Femur Certification Corridors for the Pendulum Test (Zero Cross Timing)

8th IG GTR9-PH2 meeting

Japan Automobile Standards Internationalization Center (JASIC)

Background

- At the 7th IG GTR9-PH2 meeting, the BASt method (GTR9-6-07: cut test data during Flex-PLI rebound phase) was agreed to be used in the GTR9 Phase 2 text.
- However, in the BASt method, femur outputs of Flex-PLI, which are not validated in the dynamic certification test of Flex-PLI, are used.
- Therefore, it was requested to BASt or someone to develop a requirement to confirm femur output validity.
- Based on the above situations, Japan volunteered to develop femur zero cross timing certification corridors for the pendulum test using two methodologies.

Methodology (1)
BASt Method

Methodology (1)

- Corridor making method
  - ✓ BASt method (TF-RUCC-4-04), which was used to develop tibia and knee ligaments (ACL, PCL, MCL) corridors.

Procedure for determination of certification corridors (as established within TEG):

TF-RUCC-4-04

1) **Definition of reproducibility corridors**

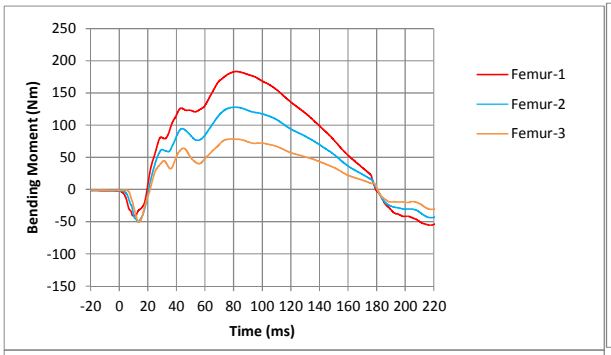
CV calculation of all segments of each impactor
Determination of segments for reproducibility corridor
Requirement: CV < 5%
Calculation of pooled means of all seven segments with CV < 5%
Calculation of reproducibility corridors (pooled mean +/- 10%)

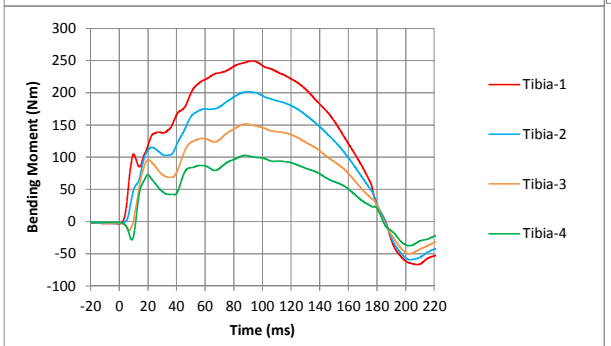
2) **Definition of certification corridors**

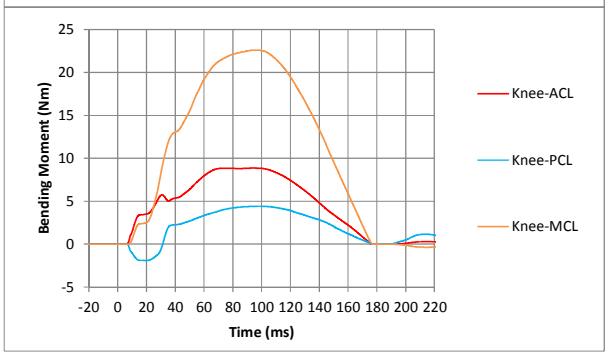
Determination of reproducible test results
Results supposed to be within reproducibility corridor
Determination of maxima and minima for each segment
Determination of corridor limits
Consideration of scatter: maxima + 5% / minima -5%

Oliver Zander June 18th, 2012 Slide No. 4

- Test data
  - ✓ Master leg (SN01, SN03, E-leg) test data (zero cross timing) which were obtained at the Master test lab (JARI, BASt, Bertrandt).







Impact timing is determined using knee acceleration output.
(knee acceleration generate timing is located within 0 +/- 1 ms)

1) Definition of reproducibility corridors

1.1.) CV calculation of all segments of each impactor
1.2.) Determination of segments for reproducibility corridor; Requirement: CV < 5%

Original Test Data		Zero Cross Timing (ms)		
lfd Nr.	Test #	Femur 3	Femur 2	Femur 1
P1	SN01@JARI, 120328-01	179.4	180.5	180.7
P2	SN01@JARI, 120328-02	178.6	179.2	180.4
P3	SN01@JARI, 120328-03	177.2	178.6	178.9
P4	SN03@JARI, 120327-01	177.8	178.9	179.5
P5	SN03@JARI, 120327-02	177.9	179.1	179.6
P6	SN03@JARI, 120327-03	178.4	179.5	179.9
P7	E-leg@JARI, 120423-01	180.2	180.9	181.9
P8	E-leg@JARI, 120423-02	181.0	181.5	182.9
P9	E-leg@JARI, 120423-03	178.1	178.7	180.2
P10	SN01@BASt, 120605-01	178.4	179.6	180.4
P11	SN01@BASt, 120605-02	178.7	179.8	180.7
P12	SN01@BASt, 120605-03	178.8	179.8	180.6
P13	SN03@BASt, 120523-01	175.8	177.2	177.6
P14	SN03@BASt, 120523-02	175.2	176.5	177.1
P15	SN03@BASt, 120523-03	175.9	177.2	177.7
P16	E-leg@BASt, 120523-01	177.4	178.5	179.1
P17	E-leg@BASt, 120523-02	177.5	178.8	179.3
P18	E-leg@BASt, 120523-03	177.3	178.6	179.1
P19	SN01@Bertrandt, 120612-01	182.9	182.2	180.7
P20	SN01@Bertrandt, 120612-02	183.0	182.4	181.0
P21	SN01@Bertrandt, 120612-03	181.4	180.5	179.3
P22	SN03@Bertrandt, 120606-01	179.9	179.4	178.0
P23	SN03@Bertrandt, 120606-02	179.1	178.5	177.4
P24	SN03@Bertrandt, 120606-03	180.4	179.8	178.5
P25	E-leg@Bertrandt, 120606-01	179.0	178.0	176.8
P26	E-leg@Bertrandt, 120606-02	180.0	178.8	177.8
P27	E-leg@Bertrandt, 120606-03	180.6	179.7	178.4

CV Values			
CV Values	Femur 3	Femur 2	Femur 1
Setup 1 - SN01 - JARI	0.6%	0.5%	0.5%
	Pass	Pass	Pass
Setup 2 - SN03 - JARI	0.2%	0.2%	0.1%
	Pass	Pass	Pass
Setup 3 - E-leg - JARI	0.8%	0.8%	0.8%
	Pass	Pass	Pass
Setup 4 - SN01 - BASt	0.1%	0.1%	0.1%
	Pass	Pass	Pass
Setup 5 - SN03 - BASt	0.2%	0.2%	0.2%
	Pass	Pass	Pass
Setup 6 - E-leg - BASt	0.1%	0.1%	0.1%
	Pass	Pass	Pass
Setup 7 - SN01 - Bertrandt	0.5%	0.6%	0.5%
	Pass	Pass	Pass
Setup 8 - SN03 - Bertrandt	0.4%	0.4%	0.3%
	Pass	Pass	Pass
Setup 9 - E-leg - Bertrandt	0.5%	0.5%	0.4%
	Pass	Pass	Pass

