SEAT BELT EFFICIENCY :
PAIRED CASE STUDY WITH UNBELTED AND BELTED OCCUPANTS

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1. INTRODUCTION

If the belt efficiency is not to demonstrate, we know on the contrary that its rate of wearing is not satisfactory. Yet, in this time, the French law (1) oblige the car front passengers to wear the seat belt for any travel.

Medical contra-indications and impairments are limited. The press campains are often based on this field. In fact, we constate an important regression of wearing rate, as indicated in the study realized from the bidisciplinary investigation team on road traffic accidents (2), since 1980.

This phenomena is clearly noted in the urban area : the car user thinks that when he drives quickely and for a long time, the seat belt is more useful.

In the SETRA study (3) we note during 1980-1984 years, an important diminution of seat belt wear rate : this decrease is more clear in urban area than in rural area whereas the dead rate increases significatively in urban area (15 %) (fig. 1 and 2).

The static belt efficiency is subjected to a correct wearing. The lap belt have to be worn closed without clearance between the lap belt and the user'spelvis. In fact, in BEN MALEK thesis (4) which studies the frontal impact accident involving belted occupants, the slack wearing of a static belt explains a certain number of impacts on the windshield, the upper part of the dashboard and numerous submarining lesions.

Nowadays the retractor belt offers a maximum of safety by fastening the subject more tighly on the seat (5). Also taking for granted that the retractor belt in set up in very recent cars and that its efficiency is better than the static belt one, we chose to work on a recent period (1980-1985) on recent cars equipped of retractor belts.

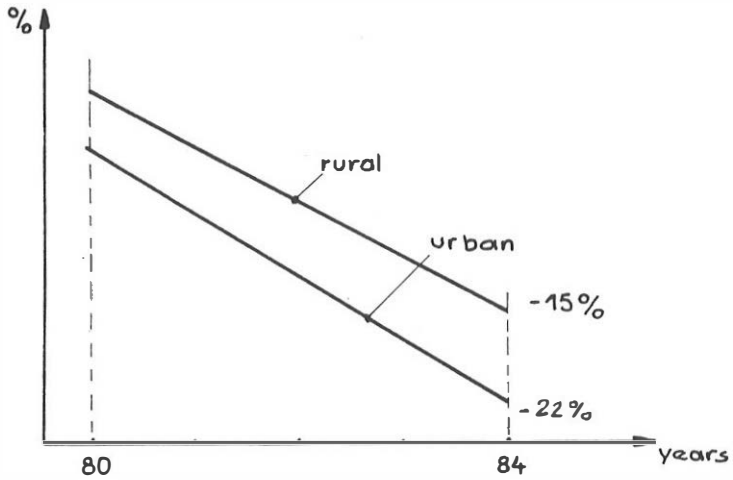


Fig. 1 : Reduction of seat belt wearing

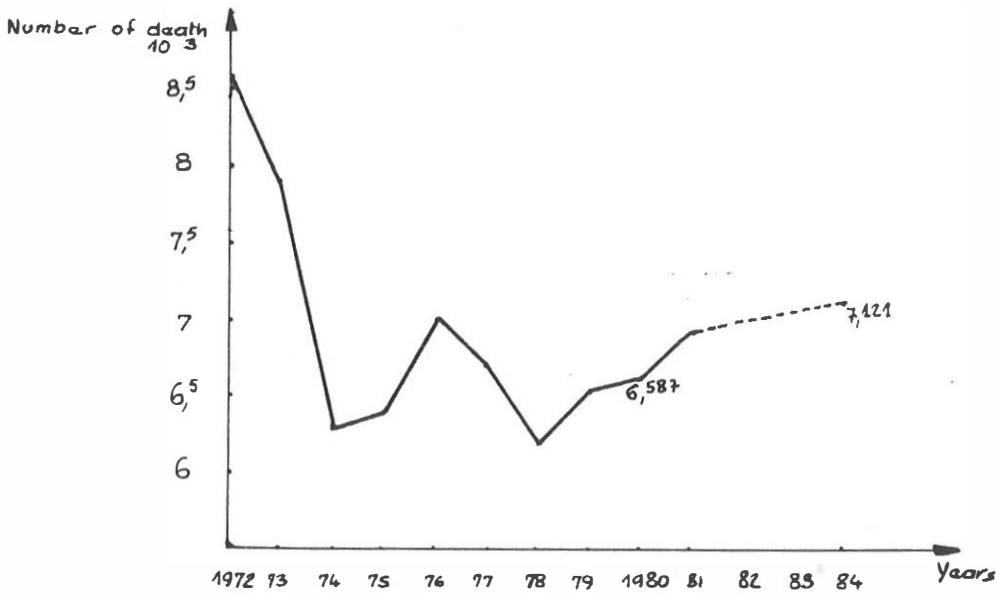


Fig. 2 : Victims in car since 1972

2. AIM OF THIS STUDY

Our purpose was to show the efficiency of seat belt wearing in a global way, but also to illustrate it with actual samples. For that, we will study 8 pairs of car accidents in comparing similar vehicles which sustain similar impacts (same impact direction and same impact load).

