



# SLAG CEMENT IN PAVEMENTS AND STRUCTURES

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# ABOUT THE ILLINOIS TOLLWAY

294-mile system throughout 12 counties in Northern Illinois

Five roadways

Nearly 1.6 million daily drivers

User-fee system





# 2024 CAPITAL PROGRAM HIGHLIGHTS



## Tri-State Tollway (I-294)

Roadway widening and reconstruction

- Wolf Road to St. Charles Road
- Cermak Road to Flagg Creek

I-290/I-88 Interchange at I-294 reconstruction

88<sup>th</sup>/Cork Avenue Interchange at I-294 reconstruction

163<sup>rd</sup> Street Toll Plaza Improvements



## I-490 Tollway

Interchange construction

- I-490/I-90
- I-490/IL 390
- I-490/I-294

I-490 Tollway advance work

Canadian Pacific Railway

Bridge construction  
(Bensenville Yard)



## Systemwide

Grading improvements

Bridge and ramp repairs

ITS improvements



# COMMITMENT TO SUSTAINABILITY

## Since 2012, the Tollway has recycled

- Nearly 4,275,000 tons of recycled asphalt pavement
- More than 4,027,000 tons of recycled concrete
- Over 119,000 tons of slag cement
- More than 191,000 tons of fly ash
- Roughly 603,000 recycled tires
- Over 166,000 tons of recycled shingles







# CONCRETE MIXTURES



# CONCRETE TYPES

## Illinois Tollway

- **Class TL**
- **Class AX**
- **Class CAL**
- **Class HP**
- **Mass concrete**

## IDOT

- **Class PV**
- **Class SI**
- **Class BS**
- **Class PC**
- **Class PS**
- **Class DS**
- **Class SC**





# CONCRETE MIXTURE TYPES

## Class TL

- Pavement

## Class AX

- High early strength patching
- 2,500 psi in 16-24 hours for pavement
- 4,000 psi in 36-48 hours for structures

## Class CAL

- Very high early strength patching
- 2,500 psi in 4 hours for pavement
- 4,000 psi in 6 hours for structures

## Class HP

- High-performance concrete
- Bridge deck, approach slab, transition approach, moment slab

## Mass concrete

- Minimum dimension of the concrete structure exceeds 5 feet
- $\Delta T \leq 35^{\circ}\text{F}$
- $T_{\text{max}} \leq 160^{\circ}\text{F}$



# GOALS FOR TOLLWAY CONCRETE MIXTURE DESIGNS

## Strength

- Adequate, but not excessively over-designed

## Durability

- Freeze/thaw
- Shrinkage
- Chloride penetration resistance
- Alkali-silica reaction

