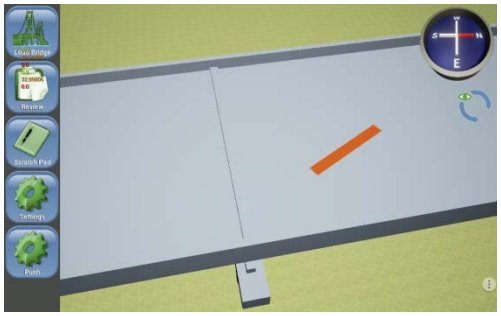
MichiganTech Research Institute

3D B^RIDG^E app overview:

Enabling the Future of Bridge Inspection Data Collection

MDOT #2013-0067, Auth. No. 2



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The Problem

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

The Problem

- Current bridge inspection practices at the Michigan Department of Transportation (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 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 tabulates overall defect quantities, & to duplicate inspections.
- Federal rules require inspectors to collect AASHTO Element level data. Current processes don't enable the efficient collection of this data, especially for recording location-specific information.

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	23123092000B020	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
Decks/Slabs								
18/ 3	Conc Dk Thn Epoxy Ov	8267	(SF)	8267	0	0	0	0
				100%	0%	0%	0%	0%
Joints								
400/ 3	Strip Seal Exp Joint	92	(LF)	92	0	0	xxxxx	xxxxx
				100%	0%	0%	xxxxx	xxxxx
401/ 3	Pourable Joint Seal	92	(LF)	0	92	0	xxxxx	xxxxx
				0%	100%	0%	xxxxx	xxxxx
Superstructure								
107/ 3	Pnted Stl Girder /Bm	1079	(LF)	1074	5	0	0	0
				100%	0%	0%	0%	0%
161/ 3	Paint Stl Pin/Hanger	12	(EA)	12	0	0	0	0
				100%	0%	0%	0%	0%
331/ 3	Concrete Bridge Rail	361	(LF)	269	92	0	0	xxxxx
				75%	25%	0%	0%	xxxxx
Bearings								
311/ 3	Movable Bearing	12	(EA)	12	0	0	xxxxx	xxxxx
				100%	0%	0%	xxxxx	xxxxx
313/ 3	Fixed Bearing	12	(EA)	12	0	0	xxxxx	xxxxx
				100%	0%	0%	xxxxx	xxxxx
Substructure								
205/ 3	Reinf Conc Column	6	(EA)	4	2	0	0	xxxxx
				67%	33%	0%	0%	xxxxx
215/ 3	Reinf Conc Abut	105	(LF)	80	25	0	0	xxxxx
				76%	24%	0%	0%	xxxxx
234/ 3	Reinf Conc Pier Cap	105	(LF)	92	13	0	0	xxxxx
				88%	12%	0%	0%	xxxxx
Other Elements								
321/ 3	Reinf Conc Appr Slab	2	(EA)	2	0	0	0	xxxxx
				100%	0%	0%	0%	xxxxx

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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/tables 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.

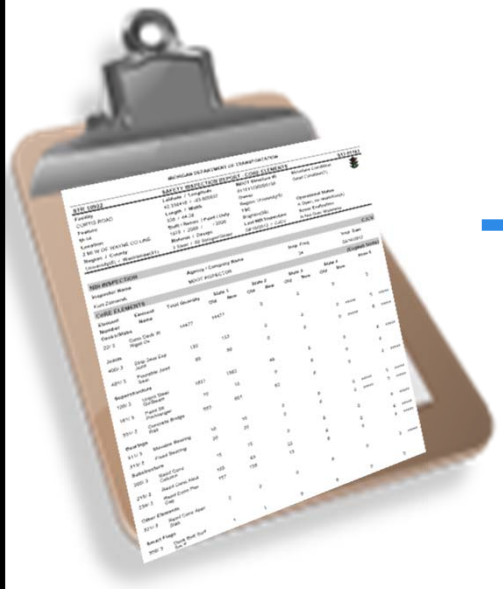
MDOT's requested solution

- A **tablet** application for MDOT Bridge Inspectors for the collection, display, and summarizing of bridge inspection data.

The 3D B^{RIDG}E app

- The 3D B^{RIDG}E 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?



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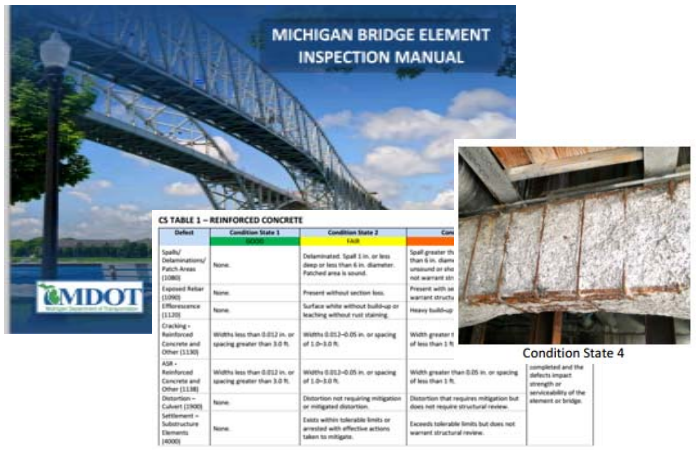

Condition State 4

+

+

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Overview videos available

https://www.youtube.com/watch?v=sCrxqZ57aoI

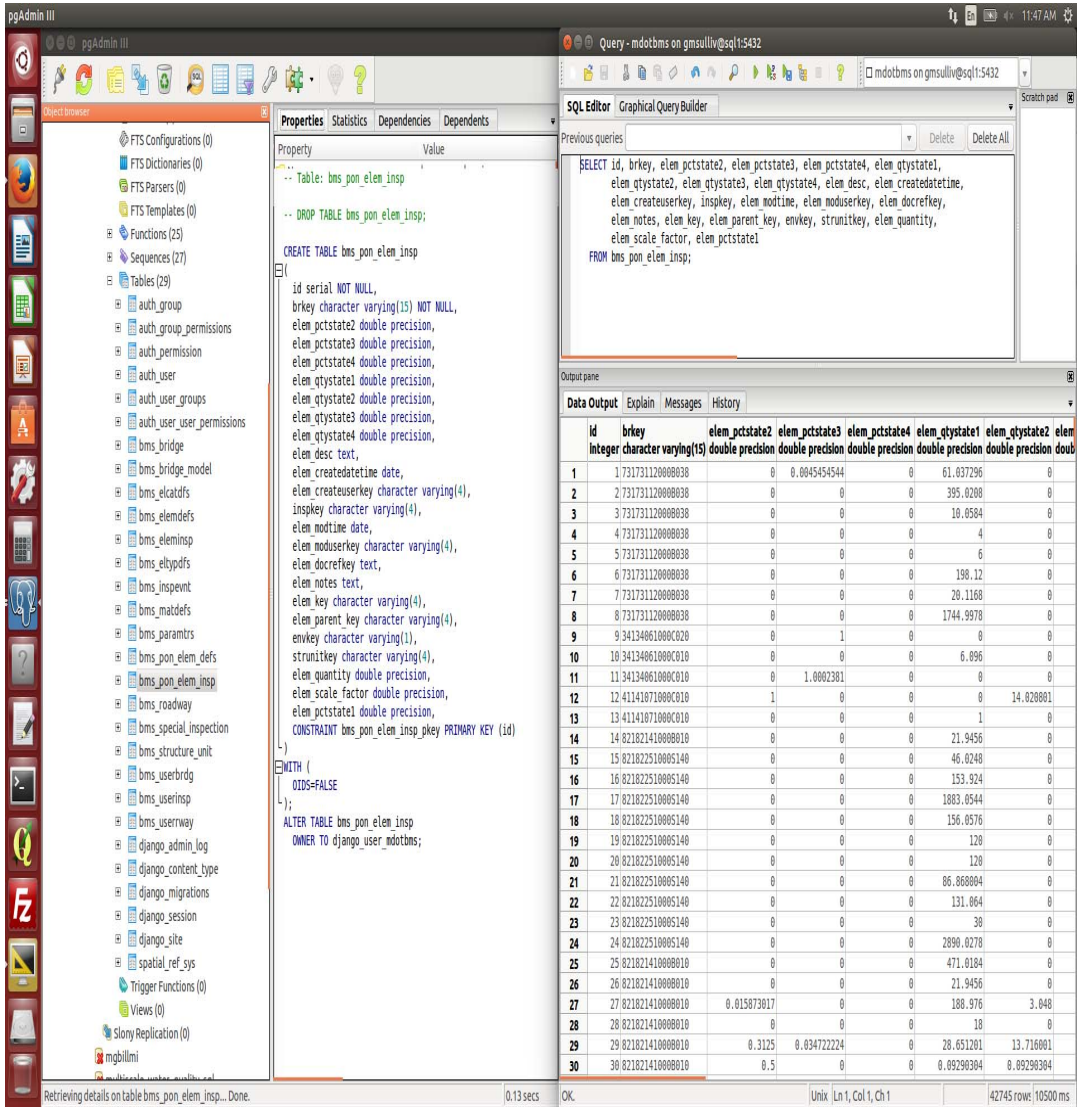
http://www.mtri.org/3dbridge.html

The 3D BRIDGE App Grabs Data from BMS Database

- With few 3D models of the bridges available, a model needed to be created from scratch
  - Wanted to be able to use a 3D model for a bridge needing inspection, regardless of whether one already existed
- Large amounts of descriptive information within MDOT's Bridge Management Database
  - Sufficient information to auto-generate a sufficiently representative model of most bridges needing inspection

