Supplementary Information

Drone-Based AI for Automated Bridge Defect Detection and Condition Assessment

Supplementary Table 1. SMART project Stage 1 Project Service Area[1]

County	Population	Community Size	No. of Census Tracts	APP	Population in APP	% Population in APP	# of OA	Population in OA	% Population in OA
Sedgwick	523,824	Large	124	53	176,418	33.7%	9	25,301	4.8%
Saline	54,303	Midsized	12	3	12,993	23.9%	2	7,954	14.6%
Cowley	34,549	Rural	11	4	10,606	30.7%	2	7,904	22.9%
Cloud	9,032	Rural	4	0	0	0%	0	2,215	24.5%
Total	621,708	—	151	60	200,017	32.2%	13	43,374	7.0%

Notes: APP = Area of Persistent Poverty; No. = Number, OA = Opportunity Zone

USDOT Grant Location Verification map

Community's Opportunity Zones map

Supplementary Table 2. Bridge Deficiency and Safety Information within the Project Service Area[2]

County	No. of Bridges	No. of Structurally Deficient Bridges	% of Structurally Deficient Bridges	Bridges Not Meeting Traffic Safety Standards
Sedgwick	1,327	46	3.47%	30.17%
Saline	371	4	1.08%	51.15%
Cowley	339	21	6.19%	76.62%
Cloud	317	15	4.73%	65.06%
	Total = 2,354	Total = 86	Average = 3.87%	Average = 55.88%

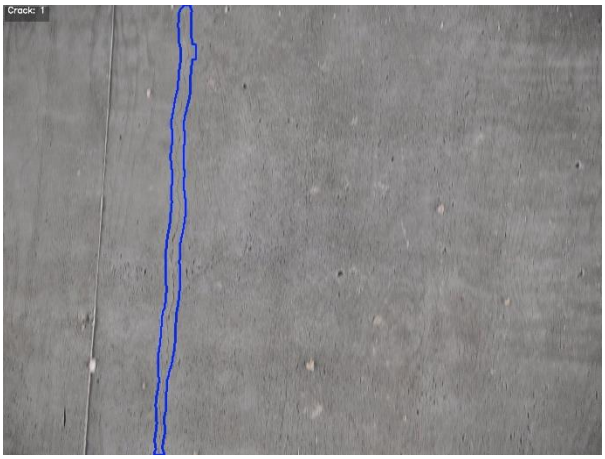
Notes: No. = Number; % = Percentage

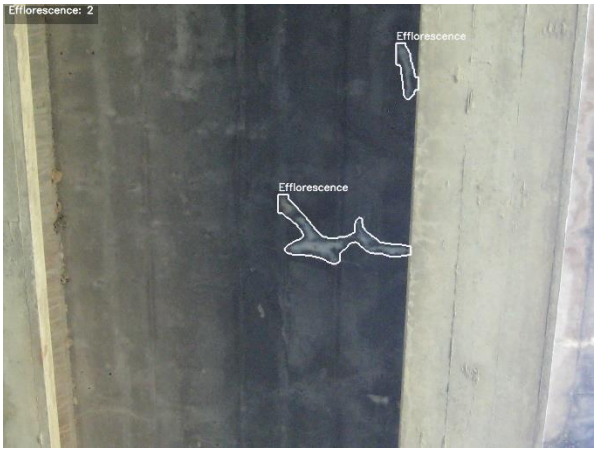
Supplementary Table 3. Bridge Inventory and Condition Ratings from SMART Stage 1 AI-Based Field Inspections

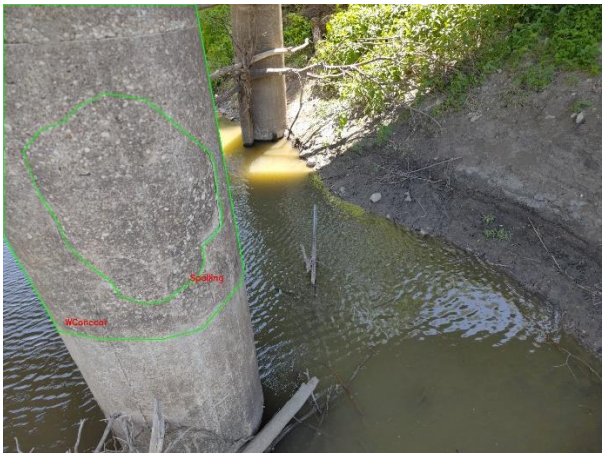
Bridge	LAT 016 (deg)	LONG 017 (deg)	Age (Yr)	STRUCTURE TYPE 043B	DECK COND 058	SUPER-STRUCTURE COND 059	SUB-STRUCTURE COND 060	BRIDGE CONDITION RATING
Cowley Co. Bridge#1	37.041578	-96.395720	64	1	6	6	7	F
Cowley Co. Bridge#2	37.171949	-97.021492	68	2	5	5	6	F
Cowley Co. Bridge#3	37.243409	-96.523818	69	4	6	7	6	G
Cowley Co. Bridge#4	38.523742	-97.312357	41	2	6	7	7	G
Cowley Co. Bridge#5	37.171810	-96.582653	72	2	5	6	6	F
Sedgwick Co. Bridge#1	37.52594	-97.253046	72	2	4	6	6	P
Sedgwick Co. Bridge#2	37.30107	-97.461568	19	1	6	7	5	F
Sedgwick Co. Bridge#3	37.54224	-97.395552	26	1	4	6	6	P
Sedgwick Co. Bridge#4	37.47481	-97.394800	26	1	4	5	7	P
Sedgwick Co. Bridge#5	37.51215	-97.232186	68	2	6	8	7	F
Saline Co. Bridge#1	38.523438	-97.475464	62	3	6	7	7	F
Saline Co. Bridge#2	38.433614	-97.411324	27	1	7	7	7	G
Saline Co. Bridge#3	38.372852	-97.363754	65	4	6	6	6	F
Saline Co. Bridge#4	38.523742	-97.312357	41	2	6	6	7	F
Saline Co. Bridge#5	38.544885	-97.240350	40	2	7	7	7	G
Cloud Co. Bridge#1	39.312875	-97.364872	56	1	7	7	7	G
Cloud Co. Bridge#2	39.595249	-97.535747	5	1	8	8	8	G

