สถาบันมาตรวิทยาแห่งชาติ
National Institute of Metrology (Thailand)
NIMT

The prototype of high stiffness load cell for Rockwell hardness testing machine calibration according to ISO 6508-2:2015

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Outline

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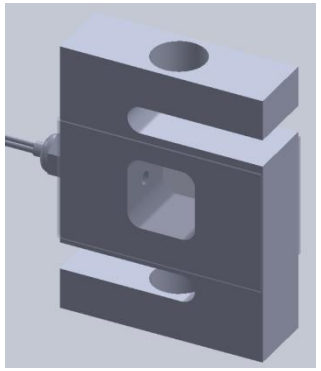
1.Introduction to the verification of hardness machine

2.Force verification of hardness testing machine

3.Conceptual design of **H**igh **S**tiffness **L**oad Cell

4.Experiment results

5.Conclusion



1. Introduction to direct verification of Rockwell hardness testing machine

1. Verification of the test force
2. Verification of the testing cycle
3. Verification of the depth measuring device
4. Verification of the indenter shape

Hardness Machine

Test Force

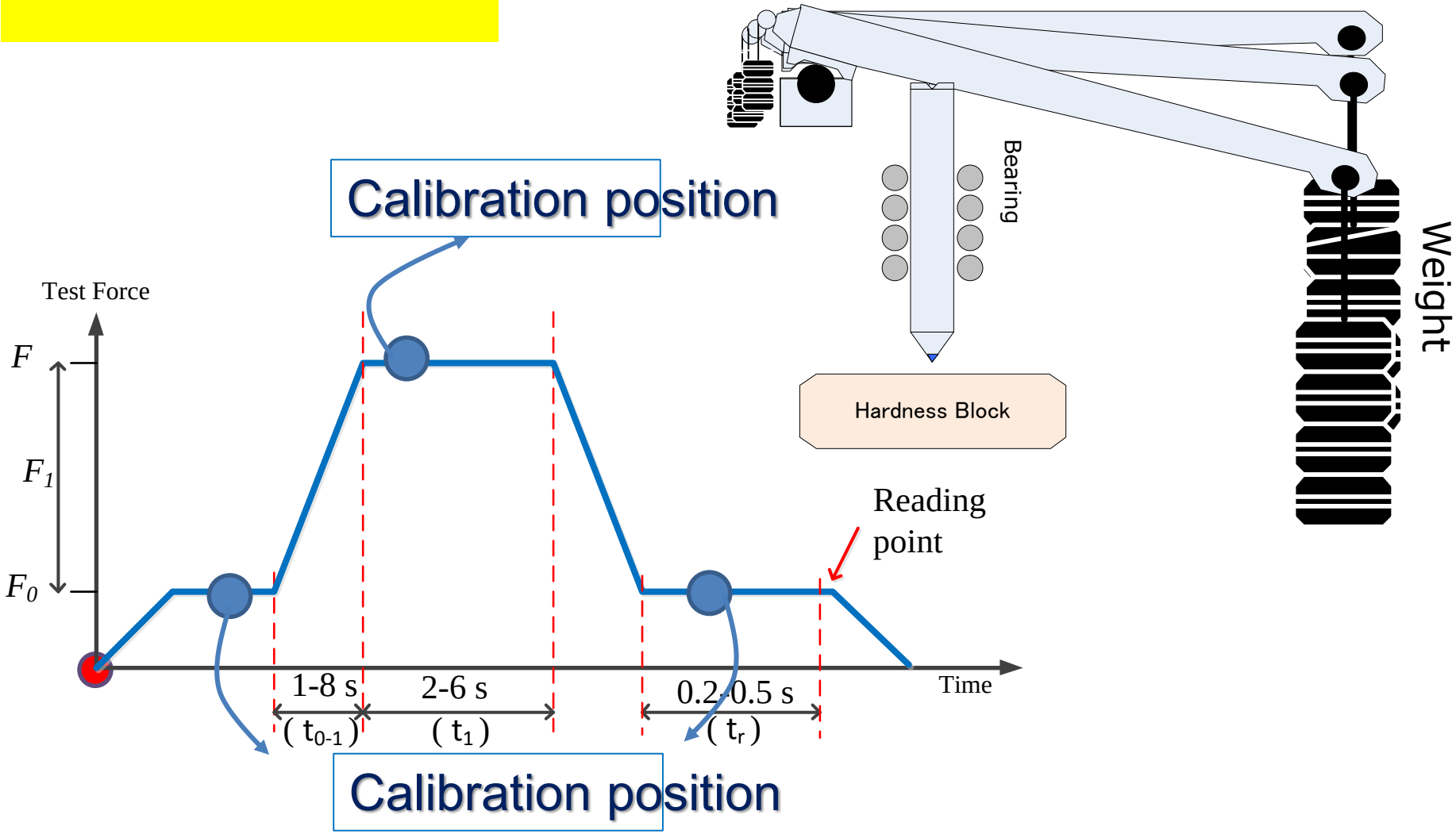
Time

Depth

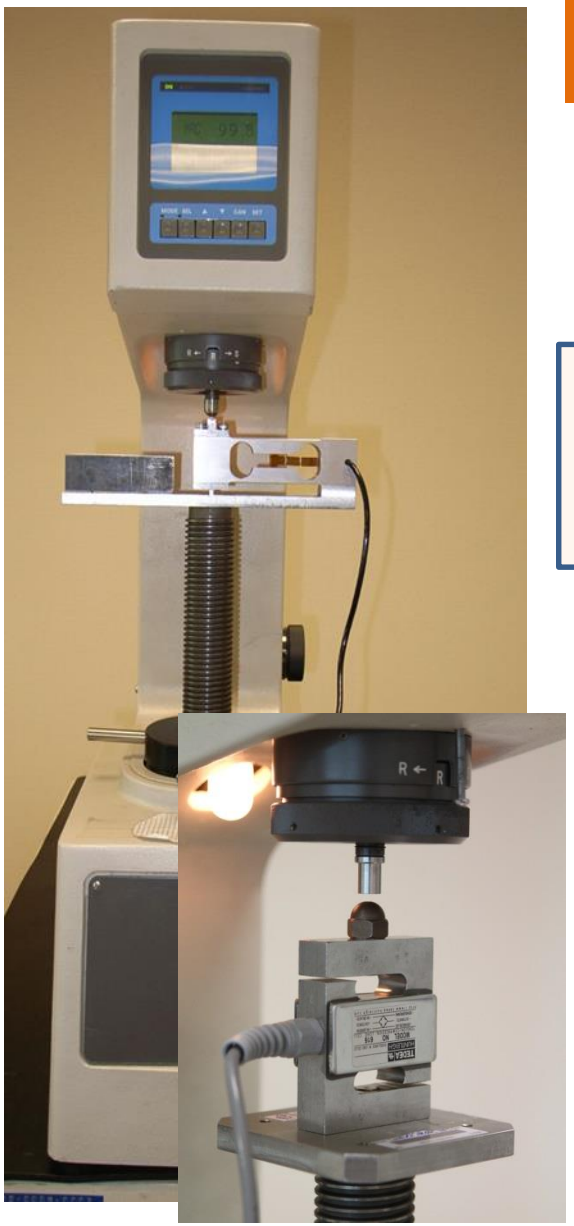
Indenter shape

Operation of hardness testing machine

Rockwell hardness



2. Force verification



- Each test force shall be measured.

- Shall be done at not less than three position of the plunger movement during test.

- Three readings shall be taken for each force at each position of the plunger.

- The preliminary test force, F_0 shall be measured before application and after removal of the additional test force, F_1.