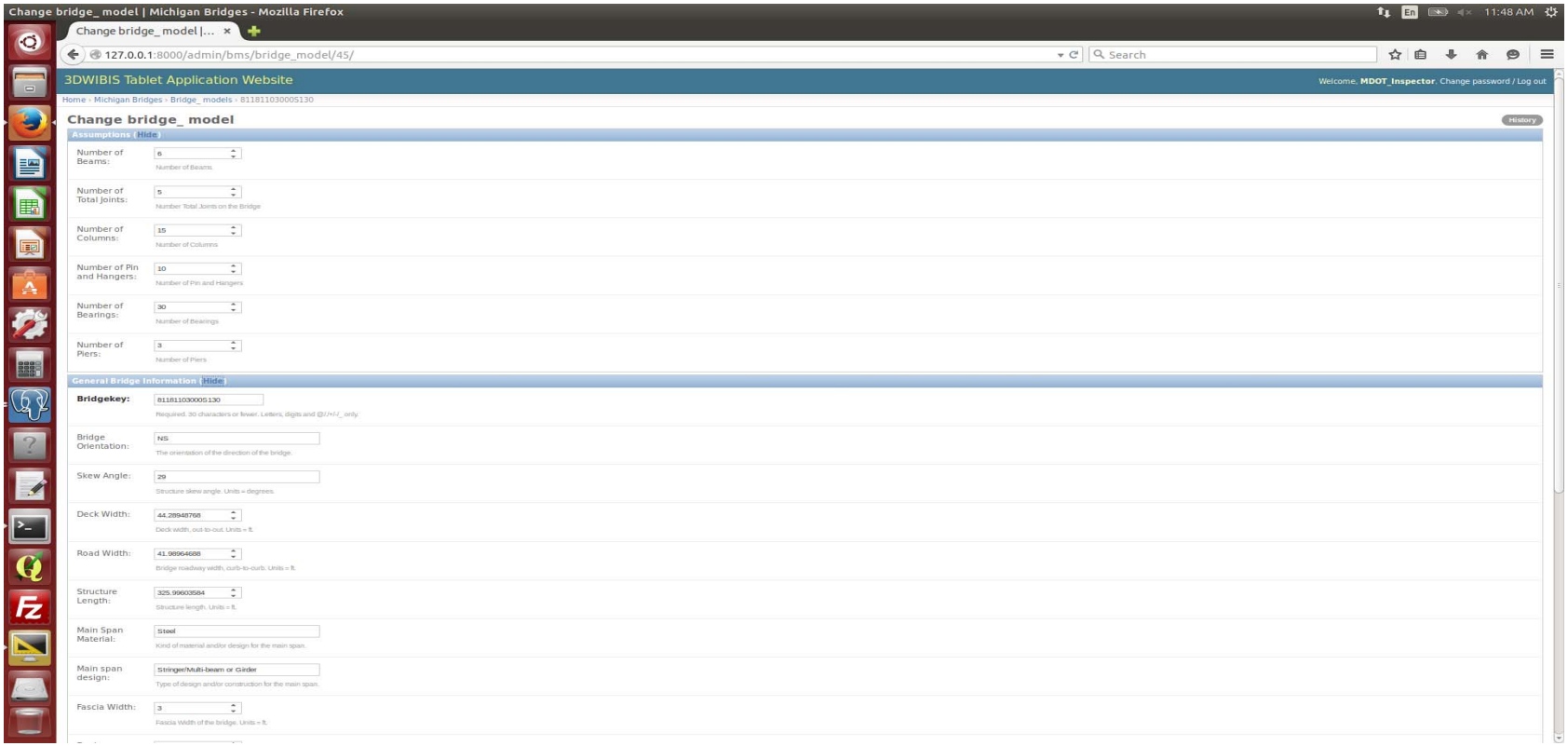
The 3D B^{RIDG}E App Grabs Data from BMS Database

- Queries all of the data from a static copy of MDOT's database.
- The MDOT bridge management database is composed of 16 tables.
- The 3D B^{RIDG}E App queries from almost all of them.



User Tuning

- Created a web-based user interface for fine tuning the 3D bridge model
- Missing data are filled in with generic assumptions.
  - Ex: locations of pin & hanger assemblies
- User can alter data to fix any assumptions that were not correct

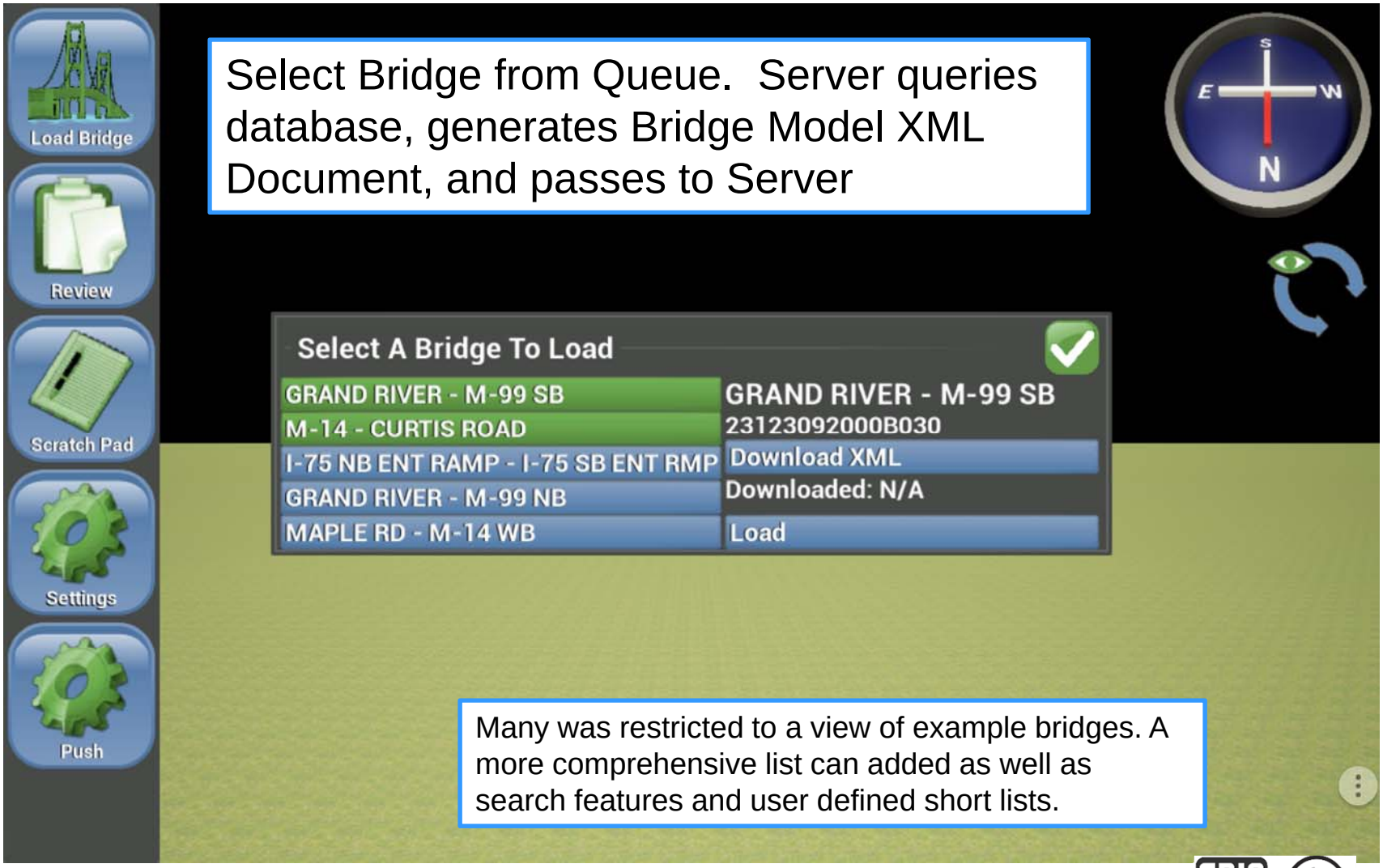


Backend Outputs XML to Frontend

- Outputs bridge XML to create model.
  - Small file transmitted to tablet to create 3D model on the fly

```
- <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>
```

