

## **MDOT 3D Bridge App – The Digital Future Of Bridge Inspections**

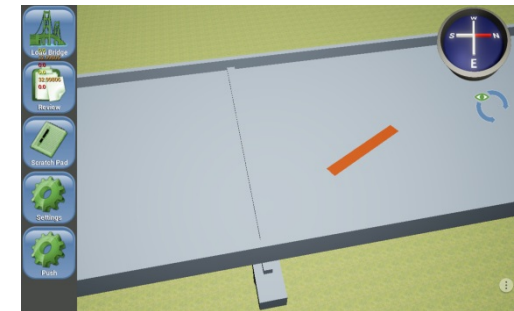
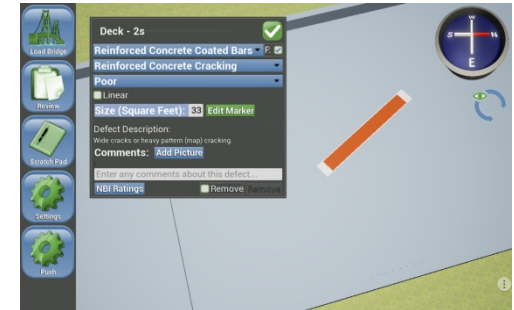
***MDOT #2013-0067, Auth. No. 2***

Reid Sawtell

Michigan Tech Research Institute

[rwsawtel@mtu.edu](mailto:rwsawtel@mtu.edu)

[www.mtri.org](http://www.mtri.org)



## The Problem

- Faced with an aging bridge inventory and increasing federal regulations for collecting element level data, MDOT wishes to increase the efficiency and reliability of collected data.





## The Problem

- Current bridge inspection practices at MDOT utilize paper forms followed by a manual data entry step to populate their database.



## The Problem

- Additionally, photographs documenting bridge deterioration are collected and stored separately from inspection data.





## The Problem

- MDOT inspectors must also carry reference manuals and past inspection reports to help verify the accuracy of the data they are collecting.



## The Problem

- The exact locations of bridge defects are not stored which creates an inconvenience as the data are difficult to visualize, to tabulate overall defect quantities, & to duplicate inspections.
- Federal regulations now require inspectors to collect AASHTO Element level data. Current processes don't enable the efficient collection of this data.

| MICHIGAN DEPARTMENT OF TRANSPORTATION |  |                       |                           |   |           |
|---------------------------------------|--|-----------------------|---------------------------|---|-----------|
| STR 2304                              | SAFETY INSPECTION REPORT - CORE ELEMENTS |                       |                           |   | B02-23092 |
| Facility                              | Latitude / Longitude                     | MDOT Structure ID     | Structure Condition       |  |           |
| M-99 NB                               | 42.630728 / -84.622691                   | 2312309200B020        | Fair Condition(6)         |   |           |
| Feature                               | Length / Width                           | Owner                 |                           |   |           |
| GRAND RIVER                           | 180 / 45.9                               | Region: University(6) |                           |   |           |
| Location                              | Built / Recon. / Paint / Ovly.           | TSC                   | Operational Status        |   |           |
| 0.5 MI S OF HOLT RD                   | 1978 / / 2008 / 2008                     | Lansing(6A)           | A Open, no restriction(A) |   |           |
| Region / County                       | Material / Design                        | Last NBI Inspection   | Scour Evaluation          |   |           |
| University(6) / Eaton(23)             | 3 Steel / 02 Stringer/Girder             | 05/07/2013 / BDYT     | 3 SC - Unstable           |   |           |

| NBI INSPECTION   |                       |             |            | BDYT |
|------------------|-----------------------|-------------|------------|------|
| Inspector Name   | Agency / Company Name | Insp. Freq. | Insp. Date |      |
| Janiene DeVinney | MDOT INSPECTOR        | 24          | 05/07/2013 |      |

| CORE ELEMENTS         |                        |                |      |              |            |         |                  |                  |  |
|-----------------------|------------------------|----------------|------|--------------|------------|---------|------------------|------------------|--|
| (English Units)       |                        |                |      |              |            |         |                  |                  |  |
| Element Number        | Element Name           | Total Quantity | Unit | State 1      | State 2    | State 3 | State 4          | State 5          |  |
| <b>Decks/Slabs</b>    |                        |                |      |              |            |         |                  |                  |  |
| 18/ 3                 | Conc Dk Thn Epoxy Ov   | 8267           | (SF) | 8267<br>100% | 0<br>0%    | 0<br>0% | 0<br>0%          | 0<br>0%          |  |
| <b>Joints</b>         |                        |                |      |              |            |         |                  |                  |  |
| 400/ 3                | Strip Seal Exp Joint   | 92             | (LF) | 92<br>100%   | 0<br>0%    | 0<br>0% | xxxxx<br>xxxxxx  | xxxxxx<br>xxxxxx |  |
| 401/ 3                | Pourable Joint Seal    | 92             | (LF) | 0<br>0%      | 92<br>100% | 0<br>0% | xxxxxx<br>xxxxxx | xxxxxx<br>xxxxxx |  |
| <b>Superstructure</b> |                        |                |      |              |            |         |                  |                  |  |
| 107/ 3                | Printed Stl Girder /Bm | 1079           | (LF) | 1074<br>100% | 5<br>0%    | 0<br>0% | 0<br>0%          | 0<br>0%          |  |
| 161/ 3                | Paint Stl Pin/Hanger   | 12             | (EA) | 12<br>100%   | 0<br>0%    | 0<br>0% | 0<br>0%          | 0<br>0%          |  |
| 331/ 3                | Concrete Bridge Rail   | 361            | (LF) | 269<br>75%   | 92<br>25%  | 0<br>0% | 0<br>0%          | xxxxxx<br>xxxxxx |  |
| <b>Bearings</b>       |                        |                |      |              |            |         |                  |                  |  |
| 311/ 3                | Movable Bearing        | 12             | (EA) | 12<br>100%   | 0<br>0%    | 0<br>0% | xxxxxx<br>xxxxxx | xxxxxx<br>xxxxxx |  |
| 313/ 3                | Fixed Bearing          | 12             | (EA) | 12<br>100%   | 0<br>0%    | 0<br>0% | xxxxxx<br>xxxxxx | xxxxxx<br>xxxxxx |  |
| <b>Substructure</b>   |                        |                |      |              |            |         |                  |                  |  |
| 205/ 3                | Reinf Conc Column      | 6              | (EA) | 4<br>67%     | 2<br>33%   | 0<br>0% | 0<br>0%          | xxxxxx<br>xxxxxx |  |
| 215/ 3                | Reinf Conc Abut        | 105            | (LF) | 80<br>76%    | 25<br>24%  | 0<br>0% | 0<br>0%          | xxxxxx<br>xxxxxx |  |
| 234/ 3                | Reinf Conc Pier Cap    | 105            | (LF) | 92<br>88%    | 13<br>12%  | 0<br>0% | 0<br>0%          | xxxxxx<br>xxxxxx |  |
| <b>Other Elements</b> |                        |                |      |              |            |         |                  |                  |  |
| 321/ 3                | Reinf Conc Appr Slab   | 2              | (EA) | 2<br>100%    | 0<br>0%    | 0<br>0% | 0<br>0%          | xxxxxx<br>xxxxxx |  |

## Objectives of MDOT Wireless Bridge Inspection Study

- The goal is to help MDOT take advantage of the advances in portable data entry technologies, reduce the time needed for field staff to collect bridge inspection data and thereby help have a safer bridge inspection program, and help provide a compatible path forward to a more efficient bridge inspection process that is available to all appropriate levels of MDOT.





## Objectives of MDOT Wireless Study

- Develop a wireless web/tablet based bridge inspection data collection system. This system would:
  - Use 3D models to help collect data.
  - Integrate with MDOT Michigan Bridge Reporting System and other current MDOT bridge inspection processes.





## MDOT's Solution

- A tablet application for MDOT Bridge Inspectors for the collection, display, and summarizing of Bridge Inspection Data.
- Leverages the latest in game development technology: Unreal Engine 4
  - Provides cross platform compatibility on everything from Windows Desktops to Android/iOS phones or tablets.

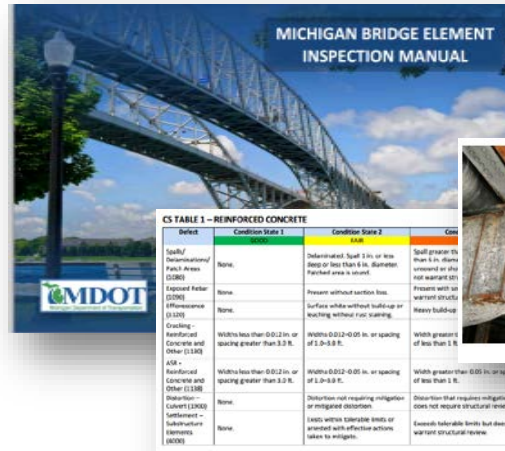
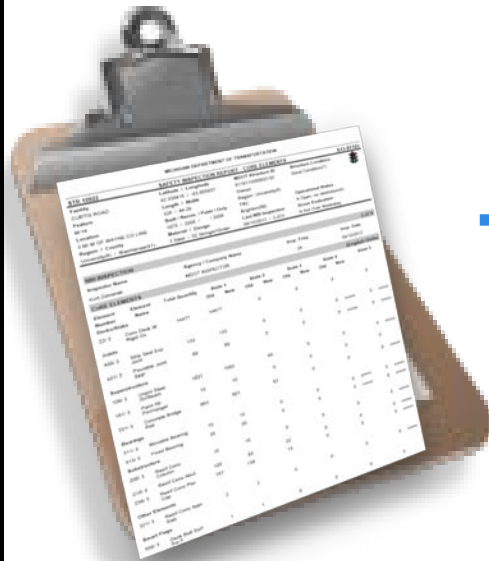


## The 3D BRIDGE app

- The 3D BRIDGE app helps MDOT take advantage of the advances in portable data entry technologies, reduce the need for field staff time to collect bridge inspection, and facilitate the bridge inspection process

