

**Informal Group on GTR9 Phase2  
(IG GTR9-PH2)  
5<sup>th</sup> Meeting**

**– Moving Ram Friction Effect –**

December 6-7, 2012

Japan Automobile Standards Internationalization Center (JASIC)

# Outline

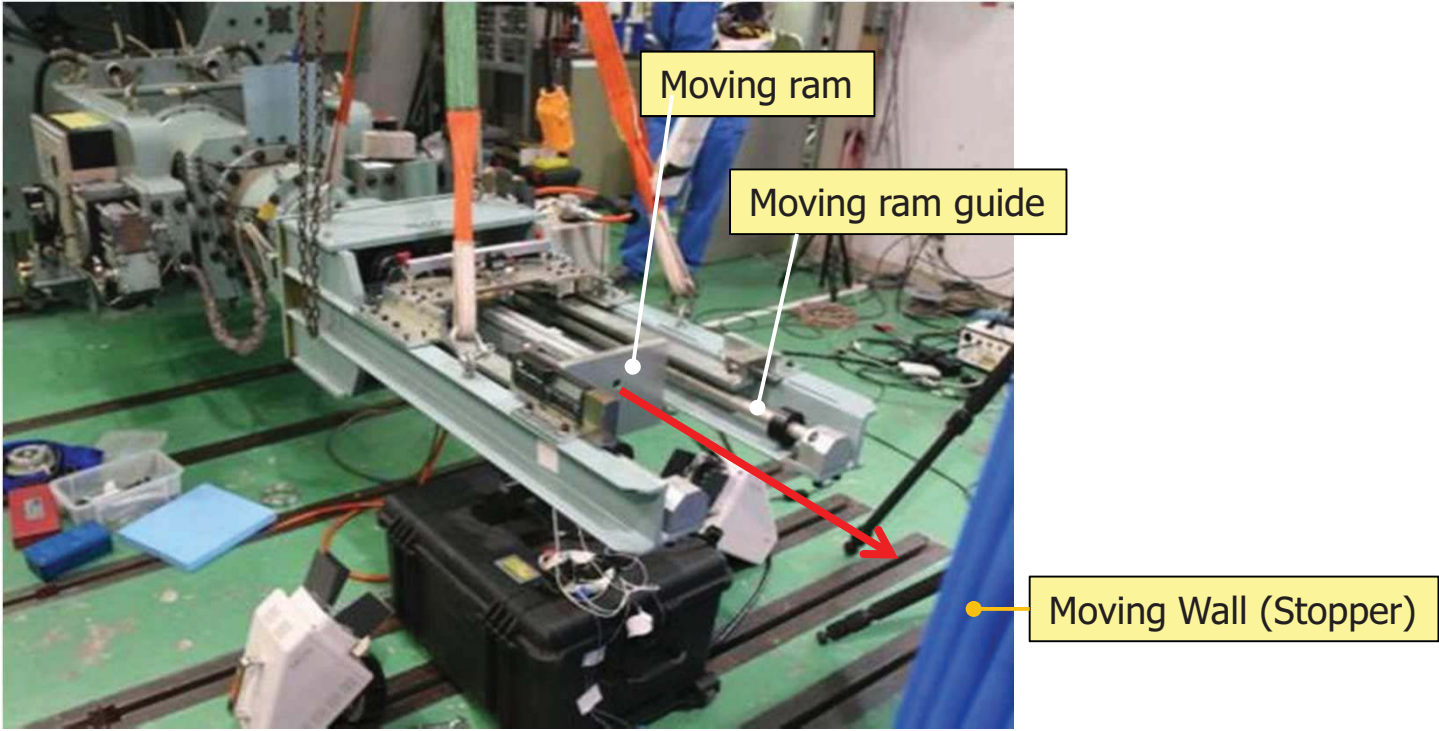
1. Background
2. Measurement: Moving Ram Friction
3. CAE Analysis: Moving Ram Friction Effect
4. Summary

# 1. Background

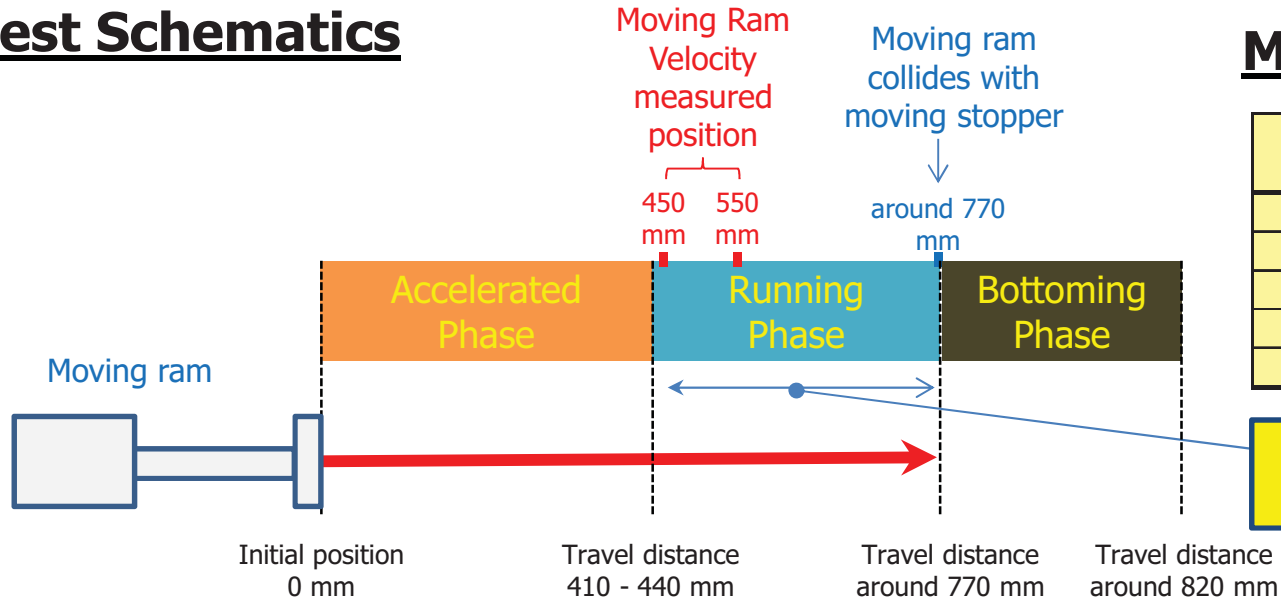
- At the 4th IG GTR9-PH2 meeting, each test lab was requested to measure moving ram friction under the inverse test.
- Japan therefore measured the friction at JARI.
- Moreover, Japan analyzed moving ram friction effect using Flex-PLI CAE model.
- JASIC therefore would like to share the information with this IG GTR9-PH2 members.

## 2. Measurement: Moving Ram Friction

# Test Setup



# Test Schematics

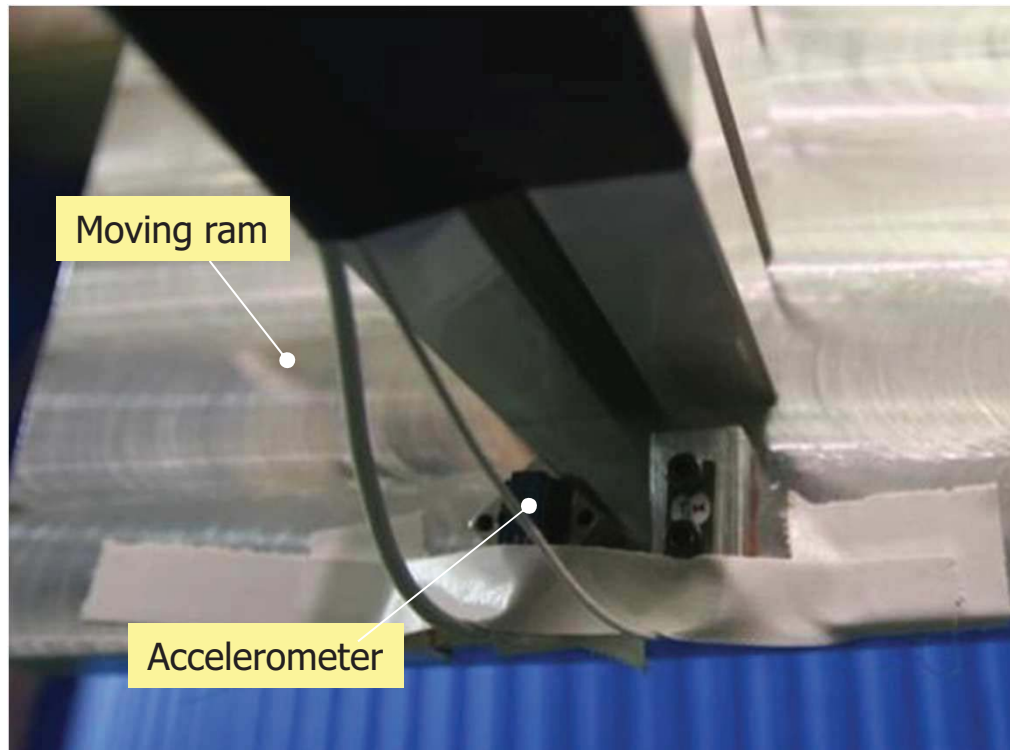


# Moving Ram Velocity

Test ID	Ram velocity (km/h)
121101-T01	39.9
121101-T02	39.6
121101-T03	39.9
121101-T04	39.9
121101-T05	39.7