## Constructability

- Batching
- Workability

## Performance-focused

- Reduce prescriptive requirements
- Encourage innovation

## Sustainability

- Increased supplementary cementing material usage
- Recycled material



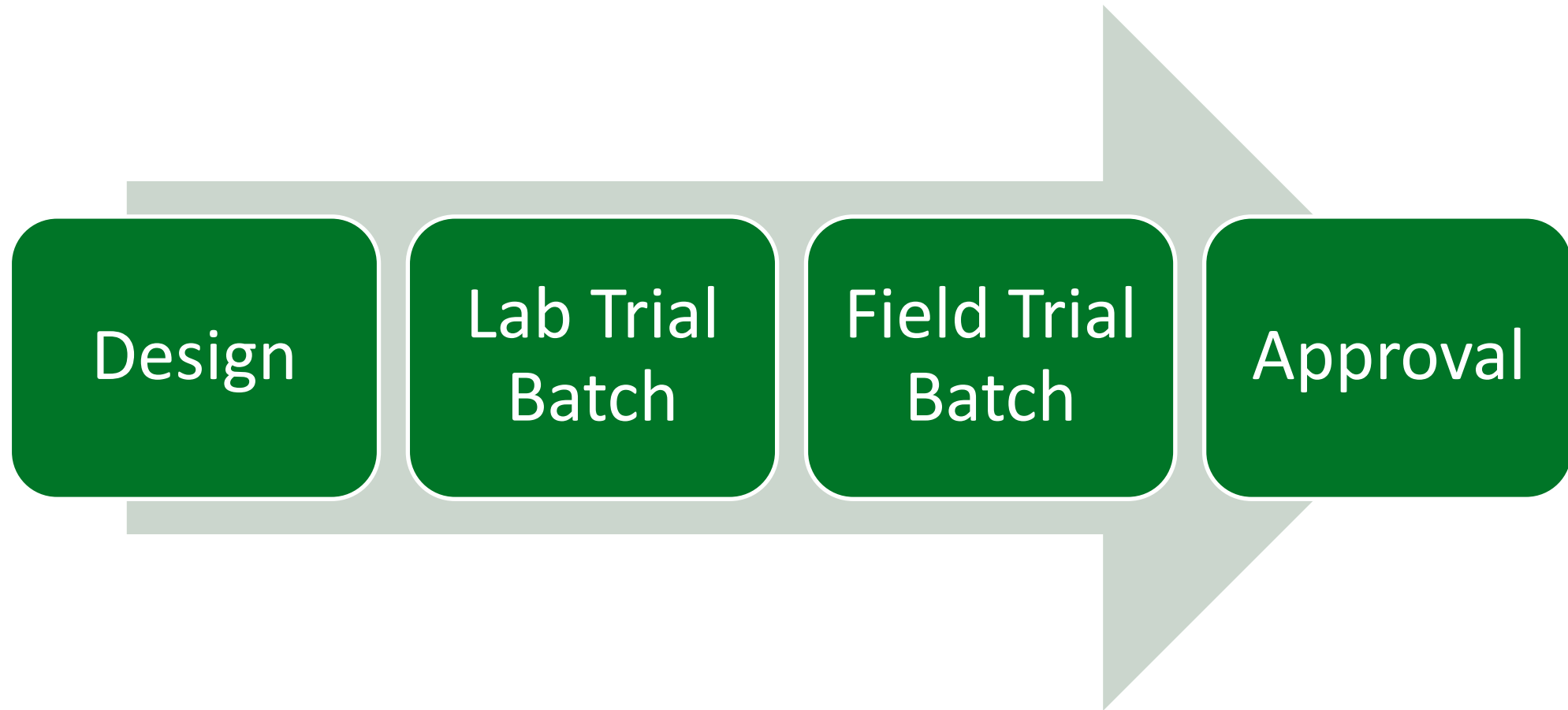


# TESTING REQUIREMENTS FOR DESIGN APPROVAL

Parameter	Test Method	Mix Types
Compressive strength	AASHTO T 22	All
Slump loss	AASHTO T 119	HP, MC
Plastic air	AASHTO T 152	All
Length change	AASHTO T 160	AX, HP, MC
Ring shrinkage	ASTM C 1581	AX, HP, CAL
Cement Alkali (for ASR mitigation)	AASHTO T 105	All except CAL
Hardened air (to avoid Freeze Thaw testing)	ASTM C 457	All except CAL
Chloride penetration	AASHTO T 277 and T 358	AX, HP



