REBEL® Concrete Sensor Test Results Overview

Summer 2023 – Fall 2024

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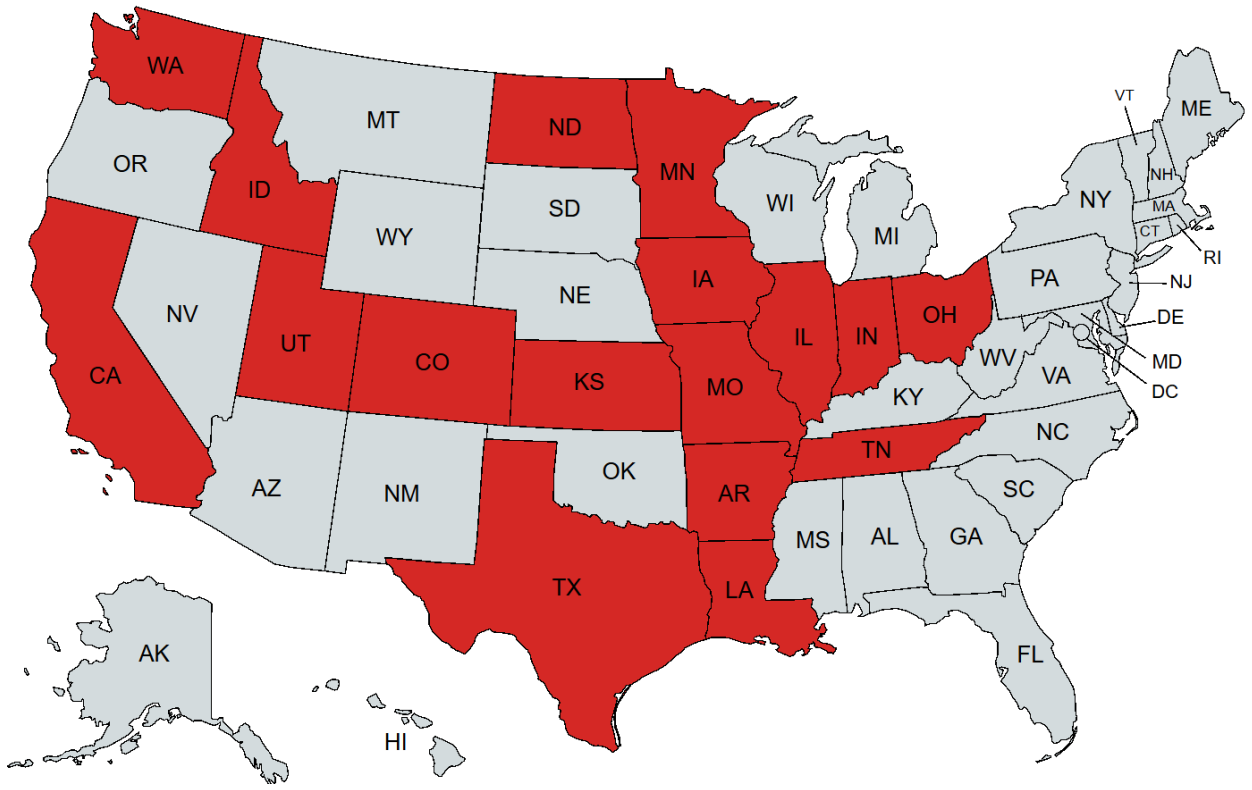
Contents

Trial Summary

- Wavelogix conducted testing in 17 states throughout July 2023 to October 2024.
- Over 200 REBEL Sensors were deployed across more than 60 projects.
- Applications included pavement, bridge deck, and road repair.
- This report highlights several projects from around the country.



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Mix Designs

- A wide variety of mix designs were covered in the trials:
  - Water-to-cement ratio range of 0.32 to 0.55.
  - Cement amount ranges from 360 lbs/CY to 800 lbs/CY .
  - Cement replacement up to 35% with Supplementary Cementicious Materials (SCM), such as slag, fly ash, silica fume, and natural pozzolan.
  - Fine-to-Coarse aggregate ratio ranges from 0.60 to 0.79.
  - Type IL cement used for all DOT projects.

Testing Procedure

- Each project used 2 or more sensors for corresponding group of cylinders.
- No calibration curve for specific mix designs was developed prior to the project.
- Three 4x8 cylinders were made for each testing age (1, 3, 7,14, 28-day).
- Some projects had core samples taken at 28 days to validate REBEL sensors performance as a QA tool.
- The variabilities of the cylinders and sensors were calculated respectively at each testing age, as well as the difference of the results between the two testing methods.

Key Takeaways

- The REBEL Sensor provided comparable compressive strength to cylinders, with an average ~16% difference at the 28-day.
  - For mixes with a w/c ratio of 0.35-0.55, REBEL sensor had an 8% difference from the cylinder results.

- Compared to cylinder data, REBEL sensor readings were significantly closer to the cored samples at the 28-day.
  - Sensors averaged 428 psi difference in compressive strength compared to cores, while cylinders averaged 774 psi difference compared to cores

- Cylinder testing results had higher variability than that of REBEL sensor reading at each testing age.
  - The average variability of REBEL sensors at the same testing age is ~63 psi; while the average variability of cylinder is ~130 psi.

Data Overview

Data Summary – All Testing Ages

- The following tables summarize the difference between the REBEL Sensor and cylinder testing at various testing ages.

- Across all ages, sensors were within ~570 psi of cylinder measurements, and within ~491 psi for mixes with w/c ratio between 0.35-0.55.

REBEL Sensor vs. Cylinders All Ages Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons*
All DOT Projects	569.0	17.3	363
INDOT Projects	483.8	12.3	119
W/C 0.35-0.55 Projects	491.0	15.6	92

* the number of comparisons is the number of “sensor measurement vs cylinder break” pairs

Data Summary at 1-day

- For 1-Day compressive strength, sensor measurements were within ~507 psi of cylinder breaks, and within ~421 psi for mixes with w/c ratio between 0.35-0.55

REBEL Sensor vs. Cylinders 1-Day Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons*
All DOT Projects	506.5	23.5	79
INDOT Projects	589.9	21.3	18
W/C 0.35-0.55 Projects	421.4	21.2	10

* the number of comparisons is the number of “sensor measurement vs cylinder break” pairs

Data Summary at 3-day

- For 3-Day compressive strength, sensor measurements were within ~662 psi of cylinder breaks, and within ~455 psi for mixes with w/c ratio between 0.35-0.55

REBEL Sensor vs. Cylinders 3-Day Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons*
All DOT Projects	661.8	18.5	102
INDOT Projects	453.0	11.3	24
W/C 0.35-0.55 Projects	455.3	18.1	14

* the number of comparisons is the number of “sensor measurement vs cylinder break” pairs

Data Summary at 7-day

- For 7-Day compressive strength, sensor measurements were within ~536 psi of cylinder breaks, and within ~501 psi for mixes with w/c ratio between 0.35-0.55

REBEL Sensor vs. Cylinders 7-Day Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons*
All DOT Projects	536.0	14.0	94
INDOT Projects	452.4	10.3	39
W/C 0.35-0.55 Projects	501.4	13.4	32

* the number of comparisons is the number of “sensor measurement vs cylinder break” pairs

Data Summary at 14-day

- For 14-Day compressive strength, sensor measurements were within ~391 psi of cylinder breaks, and within ~257 psi for mixes with w/c ratio between 0.35-0.55.

REBEL Sensor vs. Cylinders 14-Day Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons*
All DOT Projects	391.4	9.0	25
INDOT Projects	177.7	3.6	14
W/C 0.35-0.55 Projects	257.3	5.1	6

* the number of comparisons is the number of "sensor measurement vs cylinder break" pairs

Data Summary at 28-day

- For 28-Day compressive strength, sensor measurements were within ~798 psi of cylinder breaks, and within ~427 psi for mixes with w/c ratio between 0.35-0.55.

REBEL Sensor vs. Cylinders 28-Day Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons*
All DOT Projects	797.7	16.3	75
INDOT Projects	449.3	8.0	22
W/C 0.35-0.55 Projects	426.5	7.9	20

* the number of comparisons is the number of “sensor measurement vs cylinder break” pairs

Data Summary – Comparison with Core Drill

- For 28-Day compressive strength, sensor measurements were within ~429 psi of cores drills, while sensors were within ~774 psi of core drills.

REBEL Sensor vs. Core Drill Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons*
All DOT Projects	428.7	8.7	15

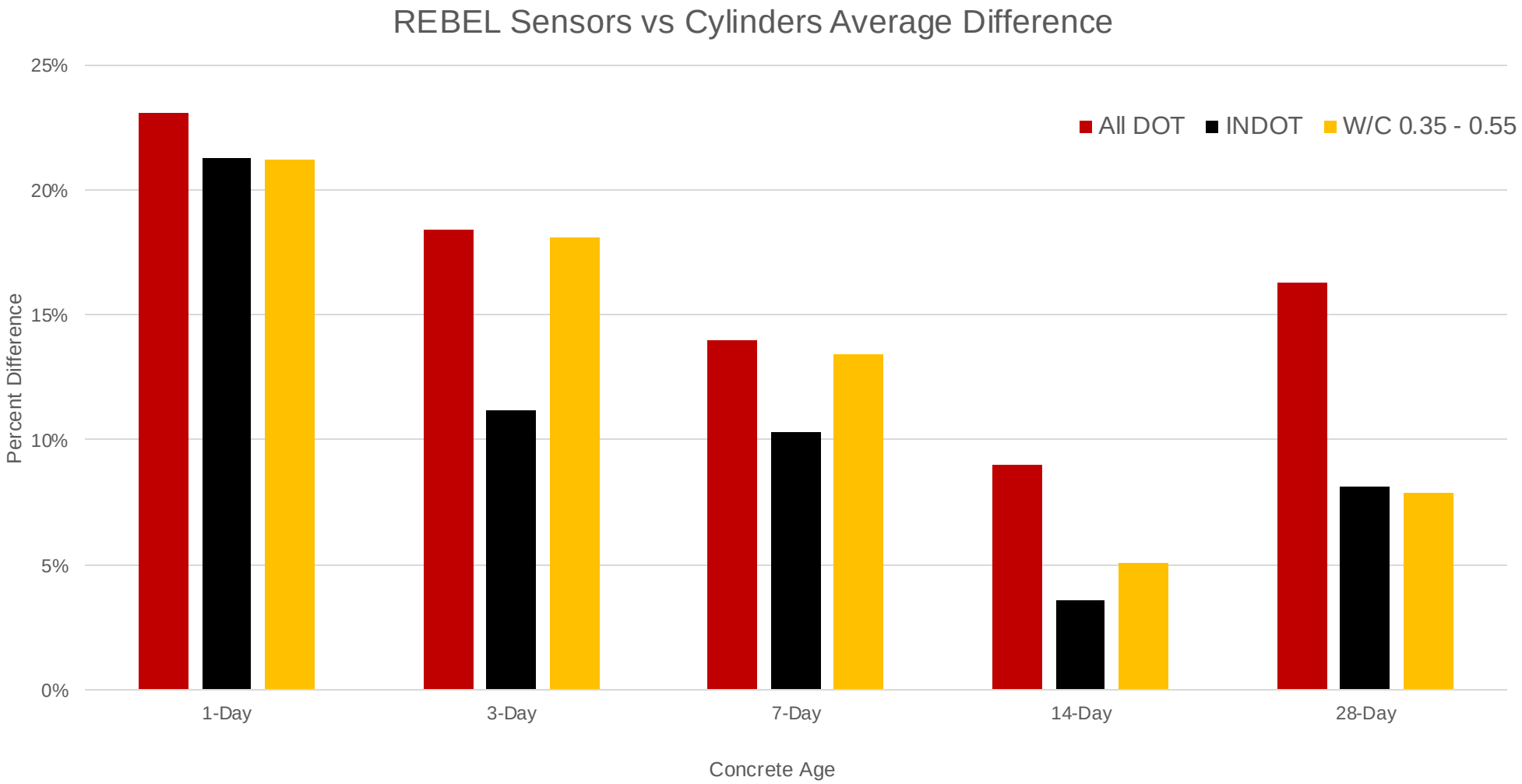
* the number of comparisons is the number of "sensor measurement vs core break" pairs

Cylinder Sample vs. Core Drill Compressive Strength

	Difference (psi)	Percent Difference (%)	# Comparisons**
All DOT Projects	774.0	15.6	15

** the number of comparisons is the number of "cylinder break vs core break" pairs

REBEL vs Cylinder Results



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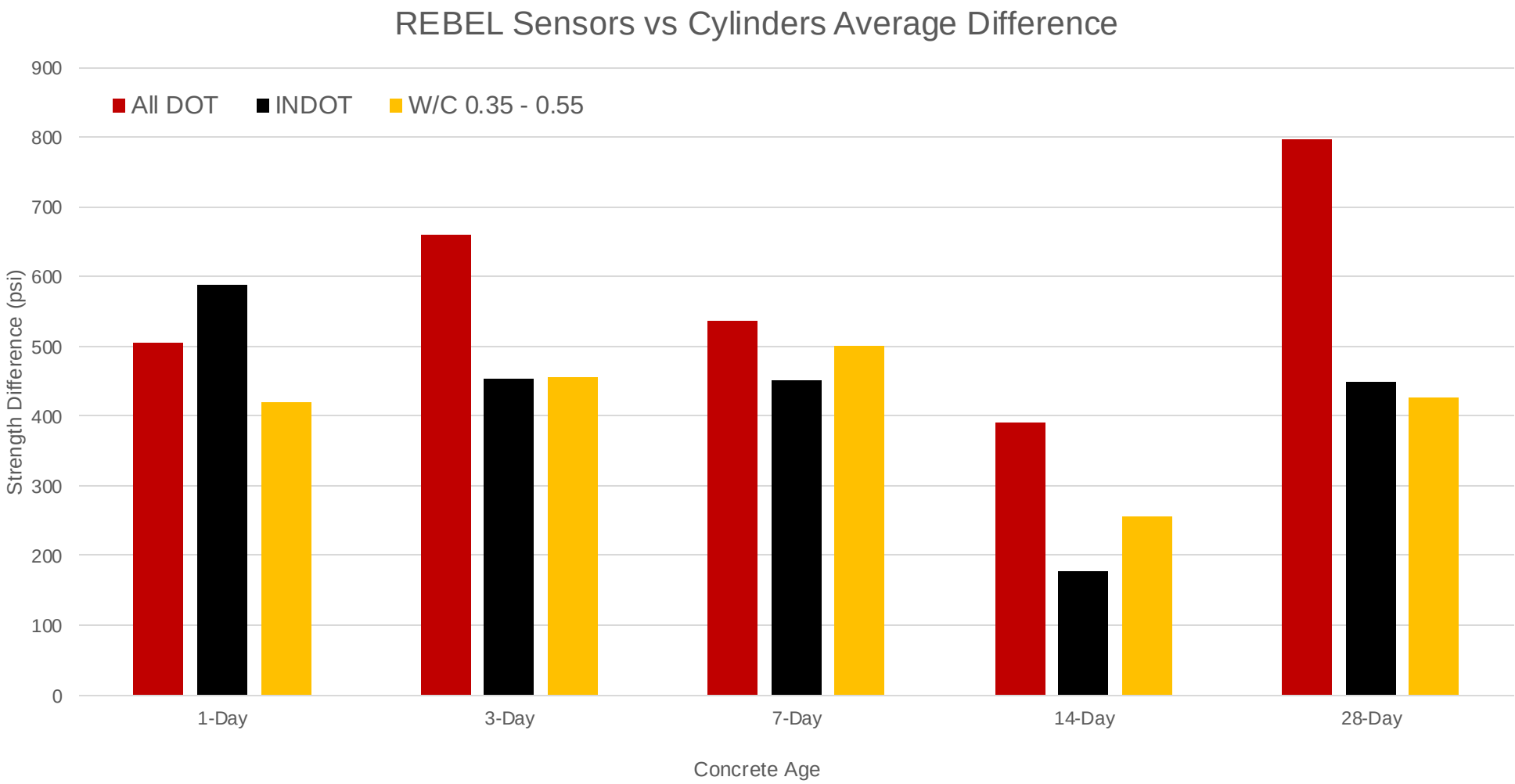
REBEL vs Cylinder Results



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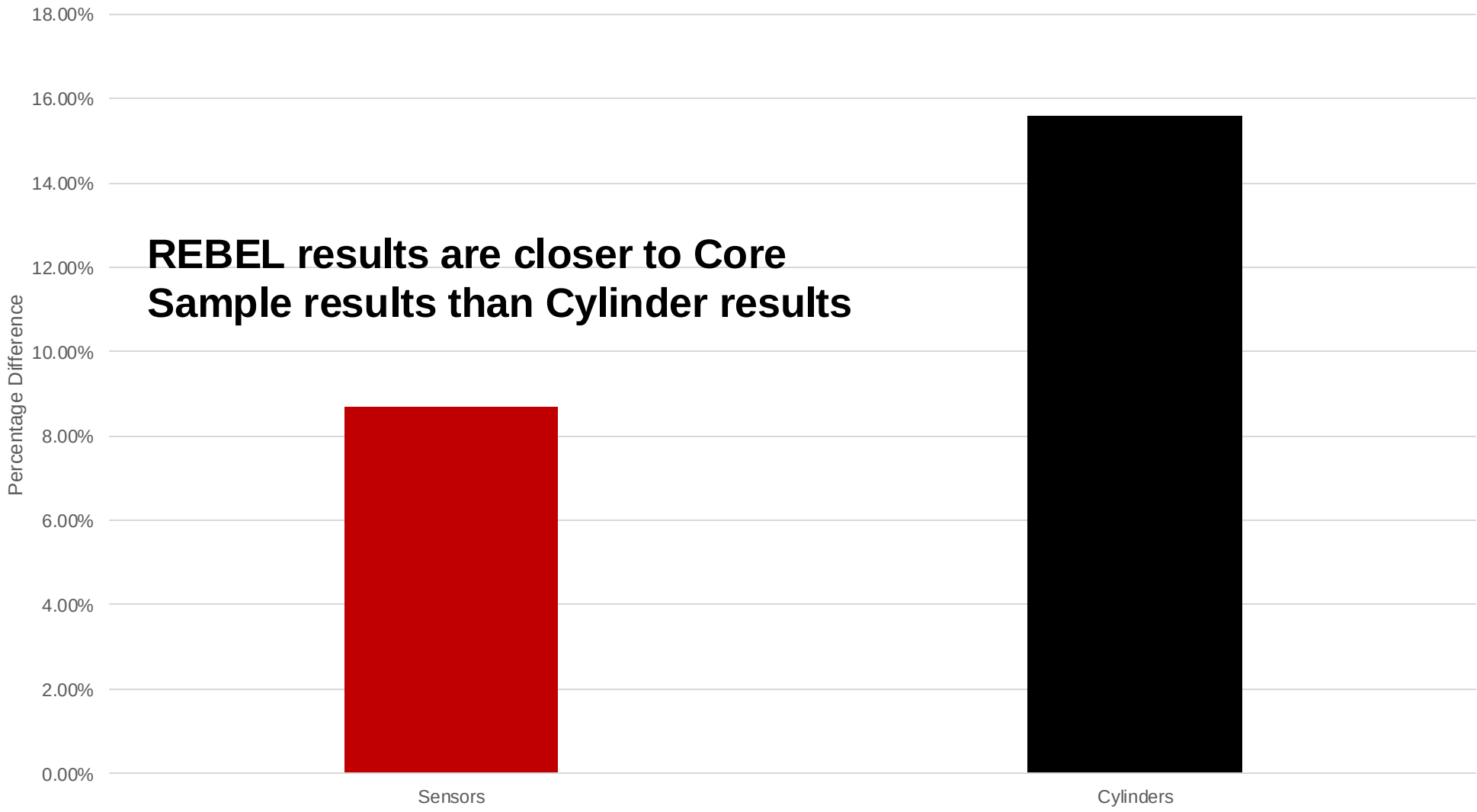
REBEL vs Core and Cylinder vs Core