Friction (deceleration) can be observed

## Measurement of the Moving Ram acceleration



- Accelerometer: ENDEVCO 7264B 2000G
- Sample Rate: 120 kHz
- SW filter: CFC180, CFC600, CFC1000

Friction force was calculated using the following equation:

- Friction Force = Moving Ram Mass (8.1kg) x Deceleration

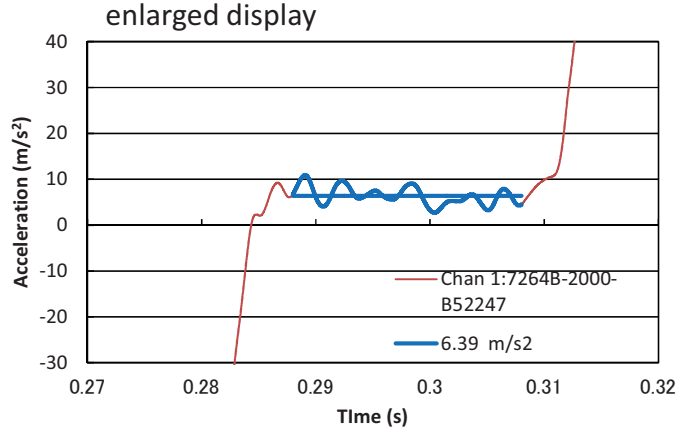
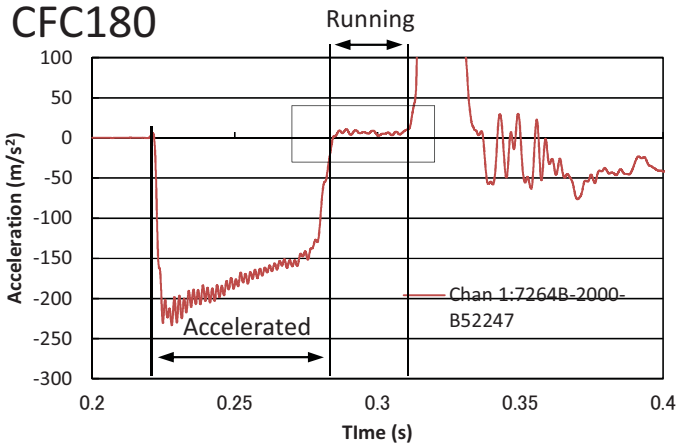
### **【Reference】**

#### **Moving Ram Frictional Force under Static Condition**

- Moving Ram was pushed by hand.
- Push-Pull type load transducer was used.

35	N
3.57	kgf

# Test Result: 121101-T01

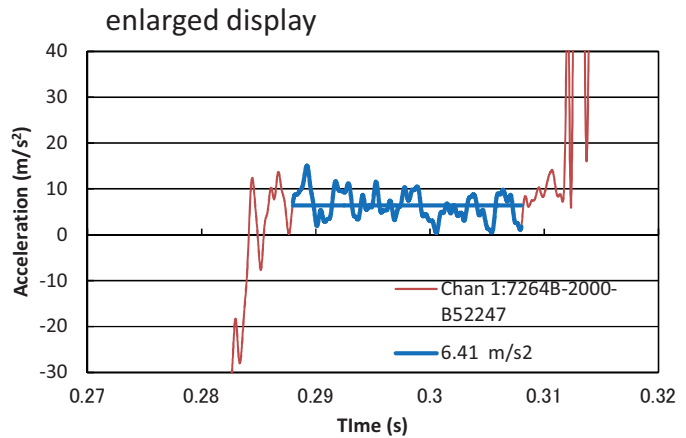
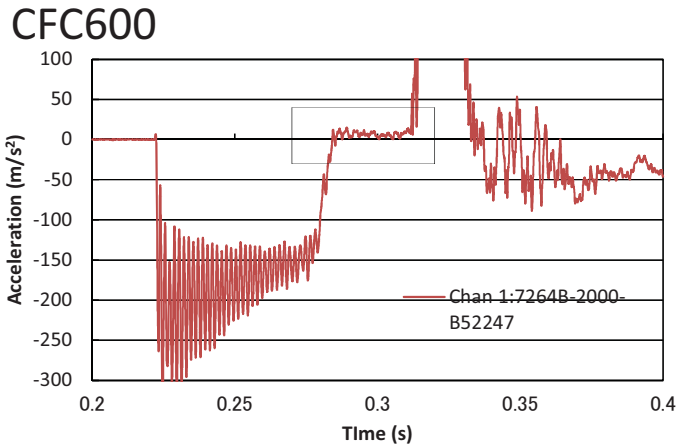


Friction Force\*

Deceleration

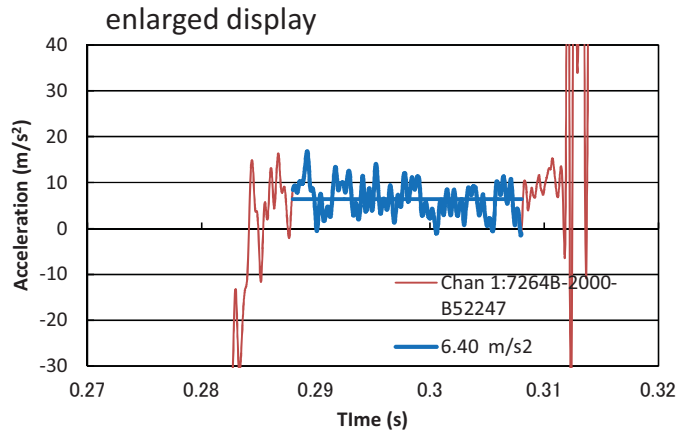
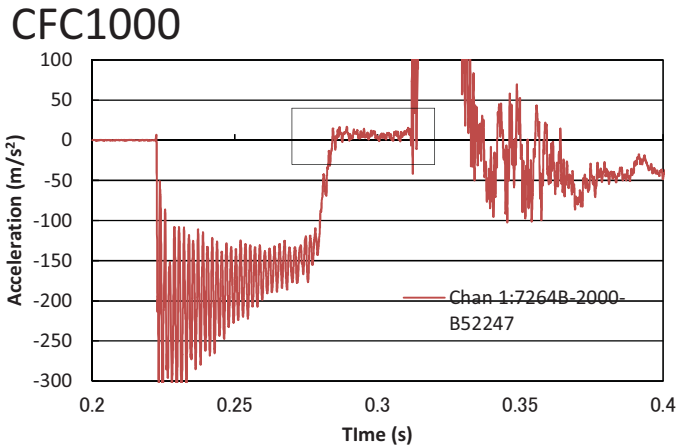
### CFC180

51.8	N
5.28	kgf
0.652	G
6.39	m/s <sup>2</sup>



### CFC600

51.9	N
5.29	kgf
0.653	G
6.41	m/s <sup>2</sup>

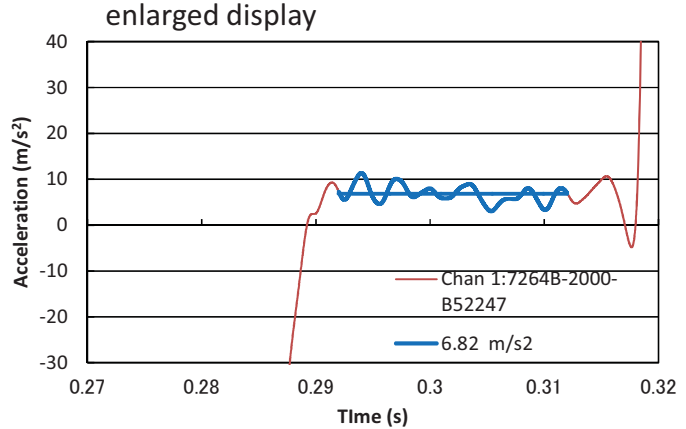
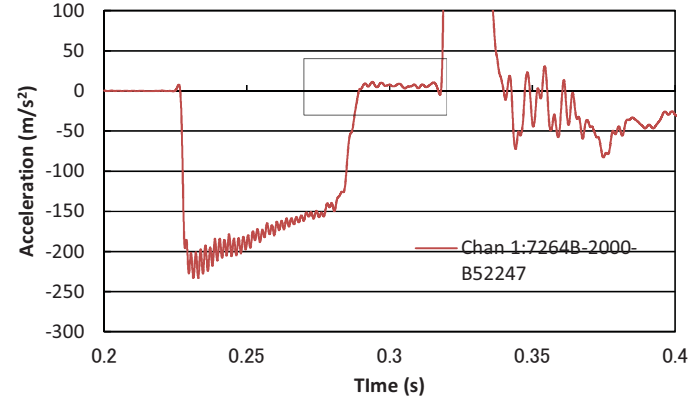


