MAIN INJURIES PRODUCT TO PEDESTRIAN BY IMPACT WITH DIFFERENT PARTS OF THE VEHICLE

Dorin Dumitrascu, Bogdan Benea

Transilvania University of Brasov, Romania

KEYWORDS – injuries, impact, vehicle, pedestrian, car body

ABSTRACT - It would to mitigate the severity of pedestrian injuries by improving the vehicles front structures. Starting at a certain speed the goal to reduce these injuries is limited, but at speeds below 40 km/h are possible significant reductions of injuries of pedestrians involved in frontal impacts with vehicles.

Between 1980 and 2000 the fatality rate was reduced by 65% from 40 to 14 per one million inhabitants.

It followed a further reduction of fatality by 30% and 17% severe injuries until 2010. Statistics show the possibility to reach this level without imposing directives or testing procedures.

EXPERIMENTAL TESTING

Experimental testing is an important component of biomechanical studies especially in automotive safety applications.

They provide researchers key information is then used to:

- Material characterization by biologically point of view;
- Develop criteria for assessing the injury;
- Design and development anthropometric test devices;
- Develop regulations and standards for crash tests;
- Determining the strength and load limits for models designed on the computer.

Physical tests can be classified on a scale from simple tests on body parts, to design the actual impact vehicle/vehicle with a few passengers.

Laborious research in this area began in the '60s by designing models. The data were used to obtain values of moments, forces, accelerations and velocities during impact.

For general assessment of injuries in any region of the body physicists have proposed a scale AIS (Abbreviated Injury Scale). Any level of harm is assessed on it, from AIS 0 to 6 with the correlation in Table 1.

Injuries with an AIS level of 3 are considered tolerable, but from AIS 4, the security standards seek to eliminate the effects. AIS levels were developed for each region of the body.

Charts 1, 2, 3 show the link between the AIS/MAIS of injuries and the impact speed. It can be observed that for a collision speed of 40km/h, the cumulative frequency of injury is about 75-80% AIS2, respectively 65-70% MAIS2.

Table 1. Correlation between severity of injury and AIS scale

AIS scale	Level of injury	The percentage of fatality
0	Without injury	0 %
1	Minor injury	0%
2	Medium injury	0.1 – 0.4%
3	Serious injury	0.8 – 2.1%
4	Severe injury	7.9 – 10.6%
5	Critical condition	53.1 – 58.4%
6	Maximum	Probability of death

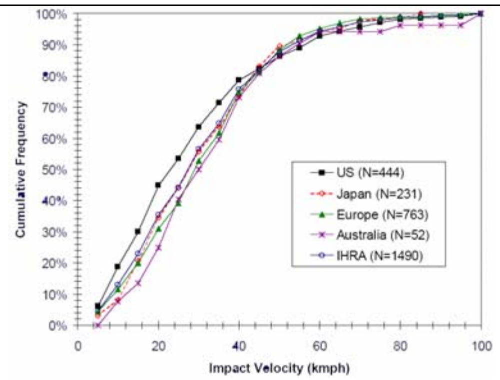

Fig. 1. Distribution of impact velocities for accidents with pedestrians (AIS 2) [32]

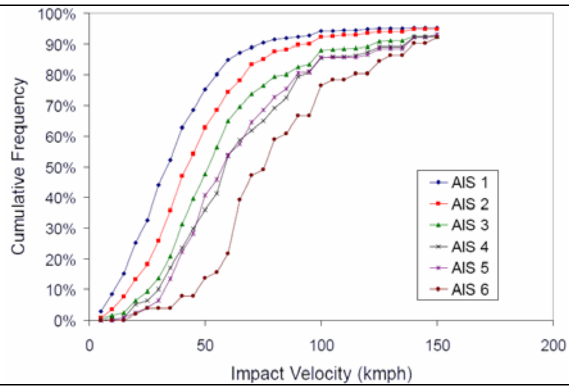

Fig. 2. Distribution of impact velocities for accidents with pedestrians [32]

