



Creation of Statewide Inventory for INDOT's Retaining walls



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Retaining Wall Asset Program



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Geotechnical Asset Management Plan

Phase I

- Know your Assets
- Quantify Your Assets
- Data & Condition Assessment
- Condition based Ranking & Monitoring program

Strategy and Planning

- Limited in-house resources
- Development of Criteria & guidelines
- Selection of consultants
- Collection of data
- Implementation

Retaining Wall Asset Program

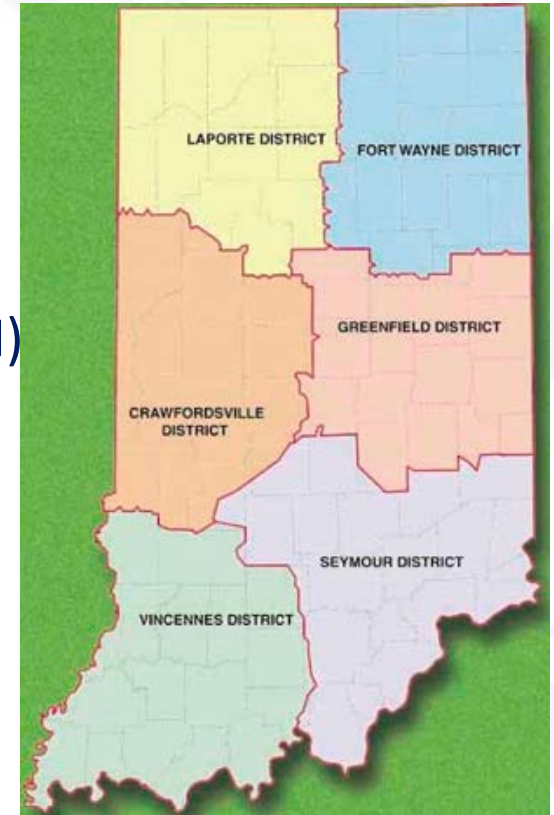
- Streamline In-house resources
- Drafted INDOT Inspection Manual for Retaining walls
- Hired consultants with experience in GAM
- Using ArcGIS, ESRI application to input data
- Condition ratings of walls recorded
- Monitoring Program → Interface to Phase II

Collect Asset Inventory

- Hired consultants
- Collector App, ESRI (GIS based)
- Consultants inspect assets as per INDOT inspection manuals
- Collect inventory- Office
 - * Plans
 - * Reports
- Collect inventory- Field
 - * Permissions / Coordination
 - * Inspection & Condition rating

Retaining Wall Asset Program

- One consultant per two districts
 - * La Porte & Fort Wayne- RII (Northern IN)
 - * Crawfordsville & Greenfield- WSP (Central IN)
 - * Vincennes & Seymour- CTL (Southern IN)
- Ensure not to overlap with the Bridge Inventory data



Retaining Wall Asset Program

Inventory challenges

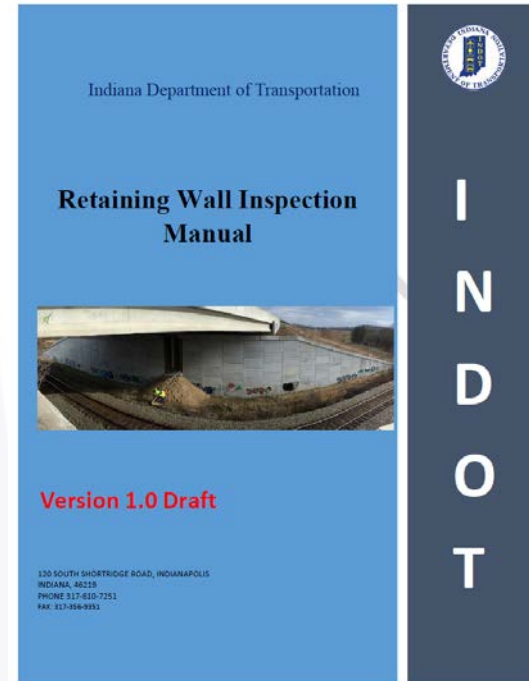
- Many dated structures without any records
- Design Data available only for last 10 -15 years
- Many structures and their locations are unknown
- Asset life of such structures is unknown
- Physically searching undocumented structures

