

A Comparative Study Between China and IHRA for the Vehicle-Pedestrian Impact

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ABSTRACT

A total of 200 detailed pedestrian accident cases of several areas in China were collected and analysed during last three years, the important information mainly include accident conditions, pedestrian information, human injury, vehicle injury sources, impact velocity, wrap around distance, and so on.

The front shape of 37 passenger cars with high occupancy in domestic market involved in the accident cases were investigated and categorized into three groups: Sedan, SUV (Sport Utility Vehicle) and 1-Box (One Box Vehicle), so that the effect of vehicle front shapes on the pedestrian impact dynamics response and body injuries were studied.

Then, the mathematical models for simulation of vehicle-pedestrian impact were developed using multi-body dynamics codes MADYMO to study response of pedestrian in vehicle-pedestrian impact. A parameter study was conducted under the conditions of different pedestrian size, impact velocities and vehicle shapes to determine and analyse the head impact condition which include HIC, head impact speed, head impact angle, WAD, head impact point, and so on.

The research result was compared to that of IHRA (International Harmonized Research Activities). It was found that the characteristics of pedestrian accidents in China had many similarities between that of IHRA. The simulation result of head impact condition according to front shape of passenger cars in Chinese market was also similar to that of IHRA pedestrian working group. This study provides an effective basis of technical

regulation for research on pedestrian test procedures and development of safer vehicle for pedestrian protection.

INTRODUCTION

Nearly 1.2 million people die annually in road crashes around the world. Pedestrian deaths are especially prevalent in developing countries because of the great variety and intensity of traffic mix and lack of separation between pedestrian and vehicle. Approximate 1/4 of traffic accidents deaths are pedestrian from 2000 to 2005 in China [1].

The IHRA Pedestrian safety Working Group (IHRA/PS-WG) is comprised of experts selected by the governments of Australia, Europe (EC/EEVC), Japan and USA. A primary task assigned to the IHRA/PS-WG is gathering the results of detailed research into the accident data to an agreed format. The data was collected from Australia, Europe, Japan and USA. The current dataset has been analyzed to determine the impact areas of vehicles, accident frequency and injured regions of pedestrian vs. passenger car crashes and to decide research priorities from these findings. The WG embarked on its research activities to develop adult and child head protection test methods, and adult lower leg/knee protection test method. By the end of 2004, the WG had completed adult and child head test methods and adult lower leg/knee test method [3].

In Japan, pedestrian accident data collected by JARI between 1987 and 1988, and in-depth case study data of pedestrian accidents conducted by ITARDA between 1994 and 1998 were combined into the IHRA accident

dataset. A total of 240 cases were acquired in the cities surrounding the Japan Automobile Research Institute (JARI). In Germany, investigation teams from both the Automotive Industry Research Association and Federal Road Research Institute collected accident information in a jointly conducted project called the German In-Depth Accident Study (GIDAS). A total of 783 cases were collected from the cities of Dresden and Hanover and their surrounding rural areas between 1985 and 1998. Detailed information from pedestrian crashes were collected in the United States through the Pedestrian Crash Data Study (PCDS). In this non-stratified study, a total of 521 cases were collected between 1994 and 1999. The Australian data is from at-the-scene investigations in 1999 and 2000 of pedestrian collisions in the Adelaide metropolitan area. Data from these four studies were combined into a single database for further analysis to develop a better basis for worldwide pedestrian impact conditions. From each of these studies, seven fields of information were identified, which were common to all four studies and were crucial to providing guidance in test procedure development [3].

During last three years, detailed pedestrian cases in China are also collected in this study. Accident data are mainly from Beijing city (North China) and Ningbo city of Zhejiang province (coastland of Southeast of China), Nanjing city of Jiangsu province (inland of Southeast of China), and cases of their surrounding rural areas are also included in this investigation. Pedestrian information mainly included age, stature, gender, injured body region, and injury severity. Vehicle information mainly included vehicle type, pedestrian contact location, damage pattern, and impact velocity.

DATA ANALYSIS

In 200 detailed pedestrian accident cases collected in China, a total of 415 injuries of AIS2-6 severity were observed, and there were 235 AIS1 injuries observed. These minor (AIS=1) injuries were excluded in some following analysis because they were not believed to be crucial in test procedure development. Injury composition in each country (for all pedestrian impact cases) is shown in Table 1[3]. It is found that the proportion of AIS1 injuries of China is slightly lower than that of IHRA. The proportion of AIS4+ in China is very low, which is similar to other IHRA countries.

Table 1. Pedestrian Injury Composition in each Country (AIS 1-6)

	Cases	Injuries	AIS1	AIS2	AIS3	AIS4	AIS5	AIS6
China	200	650	235	225	168	17	5	0
Australia	65	345	182	93	36	12	17	5
Germany	782	4056	2616	877	405	89	56	13
Japan	240	883	523	182	94	29	47	8
USA	518	4179	2837	599	477	144	99	23

Like other IHRA countries, head (38.6%) and lower extremities (27.2%) each accounted for about one-third of AIS2-6 pedestrian injuries in China, followed by chest and arms. This indicates that head and lower extremities is the leading part in pedestrian protection countermeasure. Distributions of pedestrian injury are shown in Table 2[3].