In an accident pair, the car front passengers are belted and in the other car, they are unbelted.

We will work with 452 front occupants of 320 vehicles. These cars are less than 5 years old and have been involved in a road traffic accident between 1980 and 1984. These cars were fitted out with retractor belts on front seats. They were involved in frontal impact, and the forces applied on the vehicles have the 11, 12 and 01 hour o'clock directions. They crushed into various obstacles (trucks, cars, rigid obstacles...) with variable impact forces (VDI 1 to 9).

How can we characterize the user sample ?

The frequency, as a function of sex (table 1) shows as always a clear over representation of the male population (70 %) with a majority of male drivers.

Is it making an influence on the amount of seat belt wearing ?

In fact, the rate of wearing is identical for males and females (59 %). On the other hand, if we consider the rate of wearing in function of occupied place (tables 2 and 3), we see that females more often wear their seat belt when they are passengers than when they drive, whereas it is the opposite for males.

We know that females often drive for short trip, in urban area. That shows one more time that the belt utility for this kind of use is not obvious for French drivers.

	Males		Females		Total	
	Nb	%	Nb	%	Nb	%
driver	262	84	57	43	319	72
front passeng.	51	16	75	57	126	28
total	313	100	132	100	445	100

Table 1 : Sex distribution for driver/front passenger

	Males		Females		Total	
	Nb	%	Nb	%	Nb	%
belted	186	59	78	59	264	59
unbelted	127	41	54	41	181	41
total	313	100	132	100	445	100

Table 2 : Sex distribution for belted/unbelted occupants

	Males		Females		Total	
	Nb	%	Nb	%	Nb	%
belted driver	163	52	30	23	193	44
unbelted driver	99	32	27	20	126	28
belted front passeng.	23	7	48	36	71	16
unbelted front. pas.	28	9	27	21	55	12
total	313	100	132	100	445	100

Table 3 : Sex distribution for belted/unbelted drivers and belted/unbelted passengers

The age distribution shows that the belted sample is quite older than the unbelted one without it to be very significant for extrems age slices (fig. 3).

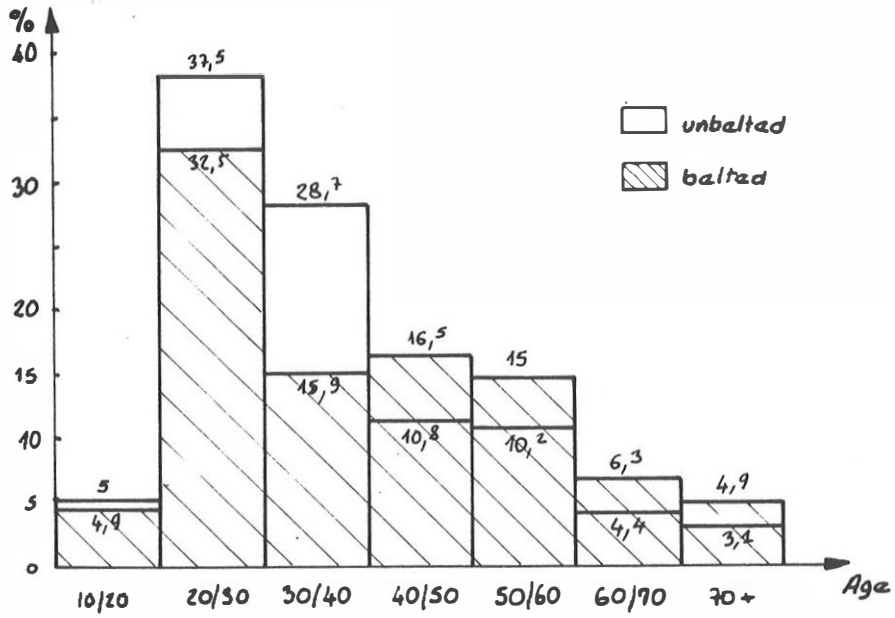


Fig. 3 : Age distribution of car occupants (belted or unbelted)

What is the influence of the safety belt wearing on the severity of the sustained injuries of front seat passengers ?