Collector Application & Pre-Field Work



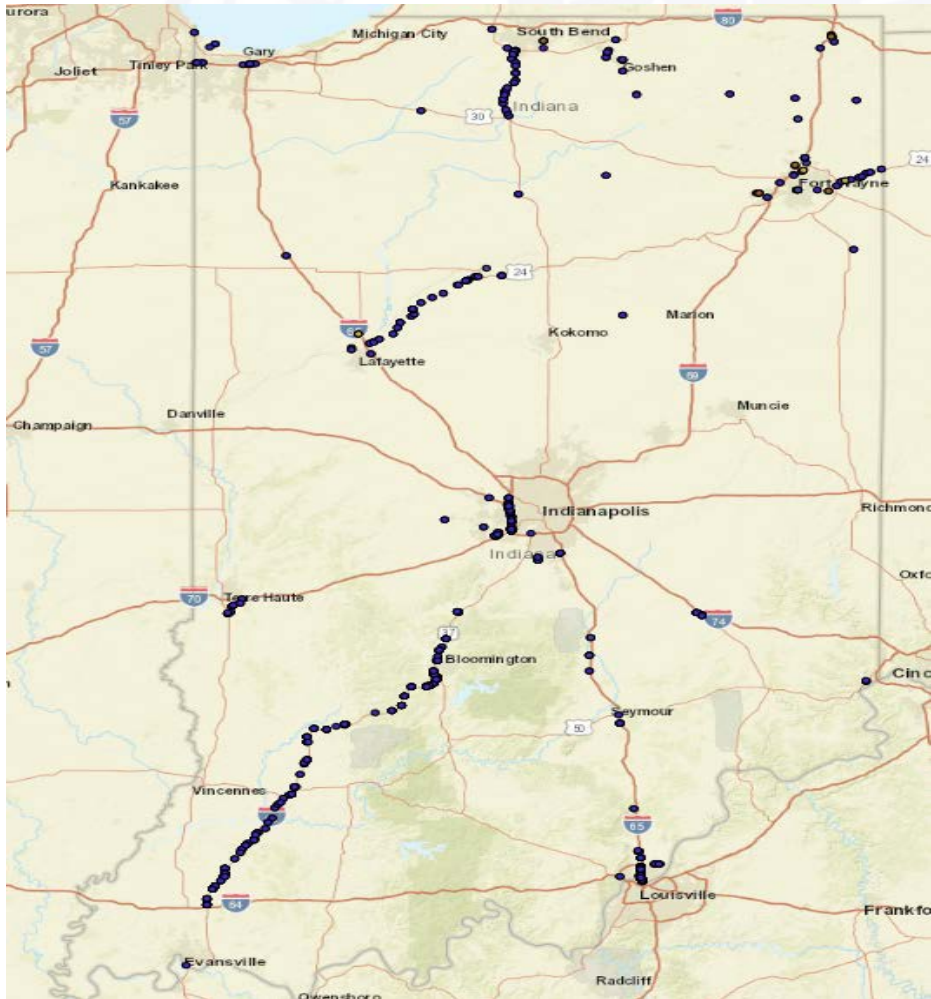
Nikhil Khedekar

ArcGIS Collector



- Application for Inventory of wall data
- General Information about the retaining wall
 - Location, Type, Height, Orientation, Owner, Wall condition Rating etc.
 - Only the walls that are taller than 5 ft (exposed height) at any point along the wall are included.
 - Culvert headwalls, abutment wingwalls, soil nail walls and noise walls are not included.

Retaining Wall Collector App



Types of Wall Elements-

Primary

- Vertical Supports
- Foundations
- Anchors
- Wall Facing

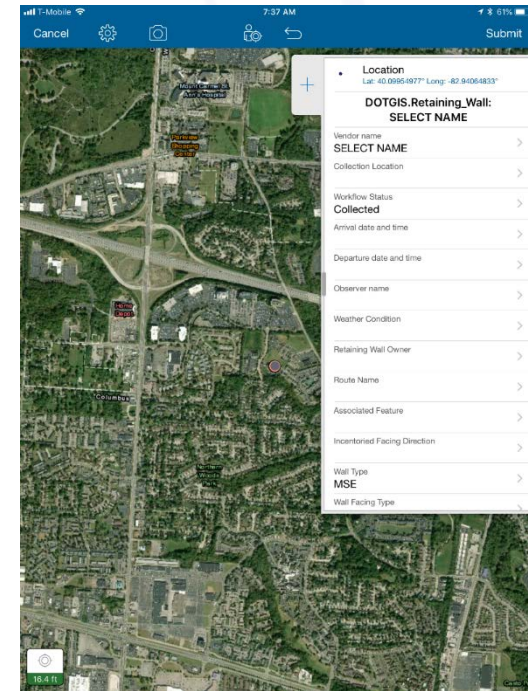
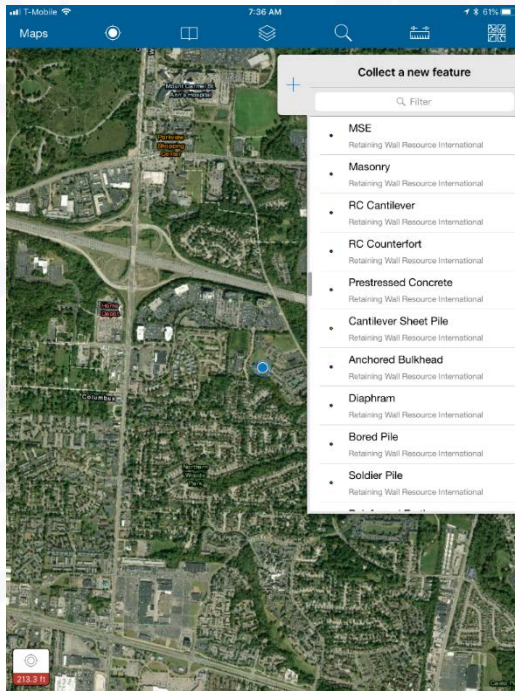
Secondary

- Coping
- Leveling Pad
- Drainage
- Slopes

Wall Type Legend-

- Masonry
- RC Cantilever
- RC Counterfort
- Pre-stressed Concrete
- Cantilever Sheet Pile
- Anchored Bulkhead
- Diaphragm
- Bored Pile
- Soldier Pile
- Reinforced Earth
- MSE
- Timber
- Bin
- Wire