Cloud Co. Bridge#3	40.000756	-97.545652	42	2	7	7	6	F
Cloud Co. Bridge#4	39.340070	-97.542383	70	2	7	7	7	G
Cloud Co. Bridge#5	39.593521	-97.555539	51	2	7	7	7	G

Supplementary Table 4. Visual Characteristics, Causes, and Examples of Concrete Defects Considered in the SMART Stage 1 AI Inspection Project

Type of Defect	**Definition**	**Causes**	**Visual examples**
Crack	Separation or fracture in concrete that may occur before or after hardening, often appearing as visible lines of varying length and depth.	Plastic shrinkage due to rapid water loss, settlement over embedded items, drying shrinkage, thermal contraction, subgrade settlement, overloading, or long-term deterioration from freeze–thaw cycles, alkali–aggregate reactivity, sulfate attack, or reinforcement corrosion[3].	
Alligator Cracks (ACrack)	A network of fine, shallow surface cracks forming a chicken-wire or map-like pattern;	Minor surface shrinkage due to rapid drying, low humidity, high temperature, direct sun, or	

	typically cosmetic rather than structural.	wind; poor curing practices; or surface treatments (e.g., dry cement dusting) that accelerate drying[3].	
Efflorescence	A whitish crystalline deposit that appears on the surface of concrete, typically soon after construction; usually aesthetic rather than structural[4].	Migration of soluble salts dissolved in moisture within the concrete to the surface, followed by evaporation of water; influenced by salt content in materials, moisture penetration, and drying conditions (temperature, humidity, wind)[3].	 

Water-concrete Corrosion (WConccor)	Surface damage to concrete that appears as erosion, abrasion, or general material loss, often presenting as washouts or planar corrosion defects that are visually difficult to distinguish.	Continuous exposure to running water (e.g., at bridge piers or abutment walls), freeze–thaw cycles, chemical attacks (acids, salts), or mechanical abrasion, all of which gradually wear away the concrete surface[5].	 
Spalling	A deeper surface defect of concrete characterized by localized breaking, flaking, or depression of the surface, often forming circular, oval, or elongated cavities.	Internal pressure or expansion within concrete, freeze–thaw cycles, chloride-induced corrosion of reinforcing steel, improper joint design or construction, bond failure, mechanical impact, or fire	

		and weathering effects[3].	
Wetspot	A darker or moist area visible on the concrete surface where water accumulates or fails to drain properly; may indicate potential deterioration zones.	Blocked or damaged drainage, leaky joints, cracks in the deck, or retained water from recent rainfall. Persistent wet areas can accelerate damage by carrying deicing salts and increasing exposure to carbonation and chloride penetration[5].	
Rust	A reddish to brownish discoloration on concrete surfaces caused by the oxidation of embedded reinforcement bars or nearby metallic elements.	Loss of the protective alkaline environment (pH > 9.5) due to carbonation, ingress of water and carbon dioxide through cracks or porous concrete, and chloride attack from deicing salts or marine exposure. These processes	 

		depassivate the steel, leading to oxidation and rust staining on the surface.	
Exposed Rebars	Reinforcing steel that has become visible and unprotected due to spalling or loss of concrete cover, leaving it directly exposed to the atmosphere[6].	Concrete spalling from reinforcement corrosion products, carbonation, or cracking; chloride penetration in coastal or deicing environments ; inadequate cover thickness; and environmenta l factors (temperature, humidity, marine salts) that accelerate uniform corrosion and mechanical property degradation of the steel[5].	

References

1. Bureau, U. C. 2020 Census Results. https://www.census.gov/programs-surveys/decennial-census/decade/2020/2020-census-results.html.
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3. Portland Cement Association. Concrete Slab Surface Defects: Causes, Prevention, Repair. Portland Cement Association (2001). Available at: https://www.concreteisbetter.com/wp-content/uploads/2013/06/Slab-Surface-Prevention-Repair-a.pdf. (accessed 28 October 2025).

4. International Concrete Repair Institute. Concrete Repair Terminology. International Concrete Repair Institute (2016). Available at: https://www.icri.org/page/repairterminology. (accessed 28 October 2025).

5. Flotzinger, J., Rösch, P. J. & Braml, T. dacl10k: Benchmark for Semantic Bridge Damage Segmentation.

6. Papadopoulos, M. P., Apostolopoulos, C. A., Zervaki, A. D. & Haidemenopoulos, G. N. Corrosion of exposed rebars, associated mechanical degradation and correlation with accelerated corrosion tests. *Constr Build Mater* **25**, 3367–3374 (2011).