alignment

\$\$\$\$

High cost solution with excellent potential for accident savings

Crash Types

- Head-on collisions
- Run off accidents

Affected Users

- Car, van, bus and truck occupants as well as motorcyclist

Treatments & Their Benefits, Vertical alignment

T1: Consistent design

As far as possible, have the vertical and horizontal turning points in the same position, and don't change curves shortly after the crest.

The vertical radii of crests and max. longitudinal fall should be for :

Motorways:	$H = 16,000 ; \leq 4\%$
Express roads:	$H = 8,000 ; \leq 4\%$
Highways	$H = 5,000 ; \leq 5,5\%$
Regional roads:	$H = 3,000 ; \leq 7\%$
Small rural roads	$H = 2,400 ; \leq 8\%$

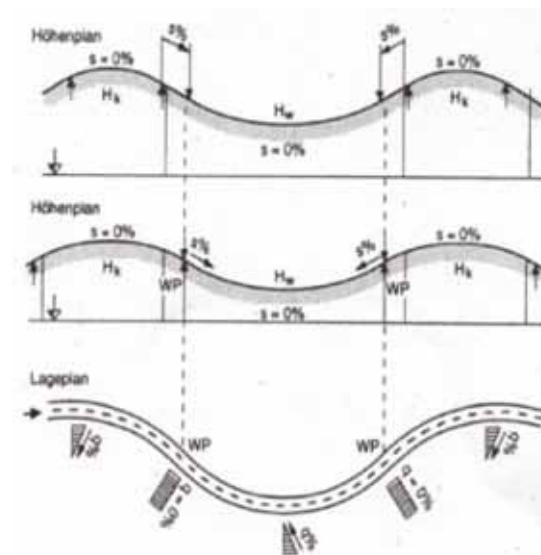


Bild 15: Zuordnung der Elemente in den Lage- und Höhenplänen

[A]

T2: Traffic signing and markings

In existing cases, speed reduction with warning signs and overtaking forbidden by suitable road markings and signs.



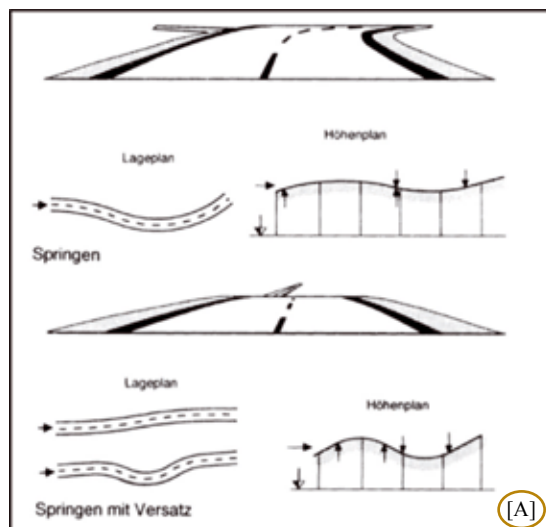
T3: Reconstruction of horizontal and vertical alignment

This is sometimes a 'last resort' solution because of the high costs. However, in particularly severe cases this may be the only solution to excessive road safety problems.

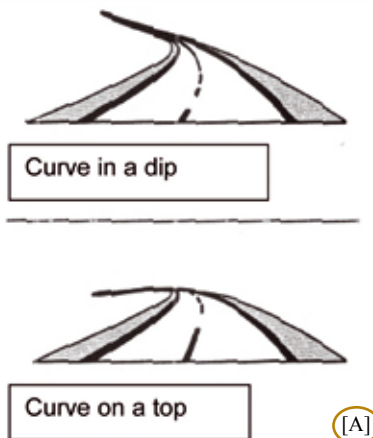


3. ALIGNMENT

CONSISTENCY OF ALIGNMENT



Problem: Optical illusions and “jumping” of the alignment. Never surprise the driver!



Optical illusion: A curve in a dip seems wider than on a crest. As a result road users drive faster in the dip than they should.

Treatment Types & Costs

T1: Consistent design avoids treatment. \$

This is expensive if the road has to be rebuilt later. (\$\$\$\$)

T2: Traffic signing and markings \$

Low cost solution with fairly good expectation of accident savings.

T3: Reconstruction of alignment \$\$\$

High cost solution with excellent potential for accident savings.

Crash Types

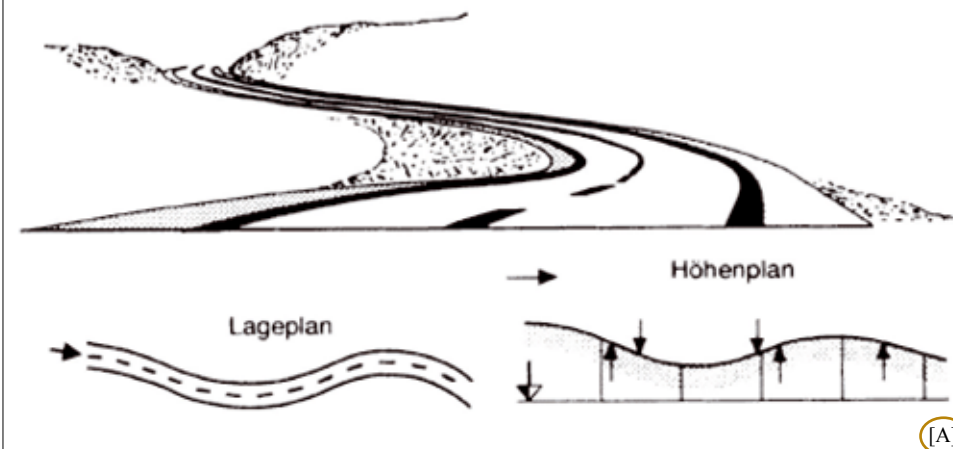
- Head-on collisions
- Run off accidents

Affected Users

- Car, van, bus and truck occupants as well as motorcyclist

Treatments & Their Benefits, Consistency of alignment

T1: Consistent design



Avoid optical illusions and “jumping” of the alignment. Give long enough sight distances for the orientation of the driver. Examples of these distances are:

Motorways:	600 – 1500 m
Express roads:	300 – 600 m
Highways and Regional roads:	200 – 450 m
Small rural roads:	150 – 300 m

T2: Traffic signing and markings

In existing cases, speed reduction with warning signs and forbid overtaking by suitable road markings and signs.



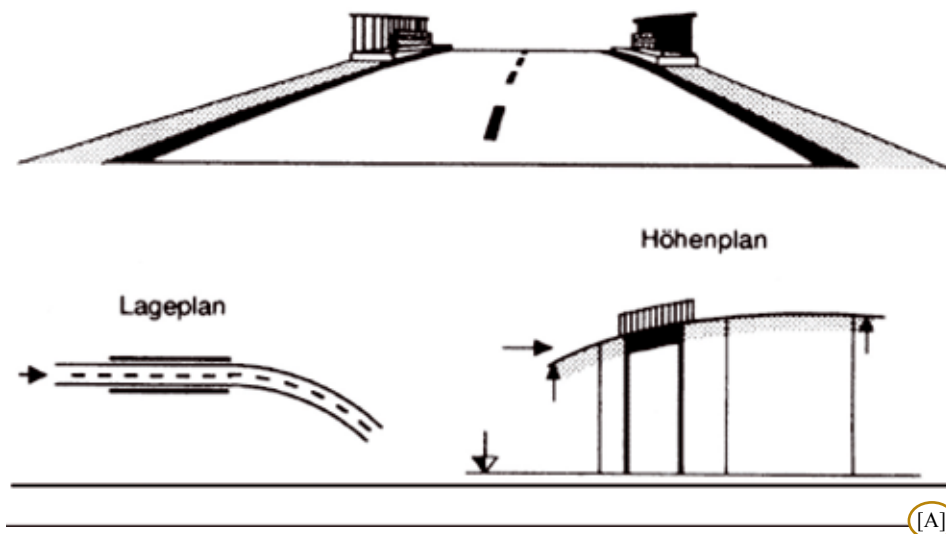
T3: Reconstruction of horizontal and vertical alignment

This is sometimes a ‘last resort’ solution because of the high costs. However, in particularly severe cases this may be the only solution to excessive road safety problems.



3. ALIGNMENT

FORWARD VISIBILITY – BRIDGES



Problem: Poor forward visibility in the vicinity of bridges.

Treatment Types & Costs

T1: Consistent design avoids treatment \$

If the alignment of the bridge allows good visibility the need for treatment is avoided. This expensive of the bridge has to be rebuilt later (\$\$\$\$)

T2: Traffic signing and markings \$

Low cost solution with fairly good expectation of accident savings.

T3: Reconstruction of alignment \$\$\$\$

In most cases, this is unrealistic during the expected lifetime of the bridge.

Crash Types

- Head-on collisions
- Run off accidents

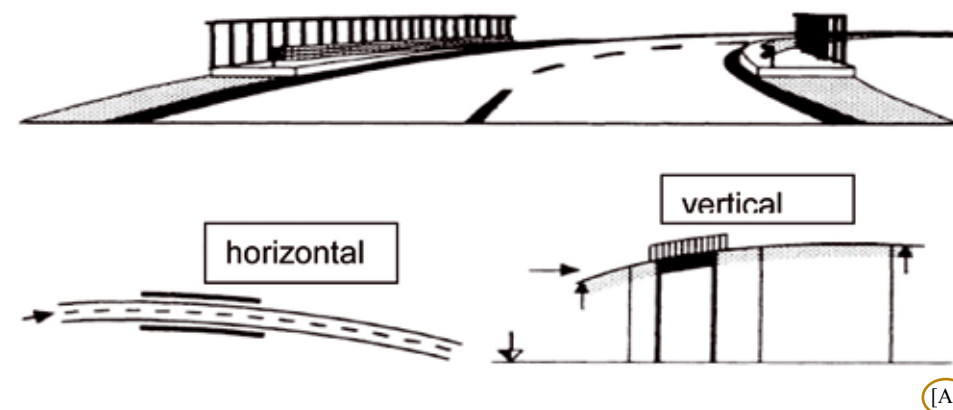
Affected Users

- Car, van, bus and truck occupants as well as motorcyclist

Treatments & Their Benefits, forward visibility – bridges

T1: Consistent design

Bridges should be aligned to allow good visibility both horizontally and vertically.



T2: Traffic signing and markings

In existing cases, speed reduction with warning signs and overtaking forbidden.

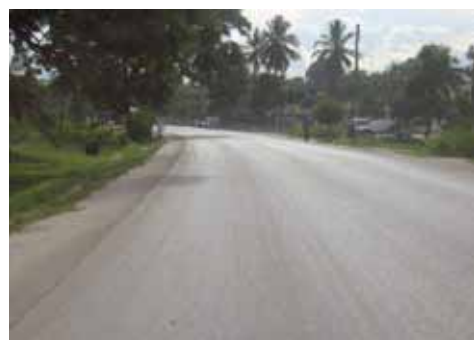
T3: Reconstruction of horizontal and vertical alignment

This is sometimes a 'last resort' solution because of the high costs. However, in particularly severe cases this may be the only solution to excessive road safety problems.



3. ALIGNMENT

LACK OF SUPERELEVATION



Problem: Superelevation assists drivers to negotiate bends by increasing the amount of friction between the vehicle wheels and the road surface. If the curve is not superelevated, there is a tendency for vehicles to lose traction and leave the carriageway, hitting road users or objects on the outside shoulder or rolling over. Adverse or no cambers on bends can also result in drivers drifting over the centreline risking a head-on collision.

Treatment types & costs

T1: Advance warning signs	\$
T2: Road markings, signs, posts and fences	\$
T3: Ensure constant condition	\$
T4: Barriers	\$\$
T5: Improved traction	\$\$
T6: Superelevate	\$\$\$
T7: Eliminate tight curves	\$\$\$

Crash Types

- Single vehicle loss of control
- Head-on
- Accident with pedestrian on outside of curve

Affected Users

- All road users

Treatments & Their Benefits, Lack of superelevation

There are three types of solution to a curve which lacks superelevation:

1. Persuade the driver to drive more cautiously (T1-T6);
2. Reduce the risk of, or prevent, an errant vehicle from leaving the carriageway (T5, T6), and
3. Rectify the lack of superelevation (T7, T8).

T1: Advance warning signs

Signs inform drivers that a tight curve is ahead and that a local speed limit is in force.

T2: Road markings, signs, posts and fences

These devices draw the driver's attention to the curve and the lack of superelevation.

T3: Ensure constant condition

A series of curves should be checked for consistency. A single un-superelevated curve amongst a series with superelevation can surprise a driver and be more dangerous than if the entire series were un-superelevated.

T4: Barriers

Crash barriers should be erected around the outside of the curve. Barriers can be constructed from w-section steel, of reinforced concrete or gabions.



T5: Improved traction

The surface of the outside lane can be treated to increase the lateral traction between surface and tyres. If this option is used, it is necessary to check frequently and regularly that the traction remains high.



T6: Superelevate

A high cost solution is to reconstruct the outer lane around the curve to provide superelevation. It is necessary to ensure that there is a smooth transition between a crown and a superelevated cross section on each end of the curve.

T7: Eliminate curves

In new construction, the alignment should be designed to require as few tight curves as possible.



3. ALIGNMENT

POOR HORIZONTAL AND VERTICAL CURVATURE



Problem: Horizontal curvature refers to the curves along a road and vertical curvature refers to the crests, dips and gradients along a road. Curvature affects two aspects of road use. The first is when curvature restricts visibility along the road and the ability to either see a potential hazard sufficiently far ahead that evasive action can be taken or safely overtake slower vehicles in front. The second is when curvature restricts the ability to travel at a preferred speed. Although these two aspects are related, tight curves with good visibility and long curves with poor visibility are possible.

Although it is known that low levels of curvature can encourage speed and lead to a rise in accidents, high levels of horizontal and vertical curvature and certain curvature combinations can also be a significant hazard. Examples of hazardous curvature include:

- A single tight curve among a series of long curves
- A horizontal curve beyond a crest
- A horizontal curve within a long ascent or descent
- A change in gradient within a horizontal curve
- A tight curve at the bottom of a long descent

Treatment types & costs

T1: Signs, road markings, raised ribs and posts	\$
T2: Skid resistant surfaces	\$
T3: Barriers	\$\$
T4: Visibility improvements	\$\$\$
T5: Curvature improvements	\$\$\$

Crash Types

- Roll over
- Lost control
- Head on impact

Affected Users

- All road users

Design/Treatments & Their Benefits, poor horizontal & vertical curvature

T1: Signs, road markings, raised ribs and posts

Advance warning of curvature ahead and guidance through the site can clearly identify the safe alignment and thereby help to reduce accidents. In many cases, the simple presence of signs and other markings also encourages drivers to drive more slowly.

Where visibility cannot be improved, it may be necessary to define a section as non-overtaking, install appropriate signs and enforce the rule.



T2: Skid resistant surfaces

Roads treated with skid resistant surfaces improve safety by increasing the speed at which a vehicle can travel on a tight curve without losing control. A disadvantage of a treated surface is that drivers often assume a higher safe speed and drive faster with a consequent increase in accident rate. If this option is used, it is necessary to check frequently and regularly that the traction remains high.