ArcGIS Collector – Types of Wall

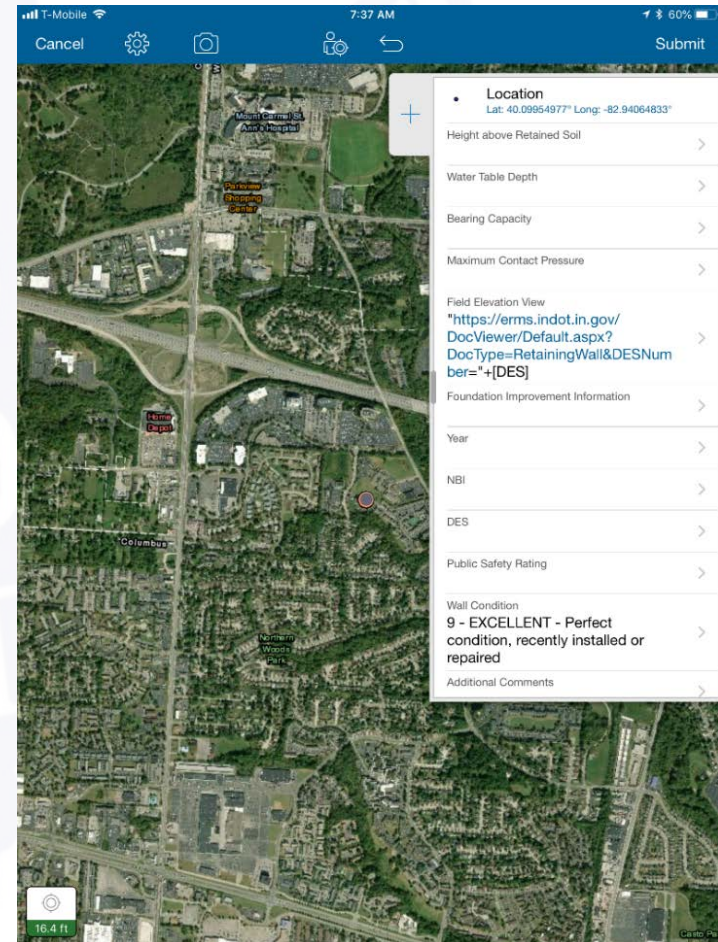
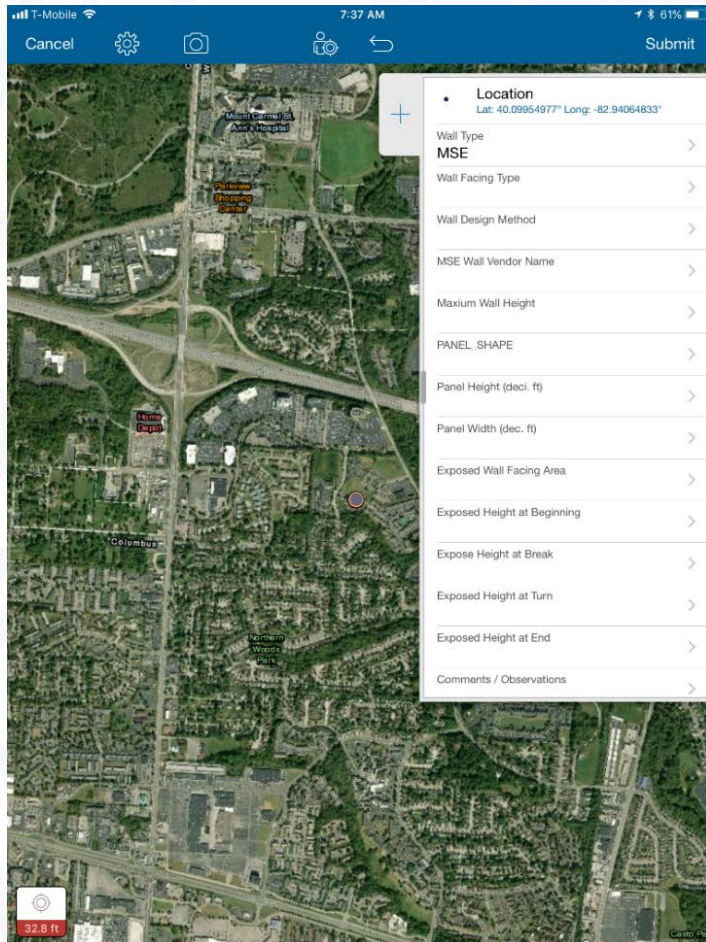


Retaining Wall Asset Program

Fields for data input in app

- | | |
|---|---|
| <ul style="list-style-type: none">• Vendor name- CTL / RII / WSP• Arrival date & time- 2/12/2019, 11:11 AM• Departure date & time- 2/12/2019, 11:22 AM• Observer name- John Doe• Weather Condition- Sunny 35°F• Wall Type- MSE• Associated Feature- Bridge abutment• Incenteroid facing direction- West• Wall Facing Type- Precast concrete panel | <ul style="list-style-type: none">• Panel height- 5 ft.• Panel width- 10 ft.• Wall design method- LRFD• Latitude- 41.06792471• Longitude- -85.01113566• Altitude- 235.2605231• Wall height- 22ft• NBI- 000000• Des- 1234567• Public Safety Rating- Green |
|---|---|

ArcGIS Collector – Inventory of Wall



Retaining Walls Defects

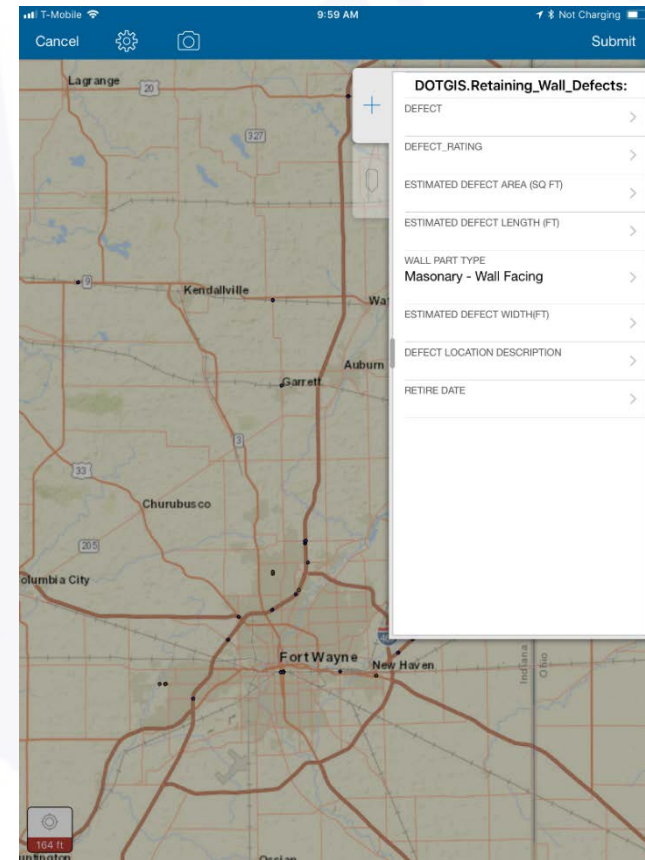
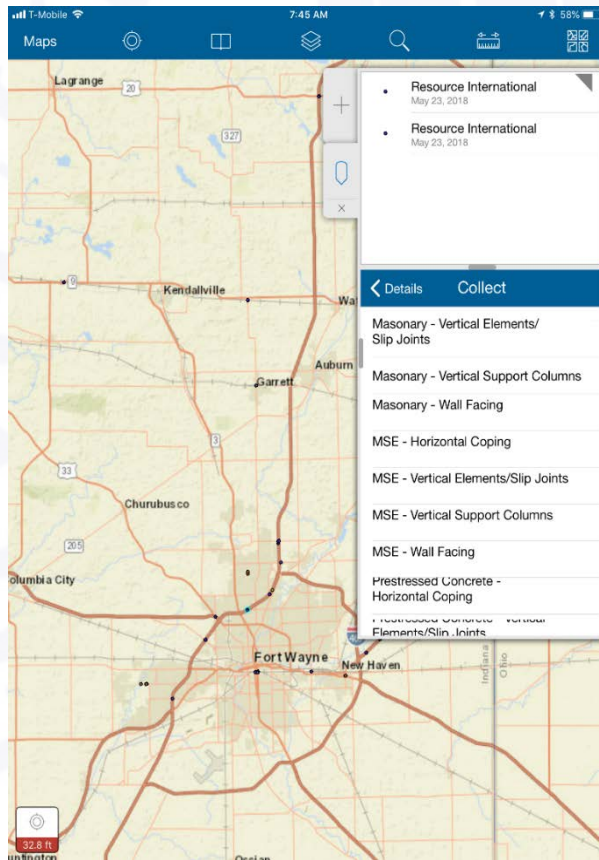
➤ Perform preliminary inspection to visually identify defects. Include location, photo, sketch and brief description.