### CFC1000

51.9	N
5.29	kgf
0.653	G
6.40	m/s <sup>2</sup>

# Test Result: 121101-T02

CFC180

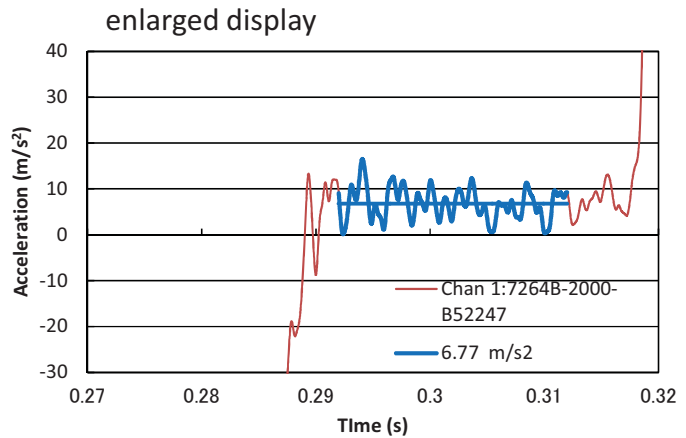
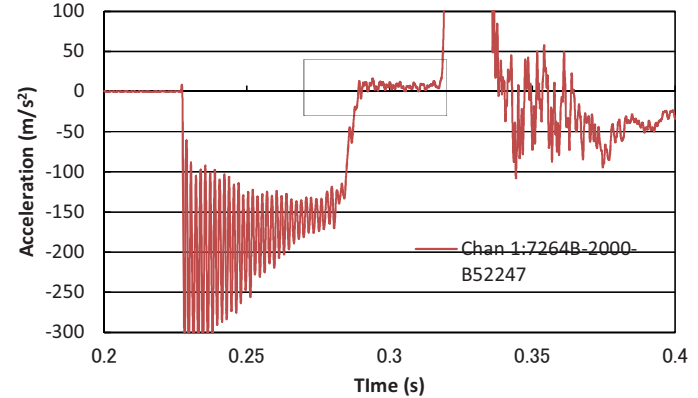


Friction Force\*  
Deceleration

CFC180

55.2	N
5.63	kgf
0.695	G
6.82	m/s <sup>2</sup>

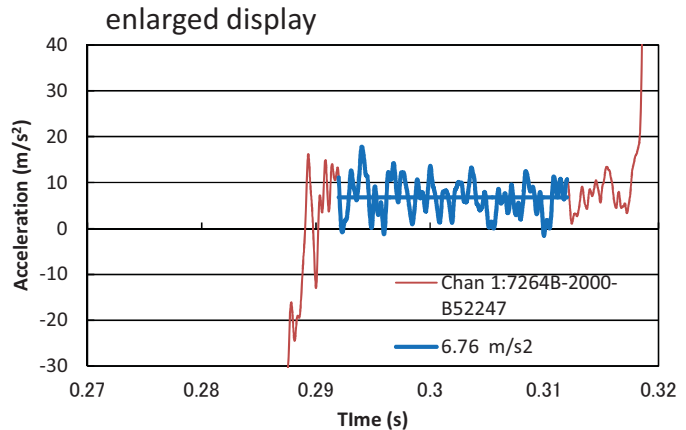
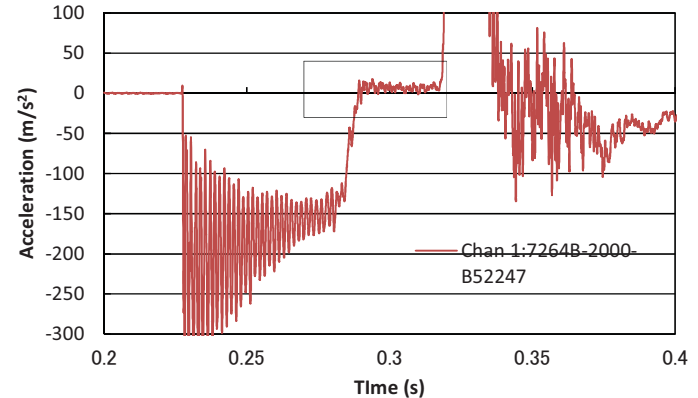
CFC600



CFC600

54.8	N
5.59	kgf
0.690	G
6.77	m/s <sup>2</sup>

CFC1000



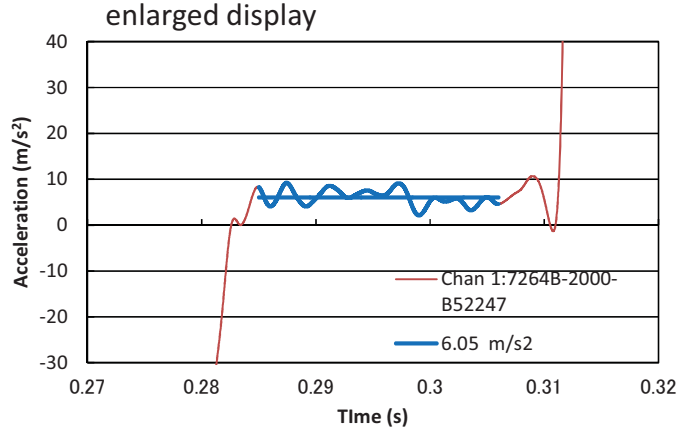
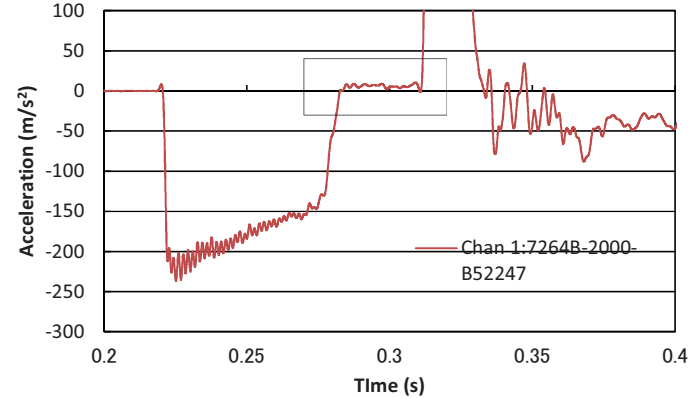
CFC1000

54.7	N
5.58	kgf
0.689	G
6.76	m/s <sup>2</sup>



# Test Result: 121101-T03

## CFC180

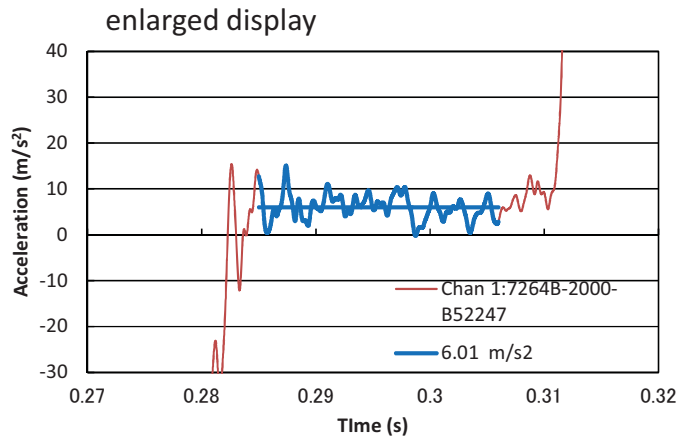
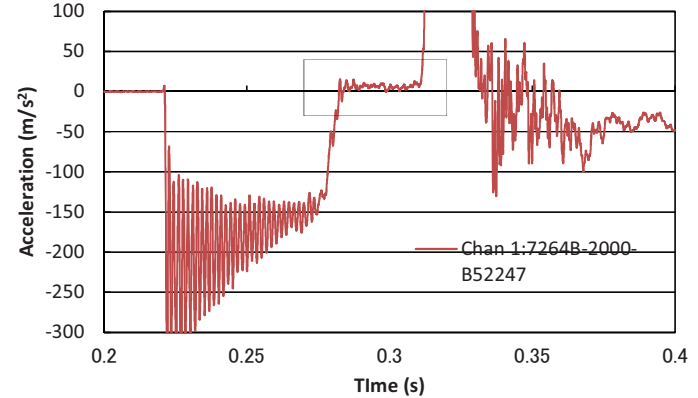


Friction Force\*  
Deceleration

CFC180

49.0	N
5.00	kgf
0.617	G
6.05	m/s <sup>2</sup>

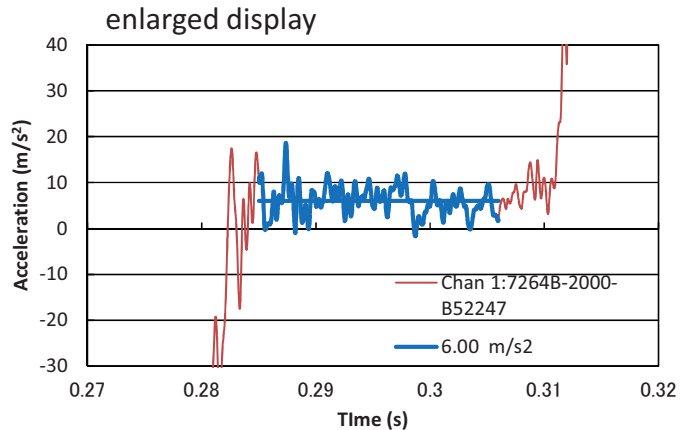
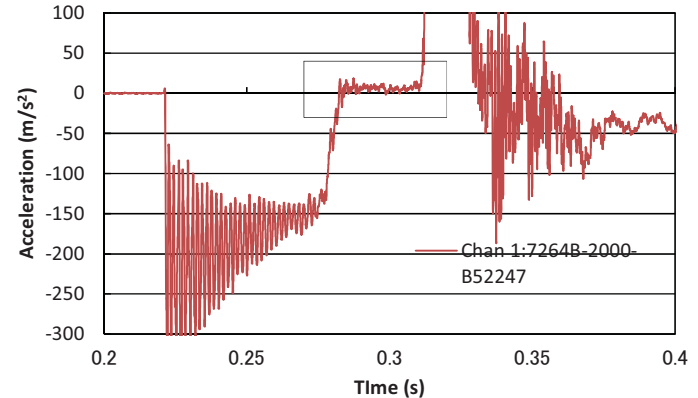
## CFC600