Table 2. Distributions of Pedestrian Injury in each Country (AIS2-6) %

Body Region	China	IHRA	USA	Germany	Japan	Australia
Head	38.6	31.4	32.7	29.9	28.9	39.3
Face	0.7	4.2	3.7	5.2	2.2	3.7
Neck	0.2	1.4	0.0	1.7	4.7	3.1
Chest	11.6	10.3	9.4	11.7	8.6	10.4
Abdomen	5.3	5.4	7.7	3.4	4.7	4.9
Pelvis	5.1	6.3	5.3	7.9	4.4	4.9
Arms	9.9	8.2	7.9	8.2	9.2	8.0
Legs	27.2	32.6	33.3	31.6	37.2	25.8
Unknown	1.4	0.2	0.0	0.4	0.0	0.0

Similar to other IHRA countries, leading sources for pedestrian injury is bumper, top surface of bonnet and windscreen glass in China. But unlike IHRA, proportion of bonnet and windscreen in China is slightly higher while proportion of front bumper is slightly lower than IHRA. Vehicle contact sources for pedestrian injuries in different countries are shown in Table 3[3].

A further breakdown of the injuries and vehicle contact sources for children and adults is shown in Table 4-5 (Some injuries were attribute to more than one vehicle contact source). Similar to IHRA, for children, top surface of bonnet is the leading cause of head injury. For adults, the windscreen glass is the leading cause of head injury, followed by top surface of bonnet [3]. Not surprisingly, the bumper is the leading sources for adult pedestrian lower extremities injury.

Table 3. Vehicle Contact Sources for Pedestrian Injuries in each Country (AIS2-6) %

	China	USA	Germany	Japan	Australia	IHRA
Front Bumper	18.2	20.7	21.0	23.0	23.5	21.4
Top surface of bonnet	22.7	21.6	15.1	14.0	15.0	17.7
Bonnet leading edge	7.0	13.9	9.7	8.5	20.9	11.8
Windscreen glass	20.8	17.2	16.0	4.5	5.9	14.8
Windscreen frame / A pillars	2.7	8.7	8.1	7.7	22.2	9.0
Front Panel	4.9	4.4	2.5	5.0	0.0	3.4
Others	2.0	7.0	4.3	12.4	8.5	6.6
Indirect contact	0.0	0.6	1.0	6.9	0.0	1.4
Road Surface	12.3	5.9	13.0	9.8	0.0	9.2
Unknown	9.4	0.0	9.4	8.2	3.9	4.8

Table 4. Pedestrian Injuries by Body Region and Vehicle Contact Sources—All Age Groups; AIS2-6

Contact \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Total
									Overall	Femur	Knee	Lower Leg	Foot	
Part of the vehicle	Front Bumper				1	6		3		6	9	53	1	79
	Top surface of bonnet	14	8		29	18	4	25	3					101
	Bonnet leading edge					7	2	5		11	1	2		28
	Windscreen glass	78	18		1			1						98
	Windscreen frame / A pillars	7		2	3	1								13
	Front Panel	3			7	1		2		4	1	1		19
	Others	2			2	2		1				4	6	17
	Sub-Total	104	26	2	43	35	6	37	3	21	11	60	7	355
Indirect contact														
Road Surface		16	5	1	1	1		8	2	1	1	5	6	47
Unknown		15	4		6	6		1		2			2	36
Total		135	35	3	50	42	6	46	5	24	12	65	15	438

Table 5. Pedestrian Injuries by Body Region and Vehicle Contact Sources—Child (Age<16) ; AIS2-6

Contact \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Total
									Overall	Femur	Knee	Lower Leg	Foot	
Part of the vehicle	Front Bumper	1				1		1		2		2		7
	Top surface of bonnet	5						2						7
	Bonnet leading edge											1		1
	Windscreen glass													
	Windscreen frame / A pillars													
	Front Panel													
	Others											2	1	3
	Sub-Total	6				1		3		2		5	1	18
Indirect contact														
Road Surface								1				2	1	7
Unknown			1											1
Total			1			1		4		2		7	2	26

Distributions of pedestrian age are shown in table 6[3]. Like other IHRA countries, the 21-60 year old age group has the highest frequency of accident involvement. Proportion of elder is also similar to IHRA, while China has lower involvements in 0-15 year old age, which probably attribute to cases mainly from cities. It is notably that proportion of 6-10 year old is the highest for the children in accidents of China, which is similar to other IHRA countries.

Distributions of age and gender of injured pedestrian are shown in Table 7, 42.1% pedestrians are female and 57.9% are male. We found that the male pedestrian encounter for higher risks than that for females in vehicle accidents. In contrast, 51.9% German pedestrians are male and 48.1% are female [9].

Table 6. Distributions of Pedestrian Impact by Ages and Countries (AIS1-6) %

	China	IHRA	USA	Germany	Japan	Australia
0—5	2	7.3	4	9	9	5
6-10	4	14.1	11	15	20	14
11-15	1.5	9.7	11	10	5	14
16-20	6	6.6	7	7	3	6
21-60	66.3	41.1	51	36	39	29
60+	20.2	21.3	16	23	23	32

Table 7. Distributions of Pedestrian Age and Gender (AIS1-6)

	0-15yr		16-60yr		>60yr		Total	
	Number	%	Number	%	Number	%	Number	%
Female	3	20	59	41.5	21	52.5	83	42.1
Male	12	80	83	58.5	19	47.5	114	57.9
Total	15	100	142	100	40	100	197	100