T3: Barriers

Since many accidents involve vehicles leaving the carriageway, crash barriers should be erected around the outside of the curve and for 20-100 metres beyond the curve in each direction. Barriers can be constructed from w-section steel, or concrete reinforced gabions.



T4: Visibility improvements

Improving the visibility of the road ahead allows drivers to take appropriate action before a hazard is reached. Visibility can be improved in many ways, including cutting back or removing vegetation, removing soil and rock slopes, and widening the carriageway. Drivers can be given more time to react and take any necessary evasive action by setting and enforcing a speed limit.

T5: Curvature improvements

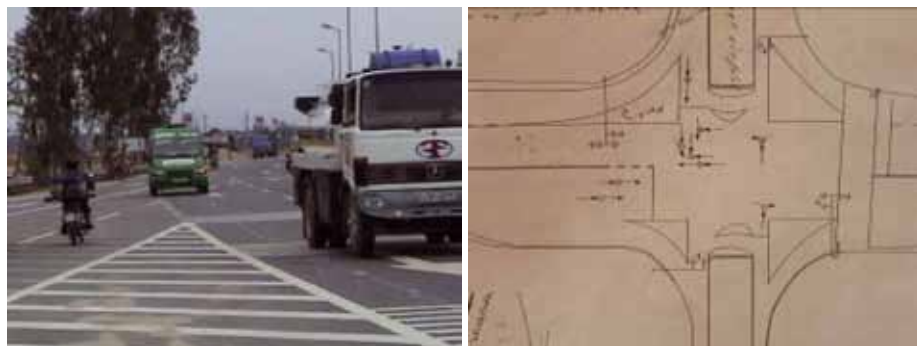
Although constructing a safe combination of vertical and horizontal curvature is normally restricted to new roads, it is possible to undertake localised curvature improvements on an existing road if the accident problem is particularly severe, traffic levels are high or the required work is not substantial. Curvature can be improved in the following ways.

- Horizontal and vertical curvature should have turning points (the place at which a curve ceases or changes direction) at the same site;
- All turning points should be visible by approaching drivers and not hidden beyond curves or crests;
- Radii of horizontal and vertical curvature can be increased to a level which is safe at the typical traffic speed on the road;
- Constructing a dual-carriageway or adding an overtaking lane can eliminate the risk of approaching vehicles and thereby allow a given curvature to be used more safely;
- Curves, sags and crests along the road should have, wherever possible, similar radii.



4. INTERSECTIONS

PRINCIPLE DESIGN POLICIES FOR INTERSECTIONS



Problems: Diagonal intersections (Y-Type) do not give a clear indication about the right of way nor do they allow a safe weaving. The traffic regulations on wide intersections are difficult to recognize and traffic signals may not be visible in sufficient time. A long time is needed to cross the junction and long inter phase times cause frustration and a lack of adherence to the signals.

Treatment Types & Costs

T1: Wait and give way

Excellent improvement of road safety for less costs. (see 4.07)

T2: Less wide intersections

Remarkable improvement of road safety for less costs.

T3: Weave in and out

Excellent improvement of road safety for Motorways and Highways.

Crash Types

- Side collisions
- Head on collisions
- Accidents with pedestrian and cyclists

Affected Users

- Trucks, buses, passenger cars and motorcyclists
- Vulnerable road users

Treatments & Their Benefits

T1: Wait and give way

Decide clearly for the right of way and connect the secondary road perpendicular to the primary road, especially in urban situations.

System	in Grundformen aufgelöste Systeme			

T2: Design these intersections as narrow as possible

By narrowing the lane width

By footpath extensions by the width of parking lanes

By reduction of access and entrance radii as far as possible

T3: Accelerate and weave in

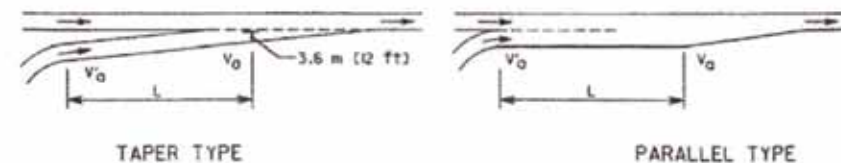
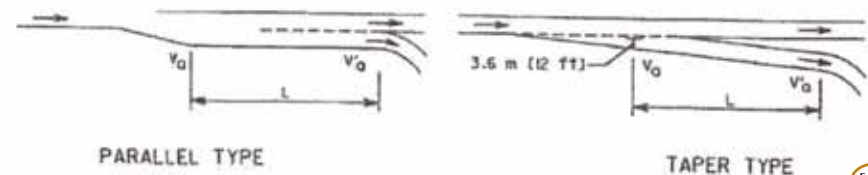


Exhibit 10-70. Minimum Acceleration Lengths for Entrance Terminals with Flat Grades of Two Percent or Less

Weave out and decelerate





4. INTERSECTIONS

(1) FAULTS AT SMALL ROUNDABOUTS



Problem:

1. An unobstructed view of the other approaches to roundabouts can lead to high approach speeds.
2. The needs of pedestrians and other vulnerable road users are not properly catered for.

Treatment Types & Costs

T1: The central island of the roundabout should be shaped as a hill.

\$

Remarkable improvement of road safety for very low costs.

T2: Entrance islands should be used for pedestrian and cyclist crossings where necessary

\$

Remarkable improvement of road safety for very low extra costs.

Crash Types

- Side collisions
- Accidents with pedestrian and cyclists

Affected Users

- Trucks, buses, passenger cars and motorcyclists
- Vulnerable road users

Treatments & Their Benefits

T1: The central island of the round about should be shaped as a hill which is at least 1.5 m high and planted with small bushes



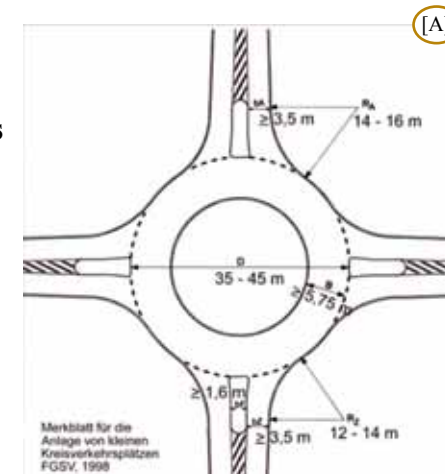
T2: Entrance islands should be used for pedestrian and cyclist crossings where necessary

Has to be combined with the planning of footways and cycle paths



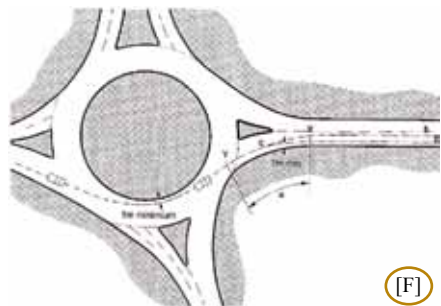
The horizontal design and measures of a small round about for one circling lane

(all examples for right hand traffic)



4. INTERSECTIONS

(2) INSUFFICIENT DEFLECTION THROUGH A ROUNDABOUT



Problem: Roundabouts operate efficiently when circulating and entering traffic flows are able to merge safely and with minimum disruption. For this to happen, it is important that vehicles are prevented from travelling through the junction in a near straight line since they may do so at high speed, endangering those in merging flows. All traffic paths should therefore be deflected to a sufficient degree that speeds are reduced to an appropriate level. Deflection is assessed by measuring the tightest curve (when measured over a 20-25 metre length) that a vehicle follows when approaching the roundabout and then travelling straight ahead through it for up to 50 metres beyond the entry Give Way line along the most direct legitimate alignment with no other traffic present and ignoring lane markings at the entry point. For a three legged roundabout, the route closest to a straight line should be assessed. In most cases, the tightest curve should have a radius less than 100 metres. An exception to this deflection requirement is a mini roundabout with a small, unkerbed island which vehicles may drive over and thereby travel through the roundabout in a straight line. Since mini roundabouts should be used only on low speed roads, dangerous merging is less likely, although measures can be taken to achieve some deflection and speed reduction.

Treatment Types & Costs

T1: Provide islands – mini roundabout	\$\$
T2: Increase the size of the centre island	\$\$
T3: Increase the size of islands	\$\$
T4: Provide subsidiary deflection islands	\$\$
T5: Stagger the approach roads	\$\$\$
T6: Realign the approach roads	\$\$\$

Crash types

- Rear shunt
- Side impact
- Roll over

Affected users

- All those using the roundabout

Treatments & Their Benefits, Insufficient deflection through a roundabout

Deflection can be achieved through the following solutions. The first solution is appropriate for mini roundabouts. The remaining five solutions are appropriate after a roundabout has been constructed and during the design of a new roundabout.

T1: Provide islands at a mini roundabout

The design and location of most mini roundabouts makes it difficult to achieve sufficient deflection. Islands can be provided at each entry to achieve some deflection.

T2: Increase the size of the centre island

This solution will necessarily deflect the circulatory path to the left and thereby increase the deflection. However, it will increase the land requirement.

T3: Increase the size of approach islands

The required deflection can be achieved by increasing the size of the islands at the entry. If the straight ahead route through a roundabout is tangential rather than diametrical, deflection can be achieved by providing side nosings which deflect vehicles away from a straight tangential line.

T4: Provide subsidiary deflection islands

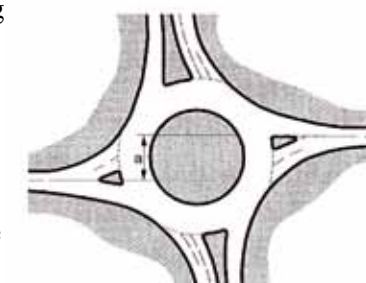
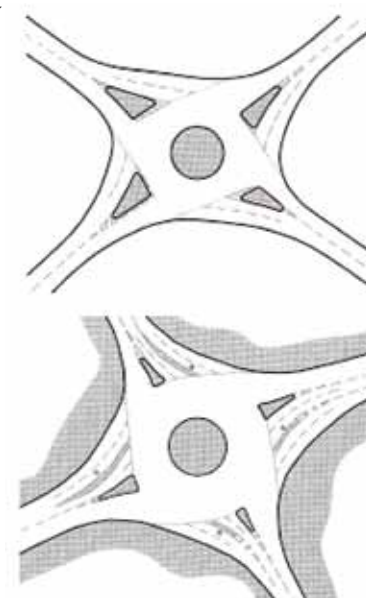
An alternative solution to increased islands is to provide subsidiary islands at the entry. Subsidiary islands are normally defined with road markings and studs rather than kerbs or a raised surface.

T5: Stagger the approach roads

This solution allows sufficient deflection to be achieved with a small central island and land-take and gives low deflection exits which are appropriate when leaving a junction with increasing speed. A left-right stagger is more appropriate than a right-left stagger when driving on the left.

T6: Realign the approach roads

The approach roads can be realigned to incorporate the required deflection on the approach. In general a right hand curve before a left hand entry deflection is preferable to a gentle left hand curve. If the curve is tighter than the minimum specification for the design speed of the approach, a warning sign will be required.





4. INTERSECTIONS

VISIBILITY AT T-JUNCTIONS

Problem: T-junctions are constructed where a minor road connects to and terminates at a major road, and allow traffic to transfer between roads with no disruption to the flow on the major road.



Vehicles waiting at a T-junction on the minor road must have good sight distances in both directions along the major road. If they do not, they may emerge in front of an approaching vehicle. This visibility should also be similar in each direction. If it is not, drivers may give unequal attention in the more obscured direction and fail to see a vehicle approaching from the clearer direction.

Conversely, unless the land is free of all obstructions and visibility is perfect over long distances, it is often recommended that vehicles approaching the T-junction along the minor road should have restricted visibility towards the major road on either side of the junction. If visibility is good or appears to be good, they may believe that the major road is clear and enter it without giving way at the junction, only to find that that have entered in front of approaching traffic that had been partially obscured.

Vehicles travelling along the major road must have good visibility of the junction and vehicles waiting there. This will allow them to be prepared for evasive action if a vehicle enters the major road incorrectly and to slow down in good time if a vehicle ahead of them is about to turn into the minor road.

Treatment types & costs

T1: Increase visual obstruction on the minor road approach	\$
T2: Provide warning signs on all approaches	\$
T3: Remove visual obstruction at the junction	\$
T4: Lane markings through the junction	\$
T5: Change Give Way sign to a Stop sign	\$
T6: Increase flare of the minor road	\$\$
T7: Enforce a speed limit through the junction	\$\$
T8: Provide a central refuge for turning traffic	\$\$
T9: Locally widen the major road	\$\$
T10: Signalise the junction	\$\$
T11: Provide a roundabout	\$\$\$
T12: Realign the roads	\$\$\$

Crash types

- Side impact
- Rear shunt

Affected users

- All road users

Treatments & Their Benefits, visibility at T-junctions

The first two solutions involve changes or improvements to the approaches to make drivers more careful at and through the junction. The remaining solutions involve improvements to the junction itself and are progressively more expensive from cutting light vegetation to realigning the roads.

T1: Increase visual obstruction on the minor road approach

Vegetation alongside the approach can be allowed to grow higher to reduce the visibility from the minor road to the major road. This reduced visibility increases the likelihood that a vehicle will stop before attempting to emerge from the minor road.

T2: Provide warning signs on all approaches

Advance warning signs should be used on all approaching roads so that drivers on the minor road slow down and those on the major road are aware of the risk of a vehicle emerging in a dangerous manner.

T3: Remove visual obstruction at the junction

Vegetation and other obstructions should be cut or removed so that a driver located 15m metres behind the Give Way or Stop line is able to see at least 70 metres in each direction along the major road for design speeds of 50kph up to 295 metres for design speeds of 120 kph. This solution must be properly maintained since if light vegetation and shrubs re-grow without being cut, the problem will recur.

T4: Lane markings through the junction

Changing lane markings through the junction to, for example prevent overtaking, has two purposes: it reinforces the indications that the vehicle is passing through a potentially dangerous site and it prevents drivers carrying out hazardous manoeuvres.

T5: Change Give Way sign to a Stop sign

Changing a Give Way sign to a Stop sign will increase the likelihood that a vehicle will stop at the junction before entering the major road, thereby reducing the chance of that vehicle entering in front of approaching traffic.

T6: Increase flare of the minor road

Increasing the flare of the kerb line from the minor to the major road increases visibility onto the major roads and allows vehicles on the minor road to partly turn in the required direction and thereby enter the traffic flow more smoothly. A significant disadvantage is that drivers are less likely to see traffic approaching from the opposite direction if it is more than 90 degrees from their line of sight.

T7: Enforce a speed limit through the junction

Reducing the speed at which vehicles travel along the major road gives drivers longer to react and take any necessary evasive action.

T8: Provide a central refuge for turning traffic

If the major road is busy, it can be difficult for vehicles to safely emerge from the minor road, cross one lane of the major road and merge with traffic on the far side. In this situation, a central refuge can be provided where vehicles can wait after crossing the first lane and before turning onto the far lane.

T9: Locally widen the major road

Locally widening the major road increases general site visibility and provides spare room in case a vehicle on the major road has to take evasive action.

T10: Signalise the junction

If other solutions are impossible or too expensive, the T-junction may be equipped with traffic signals. This solution is feasible in only urban and semi-urban areas.