CFC600

48.6	N
4.96	kgf
0.612	G
6.01	m/s <sup>2</sup>

## CFC1000

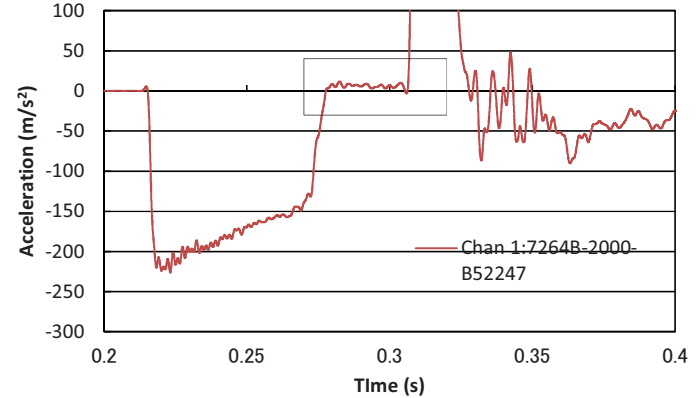


CFC1000

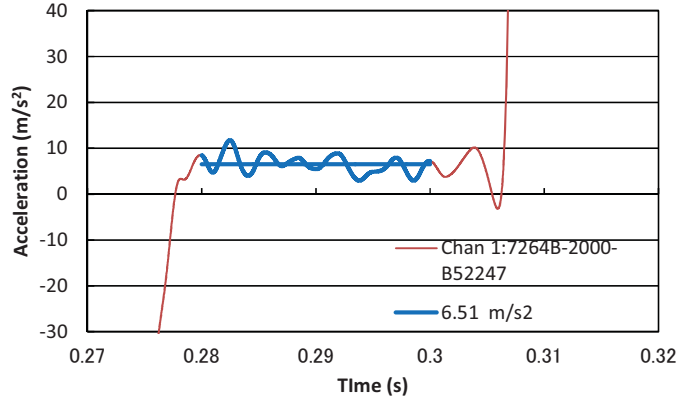
48.6	N
4.95	kgf
0.611	G
6.00	m/s <sup>2</sup>

# Test Result: 121101-T04

CFC180



enlarged display

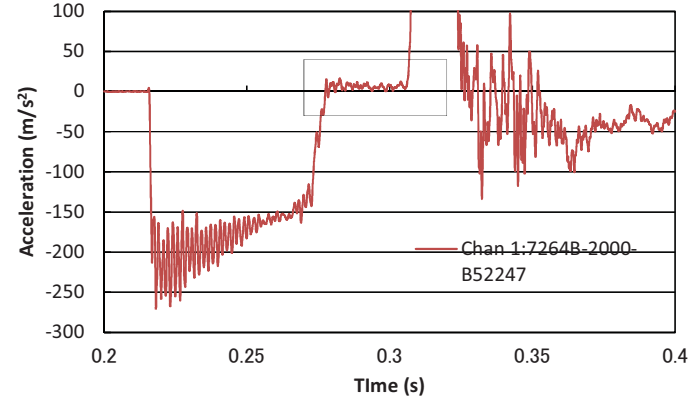


Friction Force\*  
Deceleration

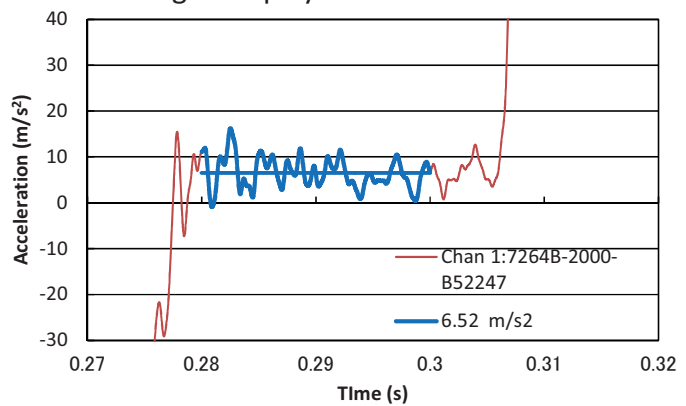
CFC180

52.8	N
5.38	kgf
0.664	G
6.51	m/s <sup>2</sup>

CFC600



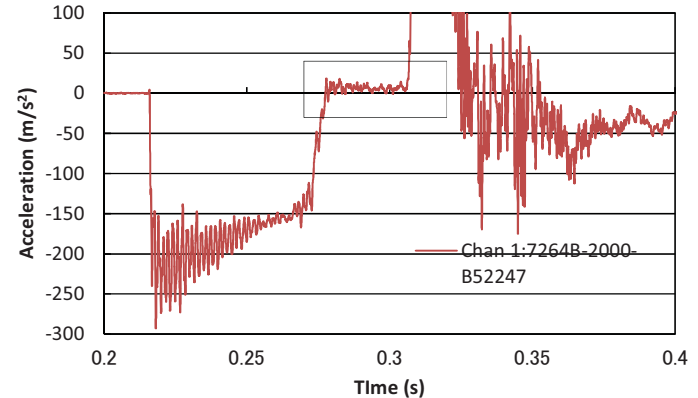
enlarged display



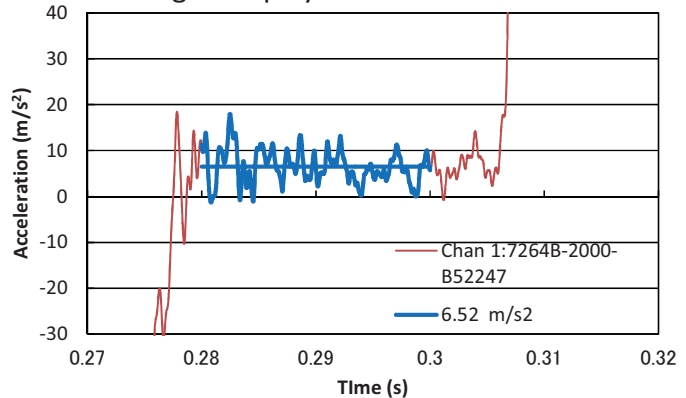
CFC600

52.8	N
5.38	kgf
0.665	G
6.52	m/s <sup>2</sup>

CFC1000



enlarged display

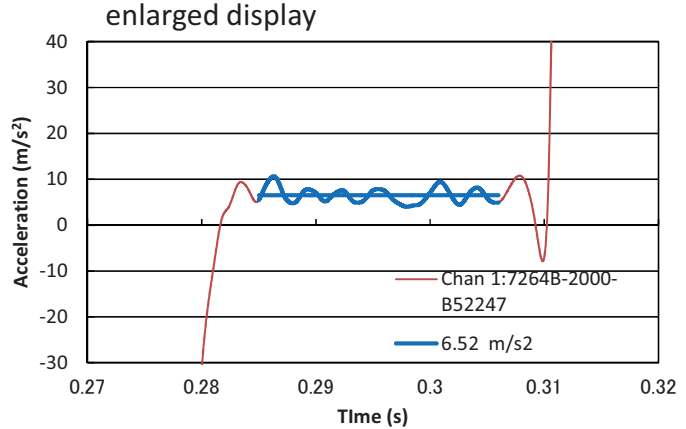
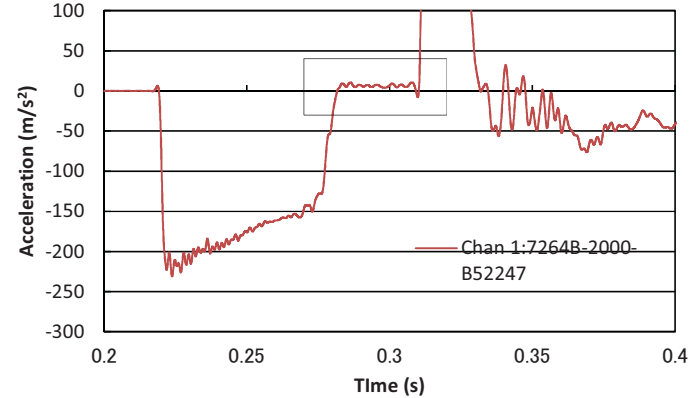


CFC1000

52.8	N
5.38	kgf
0.664	G
6.52	m/s <sup>2</sup>

# Test Result: 121101-T05

## CFC180

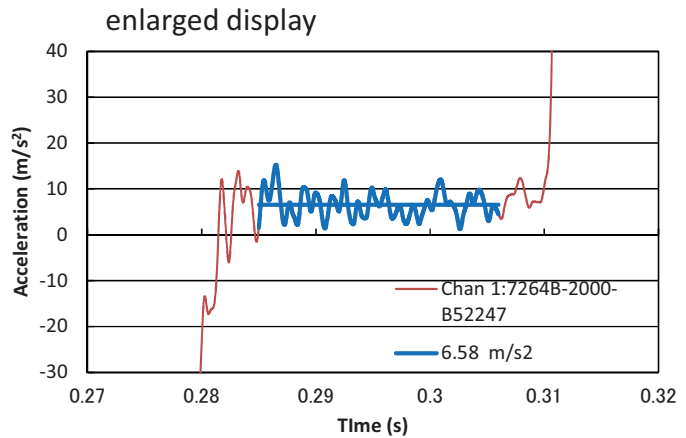
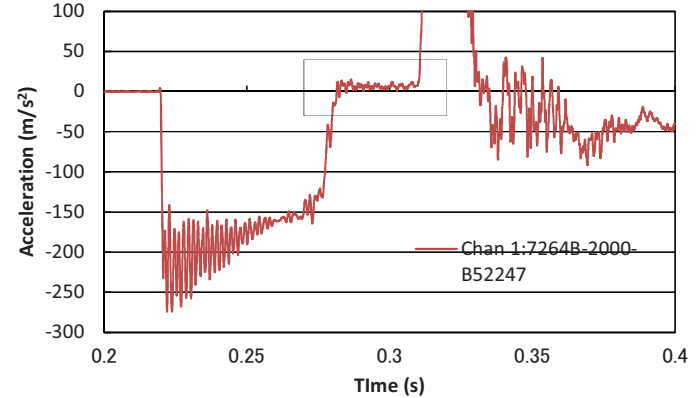


