Lunar Concrete Landing Pad to Prevent Fine-Dust in the Moon

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Topics

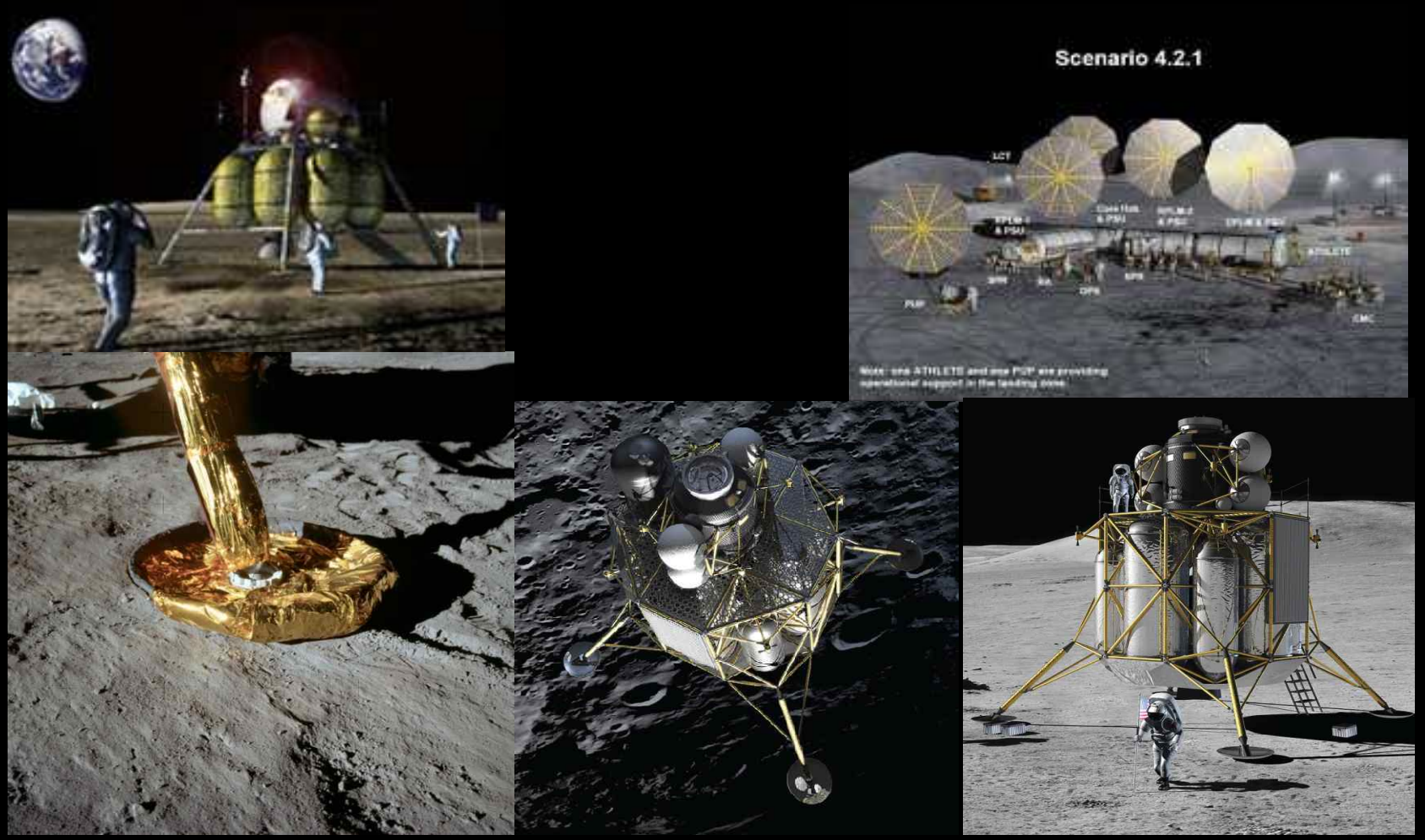
I. Need of Lunar Concrete Landing Pad

II. Selection of Method & Materials

III. Experimental Test

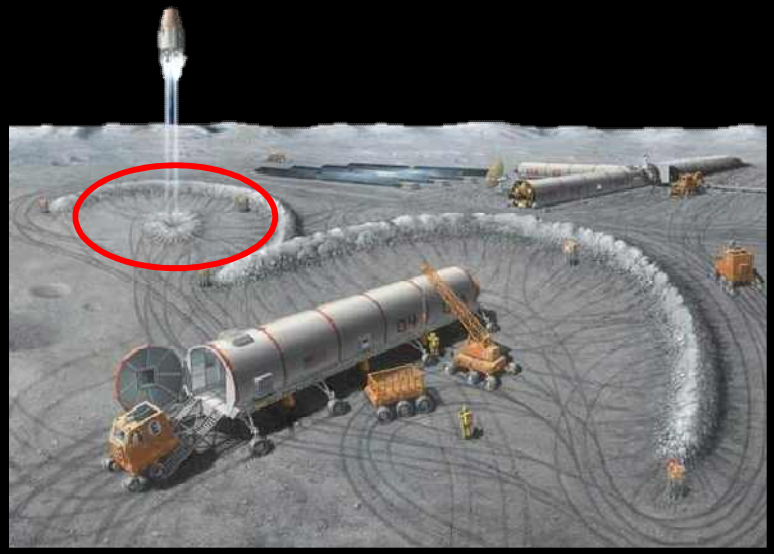
IV. Future Plan

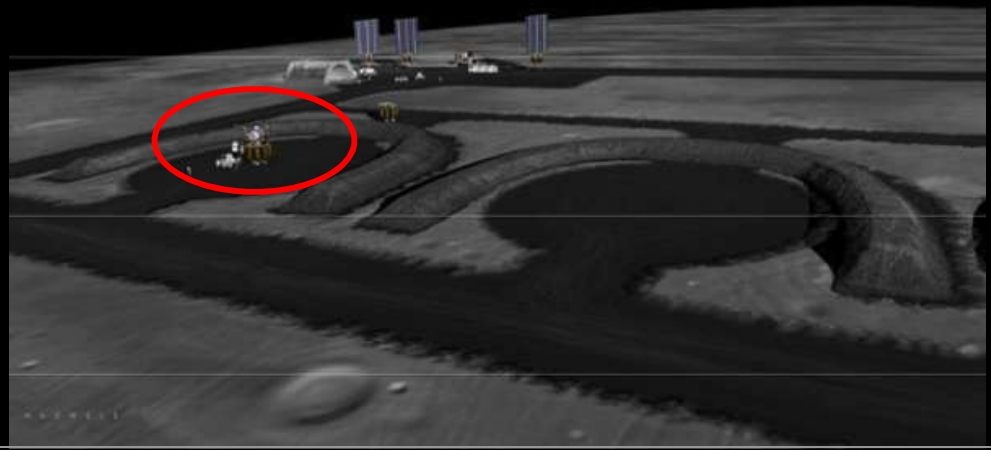
Lunar Surface Exploration Scenario



(Source: America's Spacecraft for a New Generation of Explorers, NASA, 2008)