T11: Provide a roundabout

Traffic flow patterns may have changed since the T-junction was constructed such that reconstructing the junction as a roundabout can be justified. A mini roundabout might be appropriate and would be a lower cost solution.

T12: Realign the roads

If traffic patterns still suit a T-junction, it is possible to realign the minor road, and possibly also the major road, to improve and balance the visibility.



4. INTERSECTIONS

POOR VISIBILITY OF CROSS ROADS



Problem: A cross roads is a junction type which is commonly used to connect two roads which cross each other's alignment. In most cases vehicles on the higher classification, or major road have priority through the junction and vehicles on the minor road must wait for a gap before they can cross or turn. Since the junction type is safer and more efficient if the two roads cross at approximately orthogonal directions, skew roads are often realigned locally so that they meet at right angles.

However, one problem that can occur with this junction type is that if the junction ahead is not obvious to drivers approaching on the minor road, they may enter the junction or even drive straight over before they are able to stop, thus putting themselves and road users on the major road at risk. This problem normally occurs if there are no warning signs of the junction ahead and if the natural landscape and road lines draw the eye through the junction in what is known as a 'tunnel effect'.

Although advanced warning signs may reduce the problem, the preferred solution is to stagger the minor road so that the junction becomes a pair of T-junctions and approaching drivers do not see road lines passing through the major road. Staggering a cross roads has been known to reduce accident rates by up to 60%.

A cross roads can be staggered well or poorly. Faults include poor T-junctions, inadequate signing, insufficient stagger, incorrect stagger (for vehicles driving on the right, a left-right stagger where vehicles have to turn left and then left to continue along the minor road is preferred. This is because it reduces the need for traffic on the minor road to wait in the centre of the major road and it removes the conflict between left turning vehicles off the major road).

Treatment types & costs

T2: Improve the signing	\$
T1: Improve the T-junctions	\$\$
T3: Improve the stagger	\$\$
T4: Change the junction	\$\$\$

Crash types

- Side impact
- Rear shunt

Affected users

- All road users

Treatments & Their Benefits

T1: Improve the signing

It is always important that drivers on the major and minor roads know what type of junction they are approaching and how to travel through it, and that they are given this information sufficiently long before arriving at the junction.

T2: Improve the T-junctions

The main reason why some T-junctions are seen as poorly designed is that visibility out of and into the minor road is restricted. There are a range of solutions which can be used to improve the visibility at T-junctions. These are described in Example 4.02.

T3: Improve the stagger

For vehicles driving on the right, a left-right stagger is preferred to a right-left stagger, although in many locations the roads, the terrain and nearby properties might make a left-right stagger the only possible layout.

A simple stagger, where there are no marked or kerbed islands along the centre lines of either road, should be used only on two lane normal width single carriageway roads with reasonably low flows. A stagger, with ghost islands marked on the surface of the major road to assist turning traffic, should be used only on two lane normal and wide single carriageway roads. A stagger where the major road is divided with a wide raised median can be used on single carriageway roads and dual two lane carriageway roads but not on dual three lane carriageway roads.

The minimum distance between the centre lines of the minor roads when measured along the major road is determined by the speed of vehicles along the major road and the need for a drawbar trailer combination vehicle to manoeuvre along the minor road. The minimum distances in metres are given in the following table.

Stagger	Design speed	Simple junction	Ghost islands	Single lane dual	Dual carriageway
Right-left	-	50	50	40	60
Left-right	50	50	50	-	60
	60	50	50	-	60
	70	50	60	-	60
	85	50	75	75	75
	100	50	100	100	100
	120	50	-	-	130

T4: Change the junction

Although a staggered cross roads normally has a lower accident rate than a normal cross roads, signalling the junction or providing a roundabout normally reduces accident rates still more.



4. INTERSECTIONS

POORLY DESIGNED JUNCTION

Problem: A junction is required wherever two or more roads join. So that vehicles pass through the junction in ways that are both safe and understandable by other road users, it is important that the junction is appropriate for the site and that it is clearly defined in terms of road priorities and legitimate manoeuvres.

Each junction has a shape and a type. Shape refers to how many roads join and what arrangement they join in and is generally dictated by the site itself. Common junction shapes are a T-junction, Y-junction, staggered junction and cross roads. Type refers to whether or not any of the roads are prioritised and to the degree of protection offered to vehicles which are turning at the junction. Common junction types are given in the box opposite.

Some junctions are priority junctions, whereby traffic on one road has permanent priority over traffic on the other road(s). Other junctions are non-priority, whereby priority is determined by sequence of arrival at the junction or presence on a central circulatory system rather than by the road on which a vehicle arrives.

If an inappropriate junction type is used at a particular site, significant problems can occur, including high accident rates, unnecessary delay and congestion.

Treatment types & costs

For most junction shapes, junctions can be classified into the following types:

T1: Simple priority junction \$

The roads join with slight flaring on the minor road exit, but no islands on the major road or channelising on the minor road approach.

T2: Ghost island priority junction \$

Road markings are used to provide a protected area where right turning vehicles on the major roads may wait for a gap in oncoming traffic.

T3: Single lane dualling priority junction \$\$

Similar to ghost islands except that the islands are kerbed rather than marked on the road.

T4: Roundabout \$\$\$

All roads have equal priority and flow circulates around a central island.

Crash types

- Side impact
- Rear shunt

Affected users

- All road users

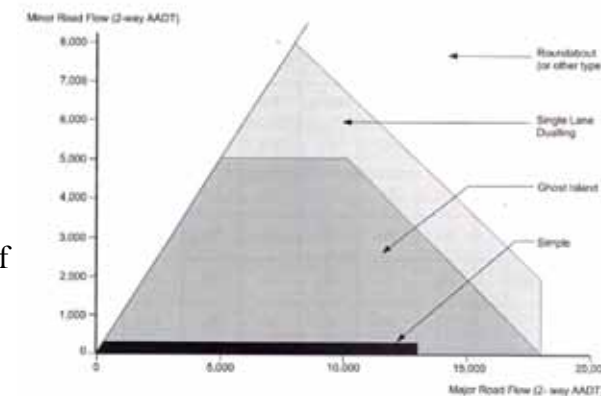
Treatments & Their benefits

The appropriate shape and type for a junction depends upon a number of factors, including the size and capacity of the roads, relative traffic volumes on each road and the layout of the site.

This table assesses the suitability of different priority junction types for particular carriageway types, locations and junction shapes. A 'Yes' indicates that the priority junction type is suitable.

Carriageway Type		Junction Type								
		Single			Ghost Island			Dualling		
Standard	Location	T	Y	C	T	Y	C	T	Y	C
S2	Urban	Yes	Yes	Maybe	Yes	Yes	No	Yes (D1)	Yes (D1)	No
	Rural	Yes	Yes	Maybe	Yes	Yes	No	Yes (D1)	Yes (D1)	No
WS2	Urban	No	No	No	Yes	Yes	No	Yes (D1)	Yes (D1)	No
	Rural	No	No	No	Yes	Yes	No	Yes (D1)	Yes (D1)	No
D2	Urban	No	No	No	No	No	No	Yes (D2)	Yes (D2)	No
	Rural	No	No	No	No	No	No	Yes (D2)	Yes (D2)	No
D3		No	No	No	No	No	No	No	No	No

T T-junction Y Y-junction C Crossroads



This graph guides the junction type at a T-junction, according to the traffic level on each of the two roads.



Ghost island cross roads



Roundabout with dualling

4. INTERSECTIONS

ACCELERATION AND DECELERATION LANES

The above example shows insufficient acceleration length for traffic driving on the RHS of the road.



Problem: Often there is insufficient length provided for either acceleration or deceleration lanes to allow traffic to merge or diverge safely. In addition sometimes an inappropriate speed is chosen by the merging or diverging traffic. This can cause collision as traffic either collides with the merging or slowing traffic or in the act of trying to avoid it collides with other road users.

Treatment Types & Costs

T1: Nearside diverging tapers allow traffic turning from the major road to slow down and leave without impeding the following through traffic. \$\$

T2: Provision of a nearside auxiliary lane could be considered for high speed traffic which would allow turning traffic to move off the mainline prior to any deceleration. \$\$

T3: Nearside Merging taper: Merging tapers permit traffic to accelerate fully before joining the faster traffic streams on the mainline where the joining traffic may otherwise impede flow and be a source of hazard \$\$

Crash types

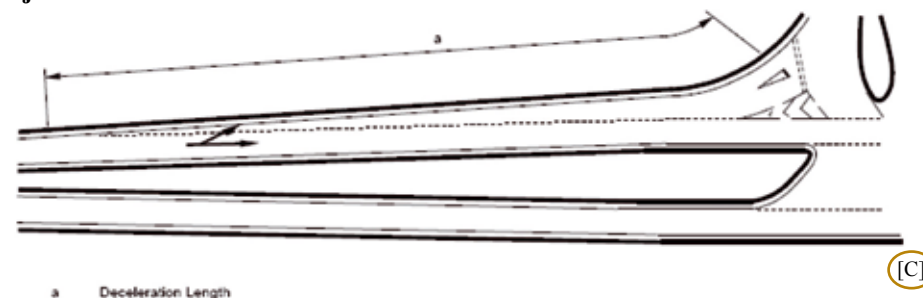
- Side impact
- Rear shunt

Affected users

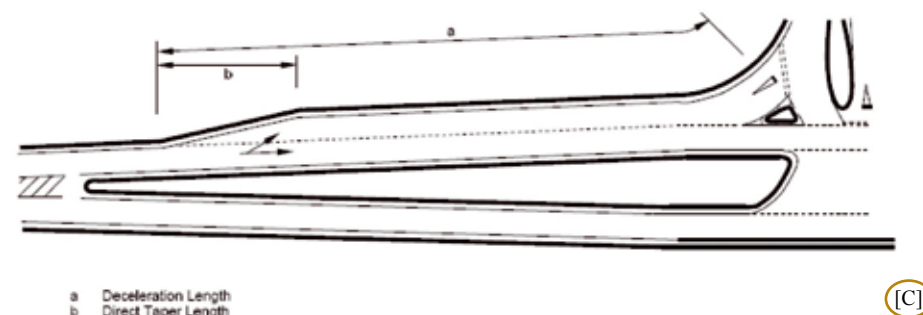
- All road users

Treatments & Their Benefits

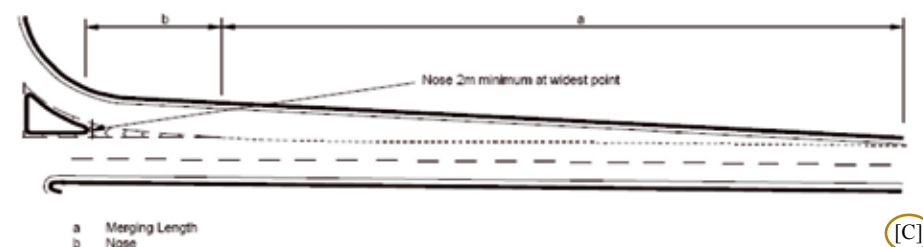
T1: Nearside diverging taper to allow traffic to slow down and leave the major road



T2: Nearside auxiliary lane to allow traffic to move off the mainline traffic prior to any deceleration



T3: Nearside merging taper to allow traffic to accelerate fully before joining the mainline traffic



The above examples are for traffic driving on the Left Hand Side of the road. For advice on desirable acceleration and deceleration lengths as well as taper and nose lengths, see TD 42/95 contained in the UK's Design Manual for Road and Bridges Volume 6, section 2.



4. INTERSECTIONS

DANGEROUS TURNING MANOEUVRES

Problem: Turning manoeuvres at intersections have always been a problem. Conflicts often tend to occur when inappropriate decisions are made concerning the available gaps in the traffic streams, direction of manoeuvre and assessment of speed of approaching traffic.

Treatment Types & Costs

T1: Turning pocket.	\$
T2: Traffic signal control.	\$\$
T3: Staggered intersection. This has been shown to reduce accidents by some 60%.	\$\$\$
T4: Roundabout. This has been shown to reduce accidents by 30% or more.	\$\$\$

Crash types

- Side collisions
- Rear shunt collisions
- Head-on collisions

Affected users

- All road users

Treatments

T1: The provision of a turning pocket.



T2: Traffic signals to control vehicular movements on the offside turn



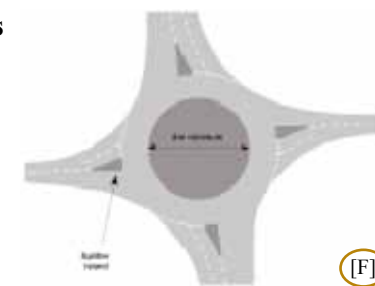
T3: Staggered intersection to spread out the conflict area due to turns



(C)

Note: this arrangement is for driving on the left hand side of the road.

T4: Roundabout provision to reduce conflicts due to offside turns



(F)

Note: this arrangement is for driving on the left hand side of the road.



4. INTERSECTIONS

DANGEROUS TURNING MANOEUVRES

Problem: Turning manoeuvres at intersections have always been a problem. Conflicts often tend to occur when inappropriate decisions are made concerning the available gaps in the traffic streams, direction of manoeuvre and assessment of speed of approaching traffic.

Treatment Types & Costs

T5: Channelisation islands on the minor road approaches at rural cross roads. \$

T6: Ghost Island Intersection.
An area is marked on the carriageway, shaped and located so as to direct traffic movement \$

T7: Traffic signal control. \$\$

T8: Roundabout. \$\$\$

Crash types

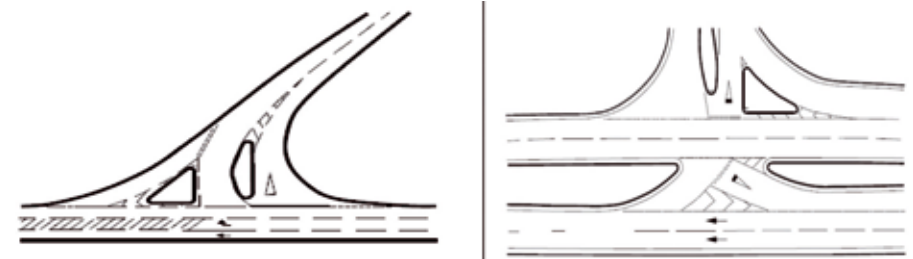
- Side collisions
- Rear shunt collisions
- Head-on collisions

Affected users

- All road users

Treatments & Their Benefits

T5: Channelisation islands on the minor road approach and within the intersection



T6: Ghost island intersection.

An area is marked on the carriageway, shaped and located so as to direct traffic movement.

T7: Traffic signals overhang at an intersection to control vehicular movements



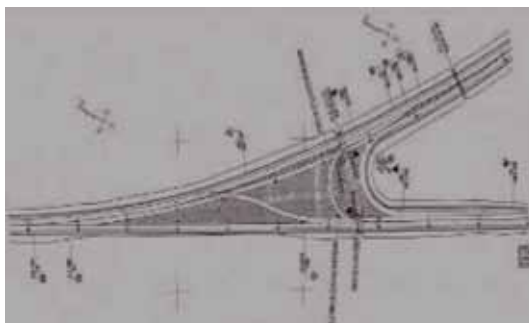
T8: Roundabout provision at an intersection to cater for the conflicting movements





4. INTERSECTIONS

Y-TYPE INTERSECTIONS



Problem: Intersections of the Y-Type don't give a clear explanation on the right of way, have dangerous conflict points and give poor safety conditions for pedestrians and other vulnerable users.