Removed: CV Values Over 5% Test Data

lfd Nr.	Test #	Femur 3	Femur 2	Femur 1
P1	SN01@JARI, 120328-01	179.4	180.5	180.7
P2	SN01@JARI, 120328-02	178.6	179.2	180.4
P3	SN01@JARI, 120328-03	177.2	178.6	178.9
P4	SN03@JARI, 120327-01	177.8	178.9	179.5
P5	SN03@JARI, 120327-02	177.9	179.1	179.6
P6	SN03@JARI, 120327-03	178.4	179.5	179.9
P7	E-leg@JARI, 120423-01	180.2	180.9	181.9
P8	E-leg@JARI, 120423-02	181.0	181.5	182.9
P9	E-leg@JARI, 120423-03	178.1	178.7	180.2
P10	SN01@BASt, 120605-01	178.4	179.6	180.4
P11	SN01@BASt, 120605-02	178.7	179.8	180.7
P12	SN01@BASt, 120605-03	178.8	179.8	180.6
P13	SN03@BASt, 120523-01	175.8	177.2	177.6
P14	SN03@BASt, 120523-02	175.2	176.5	177.1
P15	SN03@BASt, 120523-03	175.9	177.2	177.7
P16	E-leg@BASt, 120523-01	177.4	178.5	179.1
P17	E-leg@BASt, 120523-02	177.5	178.8	179.3
P18	E-leg@BASt, 120523-03	177.3	178.6	179.1
P19	SN01@Bertrandt, 120612-01	182.9	182.2	180.7
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P21	SN01@Bertrandt, 120612-03	181.4	180.5	179.3
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P23	SN03@Bertrandt, 120606-02	179.1	178.5	177.4
P24	SN03@Bertrandt, 120606-03	180.4	179.8	178.5
P25	E-leg@Bertrandt, 120606-01	179.0	178.0	176.8
P26	E-leg@Bertrandt, 120606-02	180.0	178.8	177.8
P27	E-leg@Bertrandt, 120606-03	180.6	179.7	178.4
	(a) Pooled Mean with CV < 5%	178.9	179.3	179.4
	(b) Limit Value Upper: (a) +10%	196.8	197.2	197.3
	(c) Limit Value Upper: (a) -10%	161.0	161.4	161.4

1.3) Calculation of pooled means of all segments with CV < 5%

1.4) Calculation of reproducibility corridors (limit values); pooled mean +/- 10%

2) Definition of certification corridors

Determination of reproducible test results

Test #	Femur 3	Femur 2	Femur 1	
SN01@JARI, 120328-01	179.4	180.5	180.7	
SN01@JARI, 120328-02	178.6	179.2	180.4	
SN01@JARI, 120328-03	177.2	178.6	178.9	
SN03@JARI, 120327-01	177.8	178.9	179.5	
SN03@JARI, 120327-02	177.9	179.1	179.6	
SN03@JARI, 120327-03	178.4	179.5	179.9	
E-leg@JARI, 120423-01	180.2	180.9	181.9	
E-leg@JARI, 120423-02	181.0	181.5	182.9	
E-leg@JARI, 120423-03	178.1	178.7	180.2	
SN01@BASt, 120605-01	178.4	179.6	180.4	
SN01@BASt, 120605-02	178.7	179.8	180.7	
SN01@BASt, 120605-03	178.8	179.8	180.6	
SN03@BASt, 120523-01	175.8	177.2	177.6	
SN03@BASt, 120523-02	175.2	176.5	177.1	
SN03@BASt, 120523-03	175.9	177.2	177.7	
E-leg@BASt, 120523-01	177.4	178.5	179.1	
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SN01@Bertrandt, 120612-03	181.4	180.5	179.3	
SN03@Bertrandt, 120606-01	179.9	179.4	178.0	
SN03@Bertrandt, 120606-02	179.1	178.5	177.4	
SN03@Bertrandt, 120606-03	180.4	179.8	178.5	
E-leg@Bertrandt, 120606-01	179.0	178.0	176.8	
E-leg@Bertrandt, 120606-02	180.0	178.8	177.8	
E-leg@Bertrandt, 120606-03	180.6	179.7	178.4	
Maximum	183.0	182.4	182.9	
Minimum	175.2	176.5	176.8	
Max. x 1.05	192.2	191.5	192.0	
Min. x 0.95	166.4	167.6	168.0	
Certification Corridor Upper	192	192	192	Round
Certification Corridor Lower	166	168	168	Round

2.1) Determination of reproducible test results

2.2) Determination of maxima and minima for each segment

2.3) Determination of corridor limits (maxima + 5%, minima -5%)

2.4) Round 2.3) values to define certification corridors

Comparison to certification corridors

Compared to Certification Corridors

Test #	Femur 3	Femur 2	Femur 1	
SN01@JARI, 120328-01	179.4	180.5	180.7	
SN01@JARI, 120328-02	178.6	179.2	180.4	
SN01@JARI, 120328-03	177.2	178.6	178.9	
SN03@JARI, 120327-01	177.8	178.9	179.5	
SN03@JARI, 120327-02	177.9	179.1	179.6	
SN03@JARI, 120327-03	178.4	179.5	179.9	
E-leg@JARI, 120423-01	180.2	180.9	181.9	
E-leg@JARI, 120423-02	181.0	181.5	182.9	
E-leg@JARI, 120423-03	178.1	178.7	180.2	
SN01@BASt, 120605-01	178.4	179.6	180.4	
SN01@BASt, 120605-02	178.7	179.8	180.7	
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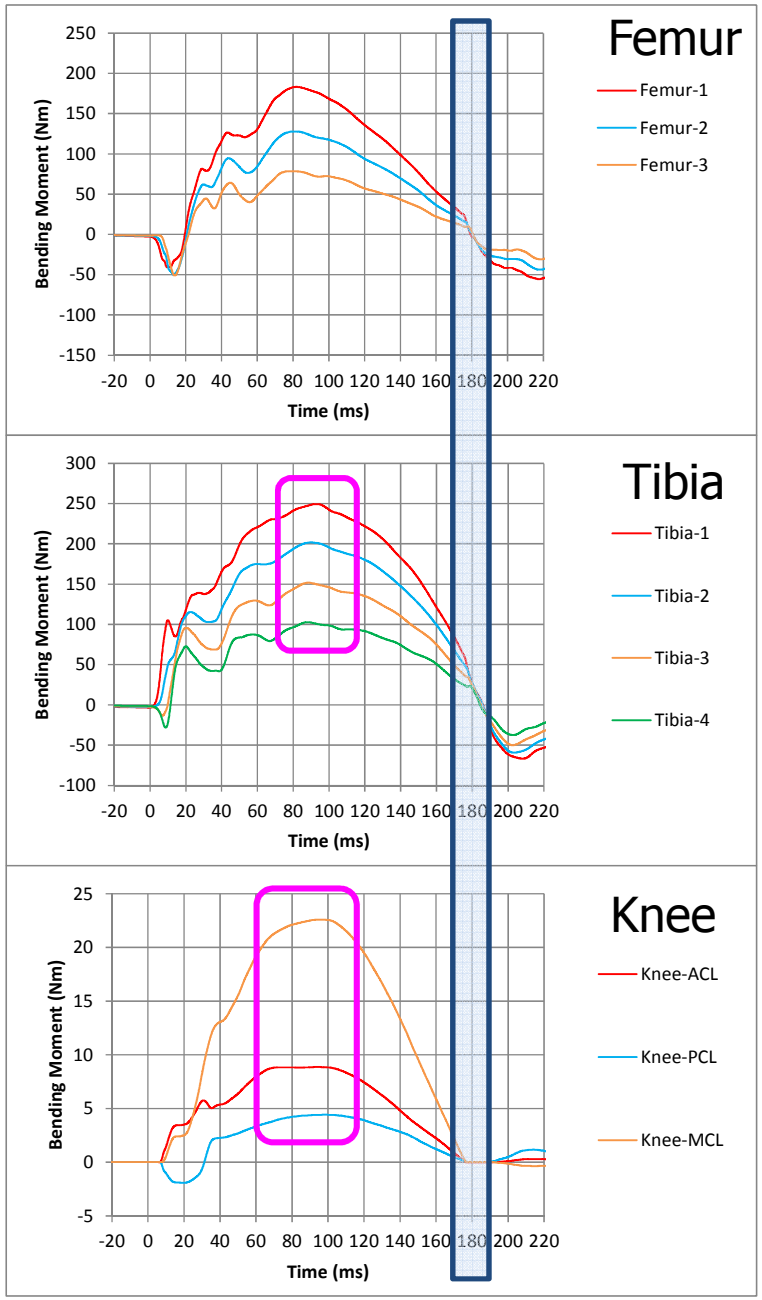
SN03@Bertrandt, 120606-01	179.9	179.4	178.0	
SN03@Bertrandt, 120606-02	179.1	178.5	177.4	
SN03@Bertrandt, 120606-03	180.4	179.8	178.5	
E-leg@Bertrandt, 120606-01	179.0	178.0	176.8	
E-leg@Bertrandt, 120606-02	180.0	178.8	177.8	
E-leg@Bertrandt, 120606-03	180.6	179.7	178.4	
Certification Corridor Upper	192	192	192	Round
Certification Corridor Lower	166	168	168	Round
	100%	100%	100%	
	Pass	Pass	Pass	

