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MOTORCYCLISTS AND ROADSIDE SAFETY HARDWARE

Malcolm D Macdonald, TRL Ltd, Crowthorne, Berkshire, U.K.

ABSTRACT

This Paper attempts to summarise the present situation regarding ”single vehicle / first event” situation for motorcyclist impacts with roadside safety hardware. Topics referred to include development work using computational mechanics and full-scale impact tests. Various systems have been developed, assessed and put into service to reduce the consequences of motorcyclists impacting roadside hardware and these are also covered.

The purpose and performance objectives of such hardware need to recognise both the range of types of traffic, and real accident data.

1. INTRODUCTION.

Over recent years, it has become apparent that varying degrees of concern have been expressed about the possible cause of injury, sometimes very serious, to motorcyclists when they impact Vehicle Restraint Systems (VRS). This term is used in Europe to cover safety fences, safety barriers, bridge parapets etc. It was invariably the case that the motorcyclist had separated from the motorcycle and subsequently impacted one or more posts of a safety fence, and as a consequence sustained serious injury.

However, it is readily acknowledged that such concern has been studied on several previous occasions and many of the anticipated items of interest have been reported. Taking this into account, many matters of current concern make reference to previous publications. However, additional observations are presented, or topics added, when appropriate.

For the purposes of this relatively short presentation, the following observations are made in order to concentrate on the more specific matters of interest.

(i) The objectives of the current European Standard, EN 1317 [(1)] and developed specifications for roadside hardware (European expression – "Vehicle Restraint Systems") in the form of safety fences and safety barriers, are primarily to set the requirement for the containment and redirection of errant vehicles. The categories for these vehicles range from small cars to heavy goods; the Standard and the systems are not designed to accommodate impacts by motorcyclists.

(ii) The Standard is generally applied to major road systems and are not necessarily to minor or country roads.

(iii) There is a distinction between a safety fence and a safety barrier installed as a permanent system. A safety fence is a 'vehicle restraint system' consisting of one or more horizontal elements supported by posts mounted in foundations. Safety barriers are normally constructed to form a continuous 'smooth' surface to the traffic, the most common form of construction uses concrete. Because of their fundamentally different forms of construction, safety barriers are not considered to present the same type of hazard to motorcyclists.

(iv) No attempt has been made to identify 'causation' for a motorcyclist to impact a vehicle restraint system. This is because it is an extensive subject in its own right, covering such matters as road surface and alignment, drainage, signage and the environment.

2. THE CAUSE FOR CONCERN

It is invariably the case that when the motion of a solo motorcyclist is significantly disturbed, he will become detached from the machine. It is also the fact that his initial speed will be similar to that of the motorcycle at the time of separation. Motorcycling provides a sense of freedom and exhilaration not available with other forms of motorised road transport except possibly that derived from performance cars. This does not mean or imply that incidents are necessarily related to incautious behaviour, only that the style of riding combined with the inherent instability of a motorcycle, is more likely to lead the unwary rider into an accident situation.

Once a rider has become detached from his machine, there is the possibility that he will be arrested by an object. This will probably be the situation for major roads in Europe where it is common practice to install roadside hardware in the central reserves and verges. It will also be similar for many of the minor roads in country and mountainous areas. Items that present themselves as hazards vary from natural objects such as trees to artificial systems such as VRS.

The most common form of safety fence consists of sheet steel posts supporting steel beams or fabricated wire cables. The majority of concerns have claimed that the hazard to motorcyclists is their impact with a safety fence and in particular with those designs that have as their primary restraining element one or more cables. However, it is now generally recognised that while the cables may well be *perceived* to be the cause of injury, it is much more likely that it is the supporting posts that are the *actual* hazard, because the motorcyclists have invariably been dismounted. An impact at or very near ground level, with a securely mounted steel (or timber) safety fence post will probably result in some form of injury. This would depend upon the impact speed as well as the attitude and point of engagement of the rider with the post.

There is no doubt that in the discipline of ‘road safety’, concern for the safety of motorcyclists needs to be considered and there is much evidence that this takes place. An extensive report by Duncan [(2)], includes an account of injuries received by motorcyclists impacting VRS (Section 4). However, he acknowledges that differences in safety systems impacted are not always explicitly recorded. For example the following descriptions are used, guardrails, guard fence, barriers, safety barrier, barrier, metal mesh fencing, and median and roadside barrier.

Conclusion:
As with any vehicular impact with a ‘barrier’, the design and installation of the system needs to be reported. This is no less the case if the impact is by a motorcycle or a motorcyclist. A limited study of car and HGV impacts with VRS by TRL in the UK [(3)], used printed cards illustrating a range of hardware systems. These cards were provided to police forces and the relevant system marked on the card and returned to TRL. Prepared descriptions of accidents can also assist the collection of accident data.

3. SAFETY MEASURES.

Devices - have been developed to reduce either the possibility of contact with safety fence posts generally, or the consequences of striking the post itself. An extensive account of work carried out up to the year 2000, is presented by Duncan [(2)] (Section 4.5), therefore only general observations on the work are mentioned below, selected illustrations are provided in Appendix “A”: -

- Changes in post section – may have a small benefit but the fundamental problem is the post itself.
- Encasing the post – a variety of systems designed to attenuate an impact.
- Additional elements – added below the existing beam to shield the posts in the form of a beam or plate. These tend to convert the traffic face of a safety fence towards that of a safety barrier.
- Wire rope ‘shroud’ – designed to cover the upper and lower wire ropes but does not modify the posts
- The majority, if not all, have been accepted by various national authorities and others for installation on their roads.
- A comprehensive list of these systems is presented in Appendix "B".