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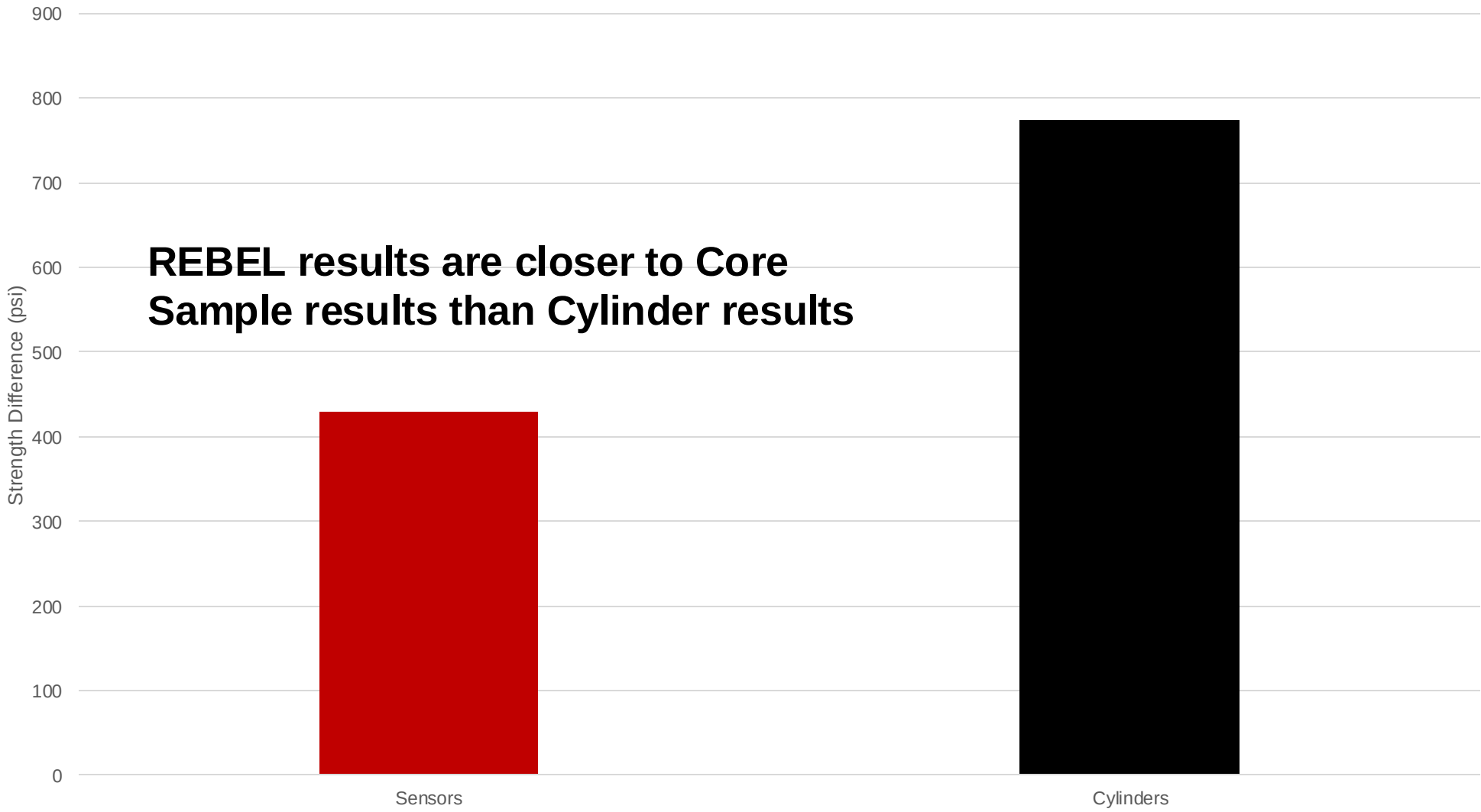
REBEL vs Core and Cylinder vs Core



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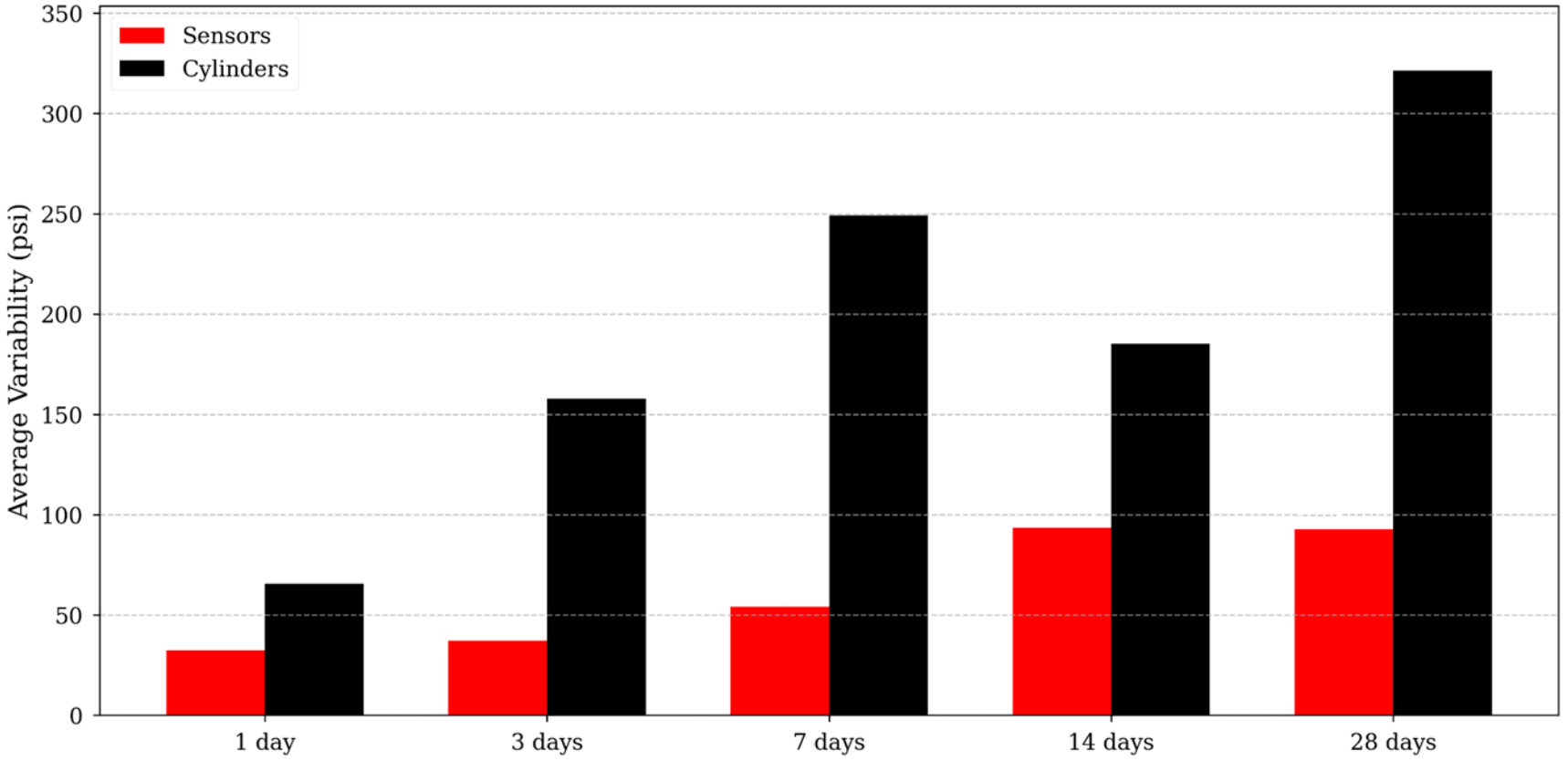
Consistency of REBEL vs Cylinder



- The average variability was calculated for projects with multiple groups of sensors and cylinders using the same mix design

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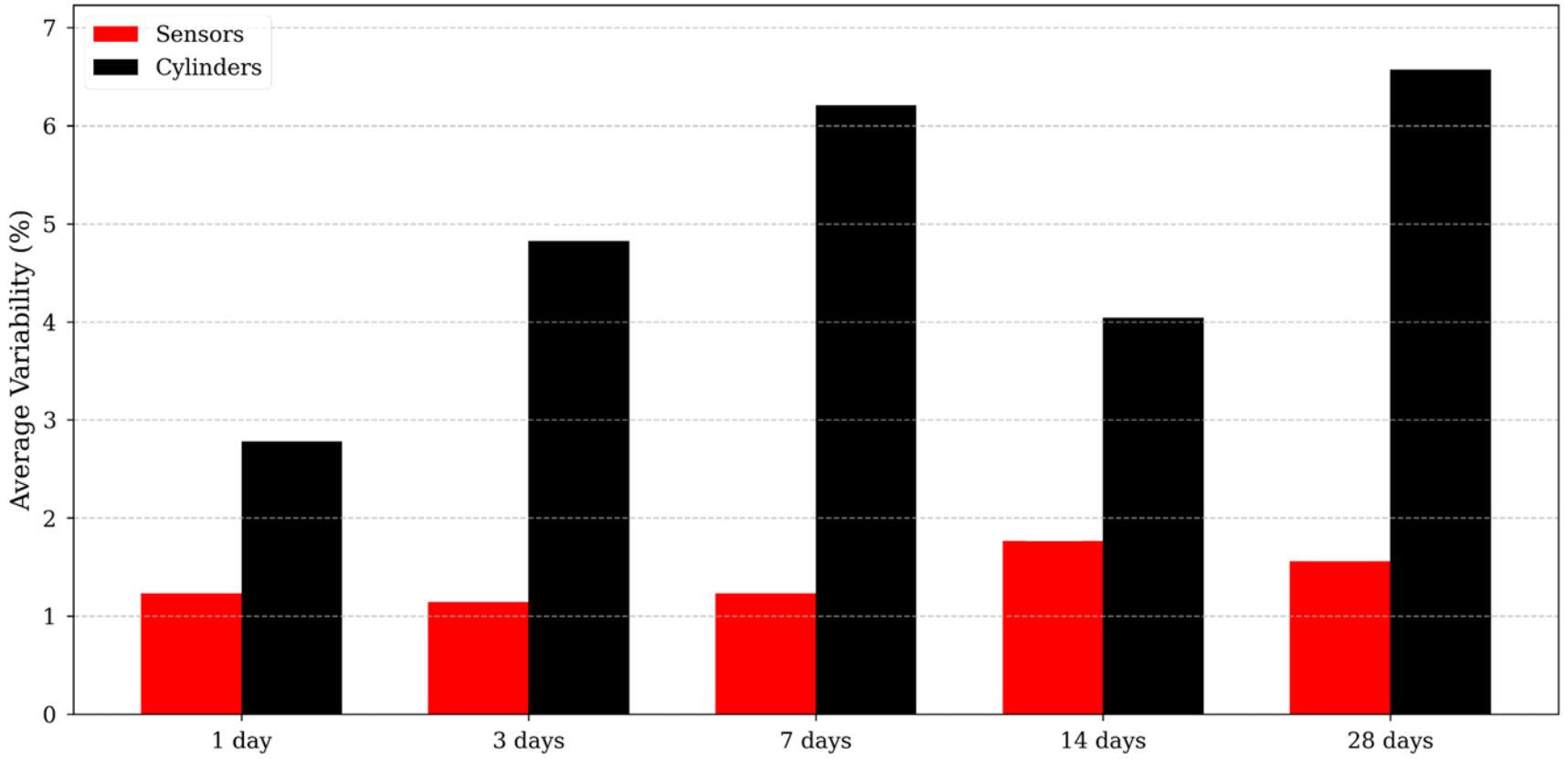
Consistency of REBEL vs Cylinder



- The average variability was calculated for projects with multiple groups of sensors and cylinders using the same mix design

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Road & Bridge Projects

INDOT I-69 Paving

Date	7-25-2023
Location	Indianapolis, IN
Pavement Thickness	11”
Rebar	#6 (0.75”)

Ingredients	**Amount (/yd^3)**
Fine Agg.	1268 lbs.
Coarse Agg.	1830 lbs.
Cement	425 lbs.
Slag	145 lbs.
Water	233.7 lbs.
W/C Ratio	0.410

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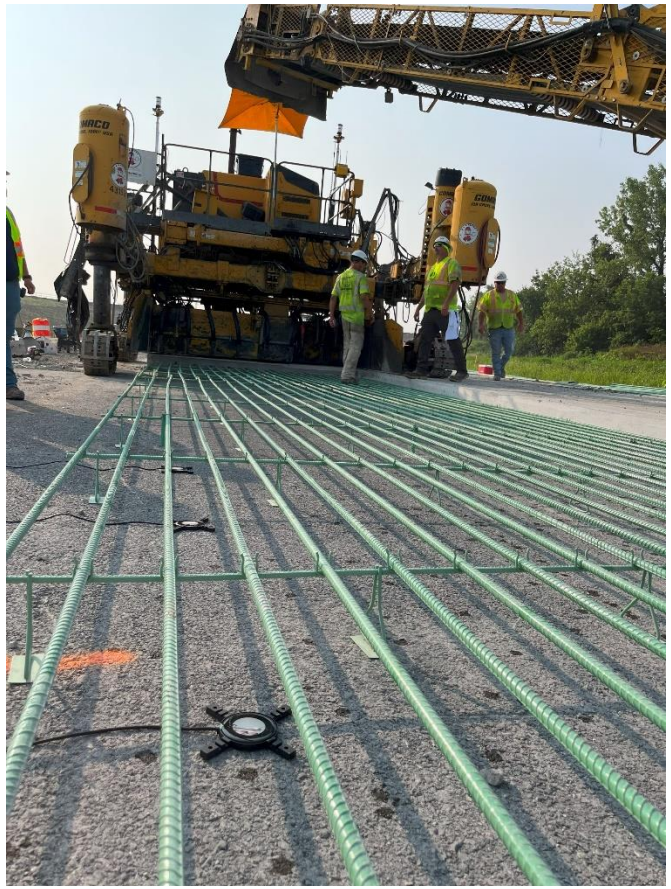
INDOT I-69 Paving



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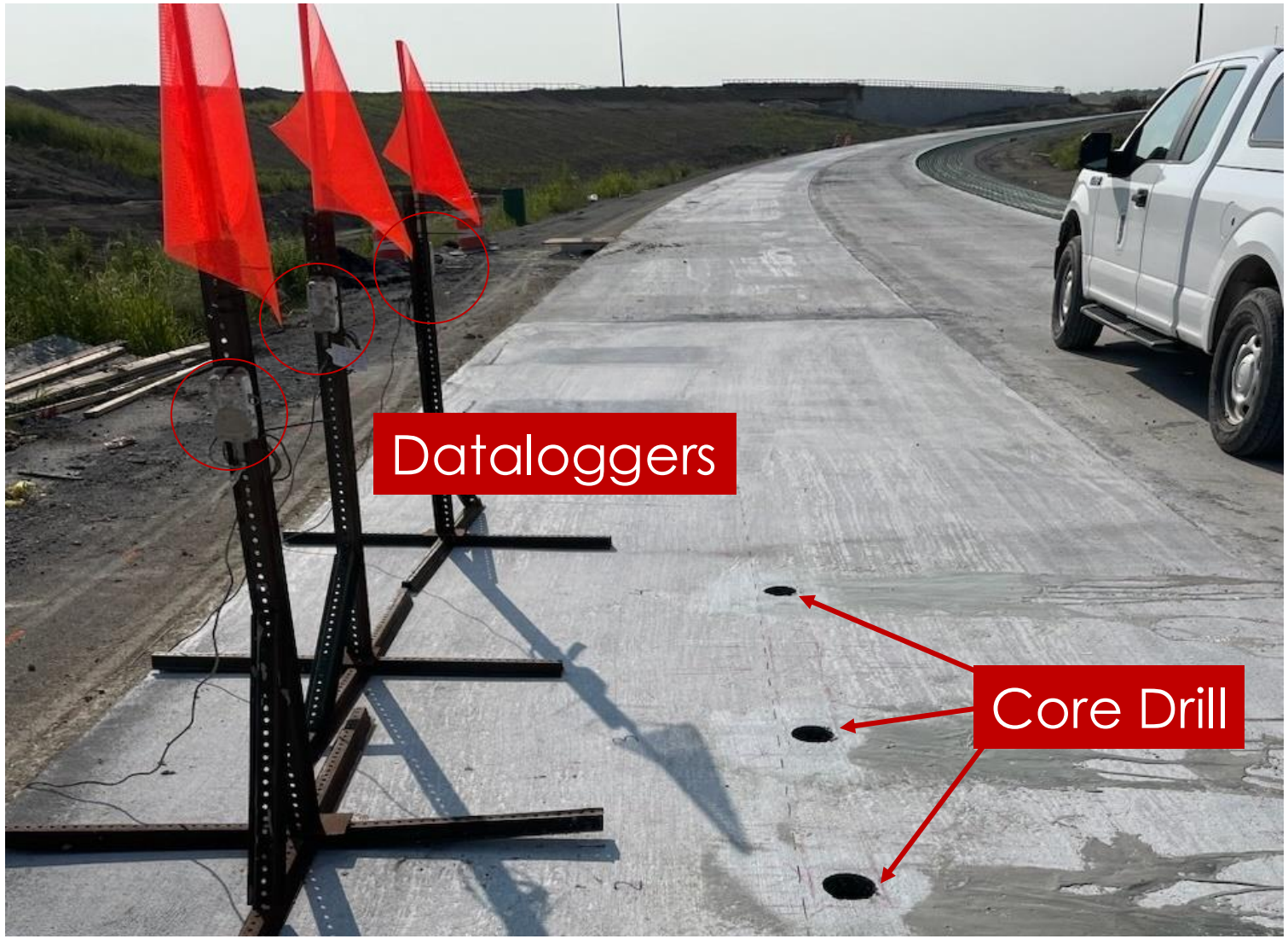
INDOT I-69 Paving



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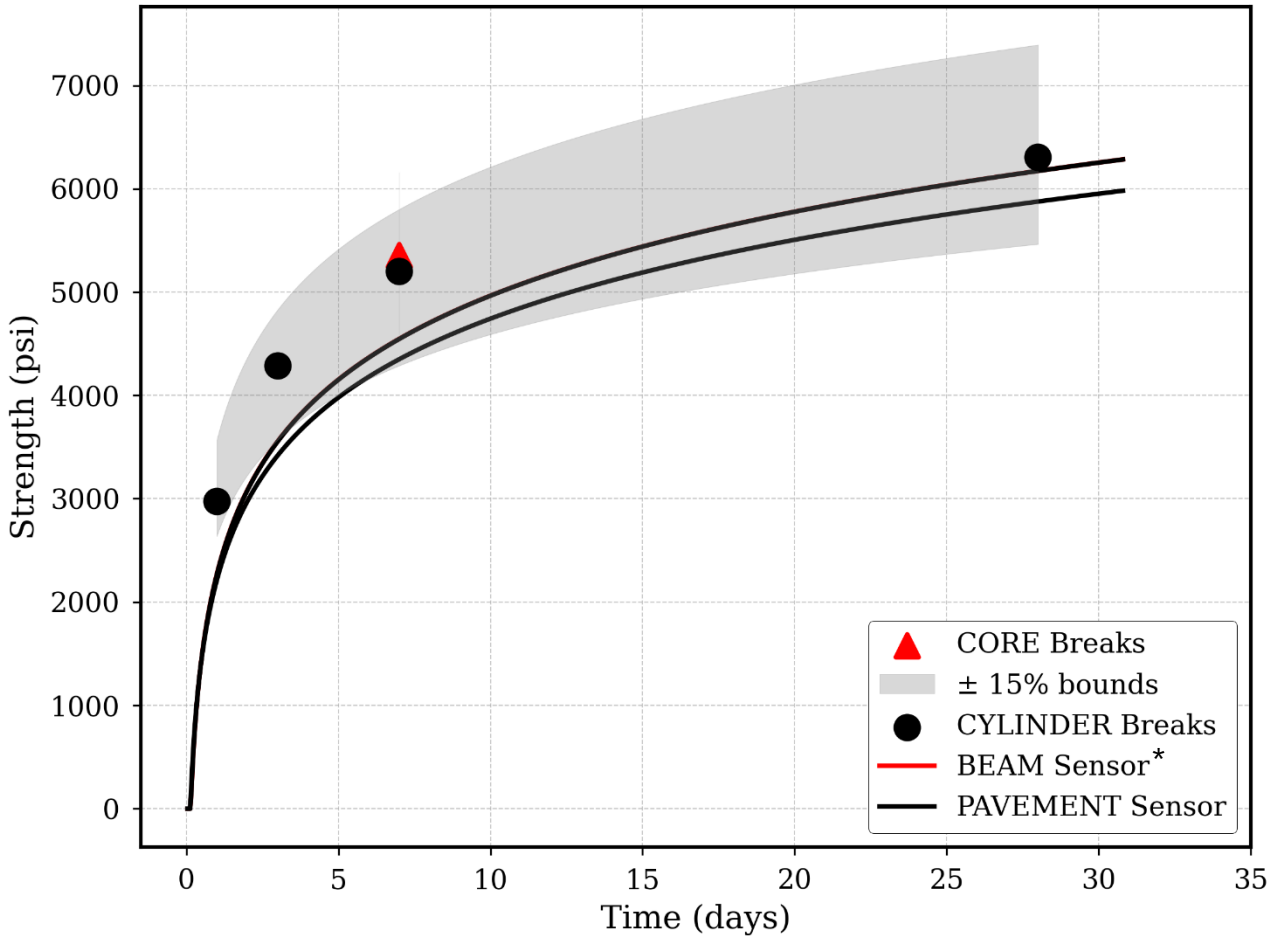
INDOT I-69 Paving

- 2 sensors placed in the pavement and 1 in a companion beam taken to the lab
- Cylinders were measured at 1, 3, 7, and 28 days
- Core was taken at 7-days
- Pavement sensors were within ACI allowable variability of 15% across all ages beyond 7 days



* Red BEAM Sensor Line Overlapped with Top PAVEMENT Sensor Line

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INDOT I-69 Paving

- REBEL Sensor measurements were within 15% of cylinders at 7-day and 28-day
- Sensor measurements were within ~16% of cores at 7-days
- Sensor variability was excellent, with <2.5% variation in measurements across sensors at all ages