- All test data fall within the certification corridors.

Comparison to certification corridors

- All test data fall with the certification corridors.

Comparison between Zero Cross Timing Corridor Location of Femur and Maximum Value Generate Timing of Tibia and Knee Outputs



Zero cross timing corridor location of Femur (around 180 +/- 12 ms)

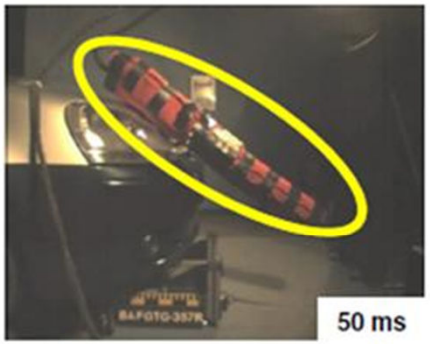
Maximum value generate timing of Tibia and Knee outputs (used for Tibia/Knee injury assessment)

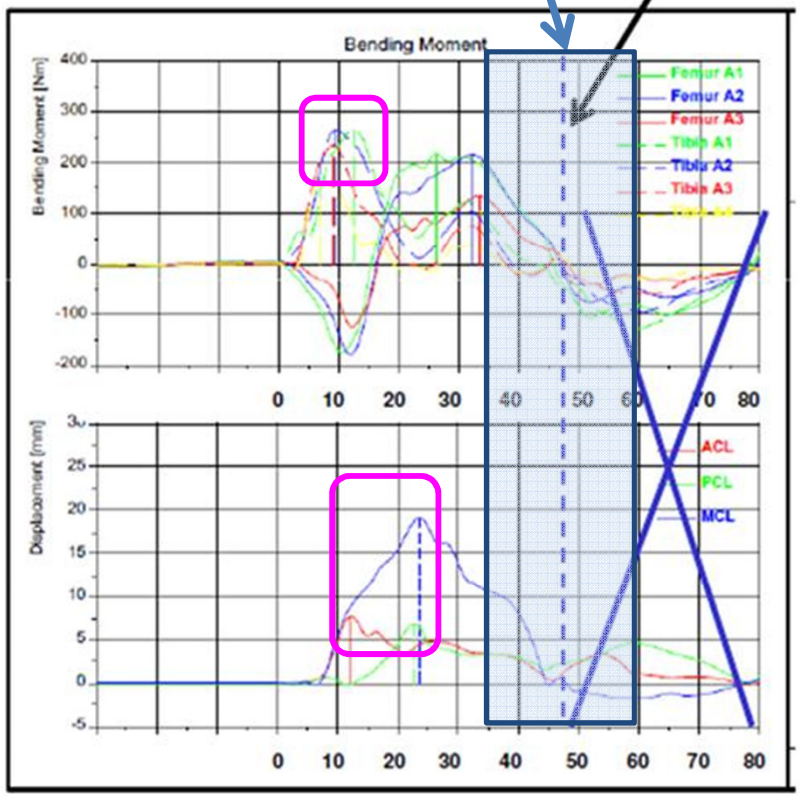
- If zero cross timing of femur falls into the developed corridor, it is clear that no concerns to be cut maximum values of Tibia and Knee inappropriately during a pendulum certification test.
- The corridor width (around +/-12 ms) acceptability is evaluated using several car tests. (see following slides)

BASt proposal – Case study (I): Sedan

Entire impactor left BAI

Zero cross timing





Acceptable

Zero cross timing corridor width (around +/- 12 ms)

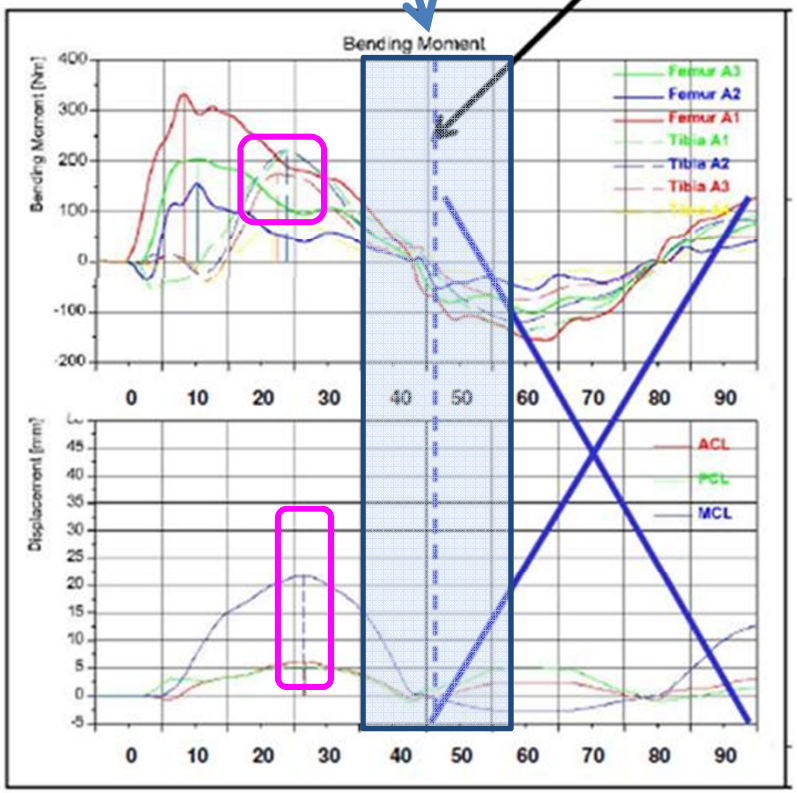
Maximum value generates timing regarding Tibia and Knee outputs