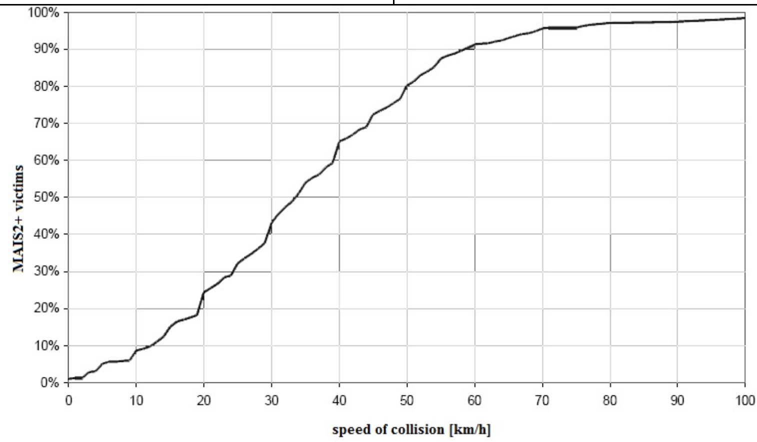

Fig. 3. Cumulative distribution of severity of injuries MAIS2 + depending on the speed of collision, using extensive GIDAS database [38]

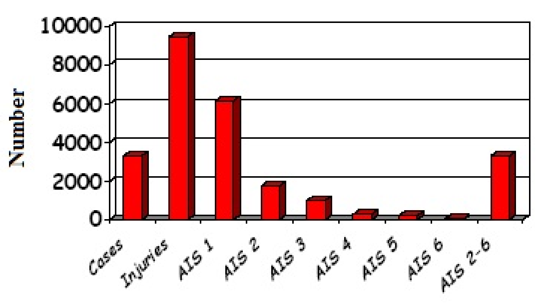

Fig. 4. Distribution of injury severity. Dataset of pedestrian accidents IHRA [32]

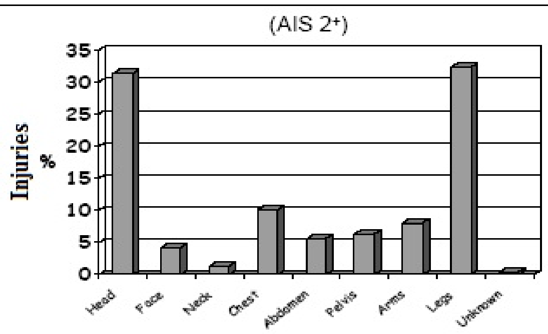

Fig. 5. Distribution of accidents according to body areas subjected to impact [32]

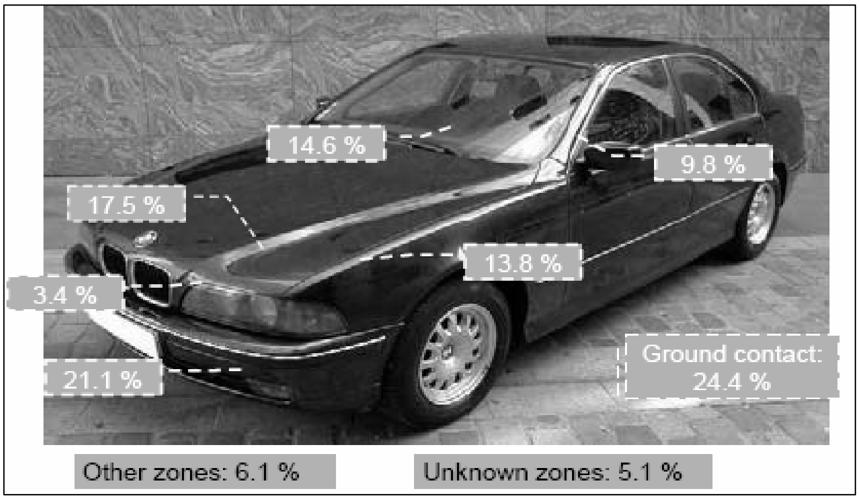

Fig. 6. Surface areas of automotive components injury-generating vehicle-pedestrian accidents [32]

THE TIBIA AND KNEE INJURIES

Accident Research Unit of Medical University Hannover/Germany studied 762 cases (1985-1995) in which pedestrians were struck by the front of the vehicle resulting in bodily injury.