Friction Force\*  
Deceleration

CFC180

52.8	N
5.38	kgf
0.664	G
6.52	m/s <sup>2</sup>

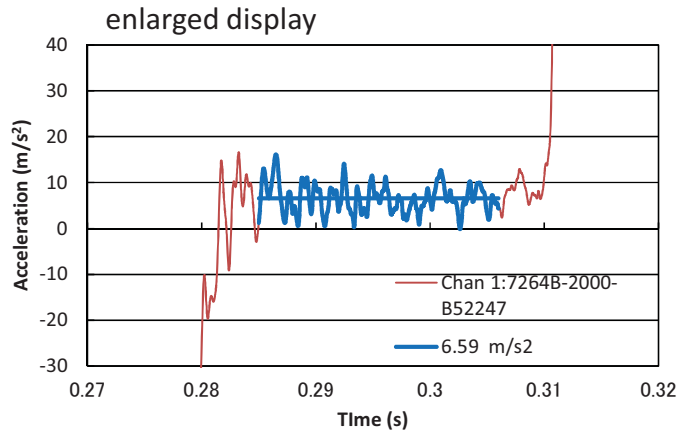
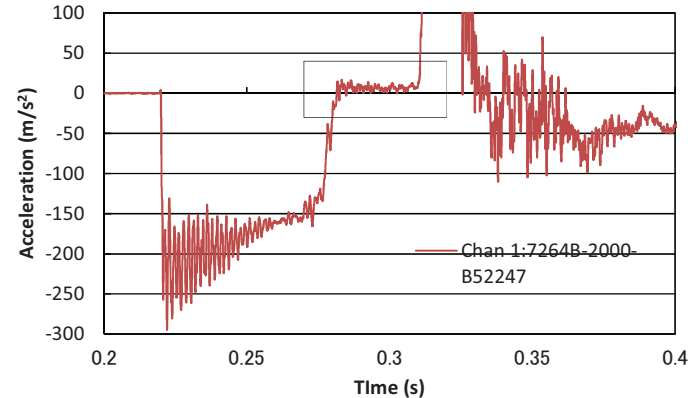
## CFC600



CFC600

53.3	N
5.43	kgf
0.671	G
6.58	m/s <sup>2</sup>

## CFC1000



CFC1000

53.4	N
5.44	kgf
0.672	G
6.59	m/s <sup>2</sup>

**Test Results (table)**

ID	Frictional force (N)		
	CFC180	CFC600	CFC1000
121101-T01	51.8	51.9	51.9
121101-T02	55.2	54.8	54.7
121101-T03	49.0	48.6	48.6
121101-T04	52.8	52.8	52.8
121101-T05	52.8	53.3	53.4
Maximum	55.2	54.8	54.7
Average	52.3	52.3	52.3
Minimum	49.0	48.6	48.6

ID	Frictional force (kgf)		
	CFC180	CFC600	CFC1000
121101-T01	5.28	5.29	5.29
121101-T02	5.63	5.59	5.58
121101-T03	5.00	4.96	4.95
121101-T04	5.38	5.38	5.38
121101-T05	5.38	5.43	5.44
Maximum	5.63	5.59	5.58
Average	5.33	5.33	5.33
Minimum	5.00	4.96	4.95

ID	Deceleration (G)		
	CFC180	CFC600	CFC1000
121101-T01	0.652	0.653	0.653
121101-T02	0.695	0.690	0.689
121101-T03	0.617	0.612	0.611
121101-T04	0.664	0.665	0.664
121101-T05	0.664	0.671	0.672
Maximum	0.695	0.690	0.689
Average	0.658	0.658	0.658
Minimum	0.617	0.612	0.611

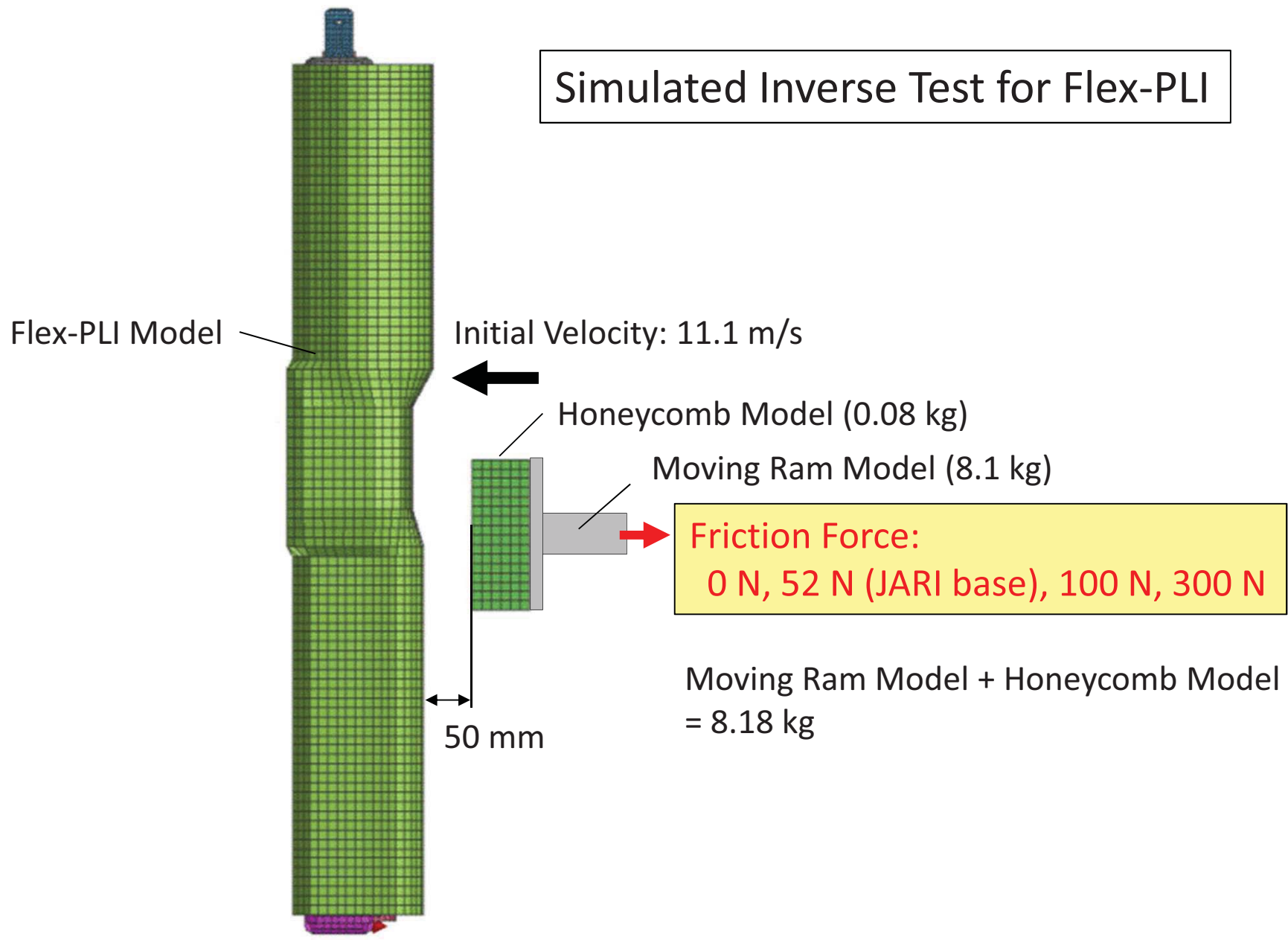
ID	Deceleration (m/s <sup>2</sup> )		
	CFC180	CFC600	CFC1000
121101-T01	6.39	6.41	6.40
121101-T02	6.82	6.77	6.76
121101-T03	6.05	6.01	6.00
121101-T04	6.51	6.52	6.52
121101-T05	6.52	6.58	6.59
Maximum	6.82	6.77	6.76
Average	6.46	6.46	6.45
Minimum	6.05	6.01	6.00

**Test Results (average of all)**

- Frictional force: 52 N (5.3 kgf)
- Deceleration: 0.66 G (6.5 m/s<sup>2</sup>)
- Variation: -7.1 % to +5.6 %