Test force of Rockwell hardness testing machine

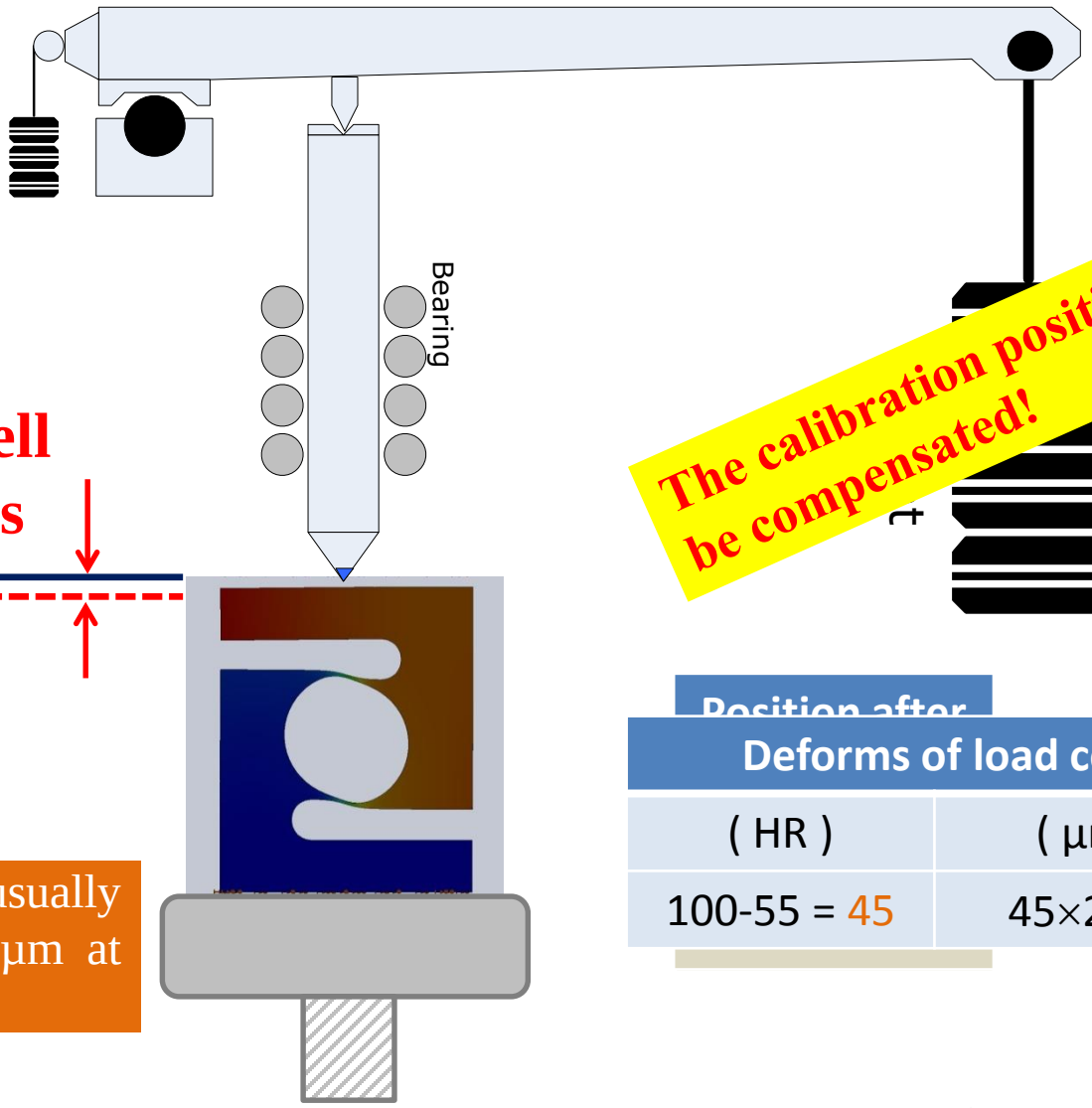
Rockwell hardness scale	Preliminary Test force, F_0 (kgf)	Total test force, F (kgf)
15N, 15T	3	15
30N, 30T		30
45N, 45T		45
A, F, H		60
B, D, E	10	100
C, G, K		150

Preliminary Test force, F_0

Total test force, F

Calibration position of *Rockwell A*	
Hardness	Position
HRA	(µm/HR)
85	-30/-15
60	-80/-40
30	-140/-70