Investigations – have been carried out by a variety of means. In examples of computer modelling, impacts have been studied with the rider sliding along at ground level Appendix "C" and mounted Appendix "D". Full-scale impact tests have also been carried out by impacting a dummy into a safety fence, LIER [(4)]. Similarly, full-scale tests have been reported where a mounted rider (an anthropomorphic dummy) impacts a variety of 'barriers' both in the upright position and sliding along at ground level. Illustrations are shown in Appendix “E”.

Observation:
VRS have been certified / approved for installation on the highway to contain and redirect a range of vehicles that do *not* include motorcycles. There appears to have been little if any full-scale impact testing to confirm that the performance of the original design of the safety fence has not been adversely affected by the application of devices promoted to mitigate against impacts by motorcyclists.

Variations to Certified systems are currently being studied by Task Group 1 of the European committee CEN/TC226 WG1 under item “Equivalent products”.

4. ASSESSING THE BENEFITS.

All the mitigation measures are designed to reduce the consequences of motorcyclists impacting safety fences and in the majority of cases the element of concern is the safety fence post. However, there are at least two important aspects that would benefit from a co-operative study.

Firstly, the very nature of 'real life' accidents to classify the conditions of contact and the resulting range of injuries.

Secondly, to develop a format and procedure for assessing the performance of the mitigation measures.

These views are very similar to those expressed by Duncan [(2)] (Section 4.7.2), particularly where he reports *"There is a significant absence of information in the literature regarding the nature of motorcyclist crashes, especially those involving guardrails."* There is also a detailed description provided (Section 4.8) listing recommendations for full-scale impact testing including requirements for a 'motorcyclist dummy'.

5. THE MAGNITUDE OF THE PROBLEM.

The Federation of European Motorcyclists Association (FEMA) report [5], it records that with regard to motorcyclists and crash barriers:

> *'The seriousness of the situation is recognised by the Directorate-General VII with question of crash barriers and motorcycles being identified as a priority action in the European Commission's communication " Promoting Road Safety in the EU – The Programme for 1997 to 2001". COM (97)131 final, of the 9th April 1997.'*

It has already been stated that there is an absence of data concerning impacts between motorcyclists and safety fences. Never the less, there has been a considerable expression of concern about this type of incident covered by various publications and in exchanges of correspondence. It is also the case that safety fences and safety barriers have been developed, certified and installed to improve the safety for other road users.

While the majority of European countries have recorded car impacts with roadside safety devices for many years, the absence of similar data for motorcycle accidents has been observed on a number occasions (even though this was recognised in 1997 by the European Commission, see above): -

- EEVC/CEVE [6]:
  'The road environment' – "There is inadequate information about the impact effects of concrete and wire-rope barriers (on motorcyclists)".
- FEMA [5]:
  'Review of existing papers & research' – "Although the list of research related to crash barriers or motorcyclists seems well furnished (23 in total), they are often ancient, and few papers are really relevant to the specific cases of motorcyclists and Crash barriers".
- Duncan [2]:
  'Abstract' – *"A review of the relevant national and international literature was conducted, revealing a relative lack of published material regarding the nature of motorcycle collisions both with roadside barriers as well as motorcycle crashes in general".*
  Recommendations 6.3.1 *(i) Undertake Motorcyclist Crash Study – define the magnitude and nature of motorcyclist crashes…*
- Duncan [7]:
  The above comment and recommendation is repeated within Section G 'Overall Priorities item (2).
- ATSB [8].
  "Routine accident reporting and analysis systems do not reliably identify crashes where have played a role, and do not adequately discriminate between different types of barrier. This is particularly the case with non-fatal crashes".

There have been several publications that contain references to motorcycle accidents including Ouellet [9], Quincy [10], Ellmers [11], the Ministry van Verkeer en Watterstaat [12], TNO [13] as well as the presentation of international information Appendix "F" and Appendix "G".

However, it would appear that only moderate amounts of accident data are available identifying the specific area of motorcyclists impacting vehicle restraint systems. There is therefore a need to obtain comparative information on single vehicle, car and motorcyclist, impacts with both verge and central reserve vehicle restraint systems (VRS). This information would need to include the:

- Impact conditions, including approach speed, angle and attitude.
- Design features of the VRS and zone of contact.
- The consequential performance of the VRS as assessed by their existing criteria when impacted by vehicles and an agreed equivalent set of measurements for motorcyclists.

It is the comparison between these two sets of data that would put into perspective, in an objective and factual manner, the relative magnitude of the problem currently attributed to motorcycle accidents involving VRS.

Even if this information becomes available, it needs to be recognised that the most commonly applied criteria for the application of safety measures to the highway, tends to be the relationship between that of the rate and costs of accidents, and the relative cost of introducing mitigation measures. A safety device may well have a high "effectiveness rating" (the degree to which injury is reduced), but it may well be the "cost benefit" that decides its deployment. A further consideration is the source of funding of which there are probably two forms. The first is “national”, that is, Government or Federal, and the second is “local” that is, Metropolitan, State, County etc. It is very probable that the accident data would indicate that there are fewer motorcycle incidents on major roads (motorways, autobahns, interstate etc) relative to urban or local roads. If this proves to be the case, it could be critical to the implementation of mitigation measures. This is because “national” roads tend to be funded by Government and other roads by local authorities. The situation can then arise where the local authorities, responsible to their immediate communities have the problem but with limited resources. Central government however, rather more remote as perceived by the community, may have a lesser problem but larger resources.