We can remind the origin of the data used in this paper : it concerns accidents between one or more cars for which one occupant at least have been injured and hospitalized more than 24 hours. This choice explains the high severity of our sample with 10.2 per cent of deaths what is obviously not the case for the national sample. The SETRA statistics explains that, in 1984, 181 830 car users were accidented, including deaths that is 3,9 per cent.

Table 4 shows that the retractor belt wearing strongly decreased the rate of deaths of front occupants of frontal impacted car. On this large sample, we note the belted drivers are 4 times less exposed to death than the unbelted drivers. Talking about the passenger, his safety is multiplicated by 5.5. We can think that the steering wheel is an aggravating factor for belted driver whereas the compartment of the right front passenger is few aggressive and especially far from the occupant (cf : it's also the point of view of GLOYNS and coll. (6) who estimate that in severe or fatal accidents, 52 % of belted drivers impact the steering system with the head or the face in frontal impacts.

In the same way, the report (7) shows that the head/steering wheel contacts are the only dangerous impacts for belted drivers, whereas the dashboard creates minor lesions.

AIS	UNBELTED DRIVER		BELTED DRIVER		UNBELTED FRONT PASSENG.		BELTED FRONT PASSENG.		TOTAL	
	Nb	%	Nb	%	Nb	%	Nb	%	Nb	%
0	9	7.1	57	29.4	5	8.7	21	28	92	20.4
1	21	16.7	57	29.4	11	19.3	18	24	107	23.7
2	40	31.7	40	20.6	10	17.6	15	20	105	23.2
3	20	15.9	24	12.4	14	24.6	15	20	73	16.1
4	11	8.7	5	2.6	4	7	1	1.3	21	4.6
5	3	2.4	3	1.5	-	-	2	2.7	8	1.8
6 et +	22	17.5	8	4.1	13	22,8	3	4	46	10.2

Table 4 : Influence of retractor seat belt on front occupant injury severities

We will study the efficiency of seat belt as a function of the vehicle deformation index.

It's true that the VDI is only an impact force approach, what ever considering the size of the sample (320 vehicles) we can think that the frequency of the vehicle types are the same for belted or unbelted drivers : indeed it concerns recent vehicles (set up with retractor belts).

So, if we compare figures 4 and 5, which explain the frequency of passenger's OAIS as a function of the vehicle deformation index, we establish that the figure 4, about belted occupants, is concentrated on left what significate that most of belted occupants have minor or moderate OAIS, and althought severe or serious OAIS appear of minor VDI, it concerns exceptional cases that we will explain.

In fact, severe OAIS occur from VDI 4-5. Both cases of OAIS 1 with VDI 8 can be explained by very local deformations on the vehicle (impact on the upper part, side-swipe). When we look at graphic 5, about unbelted passengers, we can see a drop of the top values, with a very clear expansion of severe OAIS from VDI 2 with numerous OAIS 6 from VDI 4. We also can see that from VDI 4, the number of uninjured or minor injured people decrease, from VDI 5, it almost disappears, whereas in figure 4 these types are still strongly representated.

