ANNEX 6

INTERNATIONAL EXPERIENCE

**Table A6.1** - the minimum length of nearside safety barrier prescribed in a standard to be installed for it to contain and redirect an errant vehicle.

| Country | Document Reference | Minimum Length of Safety Barrier |
|---|---|---|
| UK | 'TD19/85', 1984 | 30m |
| Switzerland | 'Highway Crash Barriers', 1971 | 50m |
| Australia | 'ARR Report 45: A Review of Literature of Full Scale Tests on Safety Barriers and Kerbs', 1975 | 30m |
| Ireland | 'Safety Barriers', Draft 4.0, June 2001 | 30m |
| Sweden | 'Highway Crash Barriers', 1971 | 30m |
| Australia | 'Safety Barriers for Roads and Bridges', 1996 | 28m (on a two way road) |
| Netherlands | 'Highway Crash Barriers', 1971 | 25m |
| Austria | 'Bruckenausrustung Vertikale Leiteinrichtungen', 2001 | 16m |
| America, California | 'Caltrans Traffic Manual', 2000 | 15m |

**Table A6.2** - the approximate minimum approach length of nearside safety barrier prescribed in a standard for protection at the approach to road bridges over rail lines. All the lengths of barrier as quoted exclude approach ramps and any length required to pass in front of the hazard, as well as lengths on departure.

| Country | Document Reference | Minimum Approach Length of Safety Barrier to be installed |
|---|---|---|
| UK | 'BD52/93', 1993 | 30m |
| America, New York | 'Highway Design Manual', 1995 | 98m if operating speed is ≥ 90km/h |
| Germany | Letter from Peter Bürkel (of Bürkel Baumann Schuler) to TRL Ltd. dated 11/06/01 | 60m of safety fence and<br>24m of higher containment safety fence |
| France | Letter from P Mayant (of the SNCF) to TRL Ltd. dated 18/07/01 | 50m |
| America, Iowa | 'Iowa Department of Transportation Office of Design: Design Manual', 2000 | 30m |
| Austria | 'Bruckenausrustung Vertikale Leiteinrichtungen', 2001 | 16m (concrete barriers to be used) |

NB There is no information on whether these minimum lengths are to protect the end of bridge parapets or the hazard beneath the bridge.

## Table A6.3 Height (to top of barrier beam unless otherwise stated)

| Country | Document Reference | Summary |
|---|---|---|
| UK | 'TD19/85', 1985 | TD19/85 Table 1 states that all types of fence except the British Concrete Barrier are to be 0.61m high, to the centre of the longitudinal. |
| Australia / New Zealand | 'AS/NZS 3845: Australian / New Zealand Standard: Road Safety Barrier Systems', 1999 | Depends on type of safety fence installed:: 0.707 to 0.865m, though generally 0.707 on the approach to bridges. |
| Belgium | TRL File RDB/18/3, (based on information dated 1976) | Standard design for motorways and important routes, also for secondary routes in dangerous zones: 1.0m. |
| Czech Republic | Information sent by Pavel Minarik at the Directorate of Roads in the Czech Republic | NH4 Single sided road barrier: 0.75m<br>NH3 Single sided road barrier: 0.75m |
| Denmark | Information sent by Peter Johnsen at the Danish Road Directorate | SW 2.2 (double sided road barrier): 0.75m |
| Finland | Information sent by Kari Lehtonen at the Finnish Road Administration | Ty 3/51 (a single sided road barrier): 0.7m |
| France | 'Barrières de Sécurité pour la Retenue des Poids Lourds; Barrières de niveau H2 ou H3', 1999 | BN4 type-parapet height: 1.0m over railway<br>BHO safety fence: 1.0m before parapet |
| Germany | 'Richtlinien für passive Schutzeinrichtungen an Staüßen RPS', 1989 | For the application of safety fences at bridges over railways, a height (to the top of the longitudinal) of 0.75m to 0.65m is used. |
| Italy | Information sent by Italian safety fence manufacturers 'Fracasso' | German-type, single sided road barrier : 0.6m<br>French-type, single sided road barrier:<br>0.7-0.75m |
| Netherlands | 'Veilige inrichting van bermen', 1999 | Typical safety barrier: 0.75m |
| Sweden | 'VU94 Road Design - English Summary', 2001 | 'The fence height depends on the slope'. |
| USA | 'AASHTO Roadside Design Guide', 1996 | 3-Strand Wire rope: 0.61m to centre of middle rope<br>W-Beam (Weak post): 0.766m<br>Thrie Beam (Weak post): 0.84m<br>Box Beam (Weak post): 0.69m<br>Blocked out W Beam (Strong post): 0.706m<br>Blocked out Thrie Beam (Strong post): 0.863m<br>Side Mounted Thrie-Beam Bridge Railing: 0.875m |
| USA (New York) | 'New York Department of Transport Highway Design Manual', 1995. | Barrier Type / Normal Height (m) / Upper Limit (m) / Lower Limit (m)<br>Cable: 0.685 / 0.76 / 0.61<br>W-beam (weak post): 0.76 / 0.835 / 0.68<br>W-beam (heavy post): 0.685 / 0.76 / 0.61<br>Box beam: 0.685 / 0.76 / 0.61<br>Concrete (NJ&F shapes): 0.81 / 0.81 / 0.76 |

