TEG-102
31 Aug. 2009
JAMA-JARI

Review of Dynamic Calibration Corridor Making Methods

Back Ground

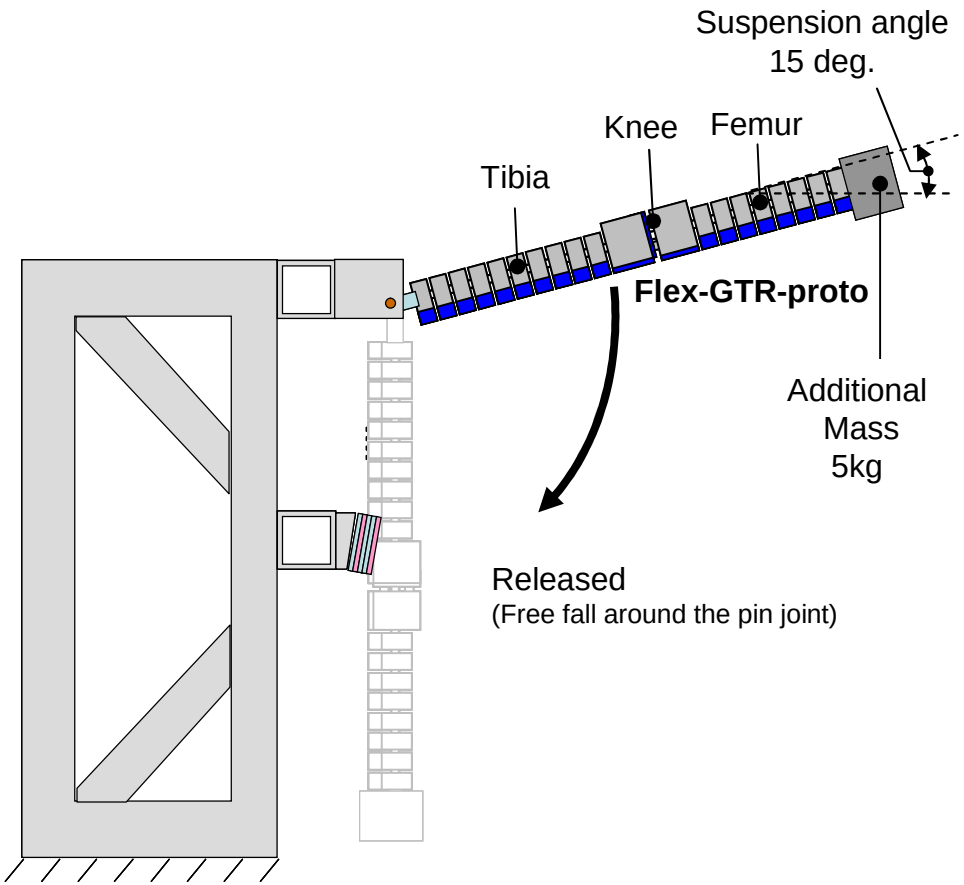
- So far, two different dynamic calibration test methods (Pendulum Type, Inverse Type) were proposed and then discussed that among the TEG members.
- On the other hands, two different corridor making methods (FTSS-Method, BASt-Method) were also proposed, however, no detailed discussion has not been made among TEG members.
- This study, therefore, reviewed the two different corridor making methods using the published two different dynamic calibration test data.

1. Review of the Two Different Dynamic Calibration Test Methods (Pendulum Type, Inverse Type) and Two Different Corridor Making Methods (FTSS-Method, BASt-Method)

Pendulum Type (Type 2) Dynamic Calibration Test Method and FTSS Corridor Making Method

Dynamic Calibration Test Method

Pendulum Type (Type 2) Dynamic Calibration Test Method
Up side down, Additional Mass 5kg, without Flesh



Corridor Making Method

FTSS-Method

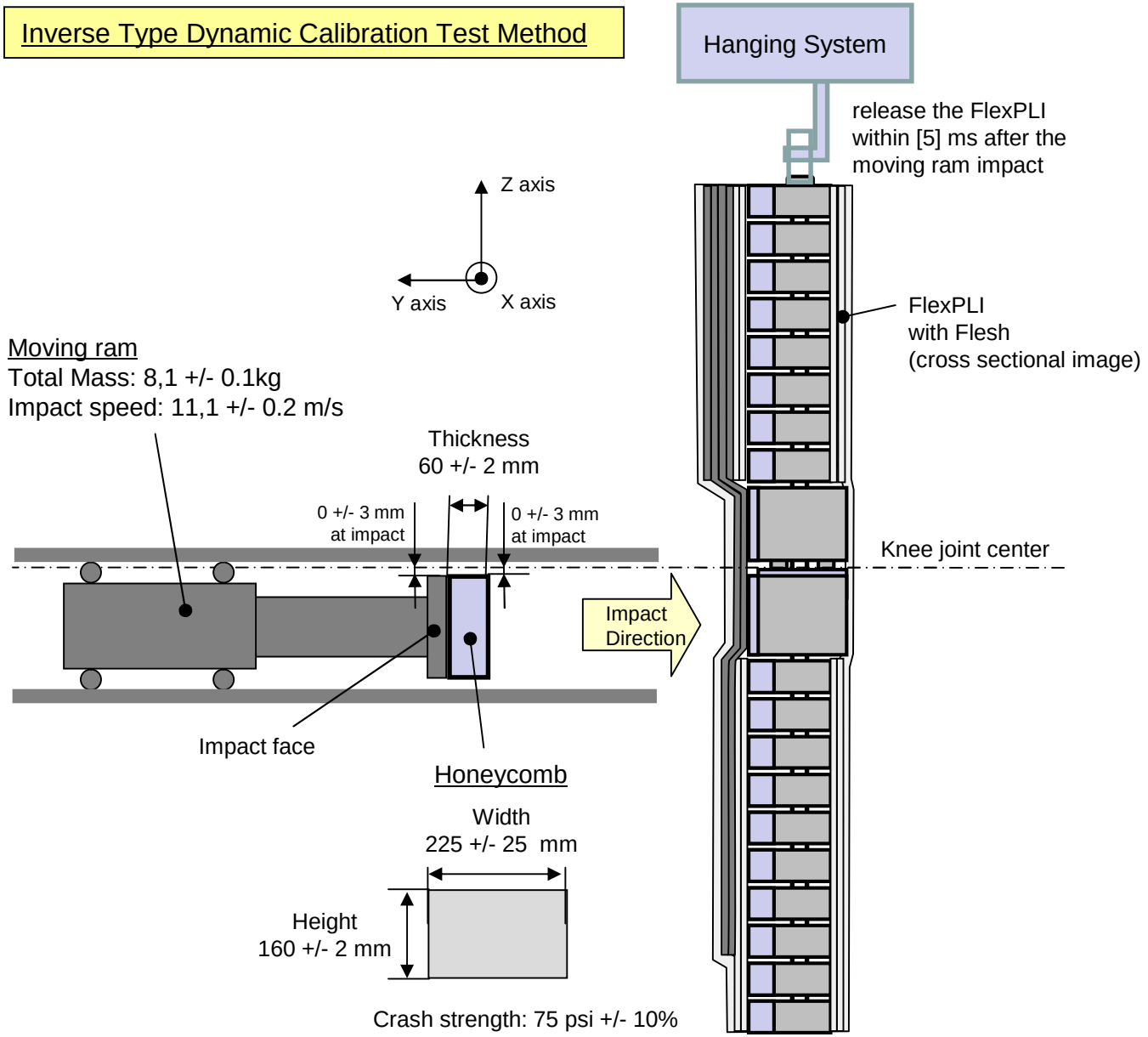
- Average +/- 10% or Average +/- 2 St. Dev (wider one)

