TEG-035
2 April 2007
4th Flex-TEG MT
BASt, Bergisch Gladbach


Flexible Pedestrian Legform Impactor Type GT (FLEX-GT) Car Test Results

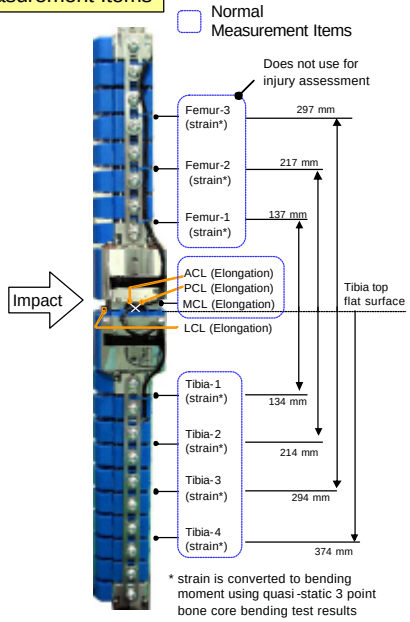

JAMA

Japan Automobile Manufacturers Association, Inc.

Flex-GT Information

Construction

Measurement Items



* strain is converted to bending moment using quasi-static 3 point bone core bending test results

Flex-GT Tentative Threshold Values

Human value

Body regions		50% injury risk level of AM50 (tentative) Human value	References
Leg	(Tibia)	BM (312 - 350 Nm)	BM (312 Nm): Kerrigan et al., 2004 BM (350 Nm): INF GR/PS/82
Knee	(MCL)	BA (18 - 20 deg)	BA (18 deg).: Ivarsson et al., 2004 BA (20 deg).: INF GR/PS/82

AM50: 50 percentile of american male

BM: Bending moment, BA: Bending angle, EL: Elongation, SD: Shearing displacement.

Convert: Human value >>> Flex-GT value

Human Tibia bending moment	Human Model Tibia bending moment	Flex-GT Model Tibia bending moment	Flex-GT Tibia bending moment
H_{TBM} (Nm)	HM_{TBM} (Nm)	$FGTM_{TBM}$ (Nm)	FGT_{TBM} (Nm)
312	312	299	299
350	350	337	337

Tentative threshold values

assumption: $H_{TBM} = HM_{TBM}$, $FGT_{MTBM} = FGT_{TBM}$

$FGT_{MTBM} = 0.9977 * HM_{TBM} - 12.325$ (from reguration curve)

Human Knee bending angle	Human Model Knee bending angle	Human Model Knee MCL elongation	Flex-GT model Knee MCL elongation	Flex-GT Knee MCL elongation
H_{KBA} (deg.)	HM_{KBA} (deg.)	HM_{MCL} (mm)	$FGTM_{MCL}$ (mm)	FGT_{MCL} (mm)
18	18	15	18	18
20	20	17	20	20

assumption: $H_{KBA} = HM_{KBA}$, $FGT_{MMCL} = FGT_{MCL}$

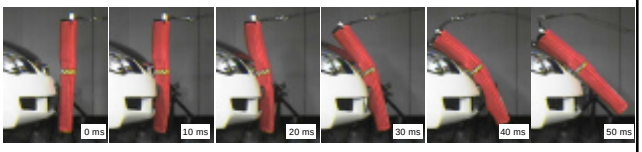
$HM_{MCL} = 0.835 * HM_{KBA}$ (from human model output)

$FGTM_{MCL} = 0.6924 * HM_{MCL} + 8.0156$ (from reguration curve)

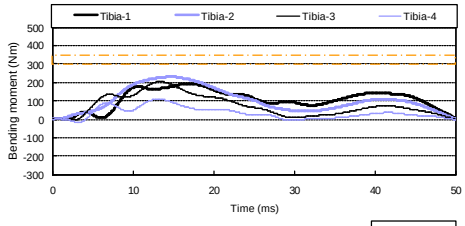
Convert human tolerance values to the Flex-GT ones (use correlation ratio/formula)