Treatment Types & Costs

T1: A perpendicular junction (T-Type) Relatively cheap and safe solution. It has a reasonable expectation of accident savings. Signalization may be necessary. **\$\$**

T2: Round about Relatively cheap and safe solution savings if traffic volume is lower than 15,000 vehicles per day. **\$\$**

T3: General solutions General recommendations of the PIARC Road Safety manual. For example, junction realignment. **\$\$\$**

Crash types

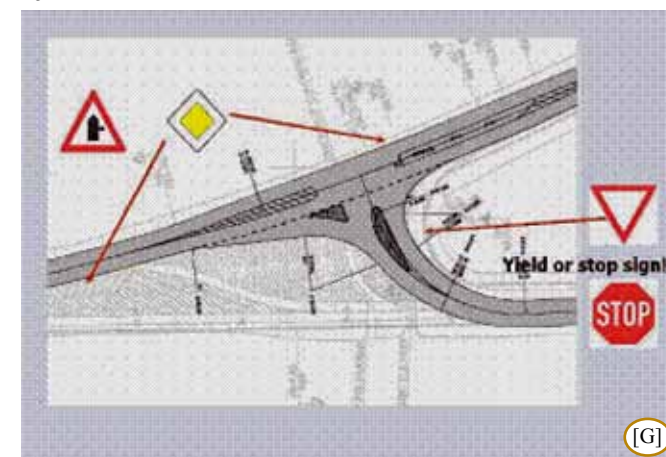
- Mainly severe accidents with pedestrians and cyclists
- Side collisions
- Head-on collisions

Affected users

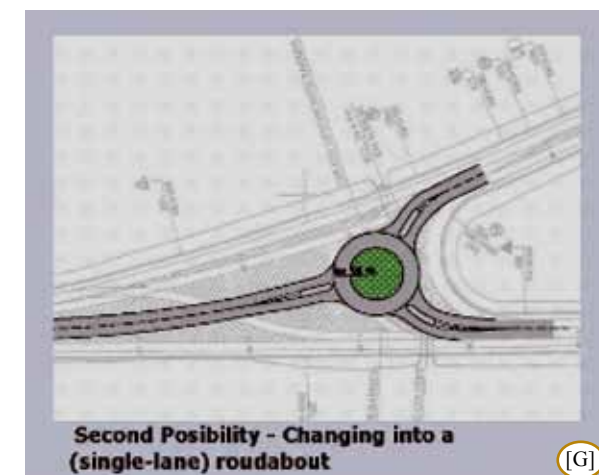
- All road users

Treatments & Their Benefits

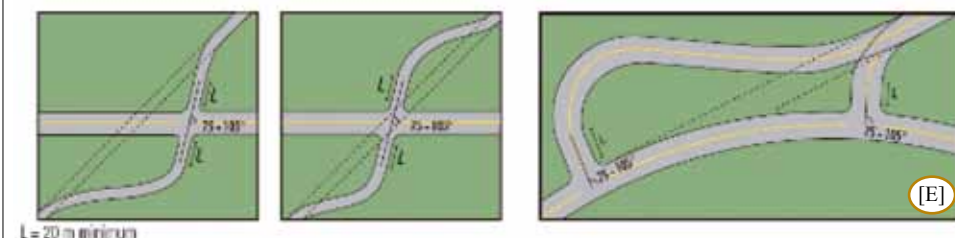
T1: Redesign to a perpendicular junction (T-Type) with signalization, if necessary.



T2: Redesign to a roundabout if necessary with pedestrian crossings.



T3: General solutions



4. INTERSECTIONS

VISIBILITY AT CROSSROADS

Problem: Crossroads with visibility straight through the intersection encourage high speeds through the intersection.

Visibility to the right/left of the intersection is obstructed within the vicinity of the intersection hence a driver on the main road would not easily recognise the presence of a crossroad or intersection until it is probably too late.



Treatment Types & Costs

T1: Advance warning signs

\$

These warn the drivers of the presence of the intersection and advise on appropriate speed on approach. Warning signs have shown to have up to a 45% reduction in accidents.

T2: Vertical deflections

\$\$

Speed humps or other suitable vertical deflections could be introduced on the approach. This solution is only appropriate in urban areas where vehicle speeds are low.

T3: Offset Intersections

\$\$\$

Offset the approach legs of the crossroad so as to deflect the path of the vehicles.

Crash types

- Mainly severe accidents with pedestrians and cyclists
- Front-nearside collisions
- Front-offside collisions
- Rear shunts

Affected users

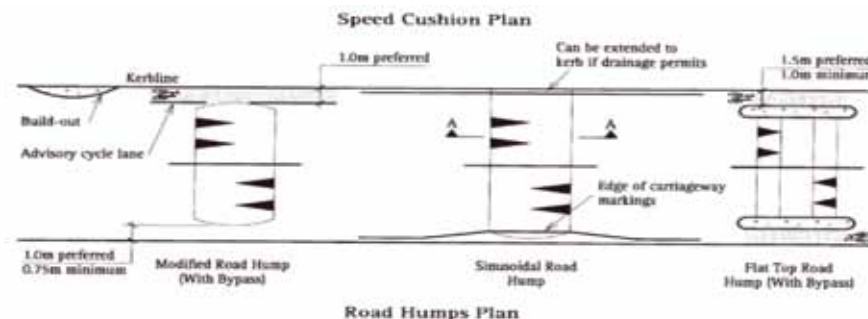
- All road users

Treatments & Their Benefits

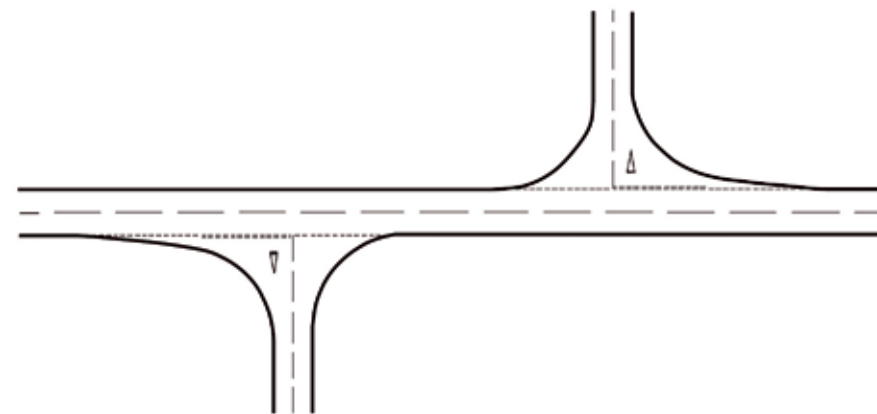
T1: Warning signs should illustrate and depict the general configuration of the intersection



T2: Vertical deflections such as road humps can reduce speeds on approaches significantly



T3: Offset the approach legs to have a positive effect on traffic speeds at the intersection



Note: this arrangement is for driving on the left hand side of the road

[C]



5. PUBLIC AND PRIVATE SERVICES

DRIVER FATIGUE – FUNDAMENTALS

Rest places and petrol stations are necessary to serve the long distance traffic between towns and regions. Drivers need to rest at least once every one or two hours in order to maintain their concentration when driving. It is useful to combine rest areas with petrol and/or service stations.

Entrances and exits to and from Service and Rest areas can cause a disturbance for traffic on the main carriageway. It is important that sufficient rest areas are provided but not too many to avoid constant disruption to the mean flow of traffic by constantly exiting and joining traffic.

Planning principles for Service and Rest Areas:

- **Distances between areas**

To provide possible rest areas every half hour, a distance of not more than 30km between the rest places is recommended. The number of petrol stations depends on a number of factors including the type of vehicles using the road. In interurban areas, a distance of about 50 km is appropriate. It is also important to have rest places and petrol stations on both sides of the road to avoid the dangerous crossing manoeuvres.

- **Entry / Exit**

The entry to and exit from service and rest areas should be located either at a safe distance away from other junctions or integrated in the junction to minimize the points of conflict. The entrance to and exit from rest areas needs a special lane for slowing down and accelerating respectively.

- **Design**

The near side rest place and station should come before the one on the off side. Sufficient visibility, small gradients (< 4%) and enough parking are factors to be considered.

The rest places should be provided with toilets and if possible also tables and benches. Shade from trees or other shelter is important to attract drivers.

It is important to erect signs in advance of a rest place, to inform the road users and thereby avoid emergency manoeuvres.

Special attention should be taken to the needs and presence of children. The areas themselves should be located some distance from the main carriageway and should be separated moving traffic.

- **Security**

Full visibility from the road to the whole parking area gives more security against robbery and attacks. Lighting and alarm buttons will also aid security. Video surveillance can also be used.



5. PUBLIC AND PRIVATE SERVICES

Problem: Even the most skilful driver becomes a highway hazard if tired and they should therefore be encouraged to stop and take a break from driving. They must find an inviting rest area to stop and rest.

Note, however, that these should ideally be located on the nearside of the road, to avoid vehicles exiting and joining from the fast lanes.

Treatment Types & Costs

T1: Adequate design Public rest areas must be inviting and landscape to take advantage of existing natural features and vegetation. To encourage their use, public rest areas should at least provide toilet facilities. Paths, sidewalks, parking, exit and entrances ramp should be included in the design in accordance with road safety standards.

\$\$

T2: Additional services In addition, public rest areas may provide tourist and public information services and many others facilities such as picnic areas, playground equipment etc.

\$\$\$

Crash Types

- Fatigue related - eg running off the road accidents

Affected Users

- All road users.

Treatments & Their Benefits

T1: Adequate design

Aesthetic aspect of the building is important to encourage the use of rest area. Exterior lighting, and particularly for parking area and pathway, contributes to the safety of the rest area users.



T2: Additional services

Rest areas can provide drivers with pedestrian features, including playground equipments, exercise stations or walking trails.





5. PUBLIC AND PRIVATE SERVICES

DRIVING IN THE WRONG DIRECTION

Problem: After having a break or while looking for a parking place some drivers lose their orientation and use the entry to get back on the motorway. Driving in the wrong direction can cause a fatal accident.

Treatment Types & Costs

T1: Warning signs Installation of two warning signs at the entry to the rest area.	\$
T2: New markings and signs.	\$\$
T3: Reconstruction of the area	\$\$\$

Crash Types

- Head on

Affected Users

- All road users.

Treatments & Their Benefits

T1: Warning signs

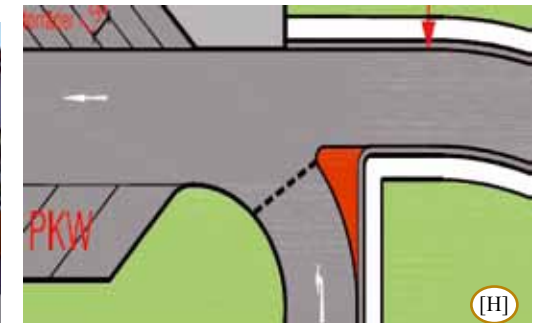
This low cost solution rapidly draws drivers' attention to the danger area ahead.



Abbildung 1: Geisterfahrerwarntafel
Regelformat 150 x 200 cm

T2: New markings and signs

These give more information to the driver for going in the right direction. For example, the red marked area guides the vehicles in the right direction. This is reinforced by the use of signing.



T3: Reconstruction of the area

Building a new state of the art rest area reduces the probability of driving in the wrong direction.





5. PUBLIC AND PRIVATE SERVICES

ENTRY/EXIT WITH HIGH LONGITUDINAL GRADIENT

Problem: A gradient of more than 4° causes problems when leaving or joining the main carriageway. In particular, it takes a long distance for heavy trucks with less engine power to get up to speed.

Treatment Types & Costs

T1: Close the area for heavy vehicles by using signing.	\$
T2: Introduce a reduced speed limit in the vicinity of the rest area	\$
T3: Build new acceleration lanes	\$\$
T4: Reconstruct area in a different location	\$\$\$

Crash Types

- Side impact
- Rear impact

Affected Users

- All road users.

Treatments & Their Benefits

T1: Close the area for heavy vehicles by using signing

The treatment is a very low cost solution. However, this depends on there being enough areas for heavy vehicles within an appropriate distance.

T2: Introduce a reduced speed limit in the vicinity of the rest area

This is another low cost solution. The reduced speed limit, which is legally enforced, is introduced on the road in the vicinity of the rest area.

T3: Build new acceleration lanes

New ramps and long acceleration strips are built to give vehicles the opportunity for speeding up to match the speed of the traffic on the main road.

T4: Reconstruct area in a different location

Close and rebuild a new area where the gradient of the road is less than 4°.





5. PUBLIC AND PRIVATE SERVICES

PEDESTRIANS ARE NOT PROTECTED

Problem: Pedestrians within the rest areas are not protected from the traffic. This can be caused by:

- the wrong location of the parking areas in relation to facilities such as toilets and shops, and
- the incorrectly placed or omission of pedestrian walkways in the trafficked areas.

Treatment Types & Costs

T1: Introduce a speed limit	\$
T2: Redesign and/or remark pedestrian walkways	\$\$
T3: Improve lighting in the vicinity of walk-ways	\$\$
T4: Redesign of the rest area to change the location of the facilities	\$\$\$

Crash Types

- Collisions between vehicles and pedestrians

Affected Users

- Pedestrians.

Treatments & Their Benefits

T1: Introduce a speed limit

Introduce and sign a speed limit of less than, for example, 30 km/h on the whole of the rest area. The lower speed should reduce the likelihood of accidents.

T2: Redesign and/or remark pedestrian walkways



T3: Improve lighting in the vicinity of walk-ways, to increase the visibility of pedestrians.

T4: Redesign of the rest area to change the location of the facilities

If the location of the facilities is reorganised the crossing points between the parking area and the service area can be reduced.





5. PUBLIC AND PRIVATE SERVICES

PARKING FACILITIES



Problems: : Parking takes place in unsafe areas because there are not sufficient parking spaces to match demand. Accessible parking spaces for recreational vehicles (RV), trucks and buses are not considered

Treatment Types & Costs

T1: Increase number of parking spaces

spaces The number of parking spaces is increased to avoid the risk of parking in unsafe areas. Because of the one-way operation of most service and rest areas, angle parking is recommended. Accessible parking spaces must be planned for cars.

\$

T2: Provide separate parking spaces for recreational vehicles, trucks and buses The parking spaces should be designed taking account of the expected usage of the service and rest area by different types of vehicles.

\$\$

Crash Types

- Head on and rear end accidents
- Accidents involving pedestrians

Affected Users

- All users of the rest area.

Treatments & Their Benefits

T1: Increase number of parking spaces

Passenger vehicles are parked in a separate area with appropriately sized bays.



T2: Provide separate parking spaces for recreational vehicles, trucks and buses

For safety, the aim should be to separate the parking spaces for larger vehicles and passenger vehicles. Recreational vehicles, trucks and buses are directed to park in an area with longer bays.





5. PUBLIC AND PRIVATE SERVICES

REST AREA SIGNING

Problem: Drivers must know where rest areas are located so that they can plan where to stop. The location of rest areas must be well signposted well in advance.