BASt proposal – Case study (II): SUV

bast

Zero cross timing

Entire impactor left BAI



Acceptable

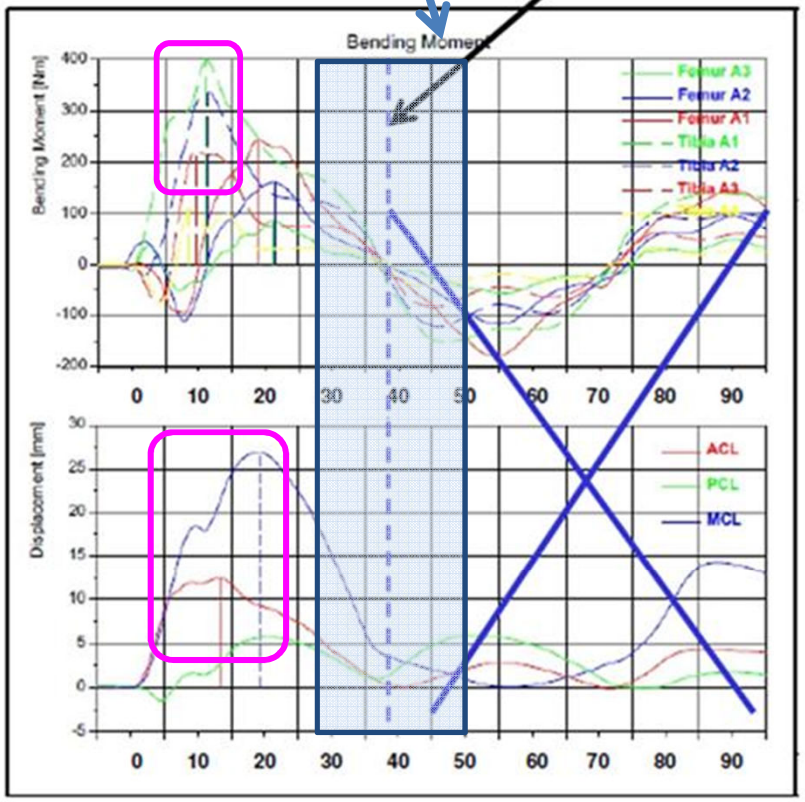
Zero cross timing corridor width (around +/- 12 ms)

Maximum value generates timing regarding Tibia and Knee outputs

BASt proposal – Case study (III): FFV

Entire impactor left BAI

Zero cross timing



Acceptable

Zero cross timing corridor width (around +/- 12 ms)

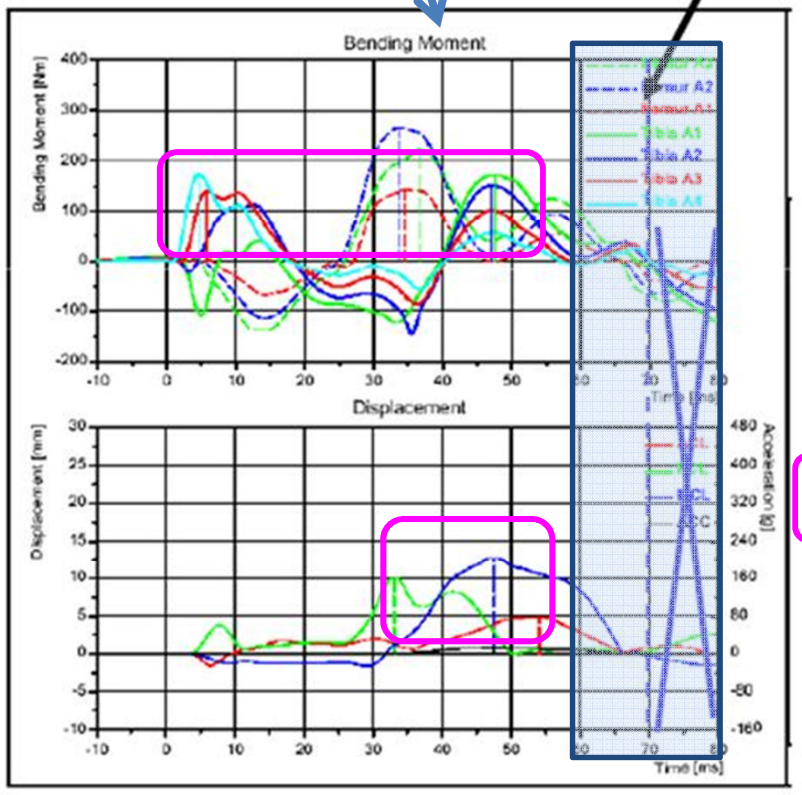
Maximum value generates timing regarding Tibia and Knee outputs

BASt proposal – Case study (IV): Sports car

bast

Zero cross timing

Entire impactor left BAI



Acceptable

Zero cross timing corridor width (around +/- 12 ms)

Maximum value generates timing regarding Tibia and Knee outputs

Methodology (2)
BASt Method with Modifications

Methodology (2)

- Corridor making method
  - ✓ BASt method (TF-RUCC-4-04), which was used to develop tibia and knee ligaments (ACL, PCL, MCL) corridors, with some modifications.

Procedure for determination of certification corridors (as established within TEG):

TF-RUCC-4-04

Modifications

1) Definition of reproducibility corridors

CV calculation of all segments of each impactor
Determination of segments for reproducibility corridor
Requirement: CV < 5%
Calculation of pooled means of all seven segments with CV < 5%
Calculation of reproducibility corridors (pooled mean +/- 10%)

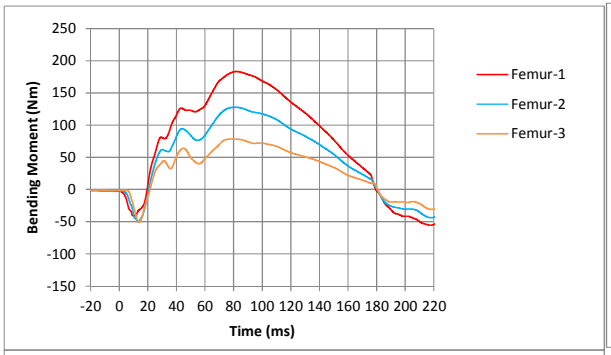
2) Definition of certification corridors

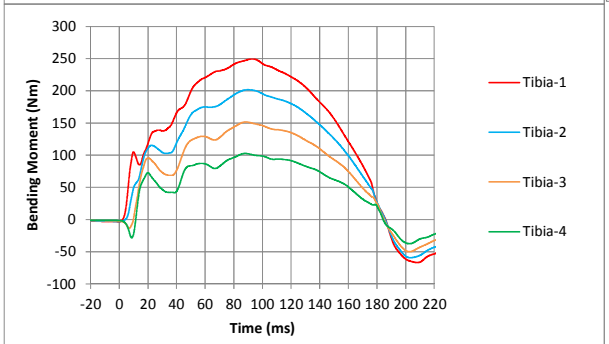
Determination of reproducible test results
Results supposed to be within reproducibility corridor
Determination of Average values
Determination of corridor limits
- Average +/- Acceptable Tolerance (15 ms)

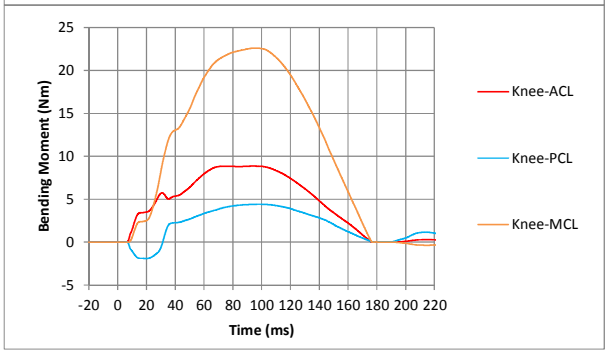
- Acceptable tolerance (+/- 15 ms) is determined using car test results. (see Appendix 1)

Same as Methodology (1)

- Test data
  - Master leg (SN01, SN03, E-leg) test data (zero cross timing) which were obtained at the Master test lab (JARI, BASt, Bertrandt).