Analysis showed that 75% of the pedestrians suffered leg injuries AIS1 + type, over 50% being localized to the tibia and about 33% at the knee. About 75% of injuries at 40% of the tibia and the knee are caused by the bumper. [34]

Accidents were divided into two groups: those involving motor vehicles on the market before 1990, namely those introduced from that date. Velocity distribution at the time of accident between groups showed minor differences.

Table 2 presents AIS1 + injuries on foot, impact velocities, respectively AIS2 + type injuries on the tibia and knee for both groups.

Table 2. Percentage of pedestrians who have suffered injuries from vehicle-pedestrian impact. Inf leg., Germany, 1985-1995 [34]

Level of injury	**Leg injury AIS1+**		**Tibia and knee AIS2+**	
Impact velocity	**Vehicle model <1990**	**Vehicle model >=1990**	**Vehicle model <1990**	**Vehicle model >=1990**
<= 40 km/h	75%	65%	25%	32%
> 40 km/h	86%	69%	52%	53%
All velocities	77%	66%	33%	38%

It can be observed a lower percentage of injuries when car models produced after 1990. However, 66% of the victims suffered leg injuries. Also, further analysis of German database for new vehicles, showed an increase in the proportion of pedestrians who have suffered injuries of tibia/knee type AIS2 +, especially for lower impact speeds of 40 km/h.

For UK, tests have been conducted by TRL using two data sources: a database drawn from police reports, respectively the Scottish Hospitals In-Patients Statistics (Ships). Ships data were used to analyze trends over time (1980-1994). The results showed an increase of about 33% (AIS2 +) and 50% (AIS3 +) of pedestrian suffering injuries of tibia and knee, resulting in 40% AIS2 + and 5% AIS3+ (see Fig. 4.).

Since 1995, a total of 1001 type car-pedestrian accidents reported in the department of Rhone, France were analyzed. Approximately 66% of the victims suffered MAIS1 + on the lower extremity, including the pelvis. More than 30% of victims over 60 years suffered MAIS2 + on the lower extremity. For that age, type MAIS2 + on pelvic injuries were predominant (12%). For the remaining age groups, the highest proportion of such injuries were reported on MAIS2 + tibia: Children 7% and 9% for adults, while the proportion of knee injuries have ranged between 1% and 5%.

THE FEMUR AND PELVIS INJURY

Hanover academics study showed that 17.4% of AIS1 + injuries were caused by the front edge of the bonnet, this percentage varies slightly depending on height, but with different areas of injury. For pedestrians with greater height of 120cm, legs (50%) and pelvis (30%) being most frequently injured regions of the front edge of the body, compared with arms (35%) and thorax (20%) for disabled height less than 120cm.

Table 3. Percentage of pedestrians who have suffered injuries from vehicle-pedestrian impact. Upper leg, Germany, 1985-1995 [34]

Level of injury	Femur and pelvis injury AIS2+	
Impact velocity	**Vehicle model < 1990**	**Vehicle model >= 1990**
<= 40 km/h	8%	0%
> 40 km/h	17%	24%
All velocities	11%	7%

Table 4. Percentage of pedestrians who have suffered injuries from vehicle-pedestrian impact. Upper leg, France, 1983-1995 [34]

Level of injury	Femur injury		Pelvis injury AIS2+	
Age	**Vehicle model <1990**	**Vehicle model >=1990**	**Vehicle model <1990**	**Vehicle model >=1990**
<= 12 years	38%	8%	8%	12%
12-49 years	20%	0%	21%	0%
> 49 years	19%	2%	22%	25%

Hanover academics study showed that in 83% of cases, the impact speed was less than 40km/h, at this speed occurred about 66% of cases with injuries AIS2 +. Type of head injury AIS1 + occurred in 59% of cases, with small differences between cars produced before 1990 and those produced after that date.

A noticeable reduction was reported for head injuries AIS2 + at speeds under 40km/h: from 18% to 15%. For speeds over 40km/h, the AIS2+ injury rate remains high: 55% for old cars, 53% for models produced after 1990.

For data presented in the table below 50% of injuries are located in the head, while about 20% in the thorax.