**Table A6.4 - Containment (Strength) Levels**: (Greater or Lower than UK Regulations)

| Country | Document Reference | Normal Containment | High Containment |
|---|---|---|---|
| UK | 'Safety Standards for Road Design and Redesign - (Safestar), 1998, 'TD19/85, 1994', and 'BS6779:1', 1998 | N2 | H4a * |
| Austria | 'Brückenausrüstung Vertikale Leiteinrichtungen', 2001 | Motorways: Greater (H2) | Motorways:Lower (H3) |
| | | Federal Highways: Lower (N1) | Federal Highways: Lower (N2) |
| Belgium | TRL File RDB/18/3 (based on information dated 1979) | - | Greater (40 tonnes at 80km/h) |
| Czech Republic | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Greater (H2) | Lower (H4b) * |
| Denmark | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Greater (H1) | Lower (H2/H3) |
| Finland | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Same (N2) | Lower (H2) |
| | Letter from Kari Lehtonen to TRL Ltd., dated 04/09/01 | Same (N2) | Lower (H2) |
| France | TRL File RDB/18/3 (based on information dated 1978) | Same (N2) - estimated | Lower (H4b) – estimated * |
| Germany | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Same (N2) - steel<br>Greater (H1/H2) - concrete | Lower (H4b) * |
| Ireland | 'Safety Barriers', Draft 4.0, June 2001 | Same (N2) | Same (H4a) * |
| Netherlands | 'Veilige inrichting van bermen', 1999 | Greater (H2) | Lower (H2) |
| | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Greater (H1/H2) - steel<br>Greater (H2) - concrete | Lower (H2) |
| Norway | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Same (N1/N2) - steel<br>Greater (H1/H2) - concrete | Lower (H2/H3) (estimated) |
| Sweden | 'VU 94 road design - English Summary', 2001 | Same (N2) | Lower (H2) |
| | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Same (N2) | Lower (H2) |
| Switzerland | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | Greater (H1) - steel<br>Greater (H1/H2) - concrete | Lower (H1) - steel<br>Lower (H1/H2) -concrete |
| | Email from Wolfgang Schuler to M.Macdonald, TRL. | Same (N2) | Lower (H2) |

* It is felt by many experts involved in the area of road restraints that an H4a test is more severe than the H4b test. This is due to the rigid nature of the vehicle in the H4a test. The current European Standard (BSEN1317-1&2) demonstrates this by showing that during impact, the force imposed on the barrier by the impacting vehicle is generally greater with a rigid impacting vehicle than with an articulated vehicle.