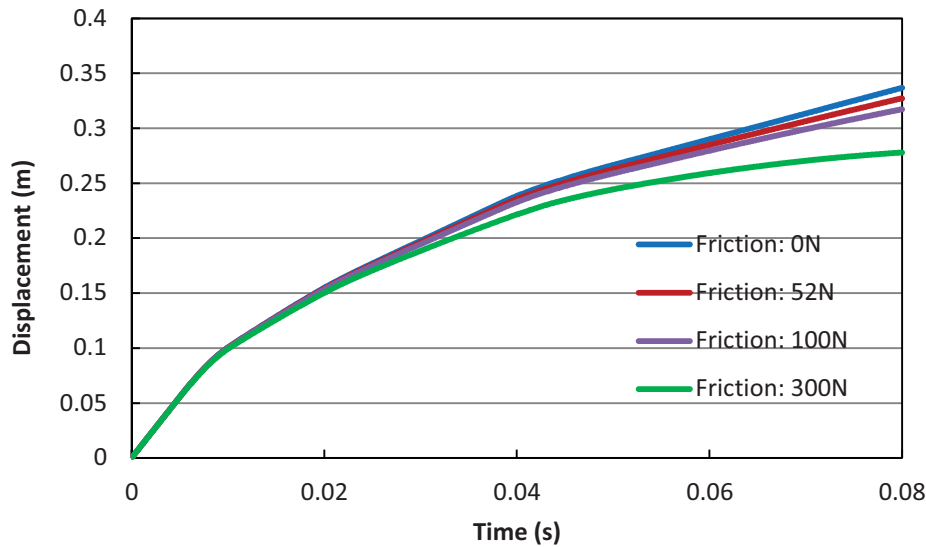
### 3. CAE Analysis: Moving Ram Friction Effect