Ref.: ESV2009, Paper Number 09-0146

Inverse Type Dynamic Calibration Test Method and BASt Corridor Making Method

Dynamic Calibration Test Method

Inverse Type Dynamic Calibration Test Method

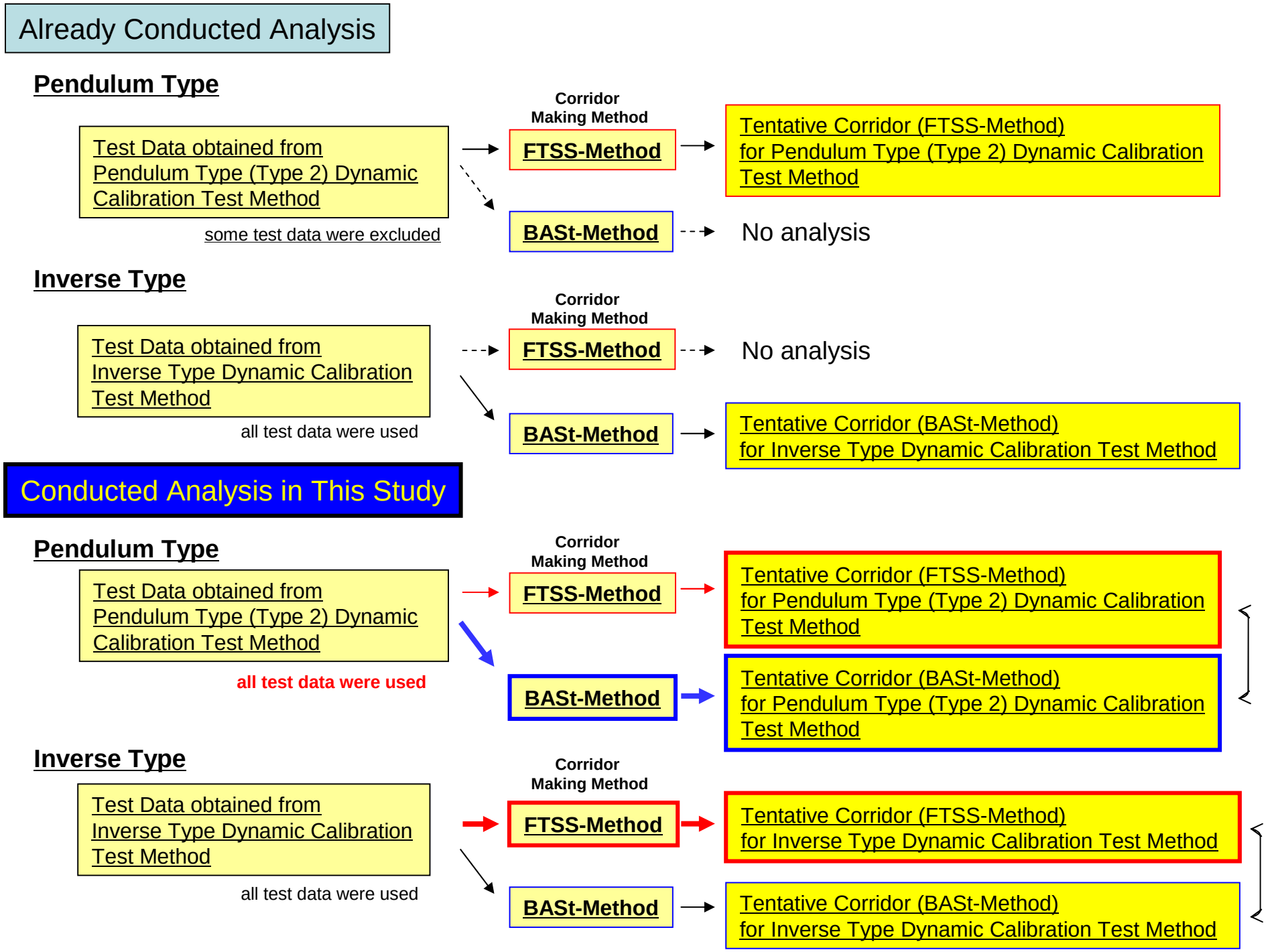


Corridor Making Method

BASt-Method

- Upper Corridor : Max. x 1.05
- Lower Corridor: Min. / 1.05

Ref.: TEG-094


Already Conducted Analysis
Pendulum Type
Test Data obtained from Pendulum Type (Type 2) Dynamic Calibration Test Method
some test data were excluded
Corridor Making Method
FTSS-Method
Tentative Corridor (FTSS-Method) for Pendulum Type (Type 2) Dynamic Calibration Test Method
BASt-Method
No analysis
Inverse Type
Test Data obtained from Inverse Type Dynamic Calibration Test Method
all test data were used
Corridor Making Method
FTSS-Method
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BASt-Method
Tentative Corridor (BASt-Method) for Inverse Type Dynamic Calibration Test Method
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Corridor Making Method
FTSS-Method
Tentative Corridor (FTSS-Method) for Inverse Type Dynamic Calibration Test Method
BASt-Method
Tentative Corridor (BASt-Method) for Inverse Type Dynamic Calibration Test Method

2. Making Corridors

2.1 Corridor for Pendulum Test

Tentative Corridor (FTSS-Method) for Pendulum Type (Type 2) Dynamic Calibration Test Method

- **Test Data: FTSS Nov. 08 Pendulum Type (Type 2) Dynamic Calibration Test Data (TEG-071, all test data were used)**
- **Corridor Making Method: FTSS-Method**

Corridor Making Method

FTSS-Method

- Average +/- 10% or Average +/- 2 St. Dev (wider one)

Ref.: ESV2009, Paper Number 09-0146

Test Data

Summary dynamic calibration TEG-071

TEST #1 Leg #1	75.1	177	135	90	246	201	160	108	8.03	22.4	4.29	4.99
TEST #2 Leg #1	82.9	181	138	92	247	201	160	109	8.59	22.5	4.33	4.41
TEST #3 Leg #1, block #1	82.2	179	136	91	245	200	159	108	8.61	22.4	4.30	4.37
TEST #4 Leg #1, block #1	78.7	175	135	90	241	195	156	106	8.64	22.5	4.24	4.38
TEST #1 Leg #2, block #2	74.0	175	134	90	235	197	152	106	8.16	22.2	4.30	4.85
TEST #2 Leg #2, block #1	69.2	177	135	92	241	199	153	107	7.79	22.4	4.42	5.26
TEST #3 Leg #2, block #2	71.6	181	137	94	245	204	158	111	7.89	22.4	4.46	5.25
TEST #4 Leg #2, block #1	72.1	176	135	92	241	199	153	107	7.84	22.4	4.44	5.22
TEST #5 Leg #2, block #1	73.3	183	140	96	248	205	158	110	7.87	22.5	4.48	5.18
TEST #1 Leg #3, block #1	77.2	183	138	91	239	204	170	107	8.34	22.3	4.34	4.90
TEST #2 Leg #3, block #2	75.3	183	138	91	241	205	171	108	8.30	22.4	4.40	4.95
TEST #4 Leg #3, block #1	71.8	183	138	91	242	204	171	109	8.17	22.4	4.43	5.12
GTR Dynamic calibration results	Acceln. knee	Femur Gauge 1	Femur Gauge 2	Femur Gauge 3	Tibia Gauge 1	Tibia Gauge 2	Tibia Gauge 3	Tibia Gauge 4	Peak ACL	Peak MCL	Peak LCL	Peak PCL
Average	75.3	179.4	136.7	91.6	242.5	201.1	160.0	108.0	8.19	22.4	4.37	4.91
St.Dev	4.2	3.1	1.9	1.7	3.7	3.3	6.8	1.5	0.3	0.1	0.1	0.3
CV[%]	5.6	1.7	1.4	1.9	1.5	1.6	4.3	1.4	3.8	0.3	1.8	7.0