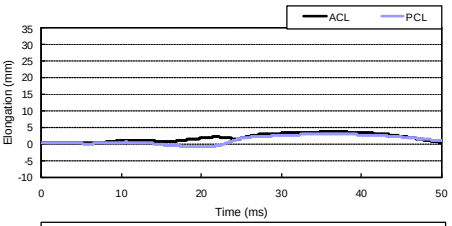
Car07A, Center Ü Flex-GT, H_i= base + 50 mm

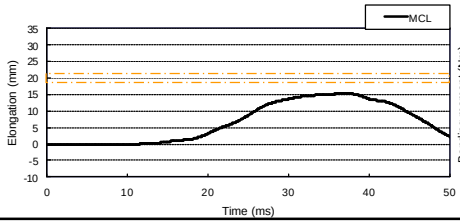
	unit	Max.
Tibia-1	(Nm)	194.6
Tibia-2	(Nm)	232.3
Tibia-3	(Nm)	204.5
Tibia-4	(Nm)	110.9
Knee-ACL	(mm)	3.7
Knee-PCL	(mm)	3.1
Knee-MCL	(mm)	15.3

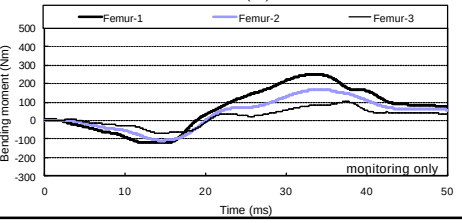


50% injury risk level of AM50
(Tentative values for Tibia, MCL)





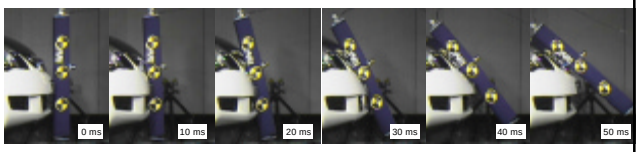




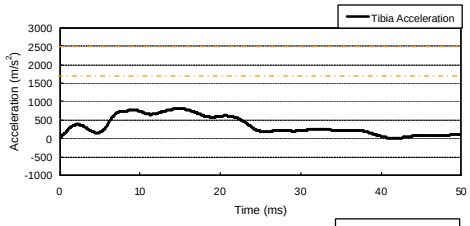
Car07A, Center Ü TRL-LFI, H_i= base

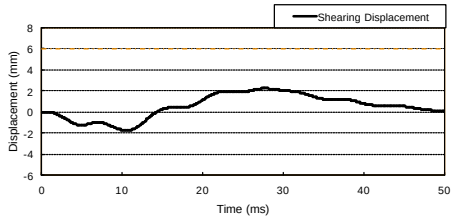
		Max.	Min.
Tibia-ACC	(m/s^2)	806.8	3.5
Knee-BA	(deg.)	3.2	0.0
Knee-SD	(mm)	2.2	-1.7

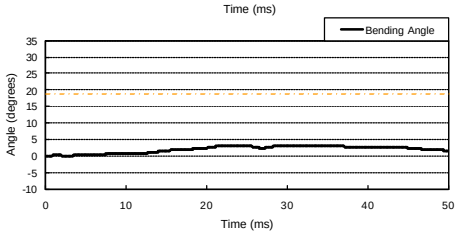
ACC: Acceleration
BA: Bending angle
SD: Shearind displacement



:GTR draft acceptance levels, June 2006 | : Initial injury detected timing

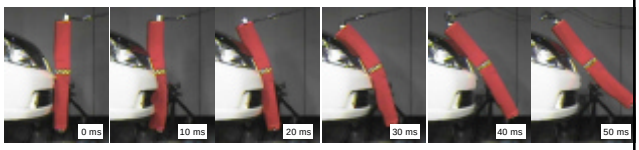




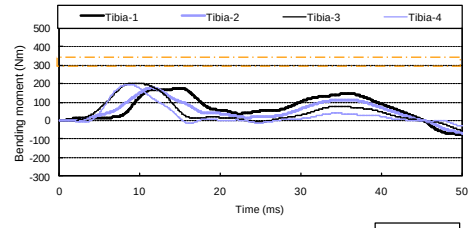


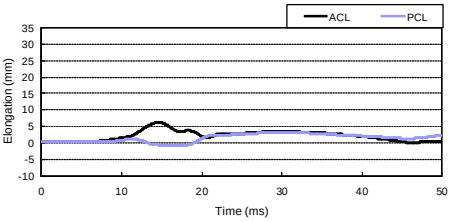
Car07B, Center Ü Flex-GT, H_i= base + 50 mm