**Table A6.5** - Additional Information: Containment Levels
(They are the full-scale impact tests which may be completed before a safety barrier can be permanently used on a road. Most containment levels require **two tests** to be completed, one to assess the strength (containment capability) of the barrier, and a second to establish the severity of an impact on vehicle occupants. This second test uses by a 'small' car, e.g. a Ford Fiesta.)

| Containment Level | Purpose of test | Speed (km/h) | Angle (degrees) | Vehicle Mass (kg) | Type of Vehicle |
|---|---|---|---|---|---|
| N1 | Severity | 80 | 20 | 1,500 | Car |
| N2 | Containment | 110 | 20 | 1,500 | Car |
| | Severity | 100 | 20 | 900 | Car |
| H1 | Containment | 70 | 15 | 10,000 | Rigid HGV |
| | Severity | 100 | 20 | 900 | Car |
| H2 | Containment | 70 | 20 | 13,000 | Bus |
| | Severity | 100 | 20 | 900 | Car |
| H3 | Containment | 80 | 20 | 16,000 | Rigid HGV |
| | Severity | 100 | 20 | 900 | Car |
| H4a * | Containment | 65 | 20 | 30,000 | Rigid HGV |
| | Severity | 100 | 20 | 900 | Car |
| H4b * | Containment | 65 | 20 | 38,000 | Articulated HGV |
| | Severity | 100 | 20 | 900 | Car |

**Table A6.6** - Risk Methodology and Responsibilities for Third Parties

| Country | Document Reference | **(a) Is a Risk Methodology used when assessing the provision of nearside safety fencing?**<br>**(b) What Responsibilities are in place for third party protection.** |
|---|---|---|
| UK | 'TD19/85', 1994 | (a) No - specific hazards warranting protection are listed |
| Australia | 'Safety Barriers - Considerations for the Provision of Safety Barriers on Rural Roads', 1987. | (a) Yes |
| Australia / New Zealand | 'AS/NZS 3845: Australian / New Zealand Standard: Road Safety Barrier Systems', 1999 | (b) 'The duty of care to be exercised is emphasised. The community of road users includes people in a variety of vehicles which vary in size, mass and methods of propulsion. What should be noted is that the users of these vehicles have different levels of protection, especially pedal cyclists and motorcyclists. The community of road users also includes pedestrians and those involved in the various construction, operational and maintenance activities that occur within the road reserve. At some sites, the community of road users should be extended to include those whose activities require them to abut the road reserve.' |
| Australia (New South Wales) | 'Road Design Guide; Section 6, Safety Barriers for Roads and Bridges', May 1996 | (a) Yes<br>(b) 'Under its enabling legislation, the authority has power to erect roadside furniture but there is no duty to do so.'<br>'Action may be brought against the authority by people who suffer injury resulting from a roadside hazard on grounds of negligence, nuisance or both.' |
| Canada | 'Geometric Design Guide for Roads', 1999 | (a) Yes |
| France | 'Choix d'un dispotif de retenue en bord libre d'un pont en fonction du site', 2001 | (a) Yes<br>(b) 'There does not nor can there exist a legal obligation to prevent and cover every driver error that occurs'.<br>'However the general objective of the state is to ensure a normal level of public safety.<br>'The Administration has a duty to achieve this level, more so as innocent third parties are most often the victims of accidents.'<br>'The choice of a level of safety is therefore in all cases a question of policy, since it implies a compromise between safety and costs. However, because of its complexity, the competent political authorities have to date been able to make no more than partial or even fragmentary decisions. It falls to the engineers, as the official delegates of the Works Engineer (Ministry or Local Authority official), to endeavour to respond homogeneously in relation to these decisions, without any partiality one way or the other.<br>In conclusion, the designer of a new structure has a moral obligation of reasonable and homogeneous appraisal in the choice and effective use of methods to be put into operation in different specific cases.' |
| Germany | 'Richtlinien für passive Schutzeinrichtungen an Staüßen RPS', 1989 | (a) Yes |
| Ireland | 'Safety Barriers', Draft 4.0, June 2001 | (a) Recommended in new draft of standard<br>(b) Safety barrier provision is specified for the protection of the following:<br>At locations where an errant vehicle may encroach onto an adjacent road or impact another significant hazard<br>At locations where an errant vehicle may encroach onto an adjacent railway |
| Netherlands | 'Veilige inrichting van bermen', 1999 | (b) 'If there are involuntary or third party risks, more stringent requirements must be stipulated for verge installation than for voluntary risks.'<br>'If a vehicle veering off course enters an opposing or underlying traffic stream, this presents great risks to third parties.' 'A (much) heavier weighting must be assigned to third party risks than to personal risks. In practice this means that, as regards third party risks, an obstacle-free zone of 13.00m is quite inadequate to bring the risk to a socially acceptable level.' 'The minimum obstacle-free zone in respect of third party risk is 25.00m.' |