6. MITIGATION MEASURES

Having obtained the detailed real life accident data for the specific case of motorcycle to VRS impacts. It is then recommended that the following be undertaken and reported:

(i) If not already available, the development of possible solutions to reduce the effects of such impacts.
(ii) The VRS be reassessed to determine if the 'solutions' adversely affect their Certified performance for impacts by other motorised vehicles, EN 1317 [(1)].
(ii) Such mitigation measures are installed at selected sites.
(iii) Before and after studies to assess the benefits of such measures.

This last point is particularly important. The subject of 'allowing' for the provision of safety features, risk compensation or "risk homoeostasis" or has recently been discussed in the British Medical Journal [(14)]. It is interesting to note that when the article refers to vehicles, they do not appear to include motorcyclists. It is suggested that the ability to maintain the 'risk factor' is probably more available to the motorcyclist than the car driver. This could be by virtue of the flexibility, sense of freedom and exhilaration provided by the machine. However, any consequential of loss of control tends to be more immediate and severe than when 'risk compensation' is exercised by the car driver.

7. CONCLUSIONS

1. There has been a considerable amount of effort expended in modelling, full-scale impact tests and the development of an extensive range of measures to reduce the consequences of motorcycle impacts with Vehicle Restraint Systems.

2. There is a general agreement that the harmful items are the exposed posts of safety fences, irrespective of their other components.

3. There is a clear indication that there is insufficient information concerning the quantity and nature of motorcycle impacts with Vehicle Restraint Systems.

4. There is a need to obtain detailed and comparative information on single vehicle (car and motorcyclist) impacts with both verge and central reserves on both major and minor roads.

5. This information would enable the relative magnitude of the problem, currently attributed to motorcycle accidents involving VRS, to be put into perspective in an objective and factual manner.

6. The introduction of any mitigating system that has a high "effectiveness rating" will need to take into account the "cost benefit" aspects as assessed by both 'national' and 'local' authorities.

Closing remarks:

In preparing this Paper, many items have been shown to discuss the matter of injuries caused to motorcyclists. Reference has been made to some, others are given in the Bibliography and numerous exchanges are available on web sites. It has therefore not been possible to do proper justice to all the information available.

Any views expressed in this Presentation are not necessarily those of either the Highways Agency or of TRL Ltd.

The support given by both the UK Highways Agency and TRL Limited is greatly acknowledged.

8. REFERENCES.

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   Part 1: *Terminology and general criteria for test methods.*
   Part 2: *Performance classes, impact test acceptance criteria and test methods for safety barriers*.

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   Accident Research Centre, Monash University, Australia.
   December 2000.

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   Research Report 75: Safety Fences and Bridge Parapets - TRRL
   Papers for the 1986 TRB Annual Meeting, Paper 2.

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   Laboratoire d'essais Inrets Equipements de la Route.

5. FEMA, — *"Final report of the Motorcyclists & Crash Barriers Project"*.
   Federation of European Motorcyclists Associations.
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   (European Experimental Vehicles Committee)
   December 1993

7. Duncan, — *"Motorcyclists and Barriers".*
   Accident Research Centre, Monash University, Australia.
   April 2001.

8. ATSB — *"Review of Wire Rope Safety Barriers".*
   [www..atsb.gov.au/road/pdf/wrbarrier.pdf]

9. Ouellet, — *"Environmental hazards in motorcycle accidents".*
   American Association for Automotive Medicine annual conference, Proceedings, pp. 117-129
   26th, October 4-6, 1982, Ottawa.

10. Quincy — "Protocole d'essais de dispositifs de retenue assurant la sécurité des motocyclistes- Rapport final " LIER - 03 août 1998.
    "*Protocol of tests of devices of reserve ensuring the safety of the motorcylcists - final Report*"
    Transportation Research Circular No 341, December 1988: International Roadside Safety Hardware Research.

11. Ellmers — *"Guardrail-post protection for improving the safety of motorcycle Riders".*
    Traffic Safety on Two Continents, 22-24 September 1997, Lisbon, Portugal.

12. Ministry van Verkeer en Watterstaat , Ongevallenanalyse motoren op autonelwegen in Nederland *"Analysis of motorcycle accidents on motorways in the Netherlands",* Directorate-General of Public Works and Water Management (Rijkswaterstaat). 15 March 2002.

13. TNO Motorfietsongevallen op autosnelwegen - analyse van in-depth en procesverbaaldata. *"Motorcycle accidents on motorways: analysis of in-depth and record data".* Netherlands Organization for Applied Scientific Research (TNO), 14 March, 2002.