# MIXTURE DESIGN AND APPROVAL PROCESS





# CONCRETE PAVEMENT

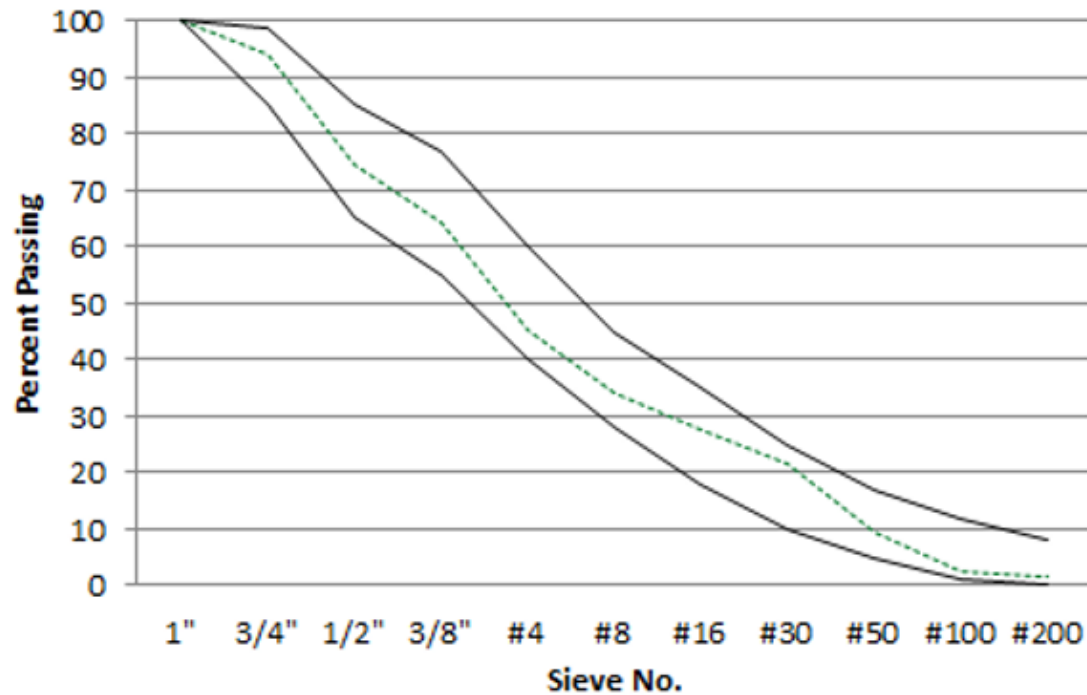
## Class TL

- Ternary
  - 35 to 50 percent SCM
- Optimized gradation
  - Two coarse aggregates
  - Virgin aggregate
- Water/cementitious ratio during production
  - Design:  $-0.03$ ,  $+0.00$
- Compressive strength
  - 2,500 psi at 3 days
  - 3,500 psi at 14 days

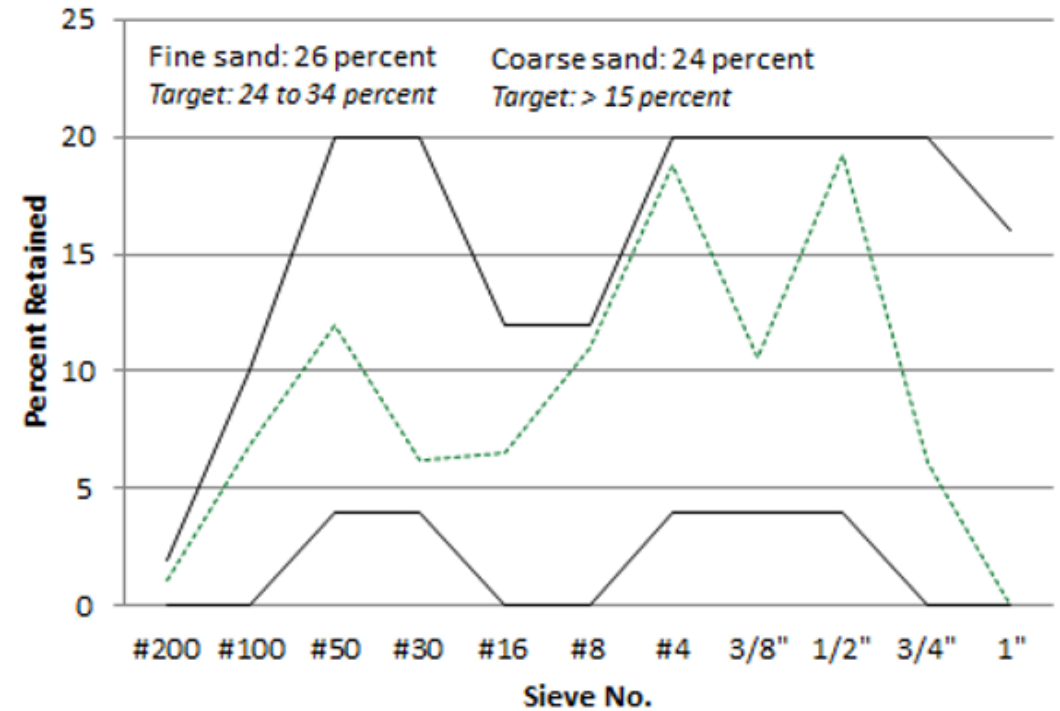


# OPTIMIZED GRADATIONS

## Class TL Combined Gradation



## Tarantula Curve





# CONCRETE PAVEMENT

## Class TL – typical mix designs

- 560-620 lbs. total cementitious
- Type IL cement – 100 percent of supply for the Tollway
- 35 to 40 percent SCM (three-day strength is important to contactors)
- SCM – 50:50 to 30:70
- 70 percent is fly ash or slag cement, depending upon producer
- Fly ash supply is *diminishing*