Calibration position changes due to load cell deformation



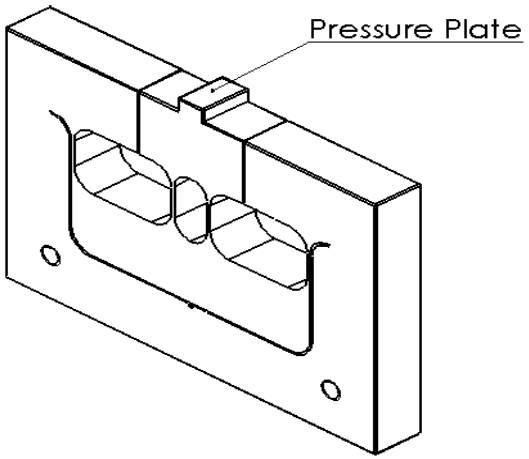
The calibration position must be compensated!

Commercial load cell usually deforms more than 200 µm at capacity

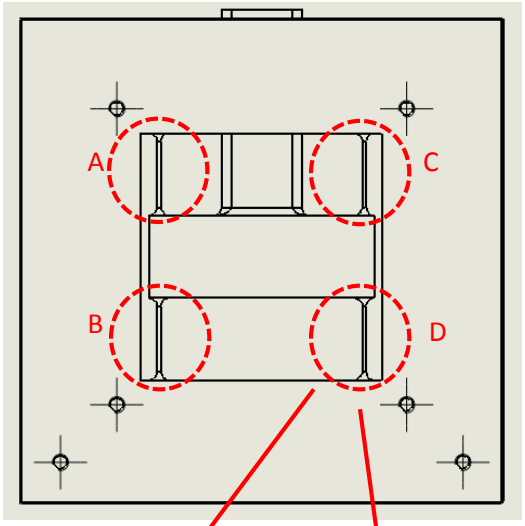
Deforms of load cell	
(HR)	(µm)
100-55 = 45	45×2=90

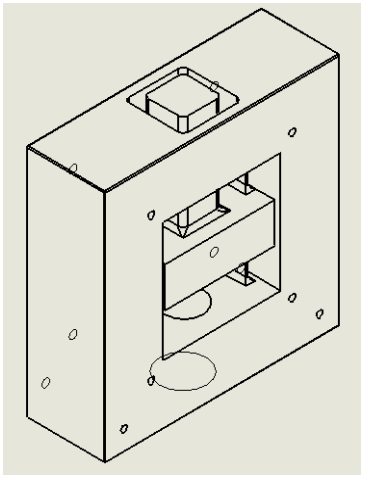
3. Conceptual design

- Capacity of load cell over 150 kgf
- Deform less than 20 μm
- Compact size, suit for hardness machine