Impact timing is determined using knee acceleration output.
(knee acceleration generate timing is located within +/- 1 ms)

Same as Methodology (1)

1) Definition of reproducibility corridors

1.1.) CV calculation of all segments of each impactor
1.2.) Determination of segments for reproducibility corridor; Requirement: CV < 5%

Original Test Data		Zero Cross Timing (ms)		
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P5	SN03@JARI, 120327-02	177.9	179.1	179.6
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CV Values			
CV Values	Femur 3	Femur 2	Femur 1
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	Pass	Pass	Pass
Setup 2 - SN03 - JARI	0.2%	0.2%	0.1%
	Pass	Pass	Pass
Setup 3 - E-leg - JARI	0.8%	0.8%	0.8%
	Pass	Pass	Pass
Setup 4 - SN01 - BASt	0.1%	0.1%	0.1%
	Pass	Pass	Pass
Setup 5 - SN03 - BASt	0.2%	0.2%	0.2%
	Pass	Pass	Pass
Setup 6 - E-leg - BASt	0.1%	0.1%	0.1%
	Pass	Pass	Pass
Setup 7 - SN01 - Bertrandt	0.5%	0.6%	0.5%
	Pass	Pass	Pass
Setup 8 - SN03 - Bertrandt	0.4%	0.4%	0.3%
	Pass	Pass	Pass
Setup 9 - E-leg - Bertrandt	0.5%	0.5%	0.4%
	Pass	Pass	Pass

Same as Methodology (1)

Removed: CV Values Over 5% Test Data

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P13	SN03@BASt, 120523-01	175.8	177.2	177.6
P14	SN03@BASt, 120523-02	175.2	176.5	177.1
P15	SN03@BASt, 120523-03	175.9	177.2	177.7
P16	E-leg@BASt, 120523-01	177.4	178.5	179.1
P17	E-leg@BASt, 120523-02	177.5	178.8	179.3
P18	E-leg@BASt, 120523-03	177.3	178.6	179.1
P19	SN01@Bertrandt, 120612-01	182.9	182.2	180.7
P20	SN01@Bertrandt, 120612-02	183.0	182.4	181.0
P21	SN01@Bertrandt, 120612-03	181.4	180.5	179.3
P22	SN03@Bertrandt, 120606-01	179.9	179.4	178.0
P23	SN03@Bertrandt, 120606-02	179.1	178.5	177.4
P24	SN03@Bertrandt, 120606-03	180.4	179.8	178.5
P25	E-leg@Bertrandt, 120606-01	179.0	178.0	176.8
P26	E-leg@Bertrandt, 120606-02	180.0	178.8	177.8
P27	E-leg@Bertrandt, 120606-03	180.6	179.7	178.4
	(a) Pooled Mean with CV < 5%	178.9	179.3	179.4
	(b) Limit Value Upper: (a) +10%	196.8	197.2	197.3
	(c) Limit Value Upper: (a) -10%	161.0	161.4	161.4

1.3) Calculation of pooled means of all segments with CV < 5%

1.4) Calculation of reproducibility corridors (limit values); pooled mean +/- 10%

2) Definition of certification corridors

Determination of reproducible test results

Test #	Femur 3	Femur 2	Femur 1	
SN01@JARI, 120328-01	179.4	180.5	180.7	
SN01@JARI, 120328-02	178.6	179.2	180.4	
SN01@JARI, 120328-03	177.2	178.6	178.9	
SN03@JARI, 120327-01	177.8	178.9	179.5	
SN03@JARI, 120327-02	177.9	179.1	179.6	
SN03@JARI, 120327-03	178.4	179.5	179.9	
E-leg@JARI, 120423-01	180.2	180.9	181.9	
E-leg@JARI, 120423-02	181.0	181.5	182.9	
E-leg@JARI, 120423-03	178.1	178.7	180.2	
SN01@BASt, 120605-01	178.4	179.6	180.4	
SN01@BASt, 120605-02	178.7	179.8	180.7	
SN01@BASt, 120605-03	178.8	179.8	180.6	
SN03@BASt, 120523-01	175.8	177.2	177.6	
SN03@BASt, 120523-02	175.2	176.5	177.1	
SN03@BASt, 120523-03	175.9	177.2	177.7	
E-leg@BASt, 120523-01	177.4	178.5	179.1	
E-leg@BASt, 120523-02	177.5	178.8	179.3	
E-leg@BASt, 120523-03	177.3	178.6	179.1	
SN01@Bertrandt, 120612-01	182.9	182.2	180.7	
SN01@Bertrandt, 120612-02	183.0	182.4	181.0	
SN01@Bertrandt, 120612-03	181.4	180.5	179.3	
SN03@Bertrandt, 120606-01	179.9	179.4	178.0	
SN03@Bertrandt, 120606-02	179.1	178.5	177.4	
SN03@Bertrandt, 120606-03	180.4	179.8	178.5	
E-leg@Bertrandt, 120606-01	179.0	178.0	176.8	
E-leg@Bertrandt, 120606-02	180.0	178.8	177.8	
E-leg@Bertrandt, 120606-03	180.6	179.7	178.4	
Average	178.9	179.3	179.4	
Average + 15 ms	193.9	194.3	194.4	
Average - 15 ms	163.9	164.3	164.4	
Certification Corridor Upper	194	194	194	Round
Certification Corridor Lower	164	164	164	Round

2.1) Determination of reproducible test results

2.2) Determination of average values

2.3) Determination of corridor limits (Average + 15 ms, Average - 15 ms)