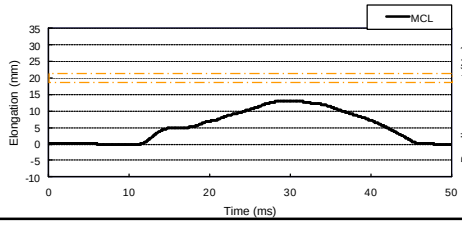
	unit	Max.
Tibia-1	(Nm)	176.4
Tibia-2	(Nm)	178.1
Tibia-3	(Nm)	203.7
Tibia-4	(Nm)	195.8
Knee-ACL	(mm)	6.1
Knee-PCL	(mm)	3.1
Knee-MCL	(mm)	13.2

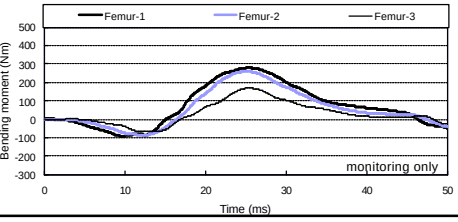


50% injury risk level of AM50
(Tentative values for Tibia, MCL)





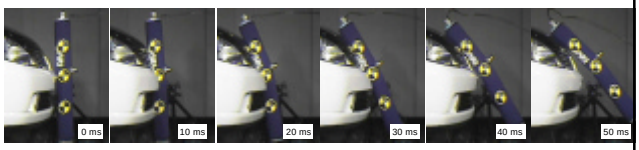




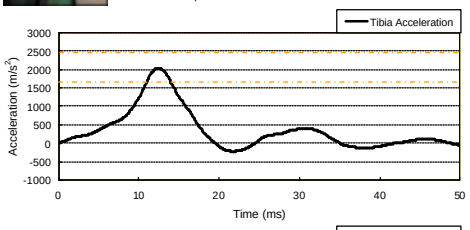
Car07B, Center Ü TRL-LFI, H_I= base

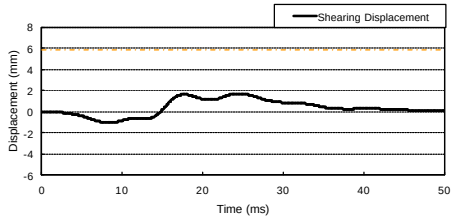
		Max.	Min.
Tibia-ACC	(m/s^2)	2039.2	-221.2
Knee-BA	(deg.)	10.1	-0.1
Knee-SD	(mm)	1.7	-1.0

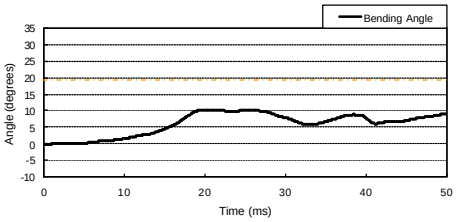
ACC: Acceleration
BA: Bending angle
SD: Shearind displacement