Pendulum Test (Type 2) Tentative Corridor
Data: FTSS (TEG-071), Method: FTSS

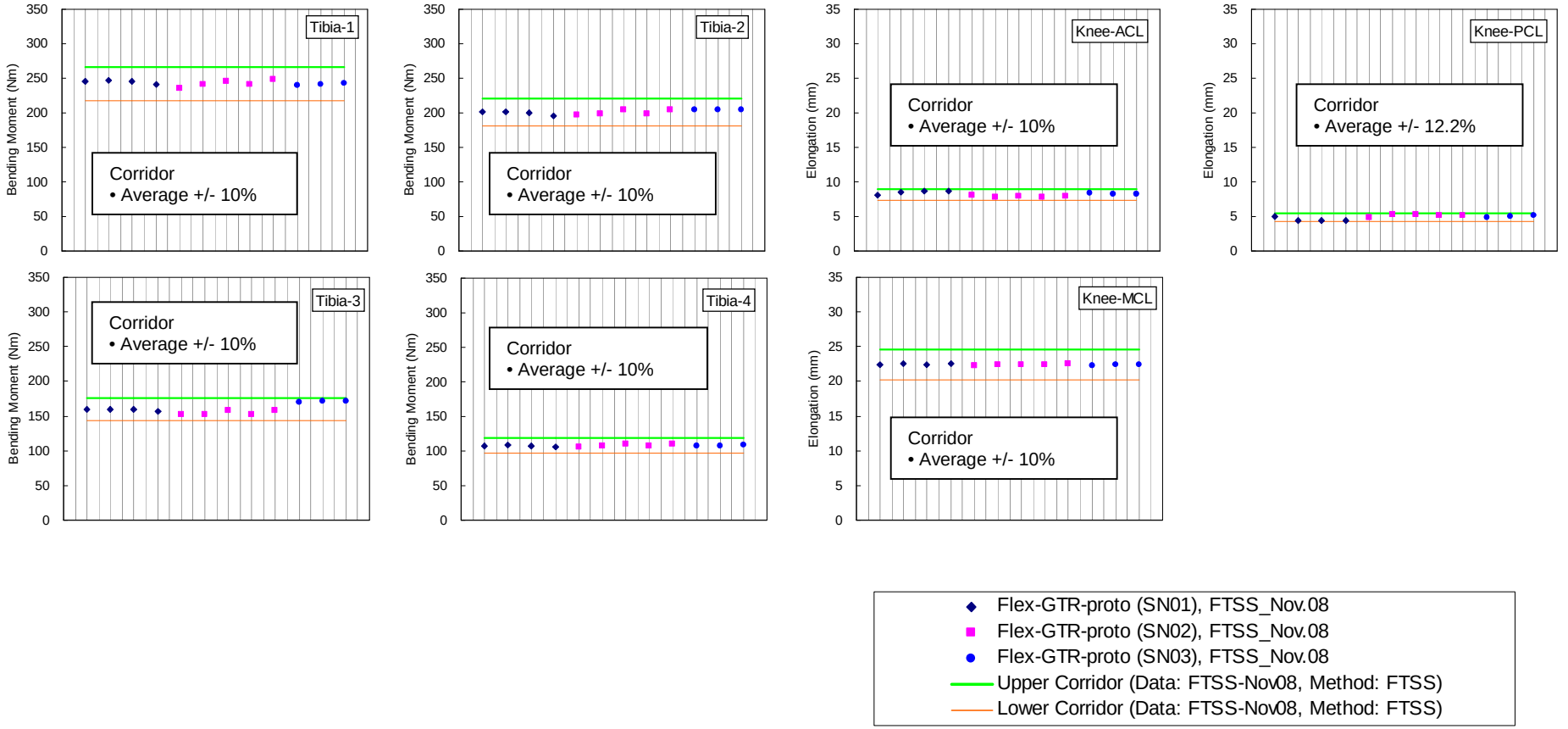
	Tibia-1 (Nm)	Tibia-2 (Nm)	Tibia-3 (Nm)	Tibia-4 (Nm)	ACL (mm)	PCL (mm)	MCL (mm)
Average	242.5	201.1	160	108	8.19	4.91	22.4
Max.	248	205	171	111	8.64	5.26	22.5
Min.	235	195	152	106	7.79	4.37	22.2
St.Dev	3.7	3.3	6.8	1.5	0.3	0.3	0.1
CV (%)	1.5	1.6	4.3	1.4	3.8	7.0	0.3
Max. Ratio (%)	2.3	1.9	6.9	2.8	5.5	7.1	0.4
Min. Ratio (%)	-3.1	-3.0	-5.0	-1.9	-4.9	-11.0	-0.9
Average x 0.1	24.3	20.1	16.0	10.8	0.8	0.5	2.2
St.Dev x 2.0	7.4	6.6	13.6	3.0	0.6	0.6	0.2
Larger value of above	24.3	20.1	16.0	10.8	0.8	0.6	2.2
Upper Corrodor	266.8	221.2	176.0	118.8	9.0	5.5	24.6
Lower Corrodor	218.3	181.0	144.0	97.2	7.4	4.3	20.2
Upper Corridor Ratio (%)	10.0	10.0	10.0	10.0	10.0	12.2	10.0
Lower Corridor Ratio (%)	-10.0	-10.0	-10.0	-10.0	-10.0	-12.2	-10.0

Pendulum Test (Type 2): Up side Down, Additional Mass 5 kg, without Flesh)
Max. Ratio: Max. / Average - 1
Min. Ratio: Min. / Average - 1
Upper Corridor Ratio: Upper Corridor / Average - 1
Lower Corridor Ratio: Lower Corridor / Average - 1

- Most of the upper and lower corridors were made by using minimum width of corridor (Average +/- 10%)

Tentative Corridor (FTSS-Method) for Pendulum Type (Type 2) Dynamic Calibration Test Method

- **Test Data: FTSS Nov. 08 Pendulum Type (Type 2) Dynamic Calibration Test Data (TEG-071, all test data were used)**
- **Corridor Making Method: FTSS-Method**



- Most of the upper and lower corridors were made by using minimum width of corridor (Average +/- 10%)

Tentative Corridor (BASt-Method) for Pendulum Type (Type 2) Dynamic Calibration Test Method

- **Test Data: FTSS Nov.08 Pendulum Type (Type 2) Dynamic Calibration Test Data (TEG-071, all test data were used)**
- **Corridor Making Method: BASt-Method**