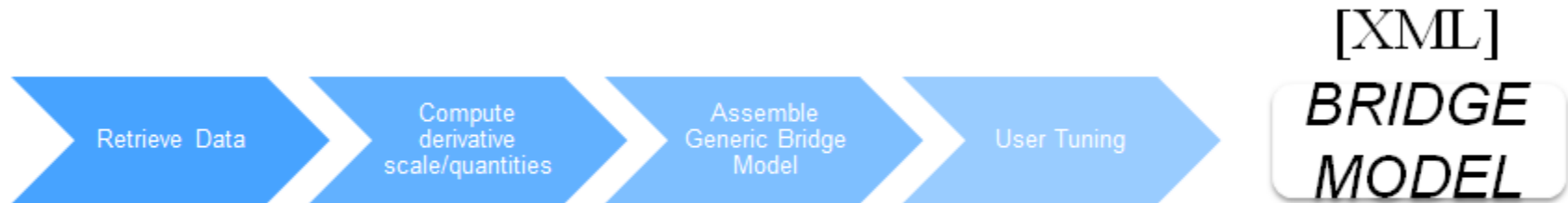


# How will this tool work from the Bridge Inspector's point of view?





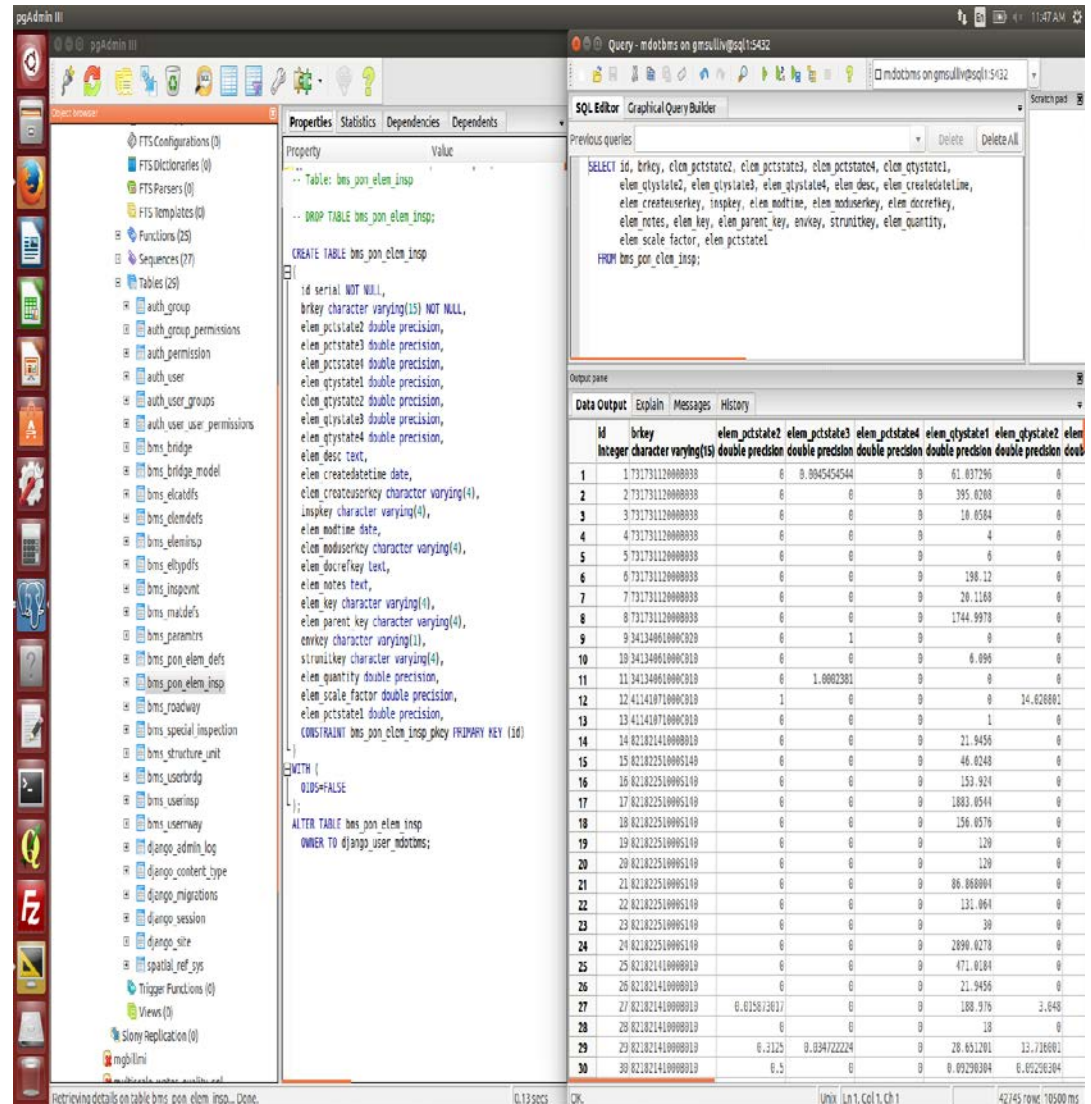
# The 3D BRIDGE App Grabs Data from BMS Database



- With no previous 3D models of the bridges available, a model had to be created from scratch
- Large amounts of descriptive information within MDOT's Bridge Management Database

# The 3D BRIDGE App Grabs Data from BMS Database

- Queries all of the data from a static copy of MDOT's database.
  - Static copy recent as of October 2018
- The MDOT bridge management database is composed of 16 tables.
- The 3D BRIDGE App queries data from almost all of them.



The screenshot displays the pgAdmin III interface. On the left, the 'bms\_pon\_elem\_insp' table is selected under the 'bms' schema. The central pane shows the table's properties, including columns like 'id', 'brkey', 'elem\_pjctstat2', 'elem\_pjctstat3', 'elem\_pjctstat4', 'elem\_pjctstat1', 'elem\_gjststat2', 'elem\_gjststat3', 'elem\_gjststat4', 'elem\_desc', 'elem\_createdatetime', 'elem\_creatorkey', 'inskey', 'elem\_mdnline', 'elem\_mdnlinekey', 'elem\_docrkey', 'elem\_notes', 'elem\_key', 'elem\_parent\_key', 'enkey', 'strutkey', 'elem\_quantity', 'elem\_scale\_factor', and 'elem\_pjctstat1'. The right pane shows the SQL Editor with a query that selects all columns from the 'bms\_pon\_elem\_insp' table. The bottom pane displays the query results as a table with 30 rows and 16 columns.

| id | brkey            | elem_pjctstat2 | elem_pjctstat3 | elem_pjctstat4 | elem_pjctstat1 | elem_gjststat2 | elem_gjststat3 | elem_gjststat4 | elem_desc | elem_createdatetime | elem_creatorkey | inskey | elem_mdnline | elem_mdnlinekey | elem_docrkey | elem_notes | elem_key | elem_parent_key | enkey | strutkey | elem_quantity | elem_scale_factor | elem_pjctstat1 |
|----|------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------|---------------------|-----------------|--------|--------------|-----------------|--------------|------------|----------|-----------------|-------|----------|---------------|-------------------|----------------|
| 1  | 1731731120000000 | 0              | 0              | 0              | 0              | 61.037296      | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 2  | 1731731120000000 | 0              | 0              | 0              | 0              | 395.0208       | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 3  | 1731731120000000 | 0              | 0              | 0              | 0              | 10.0584        | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 4  | 1731731120000000 | 0              | 0              | 0              | 0              | 4              | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 5  | 1731731120000000 | 0              | 0              | 0              | 0              | 6              | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 6  | 1731731120000000 | 0              | 0              | 0              | 0              | 198.12         | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 7  | 1731731120000000 | 0              | 0              | 0              | 0              | 20.1160        | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 8  | 1731731120000000 | 0              | 0              | 0              | 0              | 1744.9970      | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 9  | 1341340610000000 | 0              | 1              | 0              | 0              | 0              | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 10 | 1341340610000000 | 0              | 0              | 0              | 0              | 6.096          | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 11 | 1341340610000000 | 0              | 1.0002301      | 0              | 0              | 0              | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 12 | 1241410710000000 | 1              | 0              | 0              | 0              | 0              | 0              | 14.626801      |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 13 | 1341410710000000 | 0              | 0              | 0              | 0              | 1              | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 14 | 1241410710000000 | 0              | 0              | 0              | 0              | 21.9456        | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 15 | 1241410710000000 | 0              | 0              | 0              | 0              | 46.0240        | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 16 | 1241410710000000 | 0              | 0              | 0              | 0              | 153.921        | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 17 | 1241410710000000 | 0              | 0              | 0              | 0              | 1883.0541      | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 18 | 1241410710000000 | 0              | 0              | 0              | 0              | 156.0576       | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 19 | 1241410710000000 | 0              | 0              | 0              | 0              | 120            | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 20 | 1241410710000000 | 0              | 0              | 0              | 0              | 120            | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 21 | 1241410710000000 | 0              | 0              | 0              | 0              | 86.068004      | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 22 | 1241410710000000 | 0              | 0              | 0              | 0              | 131.061        | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 23 | 1241410710000000 | 0              | 0              | 0              | 0              | 30             | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 24 | 1241410710000000 | 0              | 0              | 0              | 0              | 2890.0278      | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 25 | 1241410710000000 | 0              | 0              | 0              | 0              | 471.0181       | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 26 | 1241410710000000 | 0              | 0              | 0              | 0              | 21.9456        | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 27 | 1241410710000000 | 6.012613017    | 0              | 0              | 0              | 188.916        | 3.640          | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 28 | 1241410710000000 | 0              | 0              | 0              | 0              | 18             | 0              | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 29 | 1241410710000000 | 6.3125         | 0.034722224    | 0              | 0              | 28.651201      | 13.706001      | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |
| 30 | 1241410710000000 | 6.5            | 0              | 0              | 0              | 0.09290304     | 6.09290304     | 0              |           |                     |                 |        |              |                 |              |            |          |                 |       |          |               |                   |                |

# User Tuning

- Created a user interface for fine tuning the 3D Bridge model
- Missing data is filled in with generic assumptions.
- User can alter data to fix any assumptions that were mistakes.

Change bridge\_model | Michigan Bridges - Mozilla Firefox

Change bridge\_model | ...

127.0.0.1:8000/admin/bms/bridge\_model/45/

3DWIBIS Tablet Application Website

Home - Michigan Bridges - Bridge\_model - 611811030005130

Welcome, MDOT\_Inspector. Change password / Log out

## Change bridge\_model

[Assumptions](#) [Index](#)

Number of Beams: 6  
Number of Beams

Number of Total joints: 5  
Number Total Joints on the Bridge

Number of Columns: 15  
Number of Columns

Number of Pin and Hangers: 10  
Number of Pin and Hangers

Number of Bearings: 30  
Number of Bearings

Number of Piers: 3  
Number of Piers

### General Bridge Information

[Bridgekey:](#) 611811030005130  
Required: 30 characters to lower letters, digits and @/!/\_/-/

[Bridge Orientation:](#) 905  
The orientation of the direction of the bridge

[Skew Angle:](#) 29  
Structure skew angle, Units = degrees

[Deck Width:](#) 44.28945768  
Deck width, out to out, Units = ft

[Road Width:](#) 41.90964000  
Bridge roadway width, out to out, Units = ft

[Structure Length:](#) 325.99903504  
Structure length, Units = ft

[Main Span Material:](#) Steel  
Kind of material and/or design for the main span

[Main span design:](#) Girder/Box beam or Gable  
Type of design and/or construction for the main span

[Fascia Width:](#) 3  
Fascia Width of the bridge, Units = ft



## Backend Outputs XML to Frontend

- Outputs bridge XML to create model.

```
- <Member>
  <role>Deck</role>
  <type>Concrete Deck - Coated Bars</type>
  <name>2S</name>
  <length>1451.98234368</length>
  <width>491.47385216</width>
  <height>15.0</height>
  <AASHTO_Element_803>803</AASHTO_Element_803>
  <x>1229.9850432</x>
  <y>265.73692608</y>
  <z>270.5133888</z>
```

## Select bridge by Region / StructureID

Select Bridge from Queue. Server queries database, generates Bridge Model XML Document, and passes to Server