:GTR draft acceptance levels, June 2006 | : Initial injury detected timing

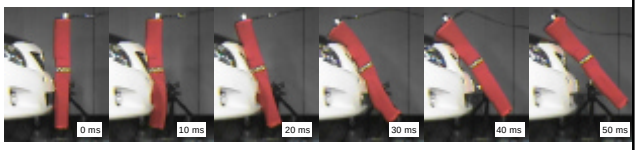




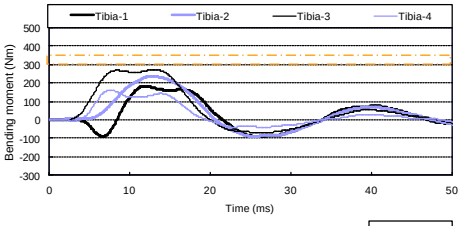


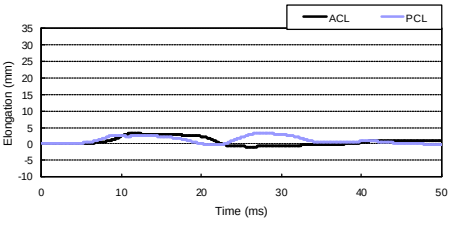
Car07C, Center Ü Flex-GT, H_I= base + 50 mm

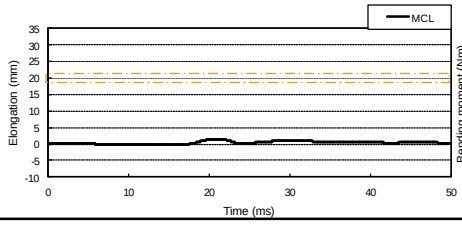
	unit	Max.
Tibia-1	(Nm)	183.4
Tibia-2	(Nm)	237.3
Tibia-3	(Nm)	273.5
Tibia-4	(Nm)	161.8
Knee-ACL	(mm)	3.1
Knee-PCL	(mm)	3.3
Knee-MCL	(mm)	1.5

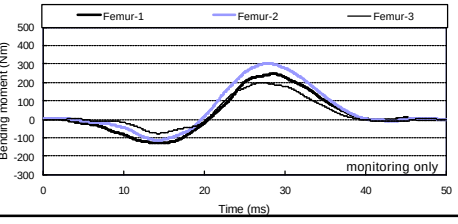


50% injury risk level of AM50
(Tentative values for Tibia, MCL)

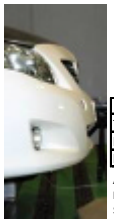






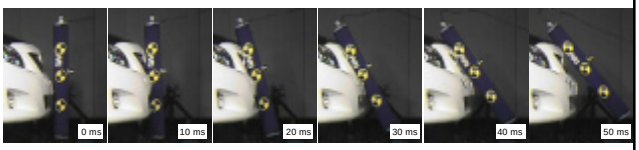


Car07C, Center Ü TRL-LFI, H_I= base

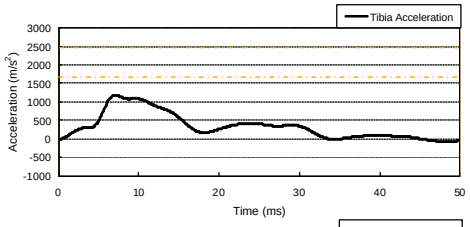


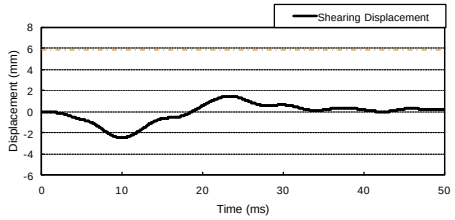
		Max.	Min.
Tibia-ACC	(m/s^2)	1173.7	-78.2
Knee-BA	(deg.)	2.4	-2.3
Knee-SD	(mm)	1.5	-2.5

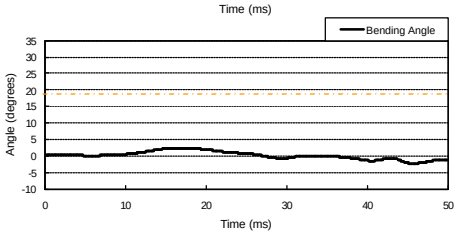
ACC: Acceleration
BA: Bending angle
SD: Shearind displacement