14. BMJ *"Does risk homoeostasis theory have implications for road safety".* British Medical Journal, No 7346, 11 May 2002, pp 1149-1152. [www.bmj.com]

15. Bast "Anprallversuche mit Motorrädern an passiven Schutzeinrichtungen". "*Motorcycle crash tests with passive safety elements*". Verkehrtechnik V90

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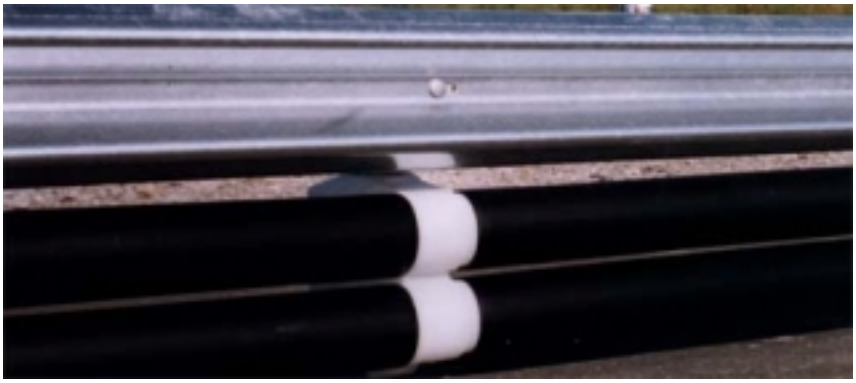
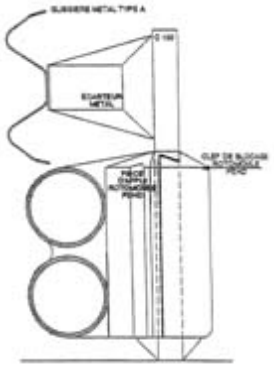
Hofbauer,	*"The effect of crash barrier protectors".* 23rd February 1995.
Bürkel Bauman Schuler	"Sicherheitsmassnahmen an Leitschranken zum Schutz der Motorradfahrer". "*Safety precautions at guard rails for the protection of the motorist"* Burkel Bauman Schuler, Ingenieure + Planer AG, 8400 Winterthur May 1997.
Koch	*"Reduction of Injury Severity Involving Guardrails by the Use of Additional W-Beams, Impact Attenuators and 'Sigma-Posts' as a Contribution to the Passive Safety of Motorcyclists".* Experimental safety vehicles.
ISO 13232-2:1996	*"Definition of impact conditions in relation to accident data".*

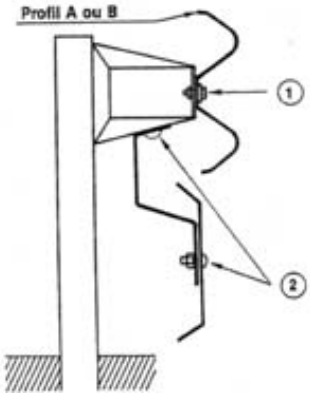
Web sites:

Nmcu@mncu.org	Norwegian Crash Barrier Manual
www.mrf.org/researchproposals.php	"Making Crash Barriers and Road Maintenance Practices Motorcycle-Friendly".
www.mrf.org/rp_barriers.php	
www.highwaysafety.org	Insurance Institute for Highway Safety.

APPENDIX "A": Ref: [www.setra.fr/groupes/glisseres.shtl]







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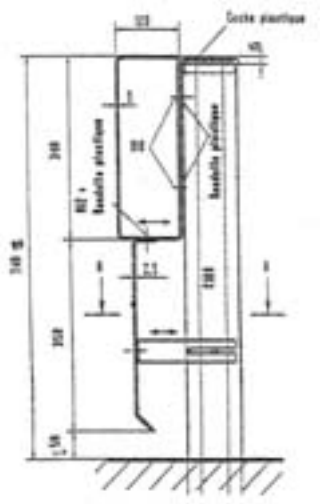

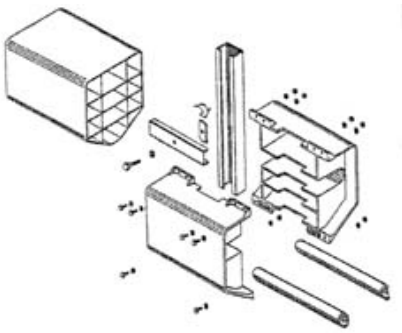

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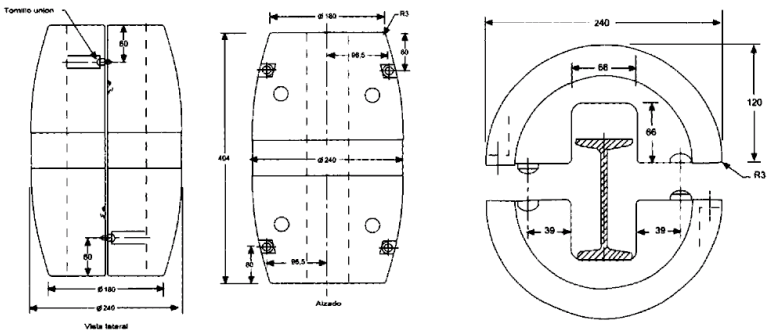
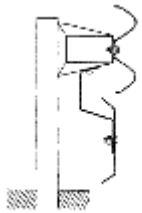
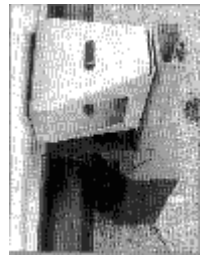
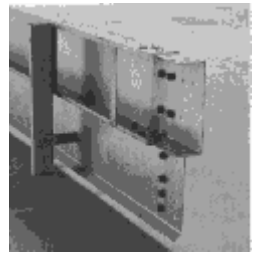
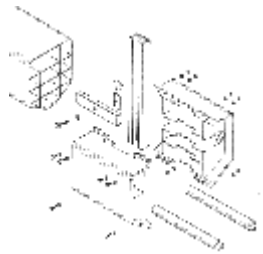
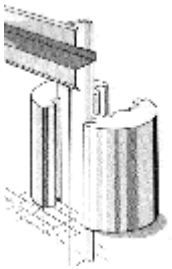
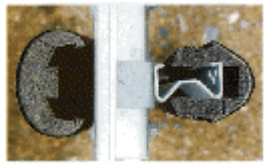