Dust Problem

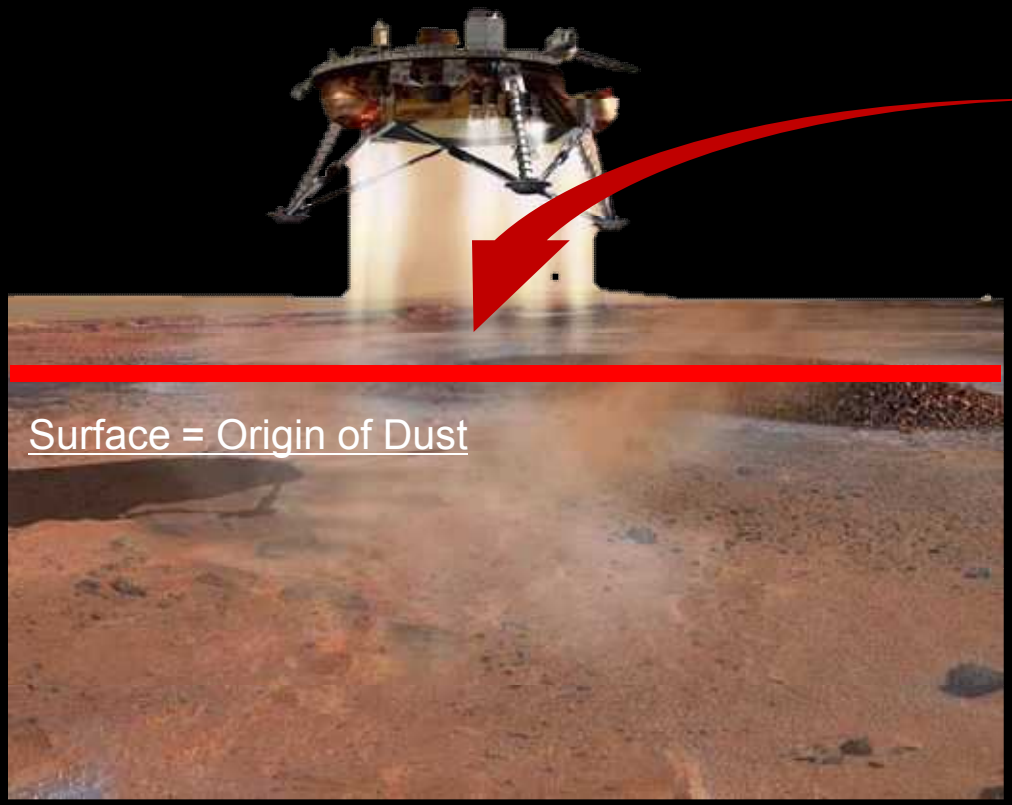


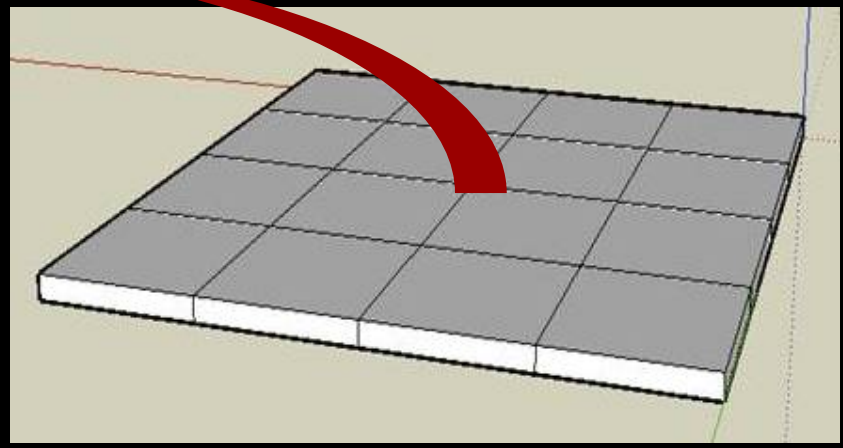


Need of Landing Pad

- **Dust Prevention Concept**

Lander = Cause of Dust





Landing Pad = Blocking

Final Goal

Method Selection

- Strength
- Safety
- Economy
- ISRU

by **Lunar Concrete**

- Ironing
- Sintering

- **Using Korea Hanyang Lunar Concrete**

- The most recent research on lunar concrete
- ISRU concept
- Proper strength

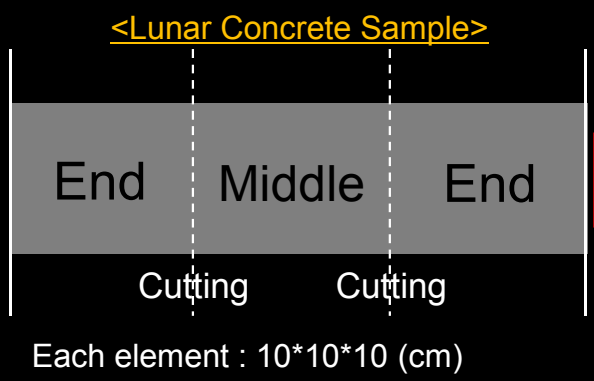
About Korea Hanyang Lunar Concrete

Compressive Strength of Lunar Concrete

- **Testing**




- **Result of the test**



Testing

Average Strength(5%) = 5.5 Mpa
Average Strength(15%) = 15.3 Mpa

(Terrestrial Concrete Strength normally 15~30 Mpa)

