



T I F

TELECOMMUNICATIONS
INDUSTRY FOUNDATION

**Friction Coefficient
Testing for Rooftop
Ballast Mounts**

Testing completed by:
Perfect Vision and Sabre Industries

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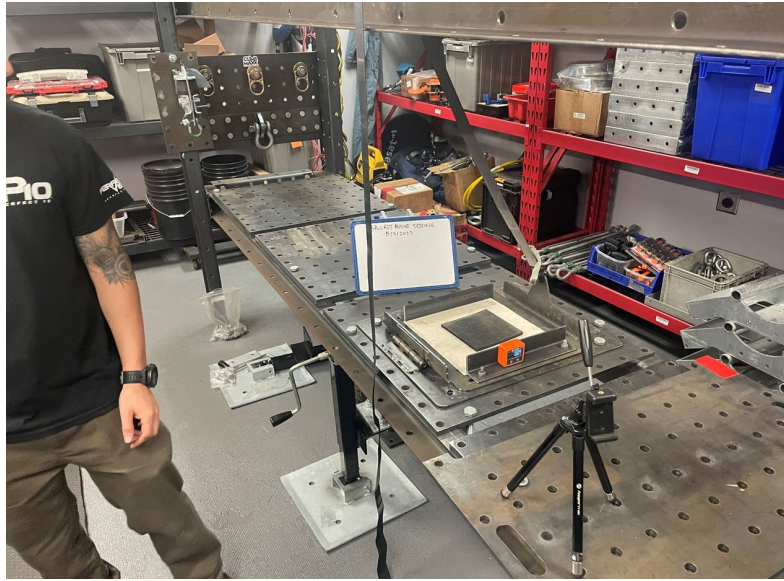
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Participation



- Testing occurred at Manufacturer locations
- Roofing material samples supplied by Nohava Construction and Congruex (True North)

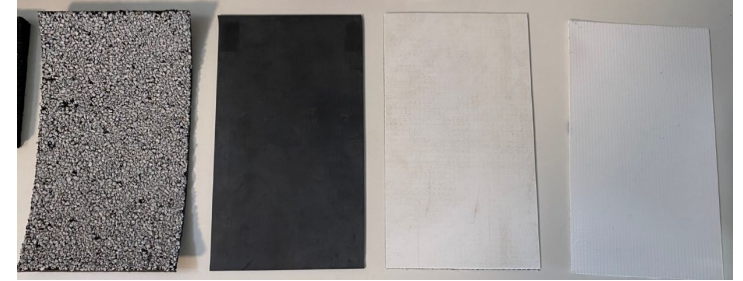
Sabre Industries™



CONGRUEX
WIRELESS SOLUTIONS

Materials Utilized in Testing

- Four (4) typical roof membranes:
 - TPO
 - PVC
 - EPDM
 - Asphalt



- Two (2) different types of typical rubber mats that are recommended to be used under rooftop ballast mounts:



- Galvanized steel parts:
 - 3.5” diameter x 1/4” thick plate (shiny sample)
 - 1.75” OD x 1/8” thick washer (one shiny, one dull)
 - 5 9/16” x 5 9/16” x 3/8” thick plate (dull sample)