7-Day Strength	Avg. Strength	Difference from Core (%)
Core	5355	--
Cylinders	5044	5.8
REBEL Sensor	4481	16.3

Age	Avg. Difference Cylinders vs Sensors (psi)	Avg. Difference Cylinders vs Sensors (%)
1-Day	730	24.3
3-Day	778	18.5
7-Day	721	13.8
28-Day	233	3.6

Age	Sensor Variability (%)
1-Day	1.2
3-Day	1.8
7-Day	2.1
28-Day	2.3

INDOT I-465 Paving

Date	9-16-2024
Location	Indianapolis, IN
Project Type	Pavement

Ingredients	**Amount (/yd³)**
Fine Agg.	1301 lbs.
Coarse Agg.	1780 lbs.
Cement	520 lbs.
Water	230 lbs.
W/C Ratio	0.442

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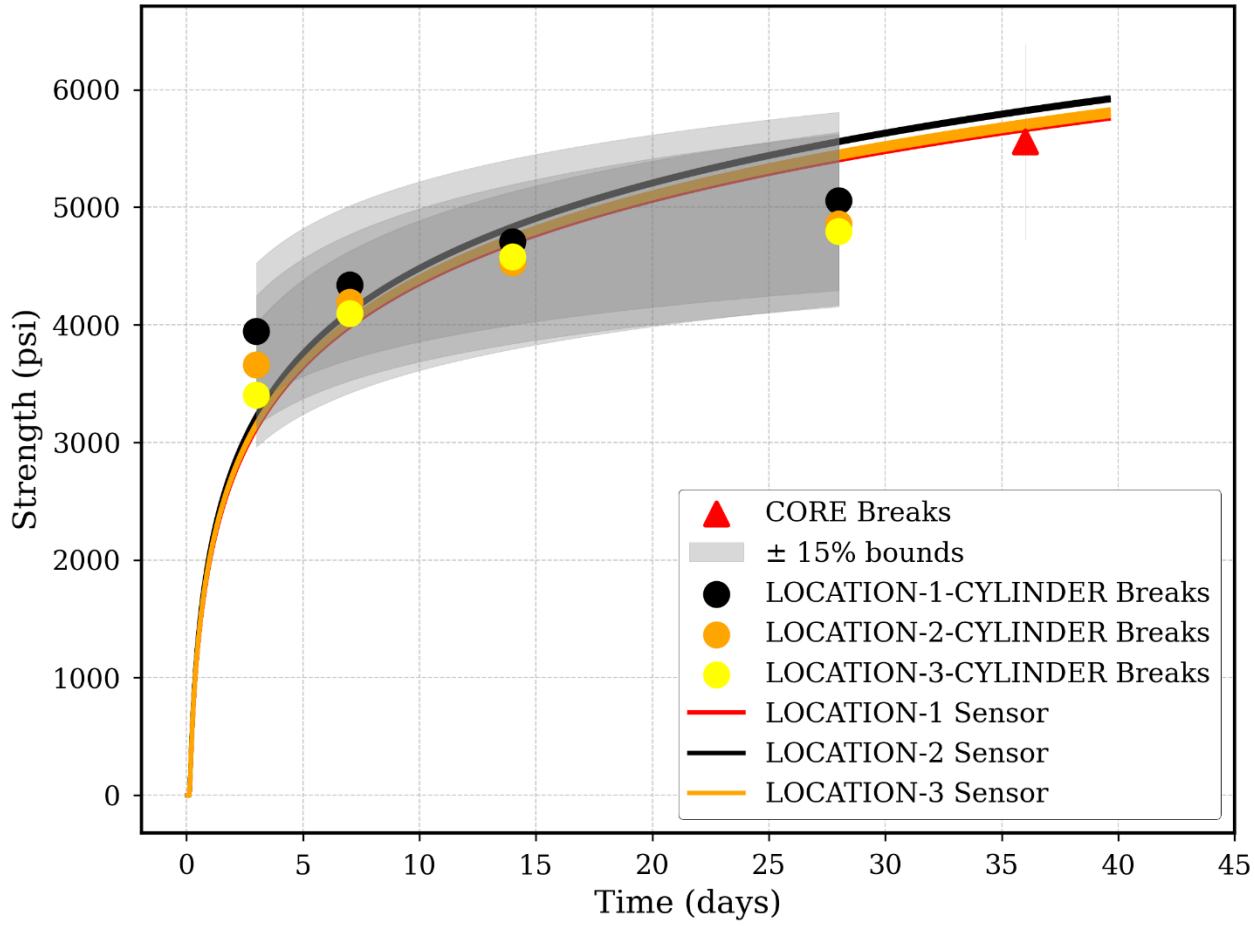
INDOT I-465 Paving

- 3 REBEL sensors were placed at different locations in the pavement
- 3 cylinders were measured for each critical age (3, 7, 14, and 28-days)
- Core was measured at day 36
- Sensors were within the 15% of cylinders across all ages, and were within 15% of the core at 36-days



* Cylinder strength extrapolated from curve fit

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INDOT I-465 Paving

- REBEL Sensors were within 15% of cylinders at all ages
- REBEL Sensors were also within 3% of the 36-day core
- Sensor variability was excellent, with <6% variation in measurements across sensors at all ages

36-Day Strength	Avg. Strength	Difference from Core (%)
Core	5557	--
Cylinders*	5087	8.5
REBEL Sensor	5720	2.9

Age	Avg. Difference Cylinders vs Sensors (psi)	Avg. Difference Cylinders vs Sensors (%)
3-Day	513	13.6
7-Day	180	4.2
14-Day	98	2.1
28-Day	552	11.3

Age	Sensor Variability (%)	Cylinder Variability (%)
3-Day	1.2	6.0
7-Day	1.1	2.4
14-Day	1.1	1.6
28-Day	1.1	2.2

* Cylinder strength extrapolated from curve fit

INDOT I-465 Bridge Deck

Date	7-2-2024
Location	Indianapolis, IN
Project Type	Bridge Deck

Ingredients	**Amount (/yd³)**
Fine Agg.	1115 lbs.
Coarse Agg.	1700 lbs.
Cement	460 lbs.
Slag	198 lbs.
Water	288 lbs.
W/C Ratio	0.438

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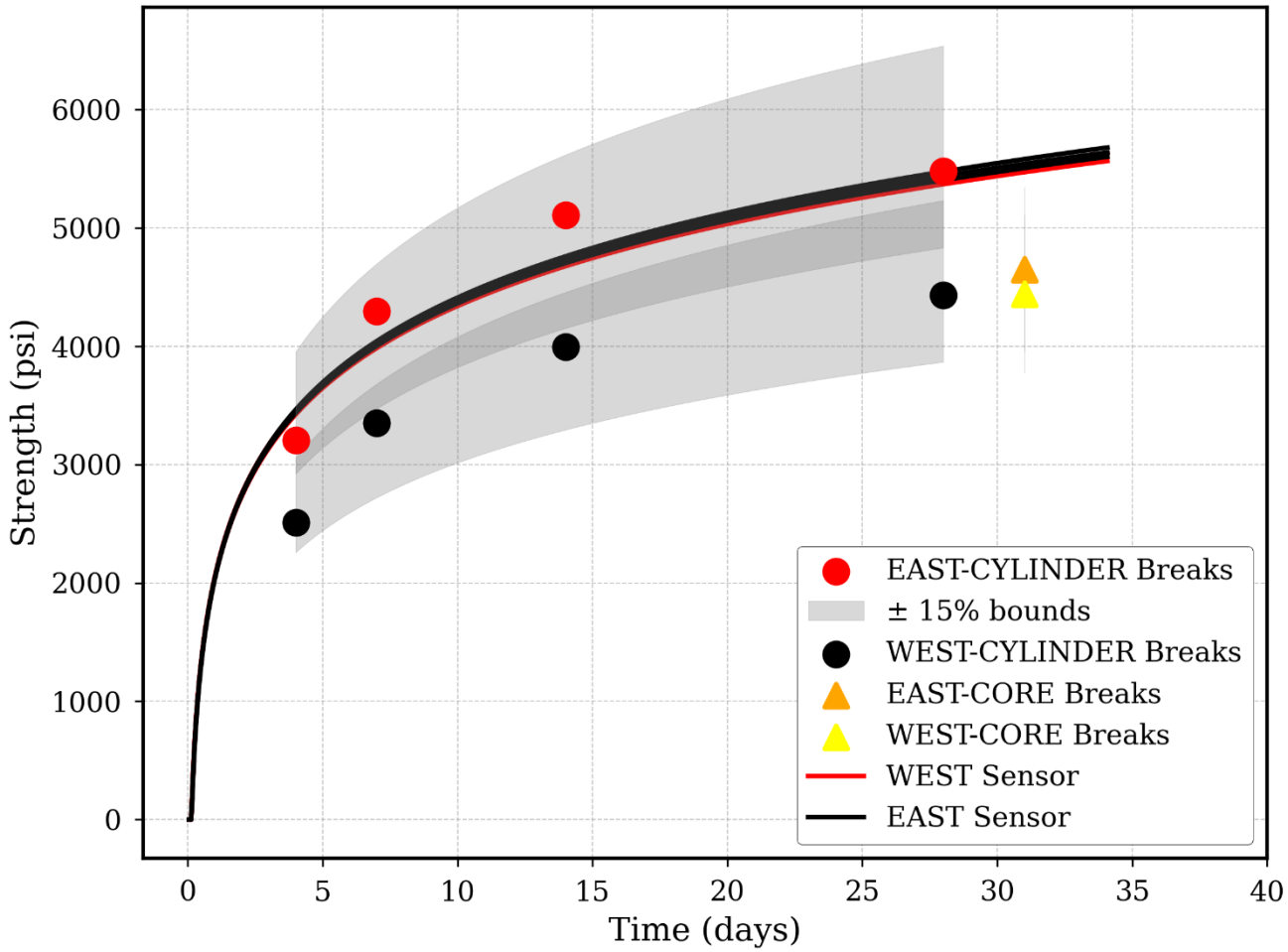
INDOT I-465 Bridge Deck

- REBEL Sensors were placed at the East and West sides of the structure
- Cylinders were measured at 4, 7, 14, and 28-Days for both the East and West sides
- Cores were taken for the East and West sides at 32 days



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INDOT I-465 Bridge Deck

- Cores were significantly lower than both sensor and cylinder measurements
- Average sensor measurements were very consistent with cylinder measurements (within 5% across ages greater than 7 days)
- Sensor measurements were significantly more consistent than cylinders, with less than 1% variability across measurements

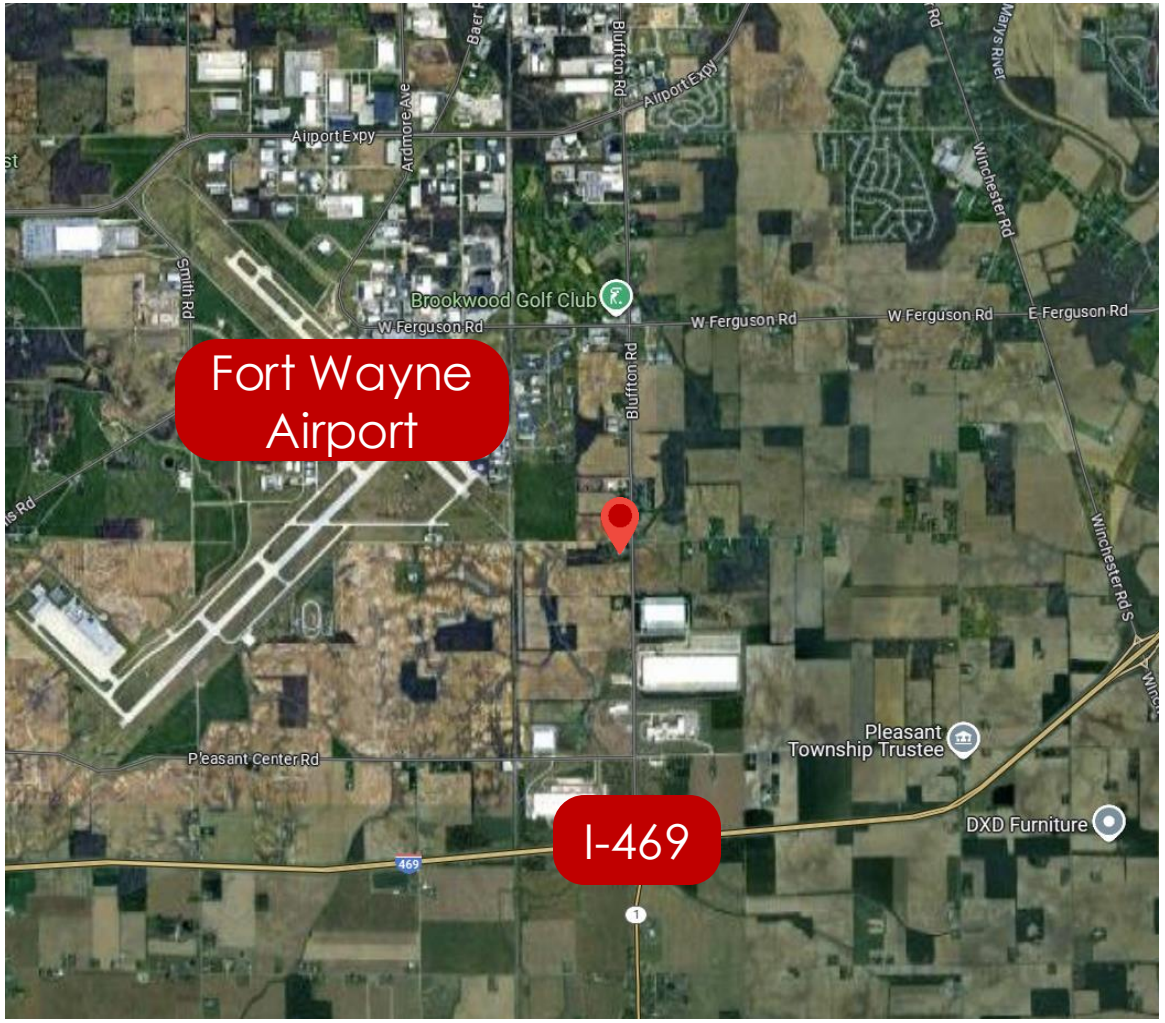
32-Day Strength	Avg. Strength	Difference from Core (%)
Core	4543	--
Cylinders*	5225	15.0
REBEL Sensor	5529	21.7

Age	Avg. Difference Cylinders vs Sensors (psi)	Avg. Difference Cylinders vs Sensors (%)
4-Day	370	12.2
7-Day	151	3.5
14-Day	257	5.1
28-Day	115	2.2

Age	Sensor Variability (%)	Cylinder Variability (%)
4-Day	0.4	12.2
7-Day	0.5	12.4
14-Day	0.6	12.2
28-Day	0.6	10.6

* Cylinder strength extrapolated from curve fit

INDOT Fort Wayne Bridge Deck



Date	9-10-2024
Location	Fort Wayne, IN
Project Type	Bridge Deck

Ingredients	**Amount (/yd^3)**
Fine Agg.	1283 lbs.
Coarse Agg.	1720 lbs.
Cement	580 lbs.
Water	261 lbs.
W/C Ratio	0.450

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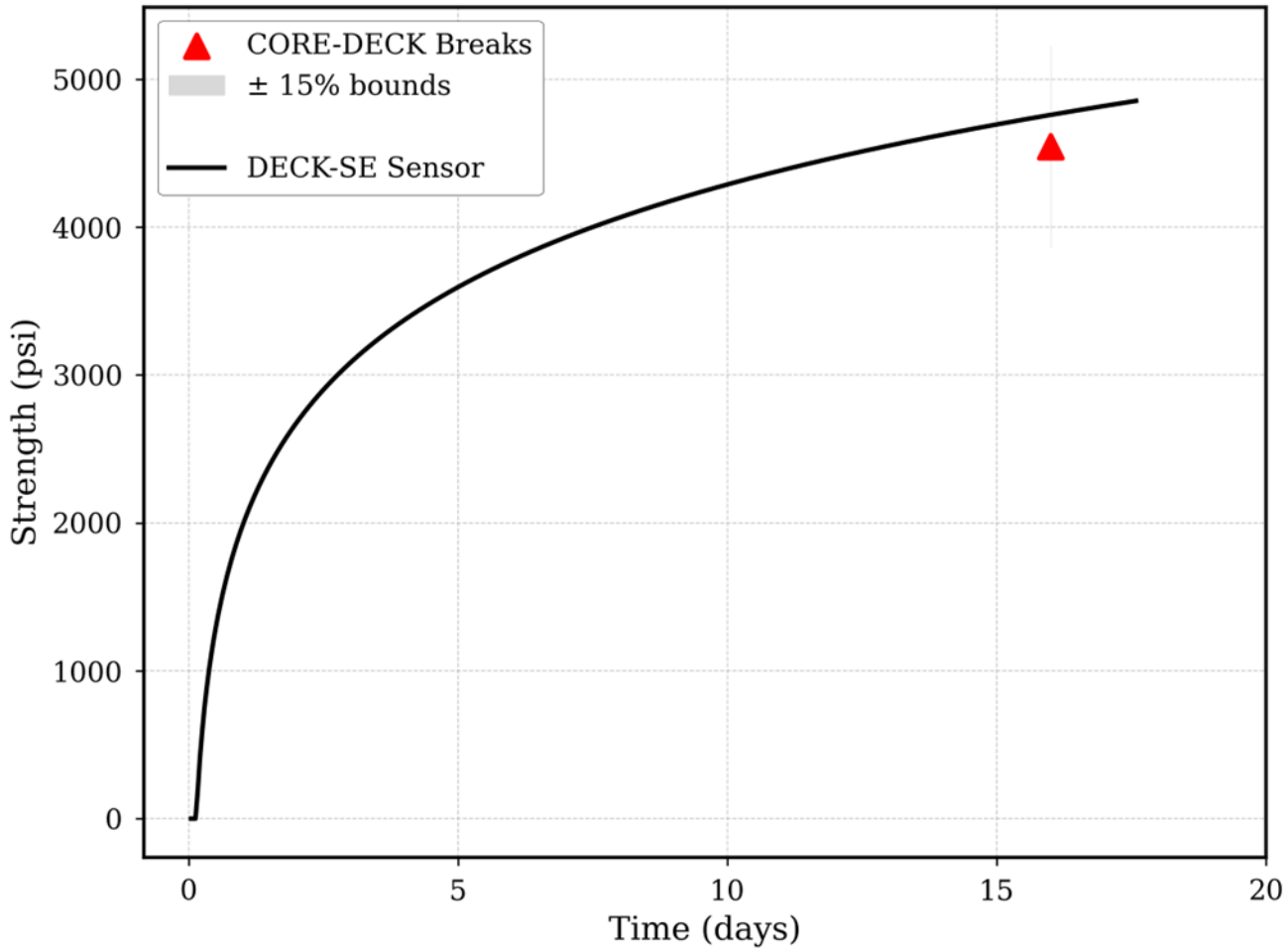
INDOT Fort Wayne Bridge Deck

- Sensor was placed in the bridge deck, with one core taken at 16-days
- Sensor was very accurate (within 4.7% of core measurement)



	Avg. Strength	Difference from Core (%)
Core	4545	--
REBEL Sensor	4760	4.7

Age	Avg. Difference (psi)	Avg. Difference (%)
16-Day	214	4.7

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INDOT I-69 Bridge Deck

Date	6-6-2024
Location	Anderson, IN
Project Type	Bridge Deck

Ingredients	**Amount (/yd^3)**
Fine Agg.	1188 lbs.
Coarse Agg.	1634 lbs.
Cement	650 lbs.
Water	287 lbs.
W/C Ratio	0.441