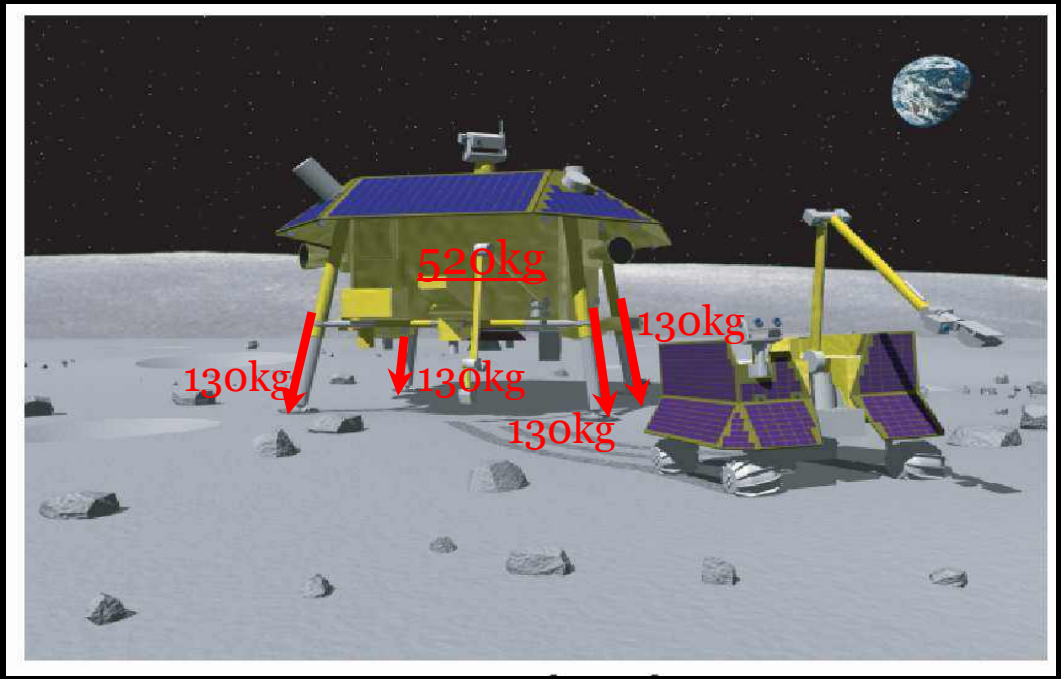
Selection of Binder Addition Rate

Assume the weight on each leg is
concentrated on 5cm diameter area

Each leg : 130kg → 21.67kg (1/6thg)
∴ P = F/A =0.1083Mpa

5% Lunar Concrete strength : 5.5Mpa(= 56.08kgf/㎠)

5.5Mpa 〉 0.1083Mpa



Characteristics of SELENE-B

(Reference: Estimate of Impact Force at Landing on Lunar Surface by SPH Method, Earth and Space, ASCE, 2008)

Using 5% binder addition rate is sufficient

Selection of Landing Pad Materials

- Glass Fiber(Chopped Strand Mat) makes possible to construct Landing Pad sequentially
- Act like terrestrial reinforcement
- Enhance tensile strength

• Other Materials

Aggregate

Cement + Water

Form oil

Preliminary Test

1st Test

※ No glass fiber
※ 10% polymer


Result

2nd Test

※ with glass fiber
※ 10% polymer

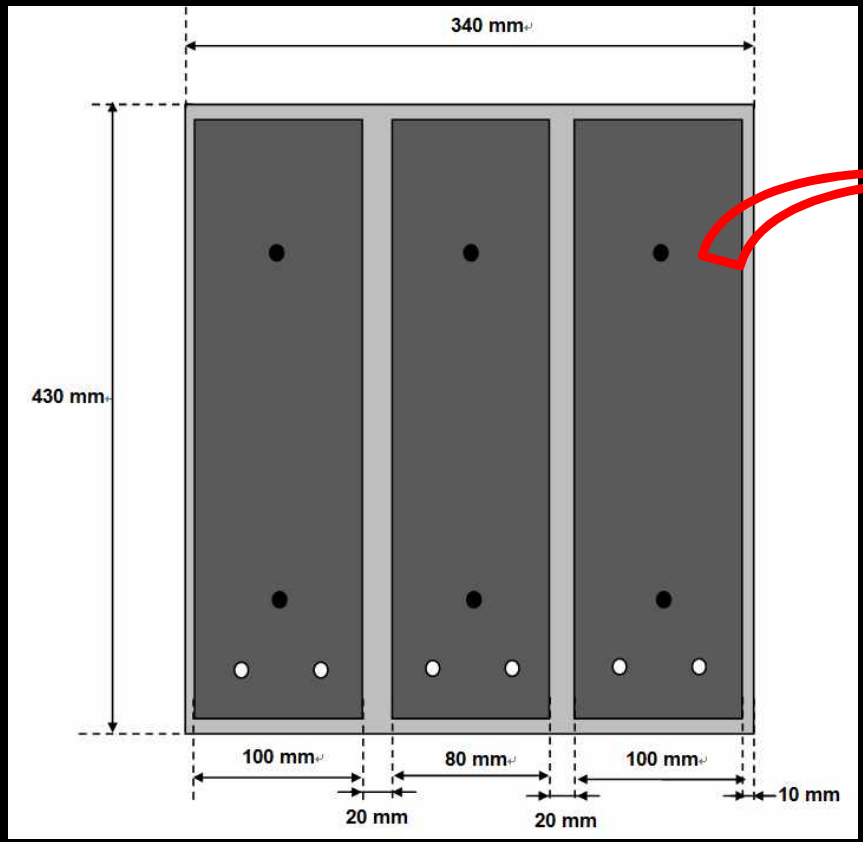

Result

Facts from preliminary test

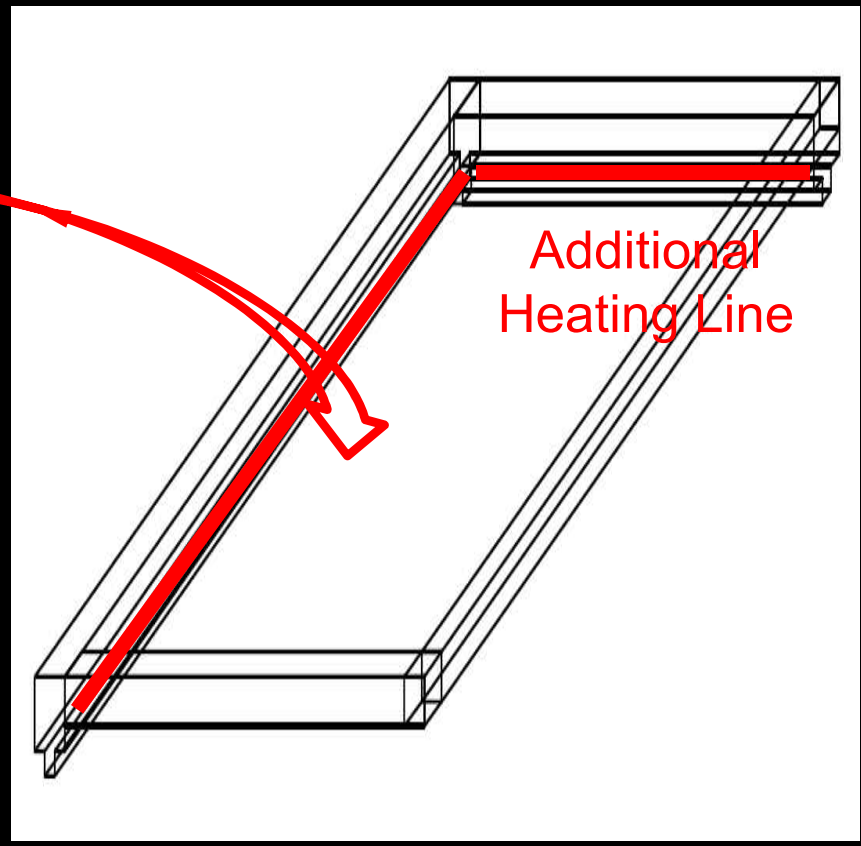
- Identified to be possible to make Landing Pad using Lunar Concrete
- Landing Pad is available to heat one way from top
- Need a formwork for Landing Pad & proper fiber to make Landing Pad
- Heat control is important (prevent burn, inner temperature is important)