### Select A Bridge To Load

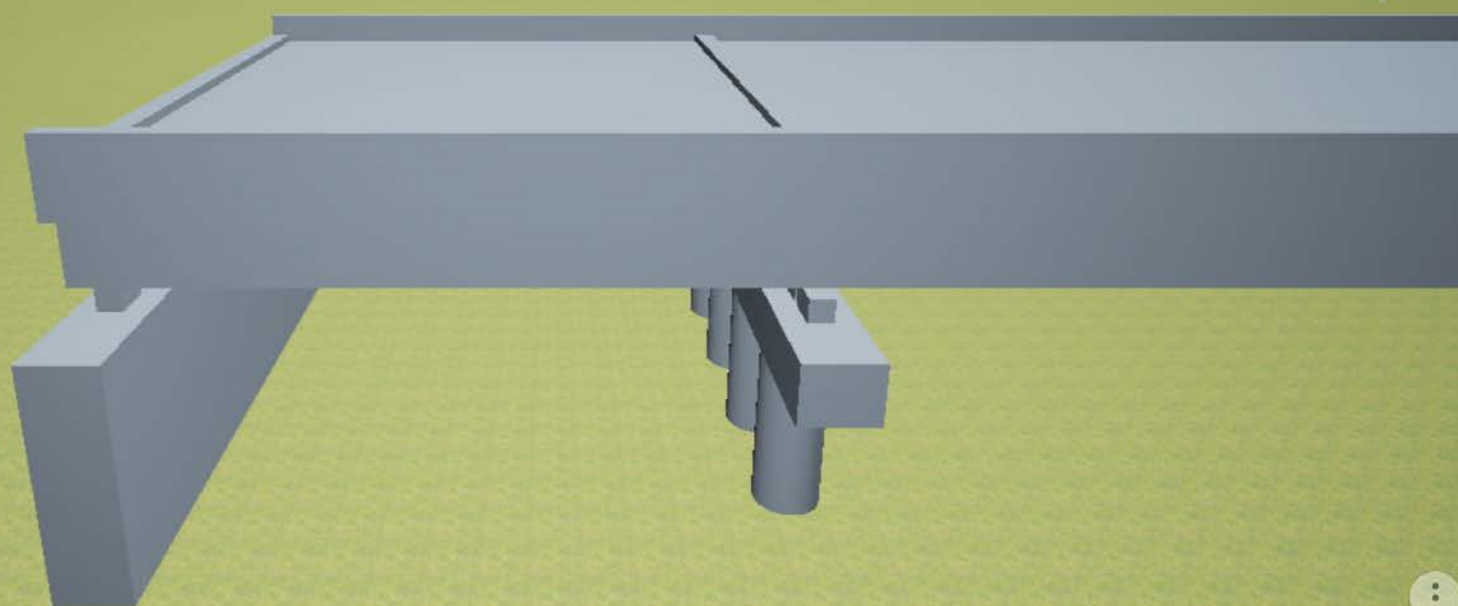
|                                    |                       |
|------------------------------------|-----------------------|
| GRAND RIVER - M-99 SB              | GRAND RIVER - M-99 SB |
| M-14 - CURTIS ROAD                 | 23123092000B030       |
| I-75 NB ENT RAMP - I-75 SB ENT RMP | Download XML          |
| GRAND RIVER - M-99 NB              | Downloaded: N/A       |
| MAPLE RD - M-14 WB                 | Load                  |

XML's can be saved locally so WiFi/Cell access is not required in the field



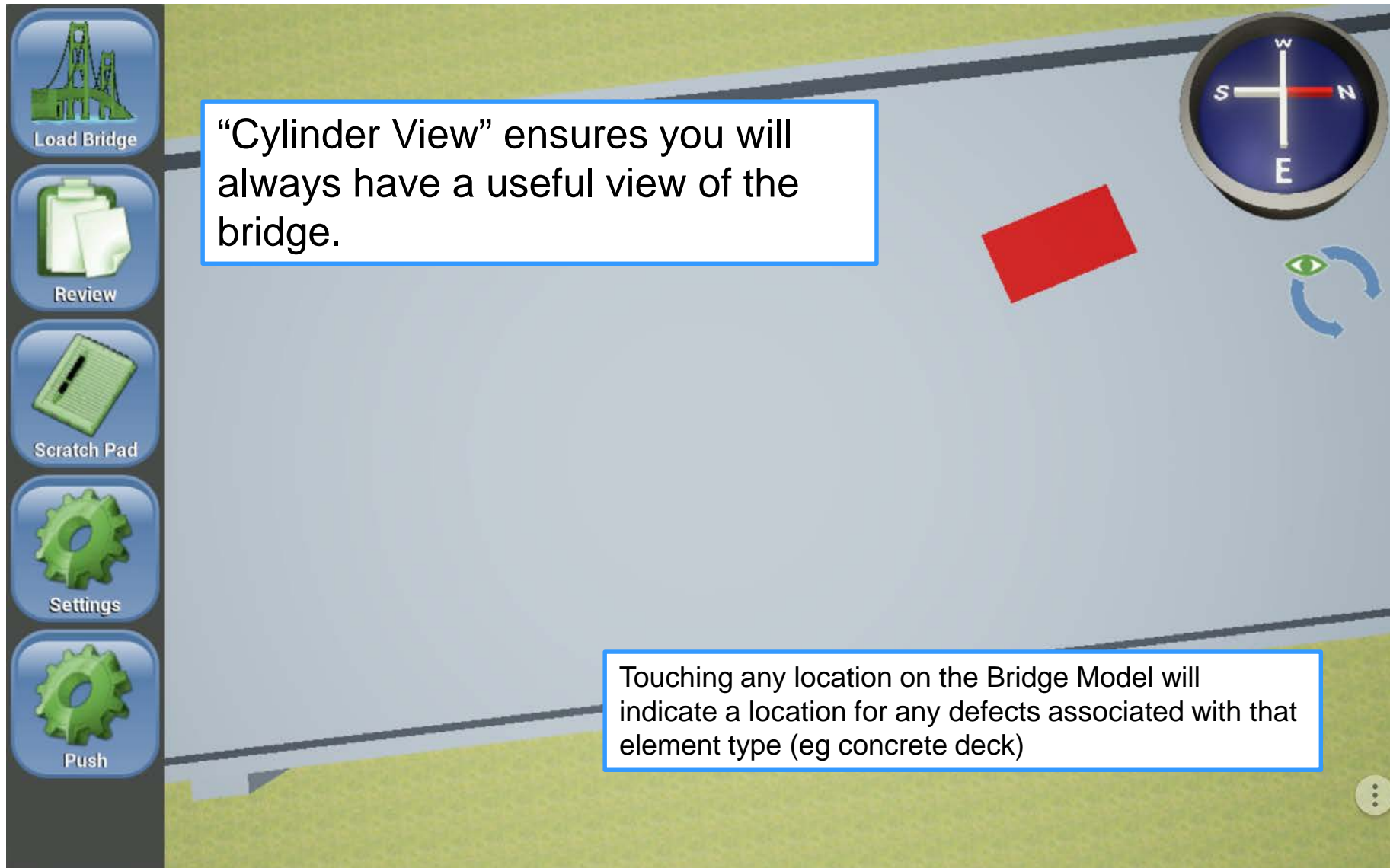
## Desired bridge loads and is rendered

Application Renders Bridge Model  
in 3D – Inspector can navigate to  
Inspection Views



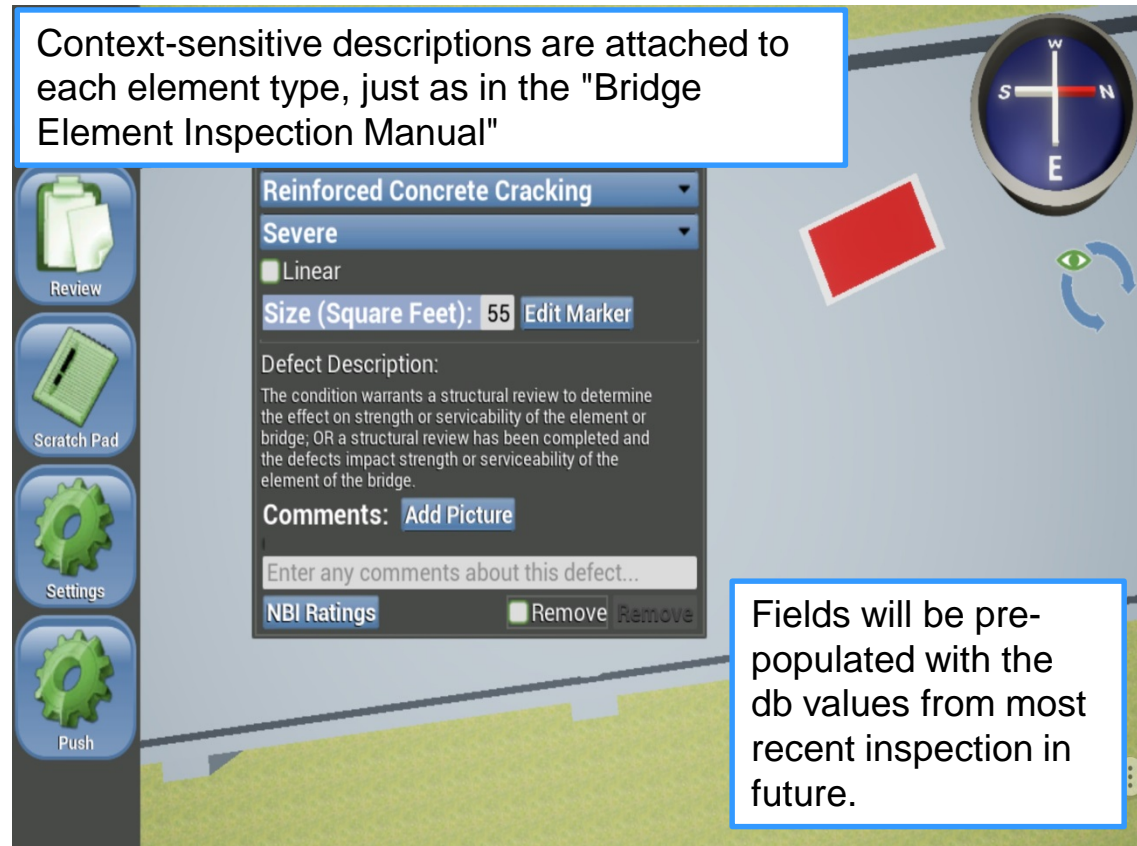


# Navigation is constrained to an orbit around the bridge

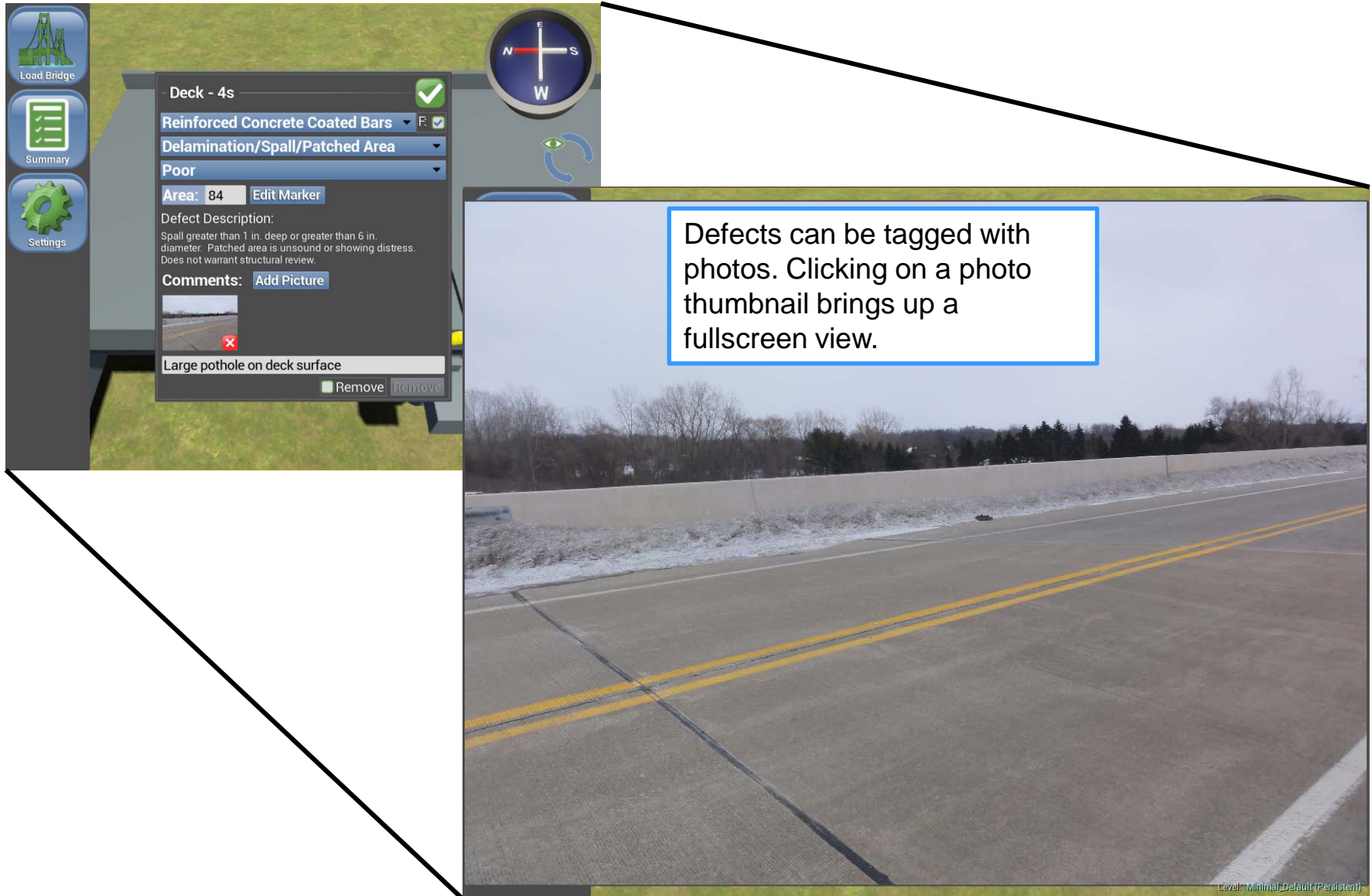


## 3D BRIDGE App Usage

- The 3D BRIDGE App enables bridge inspectors to collect and record all of the necessary data for the bridge inspection process in one tool.
- Each individual defect can be annotated with a description, photos, and quantity.
- Inspectors no longer have to carry the Bridge Element Inspection Manual