| Country | Document Reference | (a) Is a Risk Methodology used when assessing the provision of nearside safety fencing?<br>(b) What Responsibilities are in place for third party protection. |
|---|---|---|
| USA | 'AASHTO Roadside Design Guide', 1996 | (a) Yes |
| USA (California) | 'Californian Department of Transport Traffic Manual', 2000 | (a) Yes |
| USA | 'Safety Standards for Road Design and Redesign - (Safestar), 1998 | (a) Yes |

**Table A6.7** - Road Geometry

| Country | Document Reference | Summary |
|---|---|---|
| UK | 'TD19/85' 1985 | 'Safety fences shall be installed:<br>(a) On embankments 6m or more in height<br>(b) On embankments where there is a road railway water hazard or other feature (e.g. a subway entrance) at or near the foot of the slope<br>(c) On the outside of curves less than 850m radius on embankments between 3m and 6m in height<br>(d) At obstructions including bridge piers or abutments, posts of large signs and sign gantry legs<br>(e) At substantial obstructions such as retaining walls or steep sided (1 in 2 or steeper) rock face cuttings or earth banks (1in 1 or steeper) closer than 4.5m to the edge of the running carriageway o roads with speed limits above 50 mph<br>(f) At noise barriers or screens closer than 4.5m to the edge of the running carriageway |
| European Countries | 'XVIII World Road Congress, Brussels 13-19 Sept 1987: Interurban Roads', 1987 | A summary of the provision required in the verge for protection at embankments can found at the end of this table. |
| Australia | 'Safety Barriers for Roads and Bridges', 1996 | Horizontal road alignment and 'average' weather conditions are considered when estimating need for protection at a hazard. |
| | 'Safety Barriers - Considerations for the Provision of Safety Barriers on Rural Roads', 1987 | Safety Fencing is required on:<br>'Abrupt drops greater than about 10m in height' and at the top of embankments. |
| France | 'Choix d'un dispotif de retenue en bord libre d'un pont en fonction du site', 2001 | 'We have ascertained from studies that intersections in proximity to a bridge are a contributory factor to accidents and constitute a zone of risk of leaving the carriageway.' |
| | 'Accident Study into Safety Fence Provision: Final Report', 1998 | 'Safety fences are warranted on French motorways if the embankment is 4m in height or greater (2.5m in southern France). Safety fences are not required if the slope is flatter than 1:4.' |
| | 'Highway Crash Barriers', 1971 | 'Barriers are required on autoroutes as follows: at the road edge -<br>a. Along the outside of bends having a radius less than the normal minimum radius for the road.<br>b. In advance of ditches greater than 0.5m deep.<br>Barriers should always commence with a splayed end.' |
| Germany | 'Accident Study into Safety Fence Provision: Final Report', 1998 | 'For German motorways, safety fences are required for:<br>• a slope steeper than 1:8 at a distance of less than 6m;<br>• a slope between 1:8 and 1:5 at a distance of less than 8m;<br>• a slope steeper than 1:5 at a distance of less than 10m. |