:GTR draft acceptance levels, June 2006 | : Initial injury detected timing

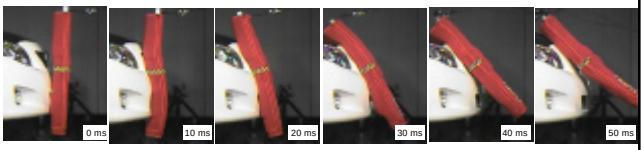




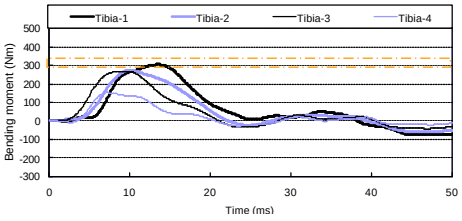


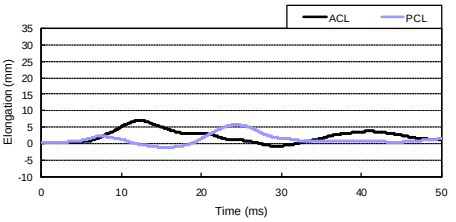
Car07C, R430 Ü Flex-GT, H_I= base + 50 mm

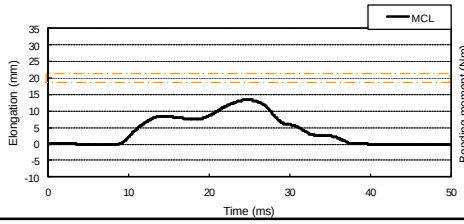
	unit	Max.
Tibia-1	(Nm)	304.0
Tibia-2	(Nm)	273.9
Tibia-3	(Nm)	267.8
Tibia-4	(Nm)	152.2
Knee-ACL	(mm)	7.0
Knee-PCL	(mm)	5.7
Knee-MCL	(mm)	13.4

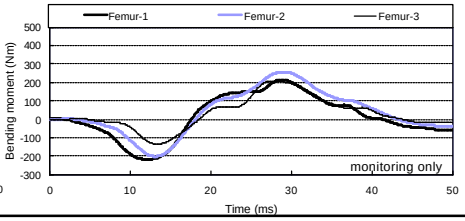


50% injury risk level of AM50
(Tentative values for Tibia, MCL)

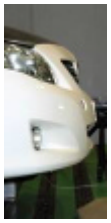






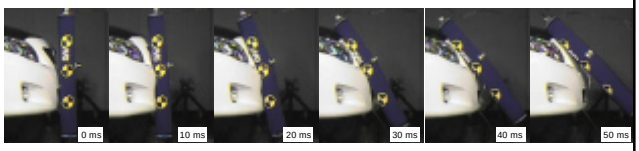


Car07C, R430 Ü TRL-LFI, H= base

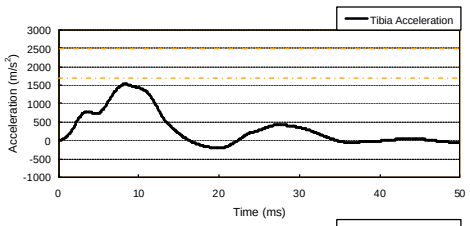


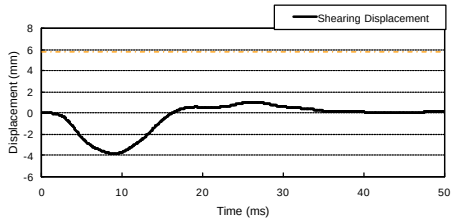
		Max.	Min.
Tibia-ACC	(m/s^2)	1528.9	-214.9
Knee-BA	(deg.)	12.1	0.1
Knee-SD	(mm)	1.0	-3.8

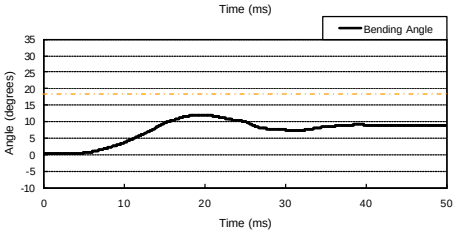
ACC: Acceleration
BA: Bending angle
SD: Shearind displacement