APPENDIX "B": BARRIER TYPES - see [*www.fema.nl/vangrail/annexe.html*]
Motorcyclists & Crash Barriers Project Report List & details of some motorcycle friendly devices identified

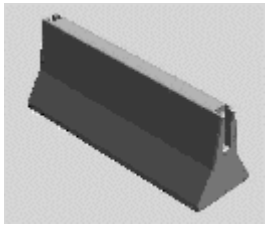
Motorcycle-friendly Roadsides: BARRIERS	Company Model	Costs (july 99)	Type	Details	Address & Contact details	
	Sec Envel Ecran Motard	Material 12 €/m Fitting 3 €/m	Adaptable to existing rail	Cheapest «secondary rail» approach	SEC Envel 18 rue Pasteur F-77250 Veneux les Sablons T: +33 160709393 F: +33 160709999	
	Sodirel Mototub	Material 21 €/m Fitting 2 €/m	Adaptable to existing rail	Made up of 70% recycled material	Sodirel Route d'Orange F-84100 Uchaux T: +33 490111600 F: +33 490516240	
	Solosar Motorail	Material 38 €/m Fitting 6 €/m	«All in one» solution	Integrated solution: Cost of metal barrier included (estimated cost of metal barrier without metal shield: 18,3 €/m)	Solosar 3 rue G.Schoettke ZI Parc d'activités du Grand Bois F-57200 Sarreguemines T: +33 387985604 F: +33 387955593	
	Sodilor Railplast	Material 23 €/m Fitting 4 €/m	Adaptable to existing rail	Joining the advantages of the «secondary rail» and the «impact protector»	Sodilor Rue du champ de Mars BP 40739 F- 57207 Sarreguemines cedex T: +33 387982588 F: +33 387984656	

APPENDIX "B": BARRIER TYPES (cont)

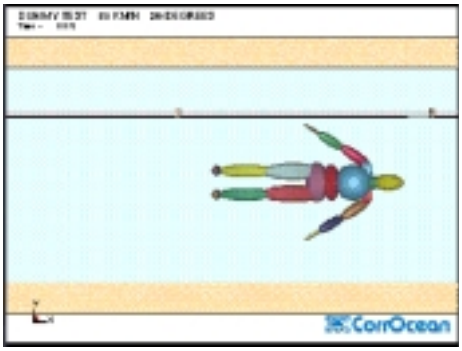
Motorcycle-friendly roadsides: **POST PROTECTOR**	**Company** **Model**	**Costs (july 99)**	**Description**	*Recommendation of use depends on the profile of crash barrier post. Contact Company directly for best advice.*	**Details**
	ADV SPU	Material 10,5 € Fitting ?	2 (½) shells	Adaptable to existing rail	Firma ADV Postfach 110067 D-63434 Hanau T: +49 6181661748 F: +49 6181499276
	Salzer Formtech Rectangular CBP	Material 4,6 € Fitting ?	1 single ¾ shell	Adaptable to existing rail	Salzer Formtech Stattersdorferstrasse 50 A-3100 St Poelten T: +43 2742290313 F: +43 2742290333
	Volkman & Rossbach SPU Crash Absorber	Material nc Fitting ?		2 (½) shells clipping together	Volkman & Rossbach Hohe Strasse 11-19 D-56401 Montabaur T: +49 26021350 F: +49 26021349

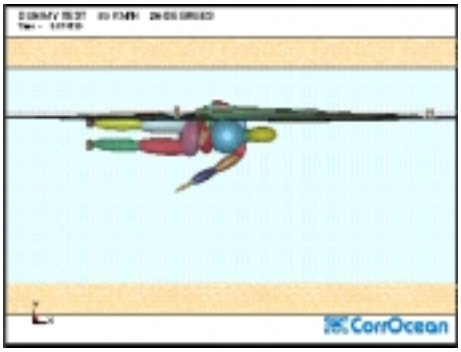
Posts are usually located every 2 meter or every 4 meter.

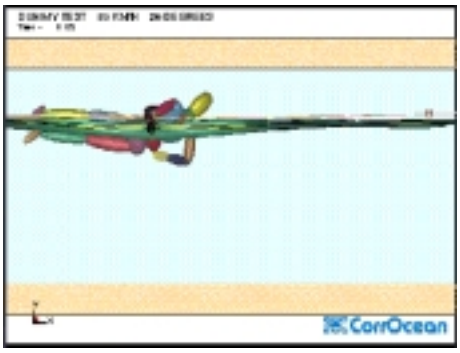
APPENDIX "B": BARRIER TYPES (cont)

