24 April 2006
3rd Flex-TEG MT
BASt, Bergisch

Information on the Flexible Pedestrian Legform Impactor GT Alpha (Flex-GTα)

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Background

- At the 2nd Flex-TEG meeting, a request is made to increase the knee bending angle limit of Flexible Pedestrian Legform Impactor G (Flex-G).
- Japan addressed the issue, and developed the Flexible Pedestrian Legform Impactor GT Alpha (Flex-GTα) in March 2006.
- The Flex-GTα is obtained a modified knee bending angle limit, and is also obtained modified specifications to improve injury assessment ability.
- This presentation explains the Flex-GTα specifications.
- Then the other presentation introduces the evaluation methodologies and results concerning the injury assessment ability of Flex-GTα.

General

Basic Structure

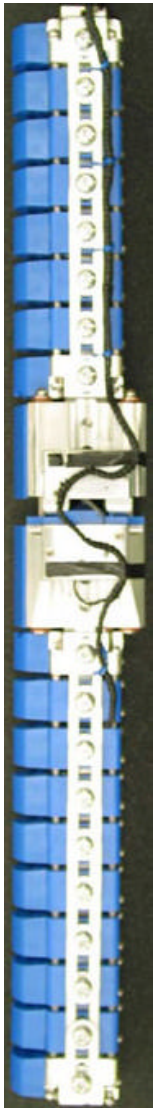
Flex-G

Thigh
flexible
bending

Knee
flexible bending
with ligament
restraint system

Leg
flexible
bending

Flex-GTα



Thigh
flexible
bending

Knee
flexible bending
with ligament
restraint system

Leg
flexible
bending

Basic structure is the same.

Length, C.G. Location, and Mass

Thigh and Leg

Length, C.G. Location, and Mass	50th percentile of American Males*	Flex-GT α***	Flex-G
a) Thigh length (mm)	428	433	433
b) Leg length (mm)	493	495	495
c) C.G. location of thigh (mm) **	218	189	213
d) C.G. location of leg (mm) **	233	197	225
e) Total legform impactor mass (kg)	13.4	12.4	13.9
f) Thigh mass (kg)	8.6	6.7	8.6
g) Leg mass (kg)	4.8	5.7	5.3

* Robbins, D.H. ' Anthropometry of Motor Vehicle Occupants, Volume 2' NHTSA Contract DTNH22-80-C-07502 Pub. 1985.

** From the knee joint center

*** Prototype (estimated values)

Flex-GTα differs slightly from the 50th percentile American male in thigh/leg lengths, C.G. locations and mass.

→These differences give Flex-GTα a better injury assessment ability than that of Flex-G.

Long Bones

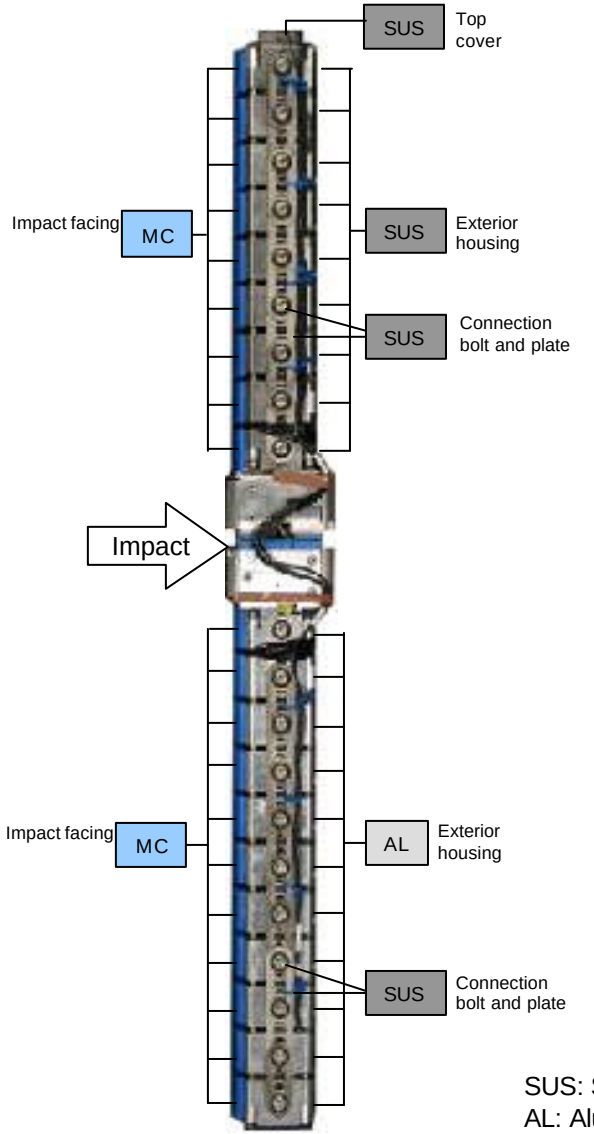
Long Bones

Materials

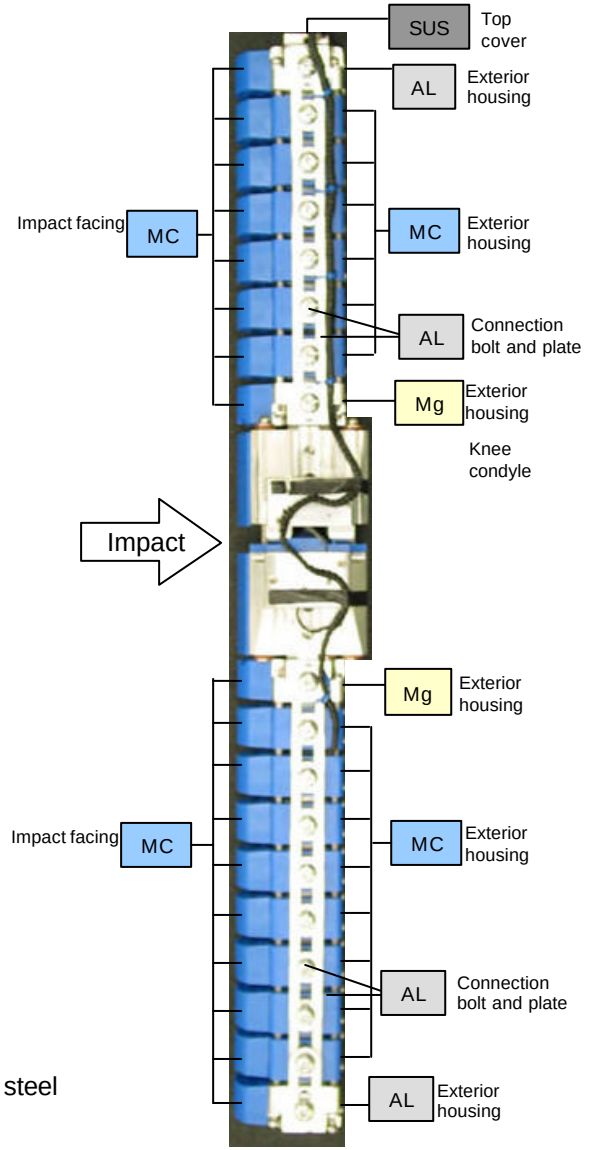
Flex-GTα uses different material for long bones as compared with that of Flex-G.

→To make the long bones lighter

Flex-G



Flex-GTα



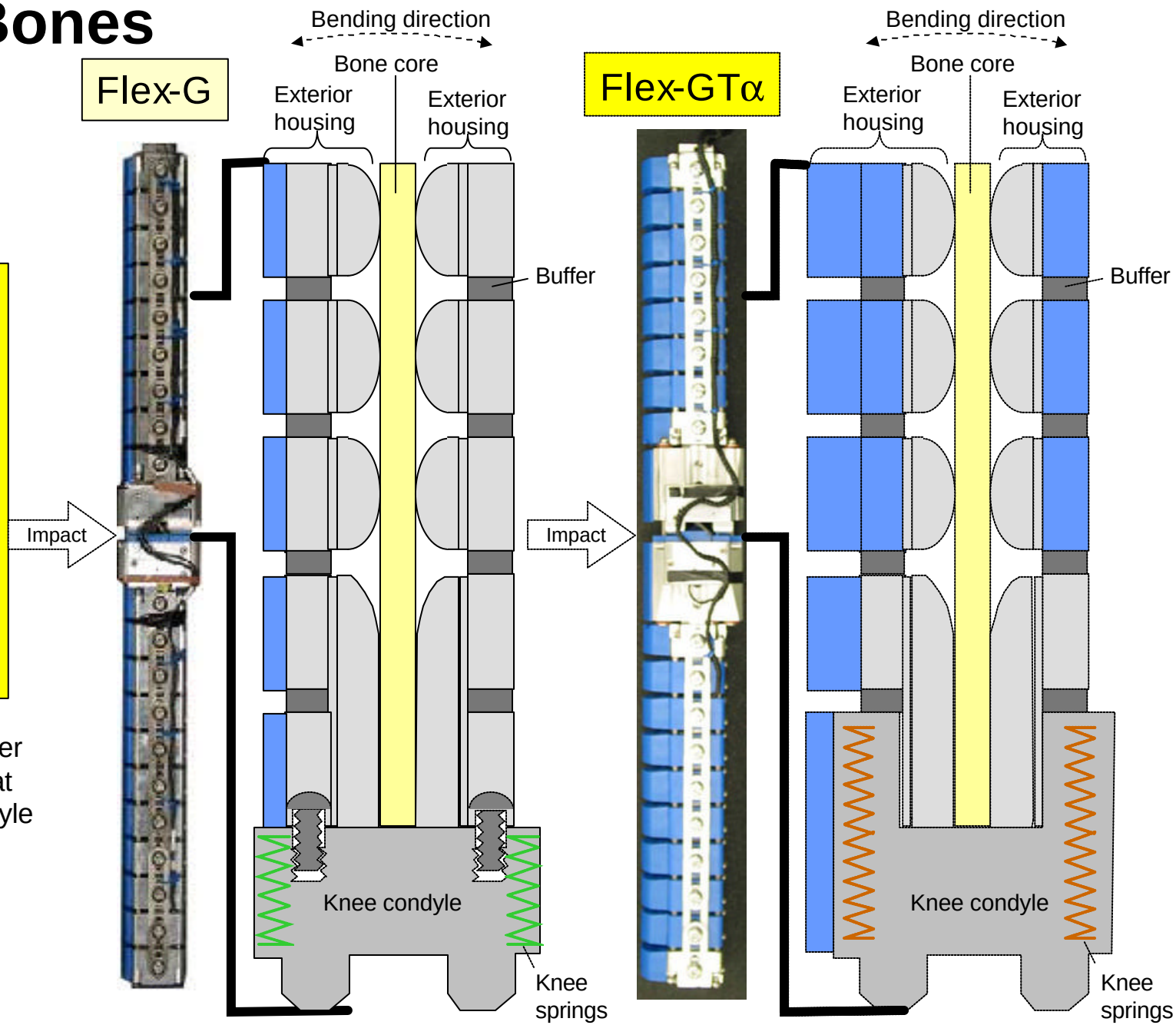
SUS: Stainless steel
AL: Aluminum
MC: MC-nylon

Long Bones

Bone and knee condyle connection

Flex-GTα connects the long bone and the knee condyle differently from the connection in Flex-G.

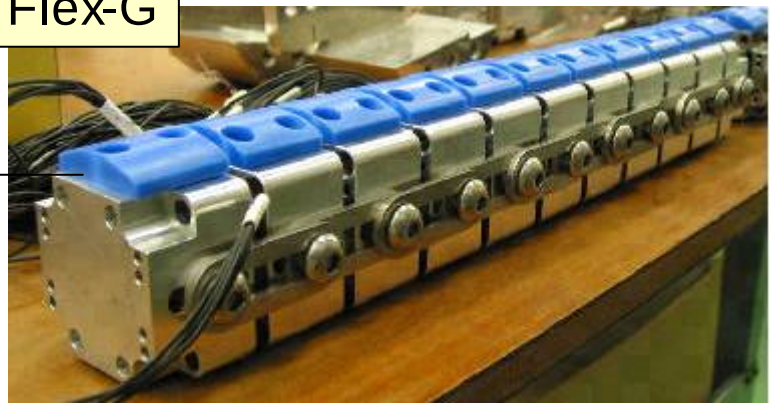
→To install longer knee springs at the knee condyle



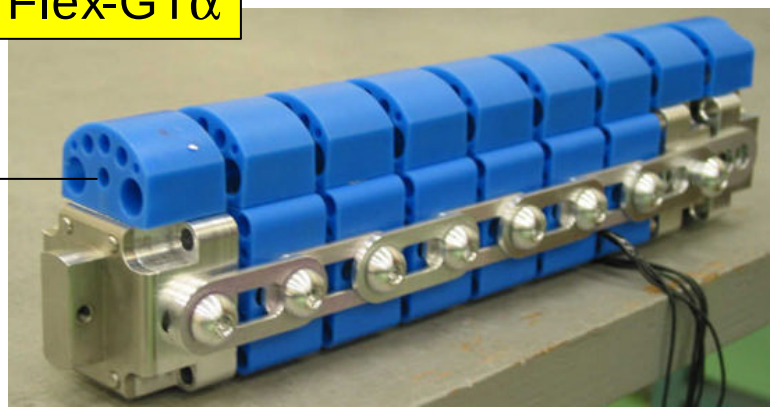
Long Bones

Impact facing

Flex-G



Flex-GTα

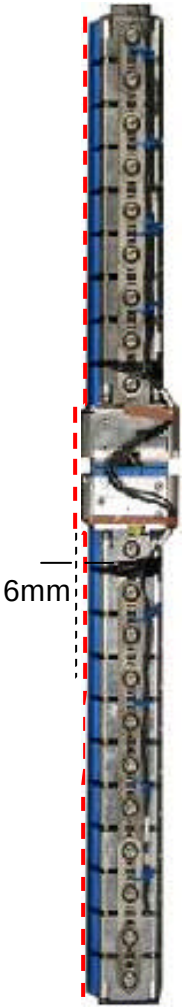


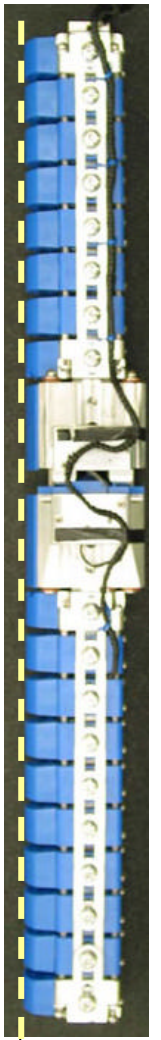
Flex-GTα has a thicker impact facing as compared with that of Flex-G.

→ To align the impact facing with the knee

Flex-G

Flex-GTα



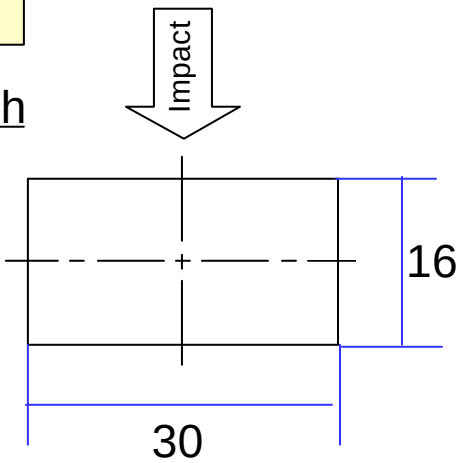


Long Bones

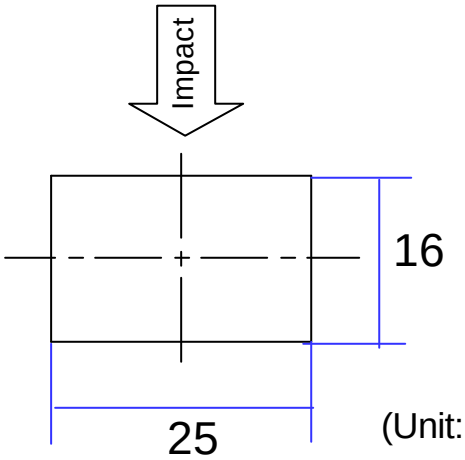
Sectional dimensions of bone core

Flex-G

Thigh



Leg

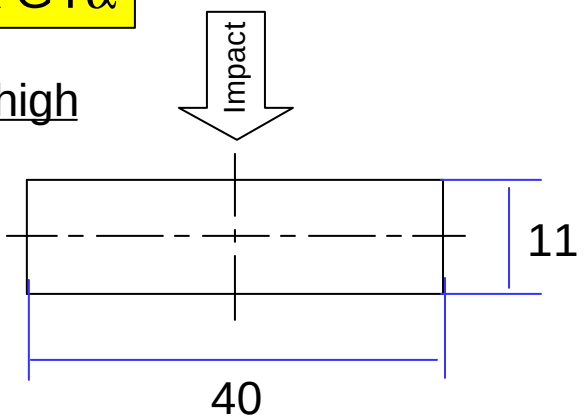


(Unit: mm)

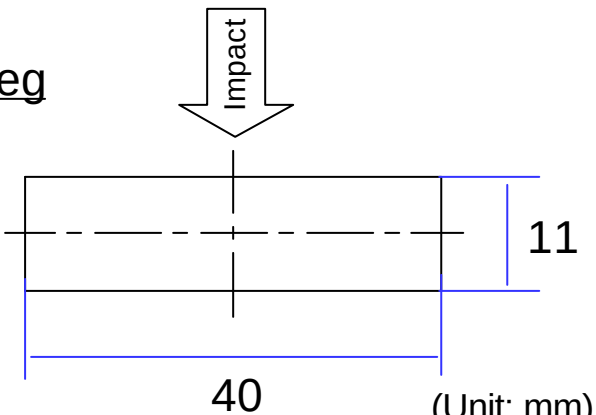
Sectional image

Flex-GTα

Thigh



Leg



(Unit: mm)

Sectional image

Flex-GTα has a thinner and wider bone core as compared with that of Flex-G. (Long bones of Flex-GTα has smaller bending stiffness as compared with that of Flex-G).