Treatment Types & Costs

- | | |
|---|--------|
| T1: Signs Install signs notifying of rest areas to provide drivers with information on rest areas and the distance to go before arrival. | \$ |
| T2: Rest areas network Adopt uniform spacing standards e.g. every 100 kilometres. This provides consistency in distance between rest areas. | \$\$\$ |

Crash Types

- Fatigue related accidents- eg running off the road accidents

Affected Users

- All users of the rest area.

Treatments & Their Benefits

T1: Signs

Rest areas signs indicate the availability of a roadside area where drivers may rest. The services provided on the site should be shown on the signs with appropriate pictograms.

A sign indicating the distances to the two next rest areas should be placed 2 km from the rest area's access ramp.



T2: Rest areas network

The road administration should have a rest area implementation policy and develop a rest area network. In adopting uniform spacing standards between rest areas, drivers can be sure they will find services and stop location at a regular spacing distance.





5. PUBLIC AND PRIVATE SERVICES

PUBLIC TRANSPORT STOPS (1)

Problem: For many people, public transport is their only option for getting to and from work, to shop or to visit friends. Buses and trams form major elements of the public transport system and, generally, use the road network. They need to offer frequent services along major connector roads with reasonably regular stops. At those stops, conflict can exist between the bus or tram, other vehicles and vulnerable road users such as pedestrians and cyclists.



Treatment types & costs

T1 Signage	\$
T2 Improved stops	\$

Crash Types

- Rear shunt
- Side impact

Affected Users

- All users of the rest area.

Treatments & Their Benefits

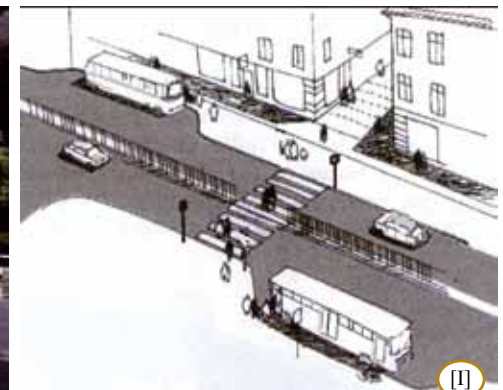
T1 Signage

This includes advance warning signs, clearer signs at the stop and attachments to the bus or tram. An example is shown opposite of a STOP sign that emerges when the doors are opened on a tram. The example below shows signage at a tram stop indicating priority for pedestrians – note there is also traffic calming at this stop.



T2 Improved stops

In some countries efforts have been made to ensure the stop is well defined, well lit and obvious to the motorist. In some countries bus bays are indented to get the bus out of the main traffic stream. Pedestrian crossings can also be added to provide further safety for people using public transport.





5. PUBLIC AND PRIVATE SERVICES

PUBLIC TRANSPORT STOPS (2)

Problem: For many people, public transport is their only option for getting to and from work, to shop or to visit friends. Buses and trams form major elements of the public transport system and, generally, use the road network. They need to offer frequent services along major connector roads with reasonably regular stops. At those stops, conflict can exist between the bus or tram, other vehicles and vulnerable road users such as pedestrians and cyclists.



Treatment types & costs

T3 Traffic calming	\$\$
T4 Separation	\$\$\$

Crash Types

- Rear shunt
- Side impact

Affected Users

- All users of the rest area.

Treatments & Their Benefits

T3 Traffic calming

A variety of techniques are used to slow traffic down around trams or other forms of public transport. This could include lower speed limits, speed humps leading up to or alongside the stop or building a tram stop so that if the bus or tram is stopped to pick up passengers, all traffic is stopped.



T4 Separation

While costly, it is possible to separate public transport corridors from the main traffic. While this is general with heavy rail, it is not common with trams and buses.





6. VULNERABLE ROAD USERS

CLOSE CONTACT WITH VULNERABLE ROAD USERS

Problem: Vulnerable road users – pedestrians, cyclists, draught animals and motorcyclists often come into close contact with faster moving, heavier motorised vehicles. This places the vulnerable road users in danger.



Treatment types & costs

T1 Edge markings	\$
T5 Proper crossing facilities	\$
T3 Relocated bus stop	\$
T2 Kerbs and barriers	\$\$
T4 Traffic calming	\$\$
T6 Wider shoulder	\$\$
T7 Wider traffic lane	\$\$
T8 Segregated footpath	\$\$
T9 Segregated cycle lane	\$\$

Crash Types

- Motorised vehicle with vulnerable road user

Affected Users

- All road users

Design/Treatments & Their Benefits

All solutions entail protecting the vulnerable road users from the motorised traffic.

T1: Edge markings

Pedestrians on a busy footpath often spill onto the road while traffic often uses a shoulder if the road is congested. Marking the edge with a line or a low kerb reduces this misuse.

T2: Proper crossing facilities

Pedestrians often come into contact with motorised traffic when crossing a road. High standard crossings should be constructed and properly maintained.

T3: Relocated bus stop

Passengers boarding a bus parked at the road side and those serving food to those inside often queue onto the live traffic lane. Relocating bus stops away from the road and constructing a permanent barrier will help prevent people from being hit by passing vehicles.

T4: Kerbs and barriers

A high kerb or barrier will mark the edge of the road and will physically prevent a vehicle leaving the carriageway. If large vehicles use the road, barriers should be used because large vehicles may ride over high kerbs. Kerbs should have gaps to allow water to enter the drain.

T5: Traffic calming (see also section Function - Traffic Calming section 1.04)

The drivers of slower moving traffic have more time to see vulnerable road users and take evasive action and the effect of an impact will be less severe. A variety of traffic calming measures in areas where vulnerable roads users are present can be installed.

T6: Wider shoulder

A wider shoulder allows pedestrians to walk further away from traffic. In most cases, a 1.5 metre shoulder provides sufficient protection. If it is much greater than this, vehicles may use the space for travelling and thereby endanger themselves and pedestrians.

T7: Wider traffic lane

A wider lane allows faster moving traffic to more safely overtake slow moving non-motorised vehicles such as draught animals and bicycles.

T8: Segregated footpath

A segregated footpath is a very effective way of protecting pedestrians from motorised traffic, although it must be wide enough for the likely demand. Footpaths can be located on the side of an embankment, in wide side drains during the dry season or along diversion roads opened up during road construction.

T9: Segregated cycle lane

A segregated cycle lane is similarly effective at protecting cyclists from motorised traffic.



6. VULNERABLE ROAD USERS

PROTECTION OF PEDESTRIANS AT INTERSECTIONS



Problem: Pedestrian conflicts with motorised traffic at intersections often result in fatalities. Provision for pedestrians at intersections should be given sufficient attention to ensure their safety without significantly affecting the journey time of the motorised traffic.



Treatment types & costs

T1: The installation of pedestrian guard rails, central refugees and pedestrian.	\$
T2: A minor road central refuge at an unmarked crossing place.	\$
T3: Zebra crossing, with or without a central refuge	\$
T4: Traffic signals to control the movements at the intersection	\$\$

Crash Types

- Pedestrian-motor vehicle collisions
- Pedestrian-cyclist collisions

Affected Users

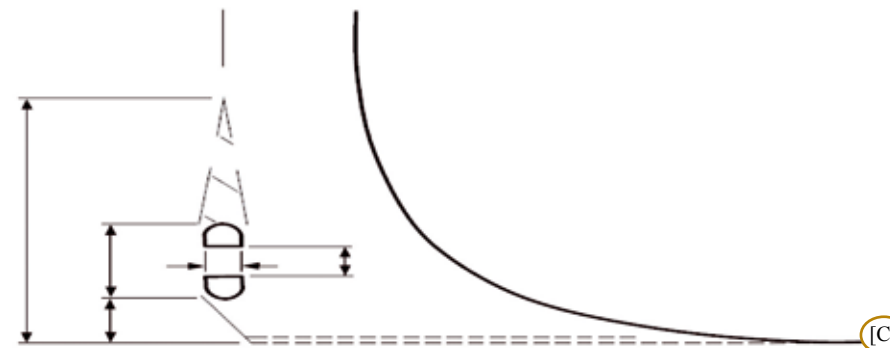
- All users of the rest area.

Treatments & Their Benefits

T1: Pedestrian guard rails, central refugees and crossings to guide pedestrians and encourage them to cross the street in 2 steps.



T2: Minor road central refuge at an unmarked crossing place



T3: Zebra crossing



T4: Traffic signals that cater for pedestrians





6. VULNERABLE ROAD USERS

PROTECTION OF CYCLISTS AT INTERSECTIONS

Problem: Cyclists are often given little consideration at intersections in regard to their vehicular rights and particular vulnerability. This scenario exposes them to motorised traffic that is often travelling at relatively higher speeds. A high percentage of cyclist accidents occur at major/minor priority intersections.



Treatment types & costs

- | | |
|---|------|
| T1: A sign-posted alternative cycle route away from the junction. | \$ |
| T2: Modify layout of the intersection to cater for the cyclists. | \$ |
| T3: Signalising the whole intersection
Should be used if the volume of cyclists is significant, but not high enough to justify economically a grade separated crossing | \$\$ |
| T4: Increase vehicle deflection on entry to roundabouts to a reduce approach speeds | \$\$ |

Crash Types

- Cyclist-motor vehicle collisions
- Cyclist-pedestrian collisions

Affected Users

- All users of the rest area.

Treatments & Their Benefits

T1: Alternative provision for the cyclists through separation from motorised traffic



T2: Modify the layout of the intersection to cater for the cyclists



T3: Signalise the whole intersection



T4: Increase vehicle deflection on entry to roundabouts to a reduce approach speeds





6. VULNERABLE ROAD USERS

PEDESTRIANS & CYCLISTS

Problem: A middle barrier is needed to avoid head on collisions. But the needs of pedestrians and cyclists have to be respected in a safe way. The treatment on the right traps the vulnerable road users in an unsafe location. There is no space between the overtaking lanes for waiting pedestrians and cyclists.



Treatment types & costs

T1: Middle island by (a) reducing the lane width & (b) protection by a crash barrier \$

Low cost treatment with expectation of high accident savings

T2: Interruption of the crash barrier and marking of the pedestrian crossing \$

Low cost treatment but still with expectation of serious accidents

T3: Speed reduction and rumble strips \$

Low cost treatment but still with expectation of serious accidents

T4: Traffic signals for pedestrians \$\$

In combination with T3 a) and b)
Medium cost solution with excellent potential for accident savings.

Crash Types

Heavy accidents of pedestrians with fast vehicles.

T1: concentration of heavy accidents of cyclists and pedestrians with fast going vehicles. In addition heavy accidents of vehicles at the concrete barrier where it is interrupted.

T2: Same as T1 with little improvement

Affected Users

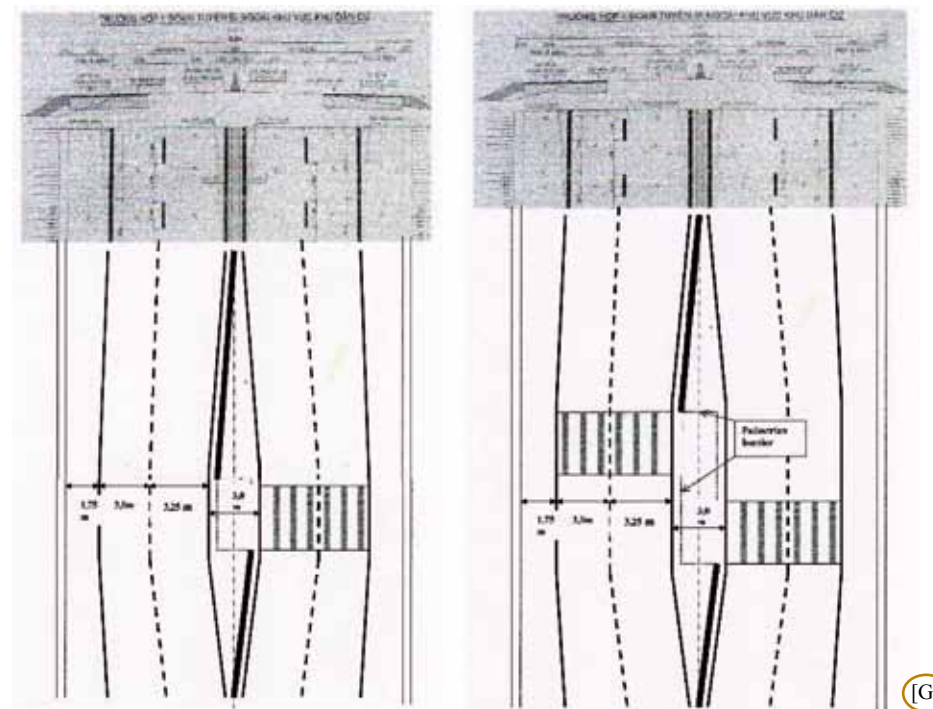
Pedestrians and cyclists.
All road users.

Treatments & Their Benefits

T1: Middle island

Like T2 below, but with narrowing the lane width for geometric speed reduction and creation of a refuge island in the middle. The crash barrier following the lane shifting protects waiting pedestrians and is no longer a road side obstacle for vehicles.

- a) Pedestrian crossing on one line. b) Pedestrian crossing is staggered to avoid U-turns of vehicles and to force pedestrian to look against the oncoming traffic



T2: Interruption of the crash barrier and marking of the pedestrian crossing
T3: Speed limit of 50 km/h, warning signs and rumble strips ahead of the pedestrian crossing.

The benefit is that this is a low cost solution that rapidly draws drivers' attention to the danger area ahead. However, the lack of refuge space on the medium makes this solution still dangerous.

T4: T1 a) and b) plus signalization for pedestrians and cyclists



6. VULNERABLE ROAD USERS

KERB RAMPS

Problem: Gaps between the sidewalk and the street make walking difficult and dangerous. Poor ramp design can make a street crossing more difficult and may lead to crashes.



Treatment types & costs

T1: Use Kerb ramp at intersection \$

This makes pedestrians crossing easier. Kerb ramps provide transition in elevation between the sidewalk and roadway for all pedestrians. Kerb ramps also address the needs of people with mobility impairments.

T2: Add tactile strips across the width of the sidewalk leading to the crosswalk \$\$

This device helps visually impaired to have adequate cues to identify the roadway's location. Colour contrasts will aid those who are partially sighted.

Crash Types

- Mainly accidents with pedestrians and motorists

Affected Users

- All users but especially pedestrians

Treatments & Their Benefits

T1: Kerb ramp

Adequate ramp design ensures that all users cross in crosswalks at the intersection. Ramp must be wholly contained within the marked crosswalk area.



T2: Add tactile strips

Intersection and pedestrian crosswalk should be identifiable to pedestrians with vision impairments. The use of tactile strips across the width of the sidewalk leading to the crosswalk should be considered. In this way, pedestrians are alerted to the presence of the crossing.





6. VULNERABLE ROAD USERS

REFUGE ISLANDS

Problem: Wide streets without any refuge island or median to break up crosswalks on a multilane road can be hazardous for pedestrians, especially for people who walk slower than 1 - 2 m/sec such as elderly pedestrians, children or mobility impaired persons.



Treatment types & costs

Medians and refuge islands break up crosswalks into shorter and easier portions for pedestrians to cross. They are a good practice in urban areas to reduce pedestrian exposure to traffic. Medians and refuge islands may be considered where the pedestrian crossing distance is more than 20 m long. They also can be used where there is a need to have shorter crossing distances.