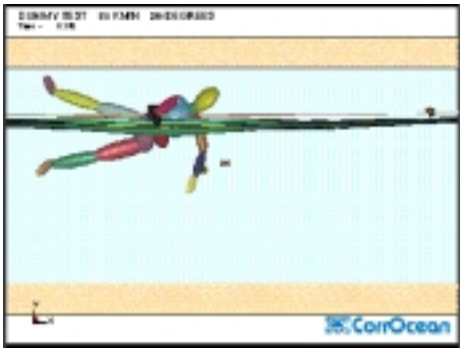
Motorcycle-friendly roadsides: **ALTERNATIVE SOLUTIONS FOR NEW INSTALLATIONS**	**Type**	**Costs**	**+**	**-**	**Remarks**	**Details**
	Concrete Walls	38 €/m	Lower maintenance costs Prevents truck crossover	No impact absorbtion property Not recommended in nordic countries	Motorcycle "friendliness" depends largely on the profile used «All in one» solution	Costs valid only for large quantities
	Obstacle free roadsides	Variable	Benefits all categories of road users Increases visibility at road junctions		Feasibility depends on road layout and location	
	Shrub planted roadsides	Variable	Benefits all categories of road users Can reduce glare on central reservation of motorway	Requires some leeway area where shrubs can grow	Complementary to the «obstacle free» roadside approach	