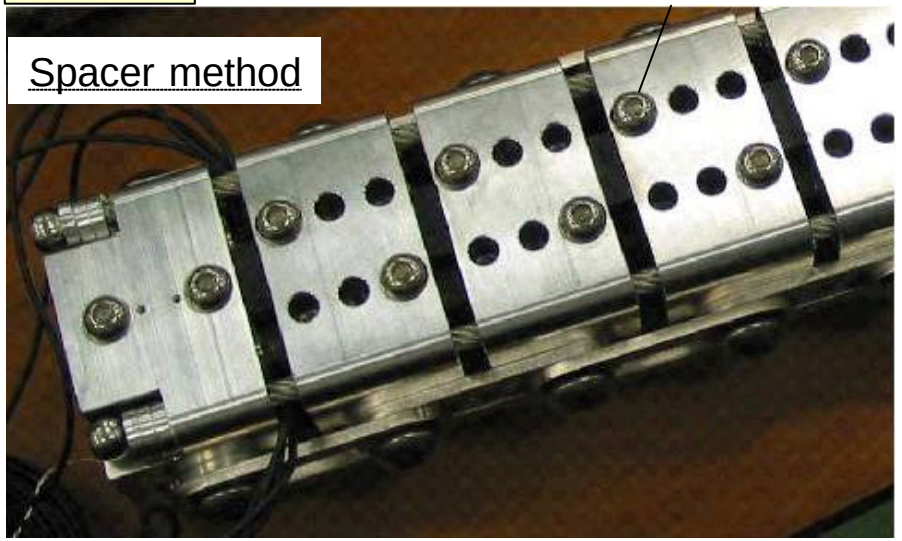
→ The difference gives Flex-GTα a better injury assessment ability than that of Flex-G.

Long Bones

Bone core binding method

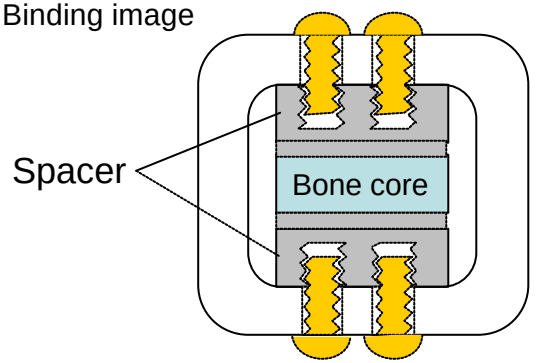
Flex-G

Spacer method



Direction of binding image

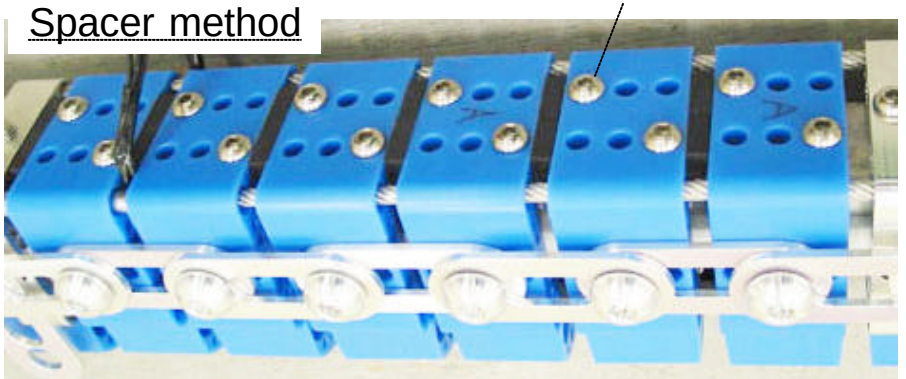
Binding image



No bone core binding by screw.
(Just keep the spacers in position.)

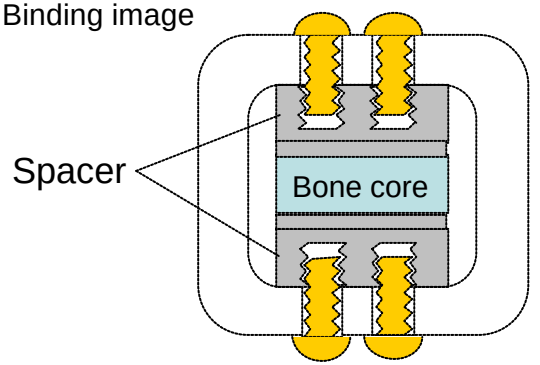
Flex-GTα

Spacer method



Direction of binding image

Binding image



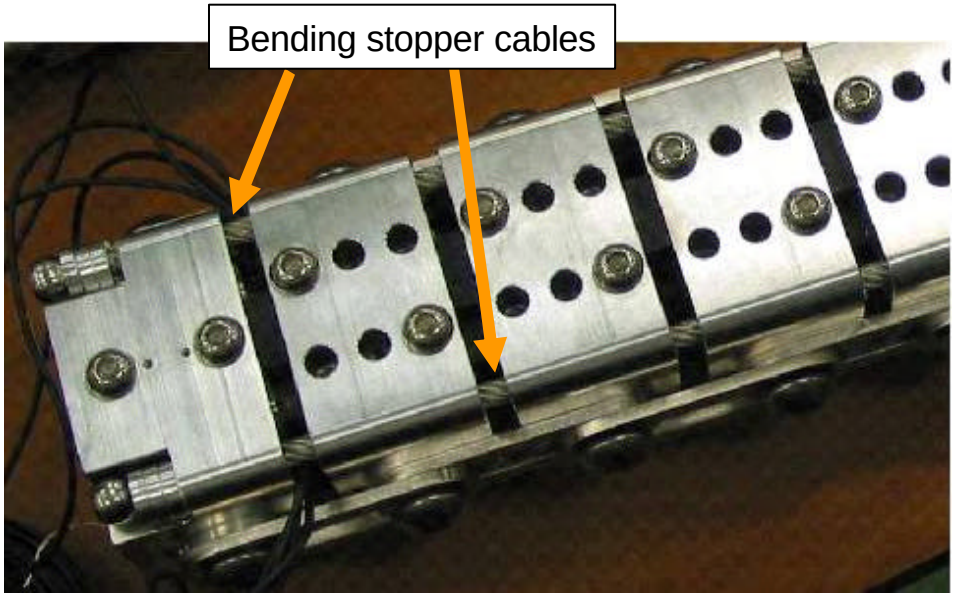
No bone core binding by screw.
(Just keep the spacers in position.)

Flex-GTα uses the same bone core binding method as Flex-G.

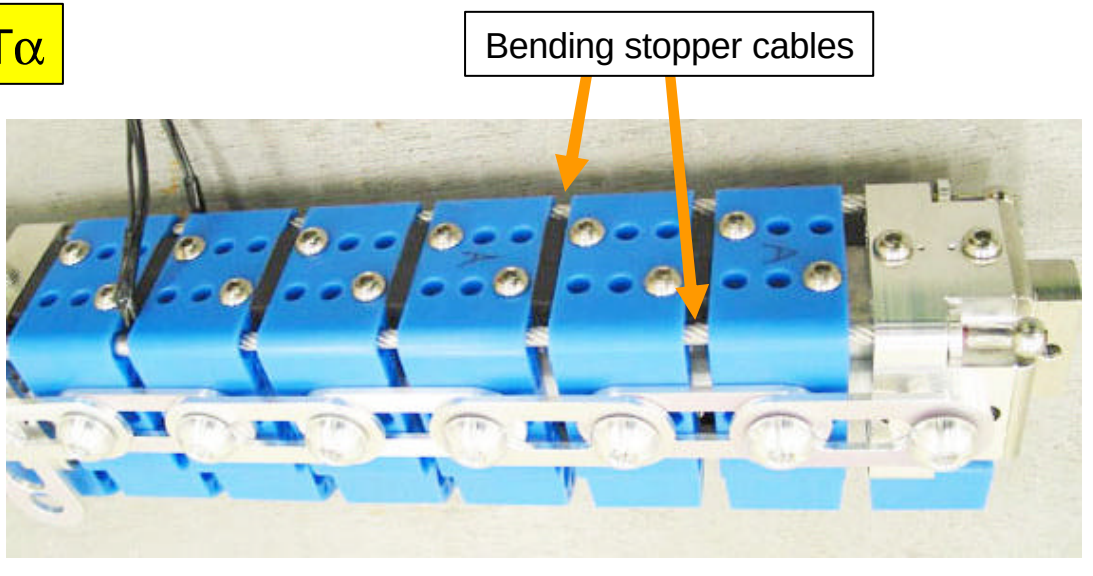
Long Bones

Bending stopper cables

Flex-G



Flex-GTα

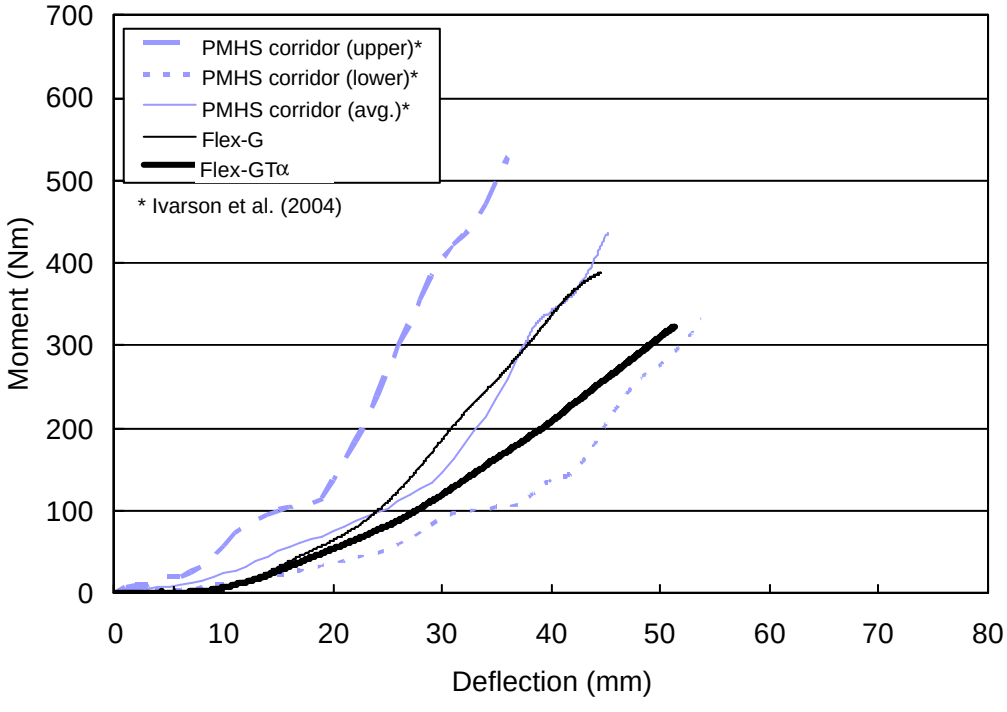


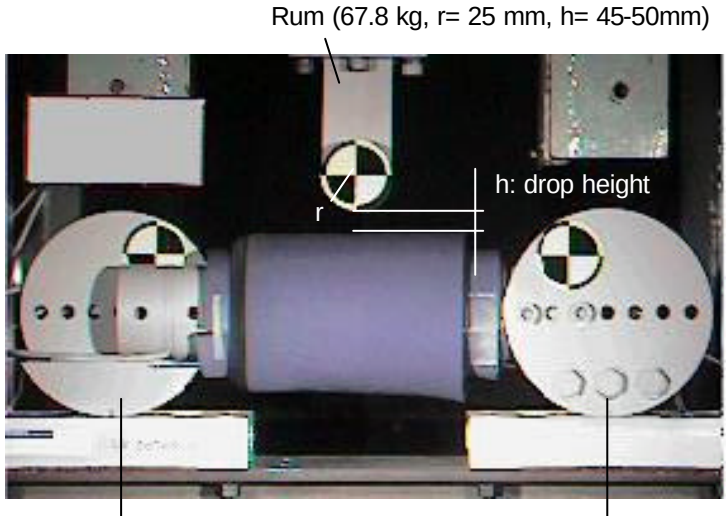
Flex-GTα has the same bending stopper cables as those of Flex-G.

Long Bones

Bending characteristics (Thigh)

Flex-G and Flex-GTα





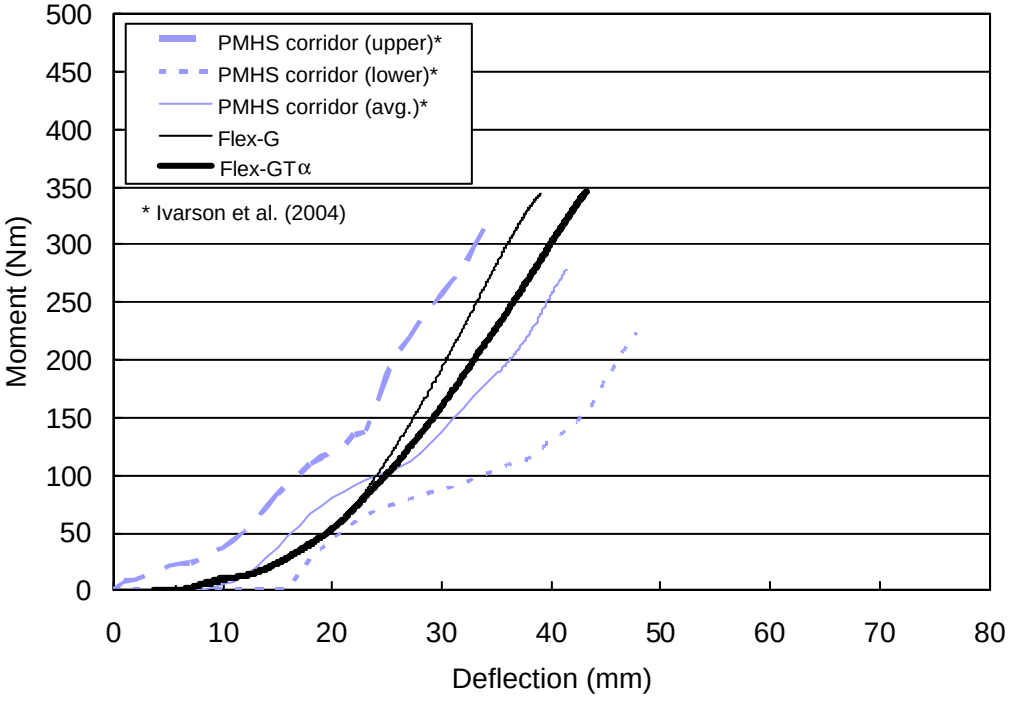
Flex-GTα (Thigh) has slightly smaller bending stiffness than that of Flex-G.

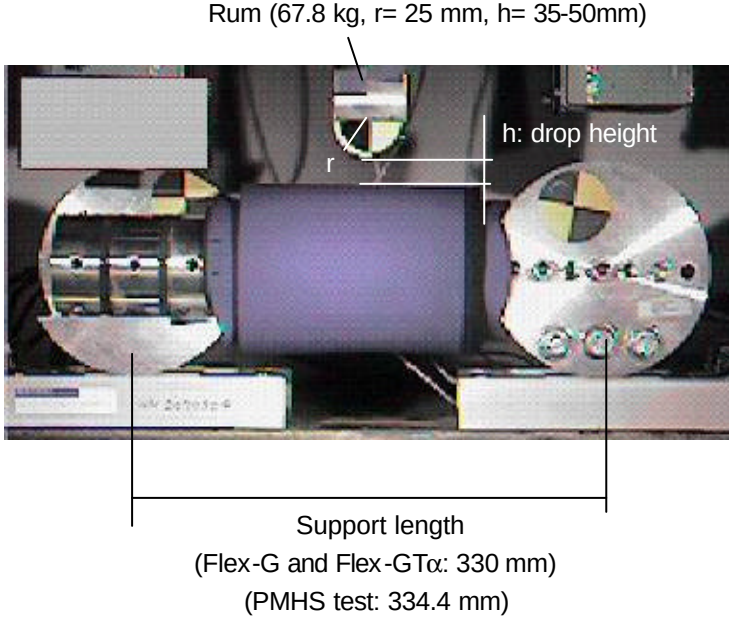
→ The difference gives Flex-GTα a better injury assessment ability than that of Flex-G.

Long Bones

Bending characteristics (Leg)

Flex-G and Flex-GTα





Flex-GTα (Leg) has slightly smaller bending stiffness than that of Flex-G.

→ The difference gives Flex-GTα a better injury assessment ability than that of Flex-G.