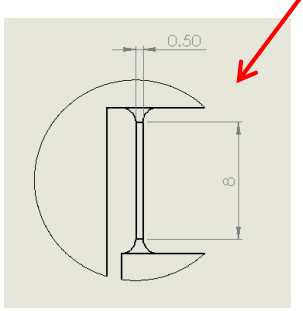
Design of HSL

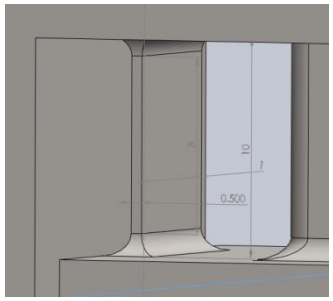


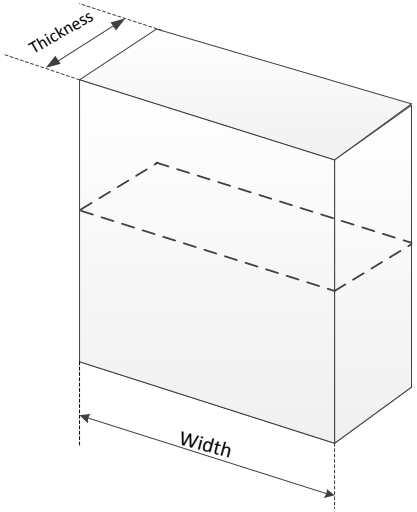


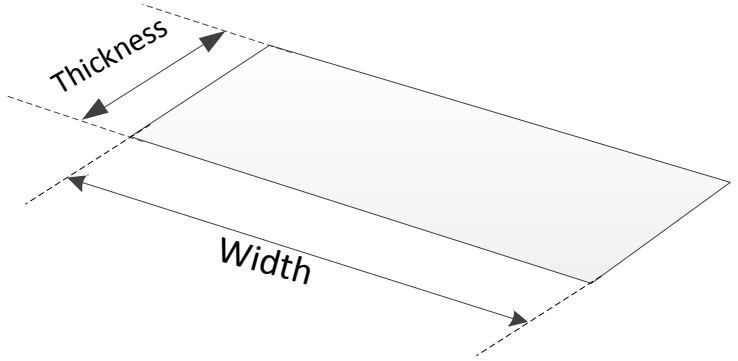
T	7	mm
W	0.50	mm
A	3.5	mm^2
	0.0000035	m^2
Strain	0.001	m/m
Young's Modulus	212.8	GPa
	2.128E+11	N/m^2
Stress	212800000	N/m^2
Force	744.80	N
	75.95	kg