## View Photos of the Desired Defect



Load Bridge

Summary

Settings

Deck - 4s

Reinforced Concrete Coated Bars

Delamination/Spall/Patched Area

Poor

Area: 84 Edit Marker

Defect Description:  
Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area is unsound or showing distress. Does not warrant structural review.

Comments: Add Picture

Large pothole on deck surface

Remove Remove

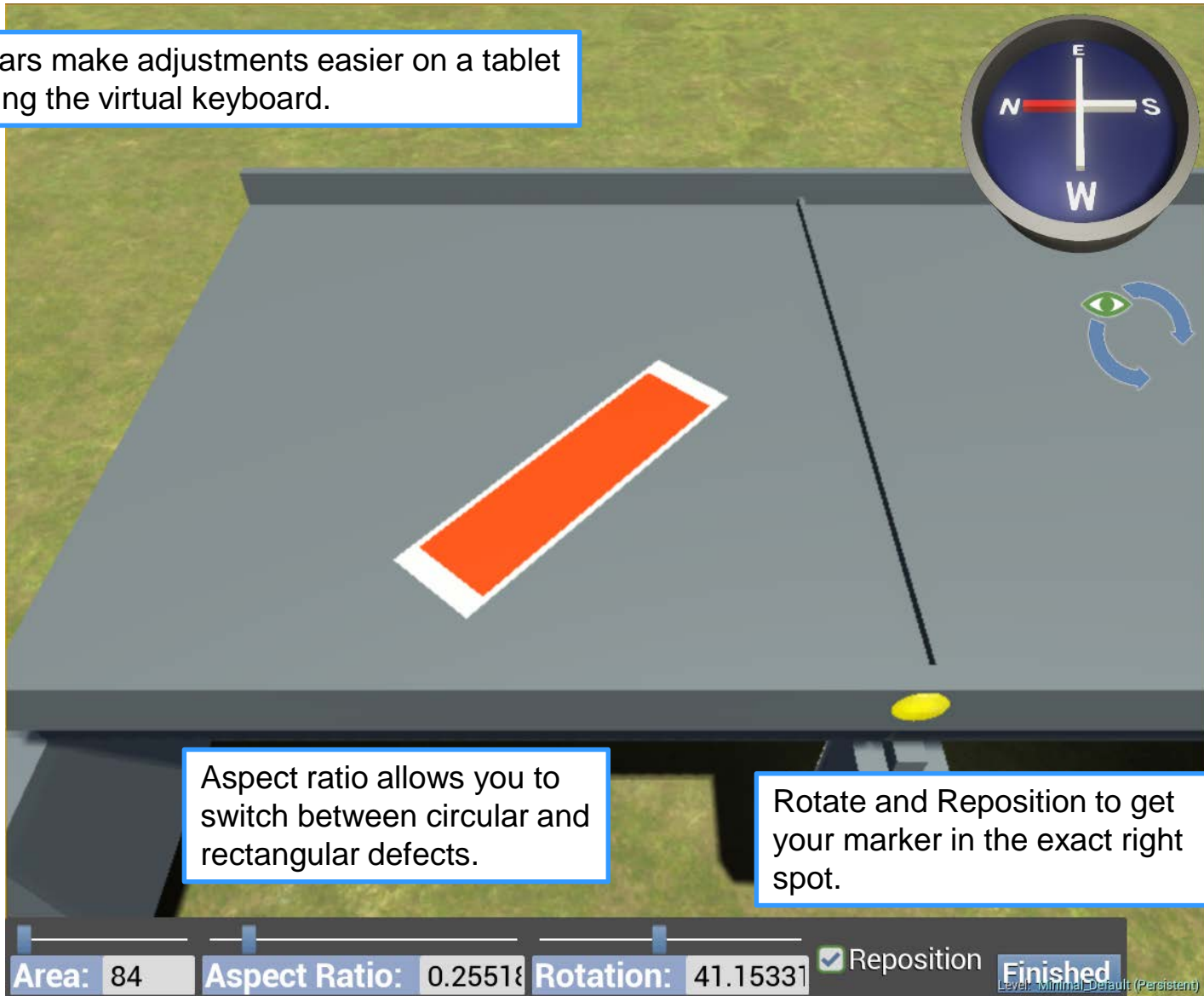
Defects can be tagged with photos. Clicking on a photo thumbnail brings up a fullscreen view.

Level: Minimal\_Default (Persistent)



## Customize the Defect's Size and Shape

Slider bars make adjustments easier on a tablet than using the virtual keyboard.



# Copy/Paste Defects

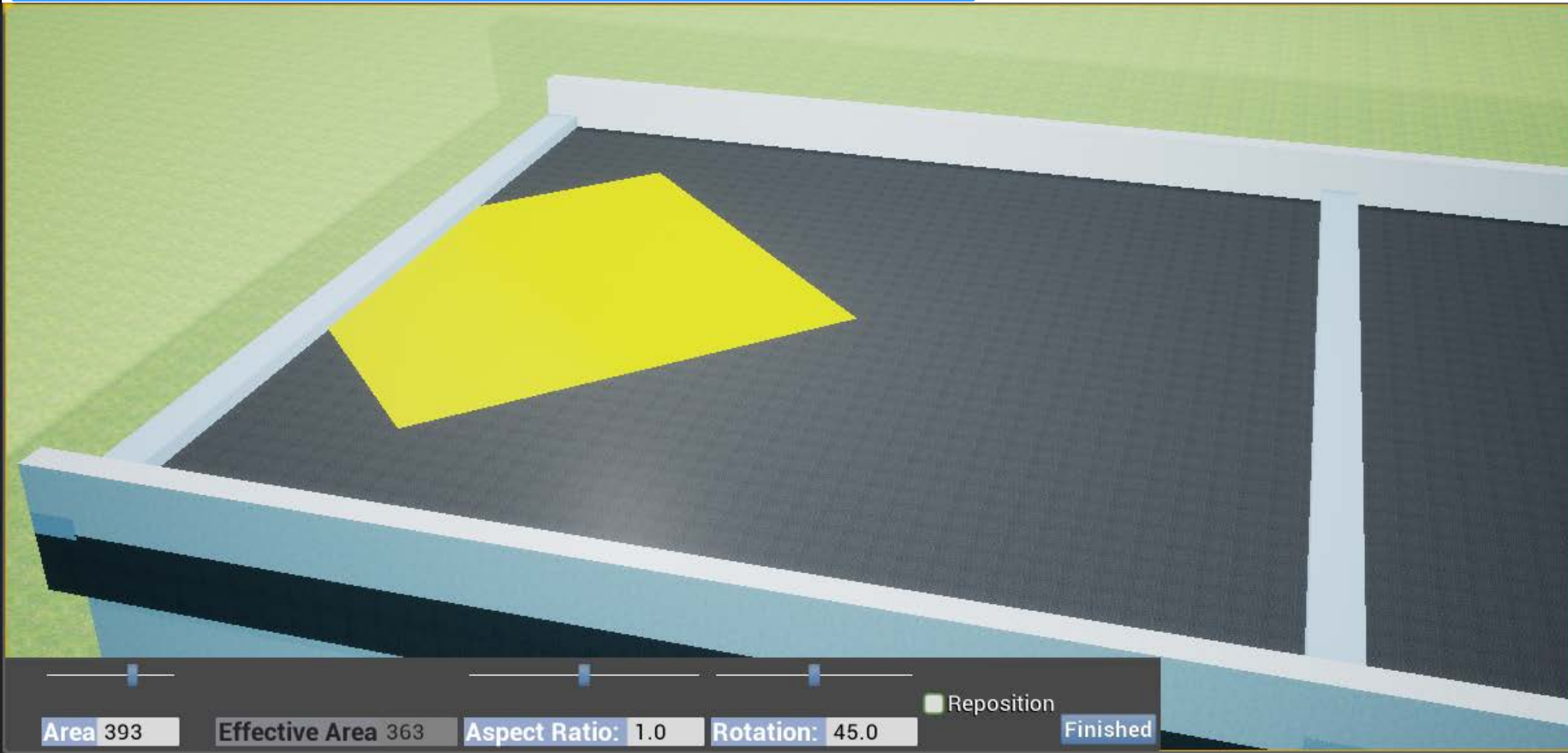
Copy/Paste defects onto the same element type



Will be developed into the ability to place defects on regular intervals: eg “vertical cracks every 10ft on railing”