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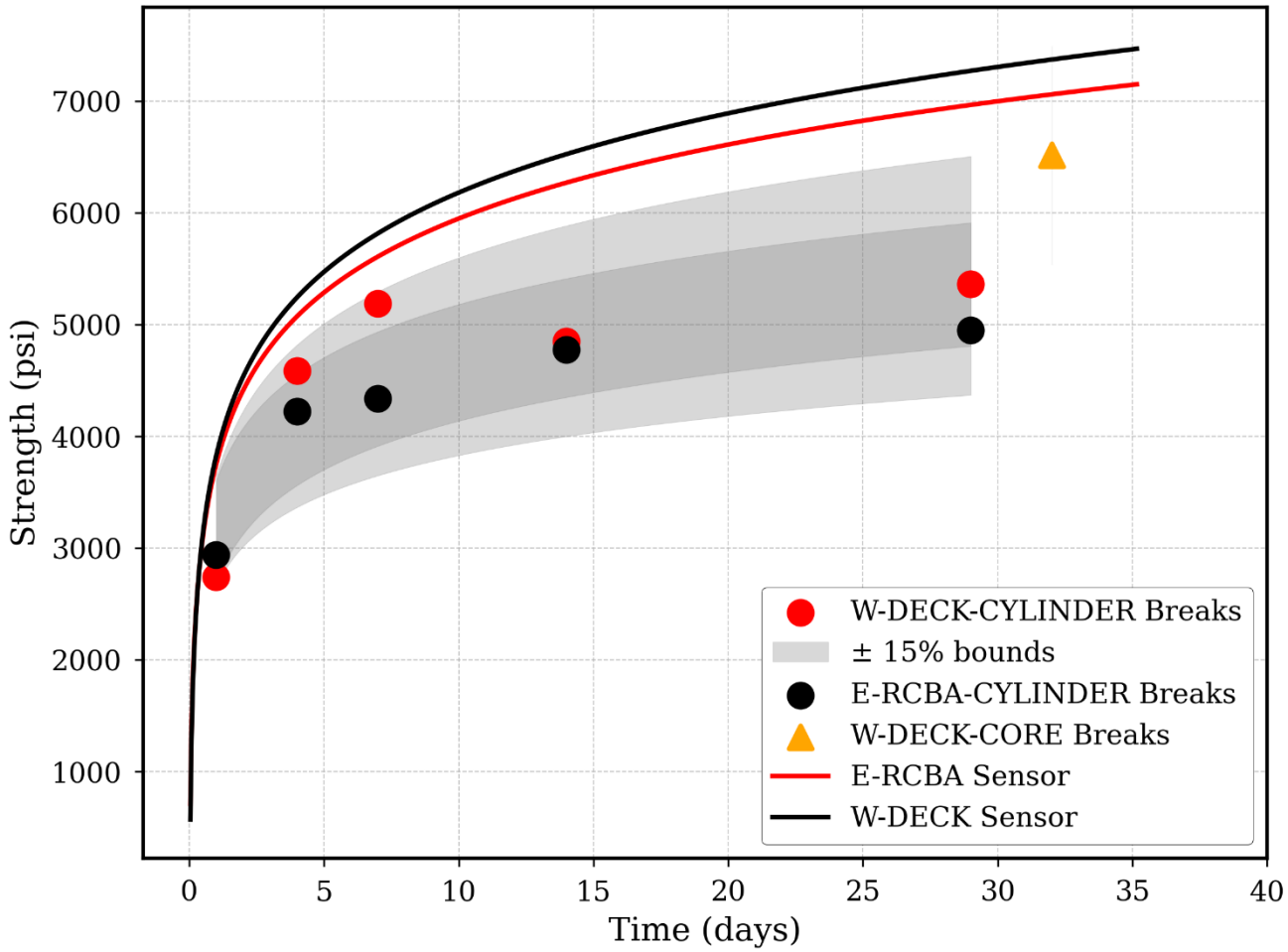
INDOT I-69 Bridge Deck

- 1 sensor was placed in the bridge deck with another in the approach
- Cylinders made for 1, 4, 7, 14, and 28-days
- Both sets of cylinders broke below expectations at 14 and 28 days
- Core break at 32 days confirms that the sensor results fall in line with the in-place strength



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INDOT I-69 Bridge Deck

- Both sets of cylinders broke below expectations at 14 and 28 days
- The core break at 32 days confirms that the sensor results fall in line with the in-place strength

32-day	Avg. Strength	Difference from Core (%)
Core	6517	--
Cylinders*	5464	16.1
REBEL Sensor	7216	10.7

* Cylinder strength extrapolated from curve fit

Caltrans I-10 Paving

Date	7-16-2024
Location	Palm Desert, CA
Project Type	Pavement

Ingredients	**Amount (/yd^3)**
Fine Agg.	1184 lbs.
Coarse Agg.	1952 lbs.
Cement	423 lbs.
Fly Ash	141 lbs.
Water	243 lbs.
W/C Ratio	0.43

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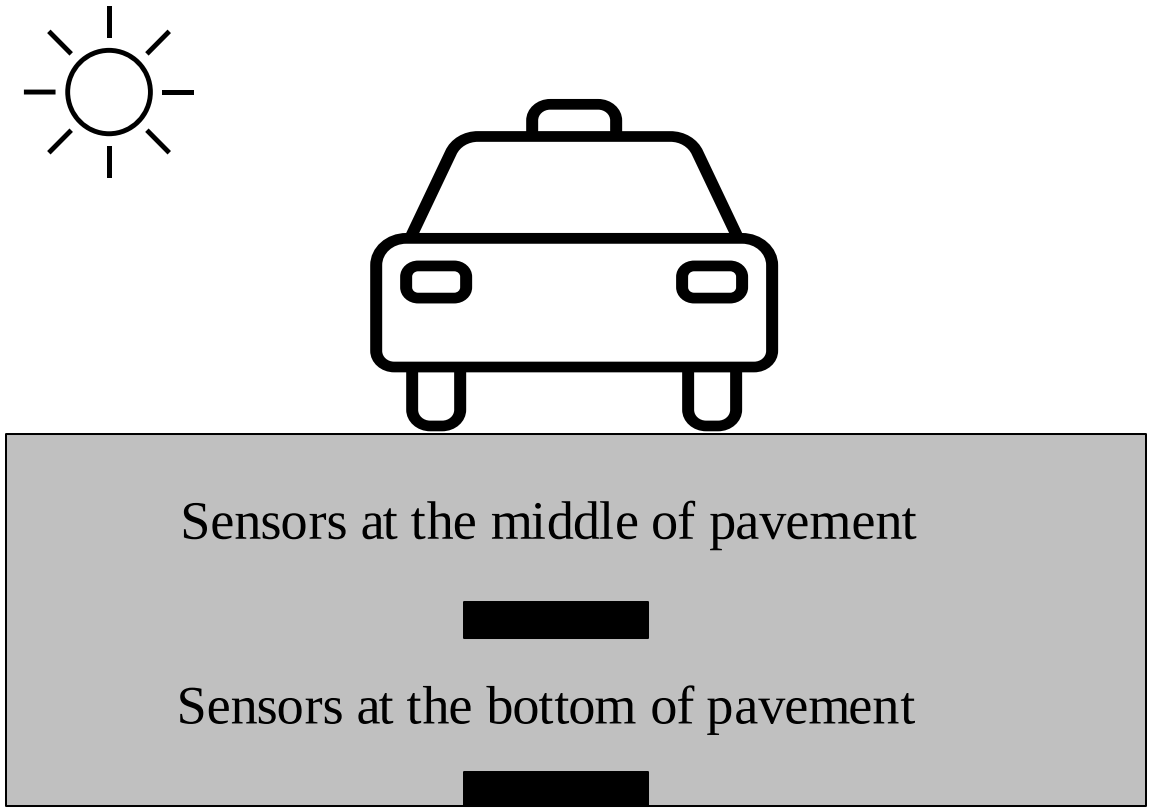
Caltrans I-10 Paving

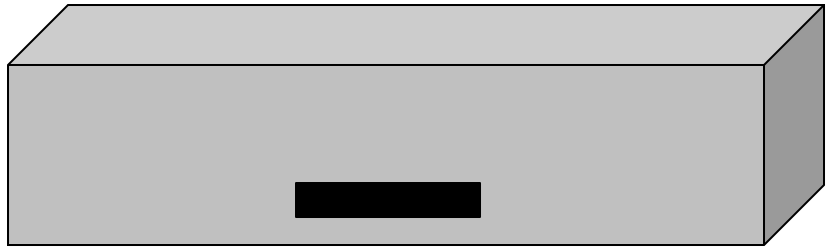
- This paving project consisted of 4 groups of sensors: 2 groups in the pavement and 2 in companion samples
- One pavement group was placed on the base and the other was raised to the middle of the pavement
- The sensors in companion samples were placed in 6” x 6” x 21” beam molds with one group left on site and the other in the lab

Caltrans I-10 Paving

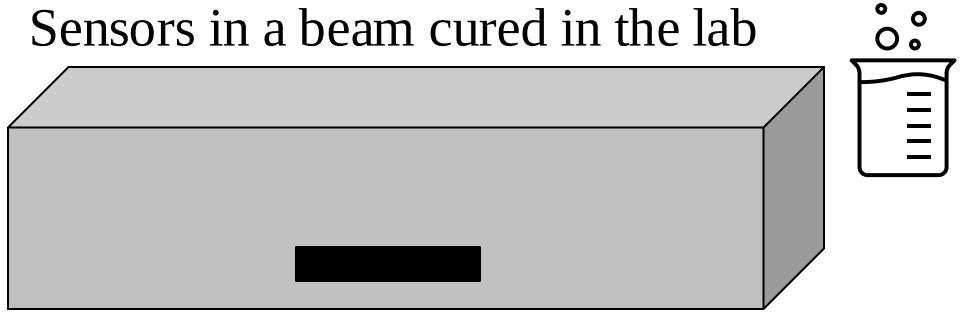
Four groups of sensors were deployed



Sensors in a beam cured in the field



Sensors in a beam cured in the lab



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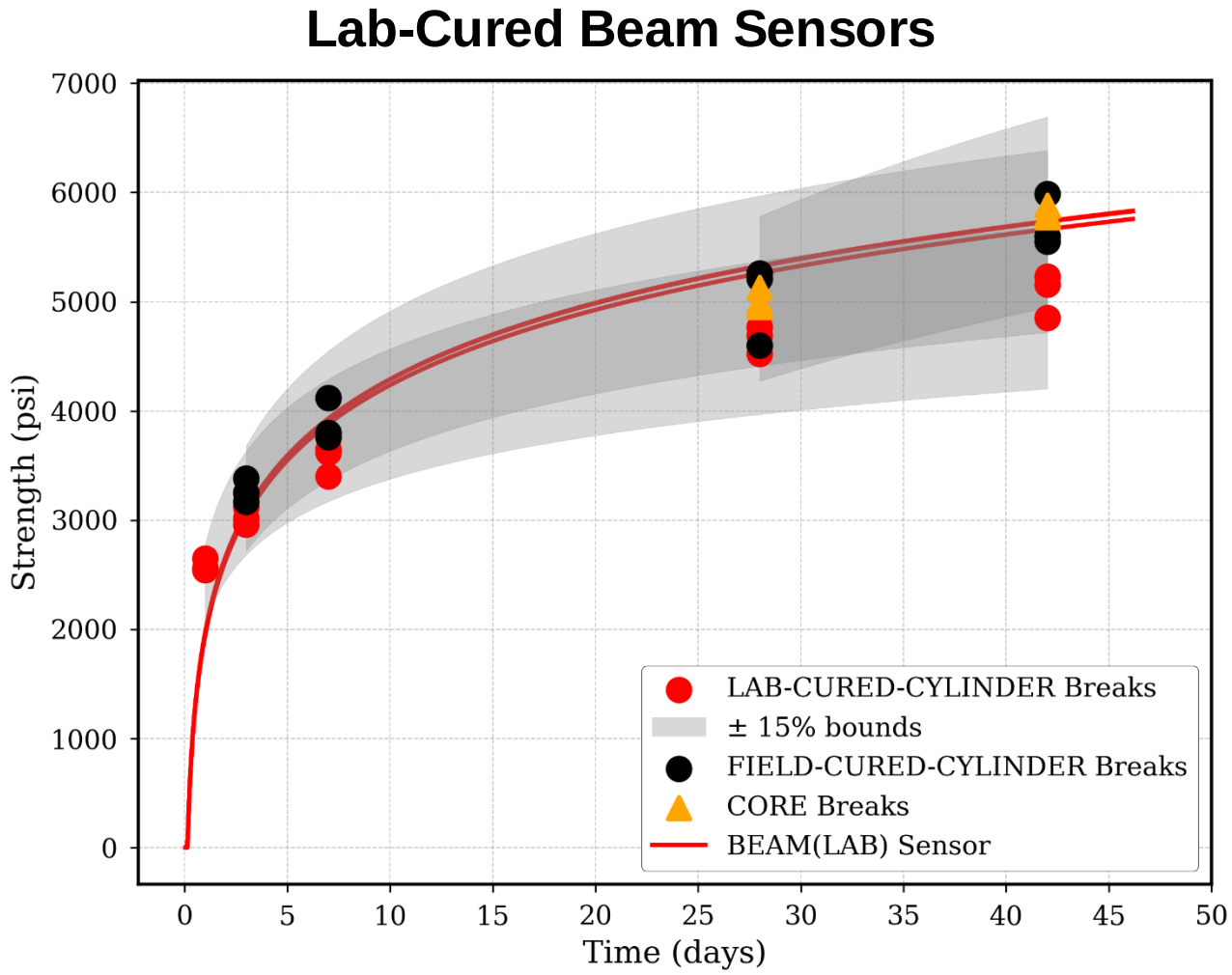
Caltrans I-10 Paving – Lab-Cured Beam Sensors

- The sensors in the lab-cured beam sample reported strength close to the in-field cylinders and sensors
- 4 sets of cylinders were measured at 1, 3, 7, 28, and 42-days
- Cores were taken at 28 and 42 days



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Caltrans I-10 Paving – Lab-Cured Beam Sensors

- Sensors were within 10% of cylinder measurements taken past day 3
- Variability was low across all sensors at all ages (<1%)
- Lab-cured sensors were within 5% of 28-day cores and within 2% of 42-day cores

Age	Avg. Difference (psi)	Avg. Difference (%)
1-Day	623	24.1
3-Day	200	6.1
7-Day	23	0.6
28-Day	462	9.5
42-Day	173	3.1

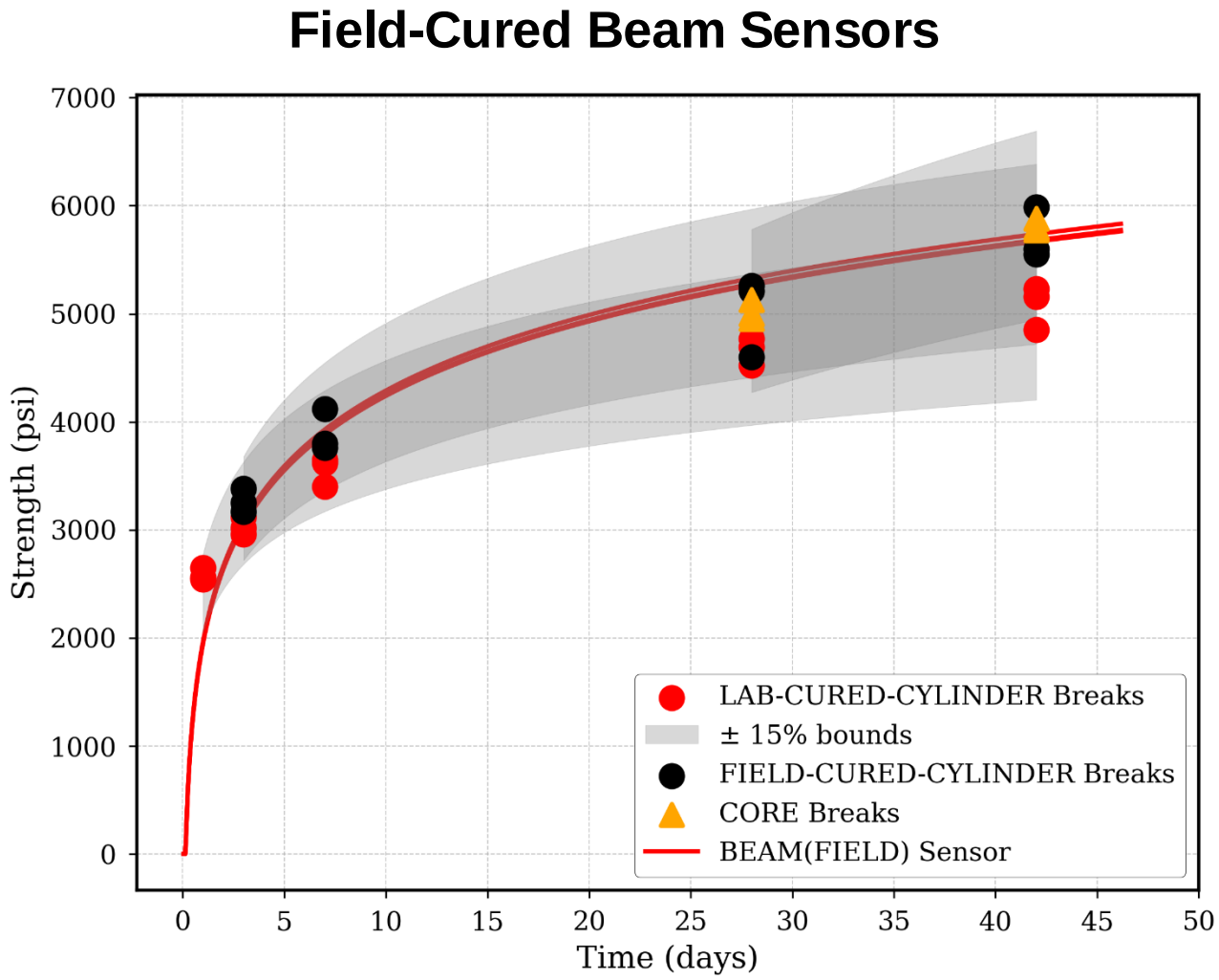
Age	Sensor Variability (%)	Cylinder Variability (%)
1-Day	0.5	1.9
3-Day	0.6	4.4
7-Day	0.6	6.0
28-Day	0.6	5.2
42-Day	0.6	6.5

28-day Comparison	Avg. Strength	Difference from Core (%)
Core	5027	--
Cylinders	4925	2.0
REBEL Sensor	5304	5.5

42-day Comparison	Avg. Strength	Difference from Core (%)
Core	5819	--
Cylinders	5237	10.0
REBEL Sensor	5710	1.9

Caltrans I-10 Paving – Field-Cured Beam Sensors

- The sensors cured in the in-field beam tracked very closely to the field-cured cylinders and core drills
- 4 sets of cylinders were measured at 1, 3, 7, 28, and 42-days
- Cores were taken at 28 and 42 days



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Caltrans I-10 Paving – Field-Cured Beam Sensors

- Sensors were within 6% of cylinder measurements taken past day 3
- Variability was low across all sensors at all ages (<1%)
- Lab-cured sensors were within 5% of 28-day cores and within 2% of 42-day cores

Age	Avg. Difference (psi)	Avg. Difference (%)
1-Day	627	24.3
3-Day	208	6.3
7-Day	13	0.3
28-Day	448	9.3
42-Day	158	2.9

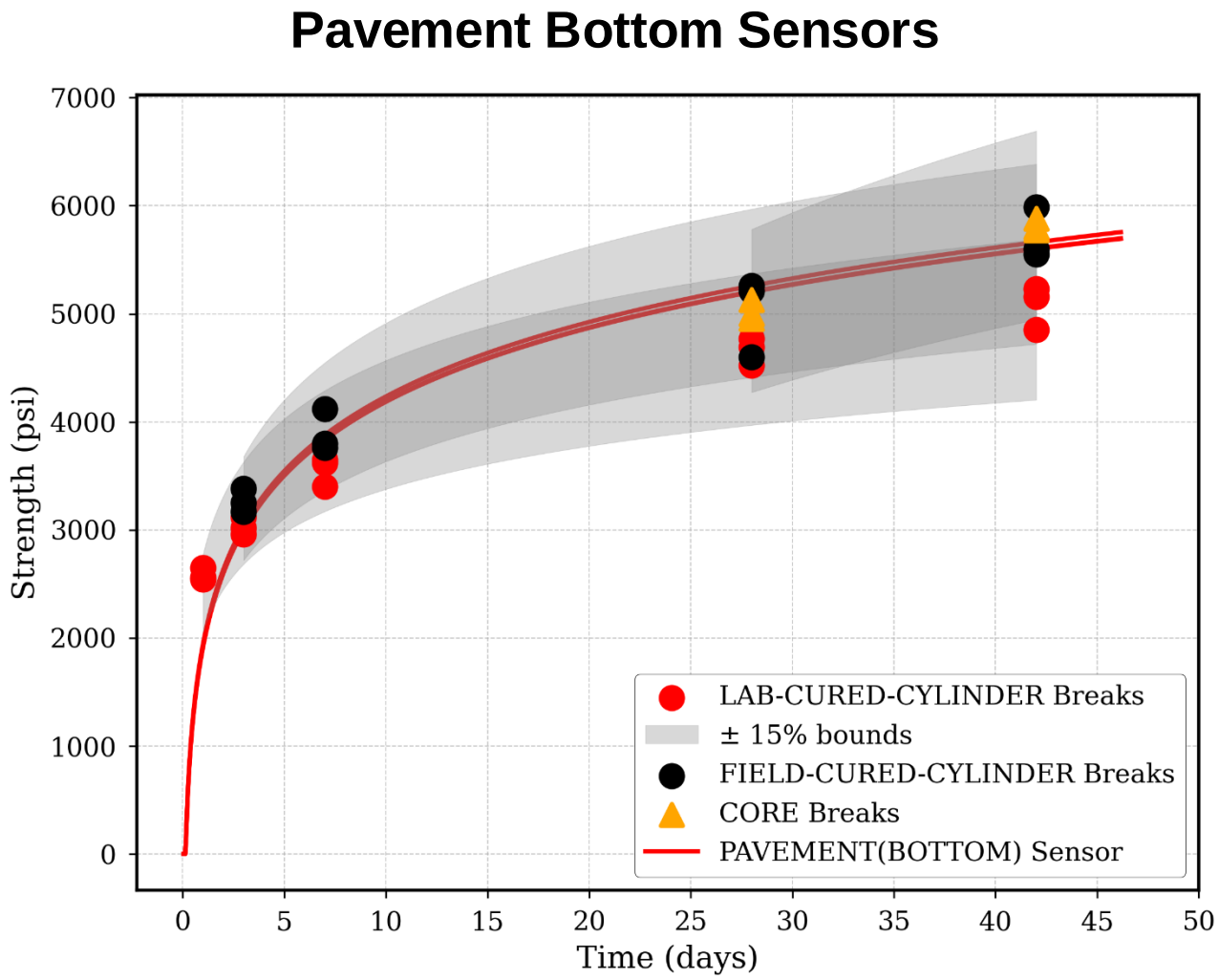
Age	Sensor Variability (%)	Cylinder Variability (%)
1-Day	0.4	1.9
3-Day	0.5	4.4
7-Day	0.5	6.0
28-Day	0.5	5.2
42-Day	0.5	6.5