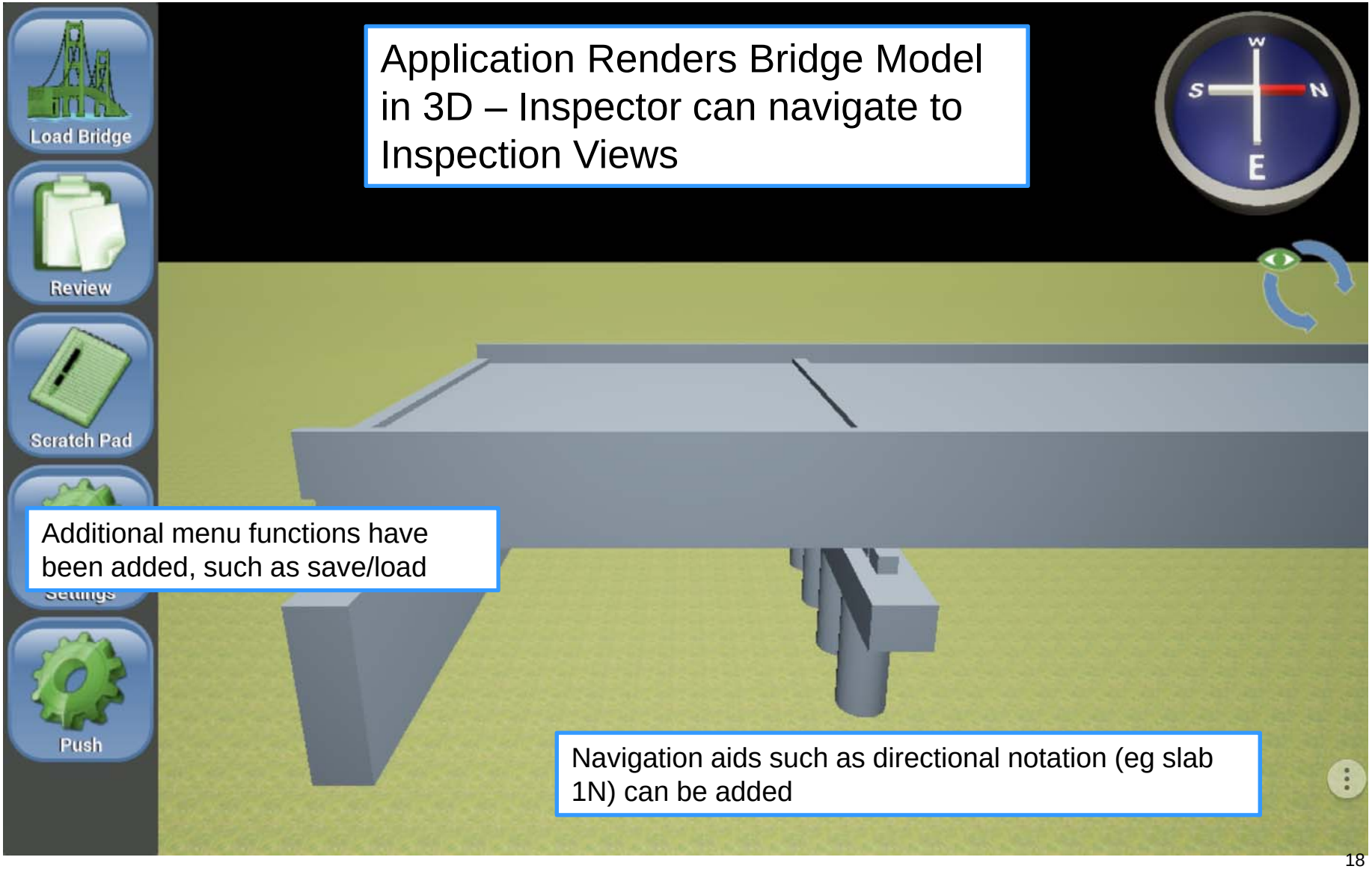
Select bridge by Region / StructureID



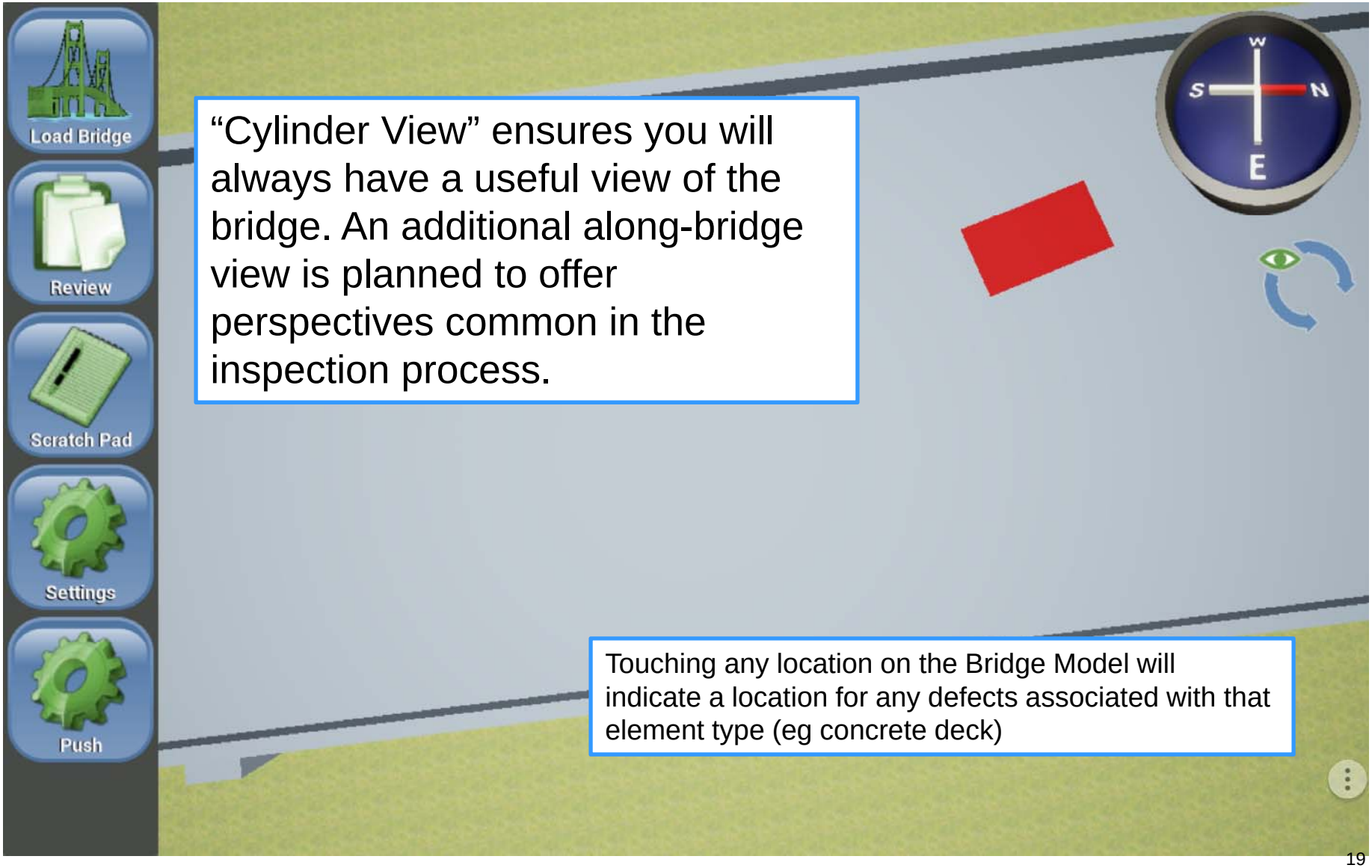
3D model is auto-generated using Epic Games' Unreal Engine, also provides user interface

Desired bridge loads and is rendered

3D model is auto-generated using Epic Games' Unreal Engine, also provides user interface



Navigation is constrained to an orbit around the bridge

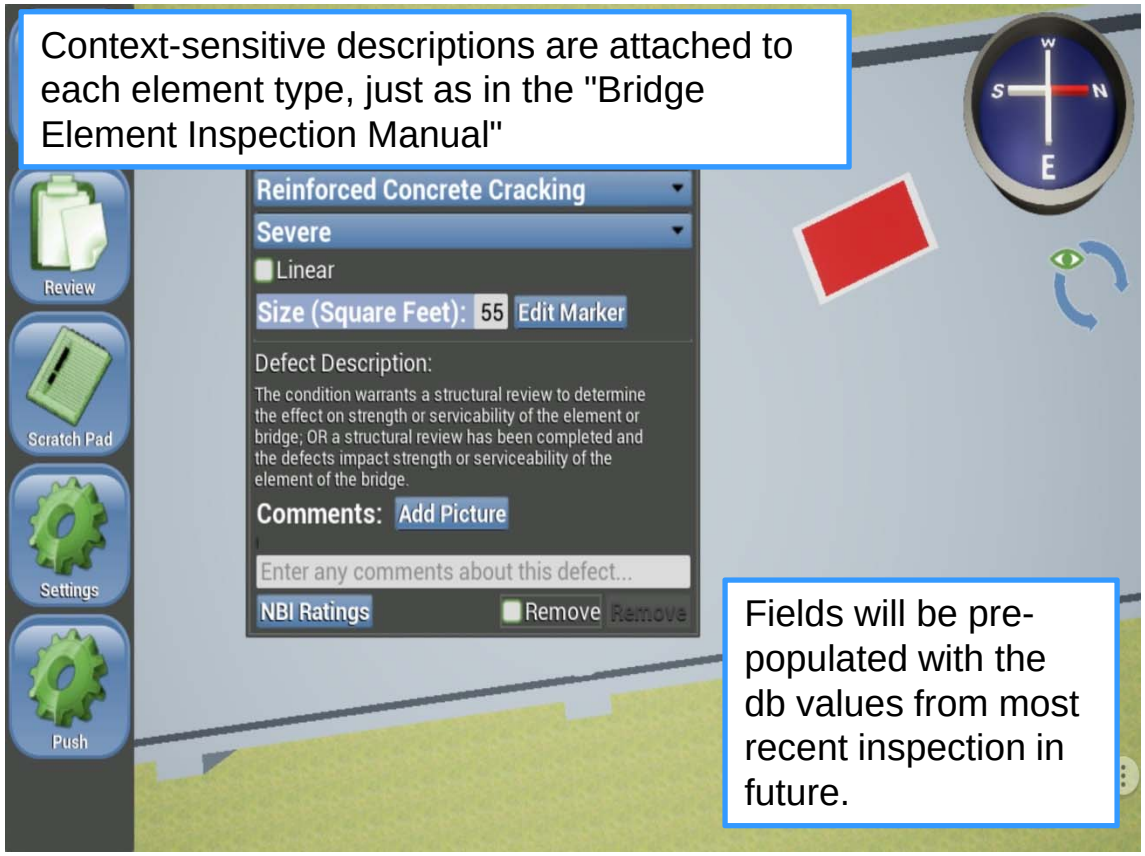


3D B[RIDG]E App Usage

- The 3D B[RIDG]E 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.

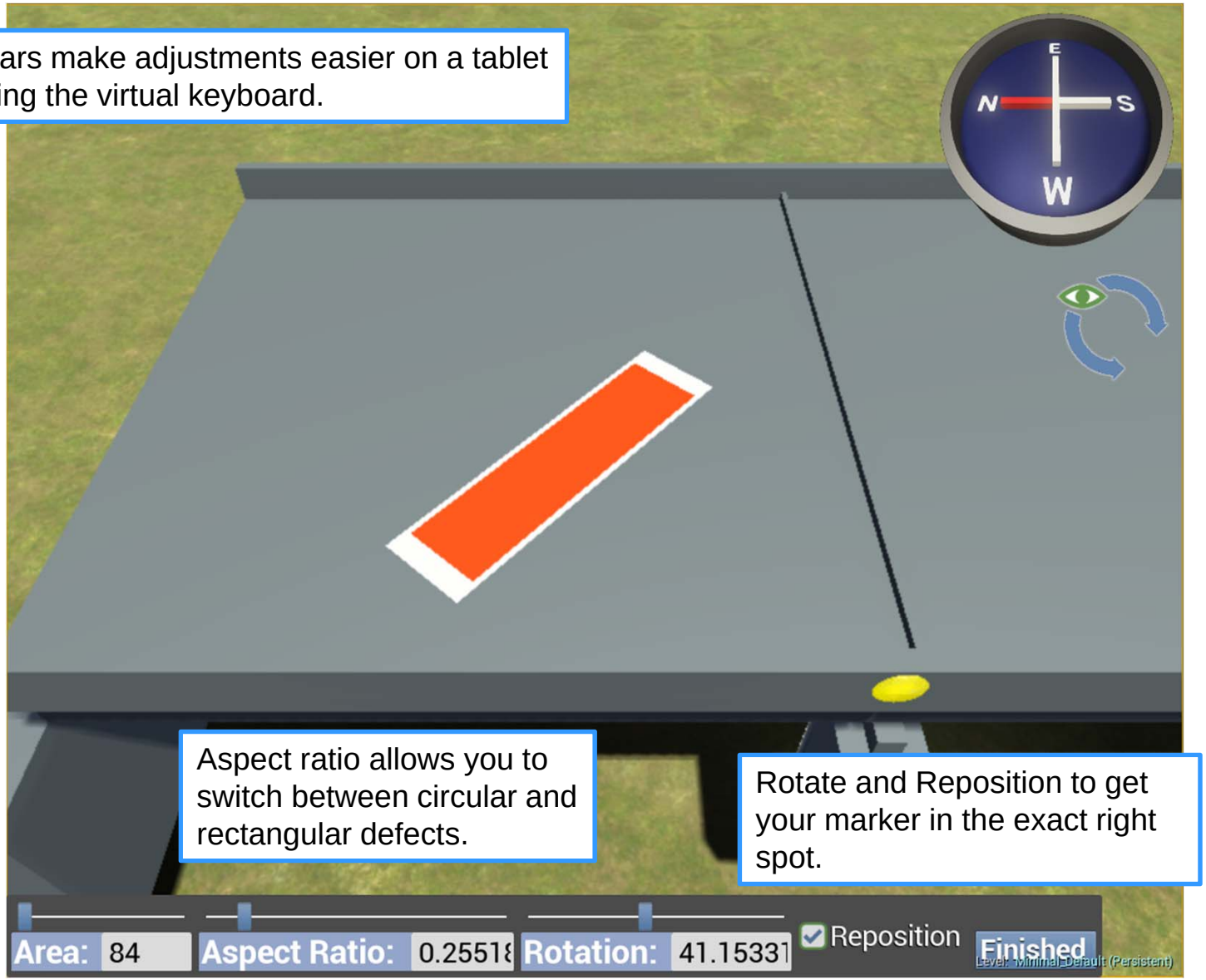
- Inspectors no longer have to carry the Bridge Element Inspection Manual