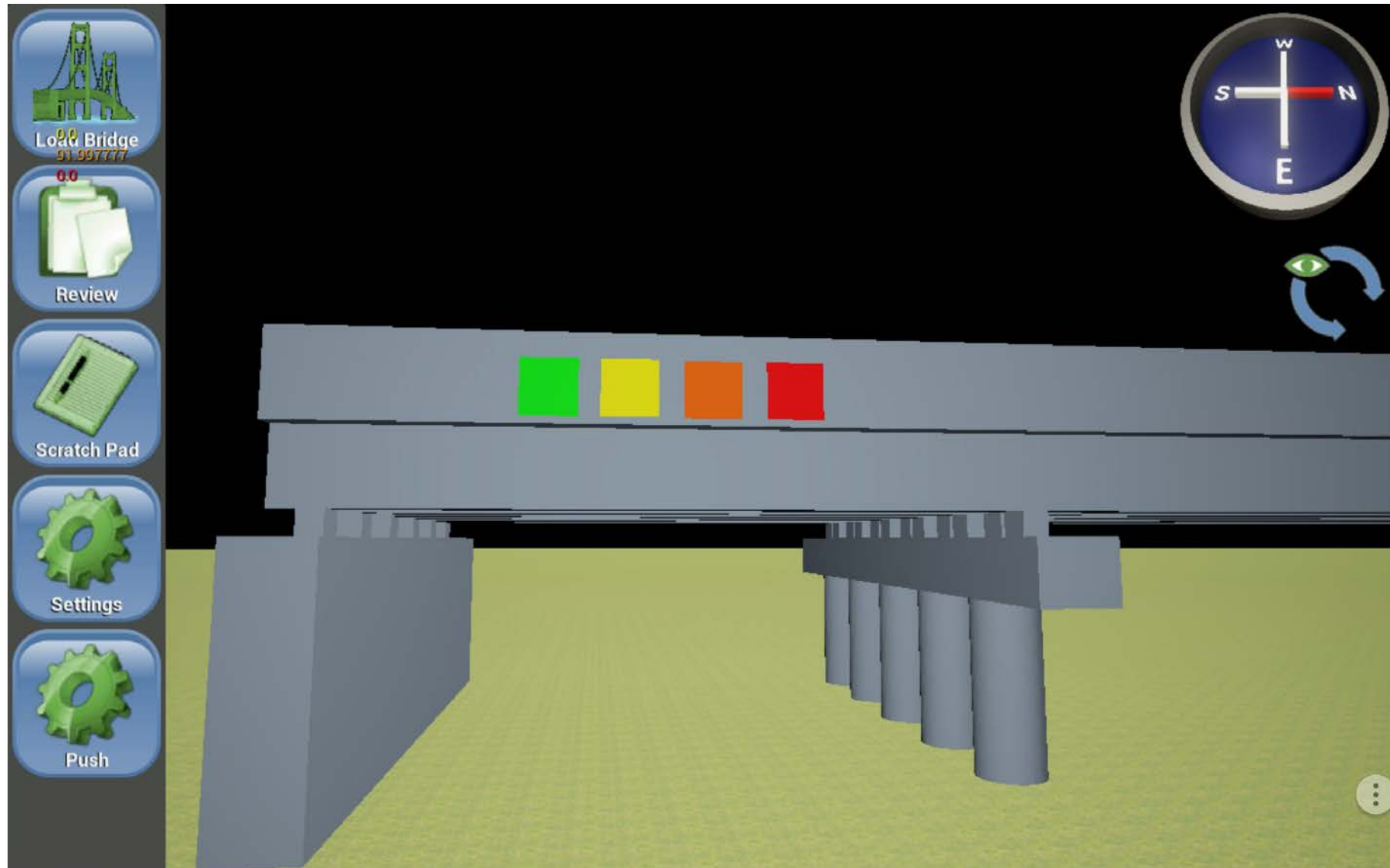
## Automatic Clipping

Defects are limited to the element they are attached to, and cannot extend beyond that to ensure accuracy of total quantity

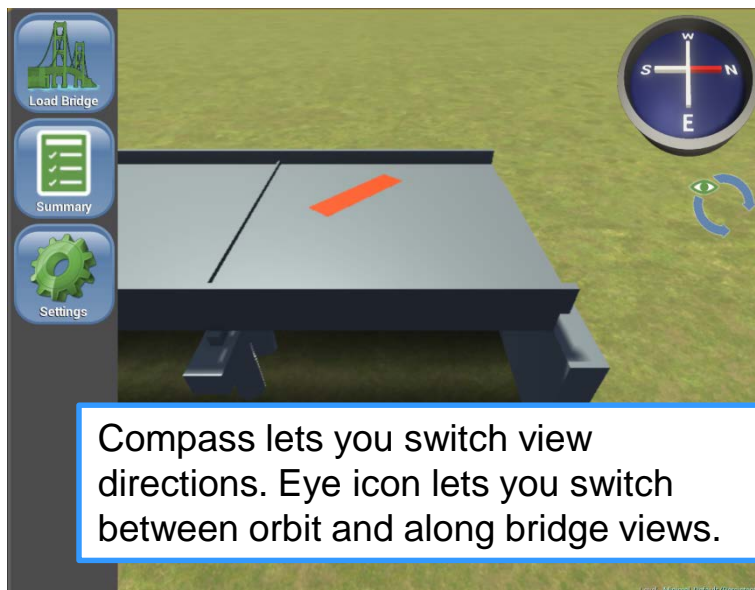
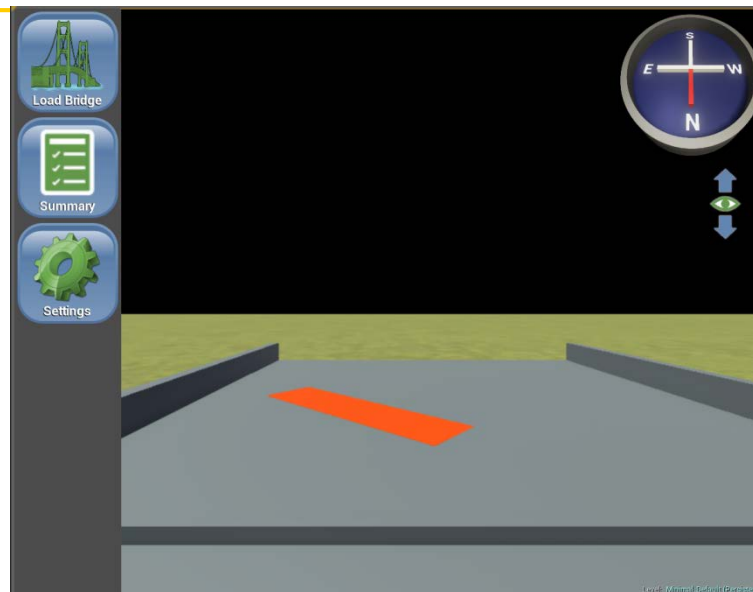
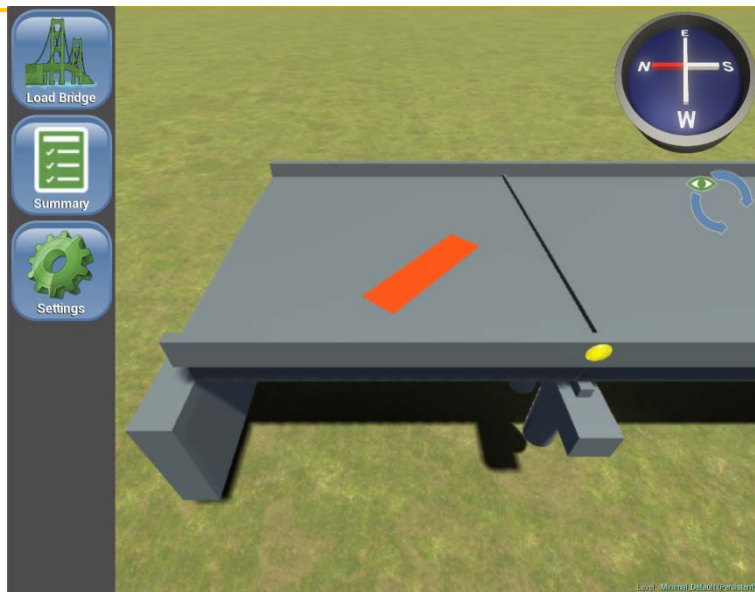




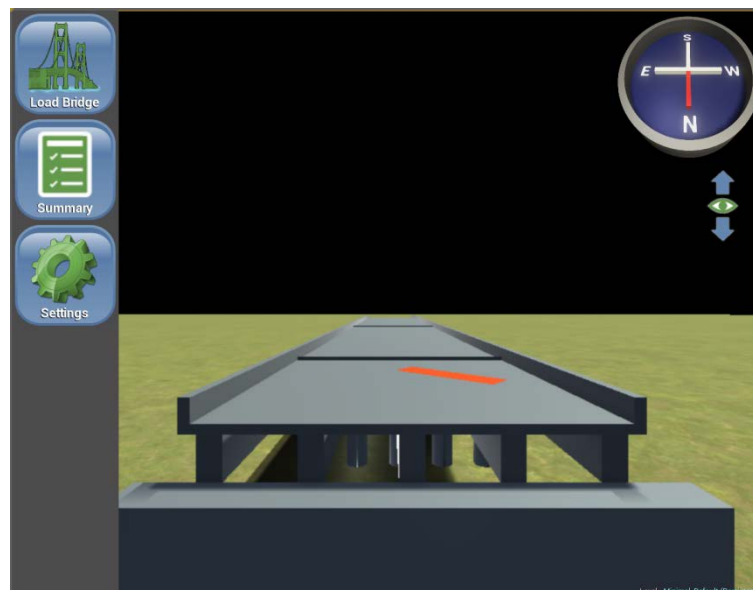
Colors indicate condition states, and  
relative sizes are proportional to "quantity"



# Saves the Defect's 3D Position For Future Inspections

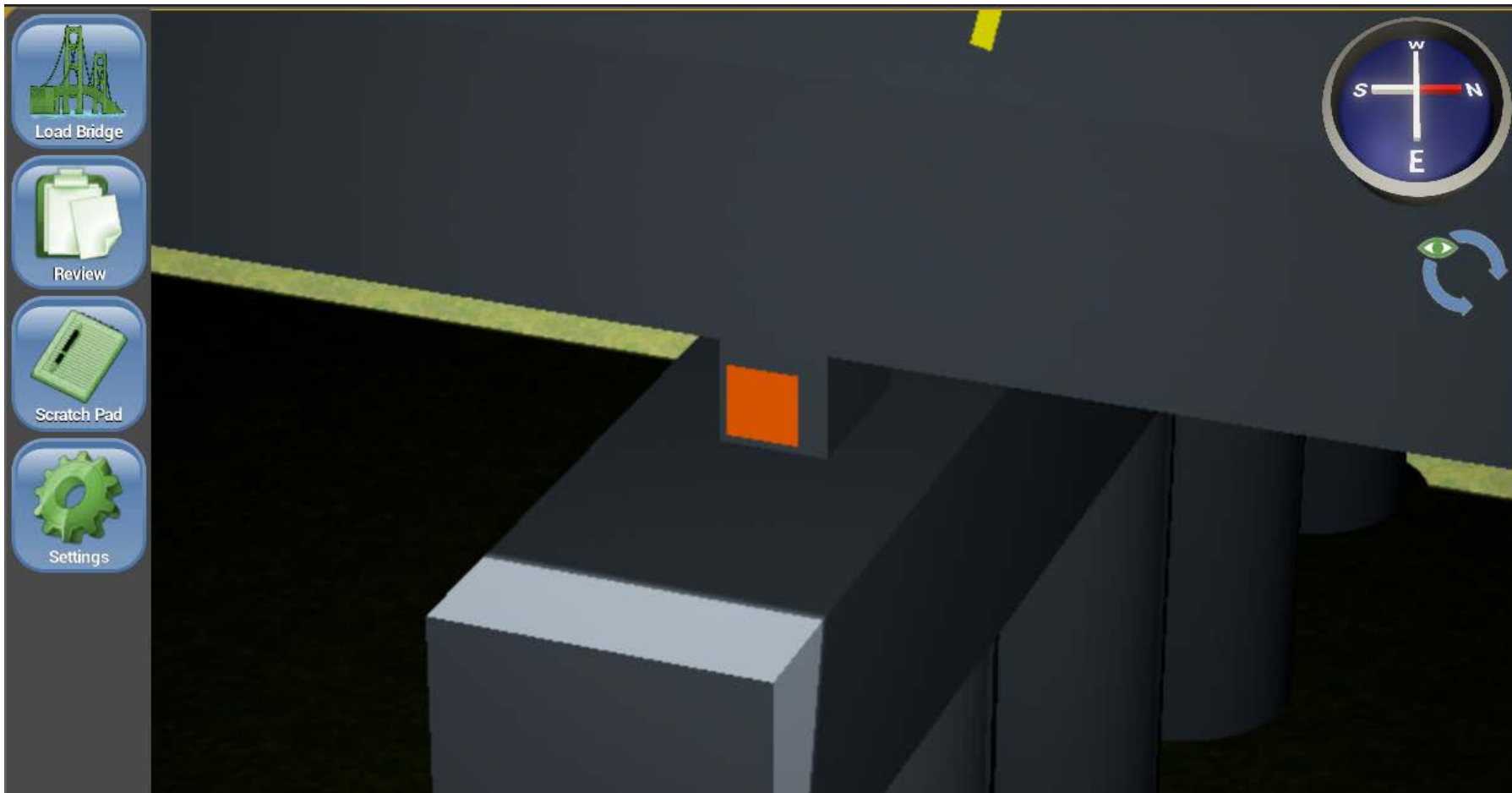


Compass lets you switch view directions. Eye icon lets you switch between orbit and along bridge views.