Corridor Making Method

BASt-Method

- Upper Corridor : Max. x 1.05
- Lower Corridor: Min. / 1.05

Ref.: TEG-094

Test Data

Summary dynamic calibration TEG-071

TEST #1 Leg #1	75.1	177	135	90	246	201	160	108	8.03	22.4	4.29	4.99
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TEST #4 Leg #1, block #1	78.7	175	135	90	241	195	156	106	8.64	22.5	4.24	4.38
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TEST #4 Leg #2, block #1	72.1	176	135	92	241	199	153	107	7.84	22.4	4.44	5.22
TEST #5 Leg #2, block #1	73.3	183	140	96	248	205	158	110	7.87	22.5	4.48	5.18
TEST #1 Leg #3, block #1	77.2	183	138	91	239	204	170	107	8.34	22.3	4.34	4.90
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GTR Dynamic calibration results	Accelr. knee	Femur Gauge 1	Femur Gauge 2	Femur Gauge 3	Tibia Gauge 1	Tibia Gauge 2	Tibia Gauge 3	Tibia Gauge 4	Peak ACL	Peak MCL	Peak LCL	Peak PCL
Average	75.3	179.4	136.7	91.6	242.5	201.1	160.0	108.0	8.19	22.4	4.37	4.91
St.Dev	4.2	3.1	1.9	1.7	3.7	3.3	6.8	1.5	0.3	0.1	0.1	0.3
CV[%]	5.6	1.7	1.4	1.9	1.5	1.6	4.3	1.4	3.8	0.3	1.8	7.0

Pendulum Test (Type 2) Tentative Corridor
Data: FTSS (TEG-071), Method: BASt

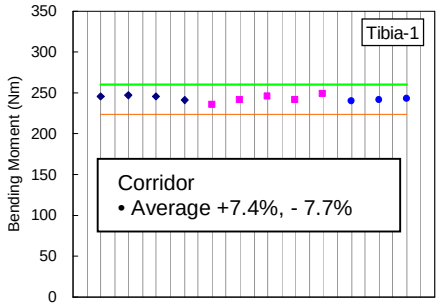
	Tibia-1 (Nm)	Tibia-2 (Nm)	Tibia-3 (Nm)	Tibia-4 (Nm)	ACL (mm)	PCL (mm)	MCL (mm)
Average	242.5	201.1	160	108	8.19	4.91	22.4
Max.	248	205	171	111	8.64	5.26	22.5
Min.	235	195	152	106	7.79	4.37	22.2
St.Dev	3.7	3.3	6.8	1.5	0.3	0.3	0.1
CV (%)	1.5	1.6	4.3	1.4	3.8	7.0	0.3
Max. Ratio (%)	2.3	1.9	6.9	2.8	5.5	7.1	0.4
Min. Ratio (%)	-3.1	-3.0	-5.0	-1.9	-4.9	-11.0	-0.9
Upper Corrodor	260.4	215.3	179.6	116.6	9.1	5.5	23.6
Lower Corrodor	223.8	185.7	144.8	101.0	7.4	4.2	21.1
Upper Corridor Ratio (%)	7.4	7.0	12.2	7.9	10.8	12.5	5.5
Lower Corridor Ratio (%)	-7.7	-7.7	-9.5	-6.5	-9.4	-15.2	-5.6

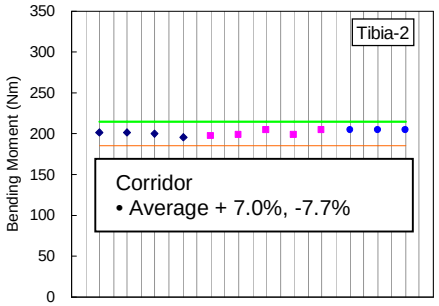
Pendulum Test (Type 2): Up side Down, Additional Mass 5 kg, without Flesh)
Max. Ratio: Max. / Average - 1
Min. Ratio: Min. / Average - 1
Upper Corridor Ratio: Upper Corridor / Average - 1
Lower Corridor Ratio: Lower Corridor / Average - 1

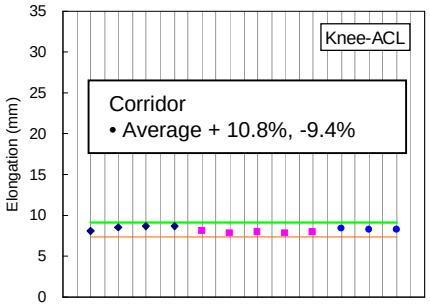
- All of the upper and lower corridors were made by using test data (Max. x 1.05, Min. / 1.05)

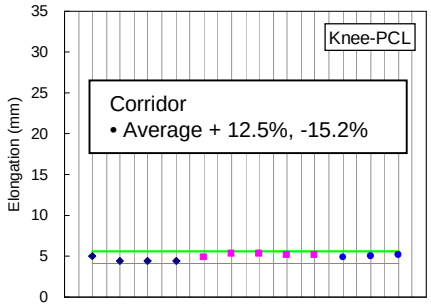
Tentative Corridor (BASt-Method) for Pendulum Type (Type 2) Dynamic Calibration Test Method

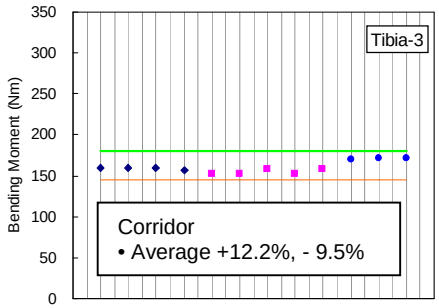
- **Test Data: FTSS Nov.08 Pendulum Type (Type 2) Dynamic Calibration Test Data (TEG-071, all test data were used)**
- **Corridor Making Method: BASt-Method**