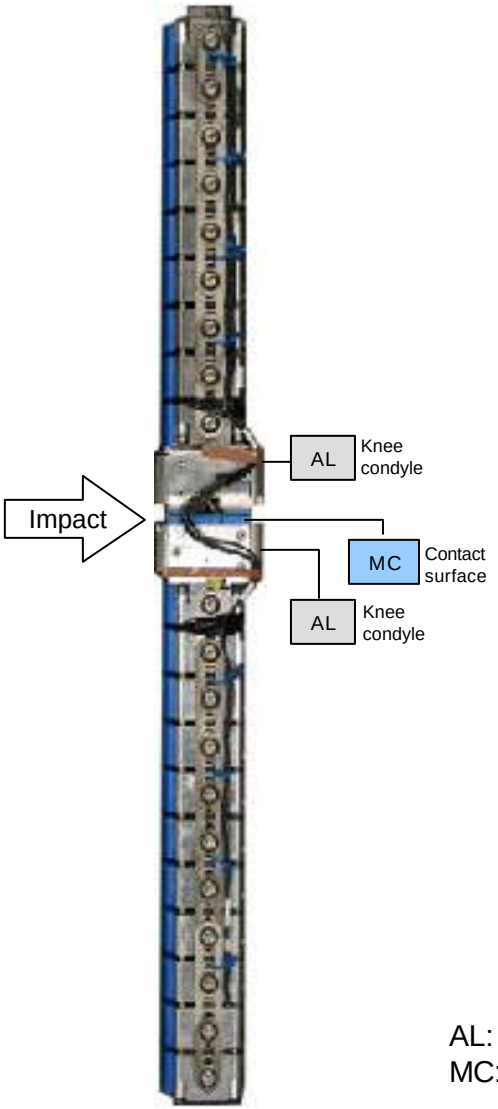
Knee

Knee

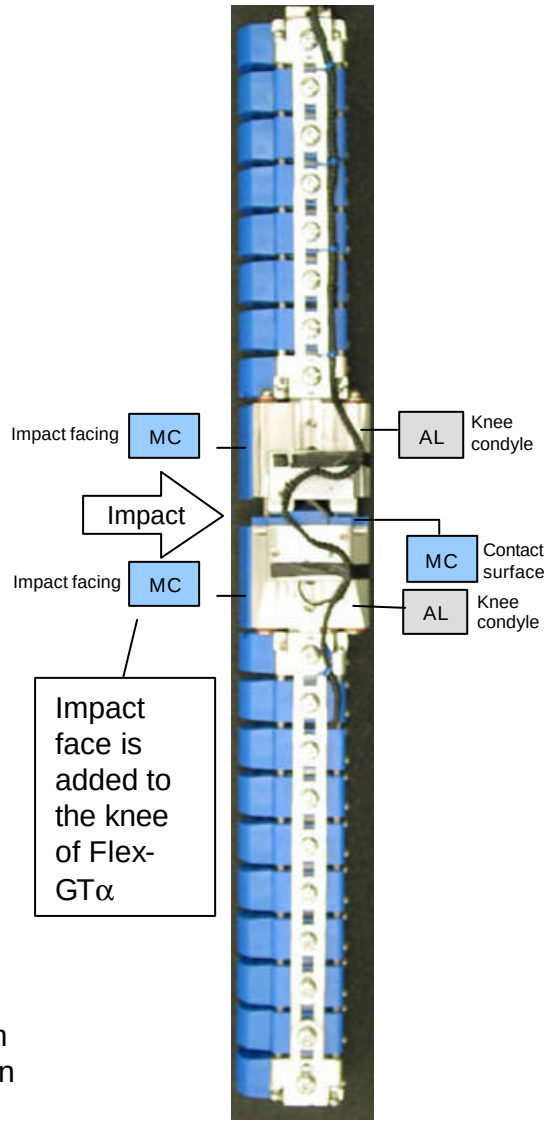
Materials

Flex-GTα basically uses the same knee material as that of Flex-G.

Flex-G



Flex-GTα



AL: Aluminum
MC: MC-nylon

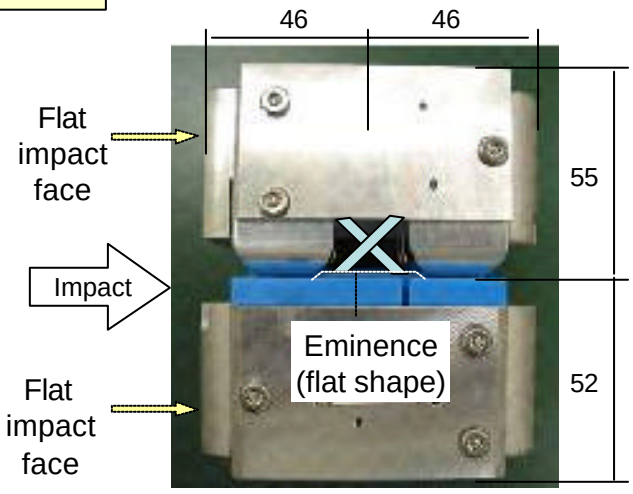
Knee

Size and design

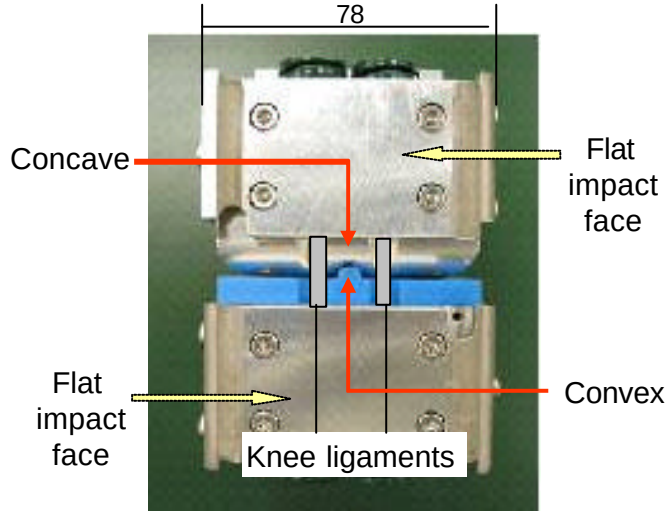
Flex-GTα has different knee size and different designs as compared with those of Flex-G.

Flex-G

Front view



Side view



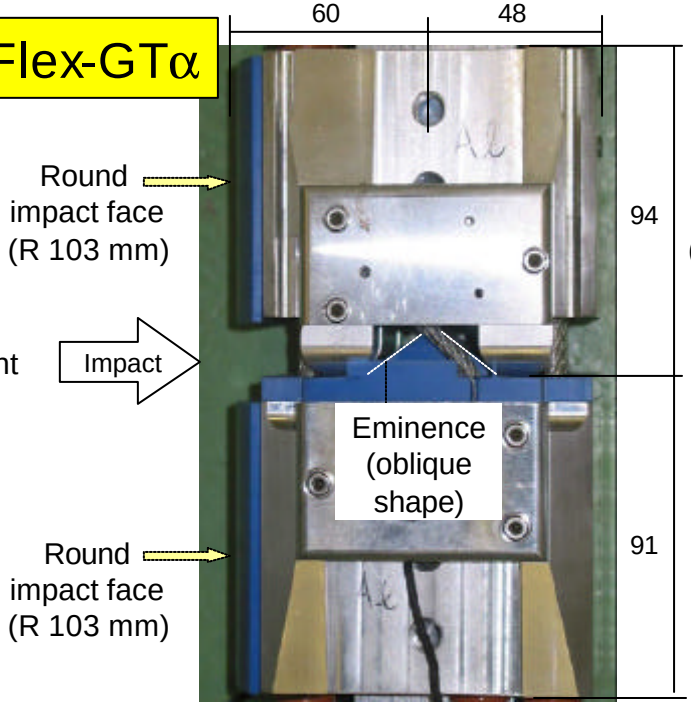
Flex-GTα

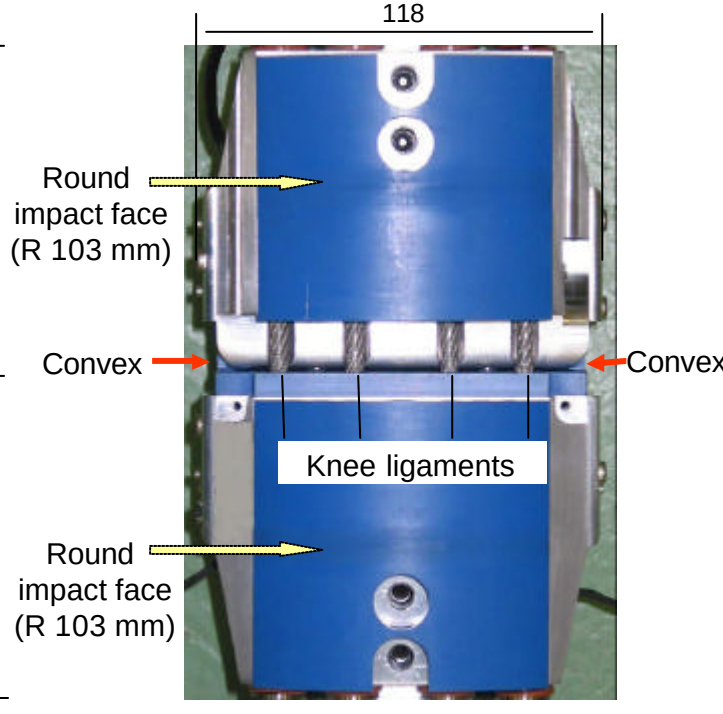
Size
→ To install longer springs

Round impact face
→ Smooth impact with car

Eminence (oblique shape)
→ Smooth condyle movement

Convex position
→ Changed its positions





Knee

Knee ligaments

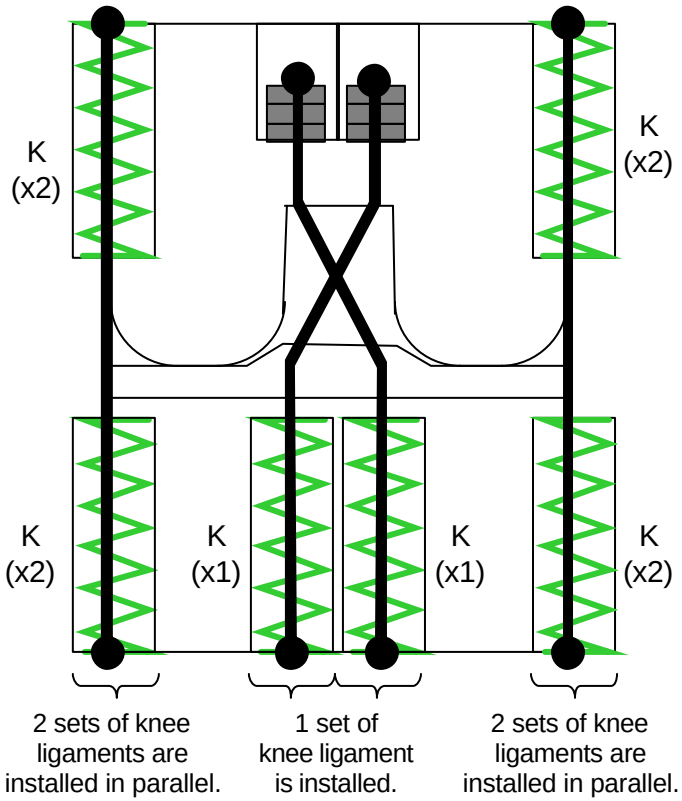
Flex-GTα has different knee ligaments as compare with those of Flex-G

Longer springs
→ To increase the maximum knee bending angle

Spring constant
→ Longer springs tend to have small number of spring constant

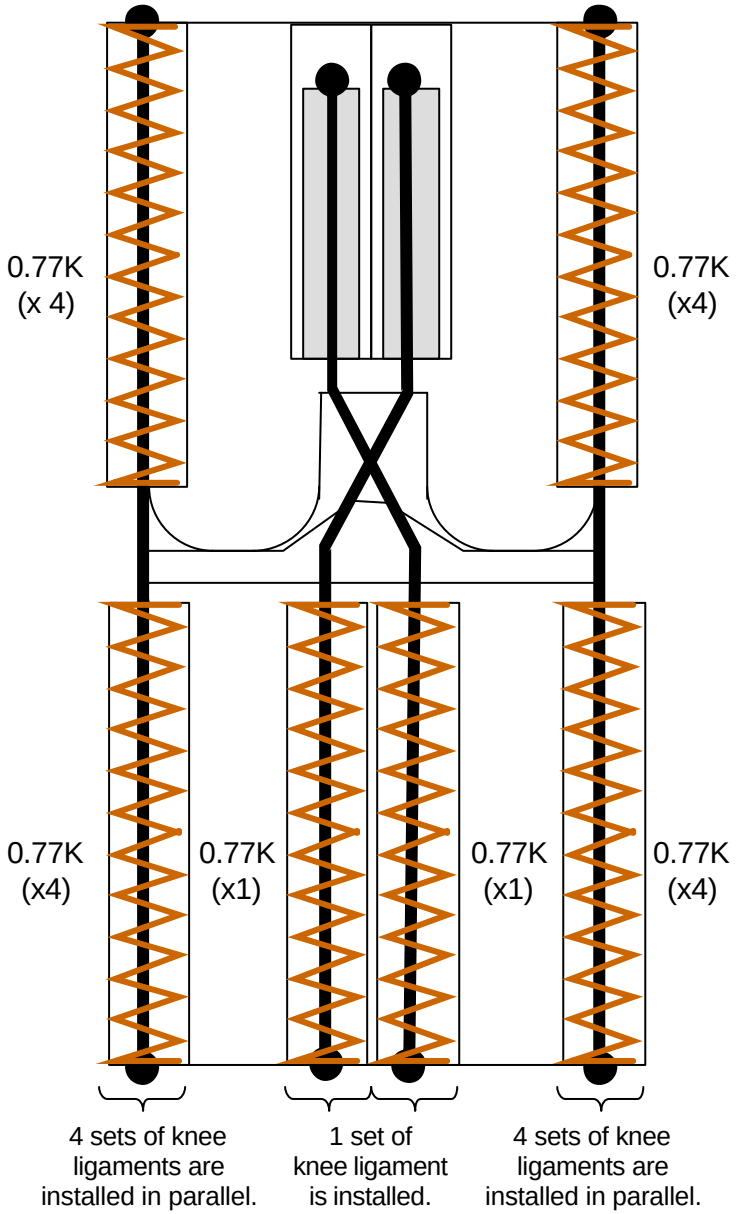
Number of knee ligaments
→ To do not weaken Flex-GTα knee bending stiffness

Flex-G
(knee spring length: 40mm)



K: spring constant

Flex-GTα
(knee spring length: 80 mm)

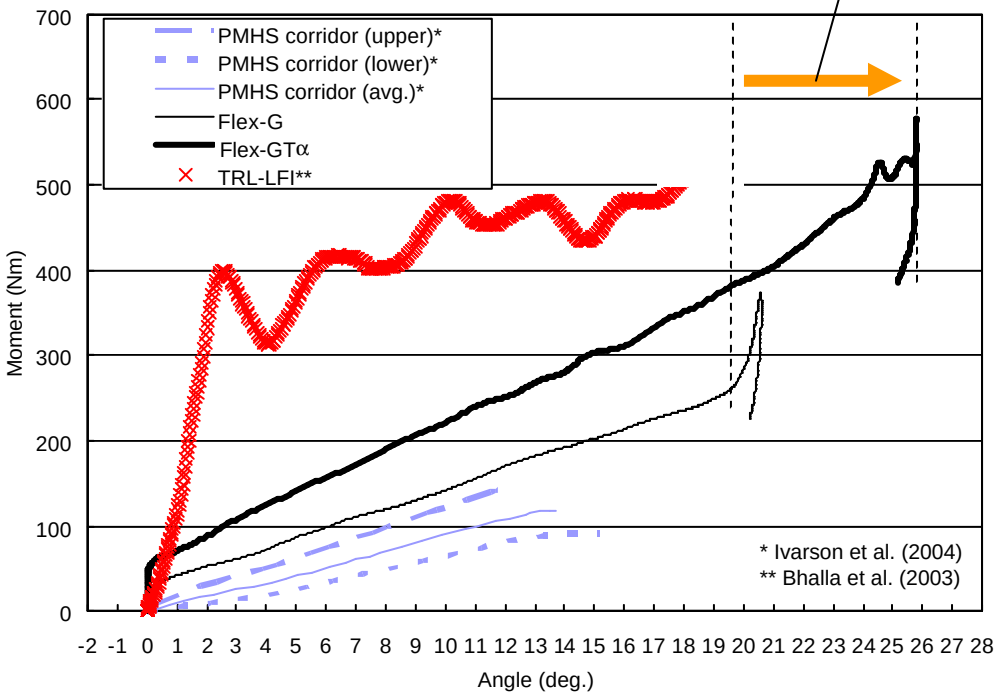


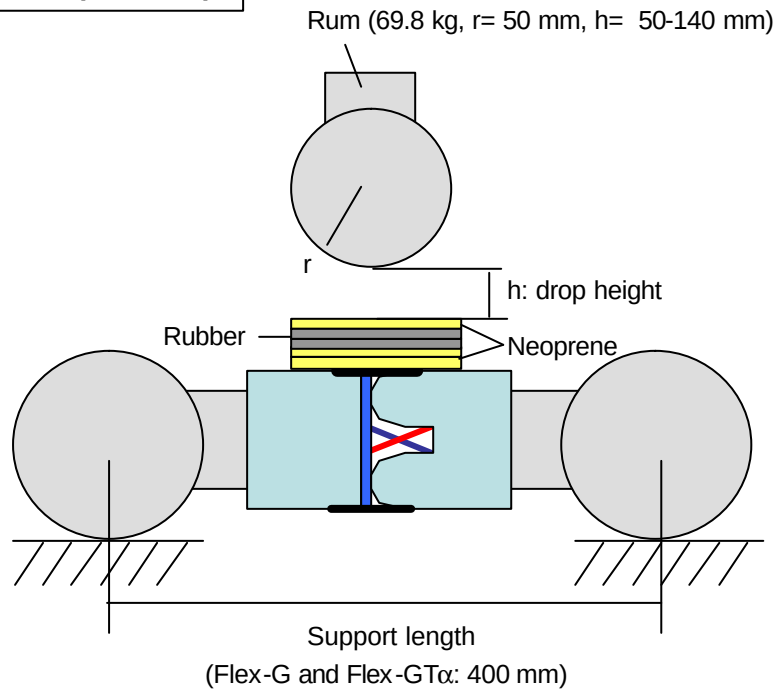
Knee

Bending characteristics (Knee)

Flex-G, Flex-GTα, and TRL-LFI

Improved knee bending limit (+30%)





Flex-GTα (Knee) has slightly greater bending stiffness than that of Flex-G (but not stiffer than that of TRL-LFI).