<table>
<tr><td>Ireland</td><td>'Safety Barriers', Draft 4.0, June 2001</td><td>'Within the clear zone:<br>Embankments:<br>Slope Angle — Slope Height<br>Steeper than 1:2 — ≥0.5m<br>Between 1:2 and 1:3 (inclusive) — >2m<br>From 1:3 and up to 1:5 — ≥6m<br>Cuttings:<br>At steep sided cuttings or earth bunds (steeper than 1:2) within the clear zone.<br>Verges:<br>At individual hazards such as bridge piers and abutments, sign posts, gantry legs, non-frangible lighting columns and tress, etc.<br>At substantial obstructions such as retaining walls which present a smooth traffic face for at least 1.5m above the carriageway level.<br>At underbridges or at retaining walls . 0.5m high supporting the road, where a vehicle parapet or vehicle/pedestrian parapet of the required performance class is not provided.'</td></tr>
<tr><td>Japan</td><td>'Highway Crash Barriers', 1971</td><td>'Barriers are required as follows:<br>On embankments where the fill height is steeper than:<table><tr><td>Height</td><td>2m</td><td>4m</td><td>6m</td><td>8m</td></tr><tr><td>Slope</td><td>1:1</td><td>2:1</td><td>3:1</td><td>4:1</td></tr></table>a. On city roads elevated more than 2m.<br>b. On other roads elevated more than 2m and with a radius of curvature of less than 300m.<br>c. On roads alongside railways if the road is higher than the railway, or if the road is less than 1.5m below the railway, and the distance between them is 5m.<br>d. On sections with S-shaped curves with a radius of curvature less than 300m.<br>e. On roads where the down gradient is more than 4%.<br>Barriers may also be installed where roads run adjacent to bodies of water, where the road suddenly narrows, at the approaches to bridges, around the pillars of overhead bridges, at places where many accidents have occurred and where forward visibility is restricted by buildings.'</td></tr>
<tr><td>Netherlands</td><td>'Veilige inrichting van bermen', 1999</td><td>'Whether slope gradients flatter than 1:3 but steeper than 1:6 are a danger zone is dependant on local circumstances. Particularly on slope gradients steeper than 1:5 there is a great chance of the vehicle flipping over.'<br>'On the basis of simulations it has been determined that the chance of accidents on a steep downward slope (steeper than 1:3) is so great that this slope is always a danger zone.'</td></tr>
<tr><td>Sweden</td><td>'Highway Crash Barriers', 1971</td><td>'Barriers are installed on embankments 2m or more in height if the slope of the embankment is more than 3:1.'</td></tr>
<tr><td>Switzerland</td><td>'Highway Crash Barriers', 1971</td><td>Barriers should be installed on roads where the average daily traffic exceeds 10,000 vehicles or where the average speeds are above 65km/hr, but only under the following conditions:'<br>'On roads parallel with railways, or watercourses deeper than 1m, if the distance between them is less than 10m. Where the railway or water course is at the bottom of a fill with a slope steeper than 3:1 barriers are installed even if the road is more than 10m away.'</td></tr>
<tr><td>USA</td><td>'AASHTO Roadside Design Guide', 1996</td><td>'Embankment height and side slope are basic factors considered in determining barrier need'</td></tr>
</table>

Summary of European Countries provision for protection at embankments (1987) (see Table A6.7)