View Photos of the Desired Defect

Customize the Defect's Size and Shape

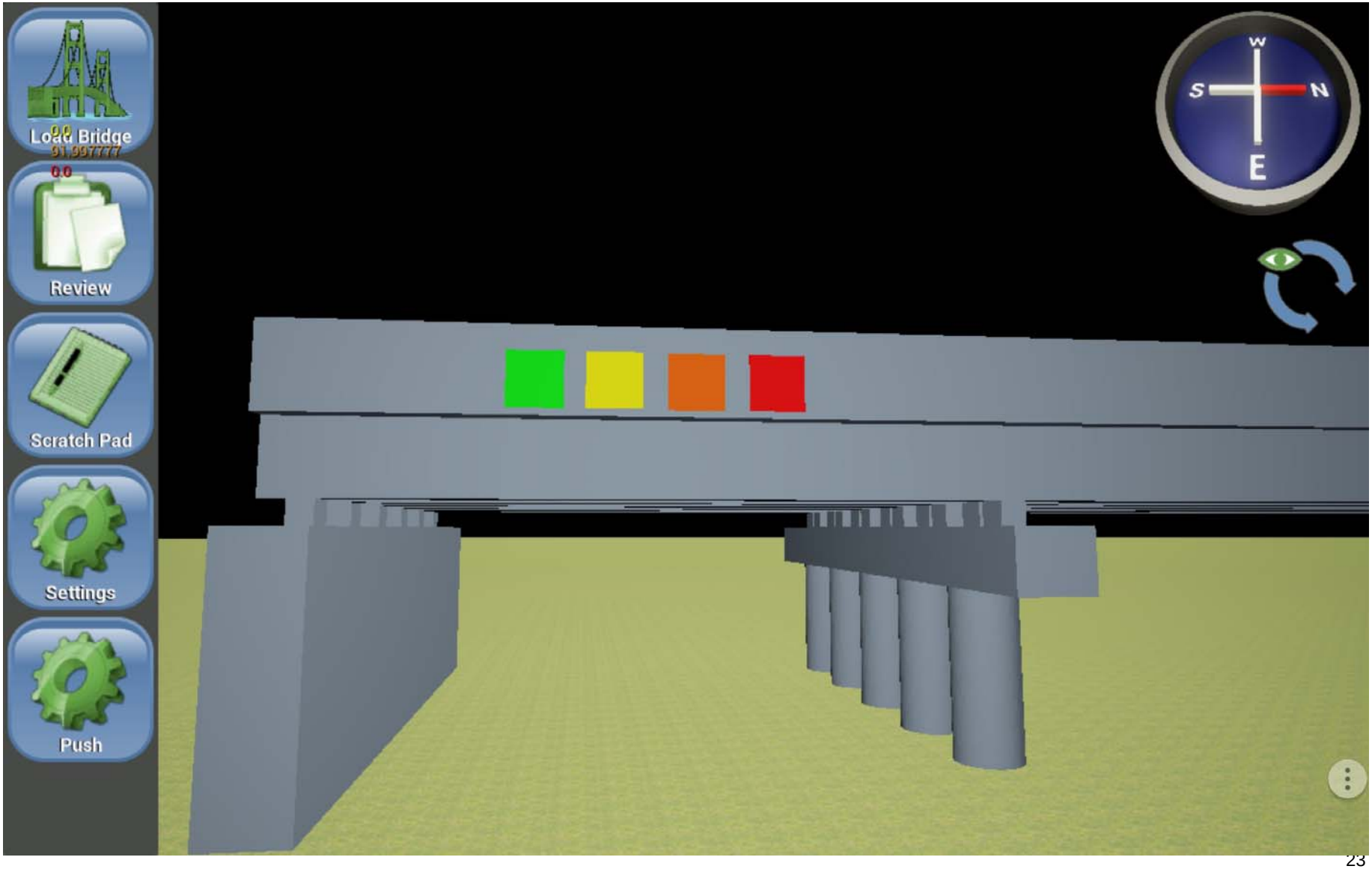
Slider bars make adjustments easier on a tablet than using the virtual keyboard.



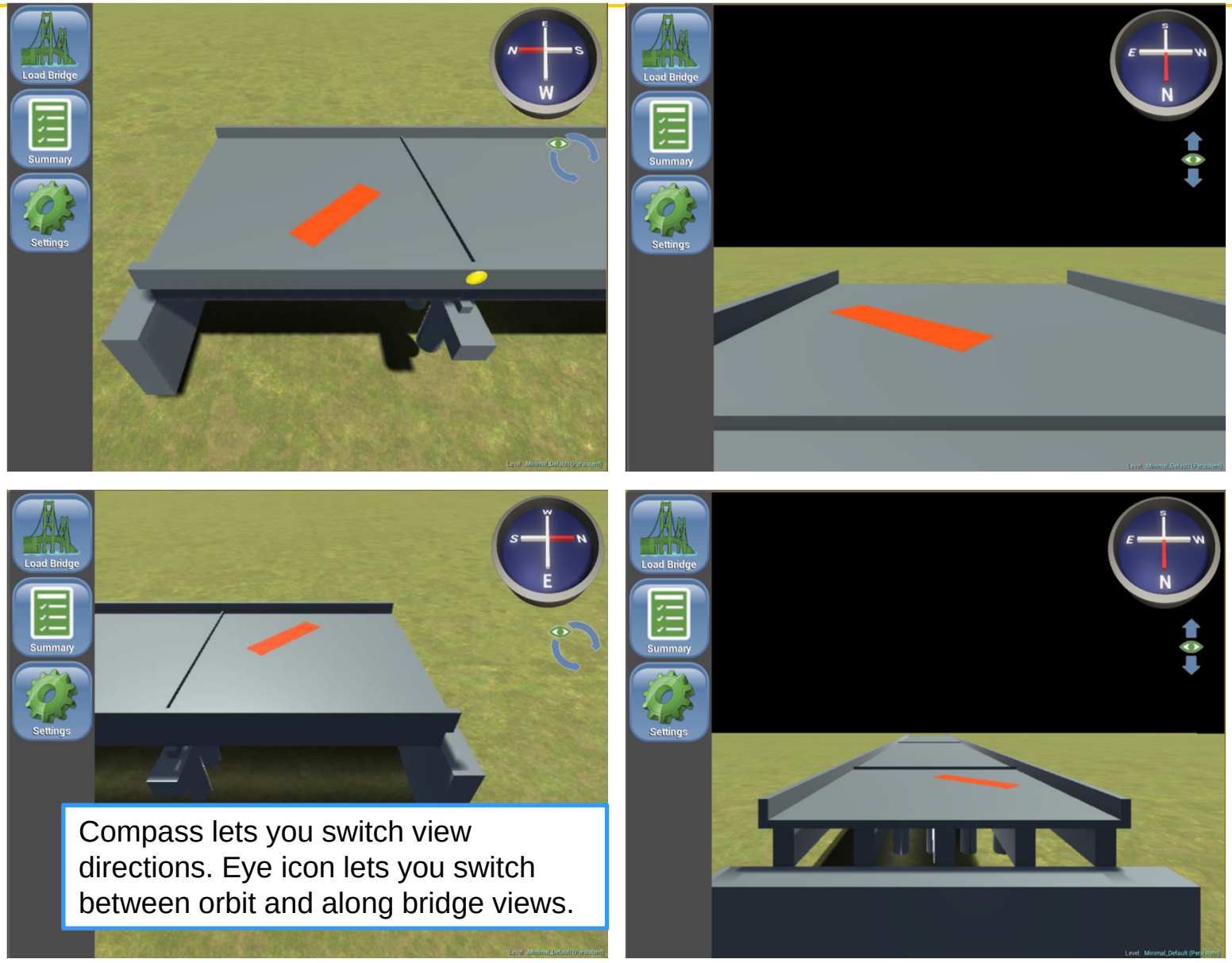
Aspect ratio allows you to switch between circular and rectangular defects.

Rotate and Reposition to get your marker in the exact right spot.