2.4) Round 2.3) values to define certification corridors

Comparison to certification corridors

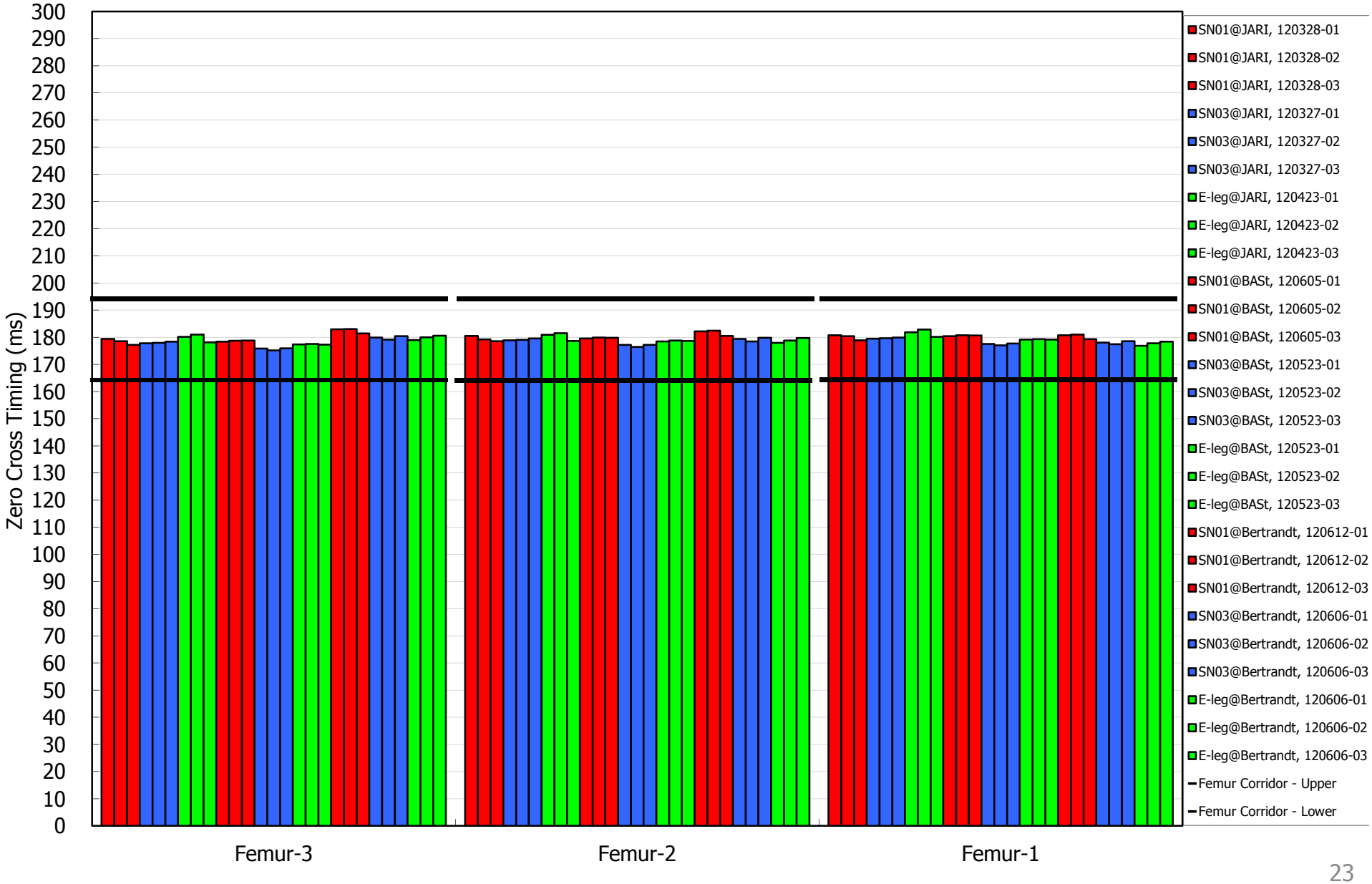
Compared to Certification Corridors

Test #	Femur 3	Femur 2	Femur 1	
SN01@JARI, 120328-01	179.4	180.5	180.7	
SN01@JARI, 120328-02	178.6	179.2	180.4	
SN01@JARI, 120328-03	177.2	178.6	178.9	
SN03@JARI, 120327-01	177.8	178.9	179.5	
SN03@JARI, 120327-02	177.9	179.1	179.6	
SN03@JARI, 120327-03	178.4	179.5	179.9	
E-leg@JARI, 120423-01	180.2	180.9	181.9	
E-leg@JARI, 120423-02	181.0	181.5	182.9	
E-leg@JARI, 120423-03	178.1	178.7	180.2	
SN01@BASt, 120605-01	178.4	179.6	180.4	
SN01@BASt, 120605-02	178.7	179.8	180.7	
SN01@BASt, 120605-03	178.8	179.8	180.6	
SN03@BASt, 120523-01	175.8	177.2	177.6	
SN03@BASt, 120523-02	175.2	176.5	177.1	
SN03@BASt, 120523-03	175.9	177.2	177.7	
E-leg@BASt, 120523-01	177.4	178.5	179.1	
E-leg@BASt, 120523-02	177.5	178.8	179.3	
E-leg@BASt, 120523-03	177.3	178.6	179.1	
SN01@Bertrandt, 120612-01	182.9	182.2	180.7	
SN01@Bertrandt, 120612-02	183.0	182.4	181.0	
SN01@Bertrandt, 120612-03	181.4	180.5	179.3	
SN03@Bertrandt, 120606-01	179.9	179.4	178.0	
SN03@Bertrandt, 120606-02	179.1	178.5	177.4	
SN03@Bertrandt, 120606-03	180.4	179.8	178.5	
E-leg@Bertrandt, 120606-01	179.0	178.0	176.8	
E-leg@Bertrandt, 120606-02	180.0	178.8	177.8	
E-leg@Bertrandt, 120606-03	180.6	179.7	178.4	
Certification Corridor Upper	194	194	194	Round
Certification Corridor Lower	164	164	164	Round
	100%	100%	100%	
	Pass	Pass	Pass	

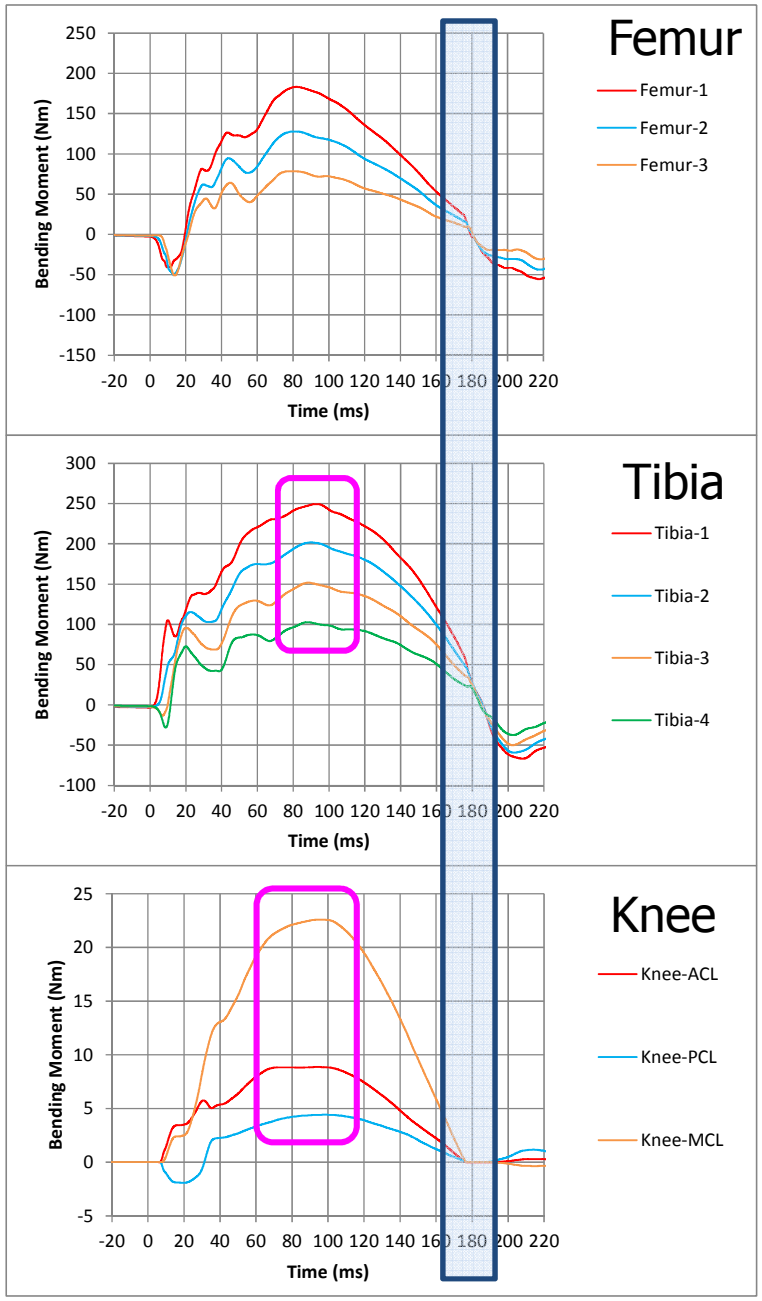
- All test data fall within the certification corridors.

Comparison to certification corridors

- All test data fall with the certification corridors.



Comparison between Zero Cross Timing corridor for Femur and Maximum values generate timing of tibia and knee outputs



Zero cross timing corridor (around 180 +/- 15 ms)

Maximum values generate timing of Tibia and Knee outputs (used for Tibia/Knee injury assessment)

- If zero cross timing of femur falls into the developed corridor, it is clear that no concerns to be cut maximum values of Tibia and Knee inappropriately during a pendulum certification test.
- The corridor width (around +/-15 ms) acceptability is already evaluated using several car test results. (see Appendix 1)

Summary

- Japan developed femur zero cross timing certification corridors for the pendulum test voluntarily using two different methodologies with Master leg (SN01, SN03, E-leg) test data (zero cross timing) which were obtained at the Master test lab (JARI, BASt, Bertrandt)

<Methodology (1)>

  - ✓ Femur-3 :166-192 (ms), Femur-2: 168-192 (ms), Femur-1: 168-192 (ms)

<Methodology (2)>

  - ✓ Femur-3 :164-194 (ms), Femur-2: 164-194 (ms), Femur-1: 164-194 (ms)

- All Master leg test data falls into the above corridors.

- In the BASt method, zero cross timing is used to cut rebound phase test data. Therefore, Japan proposes to set femur zero cross timing certification corridors for the pendulum test which are obtained by Methodology (1) or Methodology (2).