➤ Following is the list of defects,

- Abrasion/ wear (concrete)
- Freeze-thaw damage
- Masonry displacement
- Mortar breakdown
- Patched area masonry
- Rust stains
- Split/ spall masonry
- Settlement
- Backfill Leakage
- Damage
- Delamination/ Spall
- Erosion
- Exposed rebar/ fabric
- Efflorescence
- Graffiti
- Vegetation
- Bulging
- Corrosion
- Cracking
- Connection
- Distortion
- Horizontal rotation
- Separation
- Vertical rotation

➤ Perform secondary inspection in future based on the defect rating. Secondary inspection could involve digging, excavating, drilling, or geophysical studies.

ArcGIS Collector - Defects



Retaining Walls Rating Codes

Defect Rating Codes

- Code 9- Excellent (Recently installed or recently repaired)
- Code 7- Good (No repairs needed, next inspection to be examined)
- Code 5- Fair (Significant defects, frequent inspections)
- Code 3- Poor (Structural issues, repair by qualified contractor)
- Code 1- Critical (Failing or failed, major mitigation or replacement)

Overall **Retaining Wall Rating Codes** are auto populated based on the lowest defect rating.

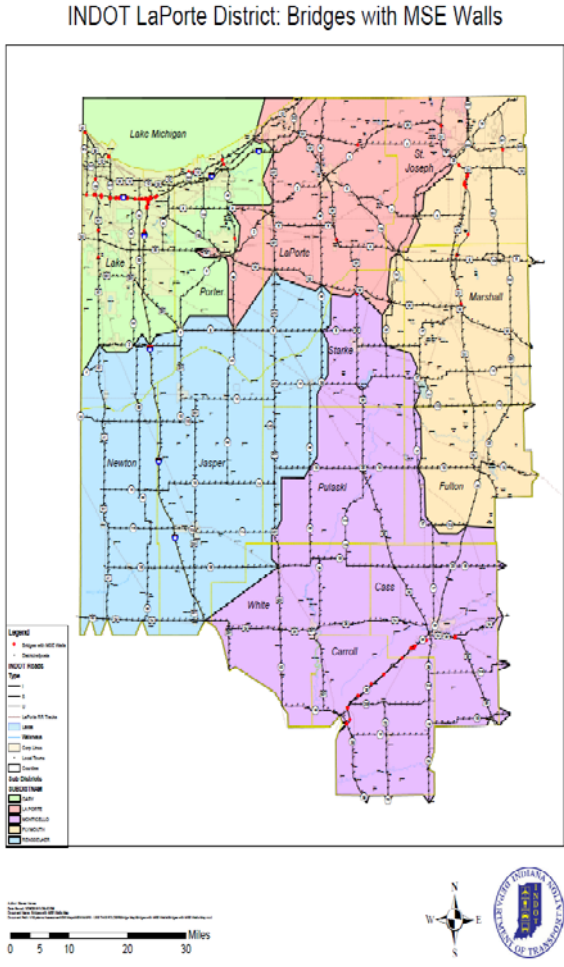
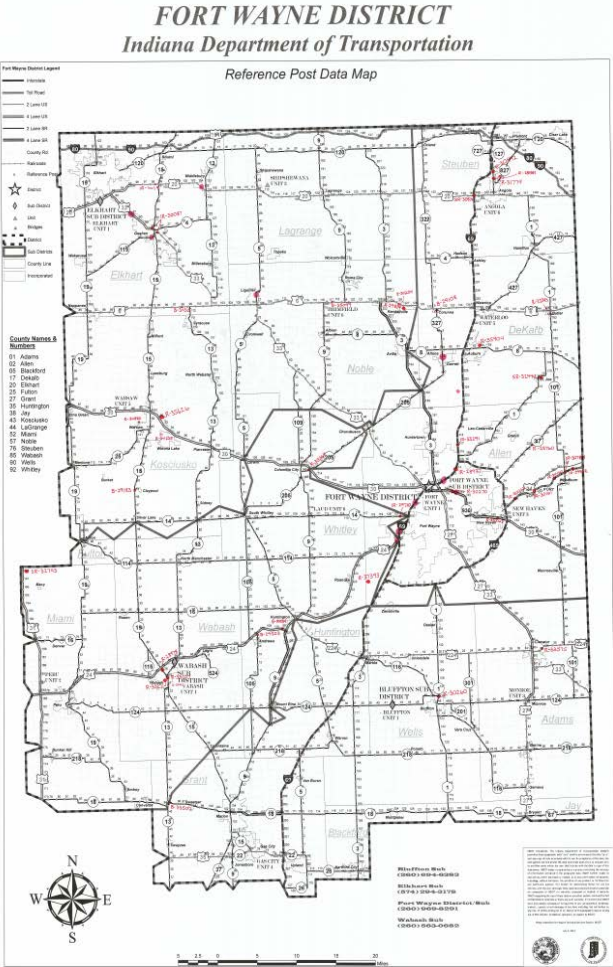
Retaining Walls Rating Codes