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

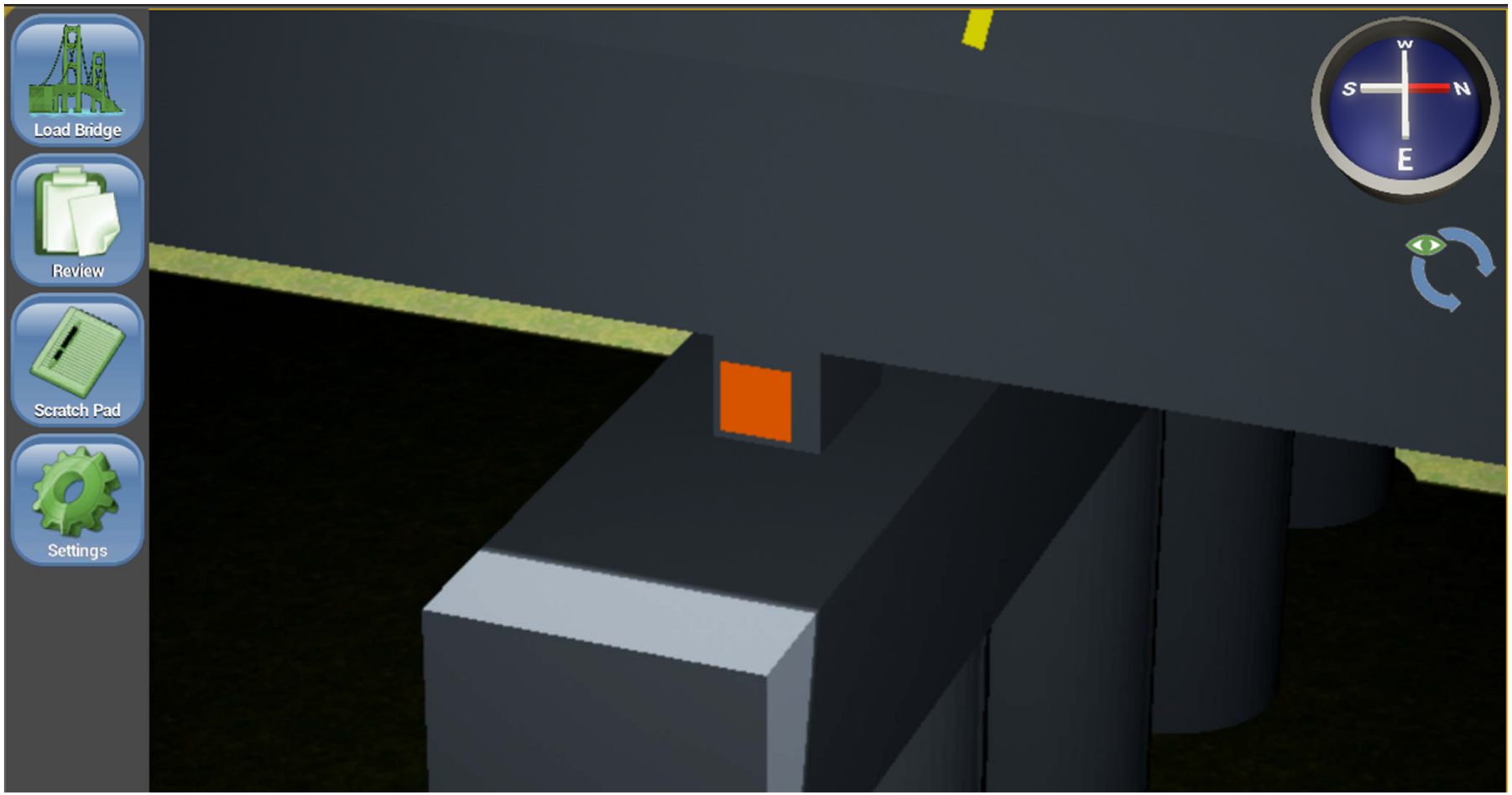


Saves the Defect's 3D Position For Future Inspections



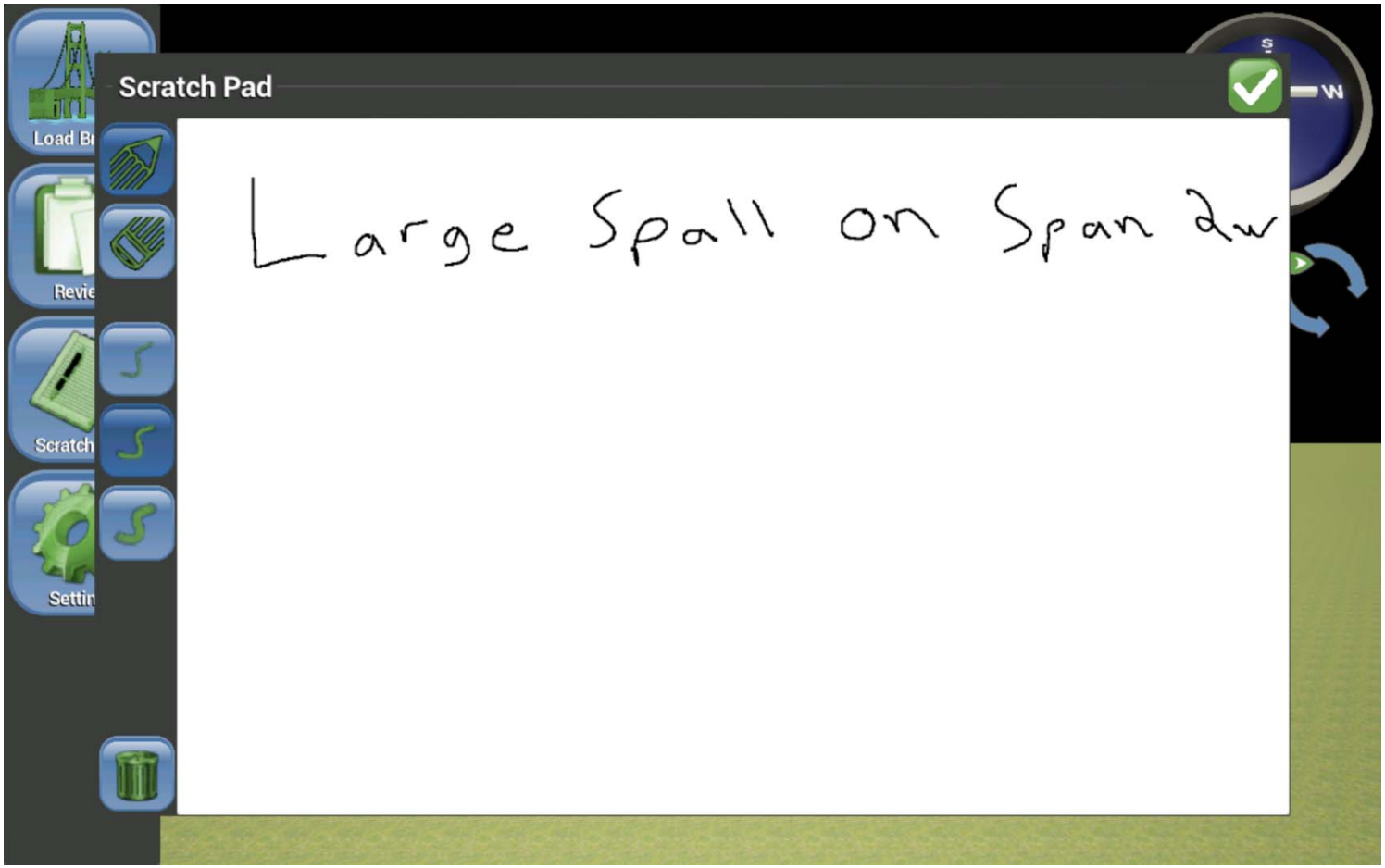
Pinch to Zoom

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

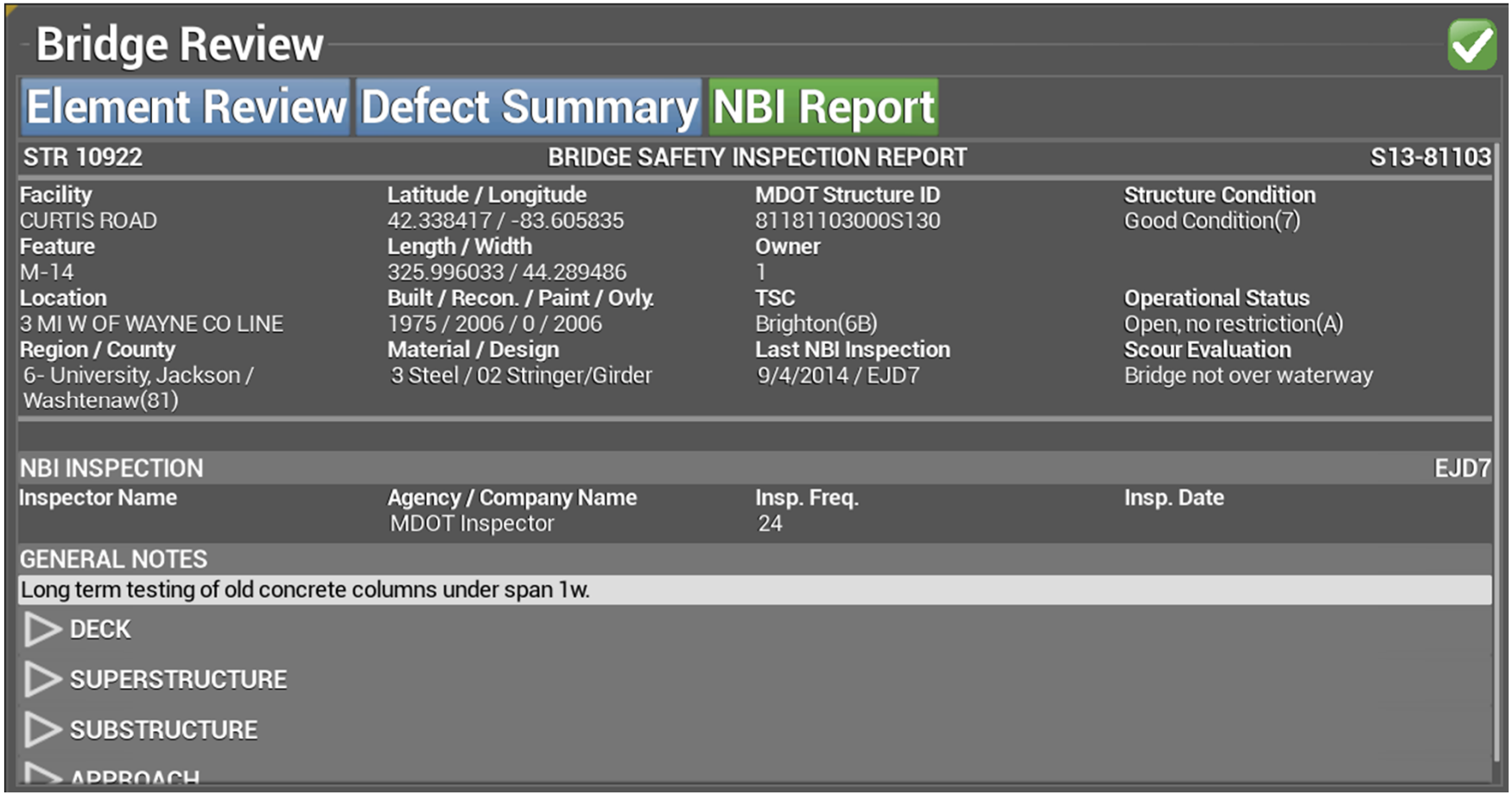


Scratch Pad

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



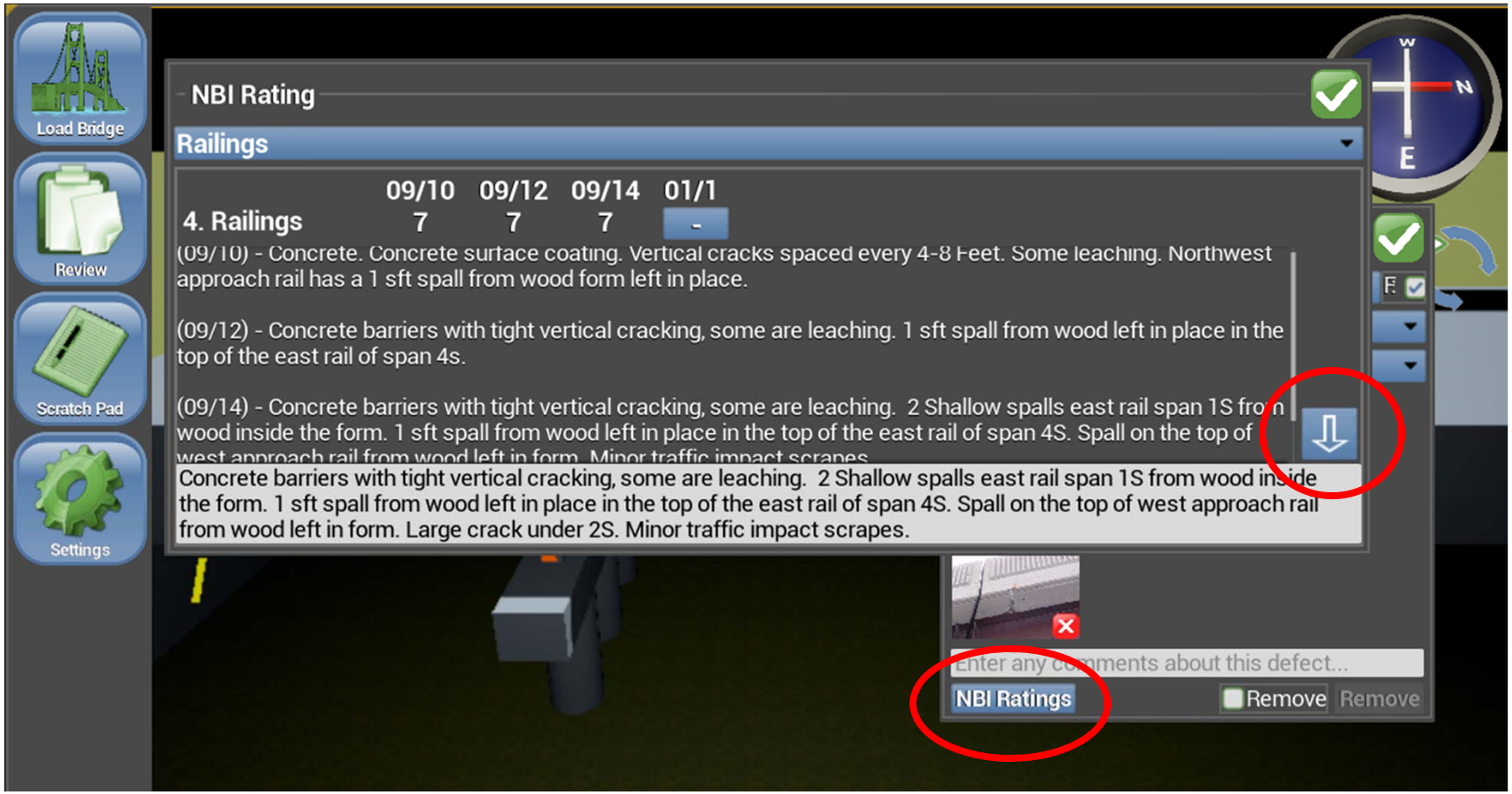
Collect and Display NBI Information



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

Collect and Display NBI Information

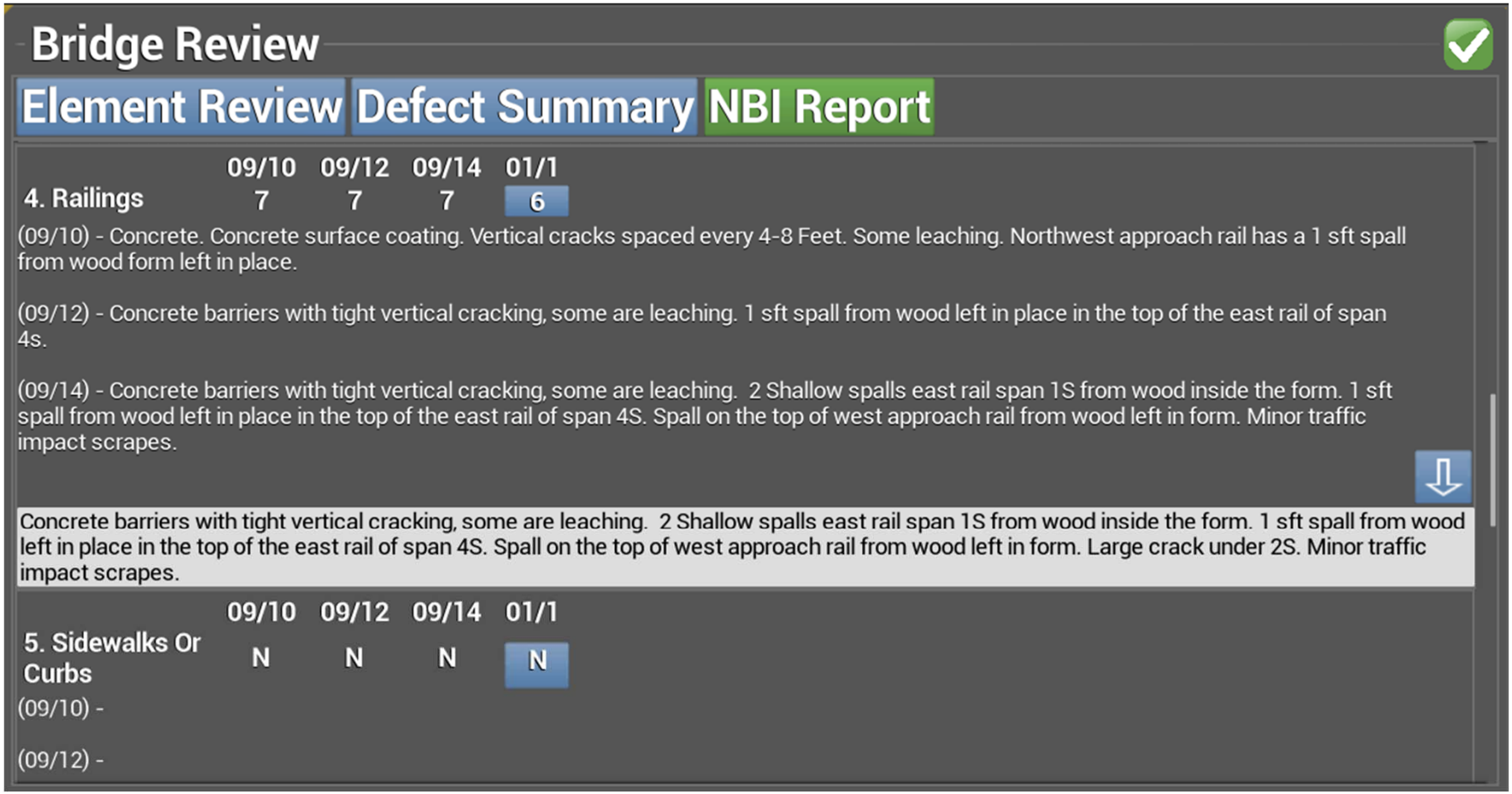