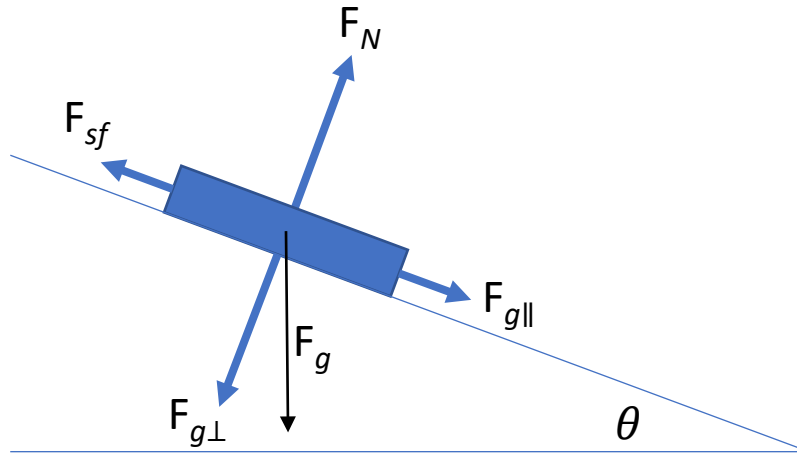
Method of Testing

- Ten (12) Test Configurations using Two (2) Different Rubber Mats, Four (4) Different Roofing Membranes plus Two (2) Galvanized Steel samples, only shiny and one dull.

Test Configuration	Material 1	Material 2	Test Configuration	Material 1	Material 2
1	Rubber Mat 1	TPO	6	Rubber Mat 2	TPO
2	Rubber Mat 1	PVC	7	Rubber Mat 2	PVC
3	Rubber Mat 1	EPDM	8	Rubber Mat 2	EPDM
4	Rubber Mat 1	Asphalt	9	Rubber Mat 2	Asphalt
5	Rubber Mat 1	Shiny Galv Steel	10	Rubber Mat 2	Shiny Galv Steel
6	Rubber Mat 1	Dull Galv Steel	12	Rubber Mat 2	Dull Galv Steel

- Testing committee had multiple meetings to discuss materials and then selected these configurations to represent most common scenarios.
- Rubber mats from different manufacturers used for representative purposes, consistency and validation.