:GTR draft acceptance levels, June 2006 | : Initial injury detected timing





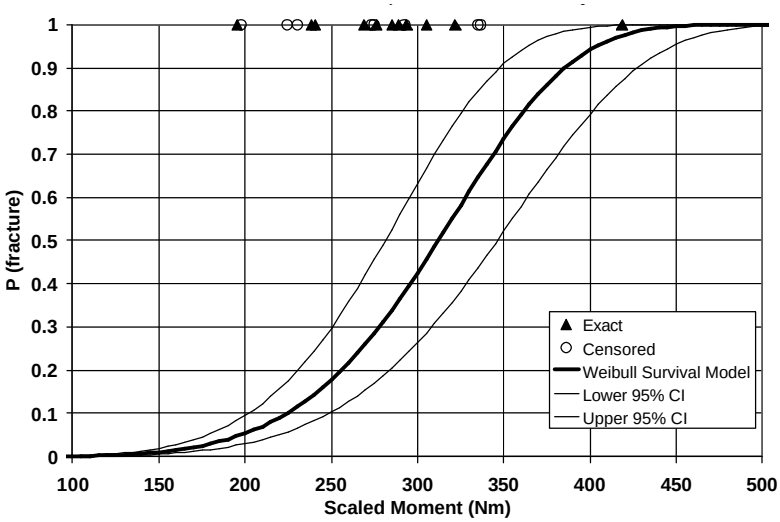


References

- Kerrigan, J.R., Drinkwater, D.C., Kam, C.Y., Murphy, D.B., Ivarsson, B.J., Crandall, J.R., Patrie, J. (2004) Tolerance of the Human Leg and Thigh in Dynamic Latero-Medial Bending, ICRASH 2004.
- Ivarsson, B.J., Lessley, D., Kerrigan, J.R., Bhalla, K.S., Bose, D., Crandall, J.R., Kent, R. (2004) Dynamic Response Corridors and Injury Thresholds of the Pedestrian Lower Extremities, Proc. International IRCOBI Conference on the Biomechanics of Impacts, pp. 179-191.
- ECE/TRANS/WP.29/GRSP/INF GR PS (2004) Discussion on Injury Threshold for Pedestrian Legform Test, INF/GR/PS/82, P. 2.
- ECE/TRANS/WP.29/GRSP (2006) Proposal for a Global Technical Regulation on Uniform Provisions Concerning the Approval of Vehicles with Regard to their Construction in order to Improve the Protection and Mitigate the Severity of Injuries to Pedestrians and other Vulnerable Road Users in the Event of a Collision, ECE/TRANS/WP.29/GRSP/2006/2 (Rev. June 2006).

References (referred contents)

Injury Risk Curve for Mid-Leg



- Kerrigan, J.R., Drinkwater, D.C., Kam, C.Y., Murphy, D.B., Ivarsson, B.J., Crandall, J.R., Patrie, J. (2004) Tolerance of the Human Leg and Thigh in Dynamic Latero-Medial Bending, ICRASH 2004.

References (referred contents)

Injury Risk Curve for Mid-Leg

Tibia Bending Strength and Response
Nyquist G. W. et al, 1985 (SAE, Paper No. 851728)

Tibia Bending: Strength and Response
Nyquist G. W. et al, 1985 (SAE 851728)

TestNo.	CadaverNo.	Sex	Age (years)	Stature (m)	Body Mass (kg)	Impact Speed (m/s)	Direction of Loading	Peak Bending at Midspan	Moment (Nm) *		
118	458	M	54	1.82	68	3.5	LM	395			
124	406	M	64	1.77	82	4.2	LM	287			
126	375	M	58	1.74	73	4.2	LM	224			
127	404	M	56	1.76	79	3.7	LM	237			
129	395	M	57	1.78	99	3.7	LM	349			
132	525	M	57	1.87	45	3.8	LM	264		Ave.	10%up
147	400	M	57	1.78	84	2.9	LM	431		**312.4**	**343.7**