- Enter in NBI Information by clicking the “NBI Ratings” button. Use previous comments from past NBI Reports using the “Download” arrow button



Collect and Display NBI Information

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

Collect and Display NBI Information



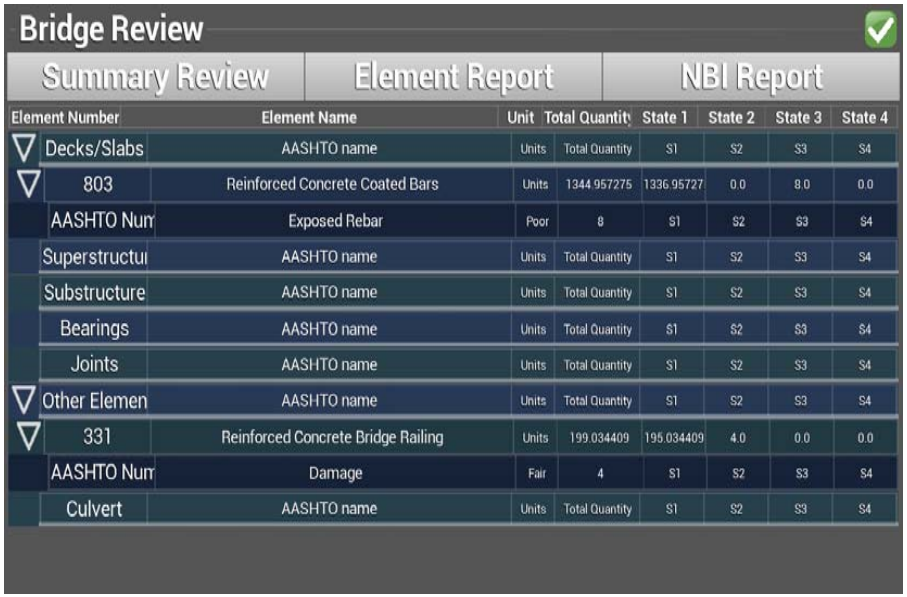
- Scroll through the entire report, and review NBI ratings of past and current reports

View Different Summaries of the Recorded Data

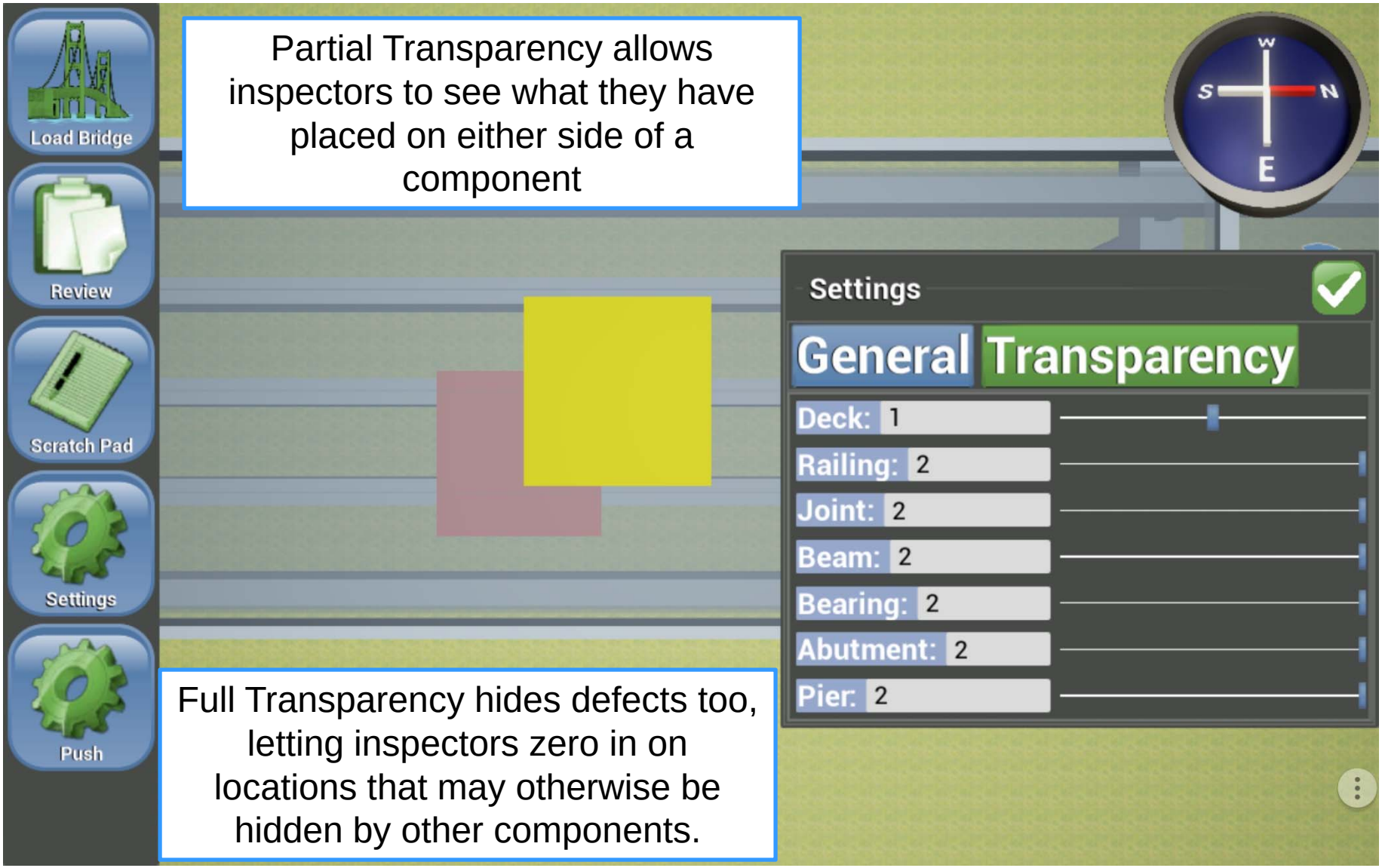
- Display and summarize the bridge inspection data with different views.