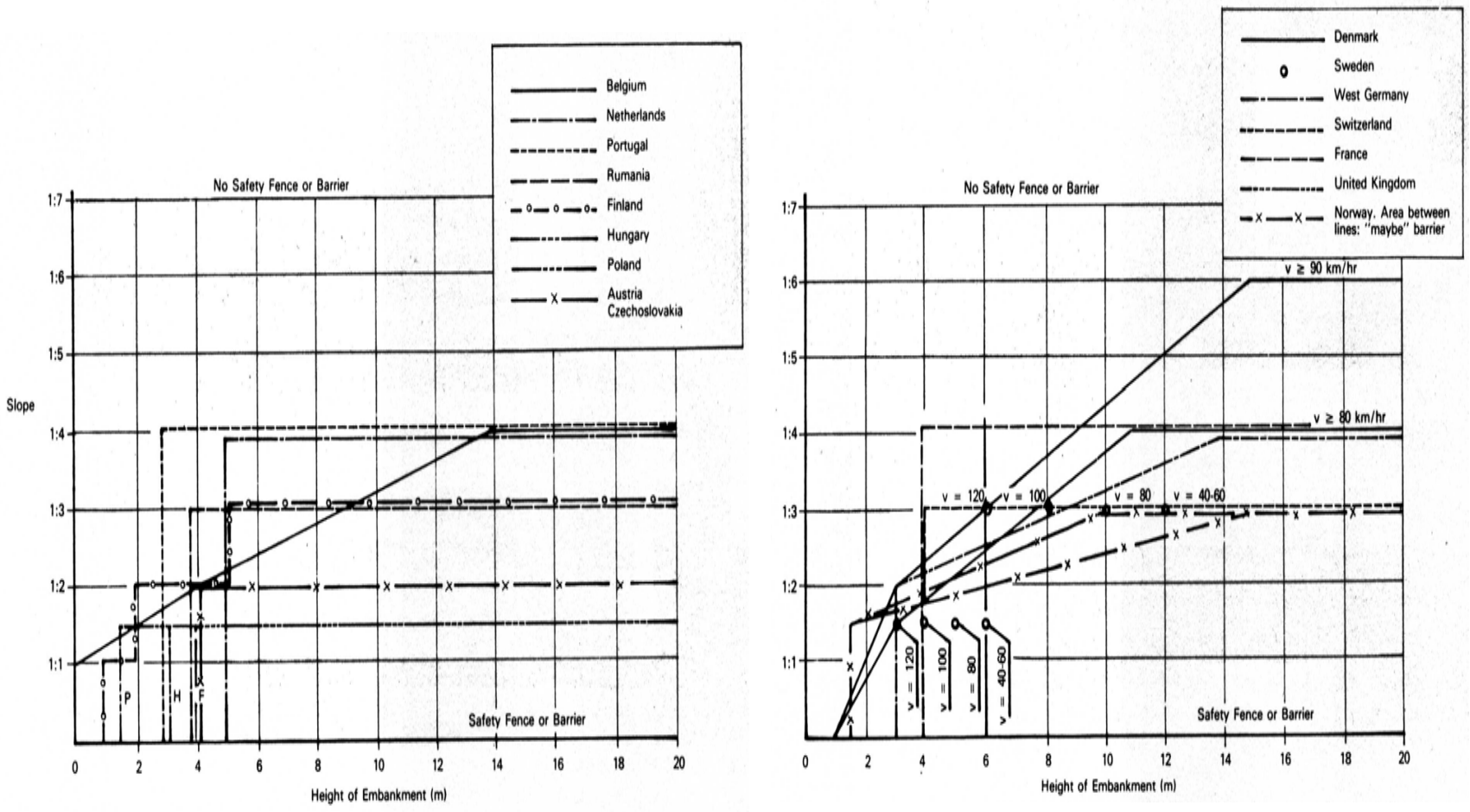

**Table A6.8** - Width of Clear Zone

| Country | Width of clear zone (m) | Further Information |
|---|---|---|
| UK | 4.5 | For motorways (3.3m hard shoulder and 1.2m set back) |
| Netherlands | 13 | If operating speed =120km/h |
| Switzerland | 12.5 | For Motorways |
| Japan | 11.5 | 4-lane major arterial road (Urban area with good residential environment) |
| France | 10 | For Motorways |
| Ireland | 10 | For straight roads with a design speed of 120km/h |
| Netherlands | 10 | For Motorways if operating speed <120km/h |
| Sweden | 10 | If operating speed =110km/h |
| America | 9 | For speed limit of 120kph |
| Denmark | 9 | For Motorways and Express Roads with operating speed ≥90km/h |
| Greece | 9 | For Motorways and Express Roads (19m near railroads) |
| Sweden | 9 | If operating speed=90km/h |
| France | 8.5 | For Express Roads |
| Japan | 7.5 | 4-lane arterial road (Urban area with good residential environment) |
| Finland | 7 | For Motorways |
| Sweden | 7 | if operating speed=70km/h |
| Japan | 6.5 | 4-lane major arterial road (Urban area other than that described above) |
| Germany | 6 | For Motorways (10m if a 'dangerous zone') |
| Netherlands | 6 | For Express Roads |
| Norway | 6 | If Average Daily Traffic ≥ 15,000 |
| Finland | 5.5 | For Express Roads |
| Japan | 5 | 4-lane arterial road (Urban area other than that described above) |
| Japan | 5 | 2-lane collector road (Urban area) |
| Norway | 5 | For Express Roads if Average Daily Traffic is 'high' |
| Switzerland | 5 | For Express Roads |
| Belgium | 4.5 | For Motorways |
| Czech Republic | 4.5 | For Motorways and Express Roads |
| Germany | 4.5 | For Express Roads (7.5m if a 'dangerous zone') |
| Belgium | 3.75 | For Express Roads |
| Poland | 3.5 | - |
| Portugal | 3.5 | For Motorways and Express Roads |
| Denmark | 3 | For Express Roads with operating speed <90km/h |
| Hungary | 2.5 | - |