28-day Comparison	Avg. Strength	Difference from Core (%)
Core	5027	--
Cylinders	4925	2.0
REBEL Sensor	5289	5.2

42-day Comparison	Avg. Strength	Difference from Core (%)
Core	5819	--
Cylinders	5237	10.0
REBEL Sensor	5696	2.1

Caltrans I-10 Paving – Pavement Bottom Sensors

- The sensors on this plot were placed in the bottom of the pavement
- 4 sets of cylinders were measured at 1, 3, 7, 28, and 42-days
- Cores were taken at 28 and 42 days



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Caltrans I-10 Paving – Pavement Bottom Sensors

- Sensors were within 8% of cylinder measurements taken past day 3
- Variability was low across all sensors at all ages (<1%)
- Lab-cured sensors were within 5% of 28-day cores and within 2% of 42-day cores

Age	Avg. Difference (psi)	Avg. Difference (%)
1-Day	656	25.4
3-Day	250	7.6
7-Day	36	0.9
28-Day	380	7.8
42-Day	85	1.5

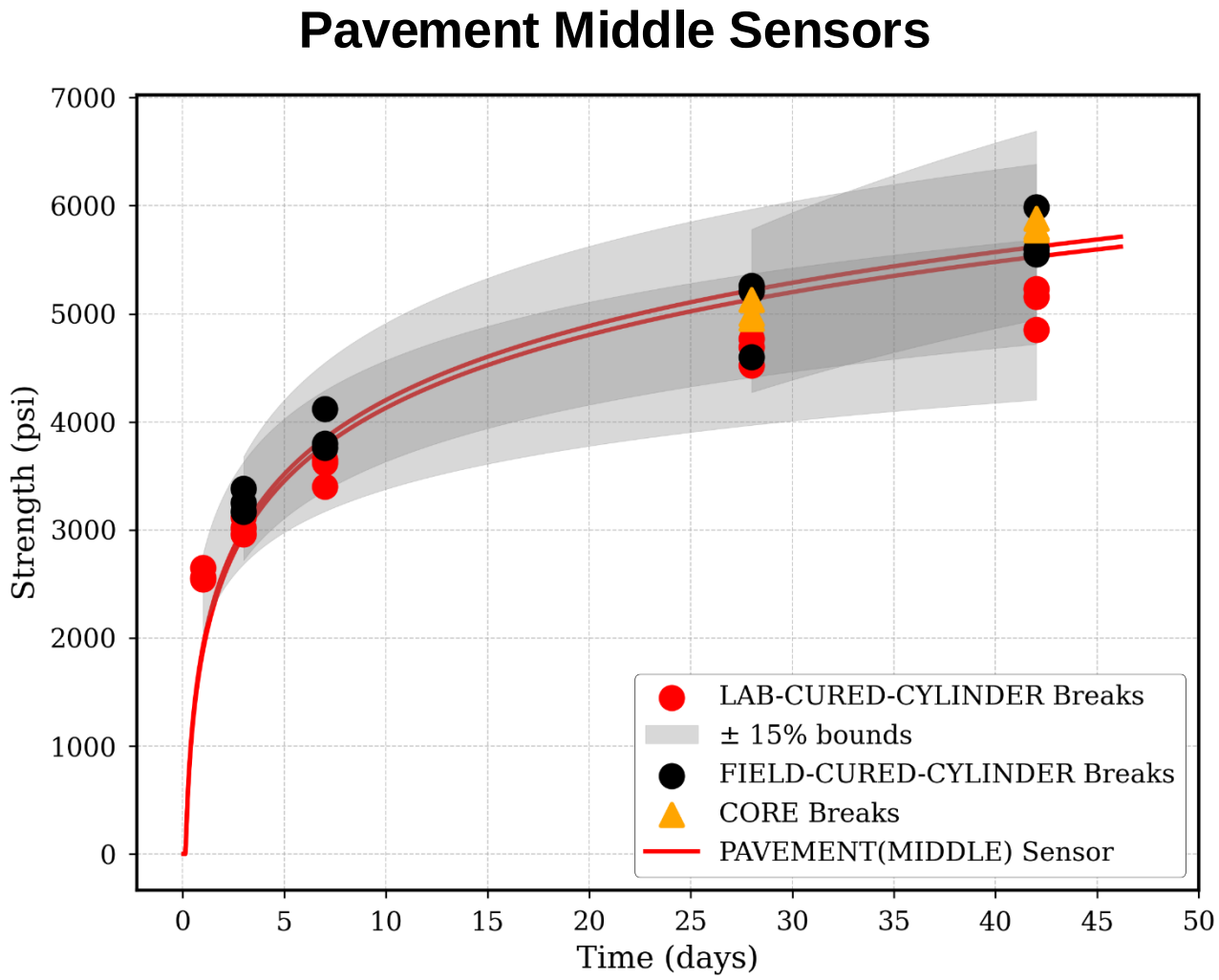
Age	Sensor Variability (%)	Cylinder Variability (%)
1-Day	0.7	1.9
3-Day	0.6	4.4
7-Day	0.5	6.0
28-Day	0.5	5.2
42-Day	0.5	6.5

28-day Comparison	Avg. Strength	Difference from Core (%)
Core	5027	--
Cylinders	4925	2.0
REBEL Sensor	5221	3.9

42-day Comparison	Avg. Strength	Difference from Core (%)
Core	5819	--
Cylinders	5237	10.0
REBEL Sensor	5622	3.4

Caltrans I-10 Paving – Pavement Middle Sensors

- The sensors on this plot were placed in the middle of the pavement
- 4 sets of cylinders were measured at 1, 3, 7, 28, and 42-days
- Cores were taken at 28 and 42 days



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Caltrans I-10 Paving – Pavement Middle Sensors

- Sensors were within 8.5% of cylinder measurements taken past day 3
- Variability was low across all sensors at all ages (<1.1%)
- Lab-cured sensors were within 3% of 28-day cores and within 4% of 42-day cores

Age	Avg. Difference (psi)	Avg. Difference (%)
1-Day	679	26.3
3-Day	280	8.5
7-Day	72	1.8
28-Day	334	6.9
42-Day	45	0.8

Age	Sensor Variability (%)	Cylinder Variability (%)
1-Day	1.1	1.9
3-Day	1.0	4.4
7-Day	0.9	6.0
28-Day	0.8	5.2
42-Day	0.8	6.5

28-day Comparison	Avg. Strength	Difference from Core (%)
Core	5027	--
Cylinders	4925	2.0
REBEL Sensor	5175	3.0

42-day Comparison	Avg. Strength	Difference from Core (%)
Core	5819	--
Cylinders	5237	10.0
REBEL Sensor	5574	4.2

Caltrans US 50 Paving

Date	9-15-2023
Location	Sacramento, CA
Pavement Thickness	14”
Rebar	6” interval, 7.5” high

Ingredients	**Amount (/yd^3)**
Fine Agg.	1426 lbs.
Coarse Agg.	1796 lbs.
Cement	510 lbs.
Fly Ash	90 lbs.
Water	189 lbs.
W/C Ratio	0.32

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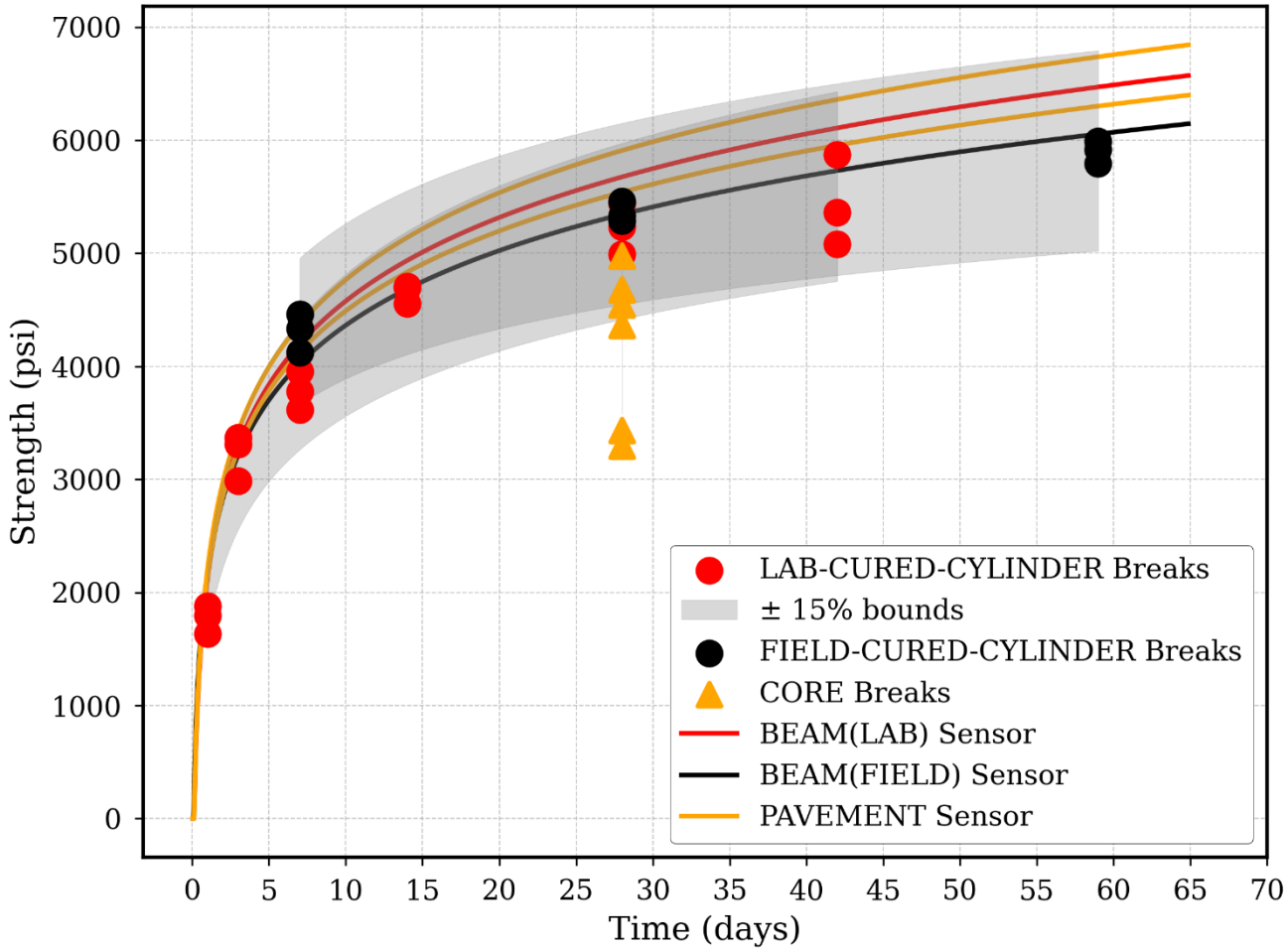
Caltrans US 50 Paving

- Cylinders were measured at 1, 3, 7, 14, 28, 42, and 59 days
- Cores were measured at 28-days
- Sensors were placed in a beam in the lab, a beam in the field, and in the pavement
- Of the 6 cores taken, 5 broke significantly lower than expected at 28-days



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Caltrans US 50 Paving

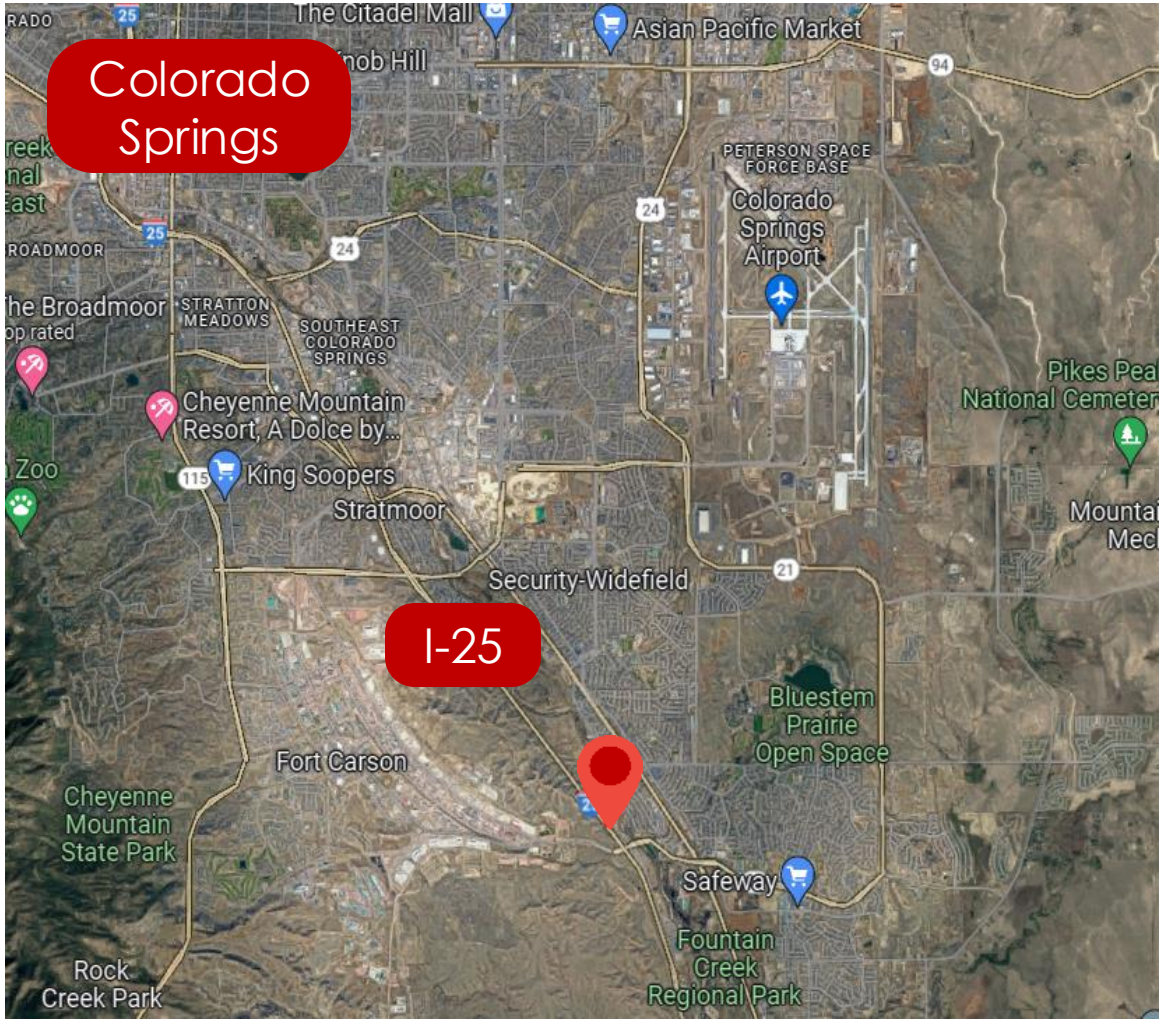
- Given the low core measurements, both sensors and cylinders were much higher than measured by the cores
- Sensors were within 15% of cylinders across ages, except for 1-day, where they were still <400psi different from cylinders
- Sensors had significantly lower variability than cylinders at most ages

28-day	Avg. Strength	Difference from Core (%)
Core	4215	--
Cylinders	5254	24.6
REBEL Sensor	5877	39.4

Age	Avg. Difference (psi)	Avg. Difference (%)
1-Day	391	22.2
3-Day	56	1.7
7-Day	395	10.5
14-Day	243	5.2
28-Day	182	3.4
42-day	720	13.2
59-day	620	10.5

Age	Sensor Variability (%)	Cylinder Variability (%)
1-Day	1.5	5.8
3-Day	2.4	5.2
7-Day	3.0	7.3
14-Day	3.4	1.5
28-Day	3.7	14.9
42-day	3.3	6.0
59-day	3.3	1.3

CDOT I-25 Paving



Date	8-8-2023
Location	Spring, CO
Pavement Thickness	9.5”

Ingredients	**Amount (/yd^3)**
Agg.	3119 lbs.
Cement	440 lbs.
C R Mineral (natural pozzolan)	109 lbs.
Water	160 lbs.
W/C Ratio	0.40

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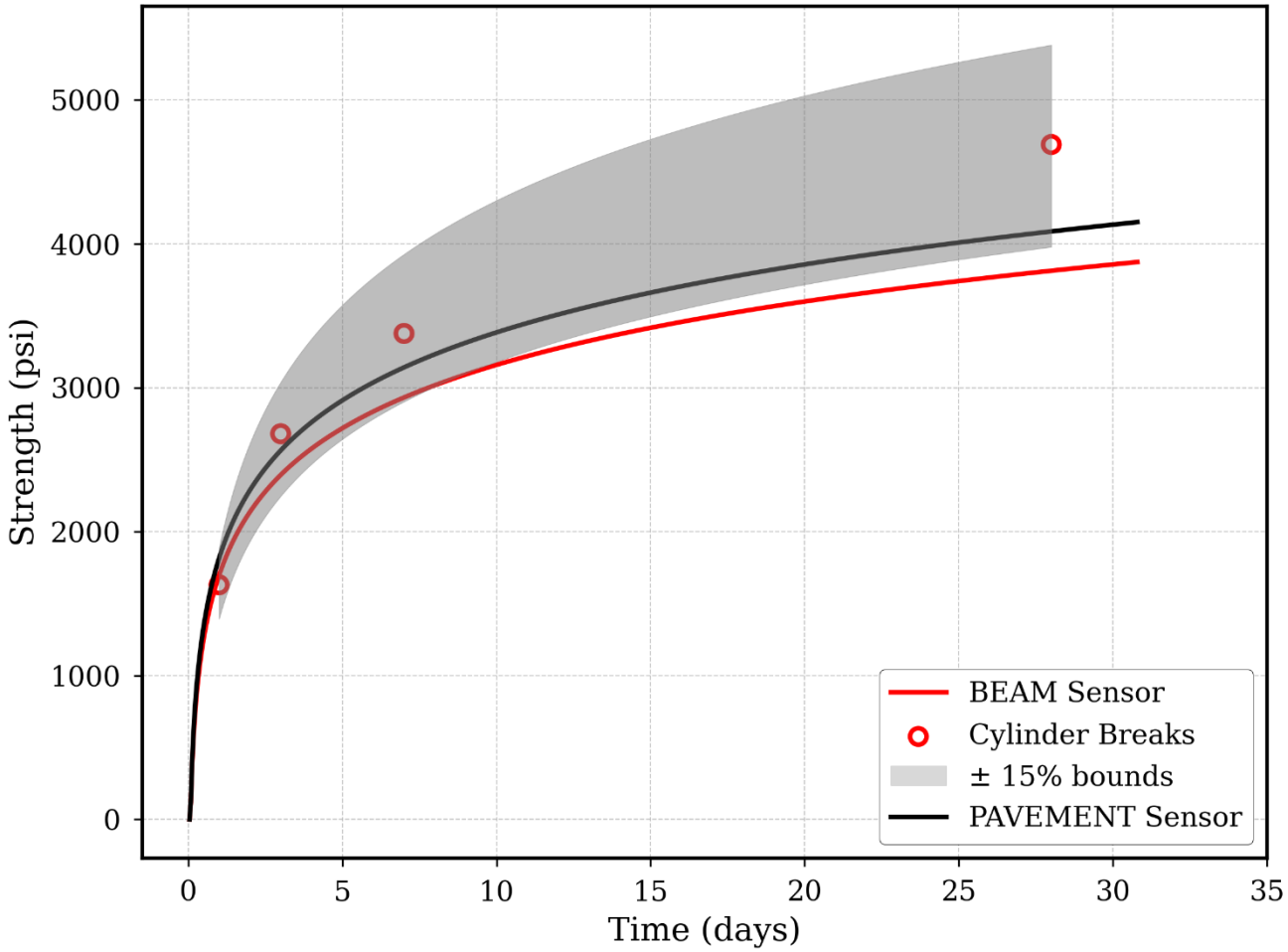
CDOT I-25 Paving

- Sensors in the pavement reported similar strength as the cylinder breaks (within 15%).
- The sensors in a separate beam sample reported lower strengths, which reflects the effect of different curing conditions for in-place structure vs separate sample.