# Model Setup

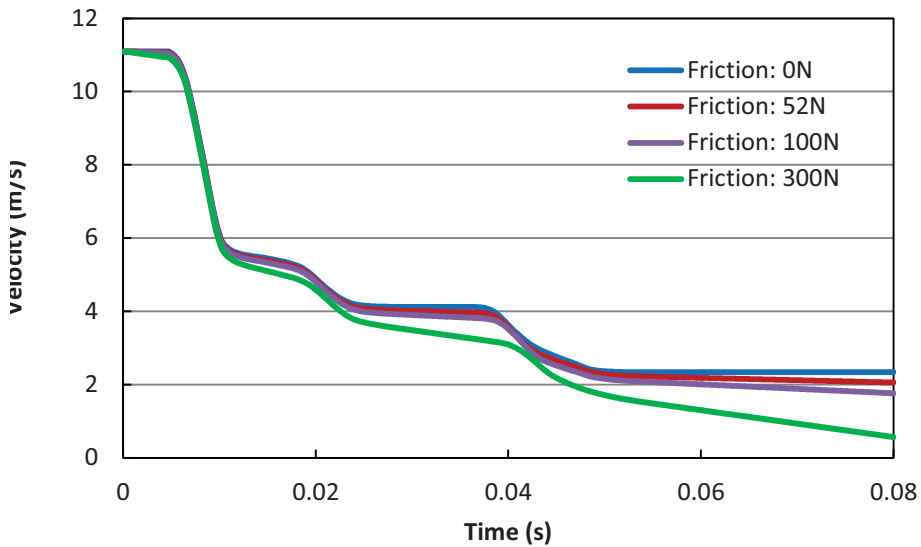


# Comparison of Displacement, Velocity and Deceleration of Moving Ram Model

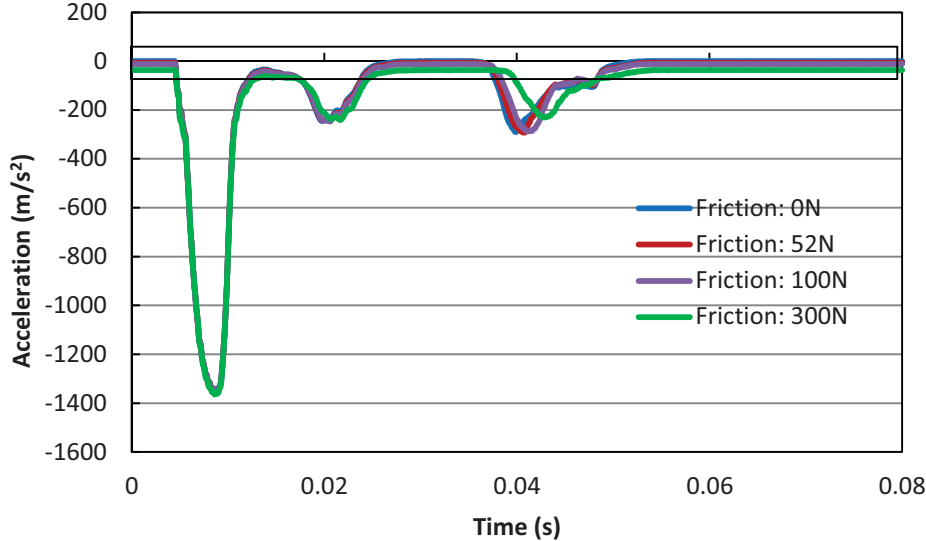
### Displacement



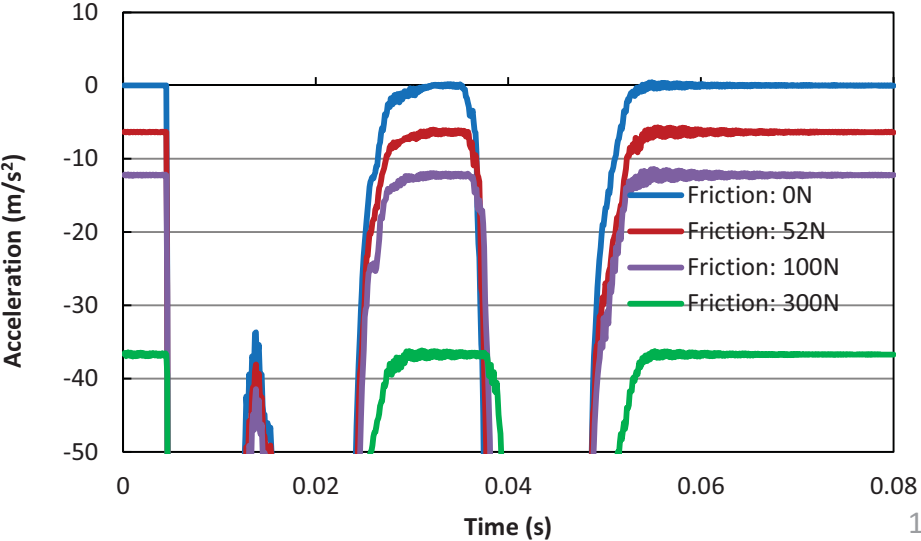
### Velocity



### Deceleration

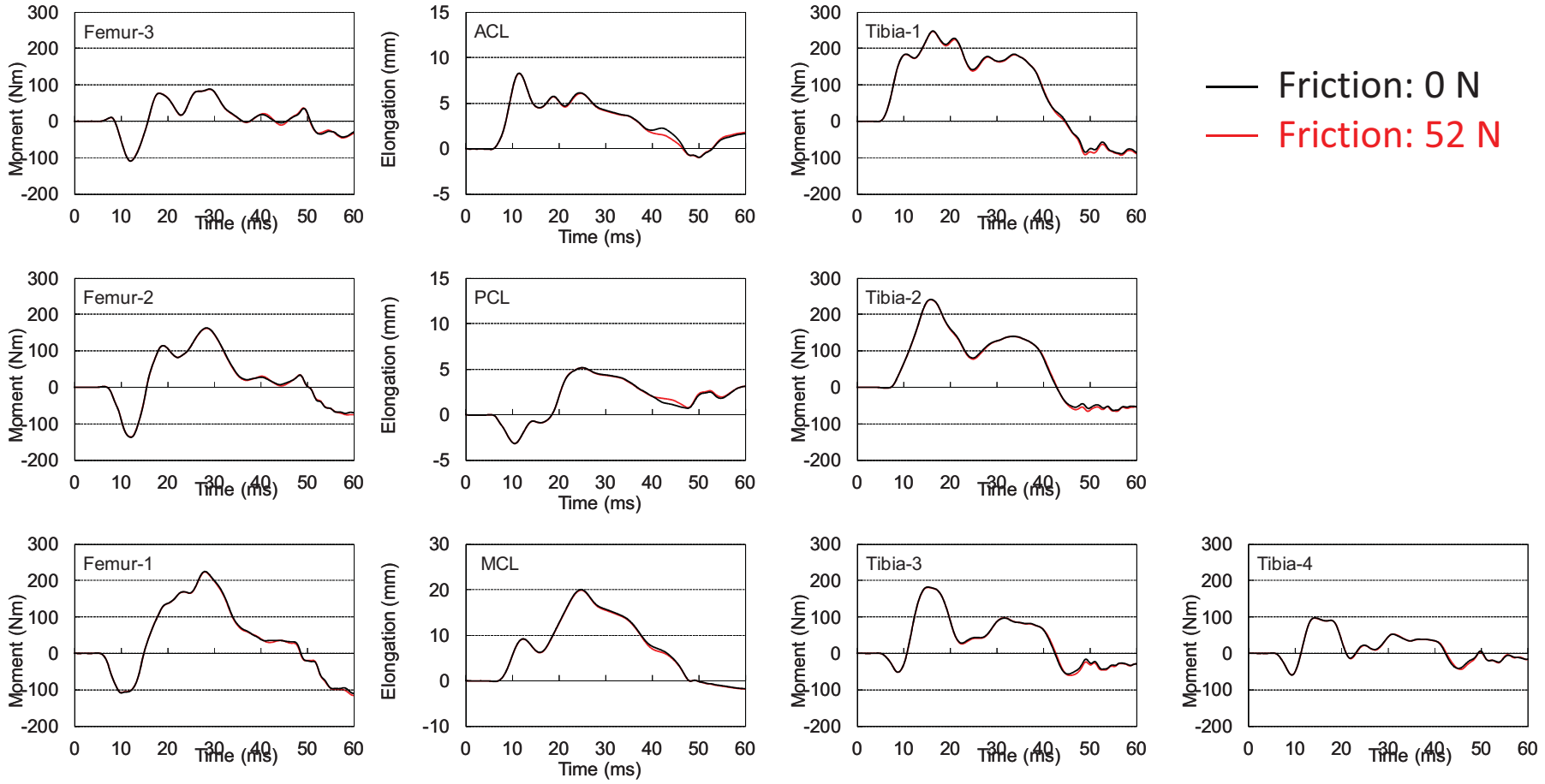


### Deceleration (enlarged display)



# Comparisons of Wave Forms of Flex-PLI Model

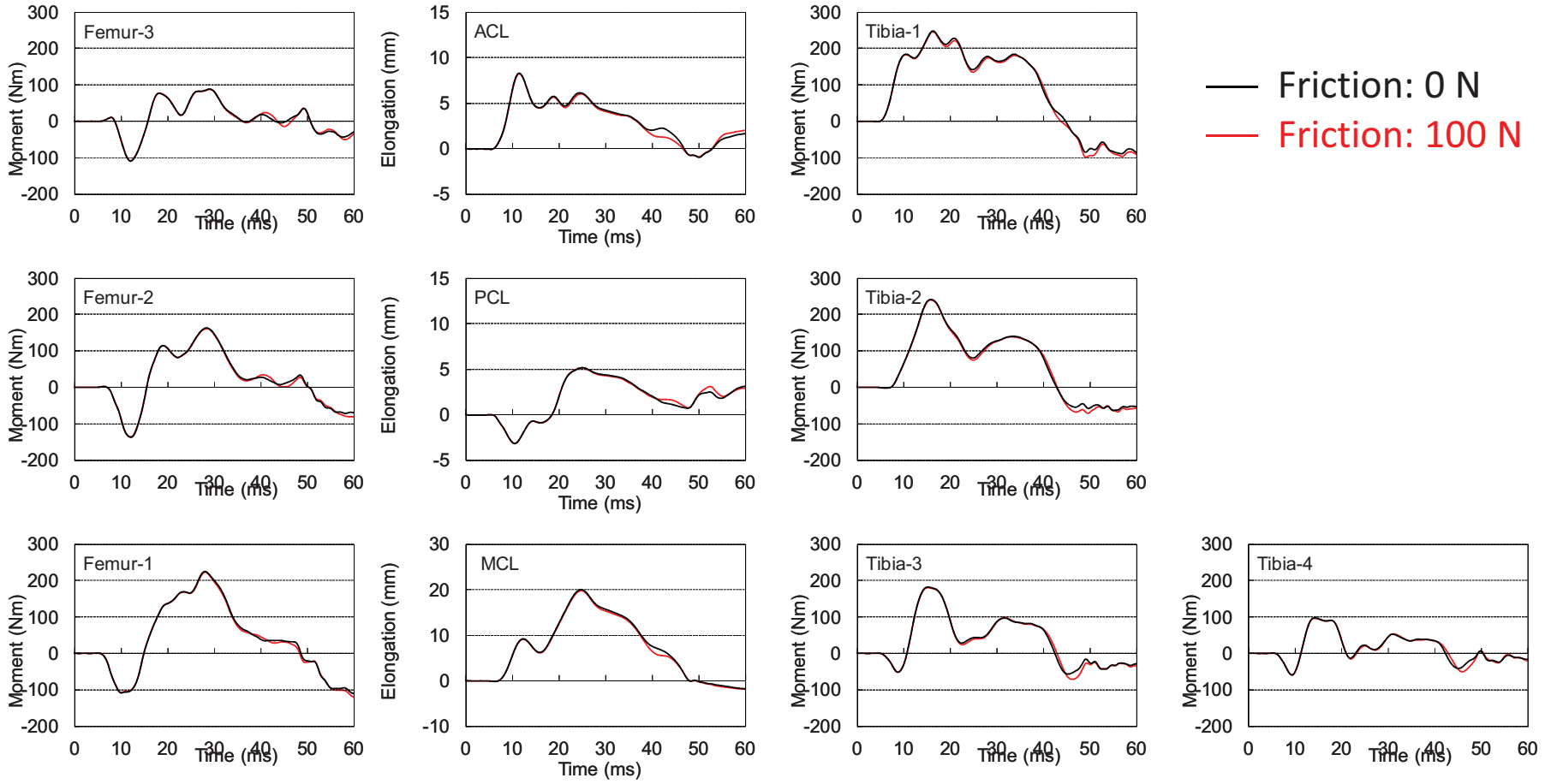
## Friction Force: 0 N, 52 N





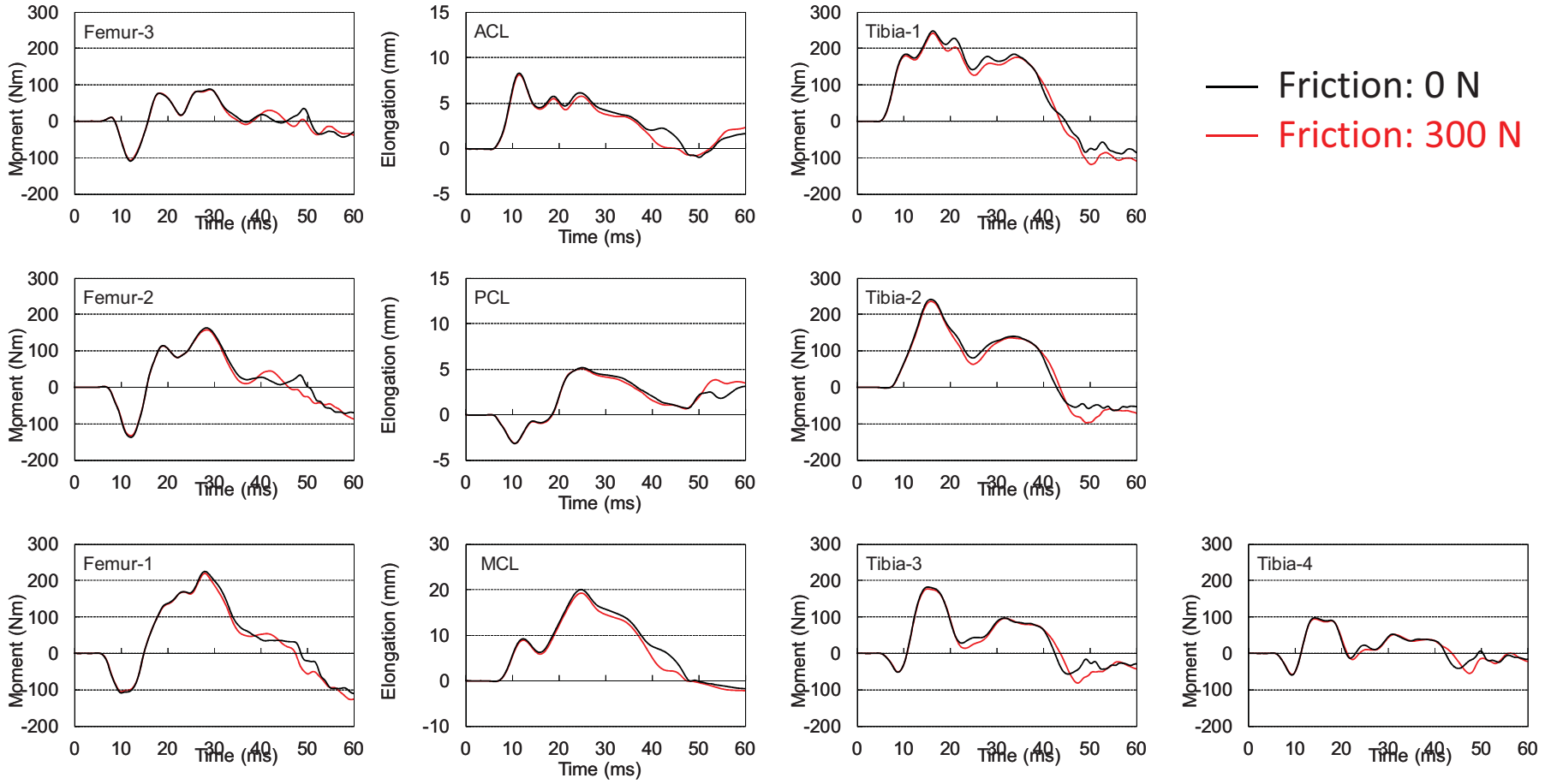
# Comparisons of Wave Forms of Flex-PLI Model