# BRIDGE DECK

## Class HP

- Compressive strength: 4,000 psi at 14 days
- Trial batch
  - Freeze/thaw or hardened air
  - Slump loss
  - Linear shrinkage
  - Chloride penetrability
- Shrinkage
  - 1.5 gal./cy. SRA and < 605 lbs./cy total cementitious or ring shrinkage in trial batch
- Water/cementitious ratio during production
  - Design:  $-0.03$ ,  $+0.00$





# BRIDGE DECK

## Class HP – mix designs

- 580-620 lbs. total cementitious
- Type II cement
- Typically 30 to 50 percent SCM (required seven-day wet cure)
- SCM – primarily slag cement



# MASS CONCRETE

## Class MC

- Compressive strength
  - 1,000 psi at two days
  - 3,500 psi at 14 days
  - 6,000 psi at 28 days
  - 7,000 psi at 56 days (trial batch)
- Freeze/thaw or hardened air (trial batch)
- Slump loss (trial batch)
- Linear shrinkage (trial batch)
- Estimated temperature rise
- Equivalent cement ratio
- Water/cementitious ratio during production
  - Design:  $-0.03$ ,  $+0.00$





# MASS CONCRETE

## Class MC – mix designs

- 525-540 lbs. total cementitious
- Low heat, low strength gain
- Type IL cement
- 35 to 50 percent SCM
- SCM – primarily slag cement