Public Safety Rating Codes

- Green flag- No danger of failure
- Orange flag- Repairs needed
- Yellow flag- Public safety issue, closure of lane/ traffic
- Red flag- Roads relying on wall for support are closed

Pre-field Work

- Initial wall list by INDOT
 - Federally and State Funded walls



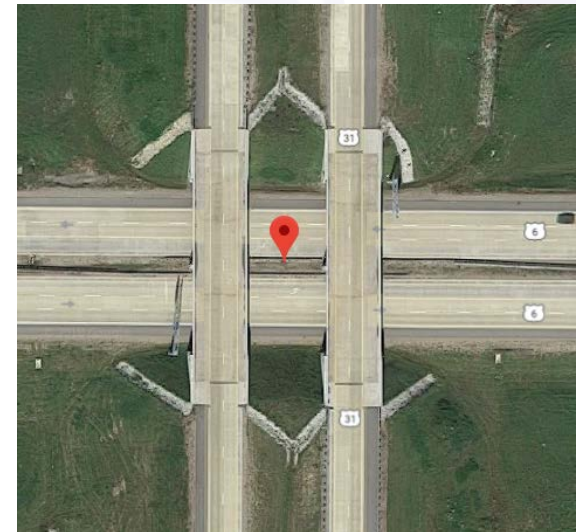
Pre-field Work

- Initial wall list by INDOT

LAT	LONG	NBI	STR NUMBER	SUB	COUNT	ROUTE TYP	ROU	DESCRIPTION	LOCATION	GOOGLE MA
41.70585	-86.3397	010214	(20)031-71-10053 WB	La Porte	St. Joseph	US	20	US20/31 Lincolnway	01.69 S I-90	Map it
41.66028	-86.1375	031504	331-71-02702	Plymouth	St. Joseph	SR	331	Ns Rr@.-Sr 331 Nb/Sb, Capital Av	00.18 S SR 933	Map it
41.63196	-86.2827	076828	020-71-08334	Plymouth	St. Joseph	US	20	Locust Road@.-Us 20/31 Eb/Wb	00.99 E SR 23	Map it
41.58979	-86.2602	079680	031-71-08918 NB	Plymouth	St. Joseph	US	31	Us 31 Nb@.-Dixie Hwy	02.64 S US 20	Map it
41.58937	-86.2604	079686	031-71-09141 SB	Plymouth	St. Joseph	US	31	Us 31 Sb@.-Dixie Hwy	02.64 S US 20	Map it
41.59382	-86.2641	079688	031-71-08942 NB	Plymouth	St. Joseph	US	31	Us 31 Nb@.-Roosevelt Rd	02.28 S US 20	Map it
41.5939	-86.2646	079690	031-71-08943 SB	Plymouth	St. Joseph	US	31	Us 31 Sb@.-Roosevelt Rd	02.24 S US 20	Map it
41.49827	-86.2536	079840	031-71-08931	Plymouth	St. Joseph	US	31	Kenilworth Road@.-Us 31 Nb/Sb	03.85 N US 6	Map it
41.6084	-86.2568	079848	031-71-08944	Plymouth	St. Joseph	US	31	Us 31 Nb/Sb@.-Kern Road	01.10 S US 20	Map it
41.61091	-86.2548	079850	031-71-08945 NB	Plymouth	St. Joseph	US	31	Us 31 Nb@.-Main Street	01.00 S US 20	Map it
41.61111	-86.255	079852	031-71-09646 SB	Plymouth	St. Joseph	US	31	Us 31 Sb@.-Main Street	01.00 S US 20	Map it
41.6108	-86.2547	079854	031-71-09647 NER	Plymouth	St. Joseph	US	31	Us 31 Nb Ne Ramp@.-Main Street	01.00 S US 20	Map it
41.61127	-86.2551	079856	031-71-09648 NWR	Plymouth	St. Joseph	US	31	Us 31 Sb Nw Ramp@.-Main Street	01.00 S US 20	Map it
41.6217	-86.2518	079858	031-71-08947	Plymouth	St. Joseph	US	31	Jackson Road@.-Us 31 Nb/Sb	00.10 S US 20	Map it
41.62413	-86.2464	079888	020-71-08964	Plymouth	St. Joseph	US	20	Fellows St@.-Us 20	0.26 E US 31	Map it
41.61662	-86.2523	080428	031-71-08946	Plymouth	St. Joseph	US	31	Johnson Rd@.-Us 31 Nb/Sb	00.50 S US 20	Map it

Pre-field Work

- Reconnaissance for additional walls
 - Walls identified during field-trips
 - Walls identified on Google maps & Street-view



Pre-field Work

- Wall List for each county
- Schedule Inspection
- RR Permissions
- Co-ordinate with INDOT