## Pinch to Zoom

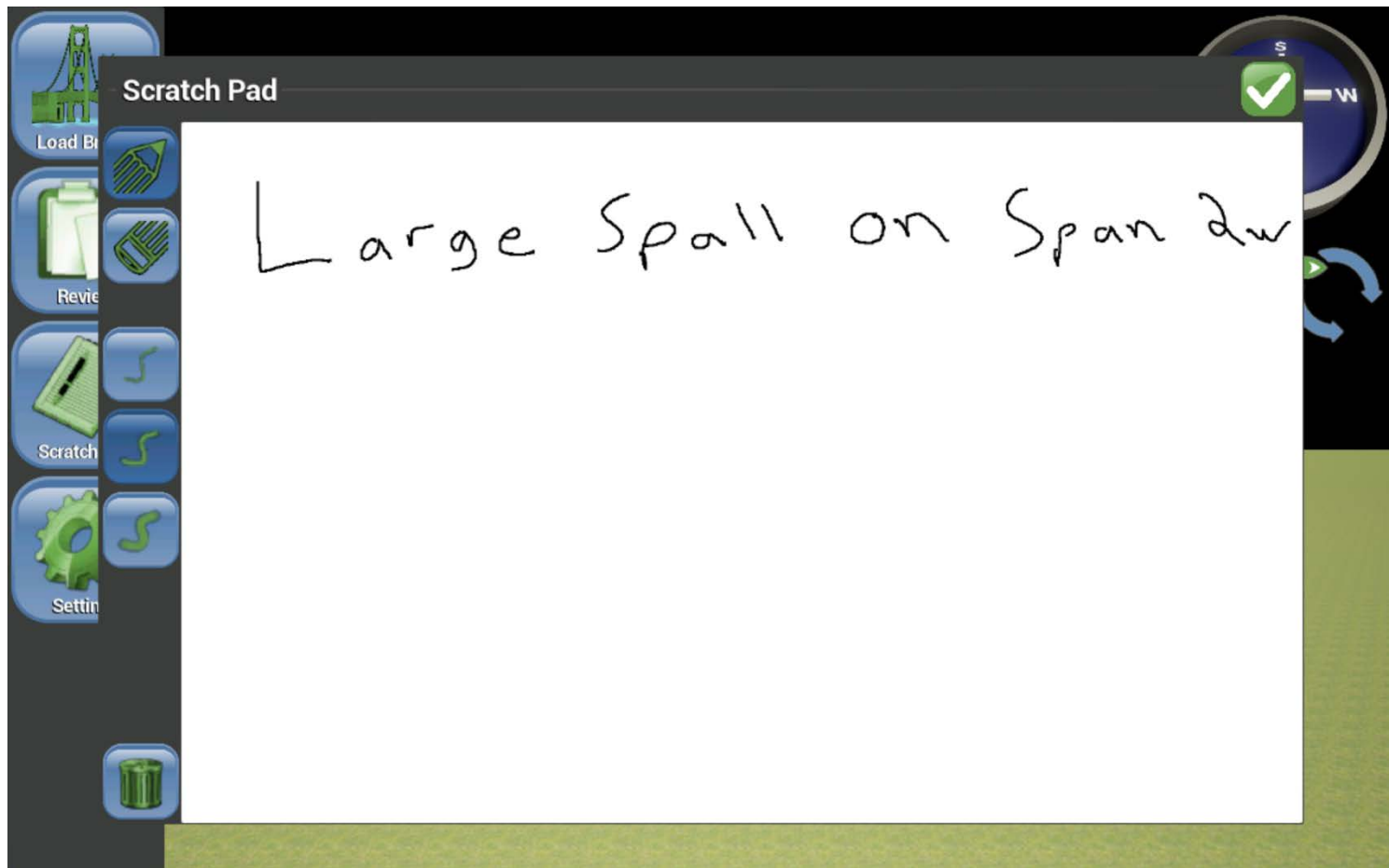
- Pinch to zoom in on a part of the bridge, or a defect.





## Scratch Pad

- Write on the scratch pad to add any additional comments or drawings



# Collect and Display NBI Information

**Bridge Review**

Element Review
Defect Summary
**NBI Report**

|  |   |   |  |                  |
|--|---|---|--|------------------|
| <b>STR 10922</b>   |   | <b>BRIDGE SAFETY INSPECTION REPORT</b>        |  | <b>S13-81103</b> |
| <b>Facility</b><br>CURTIS ROAD                                   | <b>Latitude / Longitude</b><br>42.338417 / -83.605835           | <b>MDOT Structure ID</b><br>81181103000S130   | <b>Structure Condition</b><br>Good Condition(7)      |                  |
| <b>Feature</b><br>M-14   | <b>Length / Width</b><br>325.996033 / 44.289486                 | <b>Owner</b><br>1                             |  |                  |
| <b>Location</b><br>3 MI W OF WAYNE CO LINE                       | <b>Built / Recon. / Paint / Ovly.</b><br>1975 / 2006 / 0 / 2006 | <b>TSC</b><br>Brighton(6B)                    | <b>Operational Status</b><br>Open, no restriction(A) |                  |
| <b>Region / County</b><br>6- University, Jackson / Washtenaw(81) | <b>Material / Design</b><br>3 Steel / 02 Stringer/Girder        | <b>Last NBI Inspection</b><br>9/4/2014 / EJD7 | <b>Scour Evaluation</b><br>Bridge not over waterway  |                  |

**NBI INSPECTION** EJD7

| Inspector Name | Agency / Company Name | Insp. Freq. | Insp. Date |
|----------------|-----------------------|-------------|------------|
|                | MDOT Inspector        | 24          |            |

**GENERAL NOTES**  
 Long term testing of old concrete columns under span 1w.

▷

DECK

▷

SUPERSTRUCTURE

▷

SUBSTRUCTURE

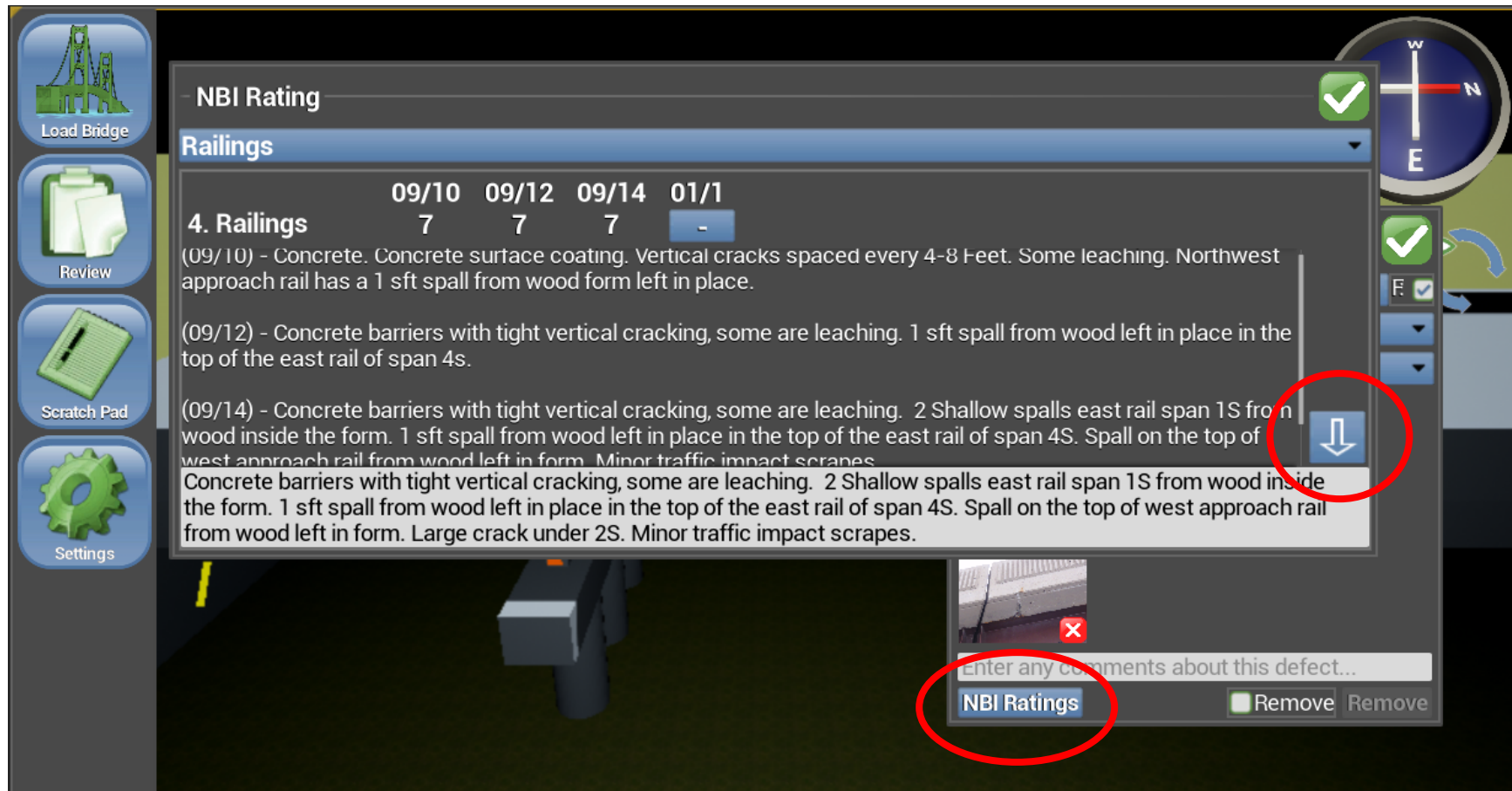
▷

APPROACH

- Review NBI Report Information in the “NBI Report” Summary Tab, and expand the report according to the category.

## Collect and Display NBI Information

- Enter in NBI Information by clicking the “NBI Ratings” button. Use previous comments from past NBI Reports using the “Download” arrow button



The screenshot shows the NBI Rating software interface. On the left is a sidebar with icons for 'Load Bridge', 'Review', 'Scratch Pad', and 'Settings'. The main window displays the 'NBI Rating' section with a 'Railings' dropdown menu. Below the menu is a table with columns for dates and ratings:

|             | 09/10 | 09/12 | 09/14 | 01/1 |
|-------------|-------|-------|-------|------|
| 4. Railings | 7     | 7     | 7     | -    |


Below the table, there are three paragraphs of text describing defects:

- (09/10) - Concrete. Concrete surface coating. Vertical cracks spaced every 4-8 Feet. Some leaching. Northwest approach rail has a 1 sft spall from wood form left in place.
- (09/12) - Concrete barriers with tight vertical cracking, some are leaching. 1 sft spall from wood left in place in the top of the east rail of span 4s.
- (09/14) - Concrete barriers with tight vertical cracking, some are leaching. 2 Shallow spalls east rail span 1S from wood inside the form. 1 sft spall from wood left in place in the top of the east rail of span 4S. Spall on the top of west approach rail from wood left in form. Minor traffic impact scrapes.

At the bottom of the window, there is a 'Download' arrow button (circled in red) and a 'NBI Ratings' button (also circled in red). A small inset window at the bottom right shows a photo of a bridge railing with a red 'X' and a text input field for comments.