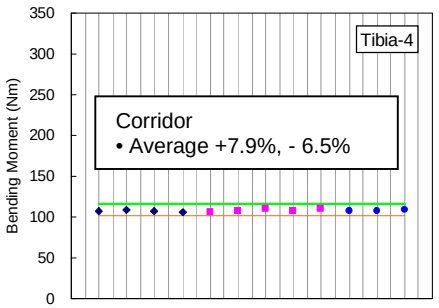


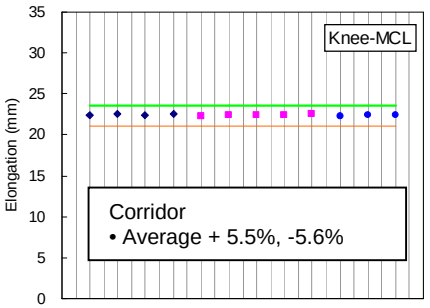


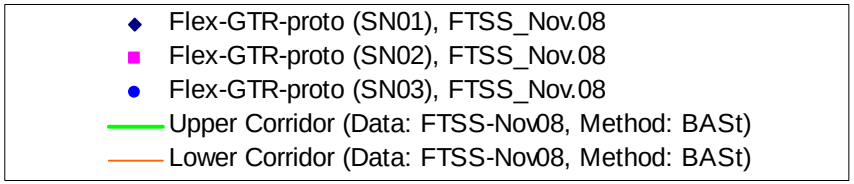






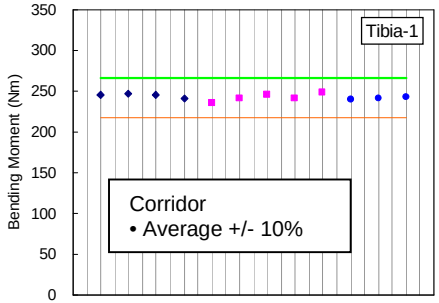


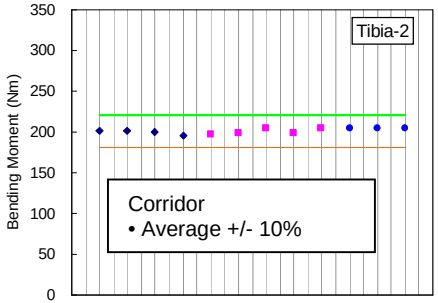


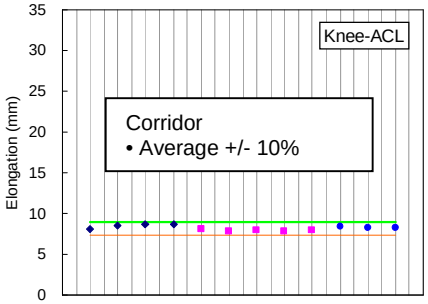


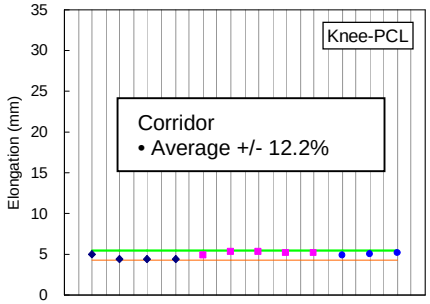
- All of the upper and lower corridors were made by using test data (Max. x 1.05, Min. / 1.05)

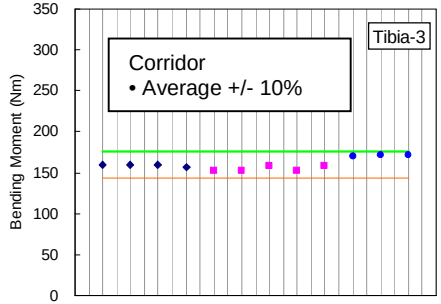
Tentative Corridor (FTSS-Method) for Pendulum Type (Type 2) Dynamic Calibration Test Method

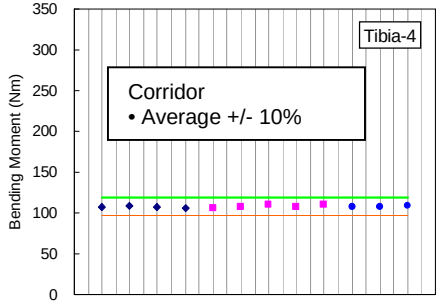


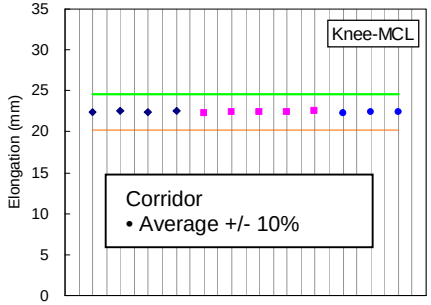






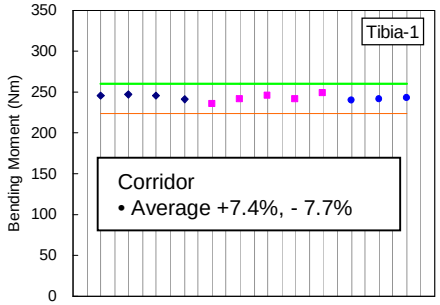


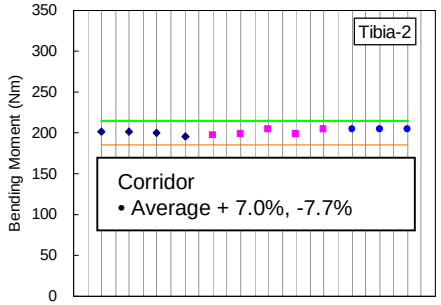


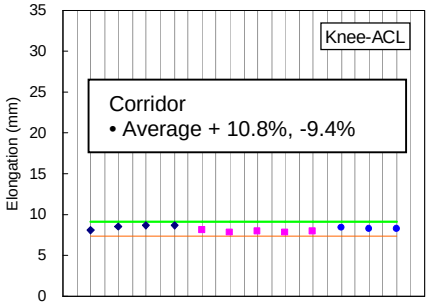


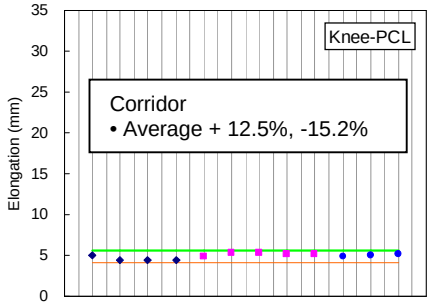
- Most of the upper and lower corridors were made by using minimum width of corridor (Average +/- 10%)

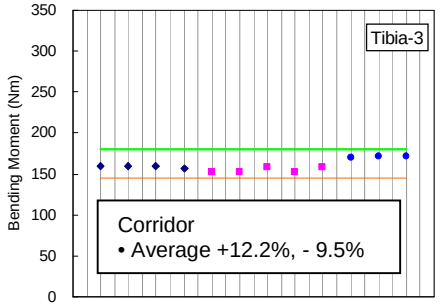
Tentative Corridor (BASt-Method) for Pendulum Type (Type 2) Dynamic Calibration Test Method

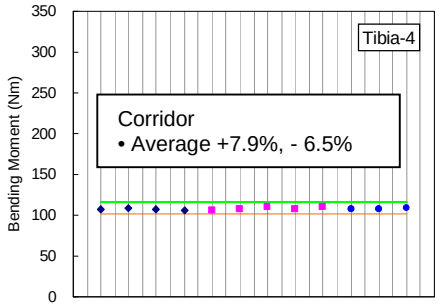


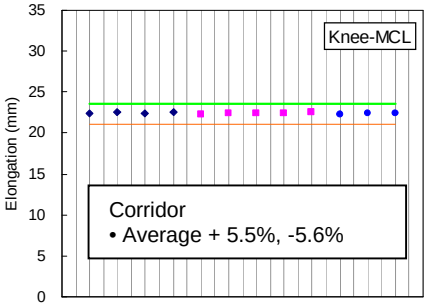












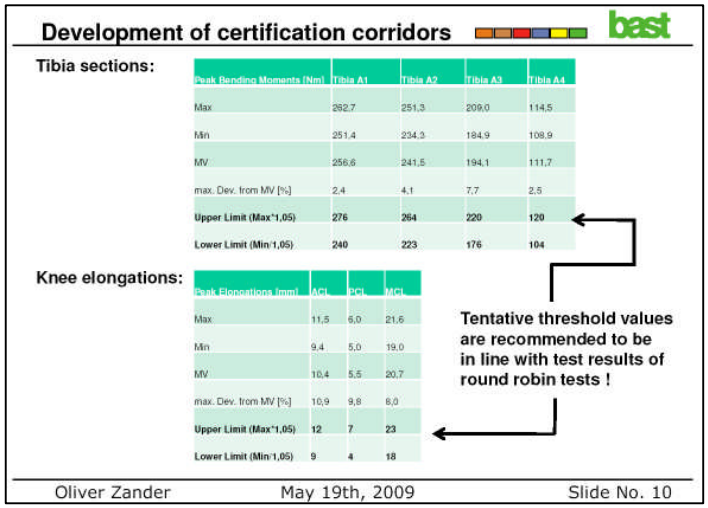
- All of the upper and lower corridors were made by using test data (Max. x 1.05, Min. / 1.05)