Appendix 1: Determination of Acceptable Tolerance for Zero Cross Timing

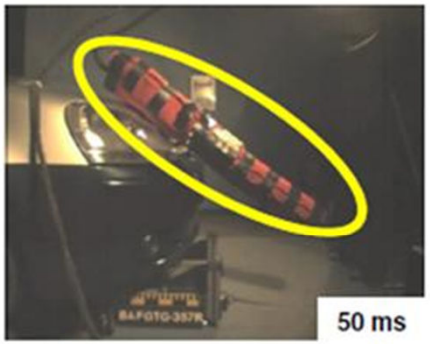
Appendix 1: Determination of Acceptable Tolerance for Zero Cross Timing

- Acceptable tolerance of zero cross timing is determined using car test results which are described in the BASt document (GTR9-6-07).

Appendix 1: Determination of Acceptable Tolerance for Zero Cross Timing

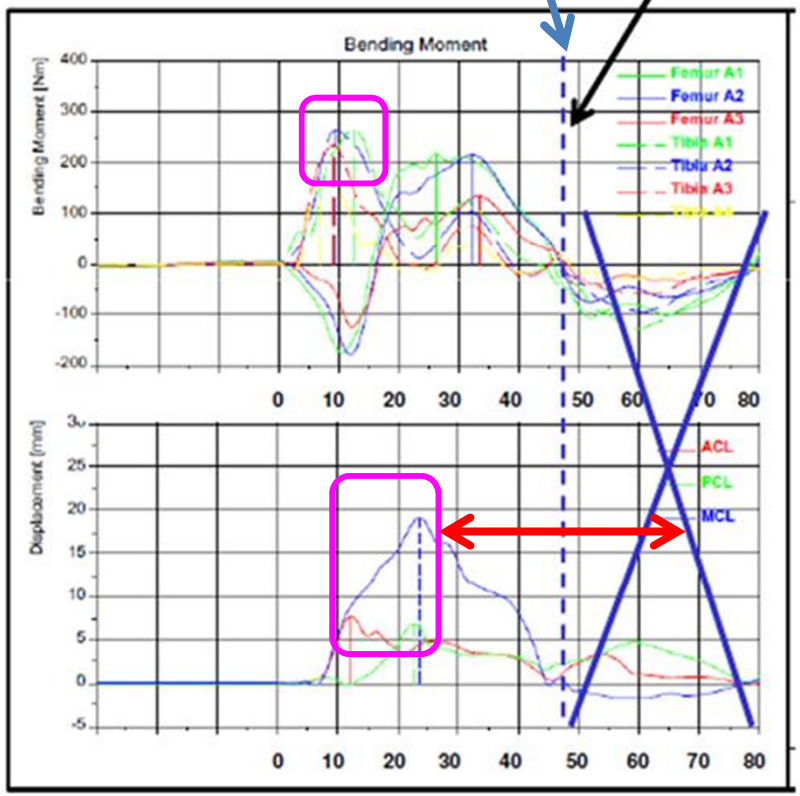
GTR9-6-07

BASt proposal – Case study (I): Sedan



Zero cross timing

Entire impactor left BAI



Maximum value generates zone of Tibia and Knee ligaments

Acceptable tolerance of zero cross timing

around +/- 20 ms in the maximum

Appendix 1: Determination of Acceptable Tolerance for Zero Cross Timing

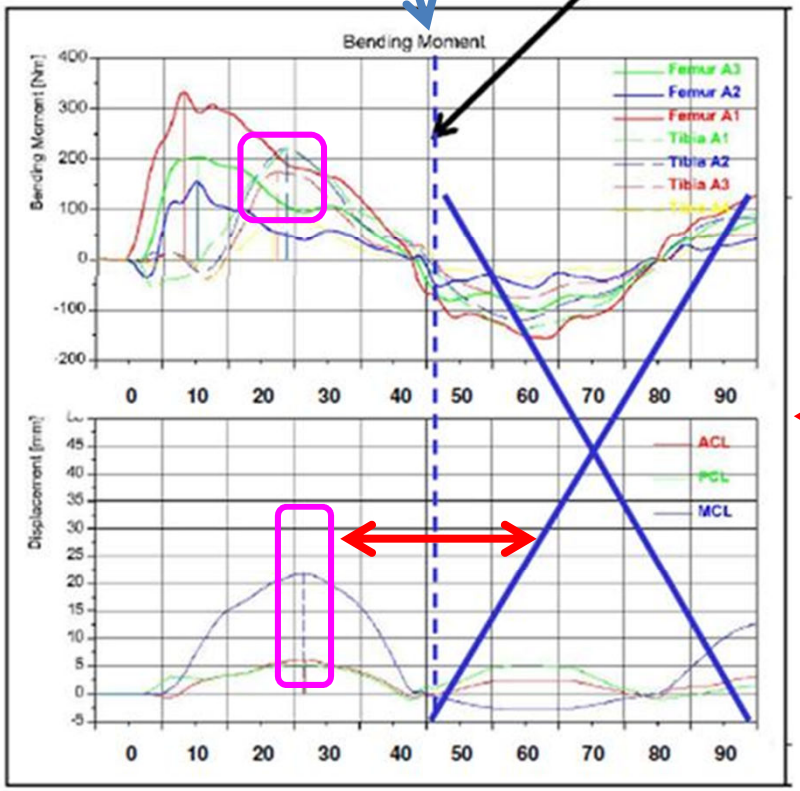
GTR9-6-07

BASt proposal – Case study (II): SUV

bast

Zero cross timing

Entire impactor left BAI



Maximum value generates zone of Tibia and Knee ligaments

Acceptable tolerance of zero cross timing

around +/- 15 ms in the maximum

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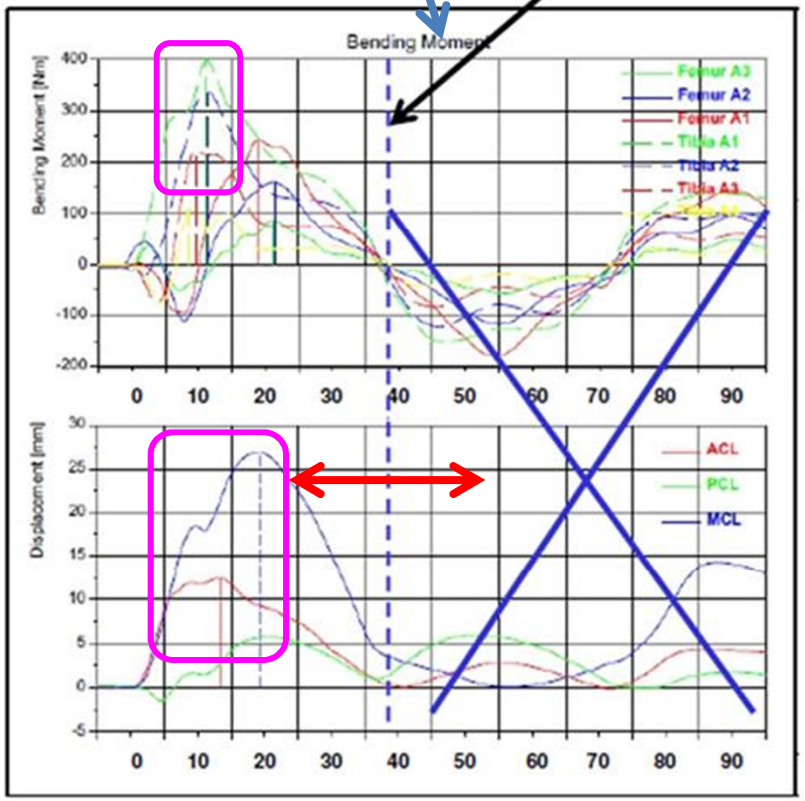
Appendix 1: Determination of Acceptable Tolerance for Zero Cross Timing