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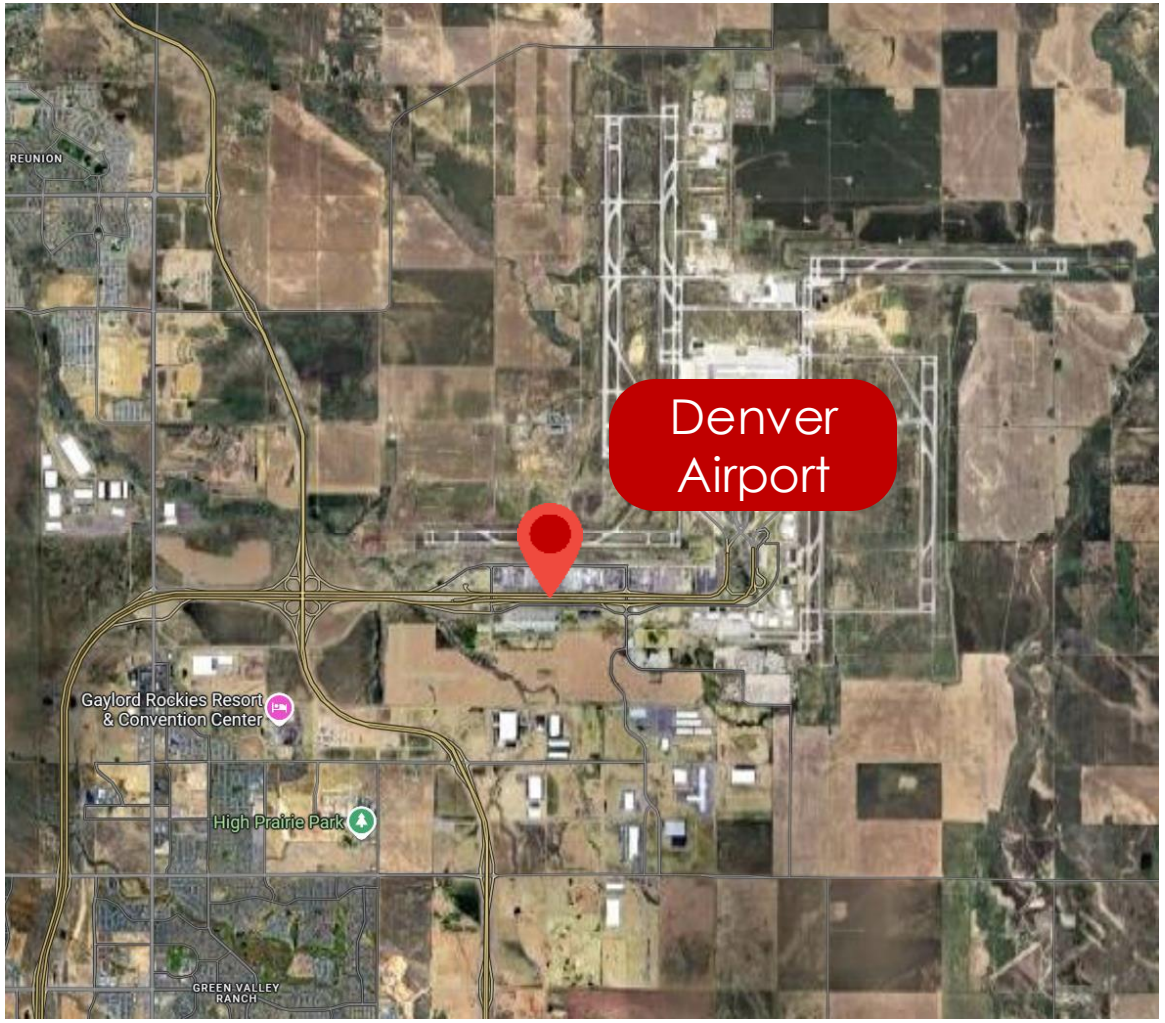
CDOT I-25 Paving

- Sensors were within 15% of cylinders at all ages except for 28-days, where it was within 16%
- Sensors were very consistent, with 3.4% variability in measurements across all ages

Age	Avg. Difference Cylinders vs Sensors (psi)	Avg. Difference Cylinders vs Sensors (%)
1-Day	125	7.6
3-Day	201	7.5
7-Day	340	10.0
28-Day	740	15.7

Age	Sensor Variability (%)
1-Day	3.4
3-Day	3.4
7-Day	3.4
28-Day	3.4

Denver Airport Paving



Date	8-8-2023
Location	Denver, CO
Project Type	Pavement

Ingredients	**Amount (/yd^3)**
Fine Agg.	1247 lbs.
Coarse Agg.	1871 lbs.
Cement	440 lbs.
C R Mineral	109 lbs.
Water	160 lbs.
W/C Ratio	0.40

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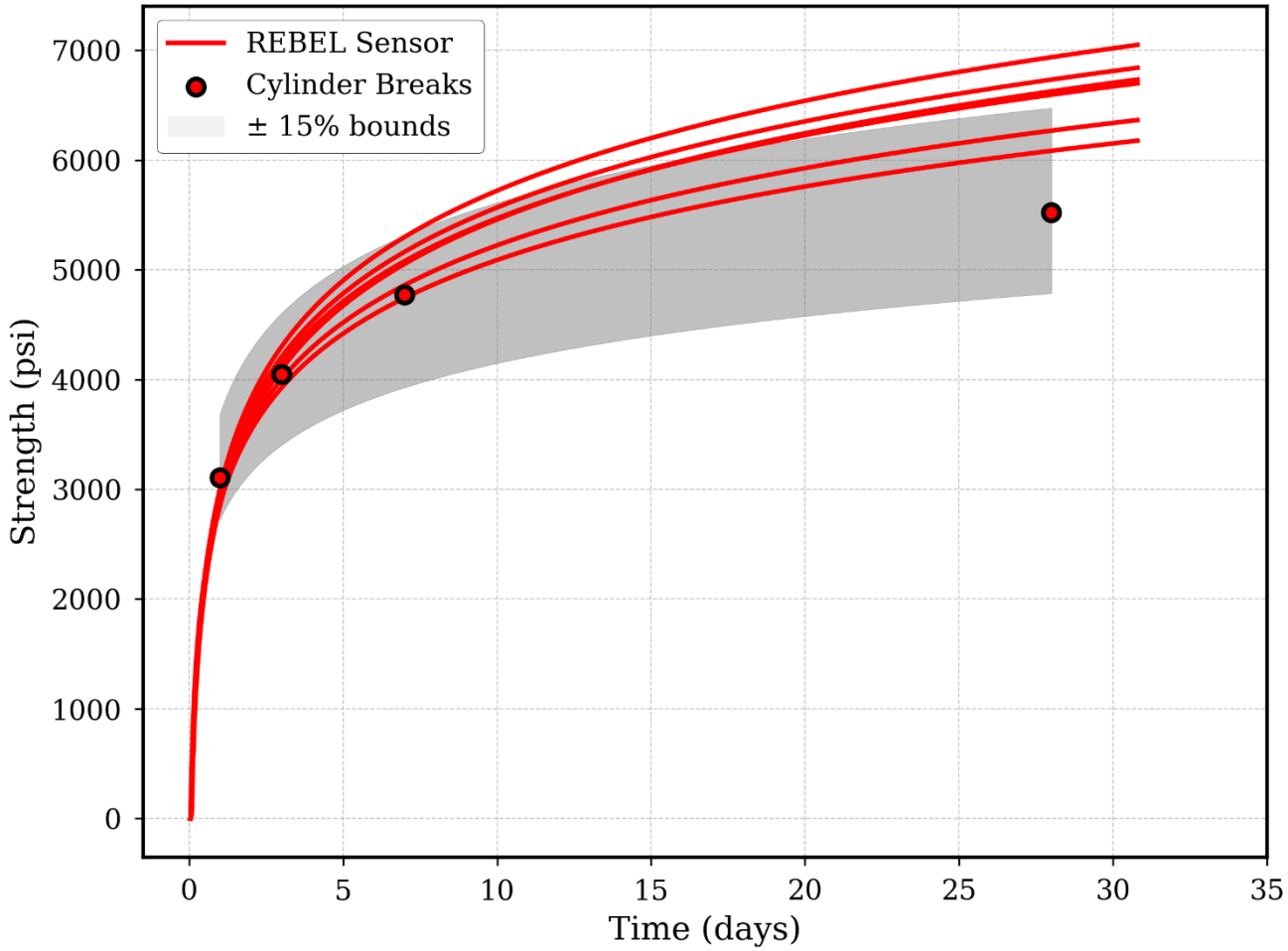
Denver Airport Paving

- Cylinder measurements were taken at 1-day, 3-day, 7-day, and 28-days
- Expected strength at 28-days was 4500 psi, so the sensor indicates the strength reached 4500 psi at about 5-day, which would have allowed earlier traffic opening.



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Denver Airport Paving

- Cylinder measurements were taken at 1-day, 3-day, 7-day, and 28-days
- Expected strength at 28-days was 4500 psi, so the sensor indicates the strength reached 4500 psi at about 5-day, which would have allowed earlier traffic opening.

Age	Avg. Difference Cylinders vs Sensors (psi)	Avg. Difference Cylinders vs Sensors (%)
1-Day	188	6.0
3-Day	112	2.7
7-Day	173	3.6
28-Day	1016	18.3

Age	Sensor Variability (%)
1-Day	1.9
3-Day	3.0
7-Day	3.7
28-Day	4.3

City of Manchester Paving

Date	10-24-2024
Location	Manchester, MO
Project Type	Pavement Repair

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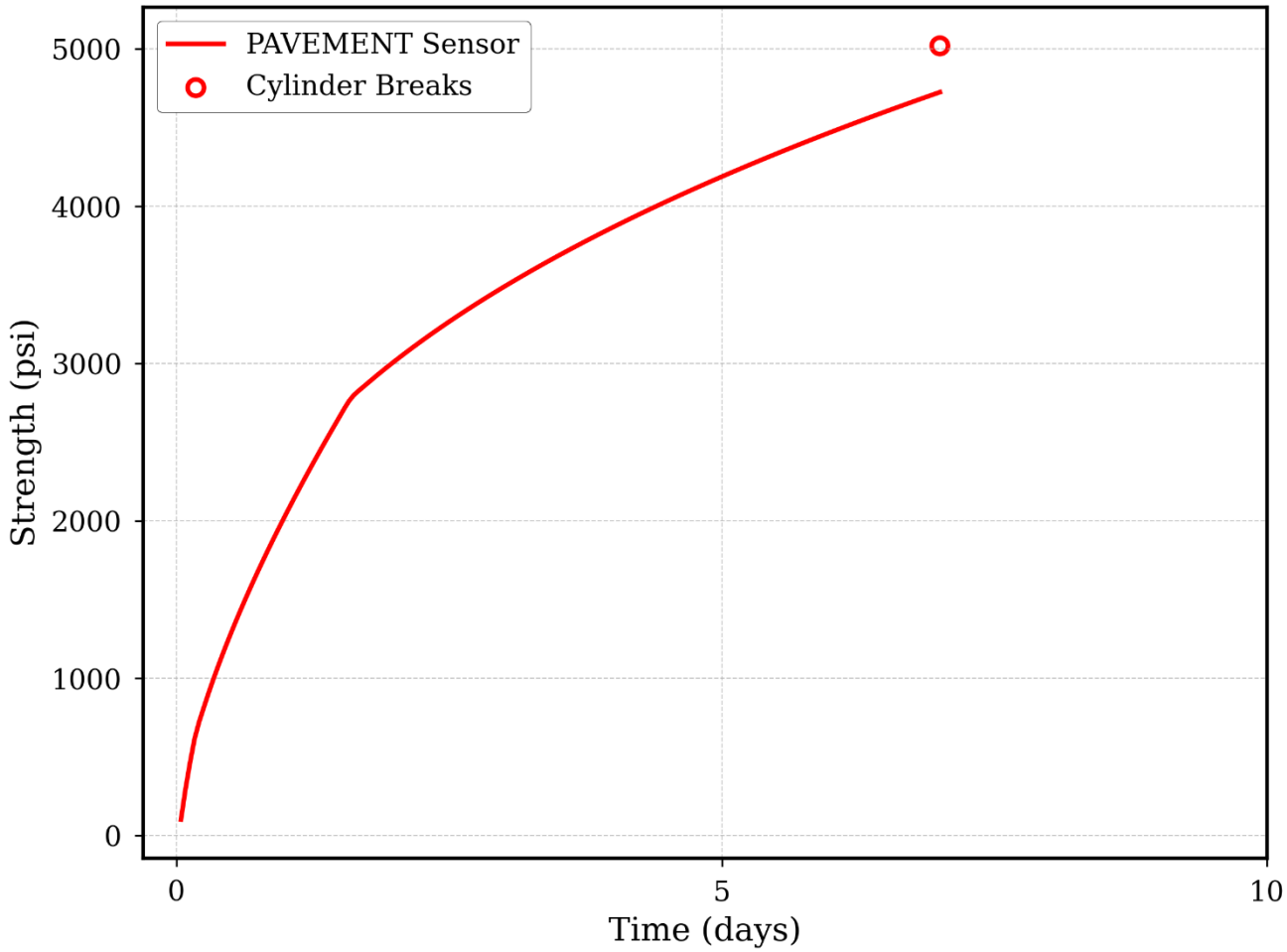
City of Manchester Paving

- Only one cylinder break was taken at 7-days
- One sensor was placed in the pavement for comparison
- Sensors were within 6% of cylinder break at 7-days

Age	Difference (psi)	Difference (%)
7-Day	294	5.8



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Patching Projects

Overview

- Wavelogix partnered with TXDOT on an 8-week program to test the REBEL Sensor on road patching projects to accelerate traffic opening.
- Each patching job deployed 4 REBEL Sensors: 3 in the patch and 1 in a 6” x 12” companion cylinder taken to the lab.
- Cylinders were broken at around 2, 4, 6, and 48 hours.
- The target for traffic opening was 1,800 psi at 6 hours.
- Across the 8-week period using the same mix design, there was a 27.9% variability for all cylinders and a 12.2% variability for all sensors.
- On average, the REBEL sensor reported target strength 1 hour before cylinder breaks and, in one case, 44 hours earlier

TXDOT SH-130 Repair

Date	7-13-2024 to 9-21-2024
Location	Austin, TX
Project Type	Pavement Repair

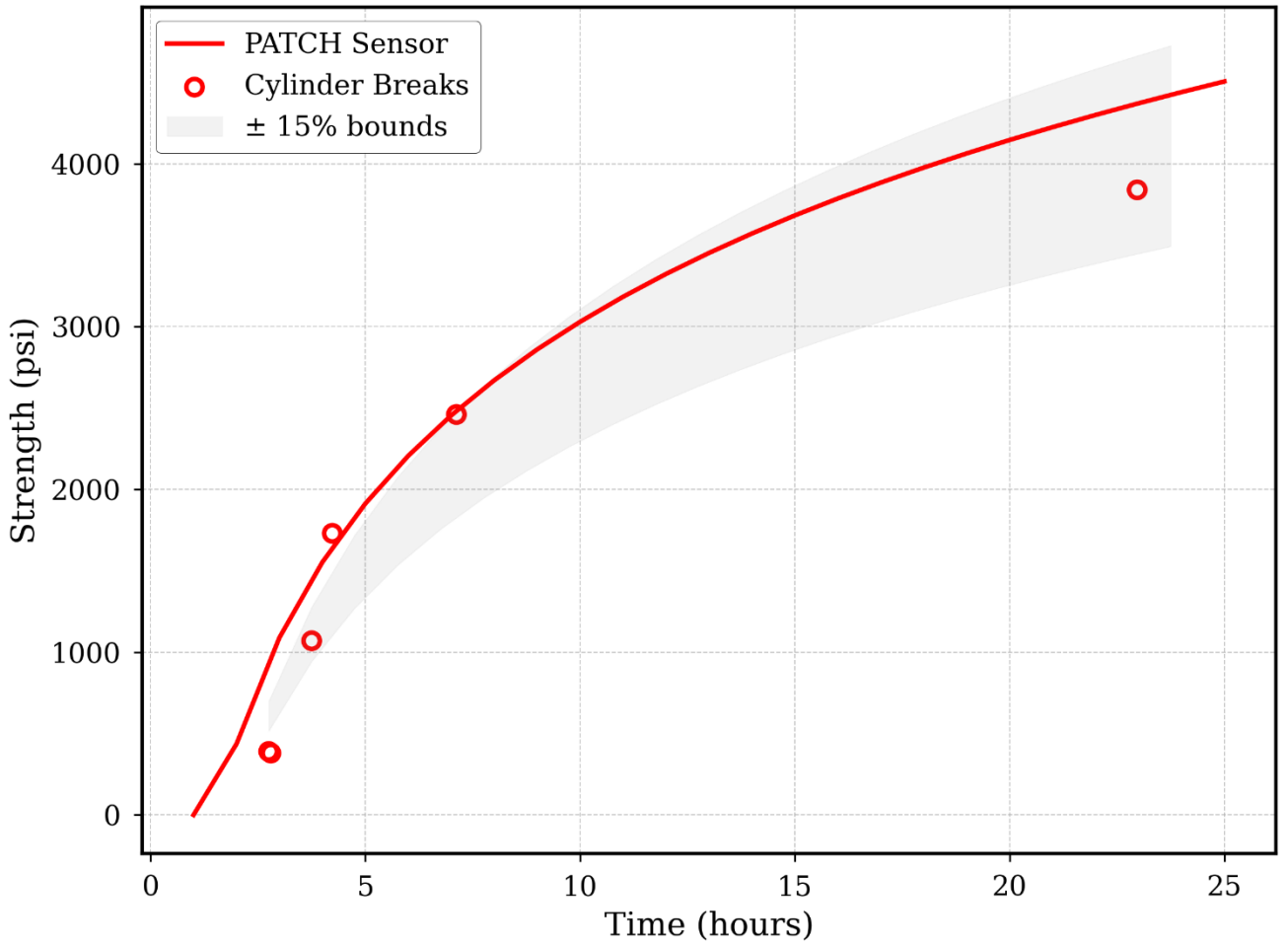
Ingredients	**Amount (/yd^3)**
Fine Agg.	1205 lbs.
Coarse Agg.	1920 lbs.
Cement	800 lbs.
Water	258 lbs.
W/C Ratio	0.32

TXDOT SH-130 Repair

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	4.8 Hours	7.1 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
3-Hour	557	145.0
4-Hour	367	34.3
5-Hour	94	5.4
7-Hour	20	0.8
24-Hour	529	13.8

Week 1 (7-13-24)



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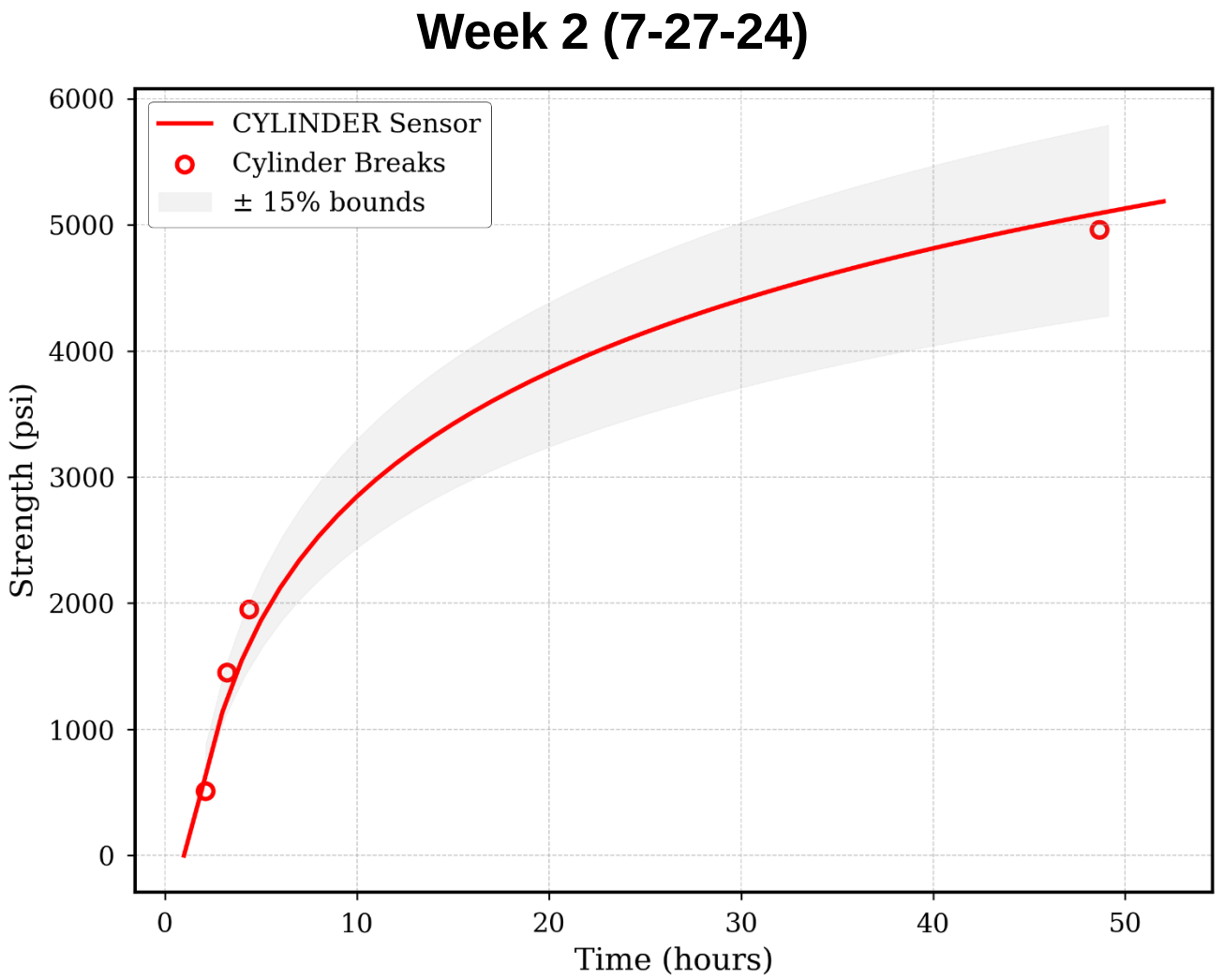
TXDOT SH-130 Repair