2.2 Corridor for Inverse Test

Tentative Corridor (FTSS-Method) for Inverse Type Dynamic Calibration Test Method

- **Test Data: BASt Inverse Type Dynamic Test Data (TEG-094, all test data were used)**
- **Corridor Making Method: FTSS-Method**

Test Data



Corridor Making Method

FTSS-Method

- Average +/- 10% or Average +/- 2 St. Dev (wider one)

Ref.: ESV2009, Paper Number 09-0146

Inverse Test Tentative Corridor
Data: BASt (TEG-094), Method: FTSS

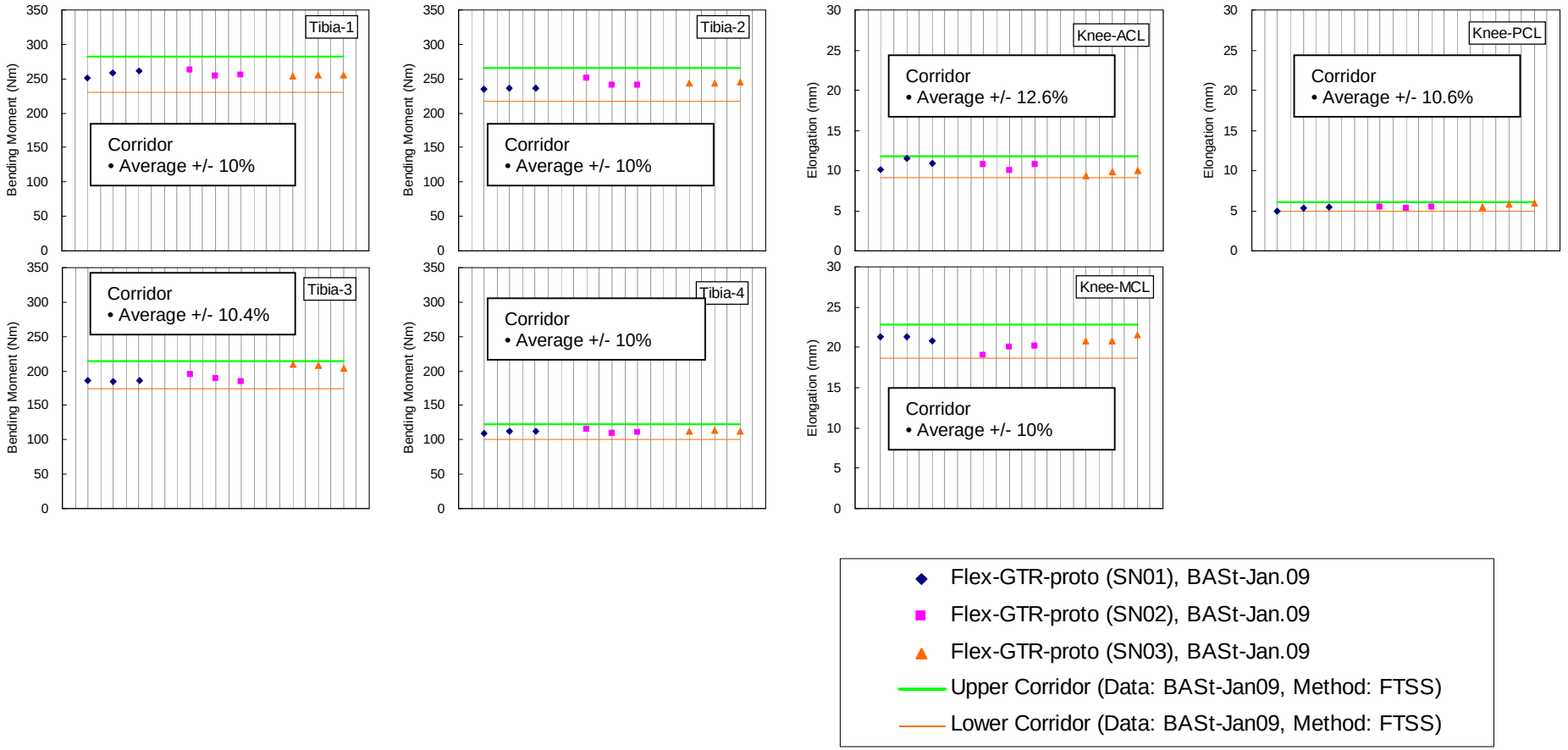
	Tibia-1 (Nm)	Tibia-2 (Nm)	Tibia-3 (Nm)	Tibia-4 (Nm)	ACL (mm)	PCL (mm)	MCL (mm)
Average	256.6	241.5	194.1	111.7	10.4	5.5	20.7
Max.	262.7	251.3	209	114.5	11.5	6	21.6
Min.	251.4	234.3	184.9	108.9	9.4	5	19
St.Dev	3.6	5.3	10.1	1.9	0.7	0.3	0.8
CV (%)	1.4	2.2	5.2	1.7	6.3	5.3	3.8
Max. Ratio (%)	2.4	4.1	7.7	2.5	10.6	9.1	4.3
Min. Ratio (%)	-2.0	-3.0	-4.7	-2.5	-9.6	-9.1	-8.2
Average x 0.1	25.7	24.2	19.4	11.2	1.0	0.6	2.1
St.Dev x 2.0	7.2	10.6	20.2	3.8	1.3	0.6	1.6
Larger value of above	25.7	24.2	20.2	11.2	1.3	0.6	2.1
Upper Corrodor	282.3	265.7	214.3	122.9	11.7	6.1	22.8
Lower Corrodor	230.9	217.4	173.9	100.5	9.1	4.9	18.6
Upper Corridor Ratio (%)	10.0	10.0	10.4	10.0	12.6	10.6	10.0
Lower Corridor Ratio (%)	-10.0	-10.0	-10.4	-10.0	-12.6	-10.6	-10.0

Max. Ratio: Max. / Average - 1
Min. Ratio: Min. / Average - 1
Upper Corridor Ratio: Upper Corridor / Average - 1
Lower Corridor Ratio: Lower Corridor / Average - 1

- Most of the upper and lower corridors were made by using minimum width of corridor (Average +/- 10%)

Tentative Corridor (FTSS-Method) for Inverse Type Dynamic Calibration Test Method

- **Test Data: BASt Inverse Type Dynamic Test Data (TEG-094, all test data were used)**
- **Corridor Making Method: FTSS-Method**



- Most of the upper and lower corridors were made by using minimum width of corridor (Average +/- 10%)

Tentative Corridor (BASt-Method) for Inverse Type Dynamic Calibration Test Method

- **Test Data: BASt Jan.09 Inverse Type Dynamic Test Data (TEG-094, all test data were used)**
- **Corridor Making Method: FTSS-Method**