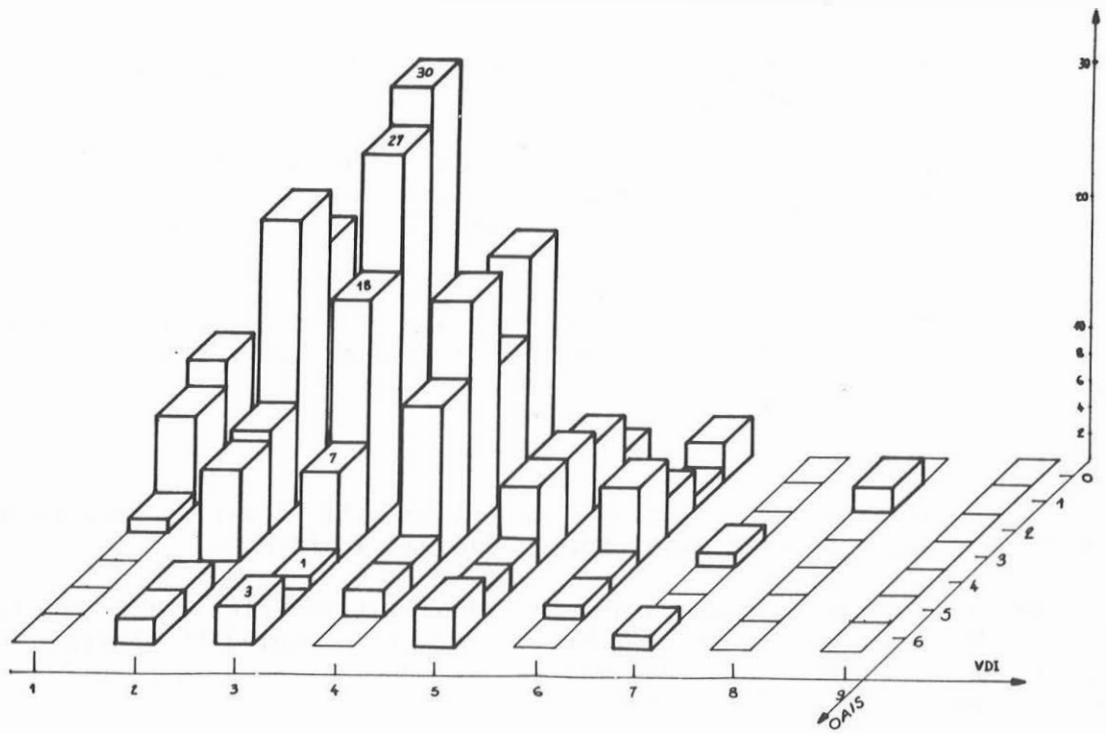


Fig. 4 : Belted occupant injuries severity distribution versus vehicle damage index

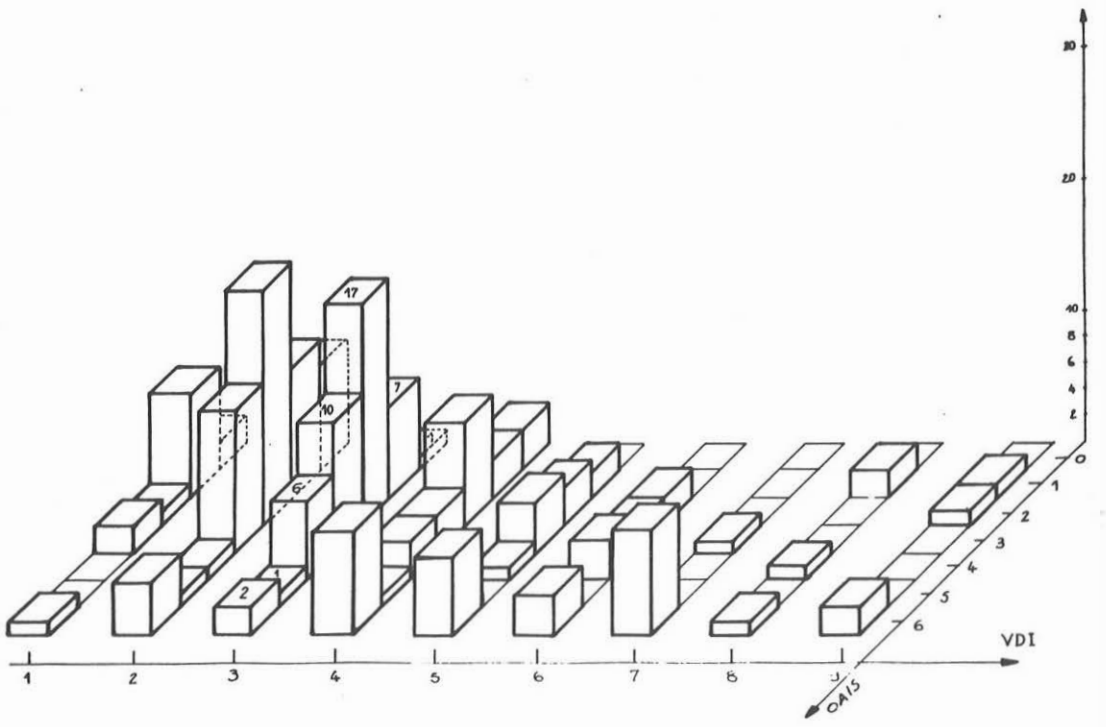


Fig. 5 : Unbelted occupant injury severity distribution versus vehicle damage index

Some cases of figure 5 have to be explained in particular at the level of VDI 9 where we find one OAIS 1 and one OAIS 2 : they are in fact cases of exceptionnally favorable ejection.