Formwork Design

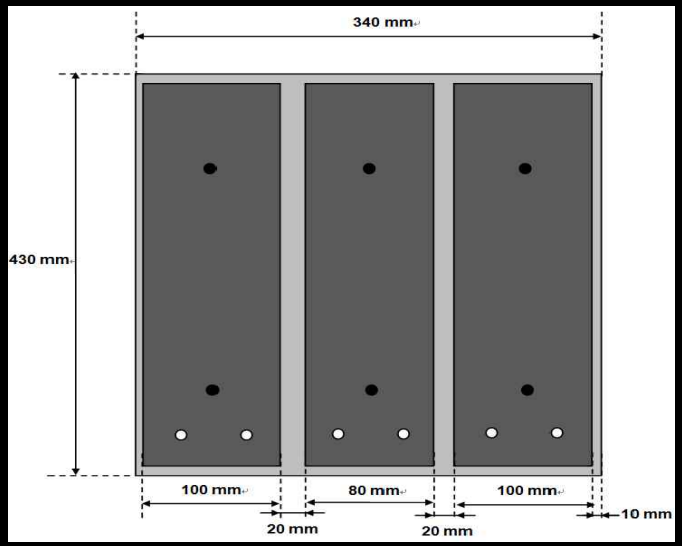
Heating Pad Form

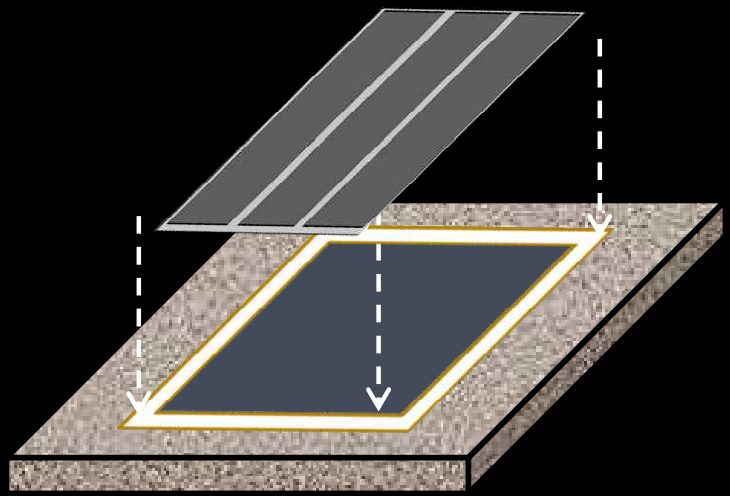


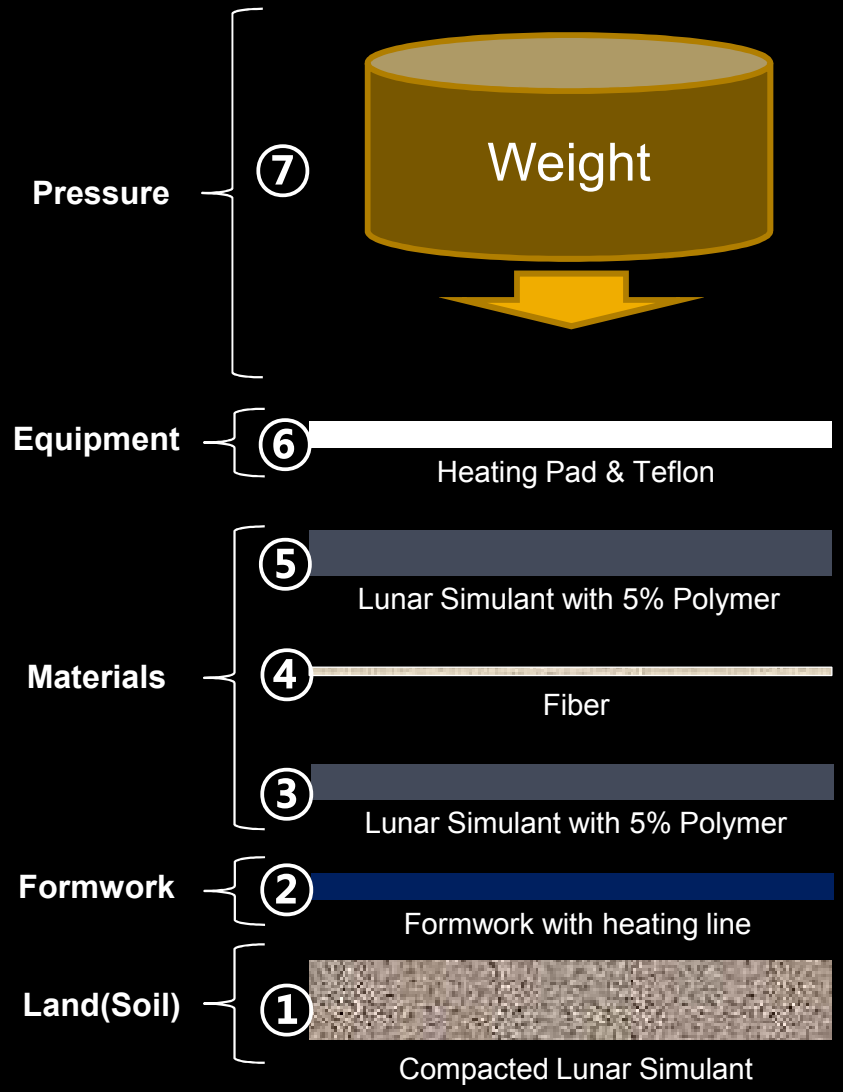
Formwork



Method of Landing Pad Construction







Preparation of Experiment

- Site preparation similar to Lunar surface

< 80kg weight >

< Compacting KOHLS-1 >

1st Experiment



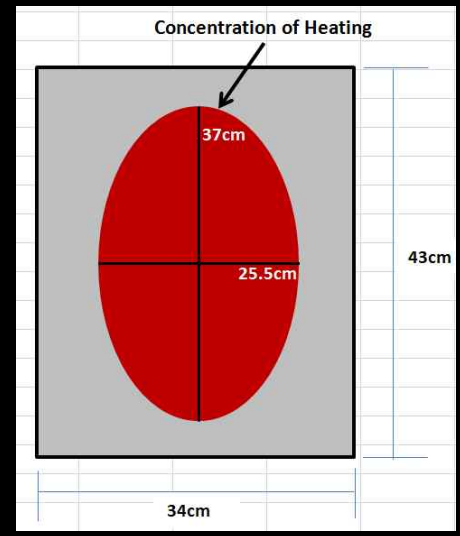




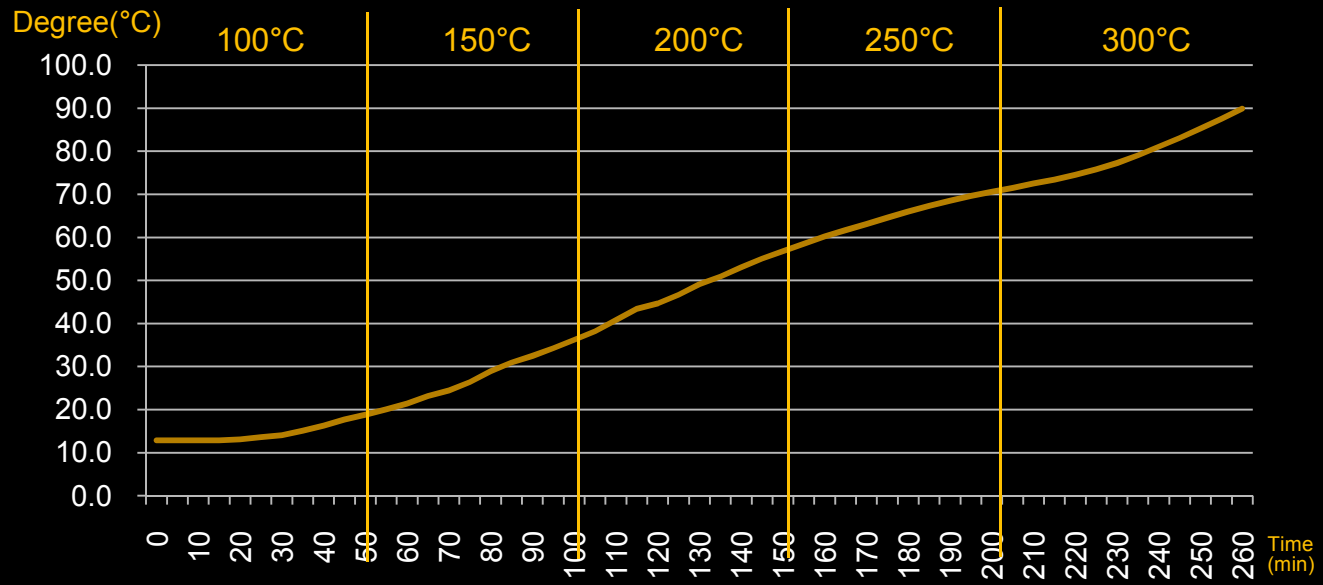
- Formwork Height = 40mm
- Mixed soil height : bottom = 20mm, middle = fiber, top = 20mm → total = 40mm
- Fiber : thinner is better, separate from the product
- Weight : Heating Pad = 18kg
- Percentage of polymer : 5%
- Compression : 5mm → total soil's height = 35mm
- Measurement of temperature : in bottom

1st Experiment Result





- Occurring heat loss from the edge→ Require additional heating line on the edge
- Inner temperature is critical ∵ Measure from bottom (most distance part from the heat)
- No shrinkage