→ The difference gives Flex-GTα a better injury assessment ability than that of Flex-G.

Flesh

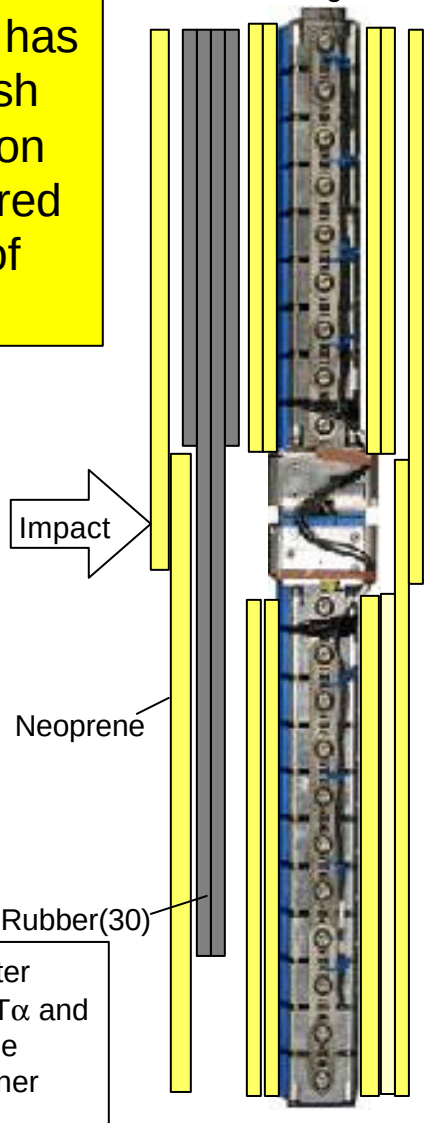
Flesh

Construction

Flex-GTα has similar flesh construction as compared with that of Flex-G.

Flex-G

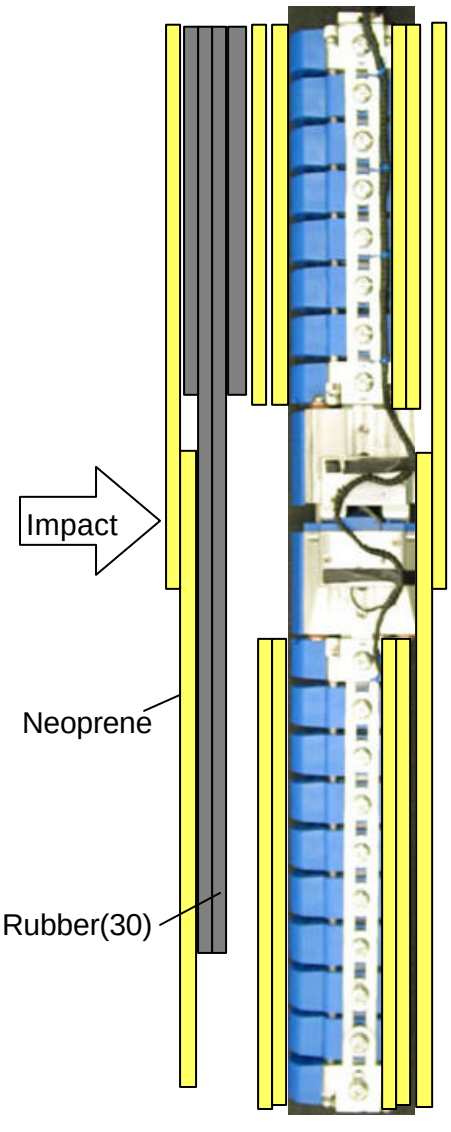
Sectional image



Outer view

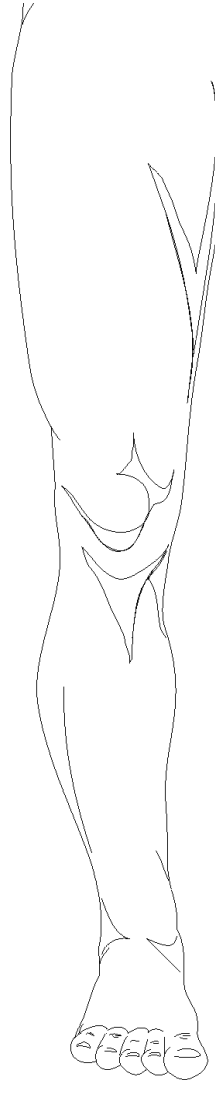
Flex-GTα

Sectional image



Outer view

Human leg illustration

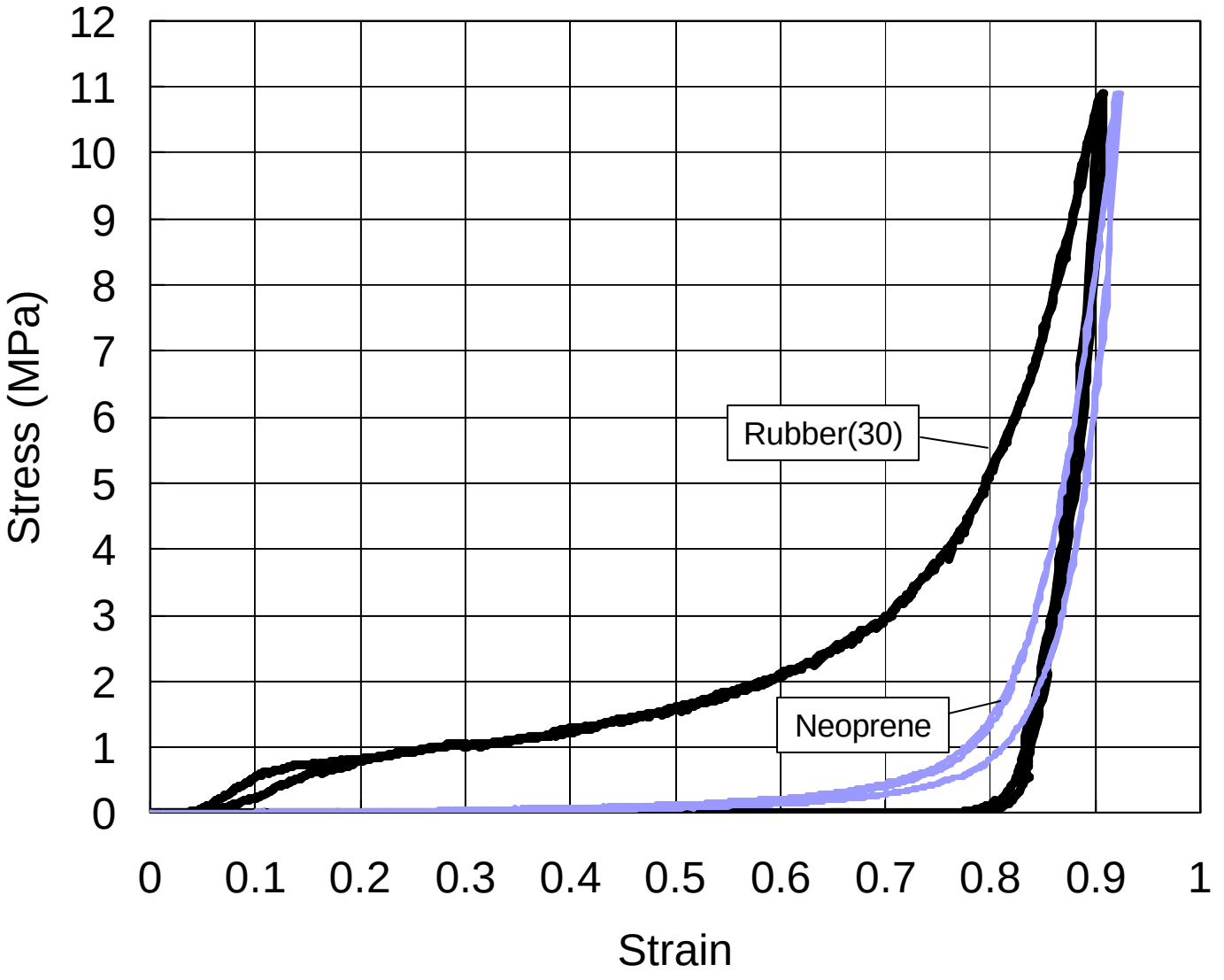


The different outer views of Flex-GTα and Flex-G reflect the differences in inner construction.

Flesh

Materials

Flex-GTα (Flesh) uses the same materials as those of Flex-G.



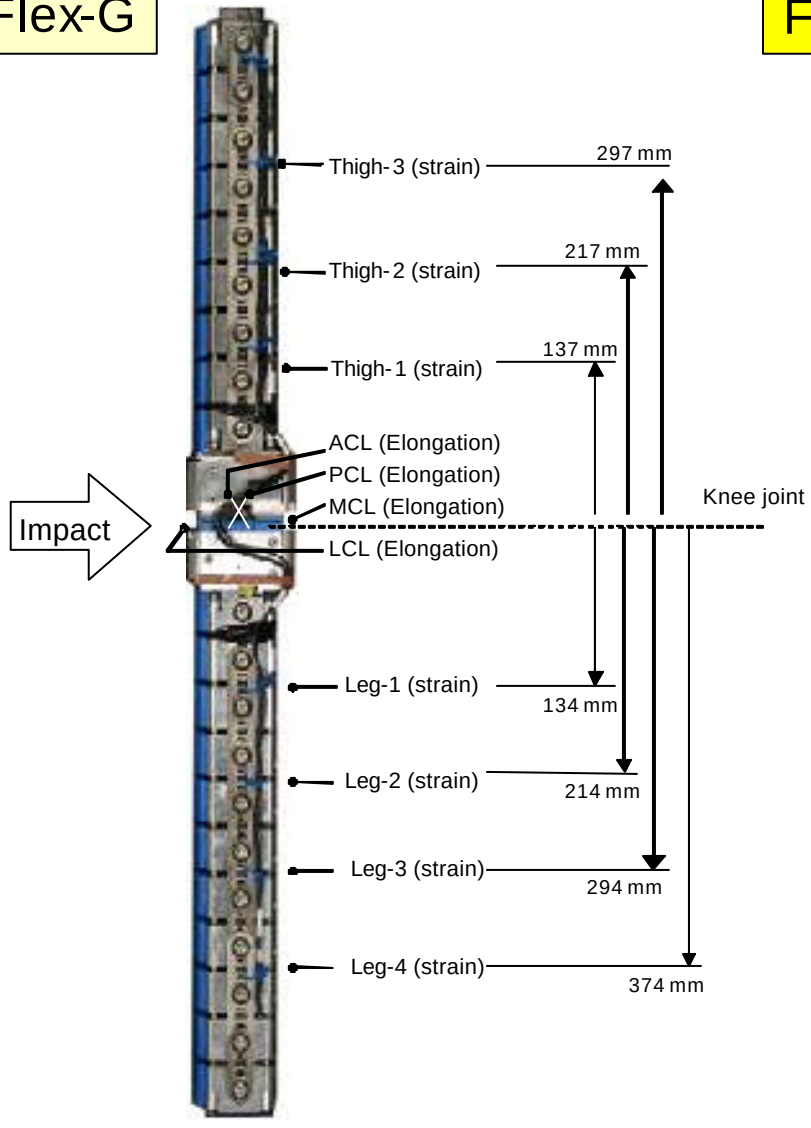
Measurements

Measurements

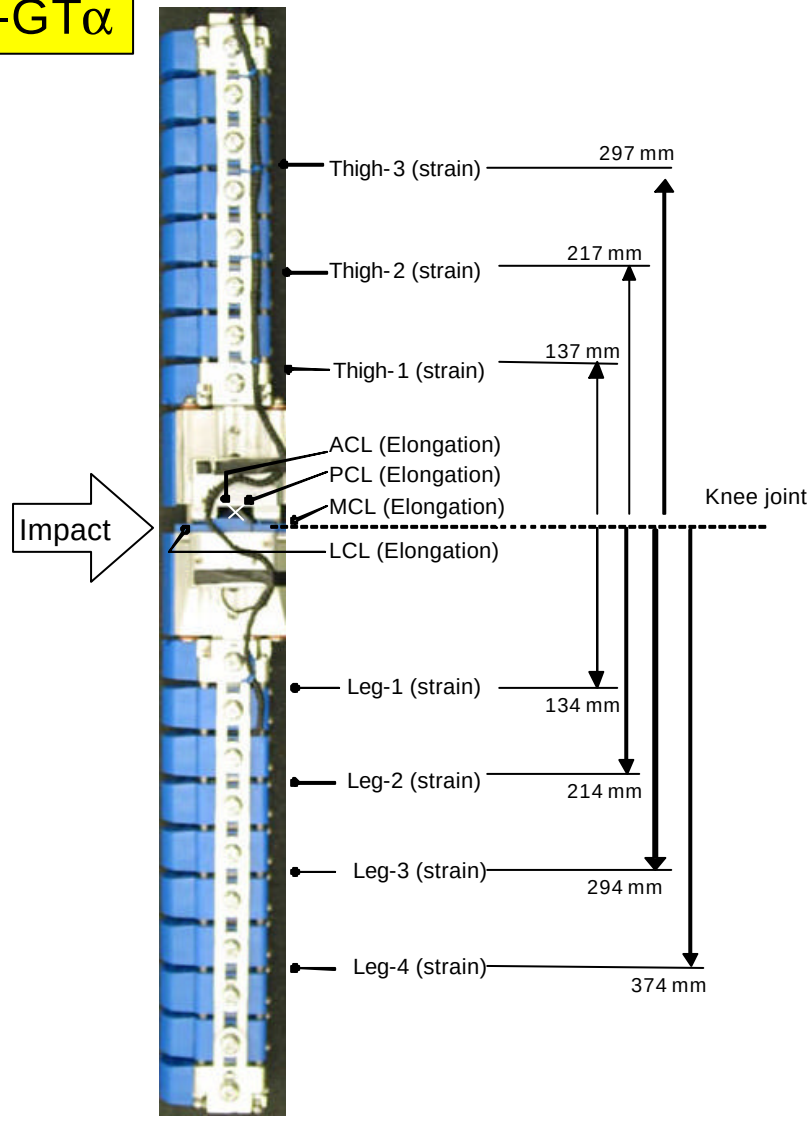
Measurement items and positions

Flex-GTα and Flex-G are identical in their measurement items and positions.

Flex-G



Flex-GTα

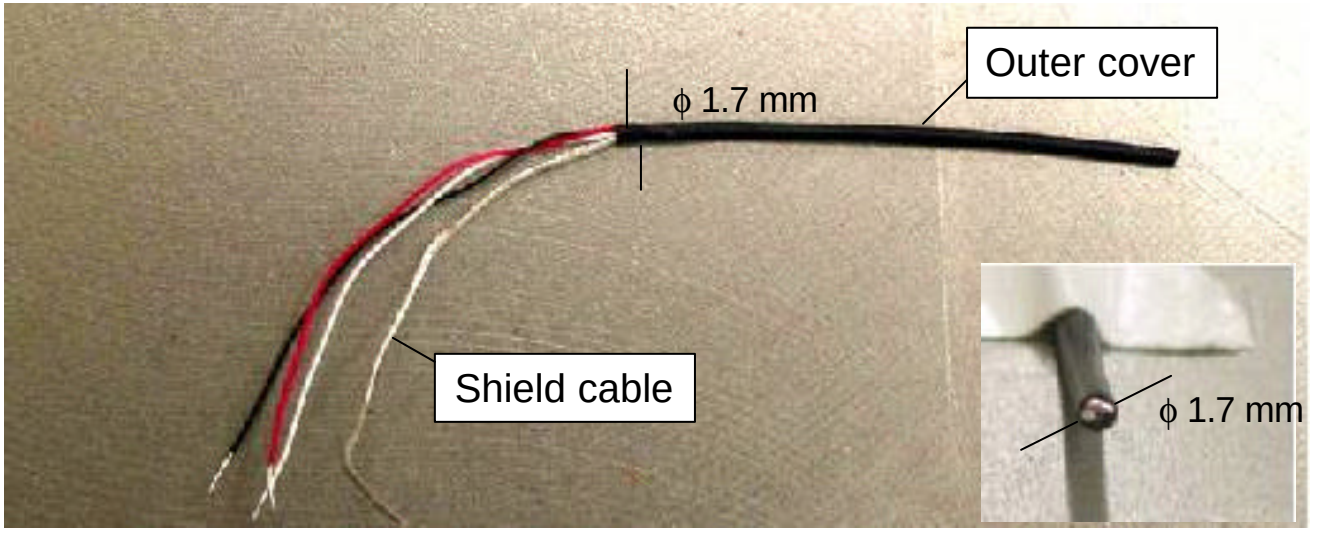


Measurements

Measurement cables

Flex-GTα uses the same measurement cables as those of Flex-G.