Bridge Review

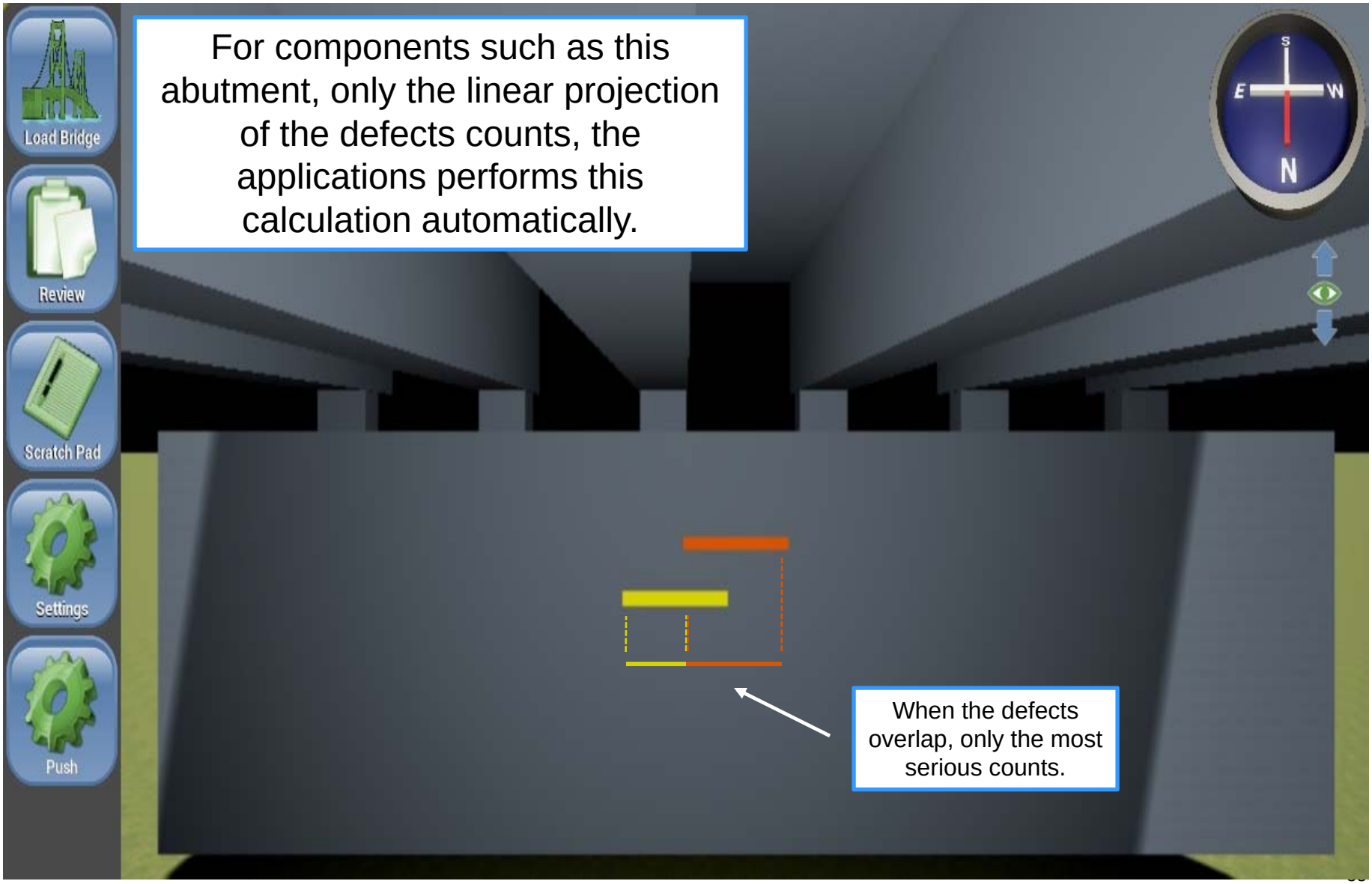
AASHTO Element Level Data View



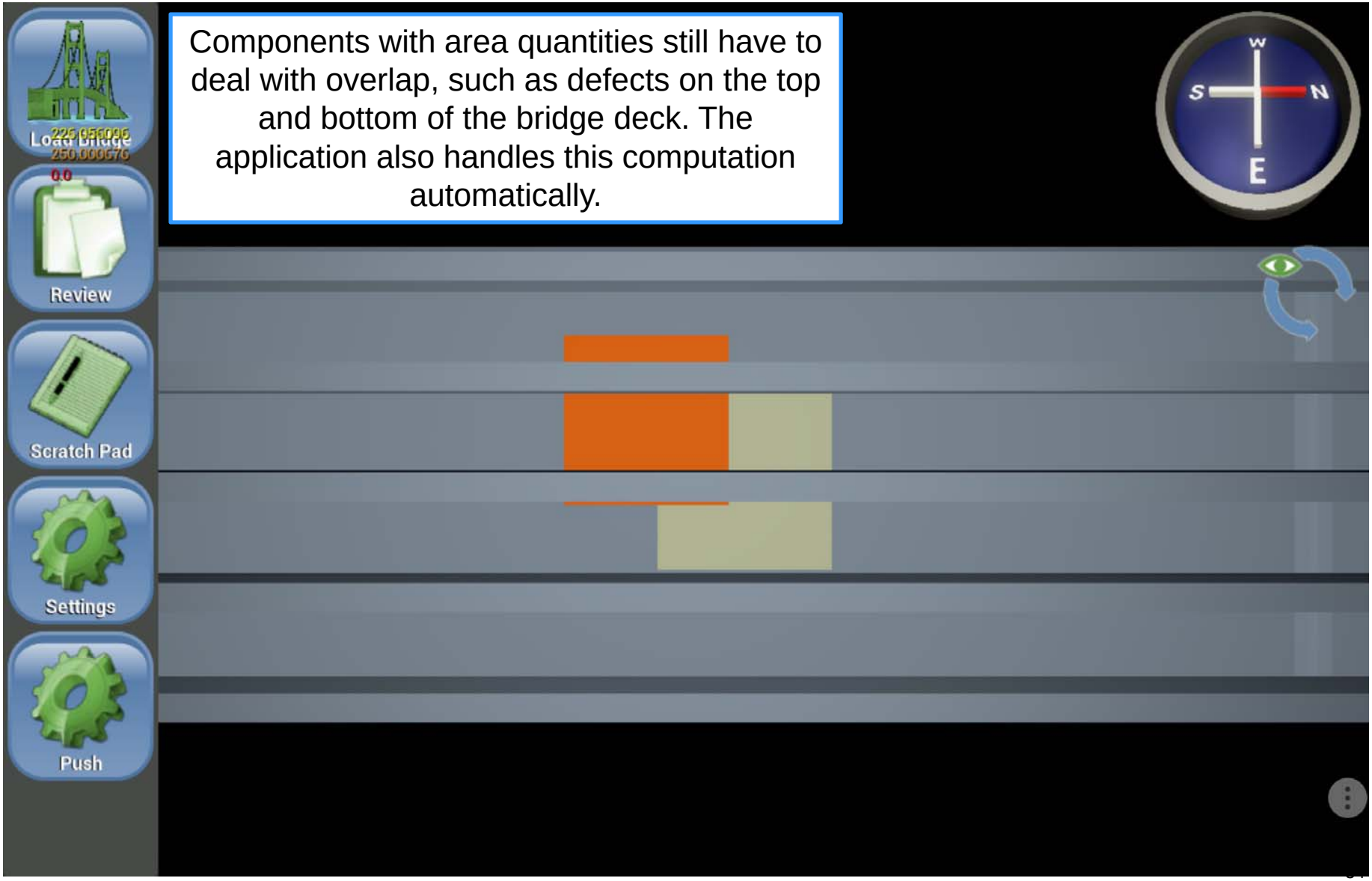
Transparency Setting (new)



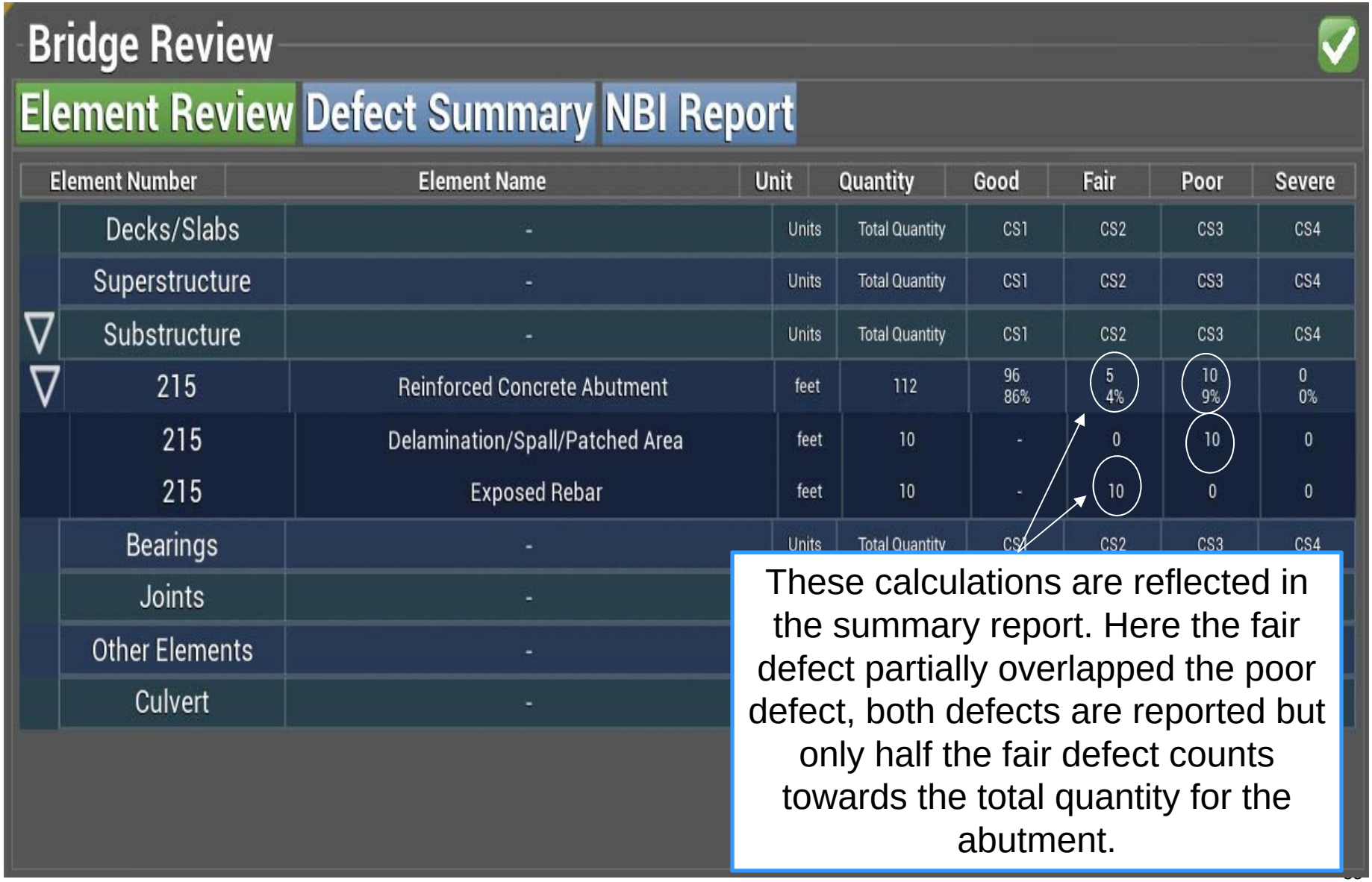
Linear Defect Calculator: abutments example (new)