RESOURCE INTERNATIONAL						
Date Inspected	Wall Project	Location	Type of Wall	Description	Railroad R/W	Total # Retaining Walls
ST. JOSEPH COUNTY - Projects Completed						
6/12/2018	IR-30116	41.564464, -86.246697	MSE	US-31/New Rd.	No	2
6/12/2018	IR-30127	41.535353, -86.249851	MSE	US-31/Pierce Rd.	No	4
6/12/2018	IR-30127 & B-37990	41.589522, -86.260325	MSE	US-31/Dixie Hwy (Old US-31)	No	2
6/12/2018	B-41215 & IR-31879	41.498272, -86.253624	MSE	US-31/Kenilworth Rd.	No	2
6/12/2018	IR-30116	41.575427, -86.248919	MSE	US-31/Miller Rd.	No	2
6/12/2018	IR-30122	41.505917, -86.250235	MSE	US-31/Lake Trail	No	2
6/12/2018	IR-30128 & B-37990	41.593808, -86.264391	MSE	US-31/Roosevelt Rd.	No	2
6/13/2018	SB-29015	41.632001, -86.282782	MSE	US-20/Locust Rd.	No	2
6/13/2018	B-34725	41.705880, -86.339762	MSE	US-31/US-20 No PDF Documents/Plans	No	2
6/13/2018	B-41209 & IR-30132	41.608398, -86.256813	MSE	US-31/Kern Rd.	No	2
6/13/2018	IR-31091	41.66028, -86.137474	MSE/Modular Block	SR-331/Capital Ave. (One Wall Modular Block)	No	3
6/13/2018	IR-30143	41.62413, -86.24638	MSE	Us-20/Fellow St.	No	2
6/13/2018	B-41209 & IR-30132	41.61111, -86.25502	MSE	US-31/Main St.	No	2
6/13/2018	IR-30134	41.61662, -86.252327	MSE	US-31/Johnson Rd.	No	3
6/13/2018	IR-30134	41.621781, -86.250458	MSE	US-31/Jackson Rd.	No	2
6/25/2018	IR-30143	41.618462, -86.252395	MSE	US-31 SB (Before Johnson Rd.)	No	1
6/25/2018	IR-30143	41.614481, -86.252466	MSE	Hildebrand St., Right along US-31 NB)	No	1
6/25/2018	B-41209 & IR-30132	41.61111, -86.25502	MSE	US-31/Main St.	No	2
8/8/2018	IR-31108	41.633206, -86.140594	MSE	SR-331	No	1
TOTAL WALLS - 6/12/18 to 8/8/18 (RII)						39
MARSHALL - Projects Completed						
6/12/2018	B-37990	41.36709, -86.27787	MSE	US-31/Plymouth Goshen Trail	No	2
6/12/2018	B-36679	41.39106, -86.287758	MSE	US-31/6th Rd.	No	2
6/25/2018	IR-30115	41.475849, -86.282937	MSE	US-31/Tyler Rd.	No	2
6/25/2018	IR-30122	41.464332, -86.288452	MSE	US-31/1st Rd.	No	4
6/25/2018	IR-30129	41.449881, -86.292535	MSE	US-31/US-6	No	4
6/25/2018	IR-30129	41.430932, -86.296456	MSE	US-31/3A Rd.	No	4
6/25/2018	IR-30143	41.415733, -86.298086	MSE	US-31/4A Rd.	No	2
6/25/2018	IR-30141	41.376685, -86.282106	MSE	US-31/Veterans Pkwy	No	2
9/20/2018	IR-30131	41.45938, -86.29032	MSE	US-31/CSX Railroad	Yes	2
TOTAL WALLS - 6/12/18 to 6/26/18, 9/20/18 (RII)						24

Pre-field Work

- Obtaining Wall Plans & Geotech Report
 - From INDOT Archives & ERMS

Enter Search Criteria:

Search By Contract Number Search By Date And District

Choose A Document Type:

Please only enter the five digit value associated with the contract number.
i.e. R-12345-A ==> 12345 is entered

Enter A Contract Number:

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Plan/Drawing Sets Number of Records: 12

Select File Wanted	Contract Number	Title	Content Id	Final Tracing Type	Document Type	District	Letting Date	Primary Designation Number	File Size in kB's
<input type="button" value="Select File"/>	IR-30129-A	FT PlansRev#1 1173060 & 1173061 for Contract Services.pdf	ERMS1_120830542	Revision	Final Tracings	LaPorte	4/18/12		3314
<input type="button" value="Select File"/>	IR-30129-A	FT PlansRev#1 0710757 for Contract Services	ERMS1_120830525	Revision	Final Tracings	LaPorte	4/18/12	0710757	8005
<input type="button" value="Select File"/>	IR-30129	FT Xsect (1 of 2) 0710757 for Contract Services.pdf	ERMS1_113621050	Cross Section	Final Tracings	LaPorte	4/18/12	0710757	31313
<input type="button" value="Select File"/>	IR-30129	FT Xsect (2 of 2) 0710757 for Contract Services.pdf	ERMS1_113621051	Cross Section	Final Tracings	LaPorte	4/18/12	0710757	31660
<input type="button" value="Select File"/>	IR-30129	FT Plans (3 of 3) 0710757 for Contract Services.pdf	ERMS1_113621043	Road	Final Tracings	LaPorte	4/18/12	0710757	20143
<input type="button" value="Select File"/>	IR-30129	FT Plans (1 of 3) 0710757 for Contract Services.pdf	ERMS1_113621041	Road	Final Tracings	LaPorte	4/18/12	0710757	33001
<input type="button" value="Select File"/>	IR-30129	FT Plans (2 of 3) 0710757 for Contract Services.pdf	ERMS1_113621040	Road	Final Tracings	LaPorte	4/18/12	0710757	38266
<input type="button" value="Select File"/>	30129	FT Plans 0710773 & 0810356 for Contract Services.pdf	ERMS1_113570392	Bridge	Final Tracings	LaPorte	4/18/12	0710773	18735
<input type="button" value="Select File"/>	30129	FT Plans 0710768 for Contract Services.pdf	ERMS1_113570345	Bridge	Final Tracings	LaPorte	4/18/12	0710768	7969
<input type="button" value="Select File"/>	30129	FT Plans 0710771 & 0710772 for Contract Services.pdf	ERMS1_113570329	Bridge	Final Tracings	LaPorte	4/18/12	0710771	14373