**Table A6.9 - International Comparison: Road Deaths per 100,000 population**

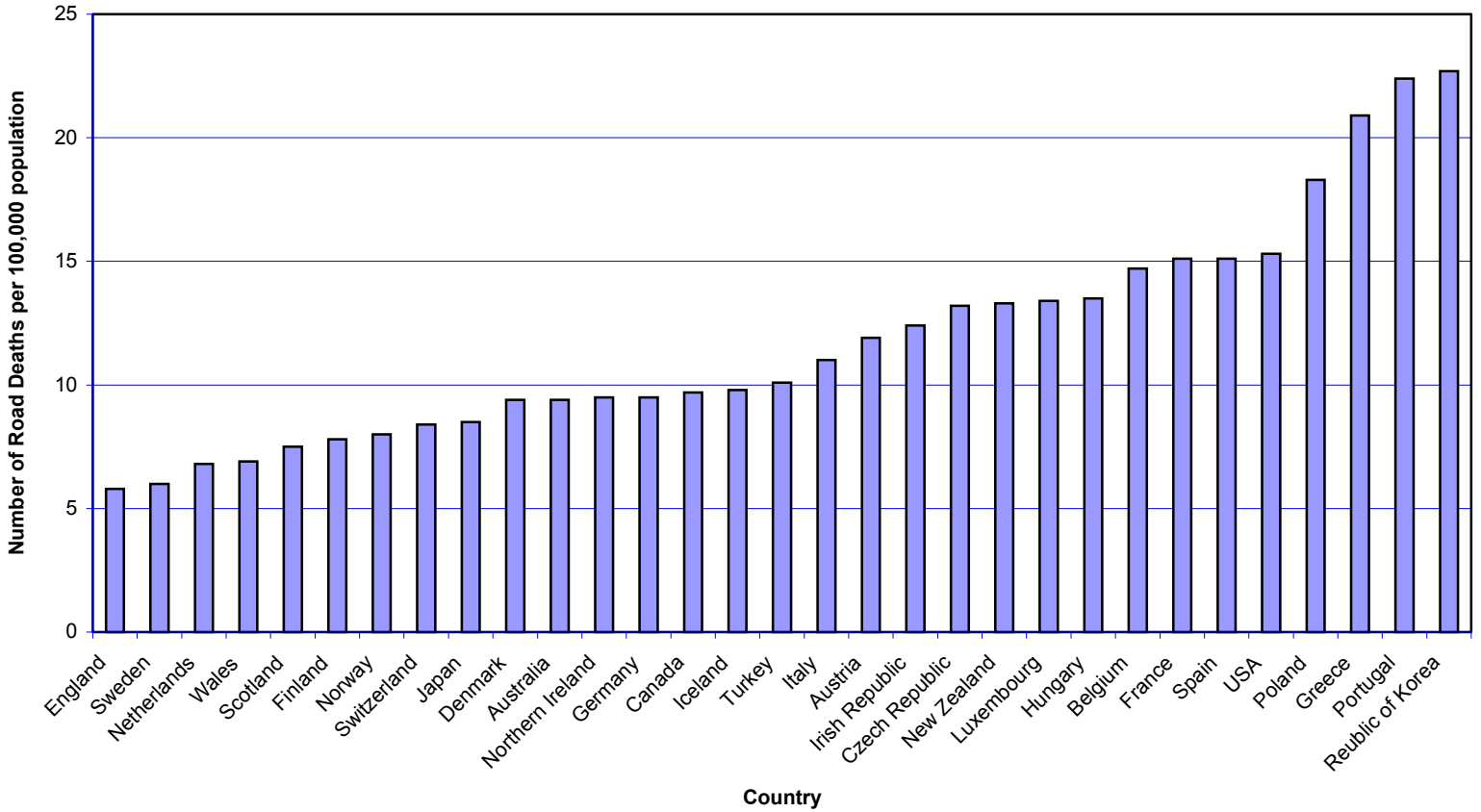

**Table A6.10 - International Experience: Fatal Accident Summary**