Flex-G and Flex-GTα

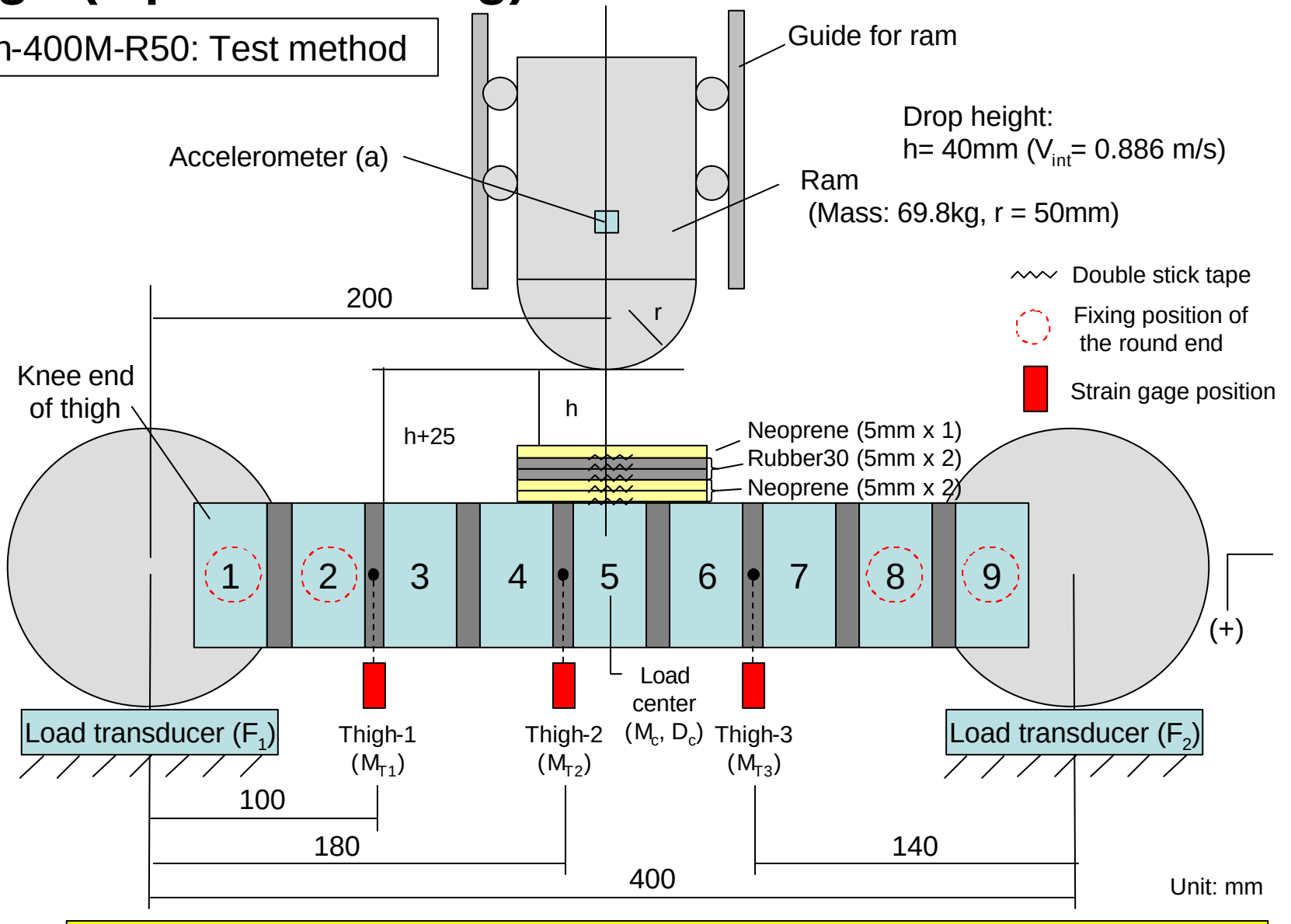


Measurement cables

Calibration

Thigh (3-point bending)

Thigh-400M-R50: Test method



Flex-GTα (Thigh) adopts the same calibration method as that for Flex-G.

Thigh (3-point bending)

Thigh-400M-R50: Equations

Bending moment estimation
(at loading center)

$$M_c(t) \cong \left| \frac{F_1(t) \times F_2(t)}{F_1(t) + F_2(t)} \times 400 \right|$$

Deflection estimation
(at loading center)

$$D_c(t) \cong V_{init} t + \frac{1}{2} g t^2 + \iint a(t) dt$$

Bending moment estimation
(at strain gage positions)

$$M_{T1}(t) \cong \left| F_1(t) \times 100 \right|$$

$$M_{T2}(t) \cong \left| F_1(t) \times 180 \right|$$

$$M_{T3}(t) \cong \left| F_2(t) \times 140 \right|$$

$M : Bending\ moment\ (Nm)$

$F : Force (kN)$

$D : Deflection (m)$

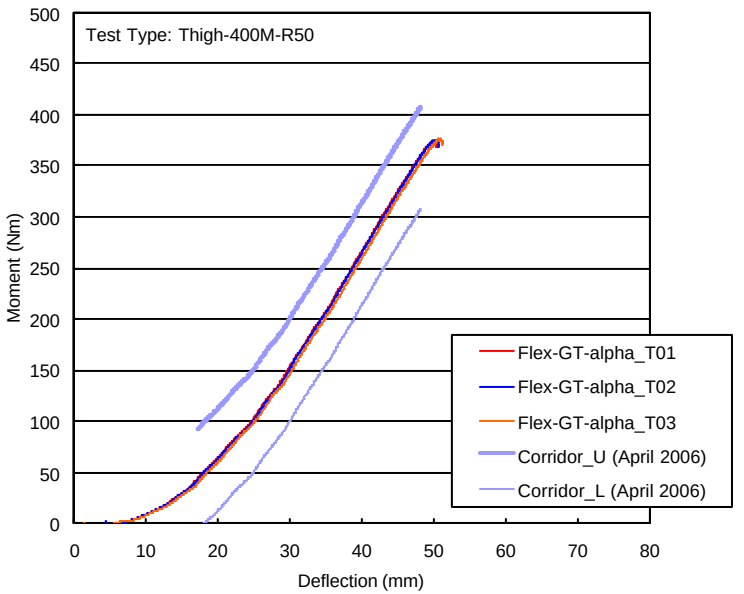
$V_{init} : Initial\ velocity (m/s)$

$g : Gravity (m/s^2)$

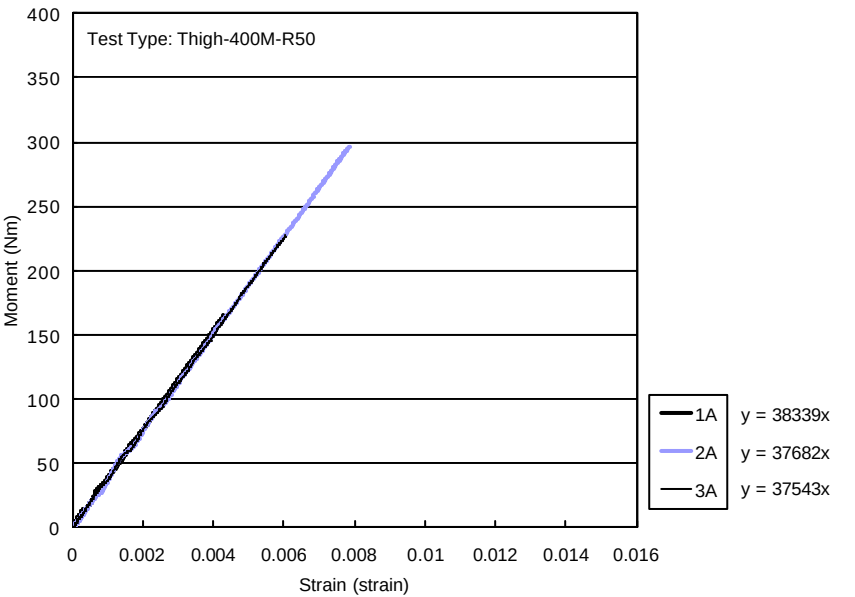
$a : Acceleration (m/s^2)$

$t : time (s)$

Evaluate: Bending characteristics

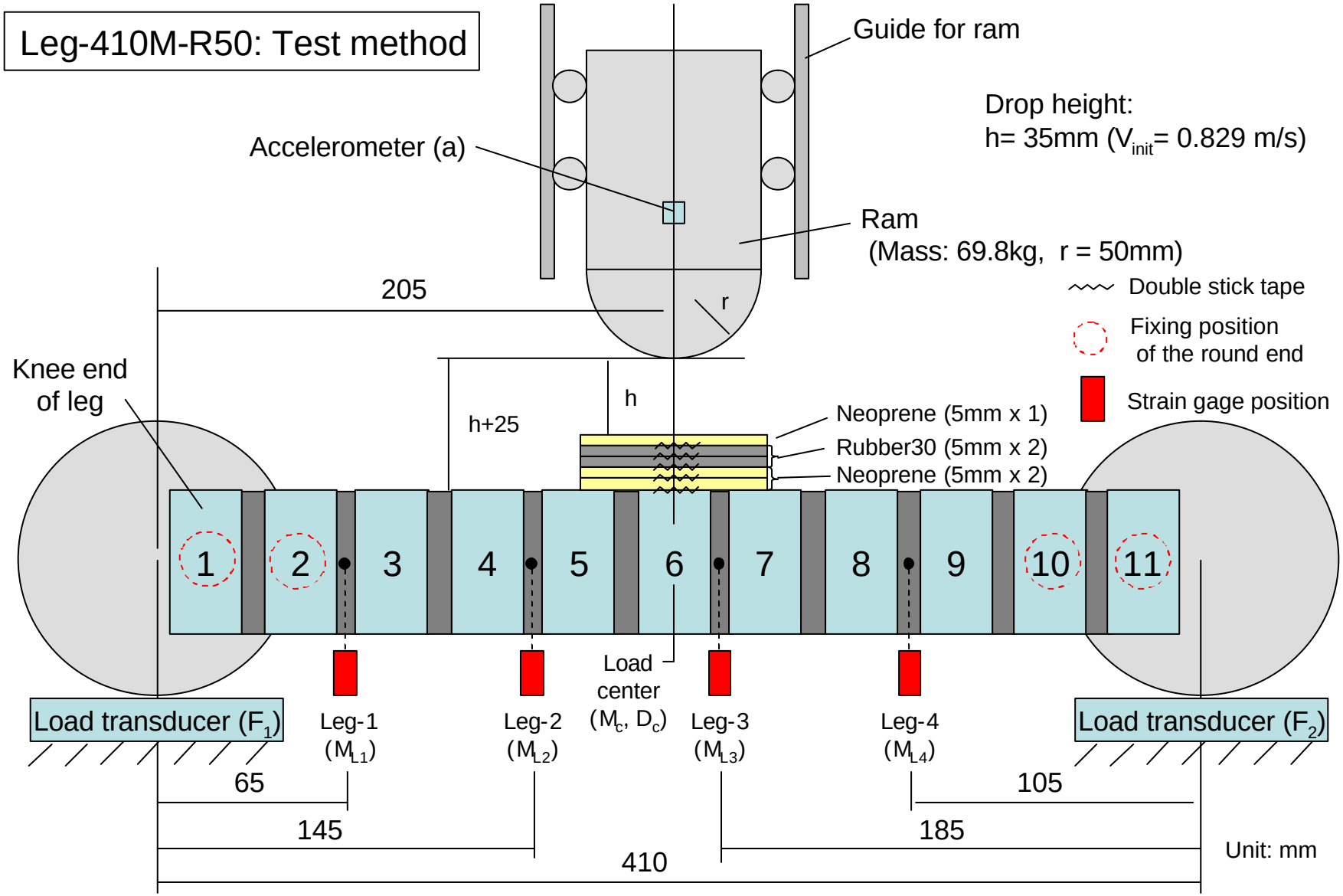


Obtain: Strain-moment relationship



Leg (3-point bending)

Leg-410M-R50: Test method



Flex-GTα (Leg) adopts the same calibration method as that for Flex-G.

Leg (3-point bending)

Leg-410M-R50: Equations

Bending moment estimation
(at loading center)

$$M_c(t) \cong \left| \frac{F_1(t) \times F_2(t)}{F_1(t) + F_2(t)} \times 410 \right|$$

Deflection estimation
(at loading center)

$$D_c(t) \cong V_{init} t + \frac{1}{2} g t^2 + \iint a(t) dt$$

Bending moment estimation
(at strain gage positions)

$$M_{L1}(t) \cong \left| F_1(t) \times 65 \right|$$

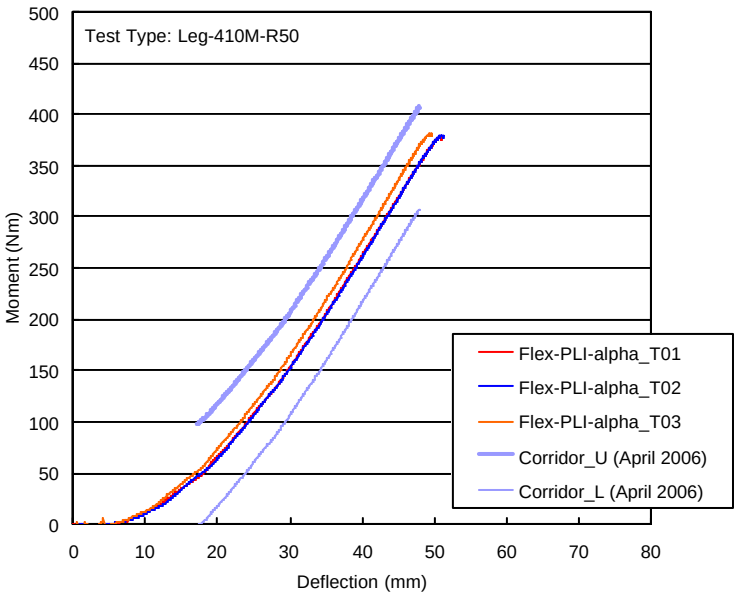
$$M_{L2}(t) \cong \left| F_1(t) \times 145 \right|$$

$$M_{L3}(t) \cong \left| F_2(t) \times 185 \right|$$

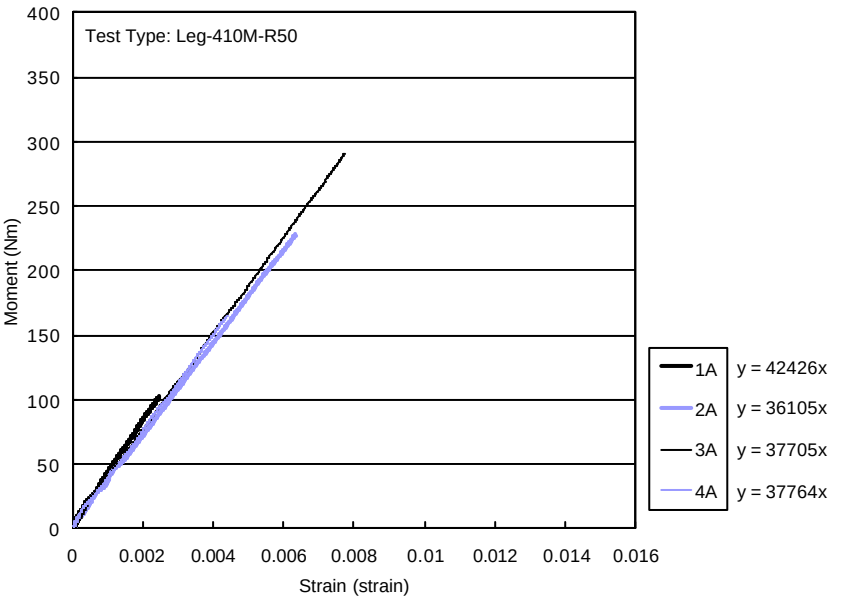
$$M_{L4}(t) \cong \left| F_2(t) \times 105 \right|$$

$M : Bending\ moment\ (Nm)$
$F : Force (kN)$
$D : Deflection (m)$
$V_{init} : Initial\ velocity (m/s)$
$g : Gravity (m/s^2)$
$a : Acceleration (m/s^2)$
$t : time (s)$