T1: Medians painted on the road \$
surface. Marking can be used to create a zone for pedestrians but it offers a refuge which is not raised above the carriageway level. However, there is no protection given to the waiting pedestrians and two wheelers.

T2: Raised medians and refuges islands. \$\$
Raised medians and refuge islands should be considered for intersections and midblock crossings with four or more lanes or high volumes of vehicle traffic and also where speeds create unsafe conditions for pedestrians.

Crash Types

- Mainly severe accidents with pedestrians and motorists
- Side collisions

Affected Users

- All road users but especially pedestrians

Treatments & Their Benefits

Short crosswalks help pedestrians to cross streets more safely with less exposure to vehicle traffic. In this case, medians allow crossing to be accomplished in two stages enabling pedestrians to concentrate on crossing one direction of the roadway at a time.

Many factors must be evaluated before installing midblock crosswalks and refuges islands: proximity to other crossing points, sight distances, vehicle speed, illumination, traffic volume and pedestrian volume.

Refuge islands should be at least 2 m wide. Refuge islands provide pedestrians a refuge area to stop partially through their crossing, within intersection and midblock crossing.

T1: Medians painted on the road surface

Medians that are only painted (not raised) do not provide the same benefits as raised ones.

T2: Raised medians and refuges islands

Raised medians provide space for landscaping that can help to modify the character of a road and reduce vehicle speed. However, landscaping should not block sight distance between motorists and pedestrians.

The use of contrasting material and bollards to delineate the pedestrian walkways help to make them more visible.





6. VULNERABLE ROAD USERS

CONFLICT AT URBAN INTERSECTIONS



Problem: In urban areas, on a road with large motor vehicle traffic volumes and high number of vulnerable road users, the categories of road users should be separated from each other. The potential for conflict between non-motorized and motorized vehicles is greatest at intersections where segregation of traffic is not possible.

Treatment types & costs

T1: Marking and signing

\$

Intersections should be appropriately marked and signed to provide a clear message to motorized vehicle drivers and non-motorized road users.

T2: Physical segregation

\$\$

The separation of the vulnerable road users (pedestrians and cyclists), from the motorized traffic is a very good solution along urban main roads.

Crash Types

- Mainly severe accidents involving pedestrians and vehicles.
- Side collisions

Affected Users

- All road users, but especially pedestrians

Treatments & Their Benefits

T1: Marking and signing

Banning of all opposing traffic movements helps to reduce the number of potential conflicts.

At traffic controlled junctions, cycle traffic signals can be used.



T2: Physical segregation

The lane for vulnerable road users should be well apart from the main carriageway in order to reduce risk. To ensure that this lane will be used by vulnerable road users, it must follow the main road and not make any detours, otherwise the vulnerable road user will use the carriageway.





6. VULNERABLE ROAD USERS

CONFLICT IN RURAL AREAS

Problem: In rural areas, on a road with heavy motor vehicle traffic volumes and mixed users, the categories of road users should be separate from each other.



Treatment types & costs

T1: Visual segregation

\$

Visual segregation of non-motorized and motorized vehicle is provided by line markings on the carriageway.

T2: Physical or total segregation

\$\$

Physical segregation of non-motorized and motorized vehicles using a barrier or raised track is intended to increase the safety of road vulnerable users (pedestrians and cyclists).

Crash Types

- Mainly severe accidents involving non-motorized vehicle and motorized vehicles
- Side collisions
- Head-on collision

Affected Users

- All road users but especially non-motorized users

Treatments & Their Benefits

T1: Visual segregation

Marking can be enhanced by providing wide marking, double-line marking or even hatched areas to denote the separation.

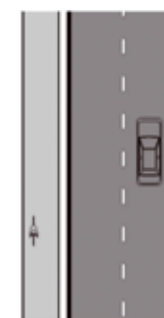


T2: Physical or total segregation

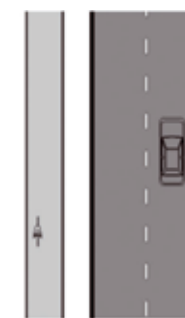
Physical or total segregation are recommended along roads with high vehicle speeds and/or high vehicle flows.



Pedestrian-bicycle path separated by kerbstone



Pedestrian-bicycle path separated by narrow strip



Fully separated path for bicyclists and pedestrians



Pedestrian-bicycle path independent of road is often easier to realize (flexible geometry)

[J]



6. VULNERABLE ROAD USERS

OBSTRUCTIONS FOR PEDESTRIANS

Problem: Equipment, such as electrical poles, sign poles, boxes, etc. on footway present dangerous obstacles for pedestrians particularly those with a visual impairment.



Treatment types & costs

T1: Give a clear path to pedestrians \$\$

Utilities should not interfere with pedestrian circulation. The pedestrian throughway zone should be entirely clear of obstacles and should provide a smooth walking surface.

Crash Types

- Accidents involving pedestrians

Affected Users

- All pedestrians but especially those with a visual impairment

Treatments & Their Benefits

T1: Give a clear path to pedestrians

The walking zone must remain clear, both horizontally and vertically for the movement of pedestrians. Remove or relocate signs, utility poles and other fixed objects to improve safety (and aesthetics).

Pedestrians should have a clear path though the walkway.





6. VULNERABLE ROAD USERS

PARKING NEAR INTERSECTIONS

Problem: Vehicles parked at corners present a threat to pedestrians' safety.

When parking is allowed close to the pedestrian crosswalk this reduces significantly the visibility of pedestrians and drivers.



Treatment types & costs

T1: Pavement Markings

\$

T2: Install Kerb extensions

\$\$

Place kerb extensions at intersection to prevent motorists from parking in or too close to a crosswalk. See and be seen is fundamental for the safety of pedestrians. By extending the line of the kerb into the travelled way, kerb extensions improve driver and pedestrian sight distance and visibility at intersections.

Crash Types

- Mainly severe accidents involving pedestrians and vehicles
- Side collisions

Affected Users

- All road users, but especially pedestrians

Treatments & Their Benefits

T1: Pavement Markings

Increase the distance between the parking space and pedestrian crosswalk by using marking and suitable parking restrictions.

T2: Install kerb extensions

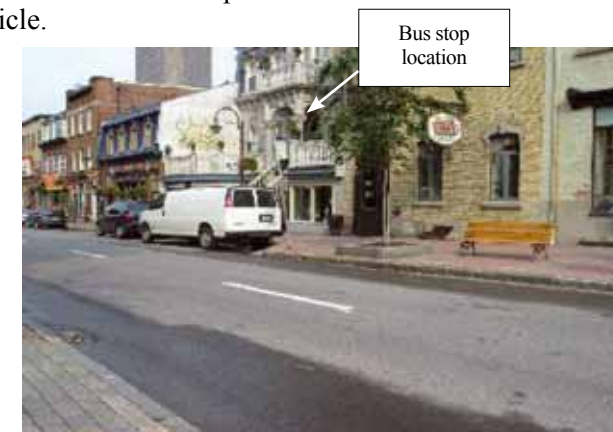
Kerb extensions encourage and facilitate pedestrian crossing at preferred locations. They help to reduce conflict between vehicles and pedestrians.



Kerb extensions extend the line of the curb which reduces the effective street width. They improve pedestrian crossing by:

- reducing the pedestrian crossing distance,
- increasing pedestrian and driver visibility at intersection, and
- reducing the crossing distance and time that pedestrians are on the street and exposed to the traffic vehicle.

Kerb extensions are only appropriate where there is on-street parking. Ensure that curb extensions do not extend into path of traffic or a cycle lane. Curb extensions can be used to define the location of bus stop.





6. VULNERABLE ROAD USERS

PEDESTRIAN CROSSWALKS - SIGNING



Problem: Crosswalk with special pavement (e.g. coloured bricks) invites pedestrians to cross at this point but without any signs to indicate the crosswalk to the motorist. The path can't be used safely by pedestrians.

Treatment types & costs

T1: Signs and marking \$
Using appropriate signs and marking to advise motorists of the crosswalk.

T2: Traffic-calming measures \$\$
In addition to installing marked crosswalks where pedestrian crossing problems exist, there are other treatments that should be considered to provide safer crossing for pedestrians.

These are:

- Installing traffic-calming measures to slow vehicle speeds
- Installing traffic signals and pedestrians signals

Crash Types

- Mainly severe accidents involving pedestrians and vehicles
- Side collisions

Affected Users

- All road users, but especially pedestrians.

Treatments & Their Benefits

T1: Signs and marking

Midblock crossings are not expected by motorists, so they should be appropriately signed, marked and illuminated. To contribute to pedestrian safety, midblock crosswalks must be well-designed and be highly visible to motorists, cyclists and pedestrians.

Crosswalks at a midblock location must be marked either by two transverse lines, diagonal lines or longitudinal lines. Warning signs should be placed visible to both directions of traffic. A pedestrian warning with an "AHEAD" sign should be placed in advance of the crossing, and a pedestrian warning sign with a downward diagonal arrow should be placed at the crossing location.



T2: Traffic-calming measures

The term "traffic calming" is used to describe a full range of methods to slow vehicles as they move through residential or commercial neighbourhoods. For pedestrians, the benefit is that vehicles drive at speeds that are safer.

Traffic-calming devices can be grouped within the following categories:

- Vertical deflection (Raised crosswalk, speed hump, raised pavement areas, etc)
- Horizontal deflection (Curb extension, curb radius reduction, traffic circle, etc.)
- Obstruction (Street closures, traffic diversion, etc.)
- Signing (Speed sign, stop sign, visual devices, surface texture, etc)

A combination of traffic-calming measures can be used.

The picture opposite shows a crosswalk combined with a vertical deflection, a flat topped speed hump.





6. VULNERABLE ROAD USERS

PEDESTRIAN CROSSWALKS – SIGNALS

Problem: The absence of pedestrian phased signals at a large intersection does not provide sufficient information on crossing opportunity for pedestrians and does not encourage them to cross at the signalised intersection.



Treatment types & costs

A traffic survey must be conducted to determine if pedestrian signals are required at an intersection with existing traffic lights.

T1: Use a pedestrian phase at the signals with symbols \$

Two symbols should be used, for example, a pedestrian walking and an orange hand. The pedestrian signal should be accompanied by adequate marking.

T2: Use a pedestrian phase at the signals with a numerical-countdown display \$\$

Crash Types

- Mainly severe accidents between pedestrians and vehicles.
- Side collisions

Affected Users

- All road users, but especially pedestrians

Treatments & Their Benefits

T1: Use a pedestrian phase at the signals with symbols

It is possible to use a partially protected or protected phase for pedestrians. With a protected phase (all-red phase), all conflicting movements are prohibited through-out the pedestrian phase.

The crosswalk below with special pavement or marked crosswalk clearly indicates to the motorist where to expect pedestrians and help keep crossing area clear of vehicles.



T2: Use a pedestrian phase at the signals with a numerical-countdown display

The use of numerical-countdown pedestrian signals ensures that pedestrians know when the signal phasing allows them to cross and when they should not be crossing. Numbers indicating the time left to cross the highway (in seconds) and accompany the symbols of a pedestrian walking and an orange hand.





6. VULNERABLE ROAD USERS

WORK ZONES



Problem: Urban work zones on sidewalks can be an inconvenience for pedestrians. Here, the work zone is not identifiable to pedestrians with vision impairments. It is particularly dangerous for pedestrians with visual disabilities if there are no detectable devices to alert and guide them around the work zone.

Treatment types & costs

The needs of all pedestrians including the visually impaired and those with other physical disabilities must be accommodated at work zones.

T1: Adequate protective barriers \$

Protective barriers are used to prevent pedestrian access into a construction area. They need to be high enough to avoid the risk of falling over them.

T2: Longitudinal barricades \$\$

Use this device for positive guidance. This guidance will assist persons with visual impairments in a work zone.

Crash Types

- Severe accidents involving pedestrians with visual impairment

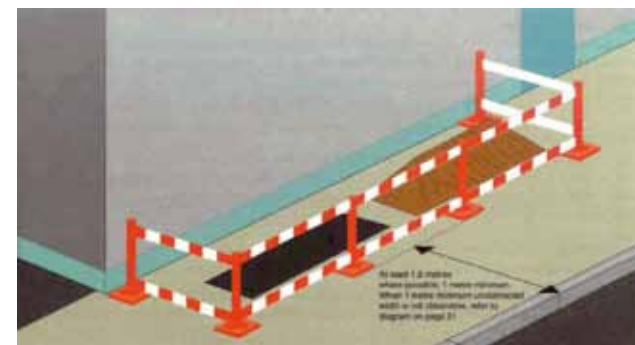
Affected Users

- All pedestrians, but especially those with visual impairment

Treatments & Their Benefits

T1: Adequate protective barriers

Protective barriers should be used so that the passage for pedestrians is well defined and pedestrians should be provided with a safe travel path. The device must be stable.



[K]

T2: Longitudinal barricades

Longitudinal barricades can also be used to prevent pedestrian access to work zones. They provide positive guidance for pedestrians, including those with visual disabilities.

An interlocking device can clearly delineate the flow of pedestrian traffic around work zones. Used instead cones, barriers, barricades, longitudinal chanelising barricades should be interlocked with no gaps to provide smooth connections for those using canes to follow the path.



If the pedestrians have to use the road an adequate protection must be installed to protect pedestrians from the vehicle flow.



7. TRAFFIC SIGNING, MARKING AND LINES

POORLY MARKED AND SIGNED JUNCTIONS



Problem: Poorly signed intersections do not clearly show which road user has the right-of-way and hence they create a potential for many conflict points to develop especially where traffic volumes are high, a situation that could lead to very severe/fatal crashes.

Treatment types & costs

T1: Road markings

\$

Cheap and effective method of reducing conflict points and assigning right-of-way. They also have an effect on reducing speeds by changing the nature and appearance of the roads. Signs may be necessary to supplement the markings.

T2: Traffic signs

\$\$

These are necessary to advise on appropriate speeds on the approaches, direction of travel and any restrictions on manoeuvres within the intersection and also impose right-of-way restrictions.

Crash Types

- Side collisions
- Head-on collisions

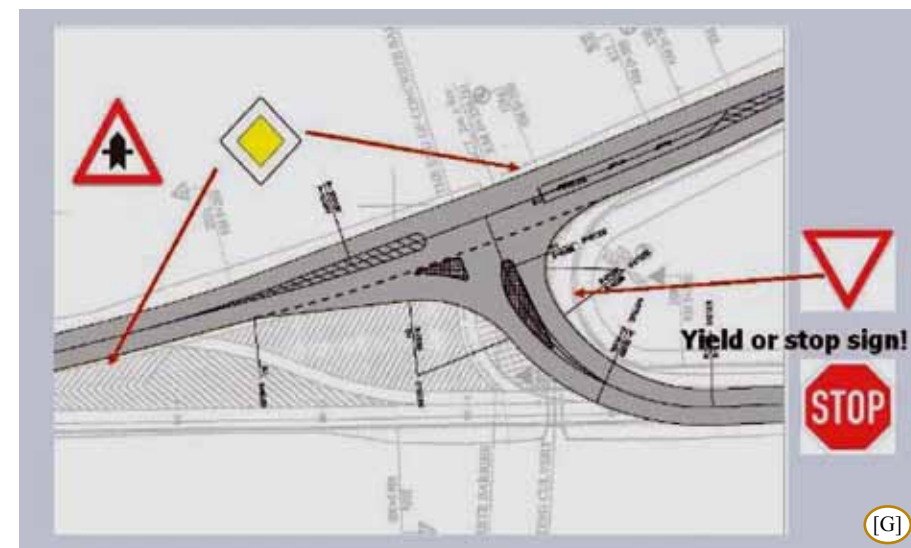
Affected Users

- All road users.