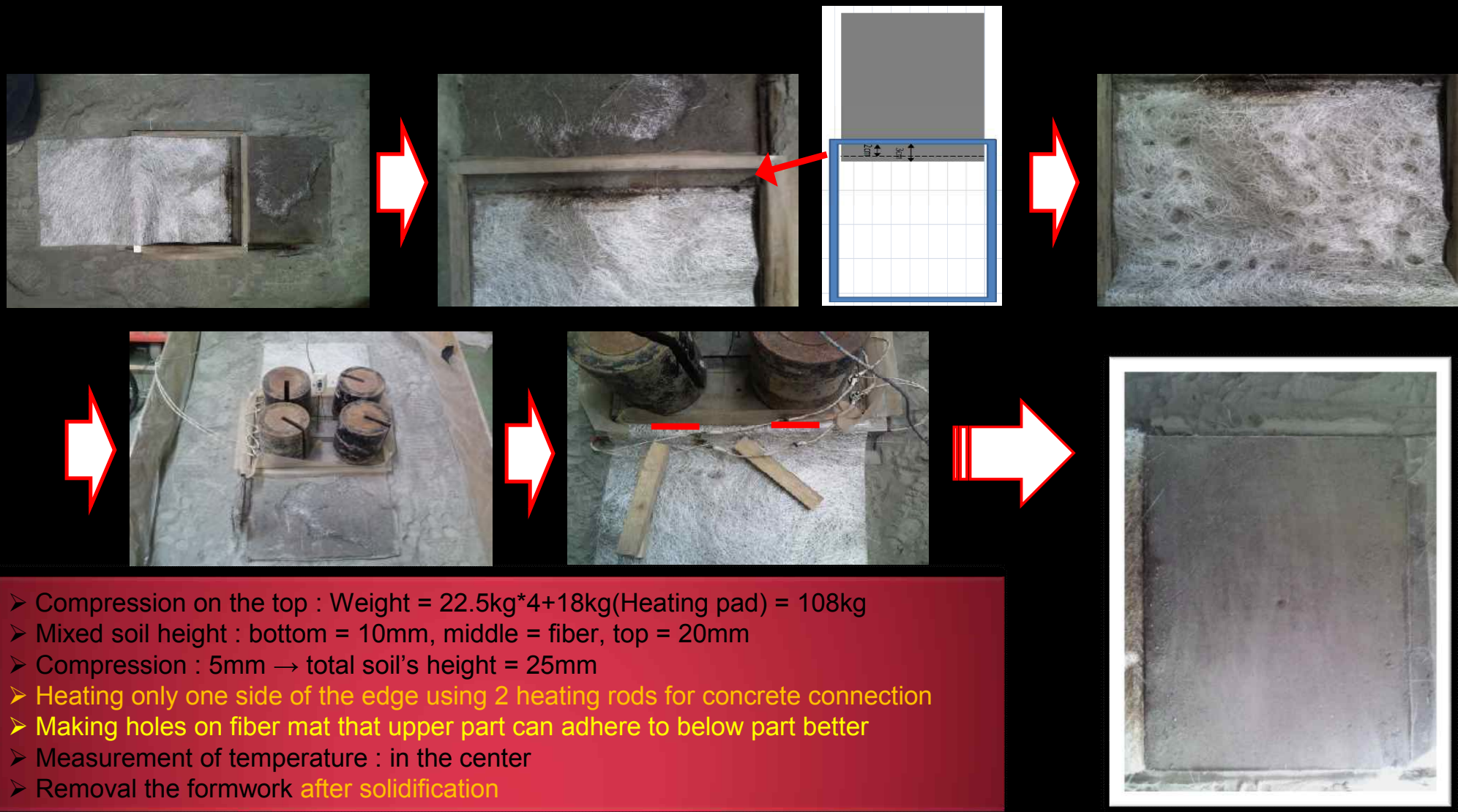
2nd Experiment - 1st Element






- Compression on the top : Weight = 22.5kg*4+18kg(Heating pad) = 108kg
- Mixed soil height : bottom = 20mm, middle = fiber, top = 15mm
- Compression : 5mm → total soil's height = 30mm
- Heating two sides of the edge part using each heating rod during whole time
- Measurement of temperature : in the center

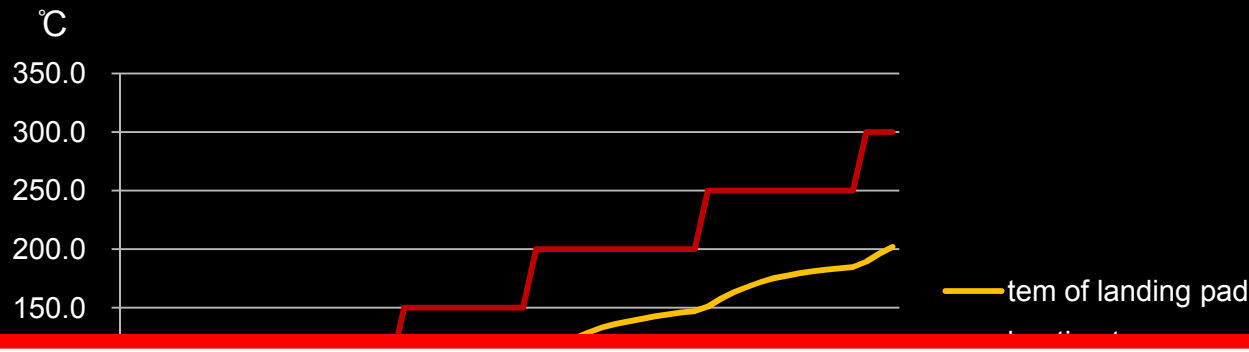
2nd Experiment – 2nd Element



- Compression on the top : Weight = 22.5kg*4+18kg(Heating pad) = 108kg
- Mixed soil height : bottom = 10mm, middle = fiber, top = 20mm
- Compression : 5mm → total soil's height = 25mm
- Heating only one side of the edge using 2 heating rods for concrete connection
- Making holes on fiber mat that upper part can adhere to below part better
- Measurement of temperature : in the center
- Removal the formwork after solidification