APPENDIX "C": Courtesy Otto Kleppe

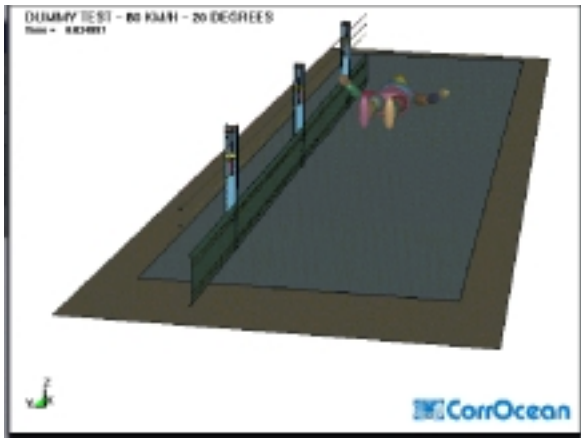


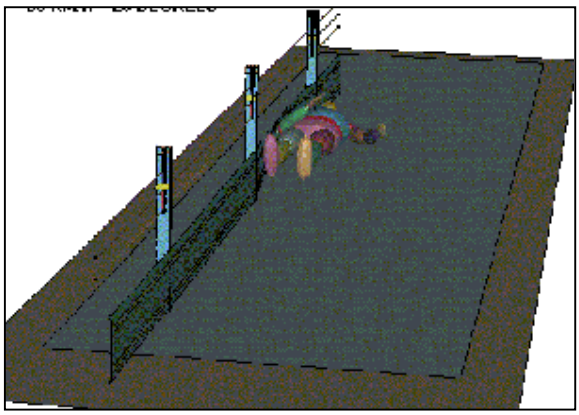


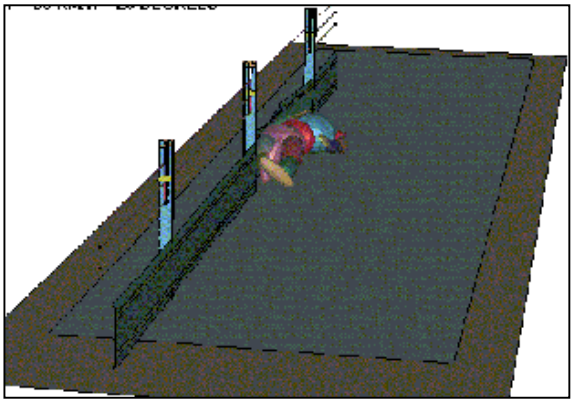


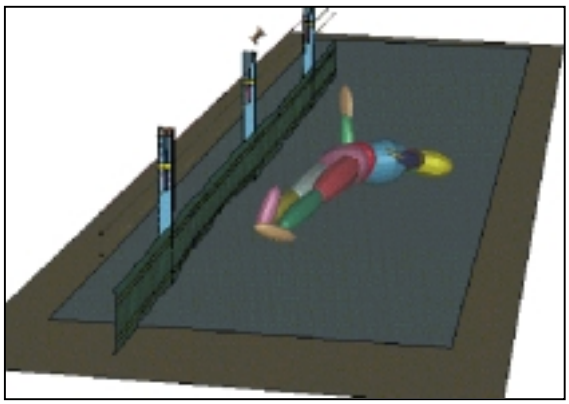


APPENDIX "C": (cont)
Courtesy Otto Kleppe

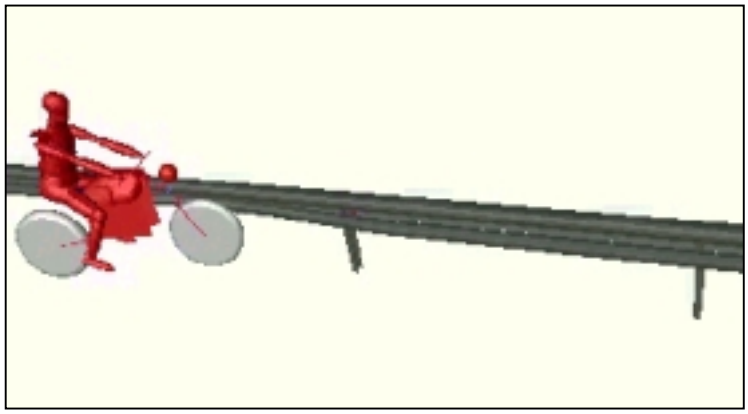


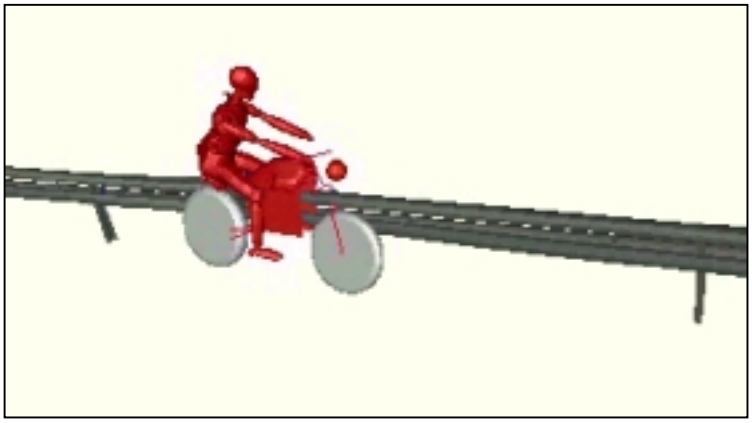


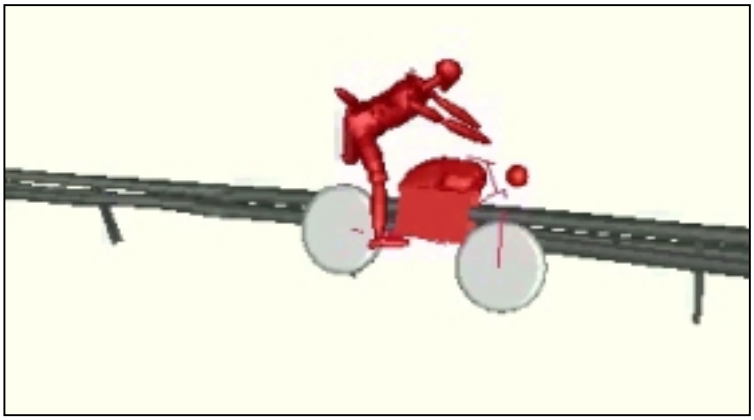


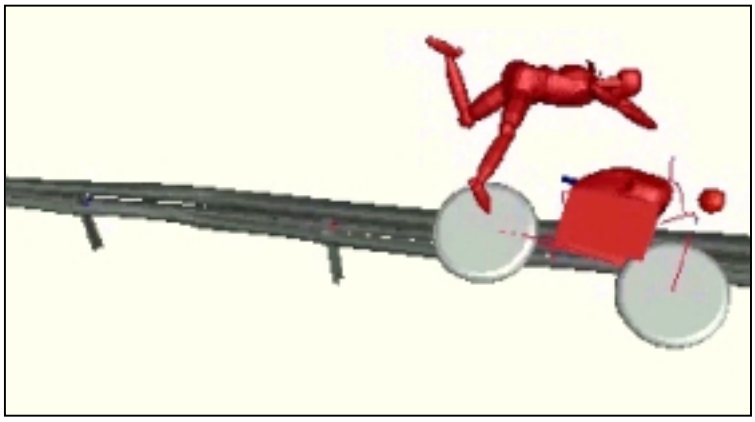


APPENDIX "D": Ref: [www.erab.se] then: "application examples" - "crash & impact" - "mc impact"









ANNEX "E": Courtesy of “bast” (see Ref. **15**)