Evaluate: Bending characteristics

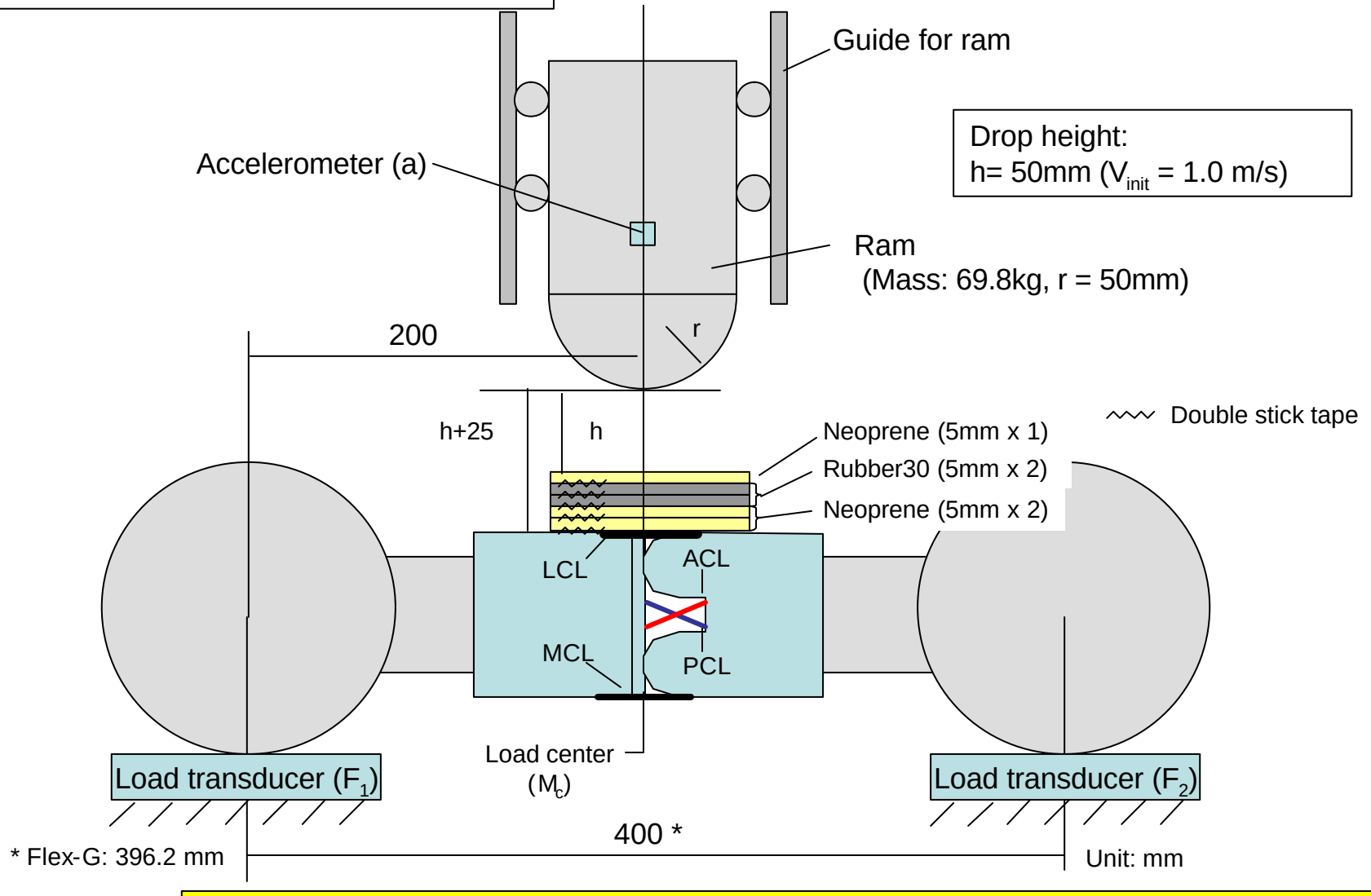


Obtain: Strain-moment relationship



Knee (3-point bending)

Knee-3PB-400-R50: Test method



Flex-GTα (Knee) adopts a calibration method similar to that for Flex-G.

Knee (3-point bending)

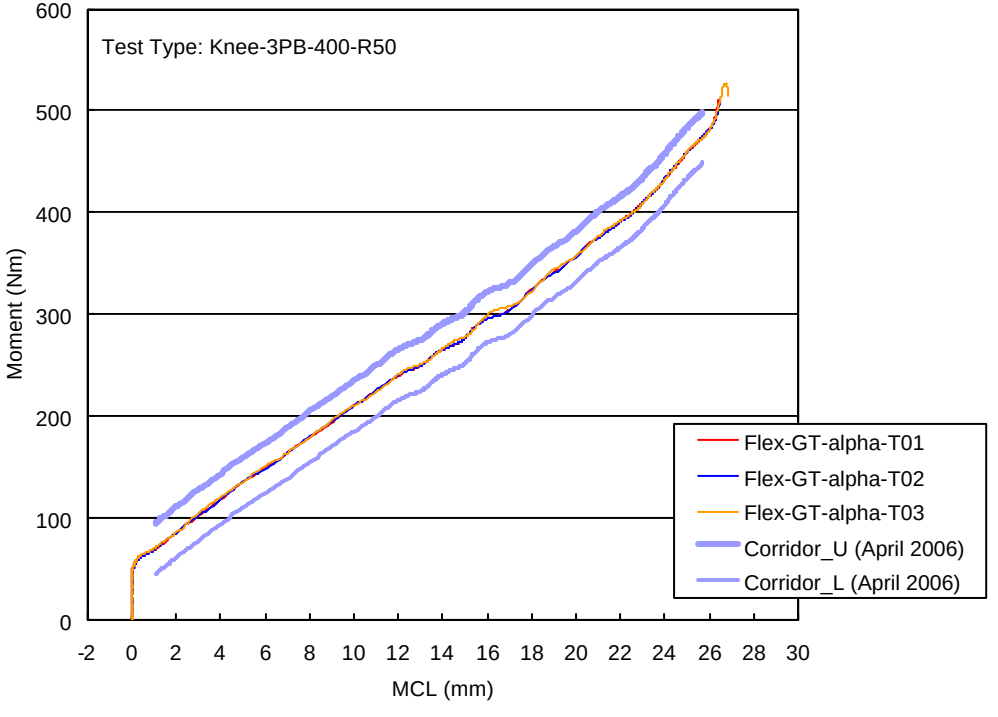
Knee-3PB-400-R50: Equation

Bending moment estimation
(at loading center)

$$M_c(t) \cong \left| F_1(t) \times 200 \right|$$

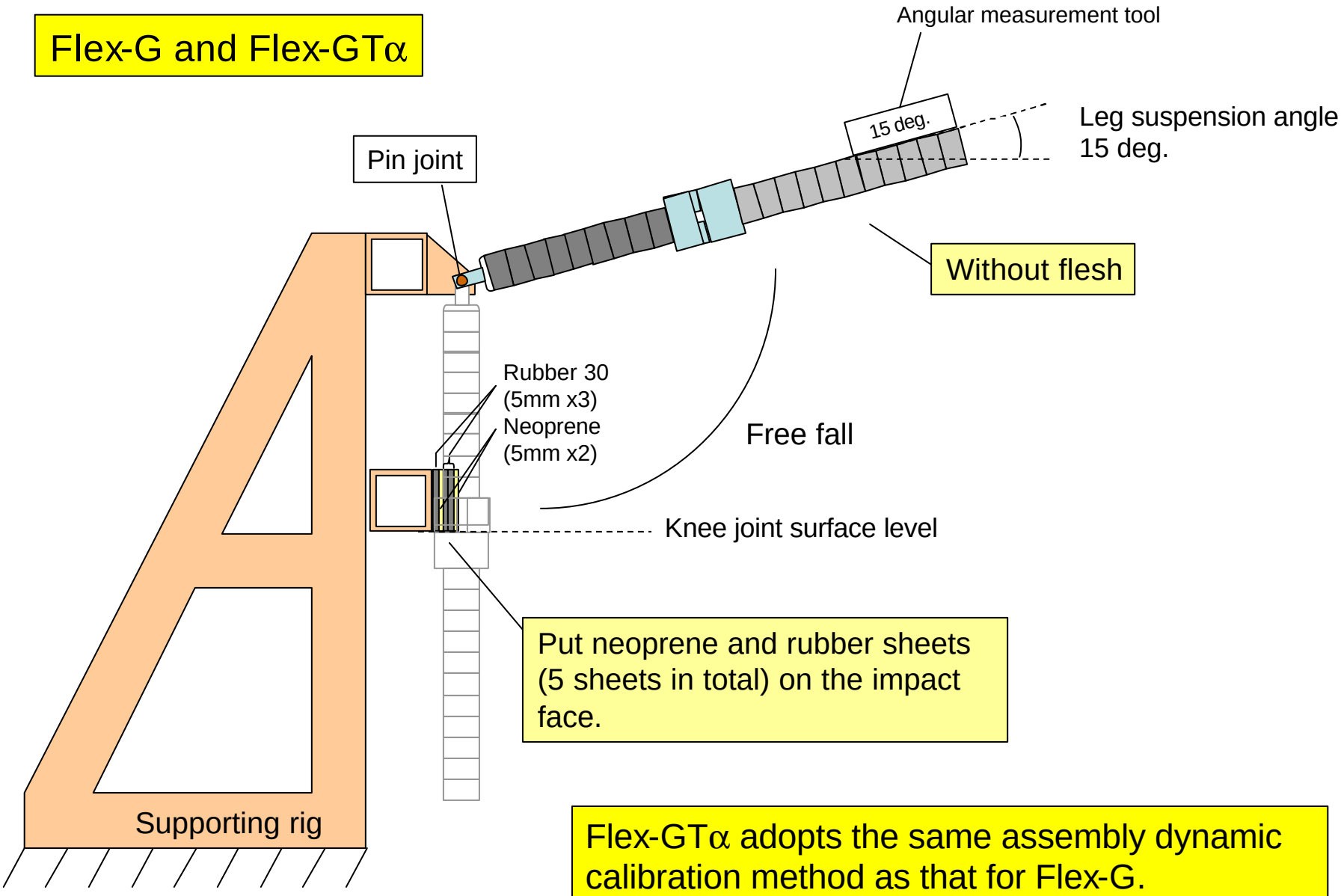
$M : Bending moment\,(Nm)$
$F : Force(kN)$
$t : time(s)$

Evaluate: Bending characteristics



Assembly Dynamic Certification Test

Flex-G and Flex-GTα

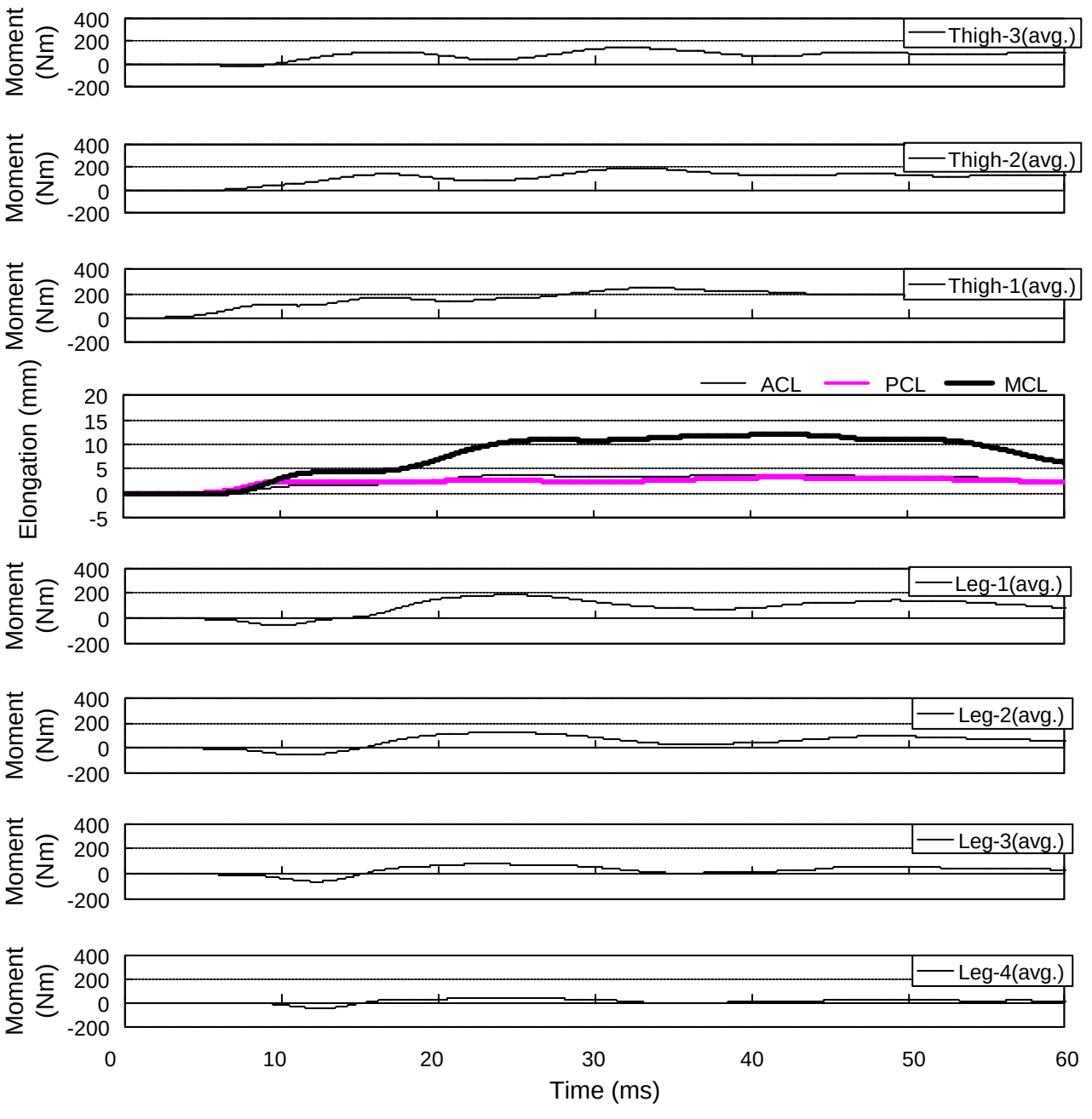


Flex-GTα adopts the same assembly dynamic calibration method as that for Flex-G.

Results

Waveform

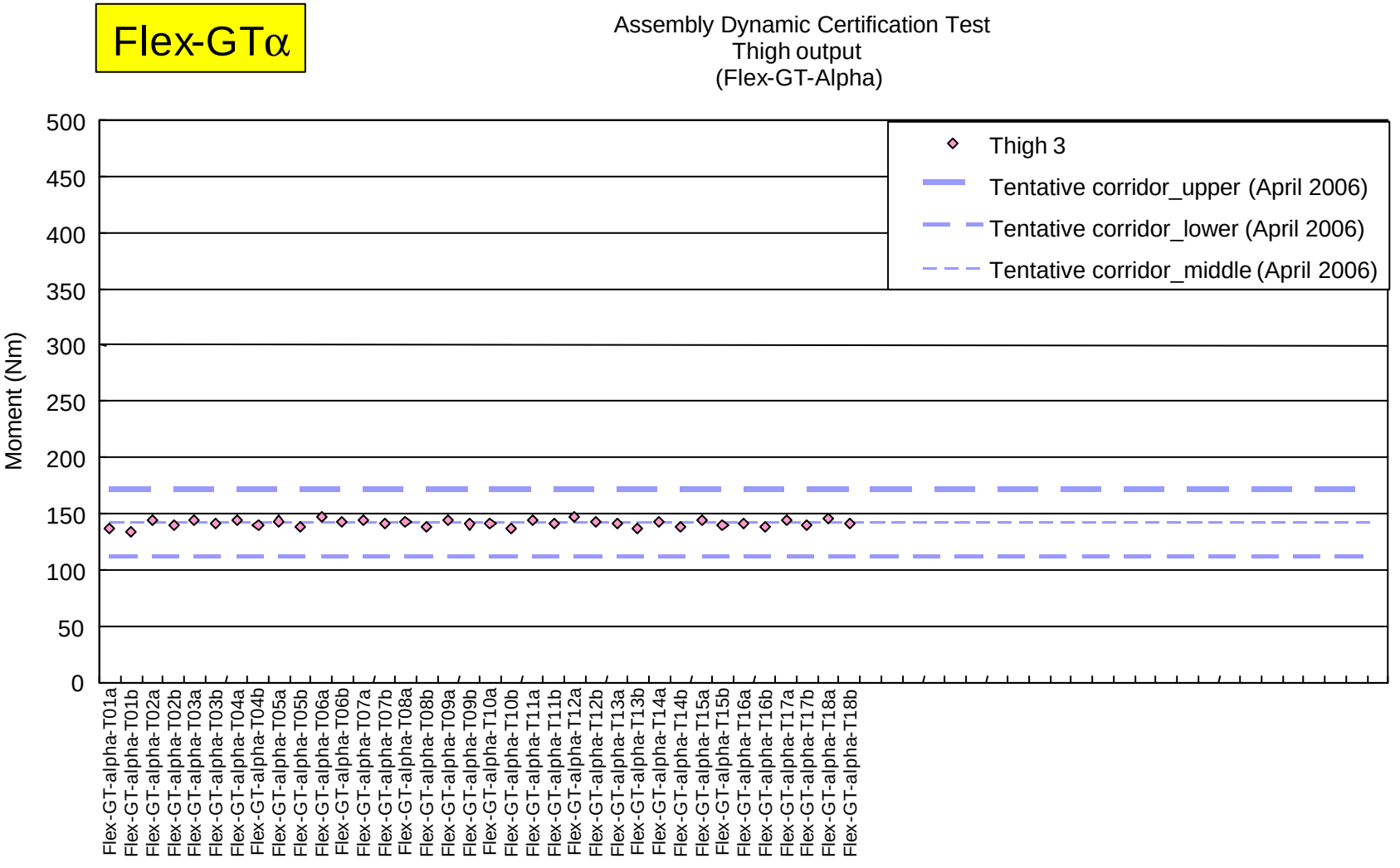
Flex-GTα



Results

Thigh-3 (maximum value)