## Collect and Display NBI Information



The screenshot displays the NBI Rating software interface. On the left, there is a vertical toolbar with icons for 'Load Bridge', 'Review', 'Scratch Pad', and 'Settings'. The main window is titled 'NBI Rating' and contains a table for 'Railings' with columns for dates (09/10, 09/12, 09/14, 01/1) and a rating column. The table shows a rating of 7 for all dates. A large, semi-transparent NBI Rating wheel is overlaid on the table, with segments numbered 1 through 9 and a 'N' for 'Not Rated'. The wheel is currently set to 6. Below the table, there is a text area for comments and a 'Remove' button. A small inset window at the bottom right shows a photo of a bridge railing with a red 'X' indicating a defect.

|             | 09/10 | 09/12 | 09/14 | 01/1 |
|-------------|-------|-------|-------|------|
| 4. Railings | 7     | 7     | 7     |      |

(09/10) - Concrete. Concrete surface coating. V...  
approach rail has a 1 sft spill from wood form

(09/12) - Concrete barriers with tight vertical...  
top of the east rail of span 4s.

(09/14) - Concrete barriers with tight vertical...  
wood inside the form. 1 sft spill from wood left in form...  
west approach rail from wood left in form...  
Concrete barriers with tight vertical cracking...  
the form. 1 sft spill from wood left in place...  
from wood left in form. Large crack under 2S...

very 4-8 Feet. Some leaching. Northwest

ft spill from wood left in place in the

allow spalls east rail span 1S from

il of span 4S. Spall on the top of

spalls east rail span 1S from wood inside

4S. Spall on the top of west approach rail

ss.

Enter any comments about this defect...

NBI Ratings Remove Remove

- Enter in the NBI Rating for a category by using user-friendly NBI Rating wheel

# Collect and Display NBI Information

Bridge Review

Element Review

Defect Summary

NBI Report

4. Railings

09/10

09/12

09/14

01/1

7

7

7

6

(09/10) - Concrete. Concrete surface coating. Vertical cracks spaced every 4-8 Feet. Some leaching. Northwest approach rail has a 1 sft spall from wood form left in place.

(09/12) - Concrete barriers with tight vertical cracking, some are leaching. 1 sft spall from wood left in place in the top of the east rail of span 4s.

(09/14) - Concrete barriers with tight vertical cracking, some are leaching. 2 Shallow spalls east rail span 1S from wood inside the form. 1 sft spall from wood left in place in the top of the east rail of span 4S. Spall on the top of west approach rail from wood left in form. Minor traffic impact scrapes.

Concrete barriers with tight vertical cracking, some are leaching. 2 Shallow spalls east rail span 1S from wood inside the form. 1 sft spall from wood left in place in the top of the east rail of span 4S. Spall on the top of west approach rail from wood left in form. Large crack under 2S. Minor traffic impact scrapes.

5. Sidewalks Or Curbs

09/10

09/12

09/14

01/1

N

N

N

N

(09/10) -

(09/12) -

- Scroll through the entire report, and review NBI ratings of past and current reports


## View Different Summaries of the Recorded Data

- Display and summarize the bridge inspection data with different views.

Bridge Review

AASHTO  
Element Level  
Data View

| Bridge Review  |                   |            |  |
|---|-------------------|------------|--|
| Summary Review  | Element Report    | NBI Report |  |
| Good  | 0 ft <sup>2</sup> |            |  |
| ▼ Fair  | 4 ft <sup>2</sup> |            |  |
| ▼ Railing   | 4 ft <sup>2</sup> |            |  |
| ▼ Reinforced Concrete Bridge Railing  | 4 ft <sup>2</sup> |            |  |
| ▼ Damage  | 4 ft <sup>2</sup> |            |  |
| Railing - 2w  | 4 ft <sup>2</sup> |            |  |
| ▼ Poor  | 8 ft <sup>2</sup> |            |  |
| ▼ Deck  | 8 ft <sup>2</sup> |            |  |
| ▼ Reinforced Concrete Coated Bars   | 8 ft <sup>2</sup> |            |  |
| ▼ Exposed Rebar   | 8 ft <sup>2</sup> |            |  |
| Deck - 1s   | 8 ft <sup>2</sup> |            |  |
| Severe  | 0 ft <sup>2</sup> |            |  |

| Bridge Review  |                                    |            |                |            |         |         |         |  |
|---|------------------------------------|------------|----------------|------------|---------|---------|---------|--|
| Summary Review  | Element Report                     | NBI Report |                |            |         |         |         |  |
| Element Number  | Element Name                       | Unit       | Total Quantity | State 1    | State 2 | State 3 | State 4 |  |
| ▼ Decks/Slabs   | AASHTO name                        | Units      | Total Quantity | \$1        | \$2     | \$3     | \$4     |  |
| ▼ 803   | Reinforced Concrete Coated Bars    | Units      | 1344.957275    | 1336.95727 | 0.0     | 8.0     | 0.0     |  |
| AASHTO Num  | Exposed Rebar                      | Poor       | 8              | \$1        | \$2     | \$3     | \$4     |  |
| Superstructure  | AASHTO name                        | Units      | Total Quantity | \$1        | \$2     | \$3     | \$4     |  |
| Substructure  | AASHTO name                        | Units      | Total Quantity | \$1        | \$2     | \$3     | \$4     |  |
| Bearings  | AASHTO name                        | Units      | Total Quantity | \$1        | \$2     | \$3     | \$4     |  |
| Joints  | AASHTO name                        | Units      | Total Quantity | \$1        | \$2     | \$3     | \$4     |  |
| ▼ Other Elemen  | AASHTO name                        | Units      | Total Quantity | \$1        | \$2     | \$3     | \$4     |  |
| ▼ 331   | Reinforced Concrete Bridge Railing | Units      | 199.034409     | 195.034409 | 4.0     | 0.0     | 0.0     |  |
| AASHTO Num  | Damage                             | Fair       | 4              | \$1        | \$2     | \$3     | \$4     |  |
| Culvert   | AASHTO name                        | Units      | Total Quantity | \$1        | \$2     | \$3     | \$4     |  |



# Transparency Setting

Partial Transparency allows inspectors to see what they have placed on either side of a component



Settings

**General Transparency**

Deck: 1

Railing: 2

Joint: 2

Beam: 2

Bearing: 2

Abutment: 2

Pier: 2

Full Transparency hides defects too, letting inspectors zero in on locations that may otherwise be hidden by other components.

# Linear Defect Calculator

For components such as this abutment, only the linear projection of the defects counts, the applications performs this calculation automatically.



Load Bridge



Review



Scratch Pad



Settings



Push



When the defects overlap, the defect with the highest severity rating takes precedence.

# Area Defect Calculator

Components with area quantities still have to deal with overlap, such as defects on the top and bottom of the bridge deck. The application also handles this computation automatically.





# Linear/Area Defect Calculator

## Bridge Review



### Element Review Defect Summary NBI Report

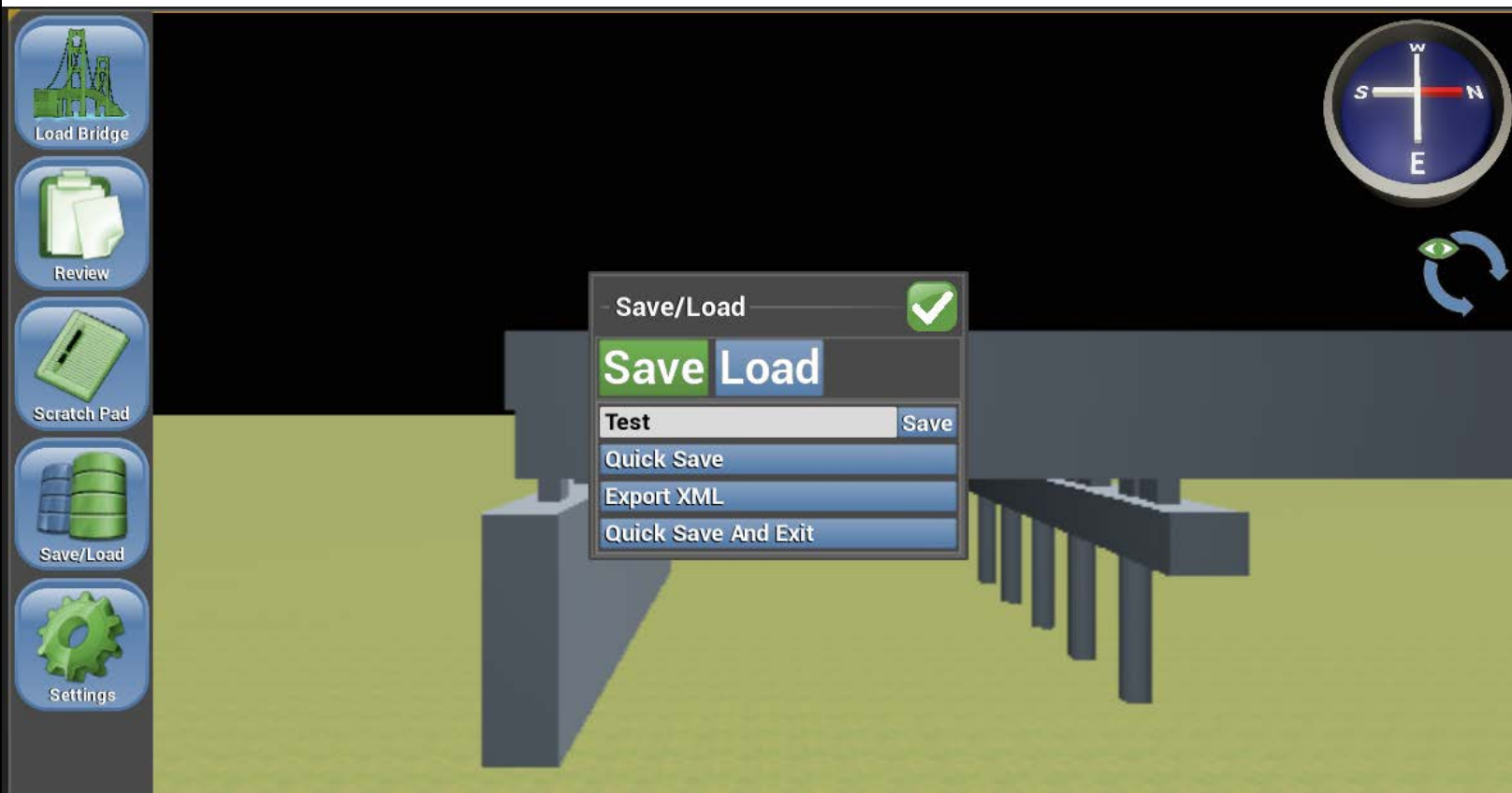
| Element Number |                | Element Name                    | Unit  | Quantity       | Good      | Fair    | Poor     | Severe  |
|----------------|----------------|---------------------------------|-------|----------------|-----------|---------|----------|---------|
|                | Decks/Slabs    | -                               | Units | Total Quantity | CS1       | CS2     | CS3      | CS4     |
|                | Superstructure | -                               | Units | Total Quantity | CS1       | CS2     | CS3      | CS4     |
| ▽              | Substructure   | -                               | Units | Total Quantity | CS1       | CS2     | CS3      | CS4     |
| ▽              | 215            | Reinforced Concrete Abutment    | feet  | 112            | 96<br>86% | 5<br>4% | 10<br>9% | 0<br>0% |
|                | 215            | Delamination/Spall/Patched Area | feet  | 10             | -         | 0       | 10       | 0       |
|                | 215            | Exposed Rebar                   | feet  | 10             | -         | 10      | 0        | 0       |
|                | Bearings       | -                               | Units | Total Quantity | CS1       | CS2     | CS3      | CS4     |
|                | Joints         | -                               |       |                |           |         |          |         |
|                | Other Elements | -                               |       |                |           |         |          |         |
|                | Culvert        | -                               |       |                |           |         |          |         |

These calculations are reflected in the summary report. Here the fair defect partially overlapped the poor defect, both defects are reported but

These calculations are reflected in the summary report. Here the fair defect partially overlapped the poor defect, both defects are reported but only half the fair defect counts towards the total quantity for the abutment.