## Friction Force: 0 N, 100 N

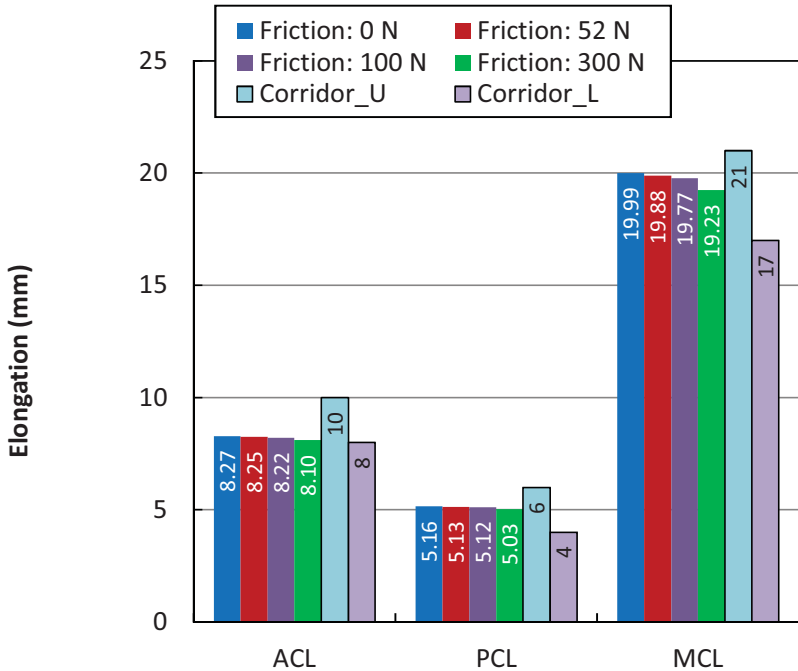
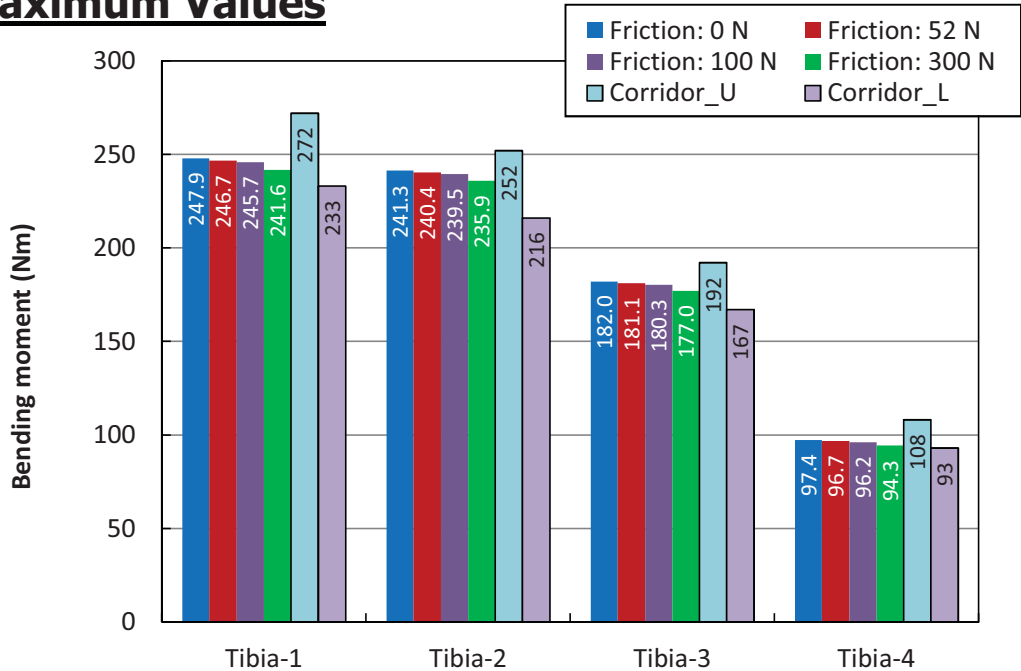


# Comparisons of Wave Forms of Flex-PLI Model

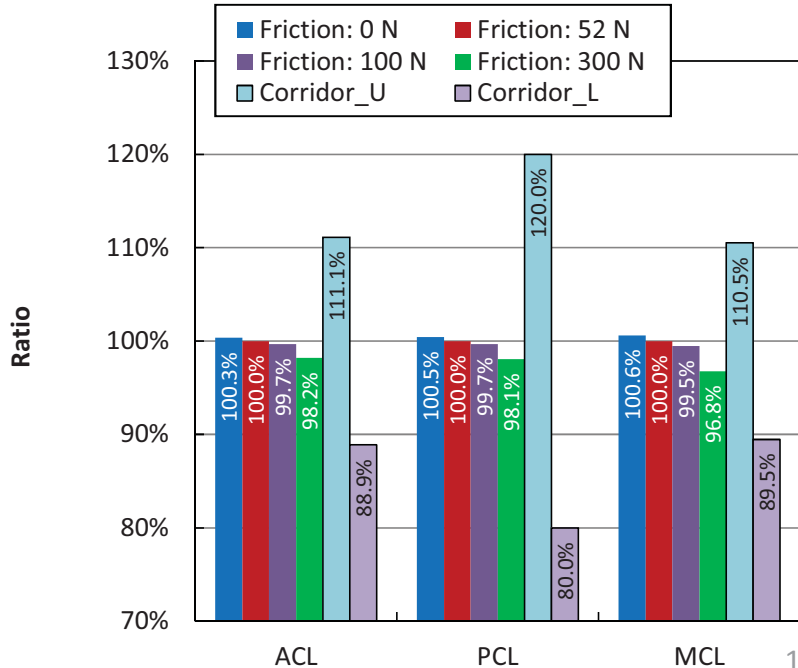
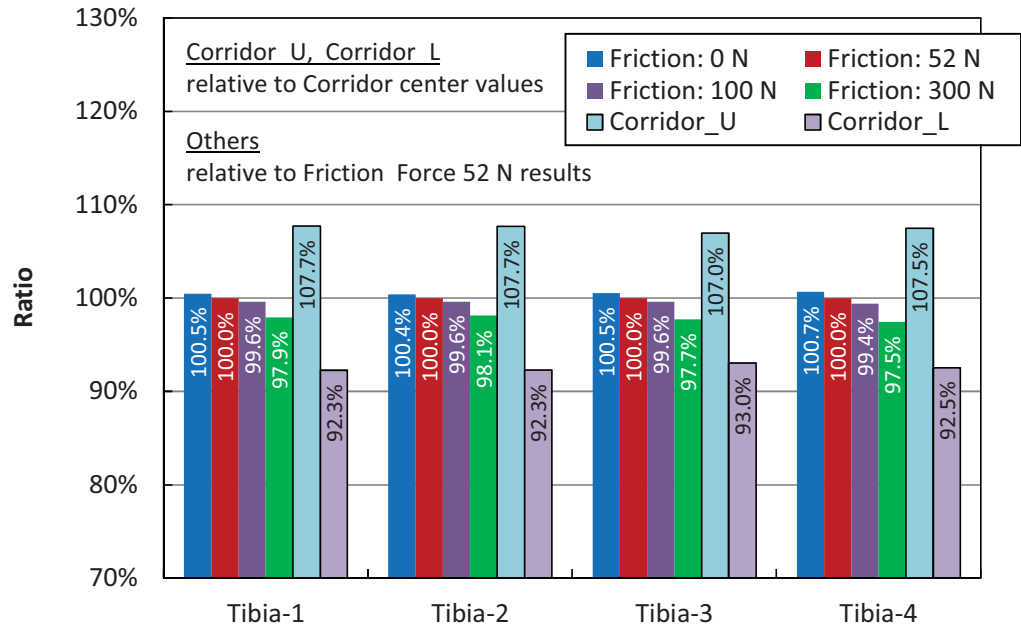
## Friction Force: 0 N, 300 N



**Maximum Values**



**Comparison Ratio**



## Comparison Ratio (table)

### Maximum Values Ratio

Ratio	Tibia-1	Tibia-2	Tibia-3	Tibia-4	ACL	PCL	MCL	Max.	Min.
Friction: 0 N	100.5%	100.4%	100.5%	100.7%	100.3%	100.5%	100.6%	100.7%	100.3%
<b>Friction: 52 N</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
Friction: 100 N	99.6%	99.6%	99.6%	99.4%	99.7%	99.7%	99.5%	99.7%	99.4%
Friction: 300 N	97.9%	98.1%	97.7%	97.5%	98.2%	98.1%	96.8%	98.2%	96.8%
Corridor_U	107.7%	107.7%	107.0%	107.5%	111.1%	120.0%	110.5%		
Corridor_L	92.3%	92.3%	93.0%	92.5%	88.9%	80.0%	89.5%		

### Maximum Values Ratio (differences)

Ratio	Tibia-1	Tibia-2	Tibia-3	Tibia-4	ACL	PCL	MCL	Max.	Min.
Friction: 0 N	0.5%	0.4%	0.5%	0.7%	0.3%	0.5%	0.6%	0.7%	0.3%
<b>Friction: 52 N</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
Friction: 100 N	-0.4%	-0.4%	-0.4%	-0.6%	-0.3%	-0.3%	-0.5%	-0.3%	-0.6%
Friction: 300 N	-2.1%	-1.9%	-2.3%	-2.5%	-1.8%	-1.9%	-3.2%	-1.8%	-3.2%
Corridor_U	7.7%	7.7%	7.0%	7.5%	11.1%	20.0%	10.5%		
Corridor_L	-7.7%	-7.7%	-7.0%	-7.5%	-11.1%	-20.0%	-10.5%		

## 4. Summary

- In this study, Moving Ram Friction was measured at JARI, then it was found that the average friction force was 52 N.
- Besides, Moving Ram Friction Effect was analyzed using Flex-PLI computer simulation model.
- As a result, it was found that the friction effect was insignificant in the range of 0 N to 100 N (Difference ratio relative to the results for 52 N friction force was less than +/- 1%).
- When we changed the friction force to 300 N, the results differed by around 4% relative to the results for 52 N friction force.
- If the friction force from other labs are similar to that from JARI, the CAE results suggest that it would not be necessary to specify requirements to measure friction force in the GTR text (no need to require additional preparations as well as additional measurements).
- Japan therefore propose to just describe a caution of moving ram friction in PADI as follows:
  - ✓ Users who install inverse test rig in their test lab shall check the average moving ram friction to make sure that the friction force is less than [100] N.

***Thank you for your attention***