GTR9-6-07

BASt proposal – Case study (III): FFV

Entire impactor left BAI

Zero cross timing



Maximum value generates zone of Tibia and Knee ligaments

Acceptable tolerance of zero cross timing

around +/- 15 ms in the maximum

Appendix 1: Determination of Acceptable Tolerance for Zero Cross Timing

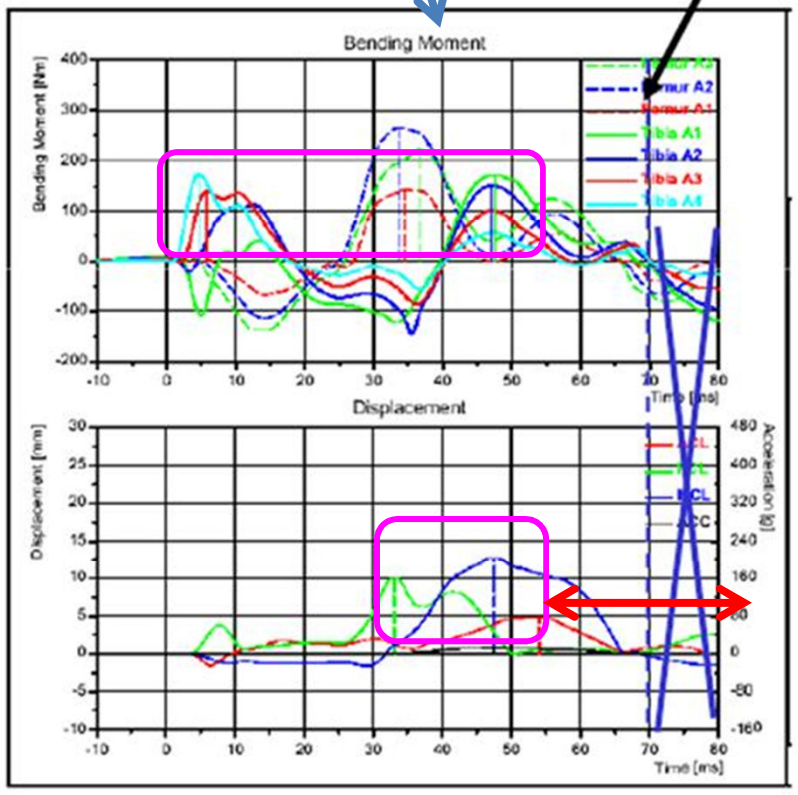
GTR9-6-07

BASt proposal – Case study (IV): Sports car

bast

Zero cross timing

Entire impactor left BAI



Maximum value generates zone of Tibia and Knee ligaments

Acceptable tolerance of zero cross timing

around +/- 15 ms in the maximum

Appendix 1: Determination of Acceptable Tolerance for Zero Cross Timing

Summary

- Acceptable tolerance of zero cross timing is determined using car test results which are described in the BASt document (GTR9-6-07).
- Based on the analysis, acceptable tolerance is determined as around +/- 15 ms.

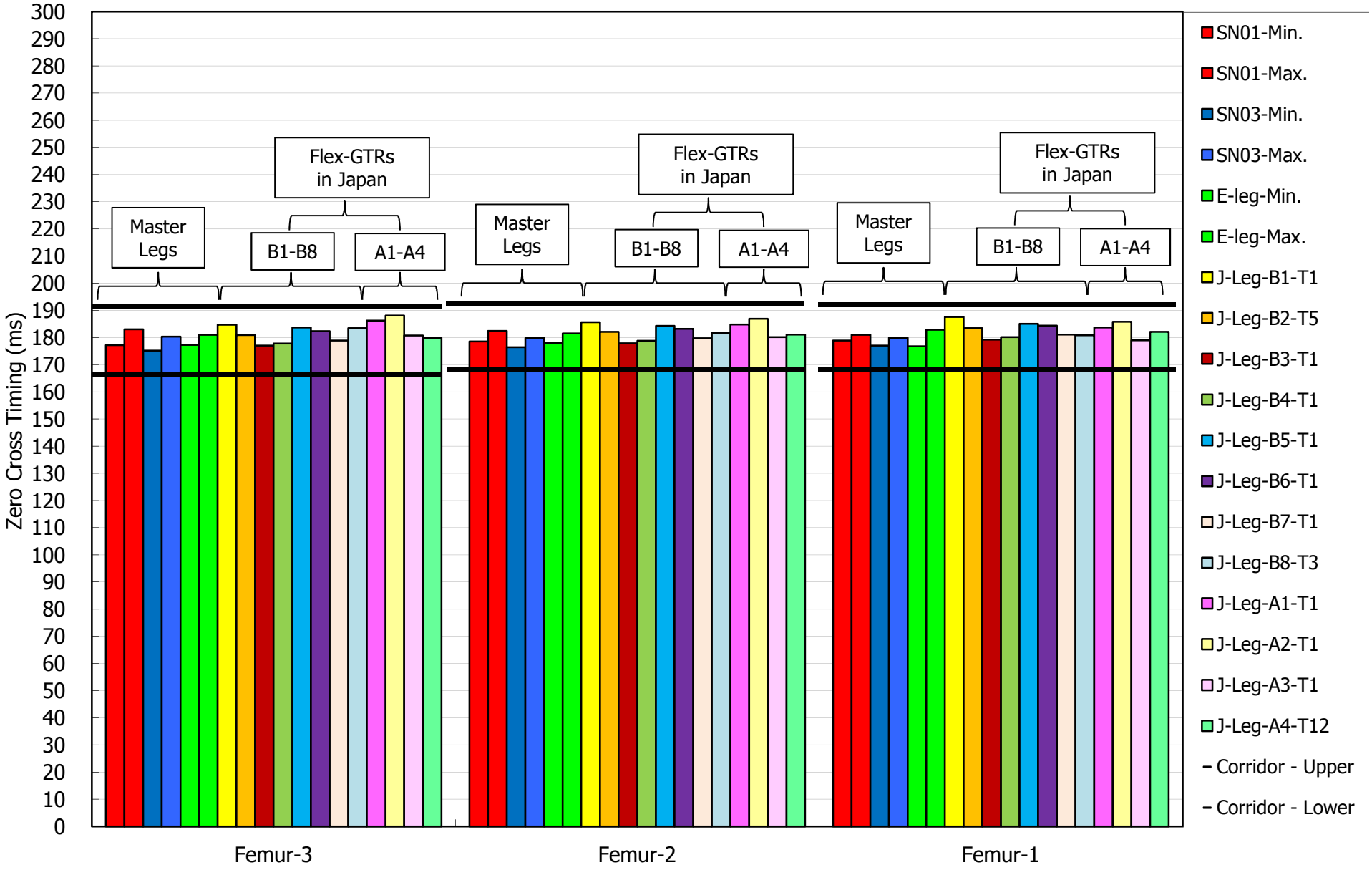
Appendix 2: Comparison to certification corridors (Flex-GTRs in Japan)

Appendix 2: Comparison to certification corridors (Flex-GTRs in Japan)

- Additionally, zero cross timing of Flex-GTRs in Japan at pendulum test data were randomly selected then compared to the certification corridors.
  - ✓ Flex-GTRs in Japan:
    - ➢ J-Leg-B1 to B8 (delivered before 12 June 2012)
    - ➢ J-Leg A1 to A4 (delivered after 12 June 2012)
- INFO: All of the Flex-GTRs fall into the latest Tibia and Knee Ligaments maximum value pendulum test corridors (developed by TF-RUCC, then accepted by IG GTR9-PH2 at the 4th meeting in Sep. 2012).

Appendix 2: Comparison to certification corridors (Flex-GTRs in Japan)

- All test data falls within the certification corridors obtained by Methodology (1).



Appendix 2: Comparison to certification corridors (Flex-GTRs in Japan)

- All test data falls within the certification corridors obtained by Methodology (2).