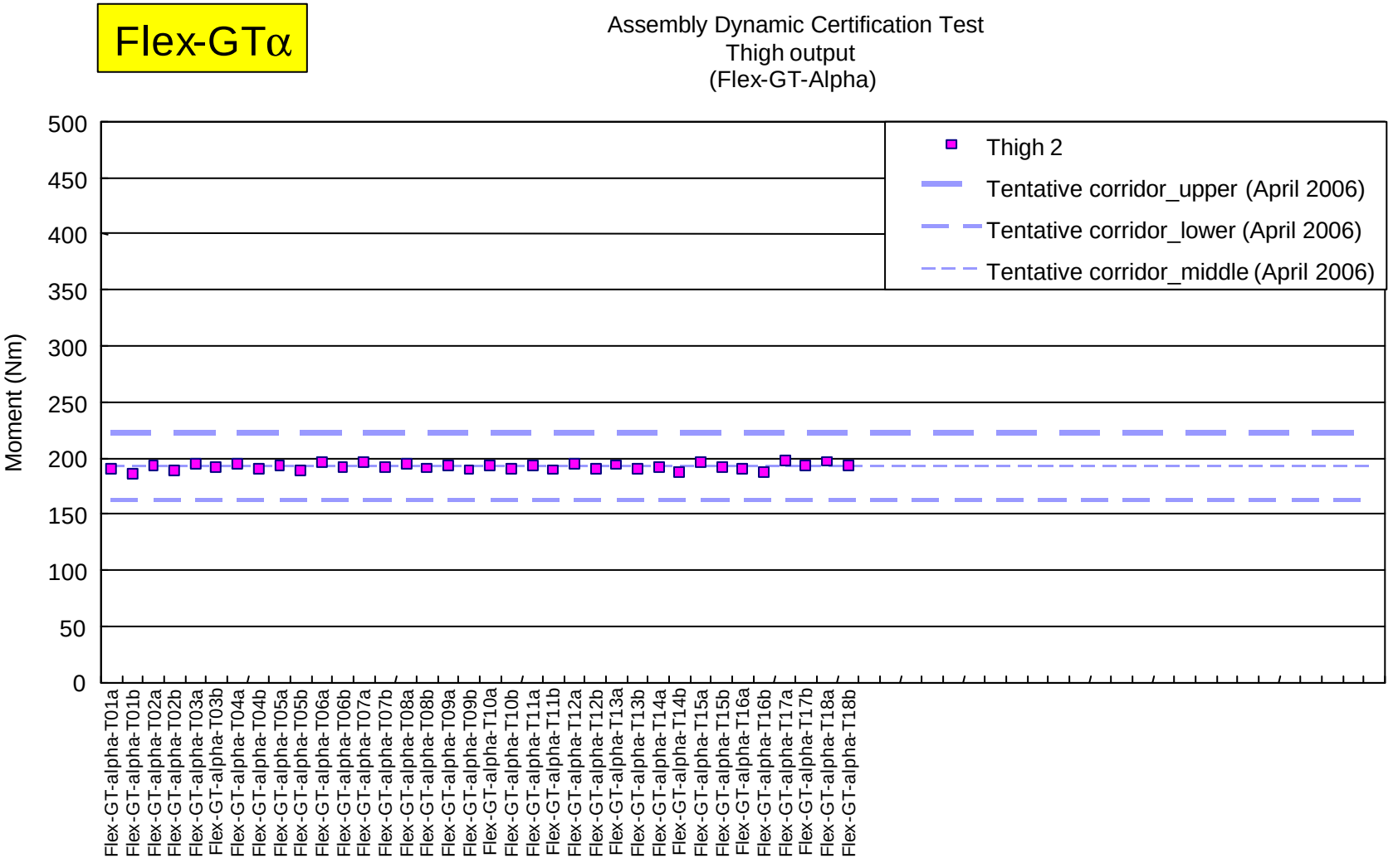
Flex-GTα



Results

Thigh-2 (maximum value)

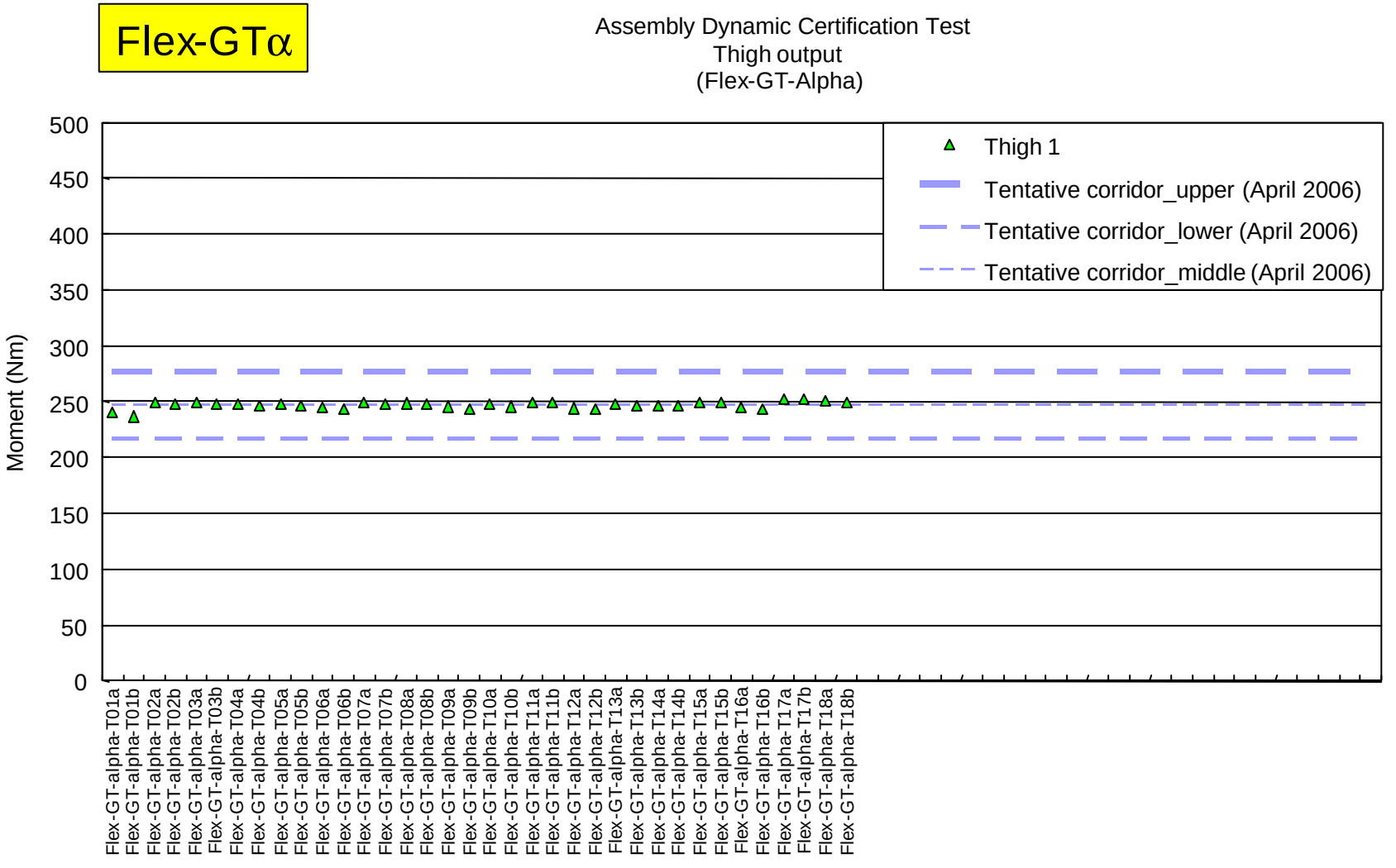
Flex-GTα



Results

Thigh-1 (maximum value)

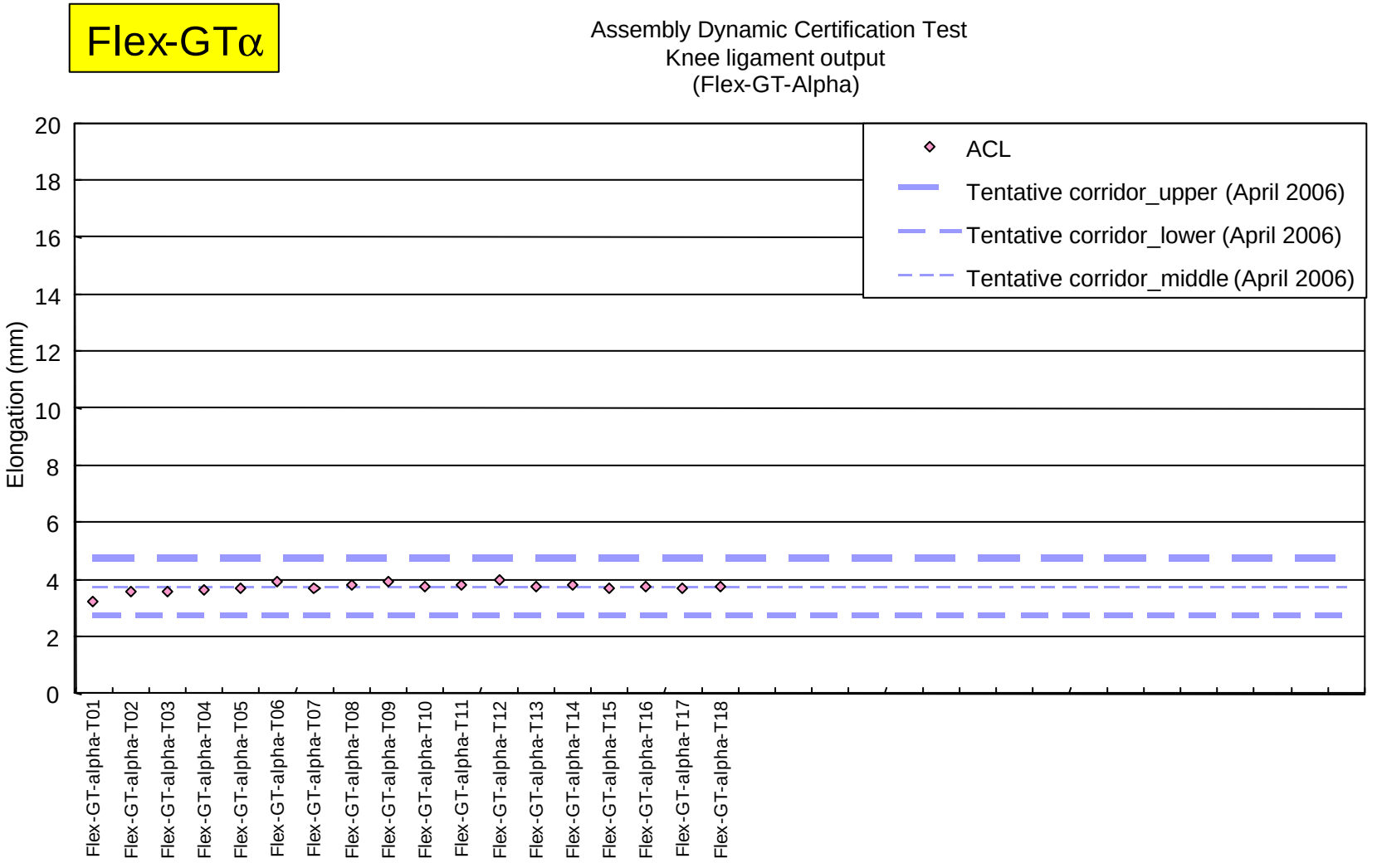
Flex-GTα



Results

ACL (maximum value)

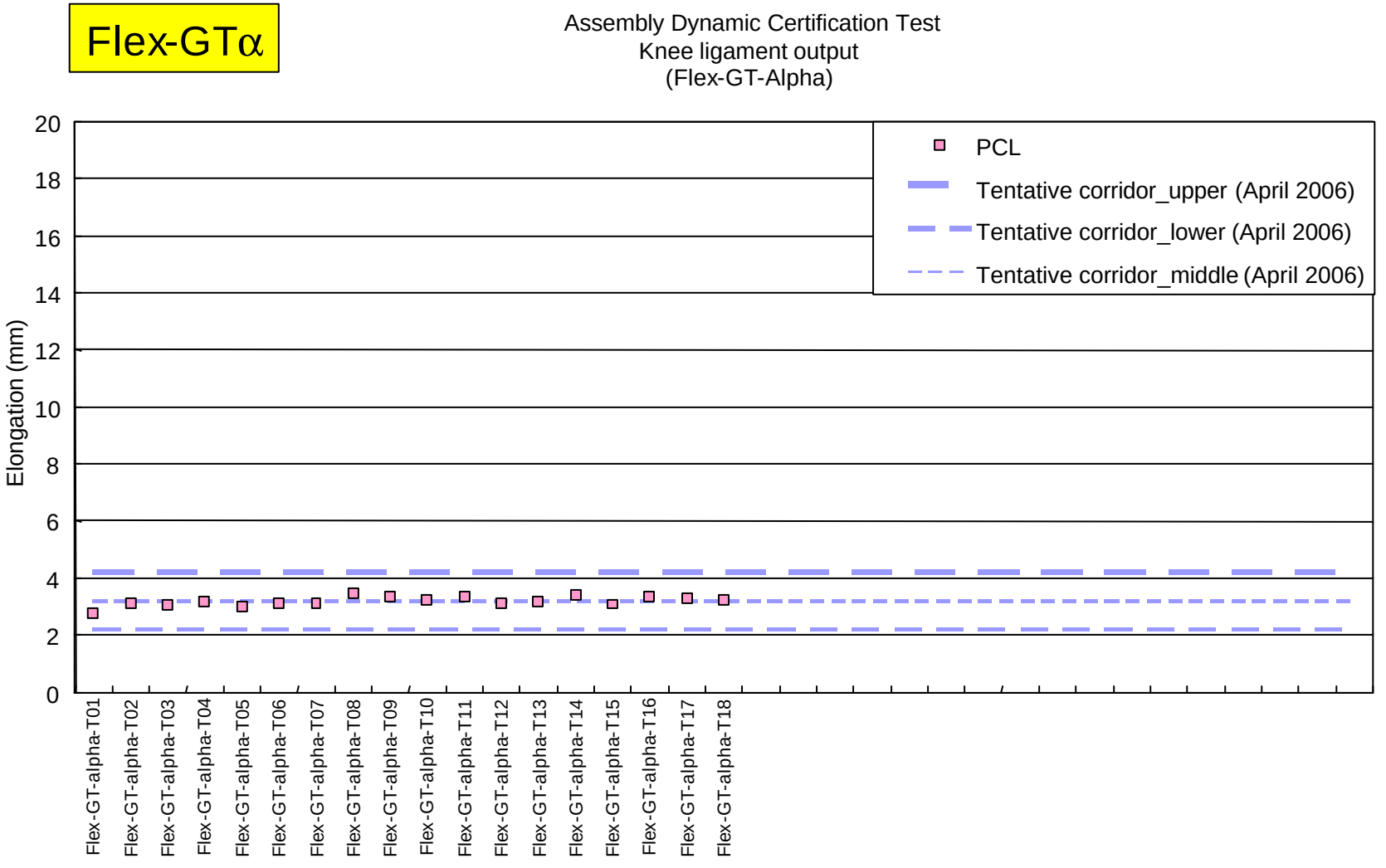
Flex-GTα



Results

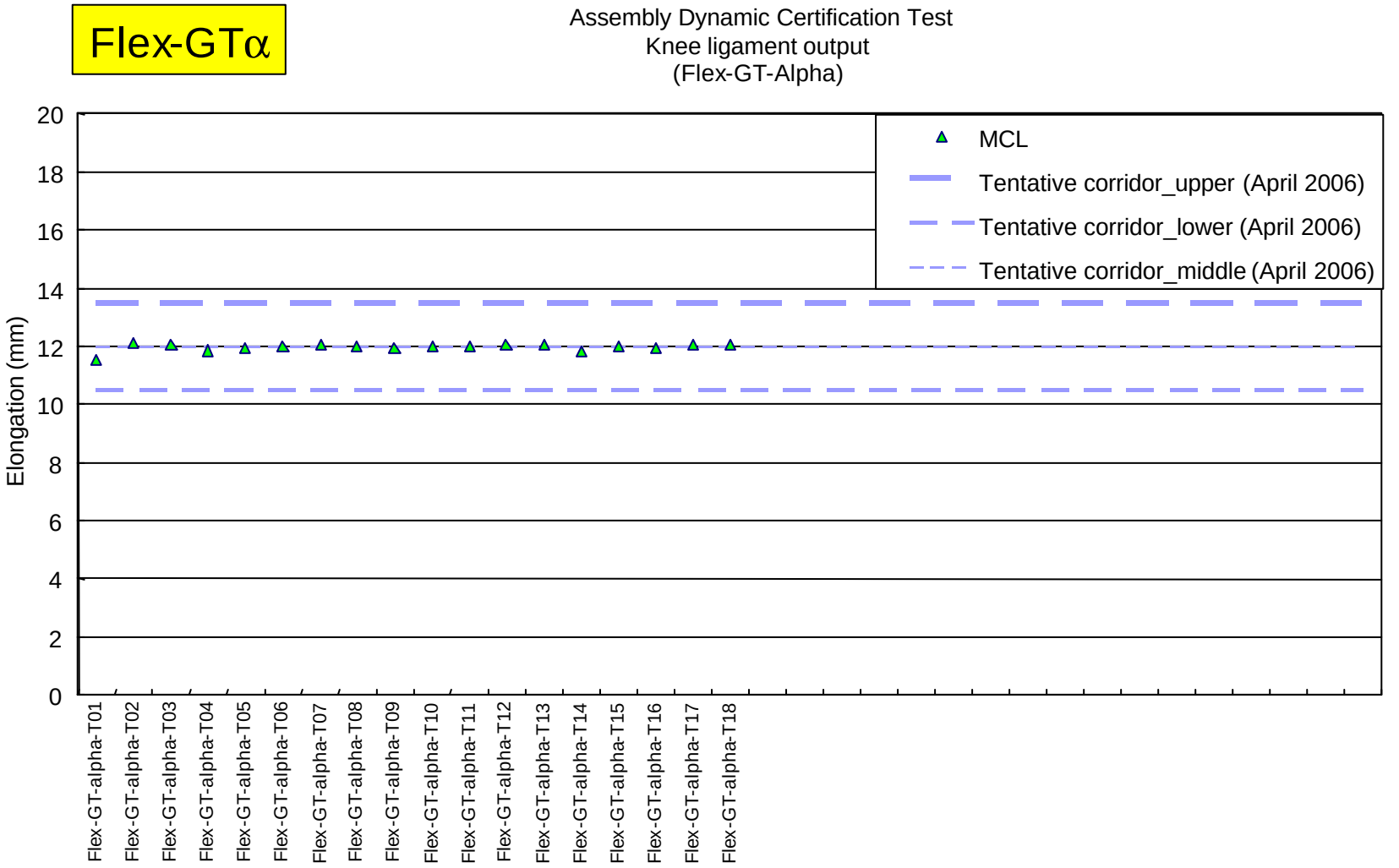
PCL (maximum value)