The comparison of these two figures call for another note : figure 4 has got a more regular aspect, with any strong step of OAIS, it seems that the seat belt is a reliable system whose efficiency decrease, concurrently with car deformations.

On the contrary, figure 5 shows that unbelted occupants sustain a more uncertain chance, VDI 1-2-3-4 deaths and some missings observed for VDI 4 or 5 shows it.

3. CASE PRESENTATION

In the leading purpose of this paper, we will illustrate the efficiency of the retractor seat belt, through actual accidents.

We found 8 pairs of comparable or identical vehicles which sustained similar crashes. For each pair of vehicles, one is occupied by restrained passengers and the other not. This shows that seat belt use is more favorable even for highly violent impacts (case 8).

Age and sex are no important parameters, in this study because it concerns young people. In one case we observe numerous lesions on a 60 years old female, her age could have an influence on the occurancy of the thoracic lesions, but she was in a very good health and her age can't explain these numerous and severe lesions. It is really the violent projection on the dashboard and the windshield during a severe impact against a truck, that is the origin of the death of this female who, restrained, would have survived.

CASE Nº 1 - We realized a comparison between 2 vehicles of closed categories : one RENAULT 25 and one AUDI 100 showing equal external deformations (VDI 3). There was no deformation of the passenger compartment.

The RENAULT 25 unbelted driver, male, 27 years old, was the only passenger of the car. He suffers a cranial concussion with unconciousness not exceeding 1 hour, cranio-facial lacerations and one minimal extradural hematoma (OAIS 4). He left the hospital in the 28th day.

The AUDI 100 driver, male of 34 years old, belted was alone inside. He was not injured.

CASE Nº 2 - It concerns 2 small vehicles that struck into cars in frontal impact. The external deformations are very similar as passenger compartment ones.

The belted driver of the FIAT UNO was 24 years old, he only suffers thoracic contusions

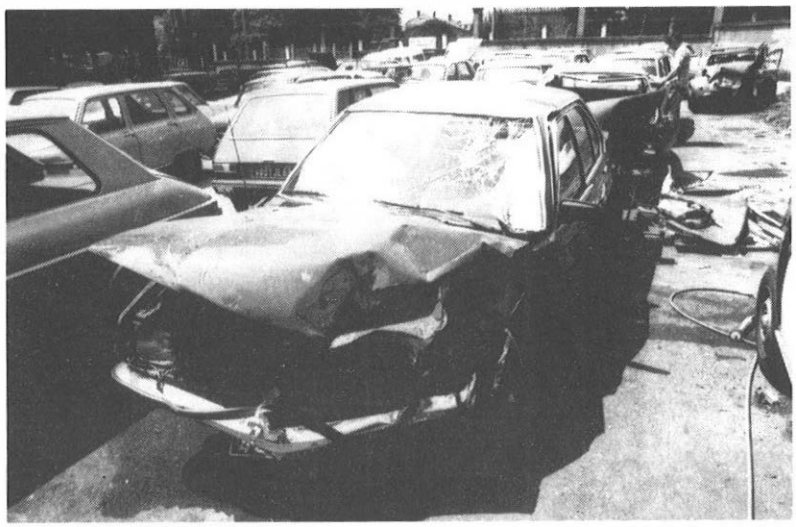
The TALBOT SAMBA was occupied by 3 unbelted passengers. The driver, a male of 26 years old suffered a concussion with unconciousness not exceeding one hour and rib fractures (OAIS 3). The front female passenger, 24 years old, suffered a concussion with loss of conciensciousness not exceeding one hour and rib fractures (OAIS 3). The right rear passenger, a male of 34 years old suffered a flail chest associated with a cranial trauma with nose fracture (OAIS 4).

CASE N° 3 - The aim is to compare 2 small cars that present similar deformations, althought obstacles were different : one fixe obstacle and one rear of truck, the impact being a hit more severe for the first car (PEUGEOT 104). In this vehicle, the driver, a male of 19 years old was belted. He suffers an opened fracture of the left leg (OAIS 3) (impact under the dashboard).

In the second car (CITROEN VISA), there were 3 unbelted passengers. The driver, a female of 29 years old was fatally injured at head and thoracic levels (steering wheel deformation). The front and the rear right passenger were sligtly injured (OAIS 2 and 1).

CASE Nº 4 - This is the case of two OPEL ASCONA built in the same year that suffered comparable impacts, althought one impacted a truck and the other a car.