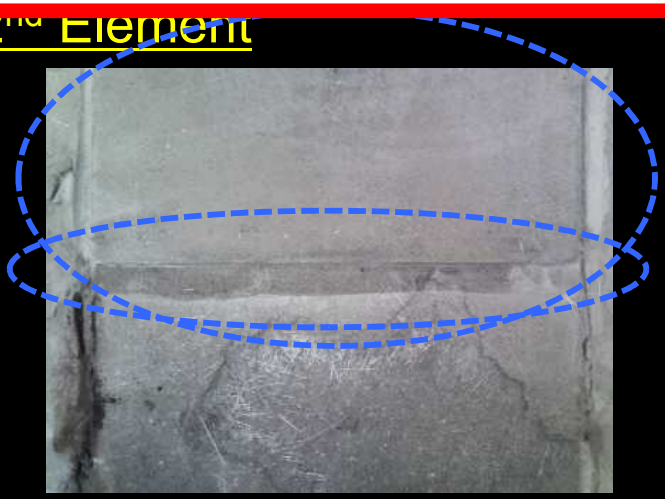
2nd Experiment Result

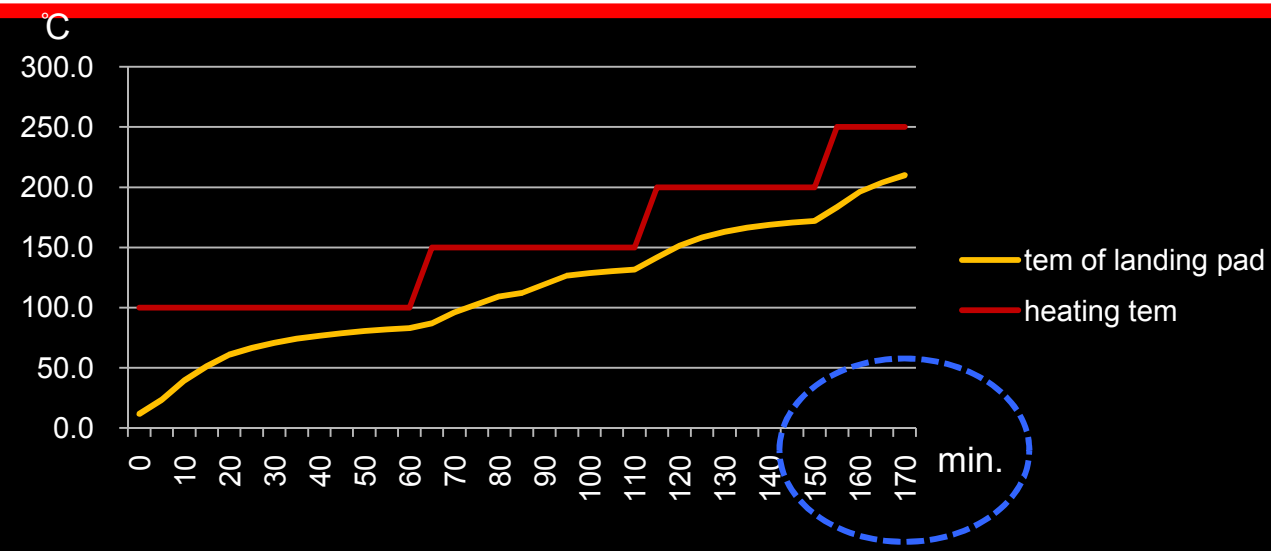
1st Element



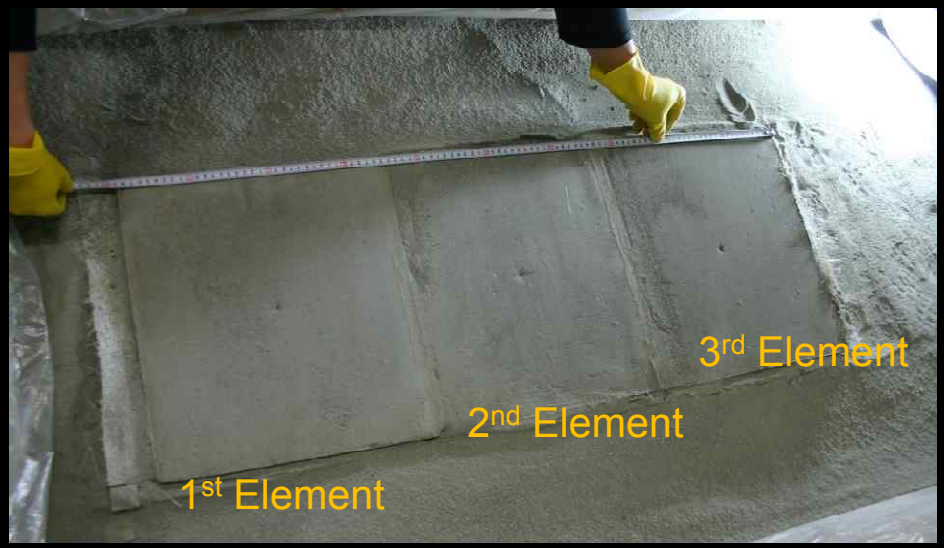
2nd Element is Better

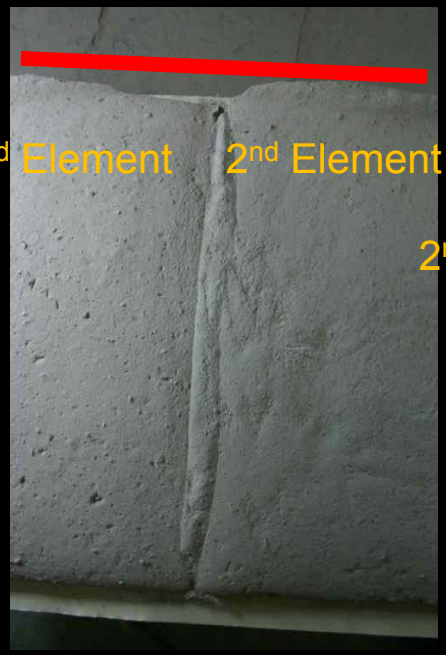
2nd Element



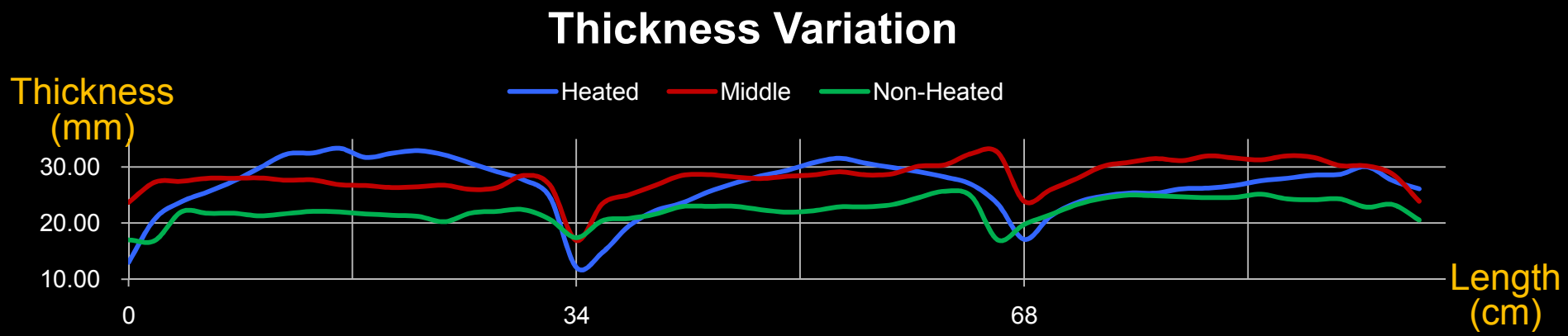


3rd Experiment Result – 3rd element





3rd Experiment Result

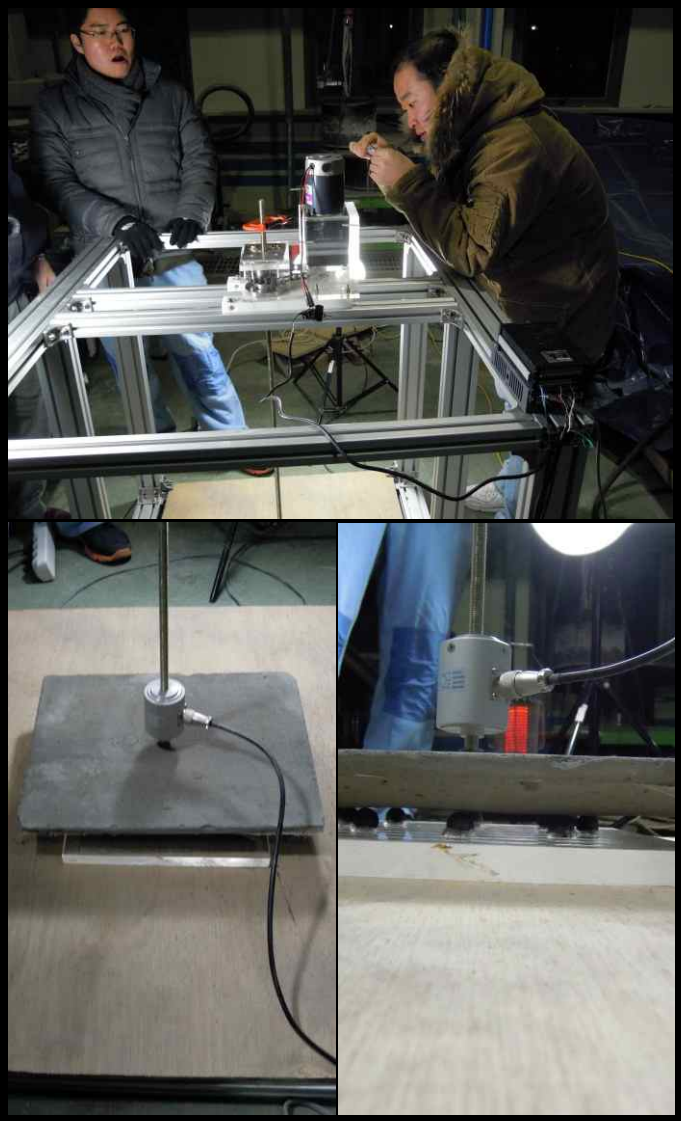


Compressive Strength of the Landing Pad

Compressive Strength

- Contact area diameter is 13.5cm (Area = 143.07㎠)
- Weight = 22.5*4=90kg
- Compressive Stress=90kg*9.8/143.07㎠= 0.062 MPa
- Landing pad was not destroyed

Max. Compressive Strength of the Landing Pad



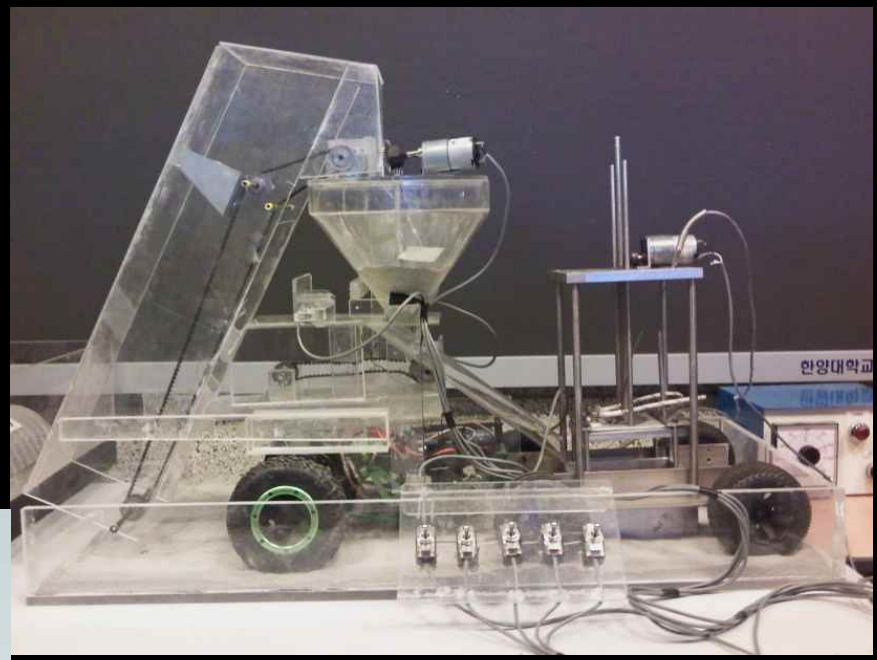