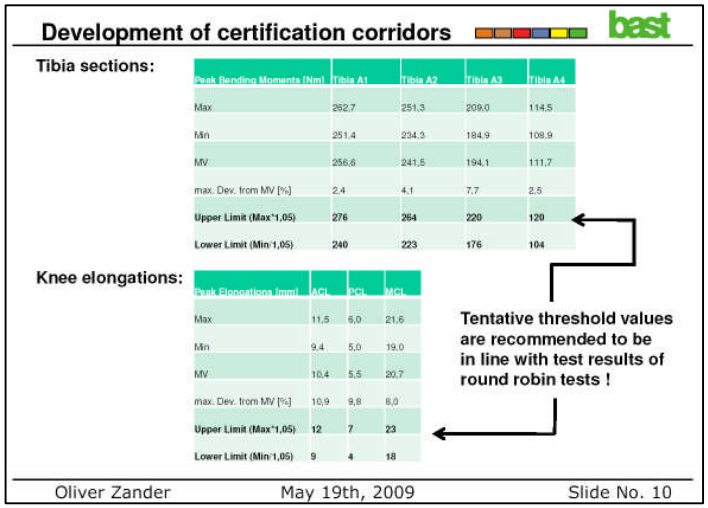
Corridor Making Method

BASt-Method

- Upper Corridor : Max. x 1.05
- Lower Corridor: Min. / 1.05

Ref.: TEG-094

Test Data



Inverse Test Tentative Corridor
Data: BASt (TEG-094), Method: BASt

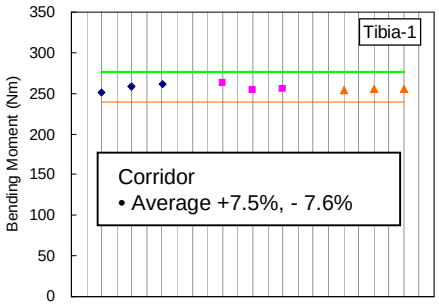
	Tibia-1 (Nm)	Tibia-2 (Nm)	Tibia-3 (Nm)	Tibia-4 (Nm)	ACL (mm)	PCL (mm)	MCL (mm)
Average	256.6	241.5	194.1	111.7	10.4	5.5	20.7
Max.	262.7	251.3	209	114.5	11.5	6	21.6
Min.	251.4	234.3	184.9	108.9	9.4	5	19
CV (%)	1.4	2.2	5.2	1.7	6.3	5.3	3.8
Max. Ratio (%)	2.4	4.1	7.7	2.5	10.6	9.1	4.3
Min. Ratio (%)	-2.0	-3.0	-4.7	-2.5	-9.6	-9.1	-8.2
Upper Corrodor	275.8	263.9	219.5	120.2	12.1	6.3	22.7
Lower Corrodor	239.4	223.1	176.1	103.7	9.0	4.8	18.1
Upper Corridor Ratio (%)	7.5	9.3	13.1	7.6	16.1	14.5	9.6
Lower Corridor Ratio (%)	-6.7	-7.6	-9.3	-7.1	-13.9	-13.4	-12.6

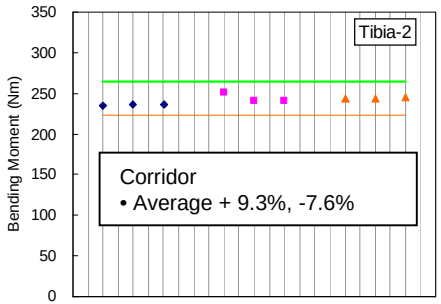
Max. Ratio: Max. / Average - 1
Min. Ratio: Min. / Average - 1
Upper Corridor Ratio: Upper Corridor / Average - 1
Lower Corridor Ratio: Lower Corridor / Average - 1

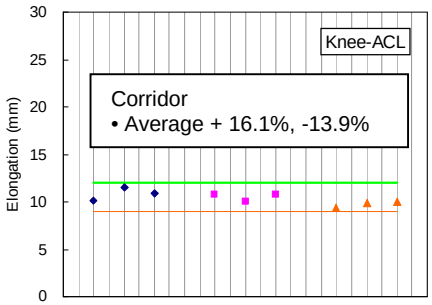
- All of the upper and lower corridors were made by using test data (Max. x 1.05, Min. / 1.05)

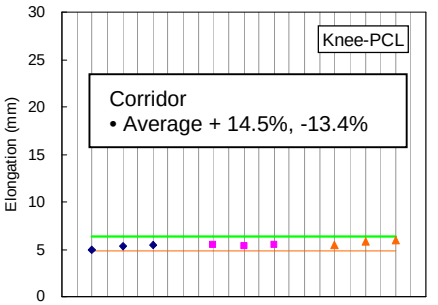
Tentative Corridor (BASt-Method) for Inverse Type Dynamic Calibration Test Method

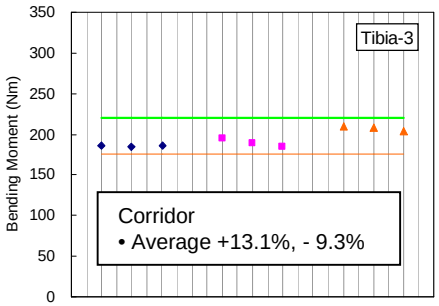
- **Test Data: BASt Jan.09 Inverse Type Dynamic Test Data (TEG-094, all test data were used)**
- **Corridor Making Method: FTSS-Method**