# MATURITY METHOD

## Pavement

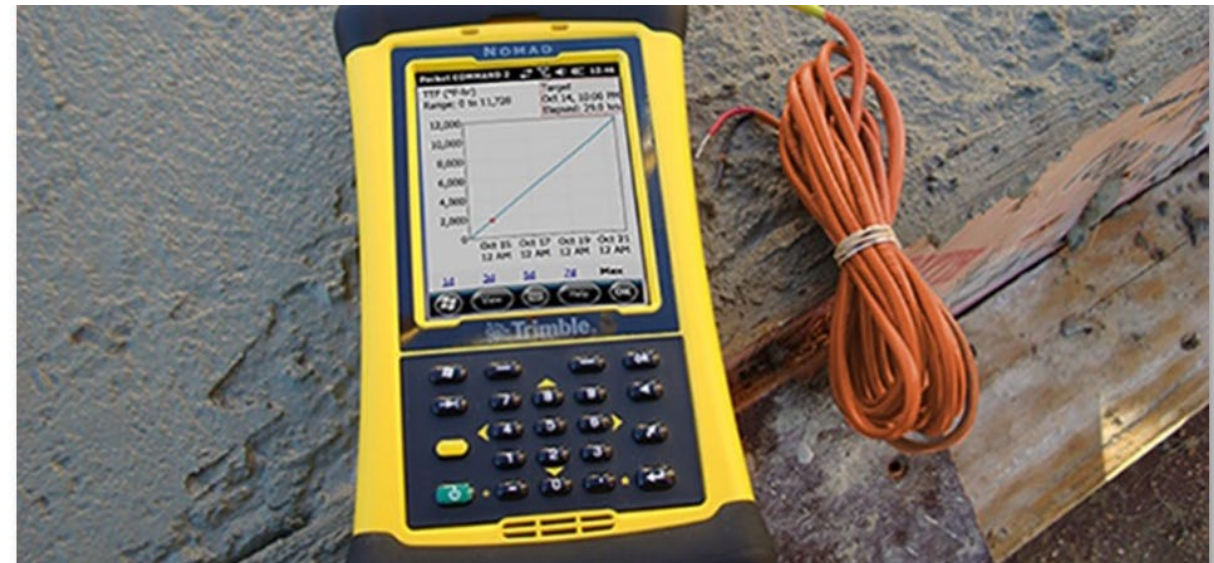
- Opening to traffic

## Structures

- Removing forms

## Cold weather

- Verify protection methods







# UPDATES ON CONCRETE INITIATIVES





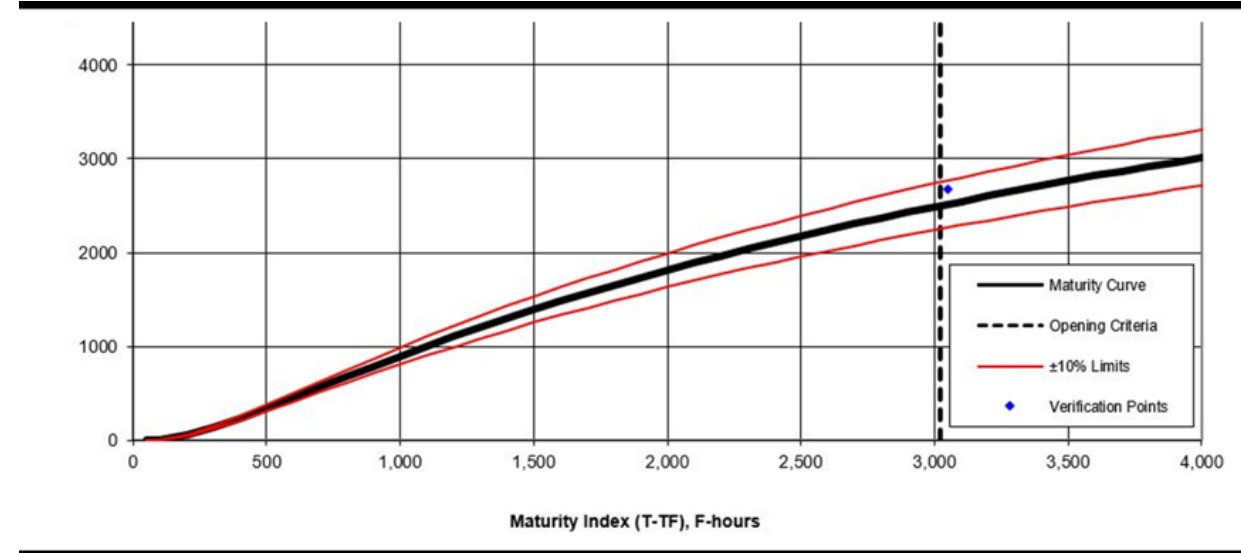
# MATURITY FOR ESTIMATING IN-PLACE COMPRESSIVE STRENGTH

## New specification

- Requires maturity to determine in-place concrete strength
- Maturity estimates in-place concrete strength from temperature probes
- Construction traffic allowed on pavement at 2,500 psi. In the summer this took 2-3 days
- Maturity also dictates when winter protection can be removed

## Reception

- Widely accepted by construction managers and contractors due to its ability to accelerate schedules
- Shown to be accurate and reliable year-round



Date	Time	Age (hours)	Air Temp (deg F)	Temp Reading (deg F)	T-TF at age (deg F-hr)	Sum T-TF (deg F-hr)
9/25/23	11:14 AM	0.00		74.93	0	0
9/25/23	3:14 PM	4.00		83.86	190	190
9/25/23	7:14 PM	8.00		91.2	222	412
9/25/23	11:14 PM	12.00		88.47	231	643
9/26/23	3:14 AM	16.00		84.78	219	862
9/26/23	7:14 AM	20.00		81.88	205	1067
9/26/23	11:14 AM	24.00		80.17	196	1263



# MIT SCAN FOR DOWEL ALIGNMENT

Significant amount of jointed plain concrete pavement quantities in *Move Illinois*

Dowel alignment tied to long-term pavement performance

Testing ensures best practices, low deficiency rate and quick adjustments



# CONCRETE RESISTIVITY

Simple and easy test

Indicates resistance to chlorides,  
durability

Portland Cement Concrete Special  
Provision requires it be tested for mix  
qualification

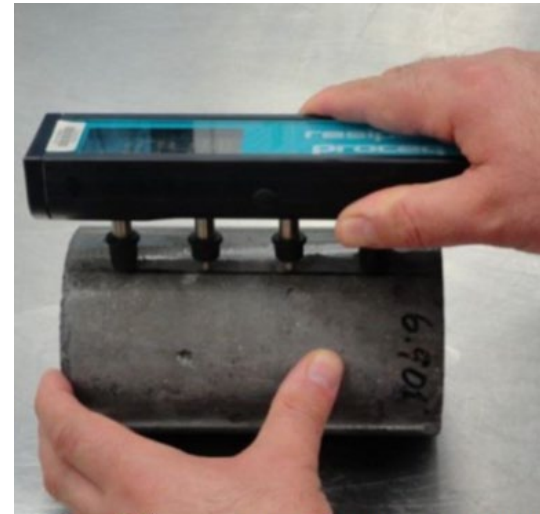


Table 3 AASHTO T 358<sup>3</sup> Chloride Ion Penetrability Classification

Chloride Ion Penetrability	Surface Resistivity, 4-by-8 in. cylinder (kΩ-cm) a = 1.5
High	<12
Moderate	12-21
Low	21-37
Very Low	37-254
Negligible	>254