Treatments & Their Benefits

T1: a) Pavement markings can be used to delineate travel lanes within wide intersections

T1: b) Markings and signs can be used to impose right-of-way restrictions



T2: Traffic signs can show the direction of travel and impose restrictions on manoeuvres





7. TRAFFIC SIGNING, MARKING AND LINES

POORLY MARKED AND SIGNED JUNCTIONS (1)



Problem: Whereas on normal carriageways most vehicles are travelling in parallel and unlikely to come into contact with one another, there is a much higher likelihood of contact at junctions due to frequent turning manoeuvres, high speed variability and dense and potentially confusing messaging.

Clear road markings and signs are necessary to help road users approach and pass through the junction safely. Absent lane and turning lines can lead to side impact accidents; absent advance warning and a sight-line through the junction can lead to overshoot accidents.

Treatment types & costs

T1: Advance warning signs	\$
T2: Road markings through junctions	\$

Crash Types

- Side impact
- Overshoot

Affected Users

- All road users.

Treatments & Their Benefits

These solutions involve informing road users of the junction type that they are approaching and how to pass through the junction more safely.

T1: Advance warning signs

Advance warning signs serve two purposes: firstly to inform road users that a junction is ahead and what the destinations are and secondly to explain to the road users what type of junction it is and how they should pass through it, including which approach has priority and how movements are controlled. Advance warning devices should be taken from the national road sign standards. Other advance warning signs could include rumble strips across the approaching lane and large distinctive boards on the opposite side.

T2: Road markings through junctions

Road markings are useful for guiding vehicles into and through a junction. If omitted, accidents are more likely to occur. The following markings should be considered.

- Lane markings: These guide vehicles along parallel and non-conflicting paths through a junction. These are important since other indications such as kerbs and shoulders are absent within a junction.
- Give Way and Stop lines: All lines at which vehicles may have to give way or stop, such as at traffic lights or stop signs, should be marked to prevent vehicles overshooting into crossing traffic.
- Markings along turning paths: These guide vehicles in smooth and non-conflicting curves. These are particularly important for vehicles turning across oncoming traffic and in need of a higher level of protection.

All road markings should be made with a durable and retro-reflective material.

road. See also 4.10, Solution T3.



7. TRAFFIC SIGNING, MARKING AND LINES

POORLY MARKED AND SIGNED JUNCTIONS (2)



Problem: Whereas on normal carriageways most vehicles are travelling in parallel and unlikely to come into contact with one another, there is a much higher likelihood of contact at junctions due to frequent turning manoeuvres, high speed variability and dense and potentially confusing messaging.

Clear road markings and signs are necessary to help road users approach and pass through the junction safely. Absent lane and turning lines can lead to side impact accidents; absent advance warning and a sight-line through the junction can lead to overshoot accidents.

Treatment types & costs

T3: Signs at junctions	\$
T4: Break up sight lines through junctions	\$\$
T5: Stagger minor roads through junctions	\$\$\$

Crash Types

- Side impact
- Overshoot

Affected Users

- All road users.

Treatments & Their Benefits

T3: Signs at junctions

Signs should guide road users through a junction, providing information which is sufficient but which can be read at typical driving speeds. Signs should be made from durable and reflective materials. Traffic lights should be used if the shape of the junction or the relative traffic flows on the legs prevents traffic on one or more legs from flowing at the demand level.

T4: Break up sight lines through junctions

If a driver's sight is attracted through a junction, for instance by kerbs, barriers or tree lines which continue in front of and beyond the junction, the driver may not notice the junction until he or she is too close, at which time it may be impossible to stop before partially entering the junction and risking impact from crossing traffic.

These sight-lines should be broken wherever possible. This can be done using a variety of techniques including a reconstructed road edge, the removal of shade trees at the junction, the construction of a median along the main road through the junction, the installation of a roundabout or the placing of signs along the sight lines.

T5: Stagger minor roads through junctions

However much the sight line through a junction is broken up, there will always be a possibility of a driver not noticing the junction ahead and the vehicle entering it, either partially or completely, and being exposed to crossing traffic. A more reliable way of preventing these overshoot accidents is to realign the minor road so that there is no straight through line and all vehicles have to make two right angle turns to continue along the road. Staggering the minor road into two T junctions ensures that drivers must stop before turning and continuing along the minor road. See also 4.10, Solution T3.



7. TRAFFIC SIGNING, MARKING AND LINES

VISIBILITY AND PERCEPTION OF SIGNS AND LINES



Problems: Drivers can only take notice of and react to instructions they are able to perceive and understand. If a sign is hidden by being placed behind another sign or obscured by overgrowing vegetation etc, the driver has no opportunity to take notice of the warning/information/instruction given by the sign.

Treatment types & costs

T1: Backing boards	\$
T2: Tactile Warning Devices	\$\$

Crash Types

Affected Users

- All road users.

Treatments & Their Benefits

T1: The Use of backing boards

Visibility of signs can be greatly enhanced by the use of backing boards. These boards should either be yellow or grey



T2: Tactile Warning Devices (Rumble Strips)

Drivers attention can be drawn to the fact that they are straying from the correct course and/or coming too close to a hazard by the use of tactile warning devices, often referred to as 'rumble strips'. These can be either raised from the road surface by the use of a suitable material, such as thermoplastic, or cut into the road surface.





7. TRAFFIC SIGNING, MARKING AND LINES

OVER PROLIFERATION OF SIGNS



Problem: Drivers only have the ability to absorb a fixed amount of information at any one time. Too many signs can confuse drivers, making it difficult for them to comprehend what is required of them and to react in the correct way. The principles are that signs should be:

- comprehensive and easily understandable
- clear and to allow a safe flow of traffic
- able to be recognized early and easily read
- in accordance with associated markings

Treatment types & costs

T1 Sign Simplification and consistency	\$
T2 Destination signing	\$\$

Crash Types

- Side impact
- Overshoot
- Head-on collisions
- Shunts

Affected Users

- All road users

Treatments & Their Benefits

T1: Sign simplification and consistency.

The key for good signing is that the signs are clear and unambiguous. They should be of a standard type, preferably using a recognised international convention. It is often better to use symbols rather than words to facilitate understanding in areas where reading skills may be lacking.

Signs should be sited far enough in advance for drivers to understand the message being given to them and to allow them to react in the required way. It is important that signs are visible in all weathers and at night time. Although reflectorised signs are more expensive than non-reflectorised, they provide excellent visibility in all weather conditions.

Sign obscuration is also a potentially dangerous situation. Signs can be obscured by other poorly placed signs, by moving vehicles or parked vehicles or by vegetation.



Great care should be taken when placing signs at intersections to avoid obstructing sight lines.

T2: Destination signing.

It is important to be consistent with destination signing. Such that once a destination has been signed, it is repeated on all subsequent signs until no longer required.

It is also important to limit the number of destinations to approx 6 on lower speed roads and 4 on higher speed roads. This is to prevent overloading drivers with too much information.



8. ROADSIDE FEATURES

UNPROTECTED EMBANKMENT EDGE



Problem: Vehicles should be prevented from leaving a road on an embankment because of the risk of rolling over or hitting people or solid objects. Vehicles may leave a road for various reasons including swerving to avoid a pothole, travelling around a curve too quickly or poor vehicle condition.

The exception to preventing vehicles leaving the road occurs when the embankment is such that a vehicle is extremely unlikely to roll over or suffer or cause damage.

Treatment types & costs

T1: Signs, edge markings, raised ribs or a low kerb along the edge of the road	\$
T2: A high kerb, posts or safety barrier in front of the embankment edge	\$\$
T3: Widen shoulder	\$\$\$
T4: Gentler slopes	\$\$\$
T5: Superelevate curves	\$\$\$

Crash Types

- Roll over
- Impact with people or solid objects

Affected Users

- All road users.

Treatments & Their Benefits

Solutions similar to these can also be used for a deep side drain close to the road (see 6.02) and where pedestrians, housing and other facilities are close to the edge of an at-level road.

T1: Signs, edge markings, raised ribs or a low kerb along the edge of the road

This solution will not prevent vehicles leaving the road, but by providing a visual cue, warning noise or jolt, the driver is alerted to the danger and may steer safely away from the edge.

T2: A high kerb, posts or safety barrier in front of the embankment edge

A kerb, posts or barrier between the road and the embankment edge will physically prevent a vehicle leaving the road. If large vehicles use the road, posts or barriers should be used because large vehicles may ride over high kerbs.



T3: Widen embankment

Increasing the distance between the carriageway and the edge of the embankment will give the driver more opportunity to recover control of the vehicle. However, a wider embankment costs more to construct than a narrow embankment, particularly when the embankment is high. The ideal distance between the carriageway and the edge depends upon the usage of the road but a typical recommended distance is 1.5 metres.



T4: Gentler slopes

Reducing the gradient of the embankment slopes reduces the likelihood of a vehicle rolling over. However it will also increase the cost of the embankment.

The minimum safe gradient depends upon the material used and the presence of water, with a typical minimum gradient being 1:3. A typical gradient which balances safety and cost is 1:3.



T5: Superelevate curves

Vehicles travelling quickly are more likely to lose traction and leave the outside of a curved embankment than they are to leave a straight embankment. Barriers are often used on curved embankments. An additional measure is to superelevate the curve.



8. ROADSIDE FEATURES

(1) DEEP SIDE DRAIN CLOSE TO THE ROAD



Problem: Deep side drains near to a carriageway can pose a series of dangers including restricting the space available to pedestrians and cyclists and trapping the nearside wheels of stray vehicles, causing them to enter the drain and roll over or to hit hard objects such as catch pits.

Treatment types & costs

T1: Signs, road markings, raised ribs or a low kerb along the edge of the road.	\$
T2: A high kerb or safety barrier in front of the drain	\$
T3: Drain covers	\$\$
T4: Wider drains with gentler slopes	\$\$\$
T5: Drains relocated further away	\$\$\$\$

Crash Types

- Motorised vehicle with vulnerable road user
- Single vehicle loss of control

Affected Users

- All road users.

Treatments & Their Benefits

T1: Signs, road markings, raised ribs or a low kerb along the edge of the road

As with the unprotected embankment edge (6.01), this solution will not prevent vehicles entering the drain, but by providing a visual cue, warning noise or jolt, the driver is likely to become alerted to the danger and may steer safely away from the drain. Low kerbs should have gaps to allow water to enter the drain.

T2: A high kerb or safety barrier in front of the drain

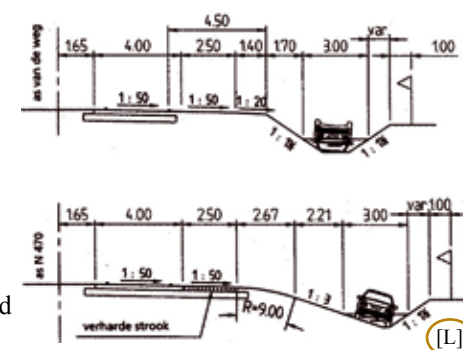
A kerb or barrier between the road and the drain will physically prevent a vehicle entering the drain. If large vehicles use the road, barriers should be used because large vehicles may ride over high kerbs. Kerbs should have gaps to allow water to enter the drain.

T3: Drain covers

In some cases, if the drain is of brick or concrete and vertically sided, it is possible to fit covers to the drain. Covers also serve to prevent debris entering and blocking the drain. The covers must be light enough to be lifted by two road workers, however consideration should also be given to theft prevention. A similar covering effect can be achieved by constructing a french drain where the drain is filled with a coarse material, sometimes with a porous pipe at the bottom.

T4: Wider drains with gentler slopes

If the inside slope of a drain is shallow enough a driver is able to steer out of the drain. Side drains should therefore be constructed with gentler slopes. It will be necessary for the drain to be wider in order to provide the required water carrying capacity. Excavating additional mitre drains can reduce the required water carrying capacity. On flat ground the base of the drain should be at least 750 mm below the level of the centre of the road to prevent the road pavement becoming waterlogged and weak.



T5: Drains relocated further away

Increasing the distance between the drain and the road will reduce the likelihood of a stray vehicle entering the drain and will provide room for pedestrians and other vulnerable road users away from motorised traffic. The ideal distance depends upon the usage of the road, but a typical recommended distance is 1.5 metres. If it is much greater than this, vehicles may use the space for travelling and thereby endanger themselves and pedestrians.



Treatments 1, 2, and 4 can also be used where a steep embankment edge is close to the edge of a road (see 6.01).



8. ROADSIDE FEATURES

(2) THE DRAINAGE SYSTEM



Problem: Deep ditches and headwalls of culverts close to the carriageway are very dangerous road side obstacles causing serious accidents. Driving mistakes or manoeuvres to avoid other accidents will not be forgiven.

Treatment types & costs

T1: Signing and marking Fairly useless	\$
T2: Rumble strips Good results like every where	\$
T3: Steel barriers Excellent results and removal of black spots	\$\$
T4: Soakaways An inexpensive and safe solution	\$
T5: Shallow green ditches Much cheaper and safer solution than concrete ditches. Excellent results and removal of hazards	\$
T6: Piped drainage Cheaper and safer solution than concrete ditches, excellent results and removals of hazards.	\$\$
T7: Avoid headwalls on culverts Inexpensive and safe solution. Excellent results and removals of hazards.	\$

Crash Types

- Single vehicle loss of control
- Vulnerable road users might fall into the ditches
- Vulnerable road users might come into conflicts with motorized traffic when using the carriageway avoiding the obstacles

Affected Users

- Trucks, buses, passenger cars and motorcyclists
- Vulnerable road users

Design/Treatment & Its Benefits:

T1: Signing and marking

As the pictures show signing and marking are not sufficient and should not be regarded as a complete solution.

T2: Rumble strips along the deep ditches and in front of the headwalls can sometimes reduce the frequency of such accidents in cases of sleepiness and poor concentration of the drivers

T3: Steel barriers along the ditches and above the culverts are a good medium term solution.

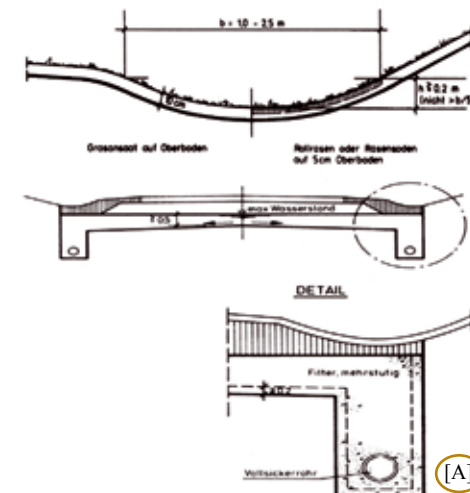
T4: Soakaways. Let the water seep into the ground at the roadside where ever it is possible. This is also a sensible ecological measure. It has been discovered that most of the critical pollutions of the water from the road, such as oil and petrol will be destroyed by soil bacteria.