In the first car, the belted driver was not injured.



In the second car, the unbelted driver, male of 54 years old suffers a concussion with unconsciousness not exceeding 5 minutes, facial tears and a right patella fracture and his wife, 60 years old, died during the S.A.M.U.* transportation. She presented a cranial trauma with cerebral hemorrage, facial lacerations (windshield) one left flail chest, pubic disjonction with abdominal lesions (dashboard).

* emergency care mobile unit

CASE Nº 5 - It concerns 2 identical vehicles, showing the same deformations, althought one struck a tree and the other a car.

In the CITROEN GSA, the belted male driver, 47 years old, suffers a cranial trauma with skinhead lacerations due to an impact on the roof and a right humeral fracture (OAIS 2).

In the CITROEN GS the female driver, 54 years old wasn't belted, she was fatally injured, with in particular one thoracic crush because of an impact on the steering wheel.

CASE Nº 6 - It is a matter of 2 RENAULT 5 that sustained a severe frontal impact on a hardly rigid fixed obstacle.

In the first RENAULT 5 the belted female driver, 24 years old, suffered a cranial trauma with loss of consciousness not exceeding 15 mn (AIS 2), one abdominal trauma with mesentery pain, associated with a small jejunum tear (AIS 4) and right leg fracture. She went to normal activities 3 monts after.

The male driver of the second RENAULT 5, 27 years old, was not belted, he was fatally injured with head, chest and lower limbs severe lesions.

CASE Nº 7 - This concerns two antagonistic vehicles, one CITROEN GSA and one CITROEN GS station wagon that struck together in a frontal impact. The deformations are the same for both cars (VDI 5)

The 2 persons in the GSA were belted : a 47 years old male who suffers a patella fracture (contact with the dash board) and pelvis abrasion under the belt (OAIS 2), a 41 years old female right front passenger who sustains thoracic pains without radiological sign (OAIS 1).

In the station wagon were 3 unbelted passengers, the driver, a 62 years old male died because of skull dislocation and right femur fracture (external examination). The front passenger, a 61 years old female, also died immediately with very extensive skull and facial massif fractures, one flail chest and lower limb pains. The central rear passenger, a 40 years old female, presents one thoracic trauma, one tibia fibula opened fracture and one ankle fracture. She was thrown on the frontal seats, that in the fact which obviously increased the frontal passenger pains (seat back rest failure).

CASE Nº 8 - This concerns two identically deformed RENAULT 5 (identical impact direction 12 hours - VDI 5).

In the first vehicle were two restrained passengers, the driver, a male of 45 years old suffers a facial fracture (AIS 3) due to impact on the roof, left ribs fractures and one left femoral fracture (OAIS 4). The front passenger, a female of 45 years old, suffers a pelvis fracture and a thoracic pain (OAIS 3).

In the second vehicle, the both unbelted passengers killed on the spot. There were two males, the driver was 48 years old and the front passenger was 35 years old, both sustained polytrauma. The autopsy has not been performed but the passenger compartment deformations explain the mean used to throw the corpses out.

CASE Nº 9 - This is a particular case that illustrate the effectiveness of rear seat belts either for security of rear passengers either for the front passenger safety.

The RENAULT 18 TURBO struck a pole : the deformations are large (VDI 5), the male belted driver, 24 years old, suffered a right leg fracture. The female belted passenger, 36 years old, suffered more severe lesions : cranial trauma with loss of conciousness not exceeding one hour (AIS 3), skinhead lacerations, dislocation of the cervical spine (C3/C4) with short neurological disease (AIS 3). Those lesions seem to be linked with the projection of the rear passenger, a 34 years old male, who suffered a thoracic trauma due to the impact on the front fight seat.

9. CONCLUSION

The seat belt efficiency is widely demonstrated : it is maximal in frontal impact as we can verify it on a sample of 320 recent damaged cars.

This efficiency is more clear for the right front passenger than for the driver. Effectively the occupant compartment is more far and less agressive than the driver one. The driver can hit the steering wheel and the wheel even if he is correctly belted.

The case study shows that for similar crash severity, the seat belt decreases the lesional risks and the possibility of death. This study verifies that rear occupant projection on the front occupant decreases the seat belt efficiency, this justifies the obligation of seat belt wearing for the rear passengers.

In studying case by case the belted and unbelted users, we reveal clearly the seat belt efficiency, but also its limits which are due to the impact condition types. This makes that a studied system for one particular configuration is, in fact, submitted to risks of real road traffic accident.

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