- The sensor in the patch failed so only the cylinder sensor is available

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	4.8 Hours	4.4 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
2-Hour	126	24.7
3-Hour	211	14.6
4-Hour	278	14.3
48-Hour	131	2.7



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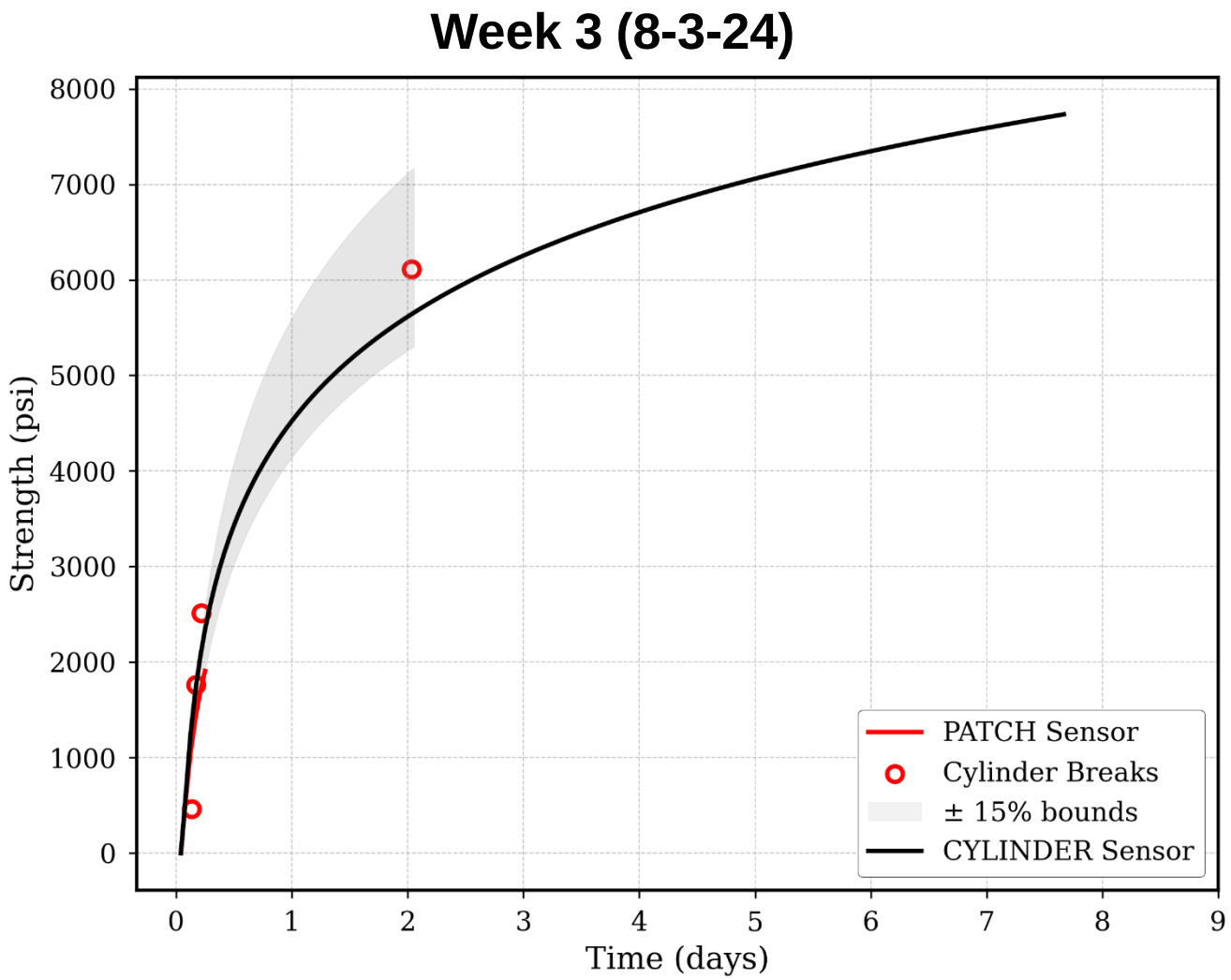
TXDOT SH-130 Repair

- The sensor in the patch was unplugged after 6 hours for traffic opening

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	4.8 Hours	5.3 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
3-Hour	800	173.9
4-Hour	152	8.6
5-Hour	573	22.9
48-Hour	466	7.6



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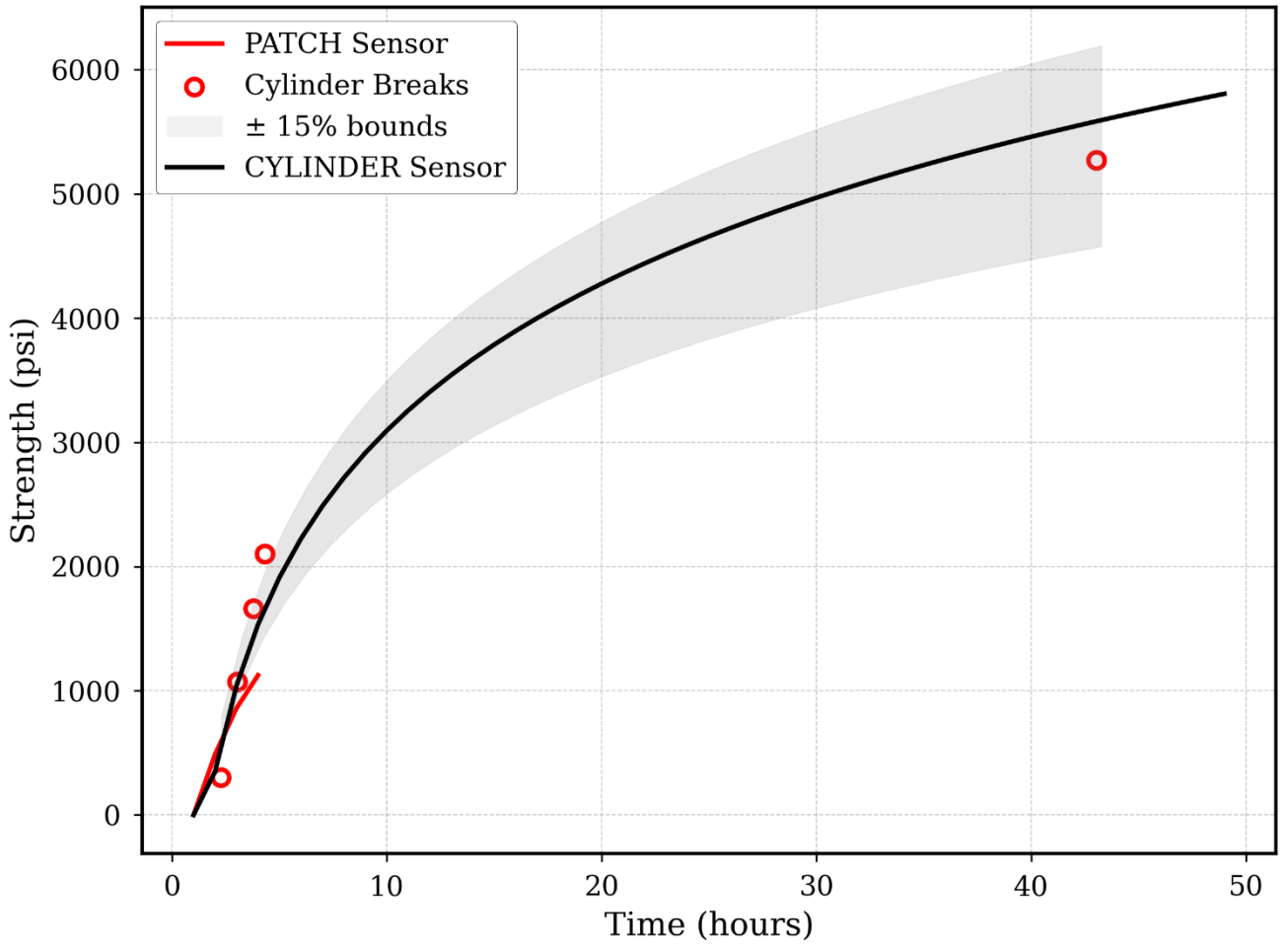
TXDOT SH-130 Repair

- The sensor in the patch was unplugged after 6 hours for traffic opening

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	4.8 Hours	4.3 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
2-Hour	267	89.2
3-Hour	100	9.3
4-Hour	461	26.4
43-Hour	315	6.0

Week 4 (8-10-24)



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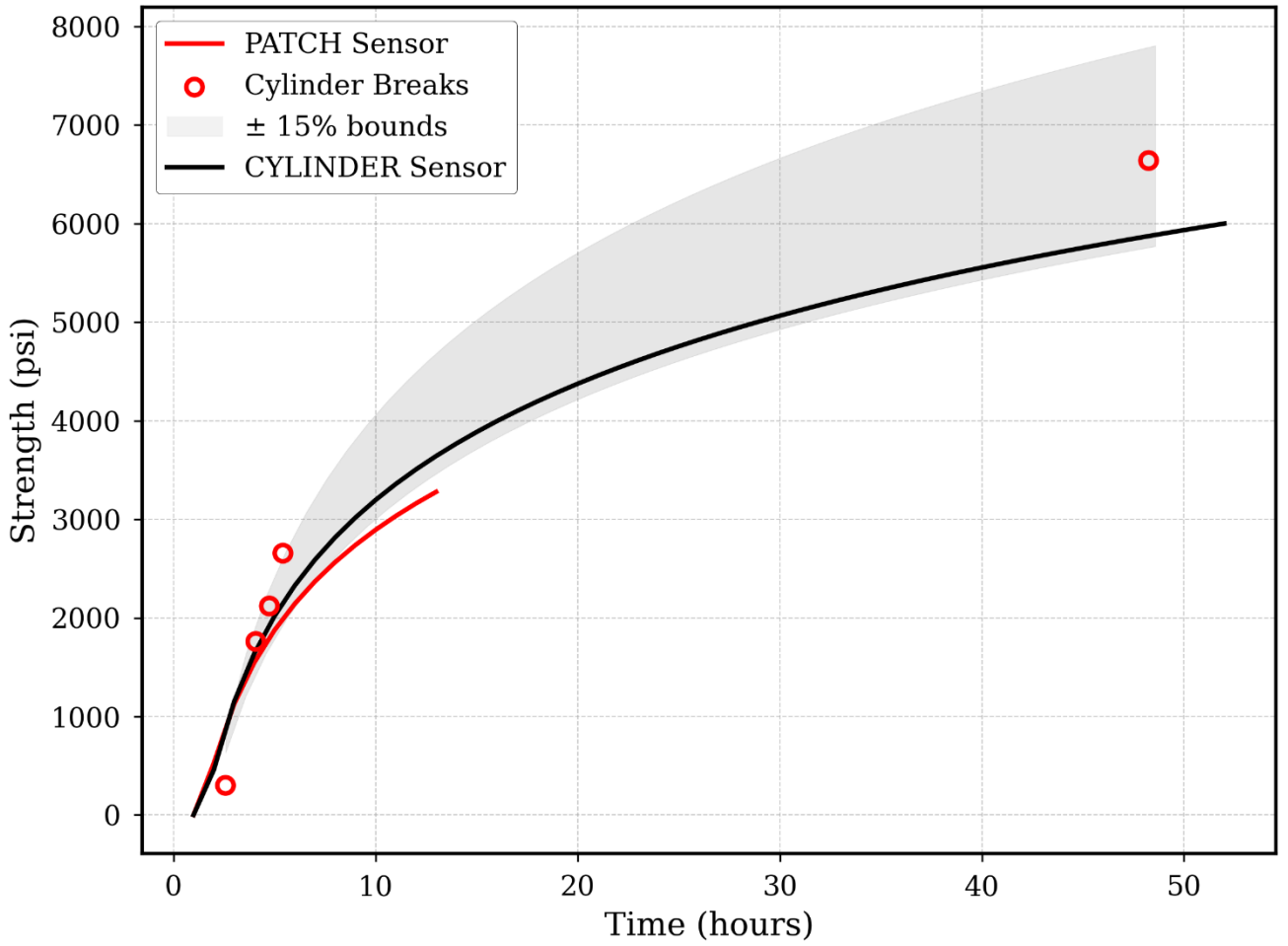
TXDOT SH-130 Repair

- The sensor in the patch was unplugged after 12 hours for traffic opening

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	5.0 Hours	4.8 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
3-Hour	564	188.0
4-Hour	141	8.0
5-Hour	264	12.5
6-Hour	590	22.2
48-Hour	766	11.5

Week 5 (8-17-24)



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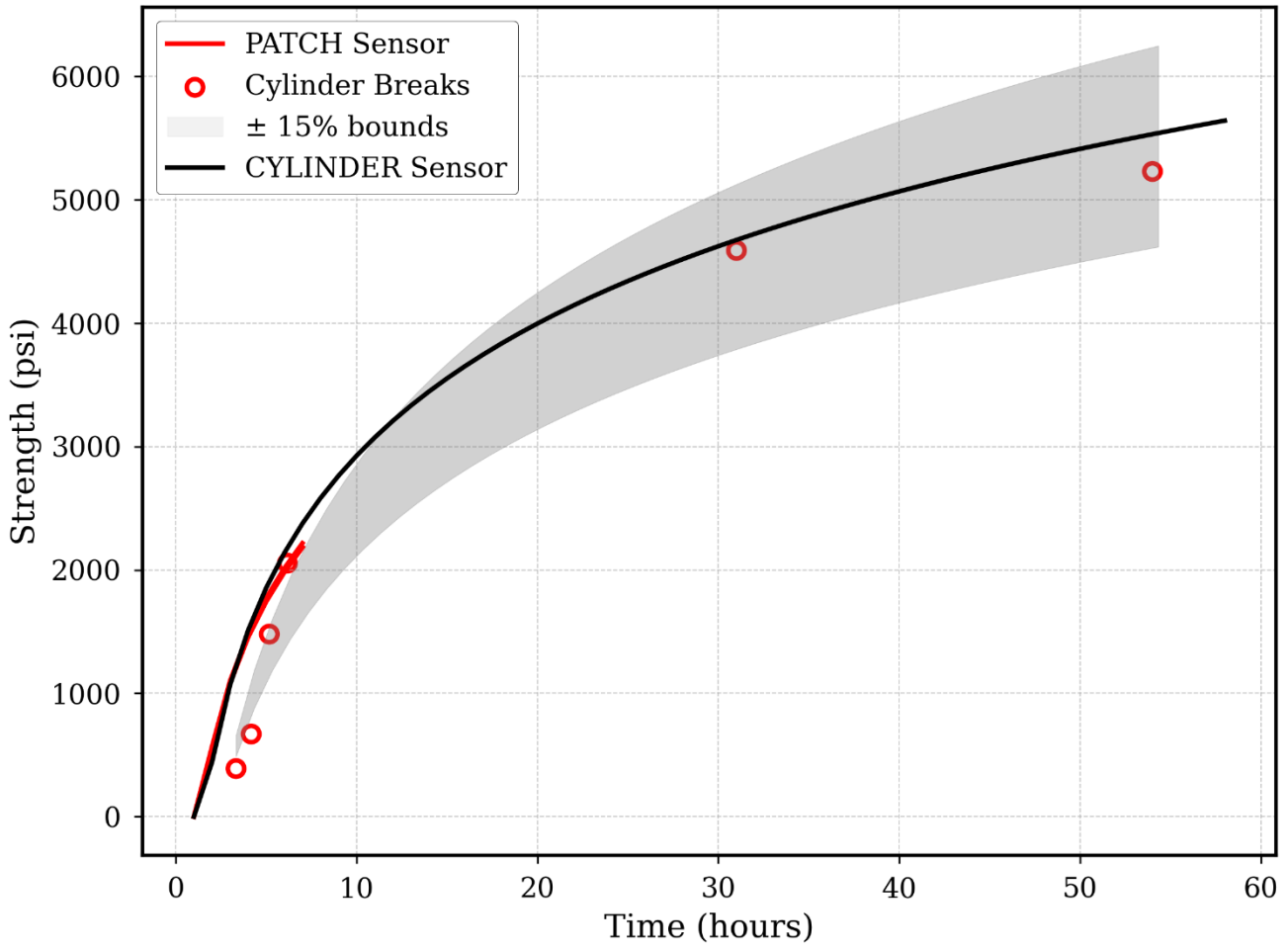
TXDOT SH-130 Repair

- The sensor in the patch was unplugged after 6 hours for traffic opening

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	4.8 Hours	6.2 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
3-Hour	822	210.9
4-Hour	857	128.0
5-Hour	342	23.2
6-Hour	75	3.7
31-Hour	84	1.8
53-Hour	302	5.8

Week 6 (9-7-24)



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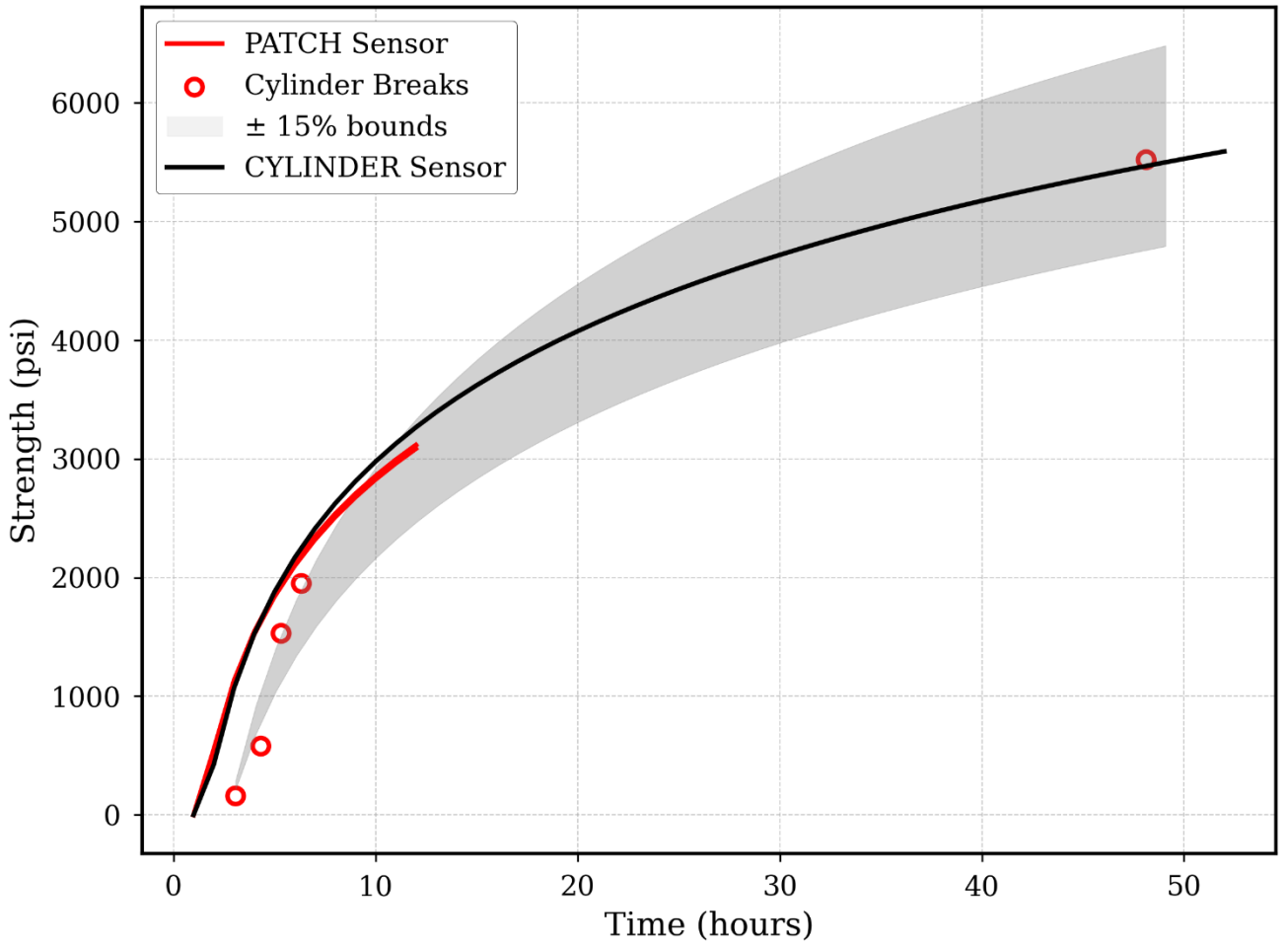
TXDOT SH-130 Repair