T5: Shallow green ditches.

These collect the water in low green ditches from where most of it will seep into the ground.

T6: Piped drainage.

Choose a subsurface piped solution if water permeability of the soil is low.



T7: Avoid headwalls on culverts.





8. ROADSIDE FEATURES

INADEQUATE SHOULDERS



Problem: Shoulders are an important element of a road, allowing pedestrians (if there is no other footpath present), parked vehicles, broken down vehicles and vulnerable users to keep clear of faster moving motorised traffic. They also provide a safety area for drivers to regain control of their vehicle if they stray from the carriageway. However, in some situations they are unable to perform this role. A shoulder in poor condition is rarely used and displaces users onto the carriageway, a shoulder with hard objects places users at risk, a narrow shoulder puts users very close to traffic and a shoulder which is too wide is often used by motorised vehicles as an additional lane.

Treatment types & costs

T1: Signs, road markings, raised ribs or a low kerb along the edge of the carriageway	\$
T2: Ensure shoulders are well maintained	\$
T3: Relocate or protect hard objects	\$
T4: Reduce shoulder width	\$\$
T5: Construct a shoulder	\$\$

Crash Types

- Motorised vehicle with vulnerable road user
- Rear shunts
- Side impact

Affected Users

- All road users.

Treatments & Their Benefits

T1: Signs, road markings, raised ribs or a low kerb along the edge of the carriageway

Shoulders are often used by motorised traffic when there is no clear distinction between the carriageway and the shoulder, although wear on the carriageway may be higher than on the shoulder. Even if the shoulder has a different surface material from the carriageway, motorised vehicles often use it because its different function is not clearly indicated. The easiest solution is therefore to use signs, road markings or a rumble strip to mark the line between carriageway and shoulder.



T2: Ensure shoulders are well maintained

If a shoulder is not seen as an important element of a road, its maintenance is taken less seriously than the maintenance of the driving surface. Maintenance must include all necessary repairs to the drainage of the shoulder since standing water can cause potholes and loss of shoulder condition.

T3: Relocate or protect hard objects

Objects such as poorly located electricity posts, cable ducts and raised drainage covers are hazardous to all users of a shoulder. Wherever possible these objects should be moved and buried. If this is not possible, the object should be clearly signed and well protected with barriers.

T4: Reduce shoulder width

In many cases the shoulder and the public space beyond the shoulder merge into a single zone, with motorised vehicles parking amongst kiosks, pedestrians and other non-motorised road users. This widened shoulder is dangerous and inefficiently used. The outer edge of the shoulder should be defined with high kerbs or other impassable barrier and the area behind the kerbs should be raised above that of the shoulder.

T5: Construct a shoulder

If a road carries a sufficient amount of pedestrian and other non-motorised traffic, the most appropriate solution is to provide a shoulder and to mark the boundary between it and the carriageway as in T1 above. The ideal width of the shoulder depends upon the usage of the road, but a typical recommended width is 1.5 metres as this provides adequate refuge for parked vehicles but does not encourage use of the shoulder as an additional lane.





8. ROADSIDE FEATURES

INADEQUATE BARRIERS



Problem: A barrier is a series of posts and cross beams, normally steel but sometimes concrete or wood, used to physically prevent vehicles passing a defined line, typically the edge of a road. Although larger vehicles may ride over barriers, they can be effective against the majority of motorised and non-motorised vehicles. However, the effectiveness of a barrier and indeed the danger that it may pose depend on how well it has been designed, located and installed. Faults include:

- Barriers which are too close to traffic or protrude into the carriageway
- Barriers which are in the wrong place given the direction from which vehicles are likely to approach
- Barriers which are a series of unconnected short pieces (for most barriers the protection is provided by a long continuous length of beam acting in tension)
- Barriers which are not connected to the objects they are intended to protect with the result that vehicles are often directed into the face of the object
- Barriers which are incorrectly terminated with a vertical face or a ramp which can cause vehicles to roll over or launch into the air.
- Barriers which, through faulty connection or termination, are not able to act in tension

Treatment types & costs

The above faults are solved by correct design, location and installation. See the 11 points opposite which address the correct design, location and installation of a safety barrier.

Crash Types

- Roll over accidents
- Impact with vertical barrier post

Affected Users

- All road users.

Treatments & Their Benefits

The following points address the correct design, location and installation of a safety barrier.

1. Barriers should be placed parallel to the edge of a road if people are at risk from vehicles leaving the road or if the vehicles are at risk of damage when doing so.
2. Barriers must comply with all manufacturers' specifications, including installation.
3. Barriers must be selected to suit the vehicles that travel along the road. A high proportion of heavy commercial vehicles may justify a stronger and higher barrier than that which most suits cars and small commercial vehicles.
4. Steel barriers are sometimes designed to be tensioned after installation in order to return stray vehicles onto the road on which they were travelling. In order to be able to be tensioned, the following should apply.
 - Each end of all lengths, whether long or short, should either have a buried anchor or be connected to an immovable object such as a large concrete plinth.
 - There should be no breaks in the barrier.
5. Even if a barrier is not designed to be tensioned after installation, it should be terminated in a well designed flare ramp or energy absorbing end so that vehicles which hit the end of the barrier do not hit a rigid vertical post or a ramped piece of barrier which may cause them to roll or lose control.
6. No barrier should present a greater danger than the hazard that it is being used to protect.
7. The face of the barrier should be approximately 1.5m metres behind the edge of the carriageway, whether the carriageway is marked with a line or perceived from general usage.
8. If the barrier is connected to an immovable object such as a large concrete plinth, the connection should be of a specified standard and the face of the barrier should be flush with the face of the object.
9. Barriers should be in the correct place to protect approaching vehicles from hitting the identified hazard.
10. Unless a suitable alternative can be established, barriers should not block routes that pedestrians naturally use. If these routes are blocked, pedestrians will continue to use the routes but be inconvenienced and placed in more danger when doing so.
11. Barriers may not be needed at sites where vehicles leaving the carriageway are extremely unlikely to roll over or suffer or cause damage.



8. ROADSIDE FEATURES

EXPOSED BRIDGE ABUTMENT/OTHER RIGID OBJECTS



Problem: Any large rigid object next to the travelled lane is a hazard as these large rigid objects quickly decelerate the vehicle and its occupants. Any deceleration of the vehicle and its occupants should be slow and smooth. In this photo above, the roadside traffic barrier acts as a guide leading the vehicle into contact with this exposed bridge abutment.

Treatment types & costs

T1: Anchor the Traffic Barrier to the Abutment \$

This is usually a low cost treatment involving a specially formed anchor plate. The barrier near the abutment should also be stiffened by doubling the number of barrier posts.

Crash Types

- Single vehicle run-off collisions
- Collision with a fixed object

Affected Users

- Drivers and Occupants

Treatments & its benefits

T1: Anchor the Traffic Barrier to the Abutment

By anchoring the traffic barrier end and stiffening the traffic barrier by doubling the number of barrier posts, the traffic barrier then becomes continuous with the bridge abutment and bridge rail, smoothly redirecting the vehicle and occupants. This smooth redirection and deceleration will reduce the level of injury experience by the driver and occupants.





8. ROADSIDE FEATURES

TRAFFIC BARRIER SPEARING



Exposed W-beam spade end



Vehicle speared by unprotected W-beam spade end

Problem: Although traffic barriers are intended to protect vehicle drivers and occupants by preventing them from running off the road, they can also be severely hazardous if the vehicle impacts the end of the traffic barrier and the traffic barrier end is not fitted with an acceptable end treatment.

Treatment types & costs

T1: Buried end terminal

\$

A low cost end treatment since no additional hardware is required

T2: Breakaway terminal

\$

This is a relatively inexpensive treatment.

T3: Energy absorbing end treatment

\$\$

A more expensive end treatment since it requires more elaborate hardware and site preparation such as levelling and hard Surfacing.

Crash Types

- Single vehicle run-off collisions
- Collision with a fixed object

Affected Users

- Drivers and occupants

Treatments and Their Benefits

T1: Buried End Terminal

The buried terminal is preferred because it eliminates any exposed end of the guardrail. The barrier is anchored into the back slope.

Note that a turned down and buried treatment is not an acceptable treatment as it causes ramping and launching of the vehicle.



T2: Breakaway terminal

As can be seen from the photo, the posts are weakened to allow shearing of the posts, allowing the end to rotate out of the way. The terminal treatment is also large enough that it does not spear the vehicle.

While allowing the vehicle to possibly travel behind the traffic barrier, this treatment reduces the severity of the collisions with the end of the traffic barrier.

Other commercial models are available.



T3: Energy absorbing end treatment

Energy absorbing end treatments are usually the best treatment for rigid barriers.

The example shown is the Narrow Connecticut Impact Attenuation System (NCIAS). Other commercial models are available.

The NCIAS consists of 8 steel cylinders in a single row with two anchored wire ropes along each side. All cylinders are 900 mm in diameter and 1,200 mm tall. Wall thicknesses vary from 3.2 mm to 15.9 mm.





8. ROADSIDE FEATURES

GUIDANCE ON CURVES



Problem: On curves, accidents are commonly caused by a car leaving the road.

Treatment types & costs

T1: Delineators	\$
T2: Rumble strips	\$\$
T3: Information boards & signs	\$\$

Crash Types

- Collision caused by leaving the road

Affected Users

- Drivers and occupants

Treatments & Their Benefits

T1: Delineators

Delineators inform drivers of the existence of a curve guiding them around the bend and effectively preventing accidents.



T2: Rumble strips

Rumble strips inform drivers that they are deviating towards the edge of the road by producing vibration and noise, effectively preventing accidents.



T3: Information boards & signs

Information boards can catch the attention of drivers by communicating more detailed information to them.



Vehicle activated signs which detect approach of an oncoming vehicle are especially effective at advising motorists to the presence of the bend.





8. ROADSIDE FEATURES

UNFORGIVING ROADSIDES (1)



Problem: When an errant vehicle leaves the road, there is often little 'forgiving' roadside space except for a narrow shoulder area, where it exists. Encountering hard objects such as trees, culvert walls, lighting columns etc can cause very severe crashes with often fatal results.

Research has shown that approximately 35 per cent of all rural road collisions can be classified as single vehicle run-off the road – a very large target group.

One solution, which should be incorporated in all new design, is providing an obstacle free flat roadside for several metres on either side of the roadway.

Treatment types & costs

T1: Obstruction Free Zone \$

T2: Shoulder Rumble Strips \$

This is relatively low cost treatment.

T3: Wider Shoulders \$\$

Research has shown that wider shoulders are associated with reduced collisions as shoulder width is increased to 3 metres. Costs of construction will increase with width and also whether the shoulder is hard surfaced.

T4: Flat Side Slopes \$\$

Flat side slopes of 5 to 1 or flatter should be provided to reduce rollover and impact with the back slope. Depending on the terrain, construction costs could increase significantly, and traffic barriers should be considered as an alternative.

Crash Types

- Single vehicle run-off collisions
- Collision with a fixed object or vehicle rollover

Affected Users

- Drivers and occupants

Treatments & Their Benefits

T1: Obstruction free zone

Removing the obstruction from an area adjacent to the road means that should vehicles leave the road the chance of them striking hard unforgiving objects is greatly reduced.



T2: Shoulder rumble strips

Rumble strips or raised edge markings warn the driver if they are straying too close to the edge of the road and allows them to correct their driving in time.



T3: Wider Shoulders

Research has shown that wider shoulders are associated with reduced related collisions. However, care should be exercised because in some countries there can be problems associated with widening the shoulder – see 6.03, Treatments T4 and T5.



T4: Flat side slopes

Side slopes of 5 to 1 or flatter should be provided to reduce rollover and impact with the back slope.

8. ROADSIDE FEATURES

UNFORGIVING ROADSIDES (2) – PASSIVE SAFETY INSTALLATIONS



Problem: : When an errant vehicle leaves the road, there is often little ‘forgiving’ roadside space except for a narrow shoulder area, where it exists. Encountering hard objects such as trees, culvert walls, lighting columns etc can cause very severe crashes with often fatal results.

Research has shown that approximately 35 per cent of all rural road collisions can be classified as single vehicle run-off the road – a very large target group.

One solution, which should be considered for inclusion in all new designs, is the provision of ‘frangible’ or break-away street furniture that provides a more forgiving roadside. If crashes occur, their severity will be greatly reduced.

Treatment types & costs

T1: Passive Safety Installations \$

Crash Types

- Single vehicle run-off collisions
- Collision with a fixed object or vehicle rollover

Affected Users

- Drivers and occupants

Treatments & Their Benefits

T1: Passive safety installations

In addition to naturally occurring hazards, such as trees, rocks etc, roadside furniture can provide significant hazards to errant vehicles leaving the road for any reason and provide a disproportionate penalty to vehicle occupants. Providing ‘frangible’ or break-away lighting columns, supports to signs etc allows the road furniture to be placed in the best position for visibility but protects errant vehicles and their occupants from severe damage.





8. ROADSIDE FEATURES

SHY LINE OR SIDE CLEARANCE

Problem: Drivers require a minimum distance on either side of their travelled path, otherwise they “shy” away from the side without the necessary clearance.

In this example, there is virtually no shoulder width and drivers move to the centre as they approach the structure raising the risk of a head on collision.



Treatment types & costs

T1: Plan for the future \$\$
What are the long-range plans for the road?

Will there be a requirement for additional lanes?

Early planning for future requirements will eliminate expensive rehabilitation costs.

T2: Provide adequate clearance in the design \$\$

Providing for a wider structure during the initial design phase to accommodate the shy line requirements would eliminate the problem at only a moderate cost, while increasing safety significantly.

T3: Increase structure width \$\$\$

It would be very expensive to treat this existing situation since it would require removal of the overhead structure and replacement with a wider structure.

Crash Types

- Side swipe collisions
- Head-on collisions
- Possible pedestrian/cyclist collisions if significant pedestrian/cyclist traffic in the area

Affected Users

- Drivers and occupants
- Pedestrians and cyclists

Treatments and Their Benefits

T1: Plan for the Future

Building the structure for future requirements such as additional lanes will reduce future costs to remove and replace the structure.

From a safety perspective, additional roadside clearance and run-off area are provided until the additional lanes are required. Structural supports are also further away from the travelled lanes.



T2: Provide adequate clearance in the design

Providing for a wider structure during the initial design phase to accommodate the shy line requirements would eliminate the problem at only a moderate cost, while increasing safety significantly.

T3: Increase structure width

Provides clearance from the structure so driver remains in centre of travelled lane. Provides additional shoulder width for possible pedestrian / cyclist traffic.





8. ROADSIDE FEATURES

SNOW MEASURES



Problem: On roads where snow has accumulated, road boundaries are unclear, creating the risk of collisions with obstructions along the roadside.

Treatment types & costs

T1: Snow pole	\$
T2: Weather vanes	\$\$

Crash Types

- Collision with roadside objects

Affected Users

- Drivers and occupants

Treatments & Their Benefits

T1: Snow poles

Snow poles show drivers the edge of the road. However, they may obstruct snow removal vehicles.



T2: Weather vanes

Weather vanes have the same effect as snow poles. They do not obstruct snow removal vehicles.