Area Defect Calculator



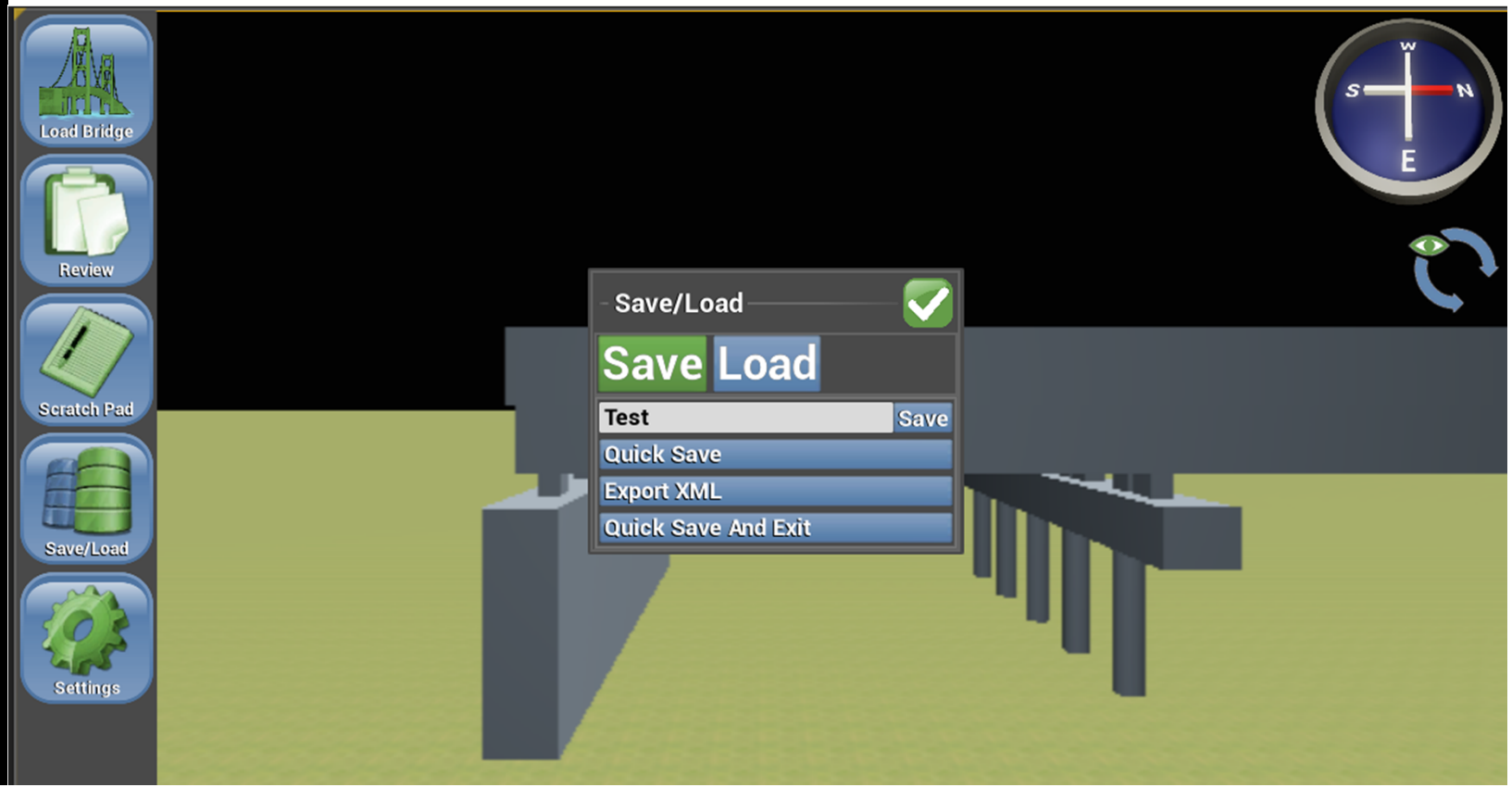
Linear/Area Defect Calculator



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.

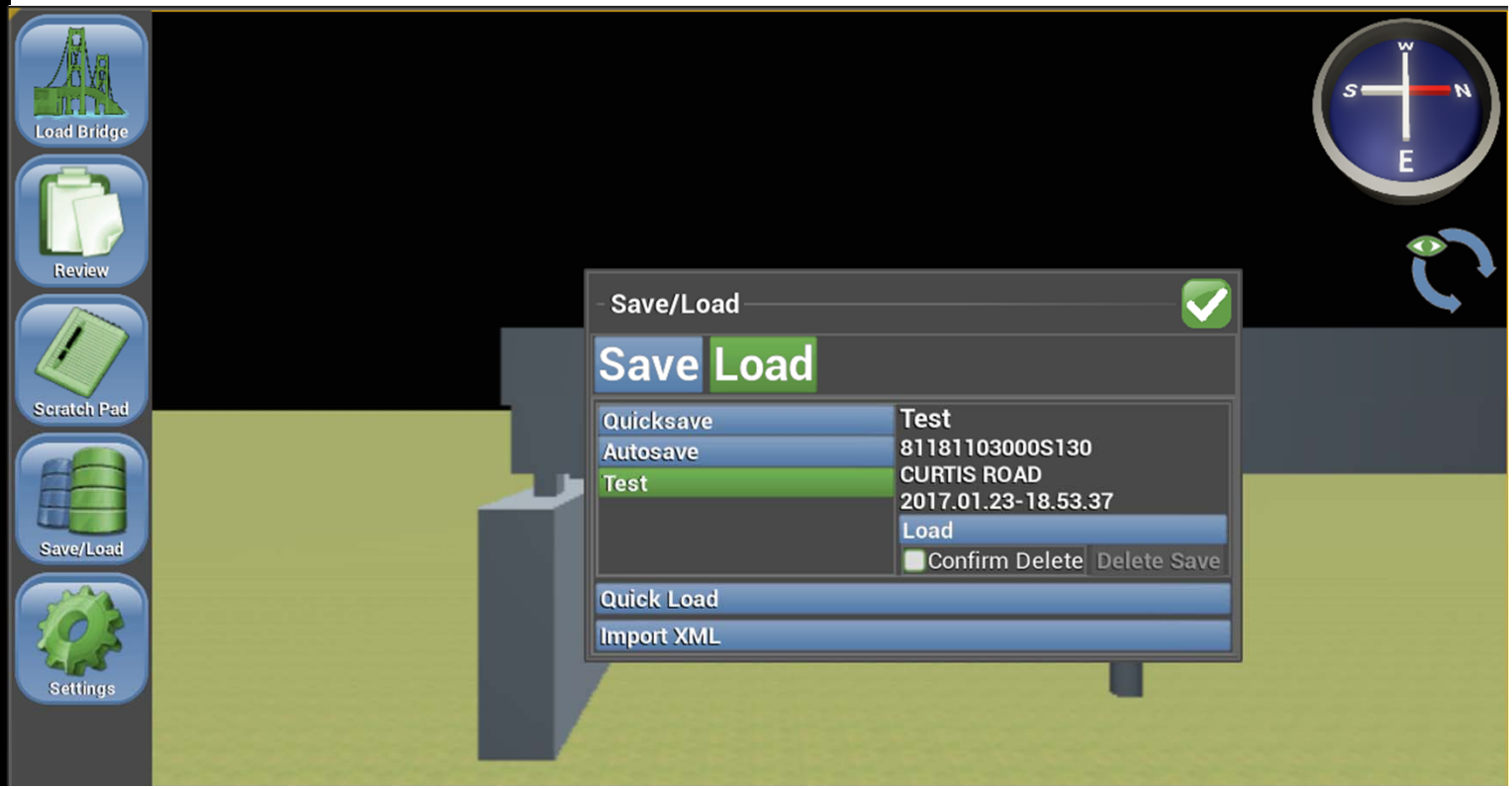
Save/Load (new)

- Users 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.
  - Would like to replace this with direct write to BrM 5.2.3 as its implemented by MDOT, with appropriate review
- 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 B^{RIDG}E App is compatible with Windows and Android, and iOS.
  - Unreal Engine platform is cross-platform compatible

Windows

Benefits

- Benefits of using a location-specific 3D interface extend beyond inspection, but also a tool for future asset management
  - 3D B^{RIDG}E App enables this future
- 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 B^{RIDG}E app is a key component towards the future goal of utilizing 3D models to monitor and review a bridge throughout its lifetime.

- Next steps:
  - MDOT: full implementation after BrM 5.2.3 deployment & integration, expand to more bridge types, user enhancements
  - integrate other distress data (from NDT / remote sensing / UAV platforms / other sources)
  - Other states: Interest in version for other states
  - National: could be a national tool; interested in AASHTOWare BrM integration; complex / big bridge application

Contact Info

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  - email: rwsawtel@mtu.edu
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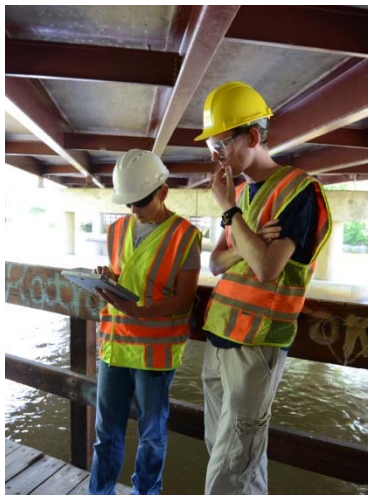
  - KathrensR@michigan.gov
- Rebecca Curtis (MDOT)
  - CurtisR4@michigan.gov



http://www.mtri.org/3dbridge.html