Geotech Reports Number of Records: 5

Select File Wanted	Contract Number	Title	Content Id	Document Type	District	Letting Date	Primary Designation Number	File Size in kB's
<input type="button" value="Select File"/>	IR-30129	Des#s 9904300 and 0710757, US 31, Marshall County,	ERMS4_018133973	Geotech Report	LaPorte	4/4/12	9904300	1699
<input type="button" value="Select File"/>	IR-30141, 30129	Des #'s 0710780, 1173060, 1173061, US 31, Bridge 6A, Marshall Co.	ERMS4_016543490	Geotech Report	LaPorte	4/4/12	0710780	1404
<input type="button" value="Select File"/>	IR-30136, 30129	Des #'s 0710770, & 9904300, US 31, New Bridge, St. Joseph County	ERMS4_009927762	Geotech Report	LaPorte	4/4/12	0710770	6338
<input type="button" value="Select File"/>	30129	GeoRpt US31 Plymouth-S Bend 0710768, 769, 782, 770, 771, 772, 767, 781	ERMS4_003737450	Geotech Report	LaPorte	4/4/12		14339
<input type="button" value="Select File"/>	30131, 30129	GeoRpt 9904300, 0710758, 0710757, 0710773, 0810356 US31 @ US6 etc	ERMS4_003726264	Geotech Report	LaPorte	4/4/12	9904300	11062

Lessons Learned

- Not all walls have record plans
- Many walls and their locations are unknown
- ERMS did not provide plans and reports for all the walls
- Searching for specific wall plans and Geotech reports from INDOT archives can be time consuming

Field Work and Collection Of Walls



Andrew Bain

Field Collection of Walls

- 2 member teams of qualified retaining wall inspectors
 - iPads with ArcGIS collector app
- Purpose:
 - To collect information about wall location, geometry, and defects
 - To provide performance oriented rating of existing wall

Purpose (con.)

Bridges

- Systematically cataloged and inspected – National Bridge Inventory (NBI)

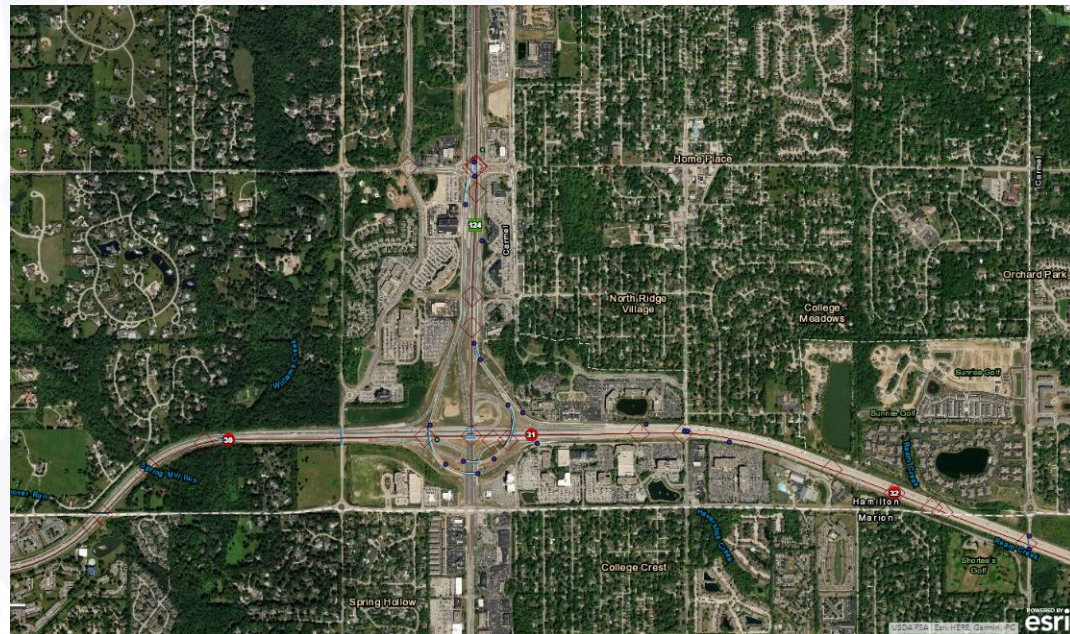
Retaining Walls

- Numbered on construction contract documents (project-specific)
- Do NOT “roll-up” to existing database
- Not inspected with regularity

Key Step: Field Collection of walls to establish and populate retaining wall inventory

Field Work Process

1. Pre-populate map for field crews to have direction (pre-field work)
2. Locate walls and input geometry/location data
3. Examine walls for defects
4. Take Pictures
5. Input defects and wall ratings
6. Submit for Review



Wall Geometry and Location Collection

- Access / Safety
- GPS wall location services with iPad
- Wall Types
- Wall Details
 - Maximum exposed height
 - Exposed wall facing area



Field Collection - Defects

- Defect Type
- Measurements/Scale
- Location on wall
- **Importantly:** Defect Rating



Defect Ratings

- Numbered description of defect severity:
- 1, 3, 5, 7 or 9

9 - EXCELLENT - Perfect condition, recently installed or repaired

7 - GOOD - No repairs needed, list specific items to consider for next inspection

5 - FAIR - Acceptable condition, increase inspection frequency

3 - POOR - In danger of failing, needs repair

1 - CRITICAL - Feature is failing

0 - Unknown / Not Found

- Corresponds to measurable action steps

Wall Ratings

- Walls rated based on presence and severity of observed defects
- Through defect and rating descriptions, we can create a system of criteria for defining the current state of the asset – with specific response actions for increased inspection or immediate remediation, if needed



Asset Management - Defects

- Identify most critical locations for maintenance funding
 - Response actions
- Able to view pictures and descriptions of defects
 - Can compare at touch of a button to see if deteriorating conditions
 - i.e., is this problem or perceived problem getting worse?