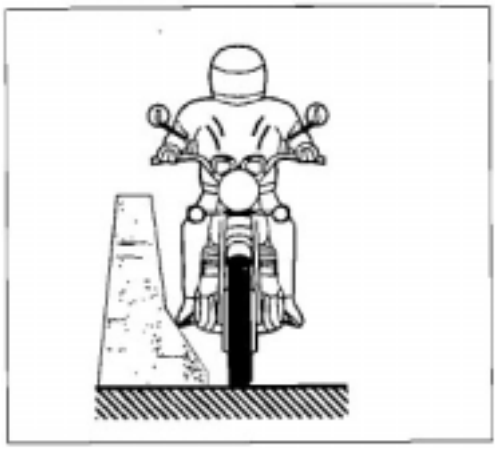


Bild 5.6: Anstoßkonstellation an der einseitigen Betonschutzwand

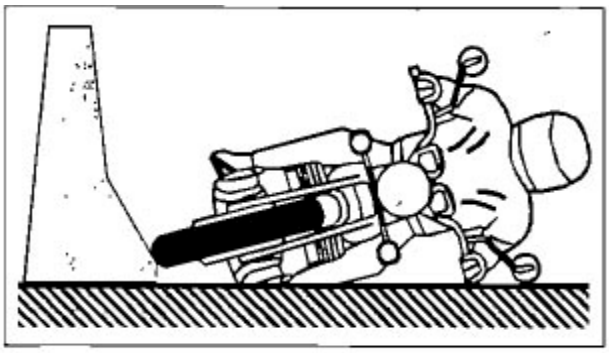


Bild 6.6: Position beim Anstoß an der Betonschutzwand

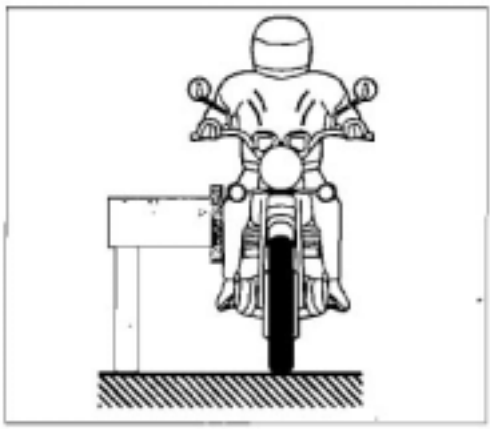


Bild 5.1: Anstoßkonstellation an der einfachen Distanzschutzplanke EDSP

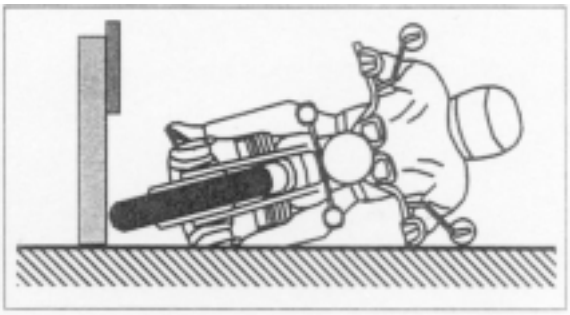


Bild 6.1: Anstoßkonstellation an der einfachen Schutzplanke

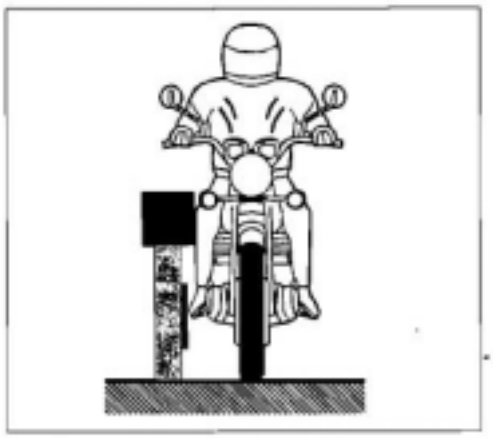


Bild 8.1: Optimierte aufrechte Anprallsituation

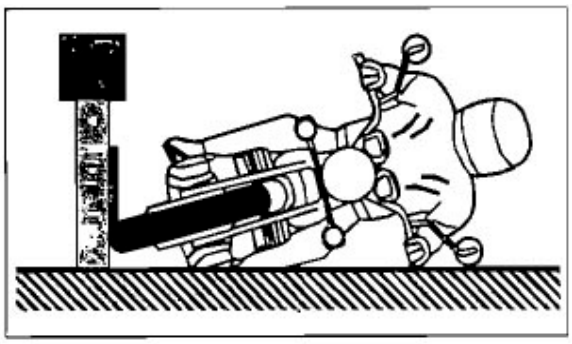


Bild 8.2: Optimierte **rutschende** Anprallsituation

APPENDIX "F":

International Road Traffic and Accident Database (OECD)
Issue: April 2002

Fatalities by Traffic Participation **)

Country	Code	Occupants of Motorized Two-Wheelers			Occupants of Passenger Cars and Station Wagons		
		1980	1999	2000	1980	1999	2000
Australia	AU	442	-	-	2 080	-	-
Austria	AT	316	151	156	1 066	614	549
Belgium	BE	349	198	182	1 227	855	922
Canada	CA	371	160	-	-	1 637	-
Czech Republic	CZ	121	118	116	397	775	784
Denmark	DK	131	67	71	300	271	235
Finland	FI	64	21	19	202	251	224
France	FR	2 556	1 445	1 392	7 267	5 455	5 291
Germany	DE	2 631	1 128	1 102	6 915	4 640	4 396
Greece	GR	241	569	-	463	856	-
Hungary	HU	267	92	85	378	520	500
Iceland	IS	2	1	0	10	14	27
Ireland	IE	48	43	39	249	236	260
Italy	IT	1 805	-	-	4 112	-	-
Japan	JP	2 201	1 764	1 847	3 006	2 804	2 901
Luxembourg	LU	-	5	8	-	49	53
Netherlands	NL	321	182	196	910	535	513
New Zealand	NZ	91	42	31	362	377	358
Norway	NO	47	38	-	199	214	-
Poland	PL	1 031	288	253	1 213	2 862	2 709
Portugal	PT	-	506	435	-	821	899
Republic of Korea	KR	-	1 642	1 564	-	3 043	2 792
Spain	ES	751	903	866	3 501	3 196	3 294
Sweden	SE	77	48	49	469	372	393
Switzerland	CH	265	99	111	577	299	273
Turkey	TR	-	242	234	-	2 699	2 027
United Kingdom	UK	1 187	556	612	2 360	1 778	1 784
USA	US	5 144	2 483	2 862	27 455	20 862	20 492

**) Killed: 30-Day-Period, except:

I,	before 1999 (7 Days) +8%;	F,	(6 Days) +5,7%, before 1993 +9%;
E,	before 1993 (24 Hours) +30%;	GR,	before 1996 (3 Days) +18%;
A ,	until 1991 (3 Days) +12%, before 1983 +15%;	CH,	before 1992 (unlimited) -3%;
J,	before 1993 (24 Hours) +30%;	KR (ROK),	before 2000 (3 Days) +15%;
TR,	(24 hours) +30%;	P,	(24 hours) changed to +14%, all figures for Portugal revised accordingly.

englisch.htmlBack (Brief Overview - International Road Traffic and Accident Data)

APPENDIX "G":

Courtesy: "Insurance Institute for Highway Safety, Status Report, Vol. 37, No 1, January 12, 2002."