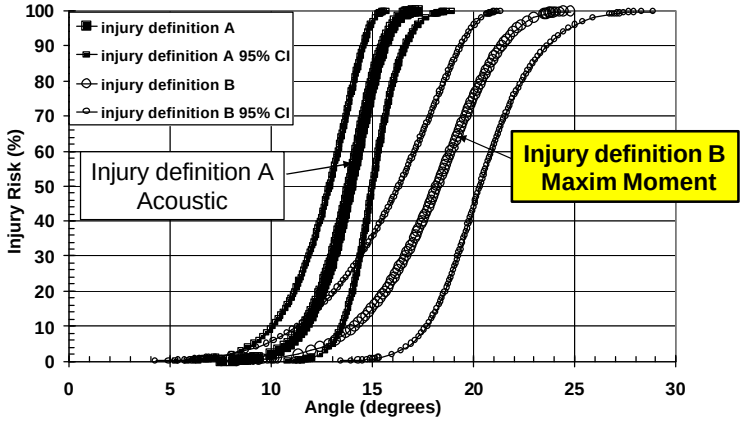
* The peak values were attenuated by 10 % by filtering (CFC 60) procedure.

Proposed injury threshold for tibia bending: 350 Nm

- ECE/TRANS/WP.29/GRSP/INF GR PS (2004) Discussion on Injury Threshold for Pedestrian Legform Test, INF/GR/PS/82, P. 2.

References (referred contents)

Injury Risk Curve for Knee (Bending)

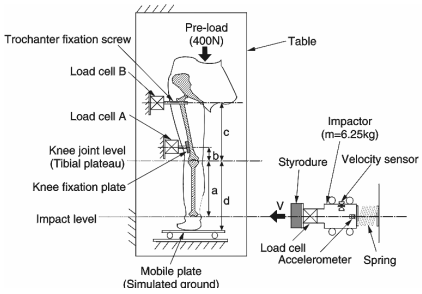


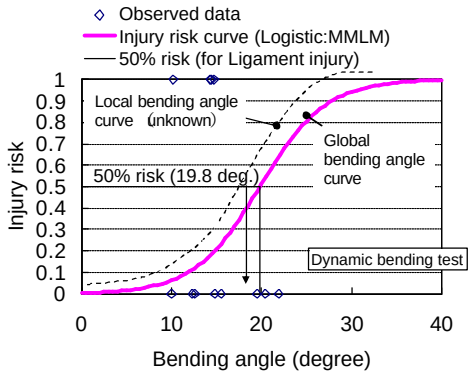
- Ivarsson, B.J., Lessley, D., Kerrigan, J.R., Bhalla, K.S., Bose, D., Crandall, J.R., Kent, R. (2004) Dynamic Response Corridors and Injury Thresholds of the Pedestrian Lower Extremities, Proc. International IRCOBI Conference on the Biomechanics of Impacts, pp. 179-191.

References (referred contents)

Injury Risk Curve for Knee (Bending)

RECONSIDERATION OF INJURY CRITERIA FOR PEDESTRIAN SUBSYSTEM LEGFORM TEST
- PROBLEMS OF RIGID LEGFORM IMPACTOR -
Konosu A. et al, 2001 (ESV, Paper No. 263)





Proposed injury threshold for Knee bending: 20 deg.

Local bending angle: Exclude Long Bone Bending Angle
Global bending angle: Include Long Bone Bending Angle

- ECE/TRANS/WP.29/GRSP/INF GR PS (2004) Discussion on Injury Threshold for Pedestrian Legform Test, INF/GR/PS/82, P. 2.

References (referred contents)

Injury Risk Curve for Knee (Shearing)

IHRA/PS/309

2) Knee injury risk curve for shearing

No injury risk curve is set by IHRA/PS because of its priority is low from the accident. IHRA/PS just described an example 10 mm from the Dr. Cesari's computer simulation analysis.

- International Harmonized Research Activity/Pedestrian Safety Working Group (2004) IHRA/PS Decisions for the IHRA/PS Legform Test Procedures, IHRA/PS/309.