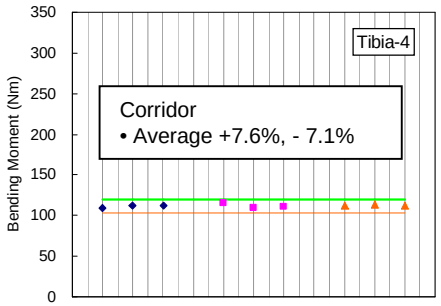


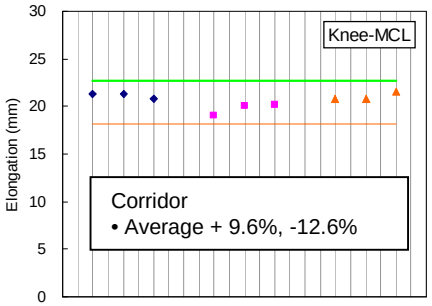


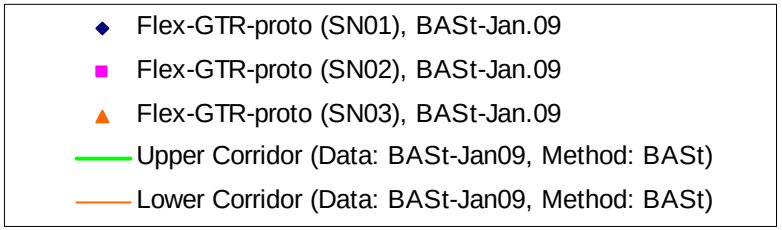






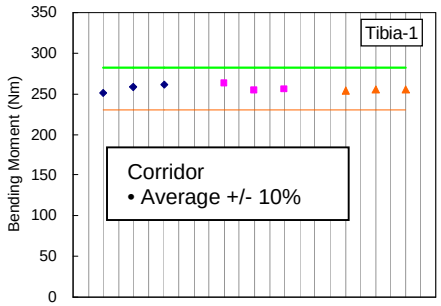


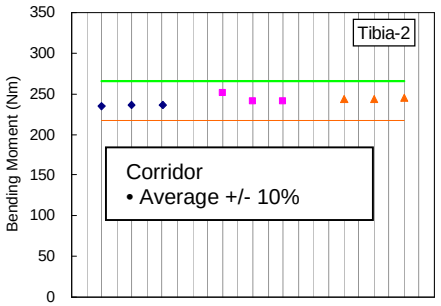


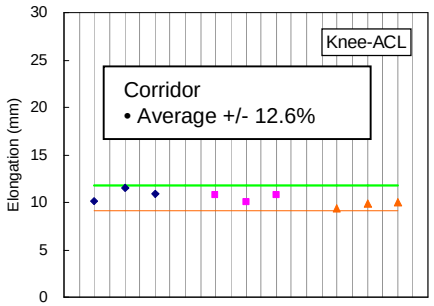


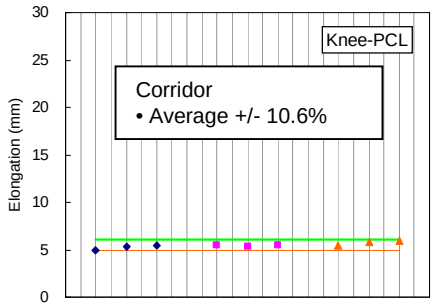
- All of the upper and lower corridors were made by using test data (Max. x 1.05, Min. / 1.05)

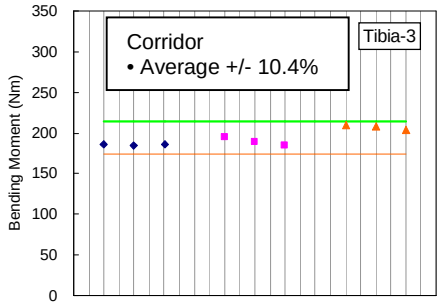
Tentative Corridor (FTSS-Method) for Inverse Type Dynamic Calibration Test Method

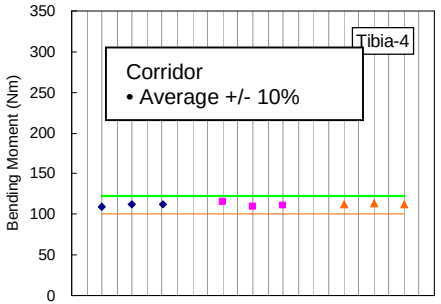


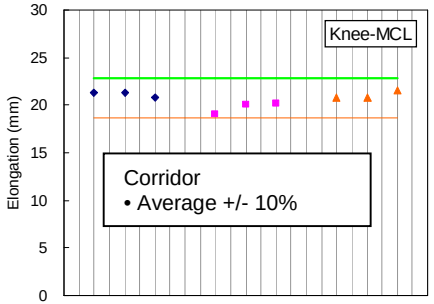






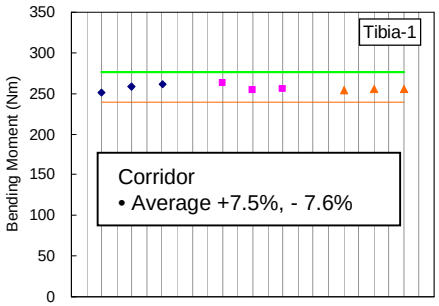


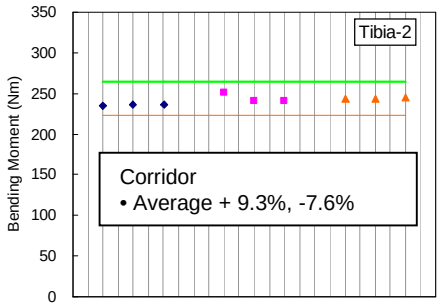


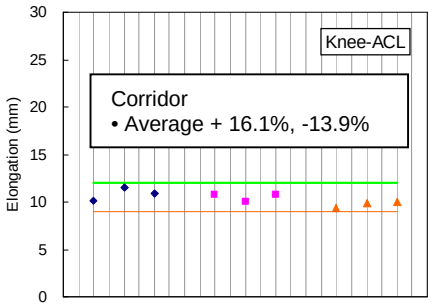


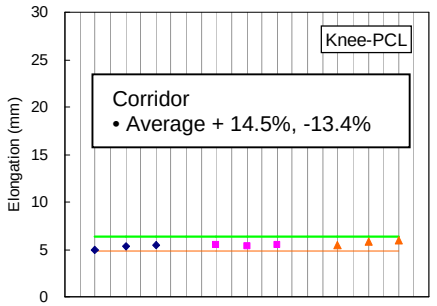
- Most of the upper and lower corridors were made by using minimum width of corridor (Average +/- 10%)

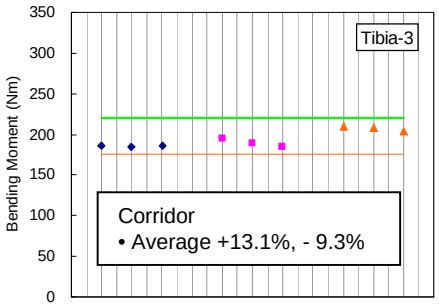
Tentative Corridor (BASt-Method) for Inverse Type Dynamic Calibration Test Method

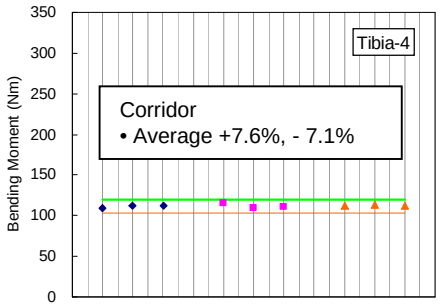


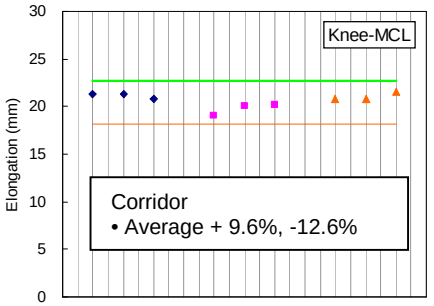












- All of the upper and lower corridors were made by using test data (Max. x 1.05, Min. / 1.05)

3. Discussion on the Corridor Making Methods

Discussion for the Corridor Making Methods

Corridor Making Method

FTSS-Method

- Average +/- 10% or Average +/- 2 St. Dev (wider one)

Ref.: ESV2009, Paper Number 09-0146

Comment

- Most of the upper and lower corridors were made by using minimum width of corridor (Average +/- 10%)

Discussion

- Why the minimum width of corridor were made by using Average +/- 10 %?
- Can not we use only Average +/- 2 St. Dev. to make all of the corridor?

Corridor Making Method

BASt-Method

- Upper Corridor : Max. x 1.05
- Lower Corridor: Min. / 1.05

Ref.: TEG-094

Comment

- All of the upper and lower corridors were made by using test data (Max. x 1.05, Min. / 1.05)

Discussion

- This method always taking account of the test data (Max. Min.) to make all of the corridor.
- However, if outliers are involved in the test data (testing error or so), the width of the corridor tend to become very wide.
- So, if we use the method, how about to add a protocol to exclude outliers from the observed test data?

JAMA-JARI Opinion

- JAMA-JARI prefer to use the BASt-Method for the corridor making because the BASt-Method always consider the test data (does not automatically set the corridor width as +/- 10% in minimum).
- However, we would like to propose to add a protocol to exclude outliers from the observed test data in order to remove outliers from the test data.