a – Wenner probe tip spacing



# CONCRETE RESISTIVITY

## 2019-2021 Tollway Test Results

Mixture Type	Average 28-day (kΩ-cm)	Minimum 28-day (kΩ-cm)	Proposed 28-day Special Provision Limit (kΩ-cm)
TL	18.7	13.7	14.0
HP	22.9	17.0	19.0
AX	17.9	15.7	15.0

## 2023 Concrete Producer Test Results

Mixture Type	Average 28-day (kΩ-cm)	Minimum 28-day (kΩ-cm)
TL	20.6	16.4
HP	22.2	16.4
AX	17.4	14.0



# CERTIFICATIONS

## Production

- NRMCA Plant and Truck Certification

## Personnel

- ACI Concrete Strength Testing Technician



American Concrete Institute

*Always advancing*





# E-TICKETING IMPLEMENTATION OVERVIEW

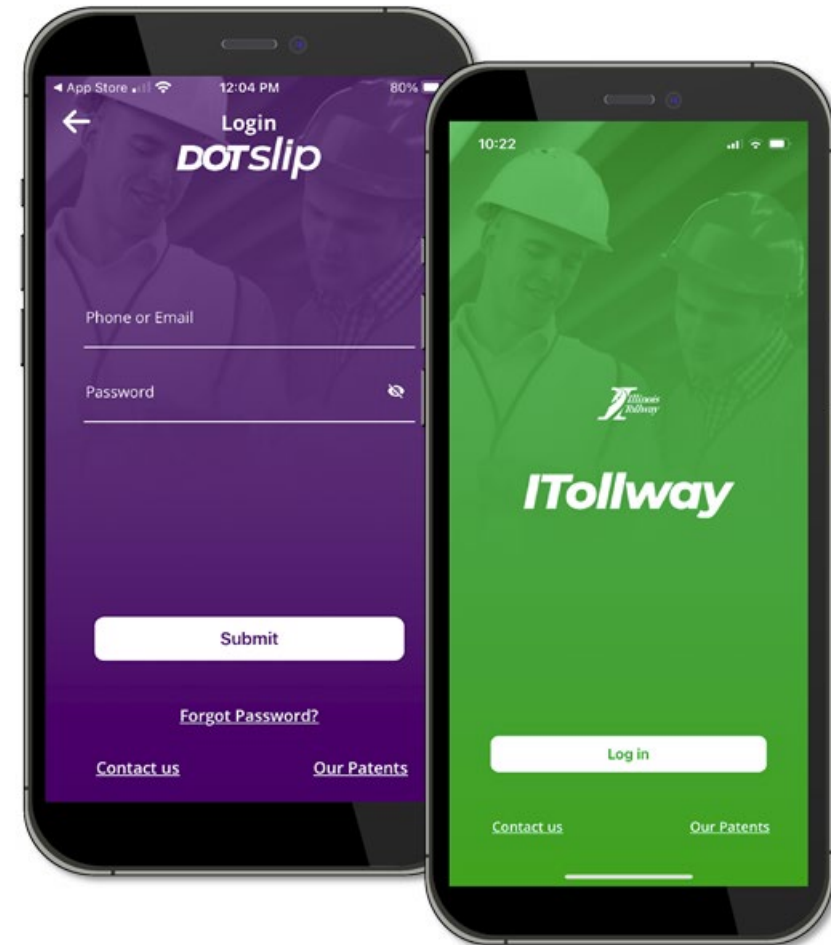
**Being used for all contracts in 2024**

## **Currently**

- 45 contracts – active and completed
- 53 producers/plants connected
- 230 users
- More than 45,000 tickets submitted in 2023

**Tutorial videos for CMs and contractors**

**Accept tickets and assign pay items in the field**







THANK YOU