Table 5. Percentage of pedestrians who have suffered injuries from AIS1+ vehicle-pedestrian impact at the front edge of bonnet Germany, 1985-1995 [34]

Level of injury	Femur and pelvis injury AIS1+	
Impact velocity	**Vehicle model < 1990**	**Vehicle model >= 1990**
<= 40 km/h	24%	21%
> 40 km/h	39%	33%
All velocities	26%	21%

CONCLUSIONS

Conclusions can be summed up as follows:

- A high percentage of pedestrian suffering injuries to the shin or knee;
- Observe a substantial reduction in the percentage of pedestrian suffering injuries to the femur, probably caused by a front edge of the body with a curvature less demanding due rounded design;
- Injuries to the head, caused by the bonnet, wings, and windshield are common. A significant percentage of adults reach areas not covered by the test method EEVC. Ex.: Pillars, windscreen, especially the impact of a car with modern design.

ACKNOWLEDGEMENT

The paper was supported under the research grant ID_130/218/1.10.2007, with CNCSIS

REFERENCES

[1]. […BOS96] BOSCH, Automotive Handbook. 4th Edition, Robert BOSCH GmbH, Stuttgart, 1996, SAE Society of Automotive Engineers, Warrendale, USA, 1996;
[2]. […ARTRI02] ARTRI. Asociația Romana pentru Transporturile Rutiere Internaționale. Raport circulație rutieră 1991-2002;
[3]. […E/ECE14] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.13 Reg. No 14 (SAFETY-BELT ANCHORAGES);
[4]. […E/ECE15] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.14 Reg. No 15 (SAFETY-BELTS);
[5]. […E/ECE16] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.15 Reg. No 17 (SAFETY-BELTS AND RESTRAINT SYSTEMS FOR OCCUPANTS OF POWER-DRIVEN VEHICLES, VEHICLES EQUIPPED WITH SAFETYBELTS);
[6]. […E/ECE17] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.16 Reg. No 17 (STRENGTH OF SEATS);
[7]. […E/ECE25] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.24 Reg. No 25 (HEAD RESTRAINTS);
[8]. […E/ECE26] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.25 Reg. No 26 (EXTERNAL PROJECTIONS);
[9]. […E/ECE32] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.31 Reg. No 32 (REAR-END COLLISION);
[10]. […E/ECE33] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.32 Reg. No 33 (HEAD-ON COLLISION);
[11]. […E/ECE42] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.41 Reg. No 42 (FRONT AND REAR PROTECTIVE DEVICES);
[12]. […E/ECE43] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.42 Reg. No 43 (SAFETY GLAZING MATERIALS);
[13]. […E/ECE58] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.57 Reg. No 58 (REAR UNDERRUN PROTECTIVE DEVICES);
[14]. […E/ECE93] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.92 Reg. No 93 (FRONT UNDERRUN PROTECTIVE DEVICES);
[15]. […E/ECE94] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.93 Reg. No 94 (PROTECTION IN EVENT OF A FRONTAL COLLISION);
[16]. […E/ECE95] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.94 Reg. No 95 (PROTECTION IN EVENT OF A LATERAL COLLISION);
[17]. […E/ECE114] E/ECE/324-E/ECE/TRANS/505 Rev.1 Add.113 Reg. No 114 (REPLACEMENT AIRBAG SYSTEM);
[18]. […E/ECERAS] E/ECE RAS2004 Statistics of Road Traffic Accidents in Europe and North America Vol. XLIX 2004