Max. Compressive Strength

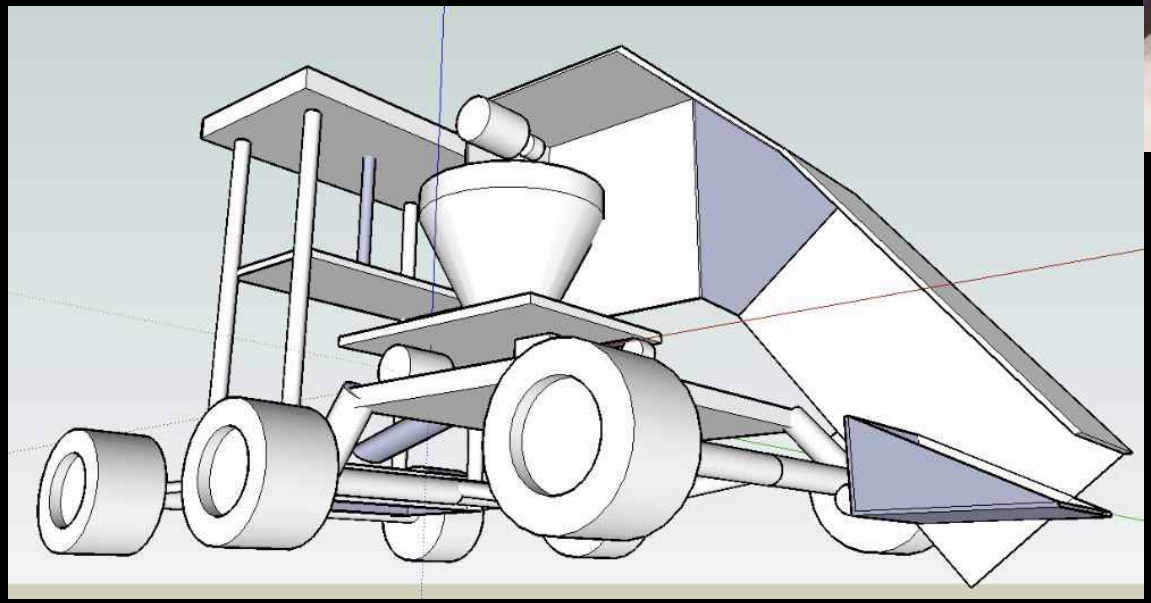
- Contact Area 2.54㎠ (Tip connect to Load cell)
- Stress before destroyed =71.5kg/2.54㎠= 2.753MPa
- Landing Pad was destroyed
- Max. Strength is 2.7 MPa

2.7Mpa 〉 0.1083Mpa (Case of SELENE-B)

Result is successful

Concept of Lunar Landing Pad Construction Rover





Concept of Lunar Landing Pad Construction Rover

Future Plan

- Develop effective and automated heating system
- Need to modify edge heater for a even surface
- What would be an alternative for glass fiber and polymer powder on Moon
- Challenge <5% Lunar Concrete Landing Pad
- Develop Lunar Concrete Landing Pad construction module

THANK YOU