4 sensing body =300 kgf



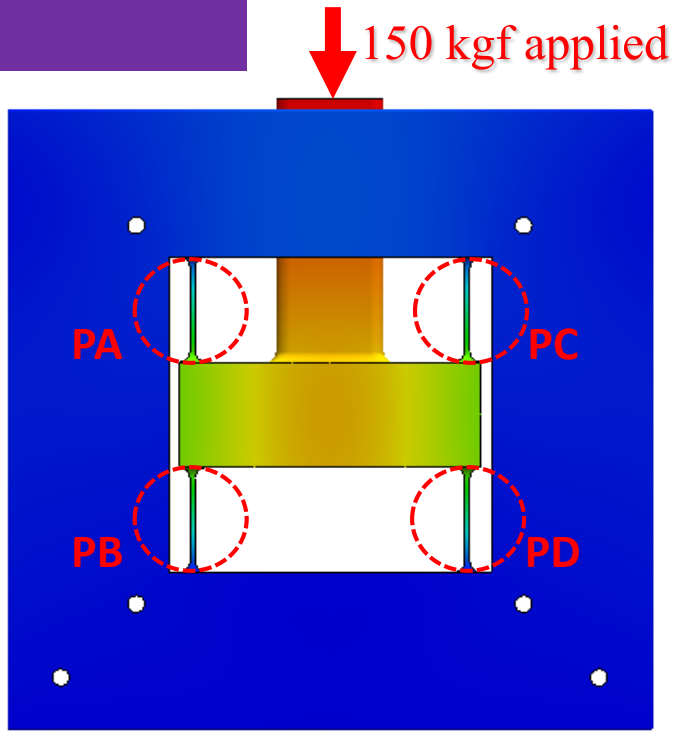






4. Experiment results

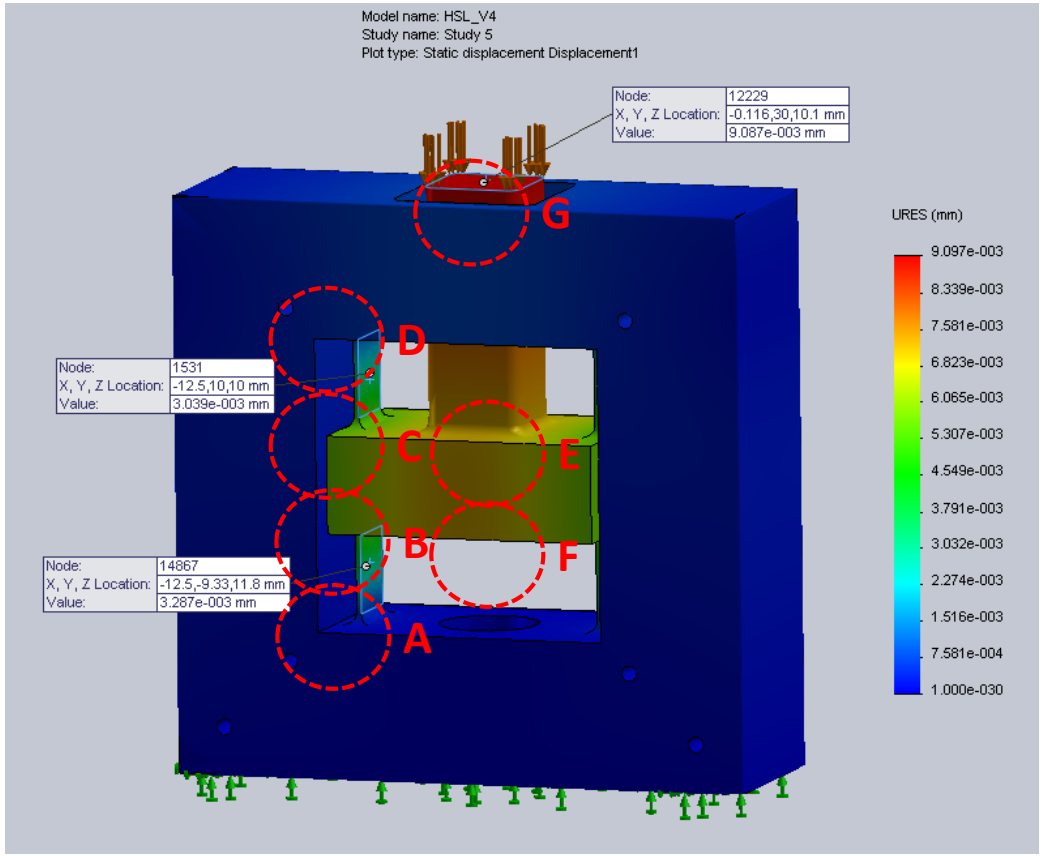
FEA simulation results



Parameters	PA	PB	PC	PD
Stress (GPa)	117.5	127.4	116.7	127.9
Strain (×10^{-6} strain)	458.0	501.3	457.9	498.7