[19]. […E/ECEWP] E/ECE TRANS/WP.1/80/Rev.1 (COLLECTION AND DISSEMINATION OF INFORMATION ON NATIONAL REQUIREMENTS CONCERNING ROAD TRAFFIC SAFETY)
[20]. […E/ECEWP] E/ECE TRANS/WP.29/861 (REPORT)
[21]. […E/ECEINF] E/ECE INF-GR-PS-12e Pedestrian Protection In Europe. The Potential of Car Design and Impact Testing
[22]. […E/ECEINF] E/ECE INF-GR-PS-102 Windscreen Tests according to EuroNCAP Protocol (Example), Paris, France, 28 Sept. – 1 Oct. 2004
[23]. […E/ECEINF] E/ECE INF-PS-45 EuroNCAP – EEVC WG17, phase1 compatibility, Tokyo, Japan, 15-16 May, 2003
[24]. […E/ECEINF] E/ECE INF-PS-69 PROPOSED DRAFT GLOBAL TECHNICAL REGULATION (GTR) on PEDESTRIAN PROTECTION
[25]. […E/ECEINF] E/ECE INF-PS-86 PROPOSED DRAFT GLOBAL TECHNICAL REGULATION (GTR) on PEDESTRIAN PROTECTION
[26]. […E/ECEINF] E/ECE INF-PS-113 PROPOSED DRAFT GLOBAL TECHNICAL REGULATION (GTR) on PEDESTRIAN PROTECTION
[27]. […E/ECEINF] E/ECE INF-PS-116 PROPOSED DRAFT GLOBAL TECHNICAL REGULATION (GTR) on PEDESTRIAN PROTECTION
[28]. […E/ECEWP] E/ECE TRANS/WP.29-GRSP-36-1 PROPOSED DRAFT GLOBAL TECHNICAL REGULATION (GTR) on PEDESTRIAN PROTECTION, 7-10 Dec. 2004
[29]. […CECWD] Commission of the European Communities, Working Document (Draft 00): Technical Prescriptions concerning Test Provisions for Frontal Protection Systems
[30]. [...ENCAP] EuroNCAP PEDESTRIAN TESTING PROTOCOL, Version 4.1, March 2004
[31]. [...AUTOLIV] AUTOLIV, R. Fredriksson, Y. Håland, J. Yang, EVALUATION OF A NEW PEDESTRIAN HEAD INJURY PROTECTION SYSTEM WITH A SENSOR IN THE BUMPER AND LIFTING OF THE BONNET'S REAR PART
[32]. [...WSITA] WorkShop: "New technologies for Reducing Injuries from Vehicles in European Traffic", Italy, 12 nov. 2004
[33]. […E/ECEWP] E/ECE TRANS/WP.29-GRSP-31-1 Summary of IHRA Pedestrian Safety Activities
[34]. […E/ECEINF] EEVC Working Group 17 Report: IMPROVED TEST METHODS TO EVALUATE PEDESTRIAN PROTECTION AFFORDED BY PASSENGER CARS, Dec. 1998, with Sep. 2002 updates
[35]. […E/ECEINF] E/ECE INF-PS-92: Technische Universitat DRESDEN, Equal Effectiveness Study on Pedestrian Protection, Apr. 2004
[36]. […E/ECEINF] E/ECE INF-PS-89: TRL, A study of the feasibility of measures relating to the protection of pedestrians and other vulnerable road users – Final report
[37]. […E/ECEINF] E/ECE INF-PS-91: MATRA - Pinin Farina, Study on Technical Feasibility of EEVC WG 17
[38]. [...SAVE-U] SENSORS AND SYSTEM ARCHITECTURE FOR VULNERABLE ROAD USERS PROTECTION: Deliverable 1-A: Vulnerable Road User Scenario Analysis, Feb.2003
[39]. [ASA2001] ASANDEI, C., Cercetări asupra dinamicii evenimentelor rutiere pieton-automobil. Teză de doctorat, 2001
[40]. [DET1997] DETTINGER, J., Beitrag zur Verfeinerung der Rekonstruktion von Fussgangerunfallen, part.1, Verkehrs Unfall und Fahrzeug Technik. 12/96;
[41]. [DET1997] DETTINGER, J., Beitrag zur Verfeinerung der Rekonstruktion von Fussgangerunfallen, part.2, Verkehrs Unfall und Fahrzeug Technik. 1/97;
[42]. [KIM2002] KIMBERLEY, W., Pedestrian Safety, Automotive Engineer. Jun 2002;
[43]. [LUC2003] LUCHES, D., Securitatea rutiera – deziderat al unei politici sociale
[44]. [PRI2003] PRITZKOW, R., Cercetari energetice in coliziunile autoturismelor. Teza de doctorat, 2003;
[45]. [TAN2003] TANASE, Gh., Cercetări teoretice si experimentale privind optimizarea structurii fata in ceea ce priveşte siguranța pasiva a automobilului, teza de doctorat, 2003;
[46]. [WUR2004] WURST, C., Knautschzone fur Kopfe, Der Spiegel. Nr.16, 4/2004;.