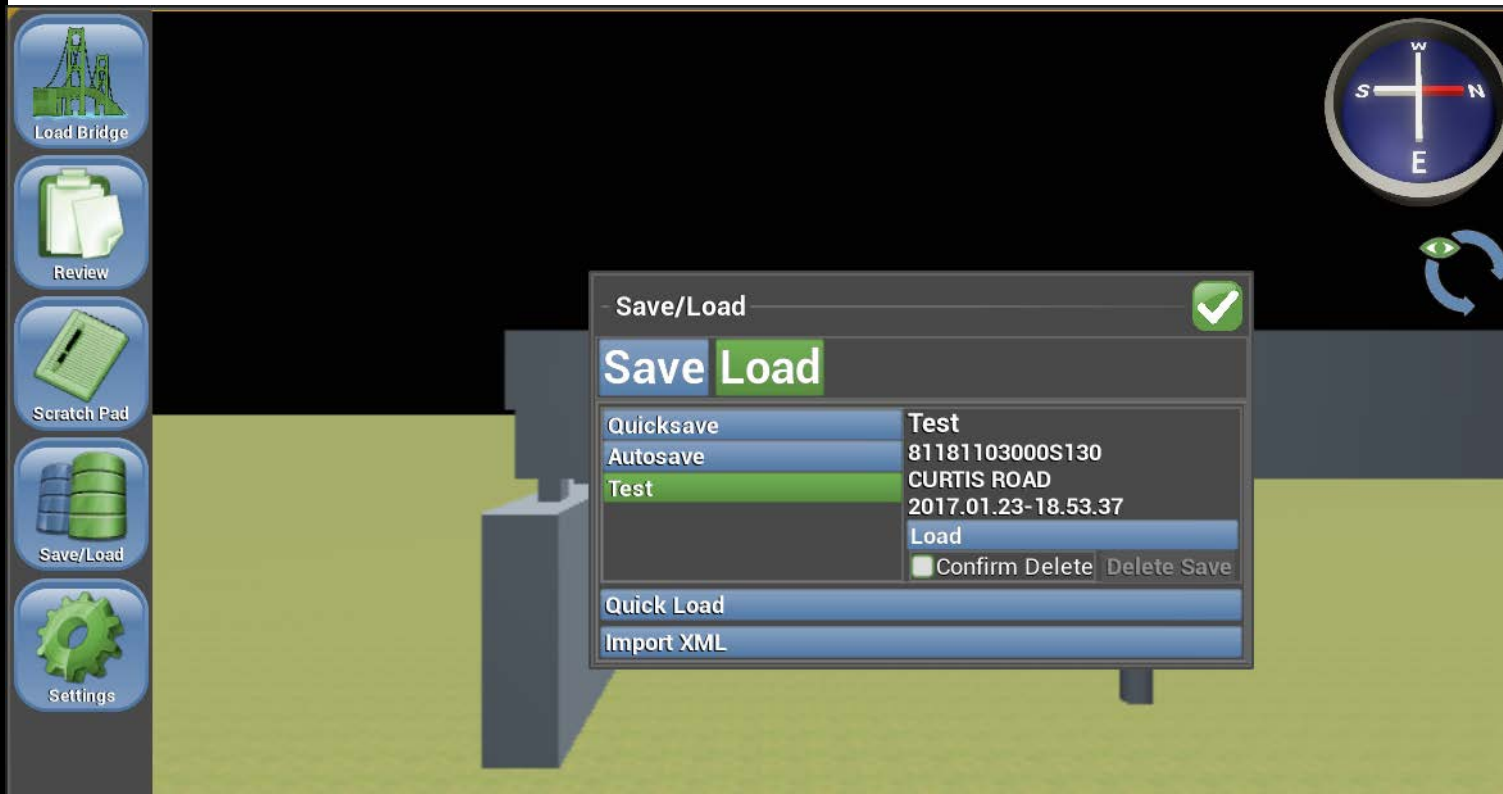
## Save/Load

- User's can save the progress of their inspection on their mobile device using named save files.
- Application also autosaves their progress every time they make an update, so they can restore should their work be interrupted unexpectedly.



## Save/Load

- Load menu gives a list of all save slots, selecting a save slot will list the bridge id, location, and date the save was created.
  - Can also delete unneeded/old saves



## XML Import/Export

- It was necessary to develop a system to import/export data from the MDOT Bridge Management Database.
- All relevant data can be saved in an XML file for later upload to the database management system
  - While not as convenient as a direct uplink, it is also independent from MDOT's database (could be readily adapted to work with other database systems, as the bridge app does not need to change)



## XML cont'd

```

    <aashto_number>331</aashto_number>
    <parent_key>0</parent_key>
    <total_quantity>652.992092328</total_quantity>
    <role>Other Elements</role>
    <unit>feet</unit>
  </aashto_element>
- <aashto_element>
  <aashto_number>321</aashto_number>
  <parent_key>0</parent_key>
  <total_quantity>2969.92778296</total_quantity>
  <role>Other Elements</role>
  <unit>sq feet</unit>
</aashto_element>
</aashto_elements>
- <defects>
  - <defect>
    <size>1</size>
    <aspect>1.0</aspect>
    <rotation>0.0</rotation>
    <severity>2</severity>
    <comment>narg</comment>
    <element>331</element>
    <type>1130</type>
    <linear>0</linear>
    <role>1</role>
    <location X="431.179199" Y="1349.943604" Z="747.372864"/>
    <orientation Yaw="-90.0" Pitch="-90.0" Roll="179.999985"/>
    <parent_location X="4968.179688" Y="1332.418823" Z="744.254028"/>
  </defect>
</defects>
</bridge>

```

- XML contains the data needed to build the bridge model, previous NBI data, and current NBI ratings and bridge defects.
  - Does not currently contain photos, but all other defect information is stored
    - Photos are still on the tablet device and could be uploaded with whatever method is currently in place to deal with inspection photos.
- Exported XML files can be imported back into the app on any device.
  - Behaves like a save file, restoring the inspection to the state it was at when exported.

## The Application is Cross-Platform

- The 3D BRIDGE App is compatible with Windows and Android, and iOS.



# Windows

## Where We Are At Now

- Currently development is focused on meeting a few remaining key priorities of MDOT
  - Handling bridge skew in model generation
  - Adding additional model components
  - “Draw On Defects”, inspectors can draw a defect onto the surface
  - Automatic conversion to gridded format
    - Useful as input to deterioration modeling
  - We also have a whole list of suggestions from inspectors that we will tackle as we have time
- We are starting a limited testing this spring
  - Select inspectors will have access to the early app version to provide feedback
    - Critical to ensure application success, we want this app to work!
- Project goes to March 2020
  - ready-to-use tool through this year’s 2019 testing & updates

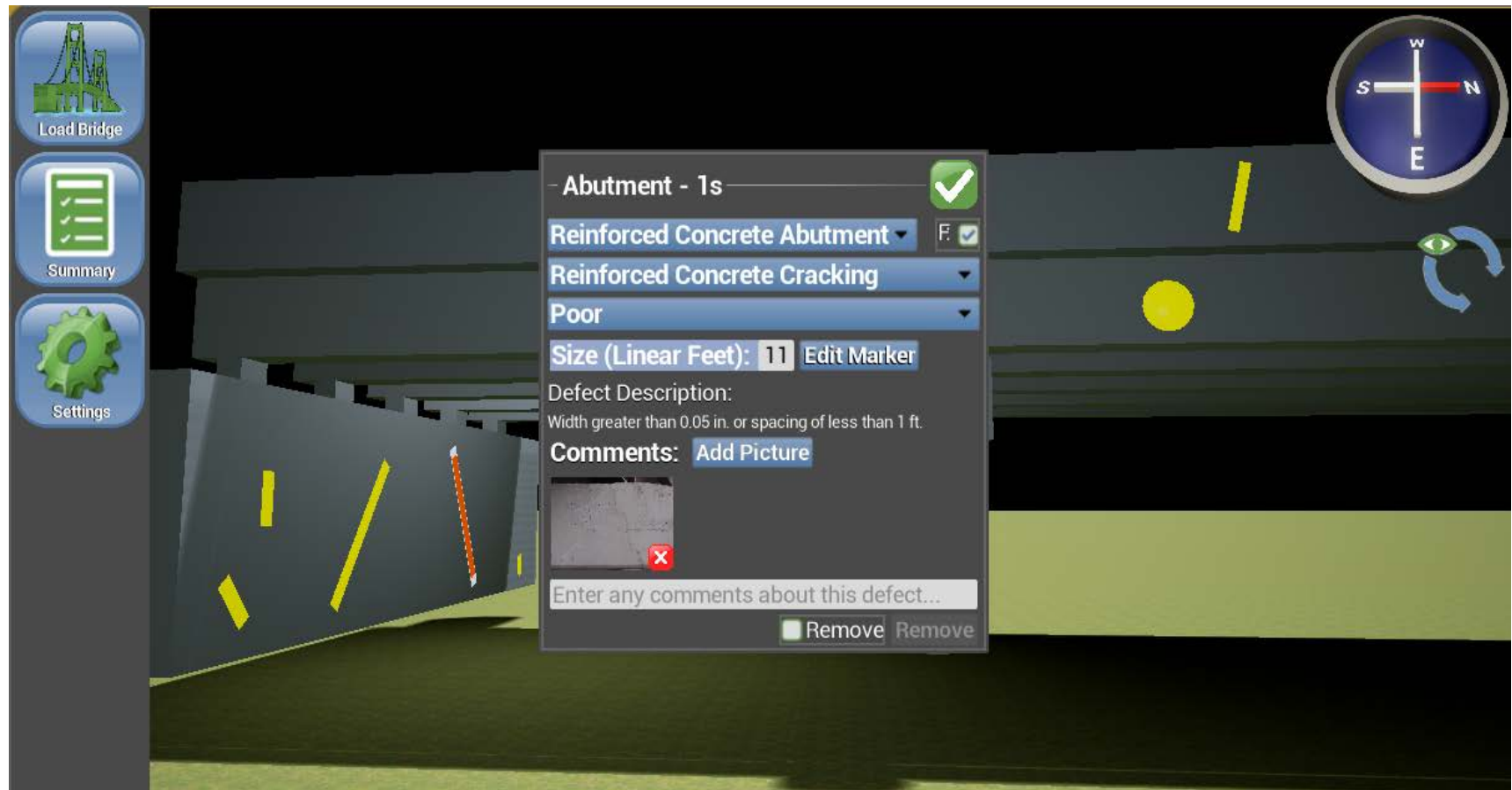
# Benefits

- Benefits of using a location-specific 3D interface extend beyond inspection, but also a tool for future asset management
  - 3D BRIDGE App enables this future
    - Rich with research opportunities, such as integration of remote sensing data, improved bridge model representations, etc.
- Enables transportation agency users (MDOT, etc.) to tie condition and deterioration of one component to related components
- Improves forecasting of condition, bridge needs
  - Leads to better, more efficient asset management



## The Future of Bridge Inspections

- 3D BRIDGE app is a key component towards the future goal of utilizing 3D models to monitor and review a bridge throughout its lifetime.



## Contact Info

- Colin Brooks – Project lead
  - Cell phone: (734)-604-4196
  - Office Phone: (734)-913-6858
  - Email: [cnbrooks@mtu.edu](mailto:cnbrooks@mtu.edu)
- Tess Ahlborn, PhD, P.E., FACI, FPCI
  - Office Phone: (906)-487-2625
  - Email: [tess@mtu.edu](mailto:tess@mtu.edu)
- Reid Sawtell
  - Email: [rwsawtel@mtu.edu](mailto:rwsawtel@mtu.edu)
- Brian Zakrzewski (MDOT)
  - [ZakrzewskiB@michigan.gov](mailto:ZakrzewskiB@michigan.gov)
- Allie Nadjarian (MDOT)
  - [NadjarianA@michigan.gov](mailto:NadjarianA@michigan.gov)