Yield strength = 350 GPa

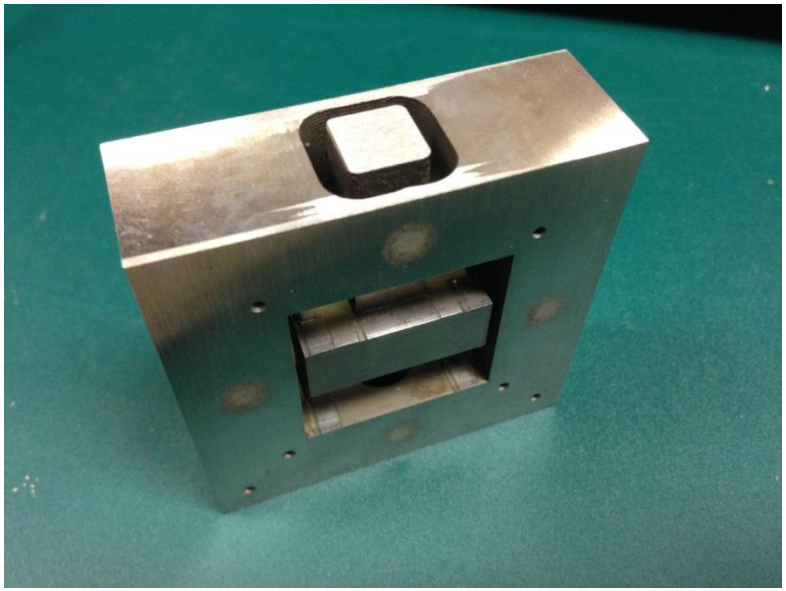
Displacement simulation results

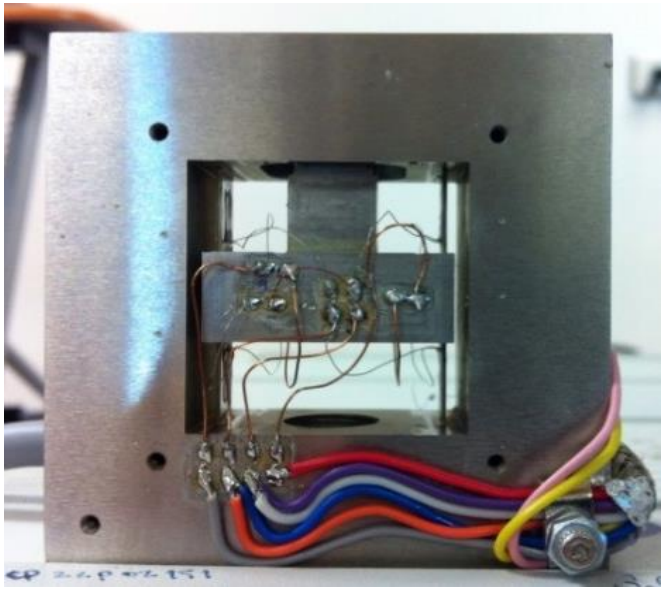


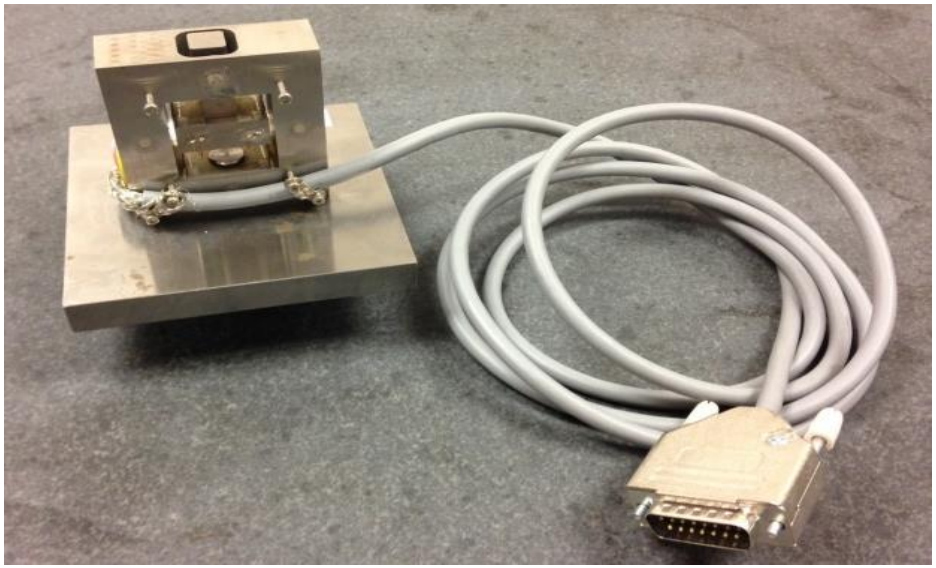
Parameters	A	B	C	D	E	F	G
Deformed (μm)	0.95	6.56	6.68	6.16	8.0	8.0	9.25
Calculate (μm)	-	-	-	-	-	-	5.00