Method of Testing

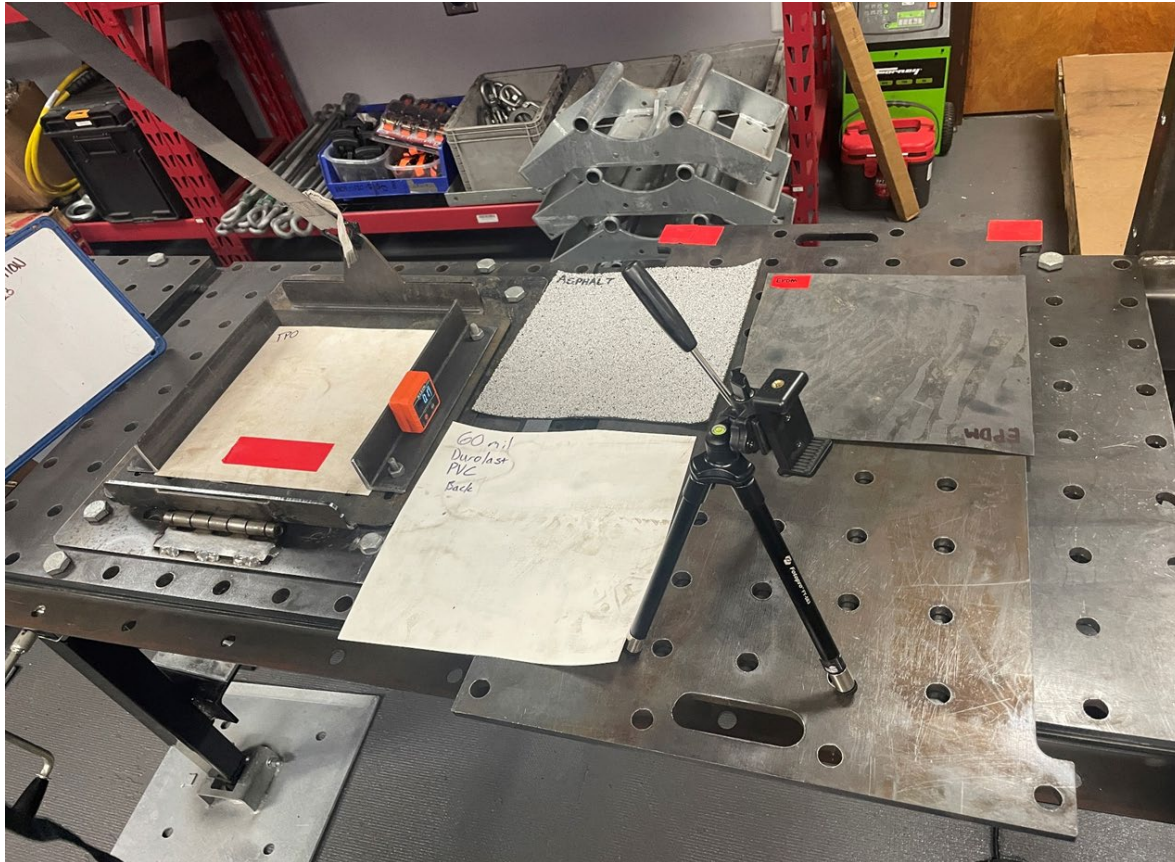


Solving for $\sum F_{\parallel}$ and $\sum F_{\perp}$

$$\mu_s = \tan \theta$$

- Minimum of three (3) tests for each configuration.
- Eight (8) tests for at least one configuration to test directionality - Two (2) tests for each sample orientation – 0, 90, 180, and 270 degrees.
- Angle when observable movement ($\sim 1/8''$) occurred was recorded for each test.
- Angles used to calculate friction coefficient.
- Testing occurred at three (3) separate locations by qualified personnel.
- Test results aggregated by third party.

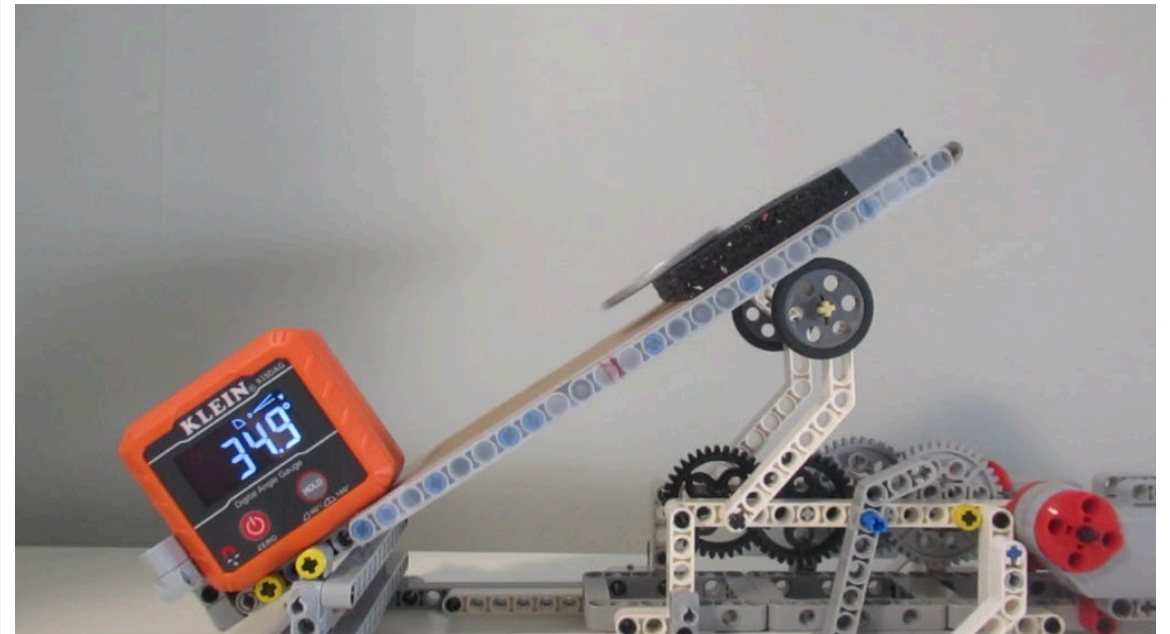
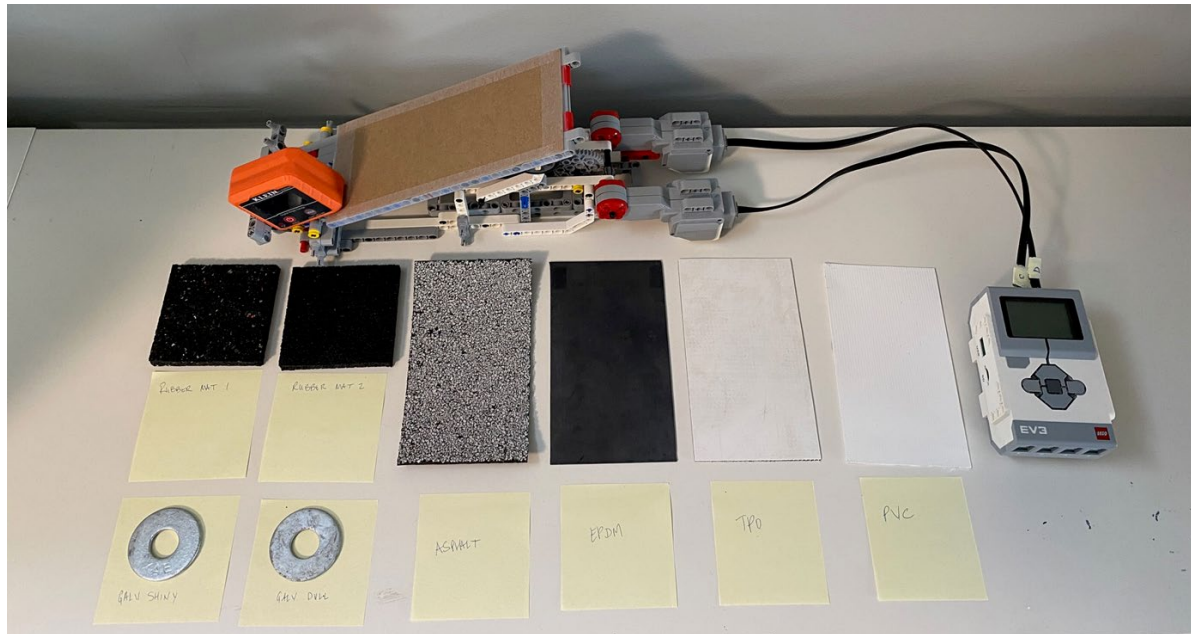
Photos of test setups