Flex-GTα



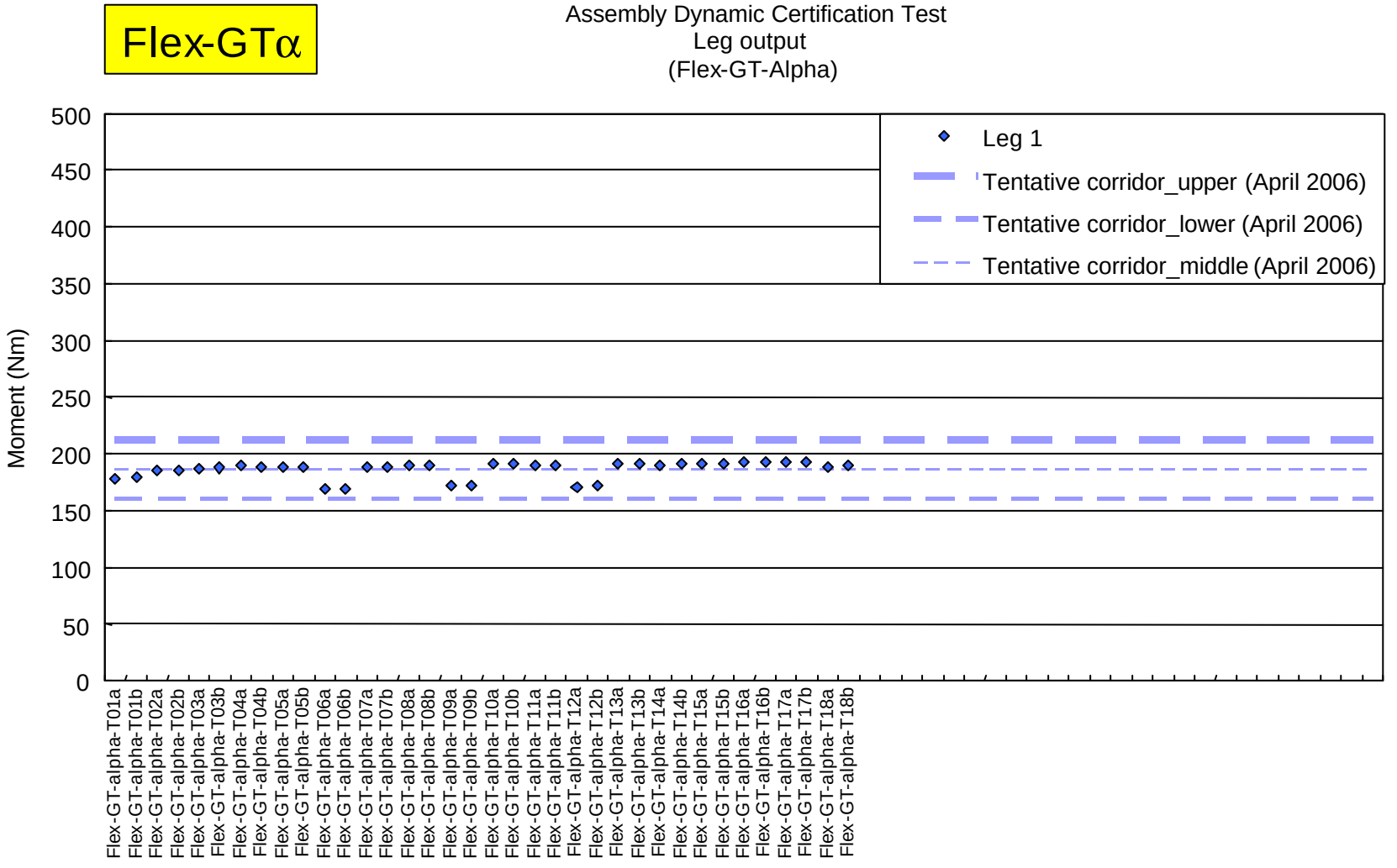
Results

MCL (maximum value)



Results

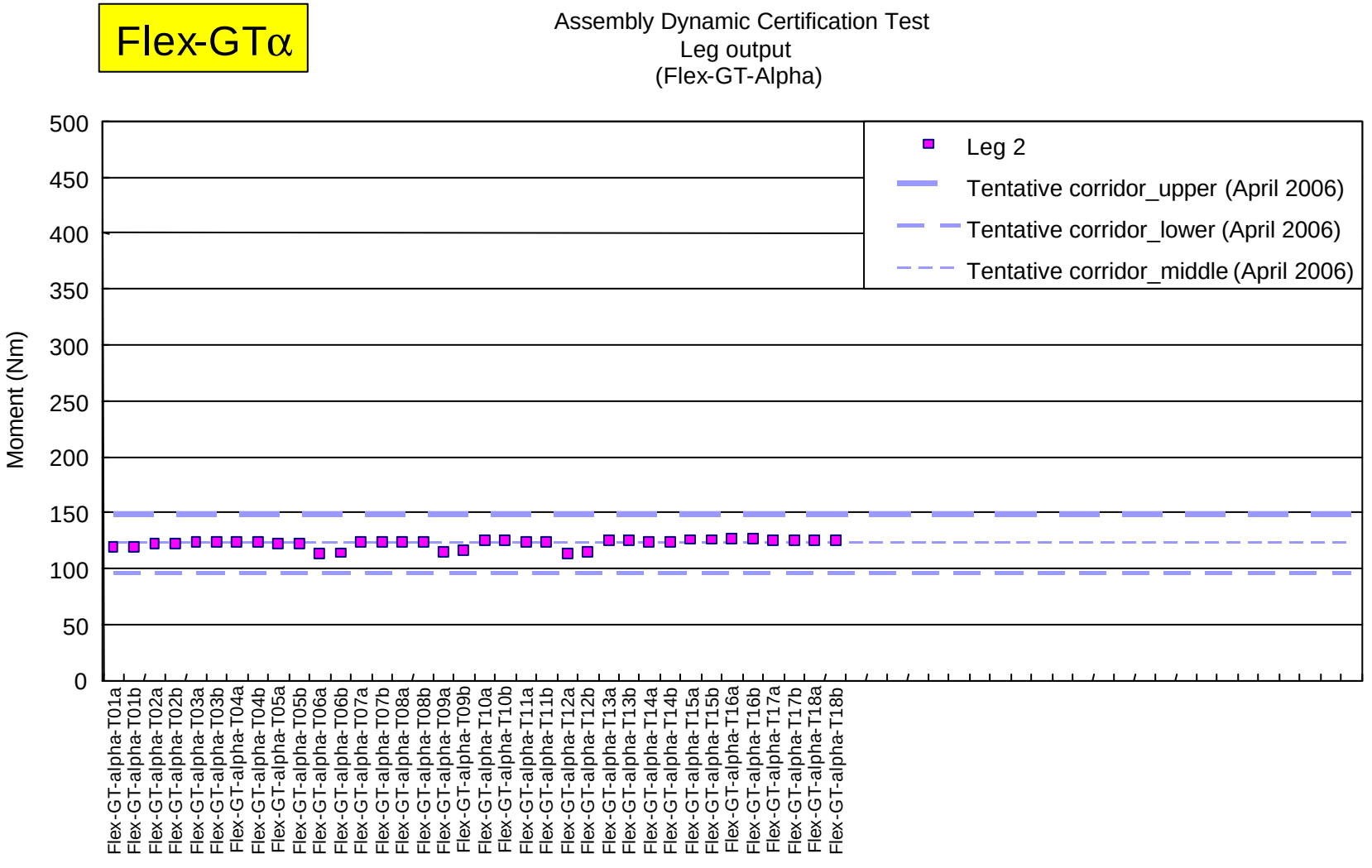
Leg-1 (maximum value)



Results

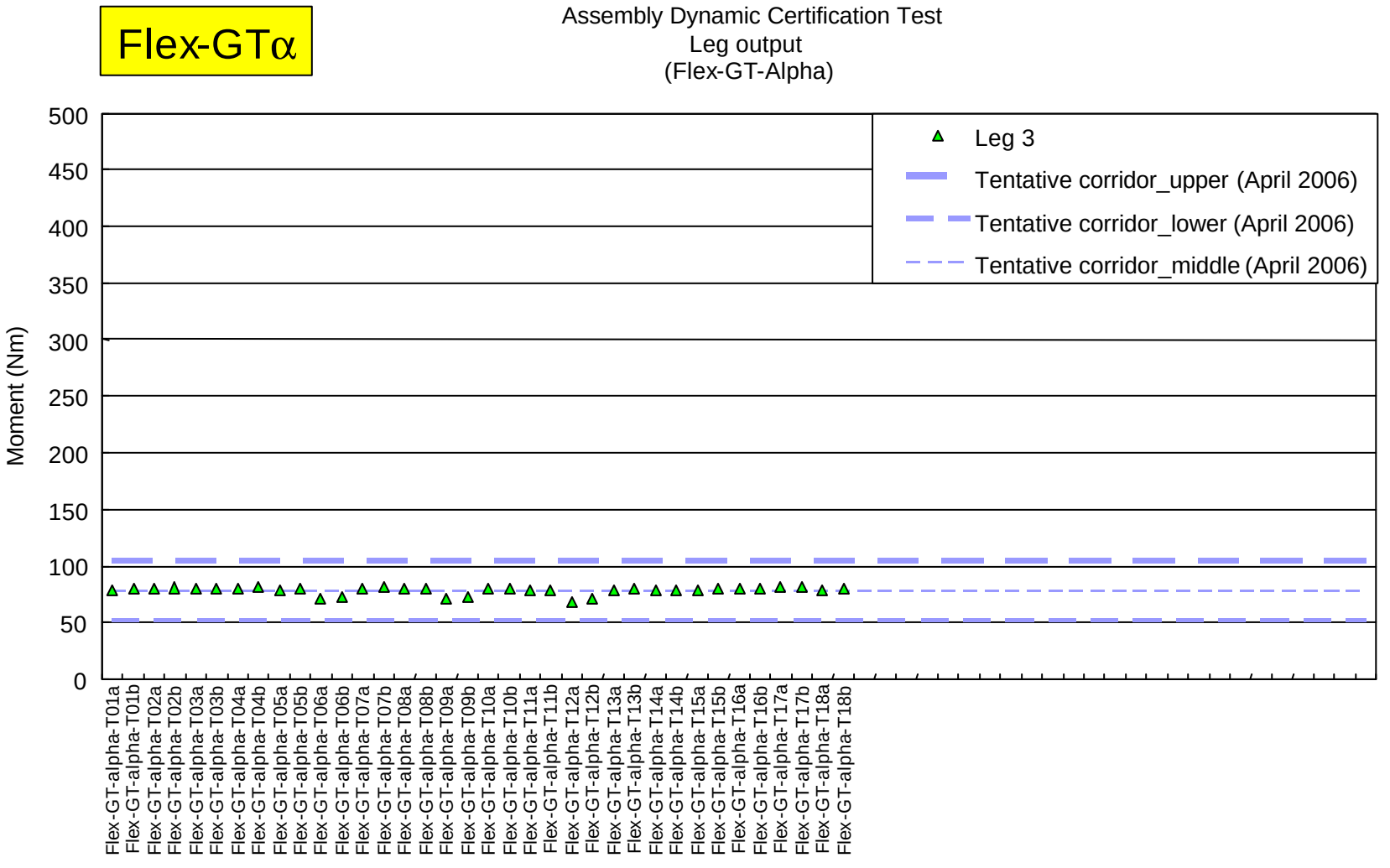
Leg-2 (maximum value)

Flex-GTα



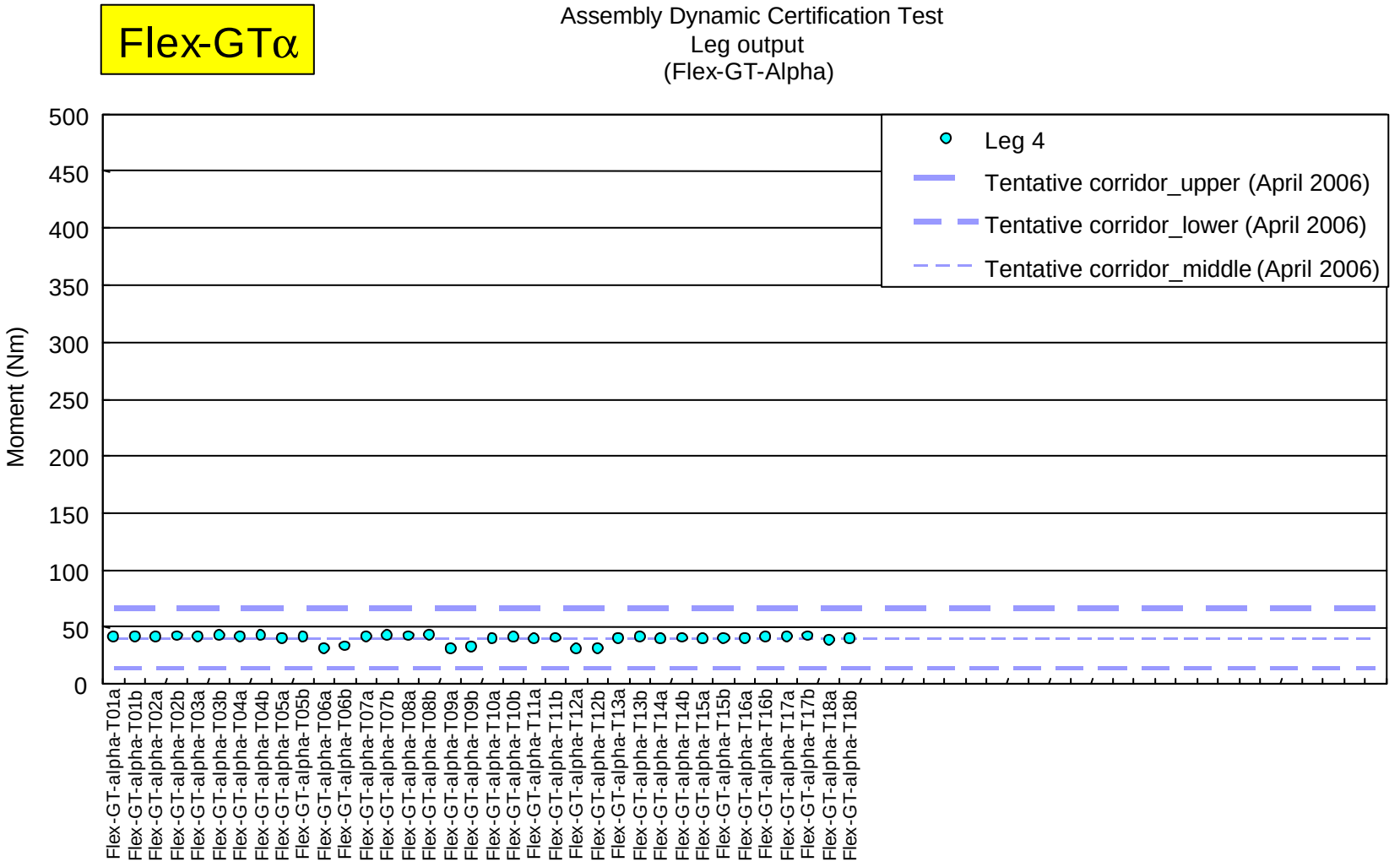
Results

Leg-3 (maximum value)



Results

Leg-4 (maximum value)



Conclusions

- The Flexible Pedestrian Legform Impactor GT Alpha (Flex-GTα) was developed in March 2006.
- The Flex-GTα knee bending limit angle is increased by around 30% (+6 degrees).
- The other presentation will introduce the evaluation method and results concerning the injury assessment ability of Flex-GTα.

Thank you for your attention!