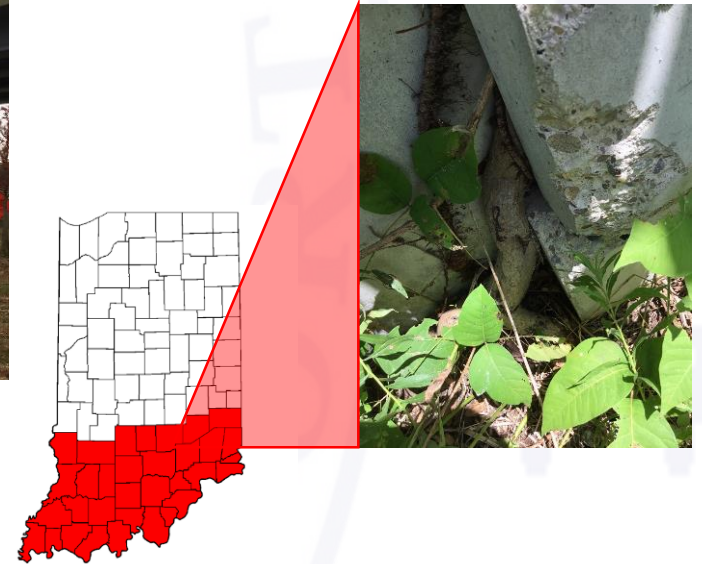


Asset Management – Defects (con.)

- Sorting Data

- Examples:

- Type of walls or wall elements corresponding to defects



- Location of walls corresponding to defects

Lessons Learned

- Work Flow
 - Walls split between bridge and road plans
- Need for a robust server
- Flexibility of entry fields
- New technology – taking advantage of satellites, Google Earth and cellular network

Wall Inspection

- Inventory and Assessment
- During Construction



Robert Goldner

Field Observations

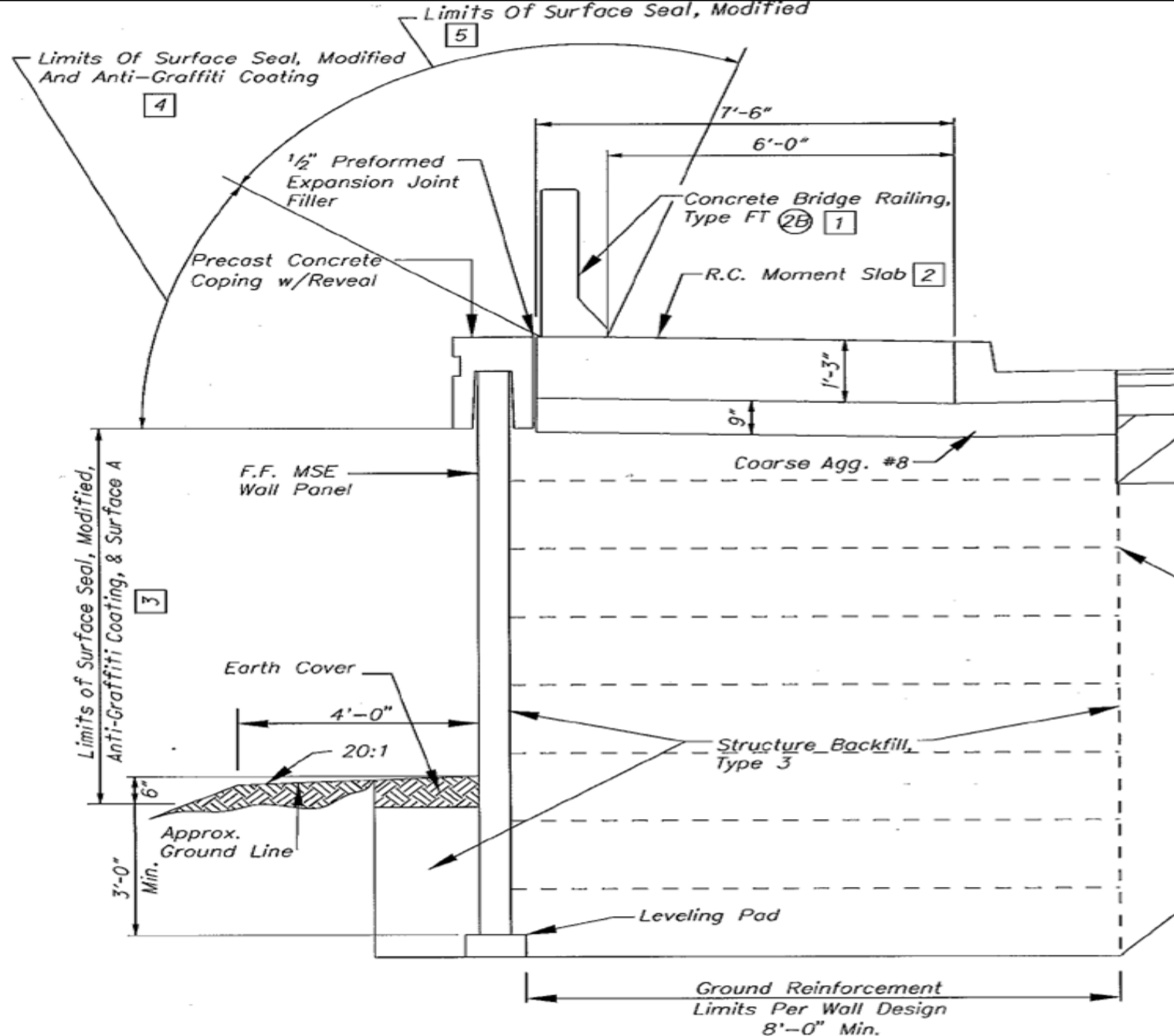
- Initial observation of a defect
- Could the defect be causing a bigger problem?
- If so, investigate the possible “bigger problem”.
- Examples











1-2 = 00070550





Inspection During Construction

- Especially critical in MSE Wall Construction
- Should be 100% inspected
- Training of contractor and inspection staff should take place prior to work.



Retaining Wall Asset Program



Aamir Turk

Geotechnical Asset Management Plan

Phase II

- Effective tool for planning
- Monitoring asset performance
- Risk Assessment
- Life cycle cost analysis
- Update inventory and condition assessments
- Program as a project
- Cost estimates for mitigation/ replacement