Weakness of pressure plate

Fabricated HSL

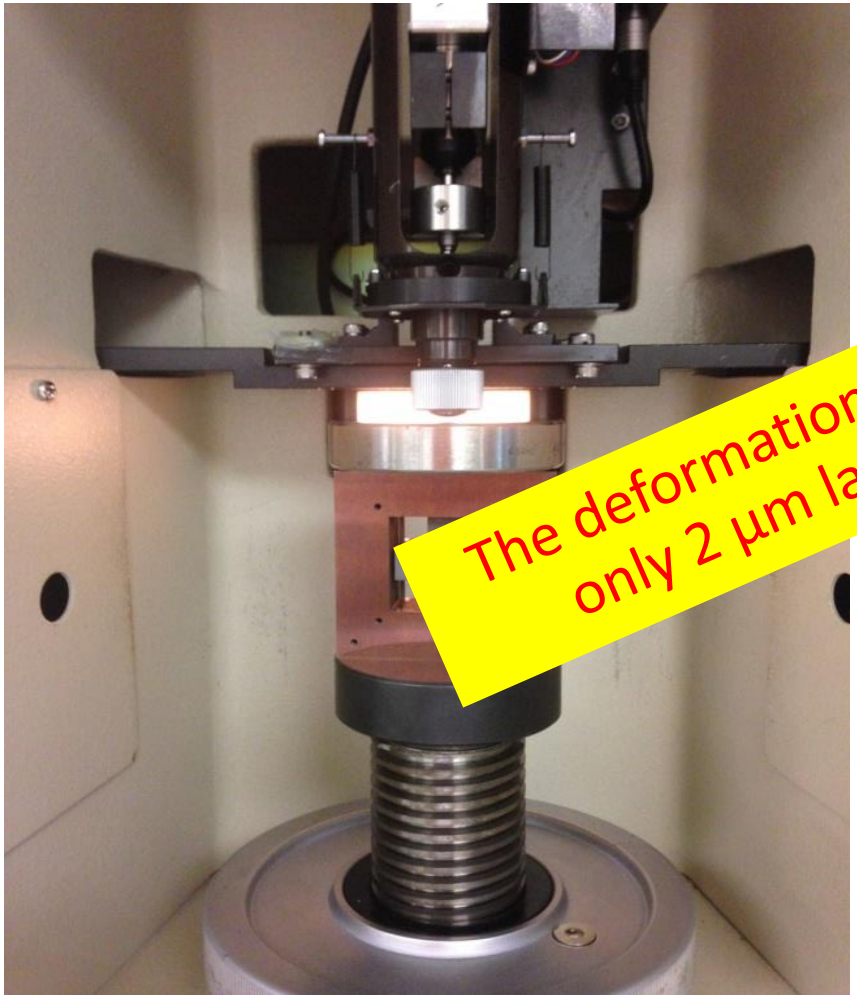






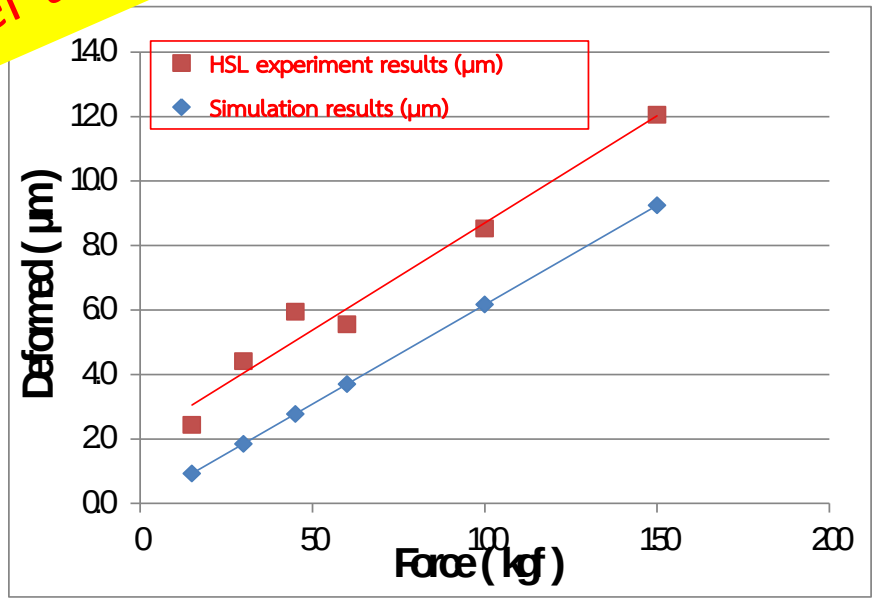
Dimension size of a fabricated is slightly different from design.

Deformation experiment results



Test force (kgf)	HSL experiment results (µm)	Simulation results (µm)
15	2.4	0.9
30	4.4	1.8
45		2.8
60		3.7
		6.2
	12.1	9.2

The deformation experiment results are only 2 µm larger than FEA results.



Conclusion

1. The 150 kgf high stiffness load cell was designed and constructed.
2. The deformation under 150 kgf is lower than 10 µm.
3. The strain under 150 kgf is 542.57×10^{-6} m/m.
4. FEA and experiments gave the consistent results within 5 µm displacement length and 50×10^{-6} m/m strain.

Future work

1. Weakness of pressure plate.
2. Load cell calibration and classification.