Photos of test setups



Photos of test setups



Photos of test setups



Observations and Summary

- Some material combinations had a gradual slip and others had more of an immediate slip at the recorded angle.
- Averages are recommended values to use for analysis or design purposes.
- Galvanized steel results reported on newly galvanized (shiny) and weathered (dull) parts.

TIF summary of friction coefficient testing

Material 1	Material 2	Number of Tests	Average Coefficient
Rubber Mat	TPO Membrane	38	0.72
Rubber Mat	PVC Membrane	28	0.75
Rubber Mat	EPDM Membrane	28	0.76
Rubber Mat	Asphalt Membrane	28	1.02
Rubber Mat	Galvanized Steel (shiny)	36	0.63
Rubber Mat	Galvanized Steel (dull)	38	0.73

TIF recommended friction coefficients

Material 1	Material 2	Number of Tests	Average Coefficient
Rubber Mat	TPO/PVC/EPDM Membrane	94	0.74
Rubber Mat	Asphalt Membrane	28	1.02
Rubber Mat	Galvanized Steel (shiny)	36	0.63
Rubber Mat	Galvanized Steel (dull)	38	0.73



Thank You

The Telecommunications Industry Foundation would once again like to thank the following participants who supported their respective employee's participation in this testing event. The participants took time out of their busy schedules to work in conjunction with competitors in order to move our industry forward. The observations and empirical data gathered from this event will serve to educate many.

- Perfect Vision
- Sabre
- TES / Congruex
- Colliers