- The sensor in the patch was unplugged after 12 hours for traffic opening

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	4.5 Hours	6.3 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
3-Hour	984	615.0
4-Hour	1060	182.9
5-Hour	418	27.4
6-Hour	252	12.9
48-Hour	52	1.0

Week 7 (9-14-24)



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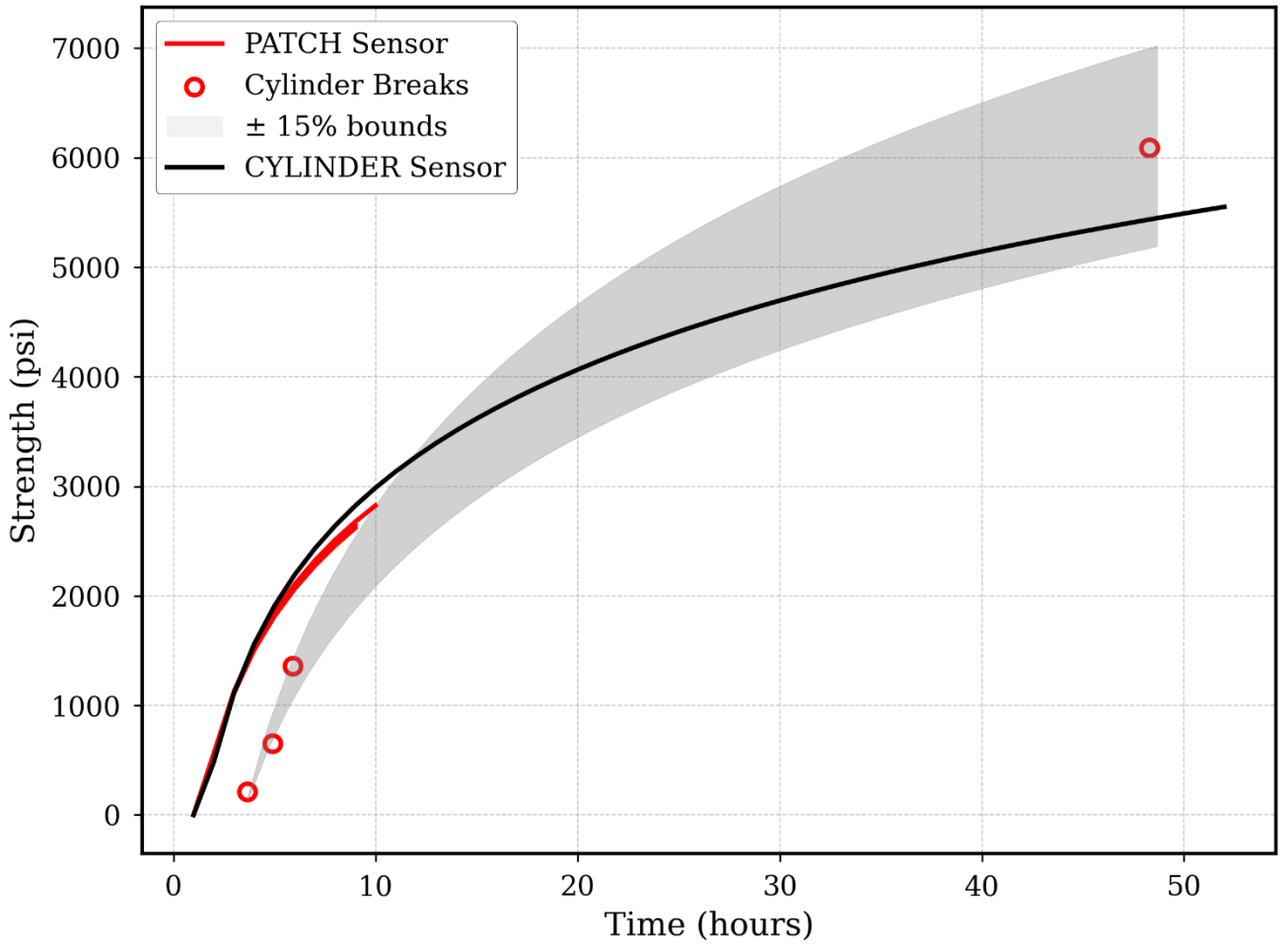
TXDOT SH-130 Repair

- The sensor in the patch was unplugged after 10 hours for traffic opening

	REBEL Sensor	Cylinder Break
Target Traffic Open 1800 psi	4.0 Hours	48.0 Hours

Age	Avg. Difference (psi)	Avg. Difference (%)
4-Hour	1185	564.5
5-Hour	1175	180.8
6-Hour	732	54.0
48-Hour	652	10.7

Week 8 (9-21-24)



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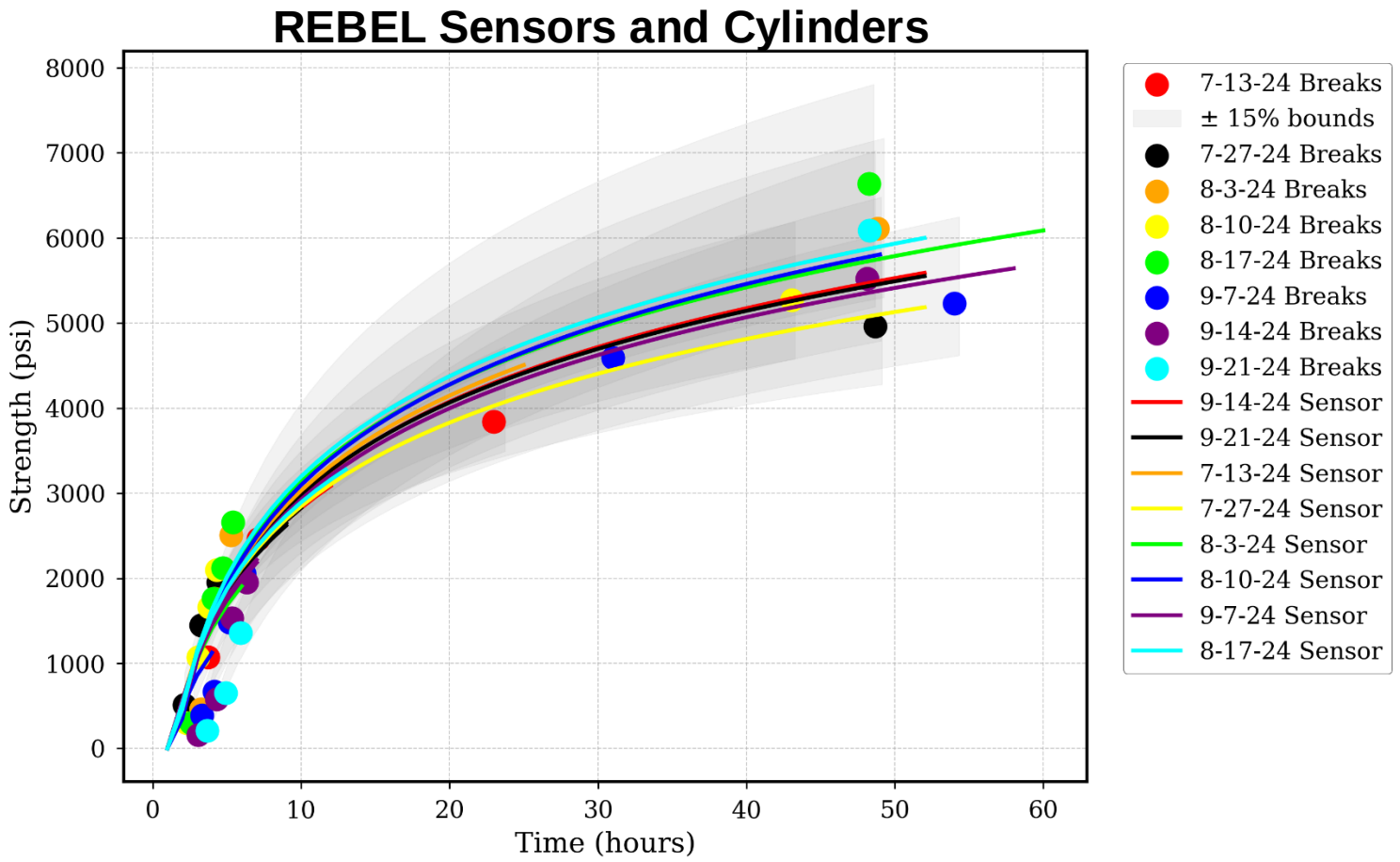
REBEL vs Cylinder Results

- The sensors had significantly less variability than the cylinders
- The sensor results are within 15% of the average of the cylinder results



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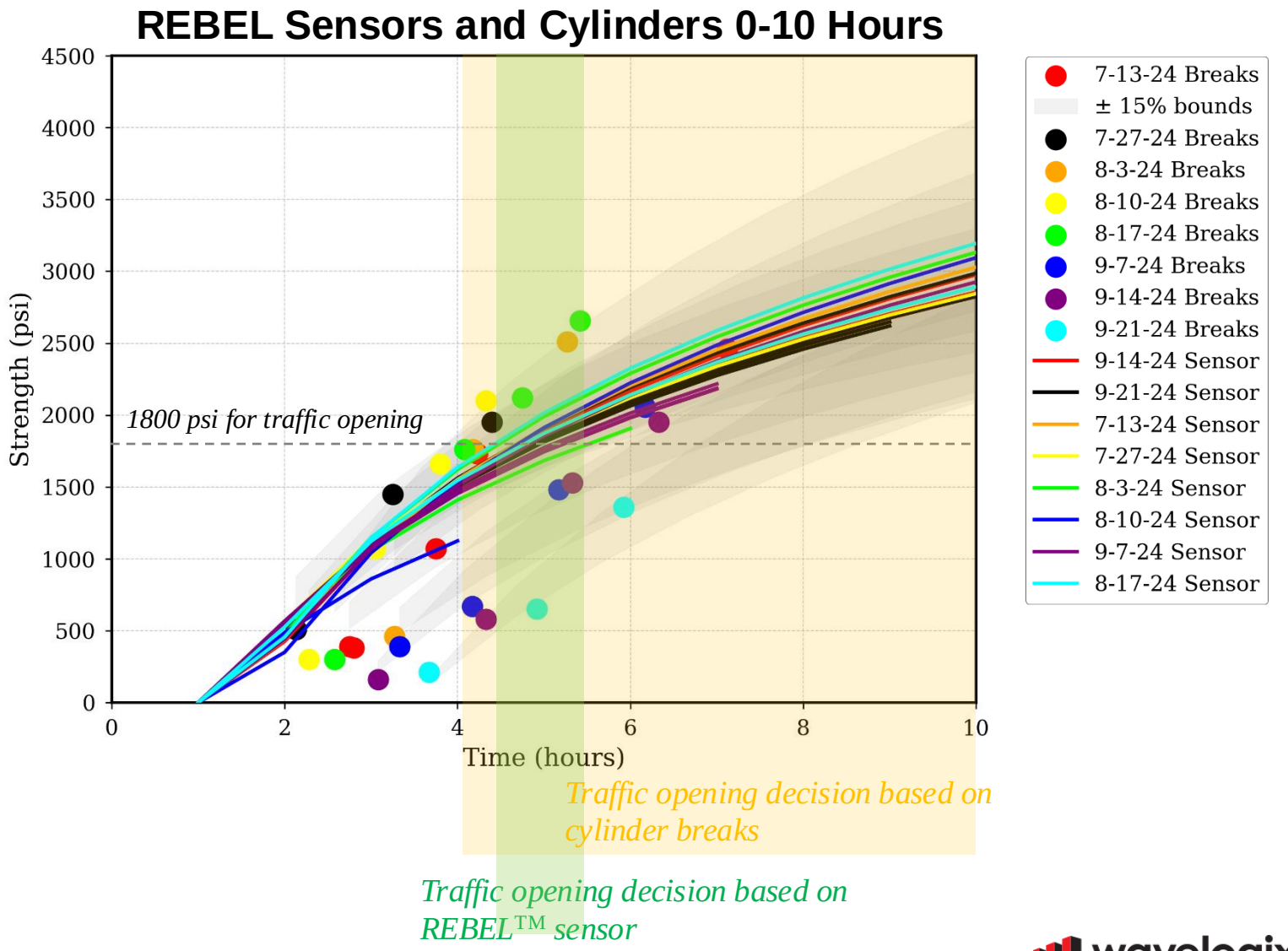
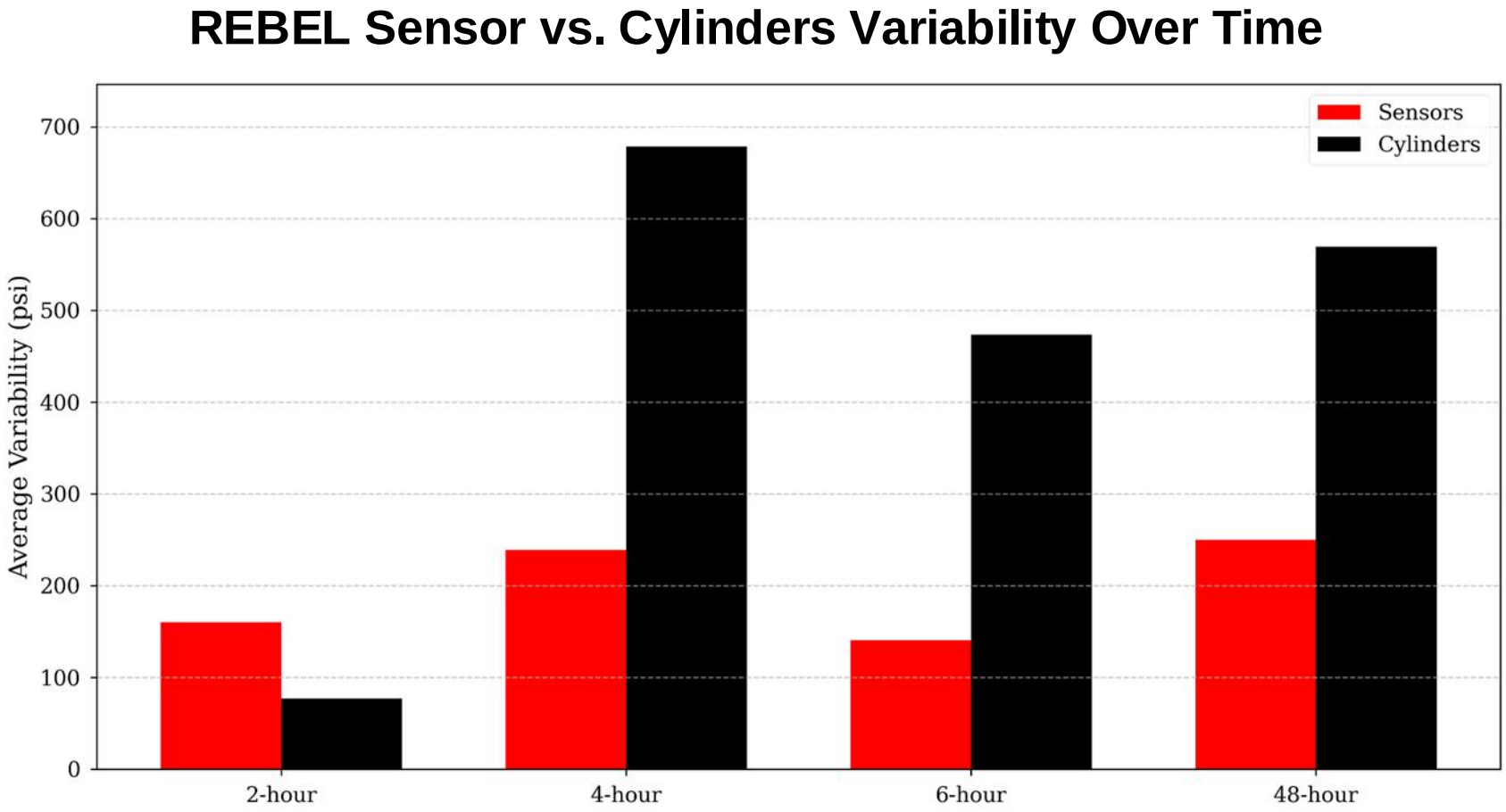
Comparison of Traffic Opening Time

- The sensors had significantly less variability than the cylinders
- **REBEL sensor indicates 5 hrs (4.5-5.5hrs) is the optimal traffic opening time; however; the cylinder shows 4-10 hrs;**
- **The current specs calls for 3 days traffic opening time; significant time saving could be realized using REBEL sensor.**



Consistency Comparison



- The sensors had significantly less variability than the cylinders at 4, 6, and 48-hours

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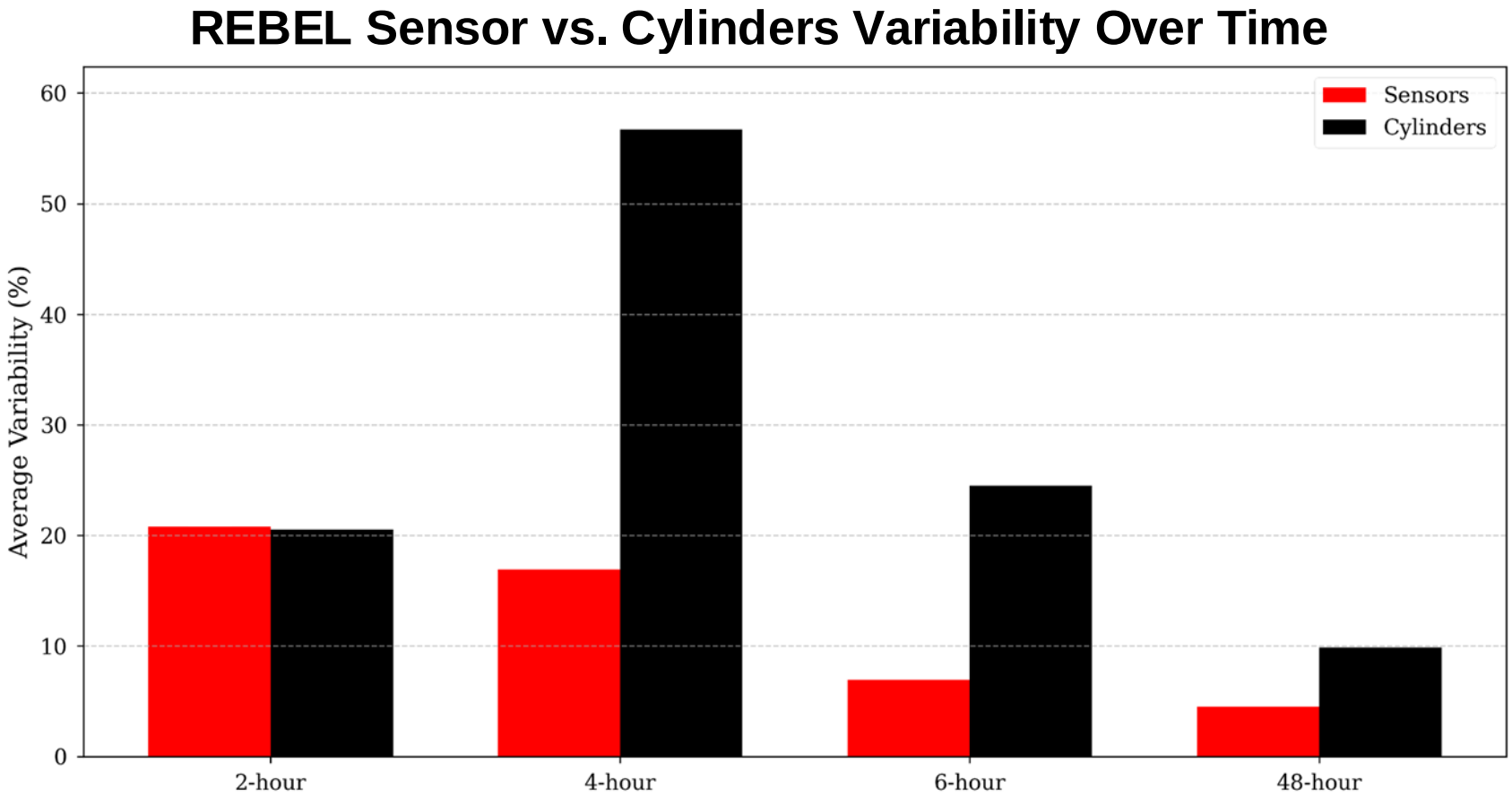
Consistency Comparison



- The sensors had significantly less variability than the cylinders at 4, 6, and 48-hours

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Conclusions

- REBEL sensors have following features
  - Superior consistency than traditional cylinder break data
  - Closer strength measurements to core drill data than cylinder breaks
  - Real-time strength data measurements and reporting

- REBEL sensors are suitable for use cases including
  - Traffic opening time decision making
  - Concrete form stripping time decision making
  - Concrete QC/QA at both early (e.g., 1-day) and long term testing ages (e.g., 28-day)