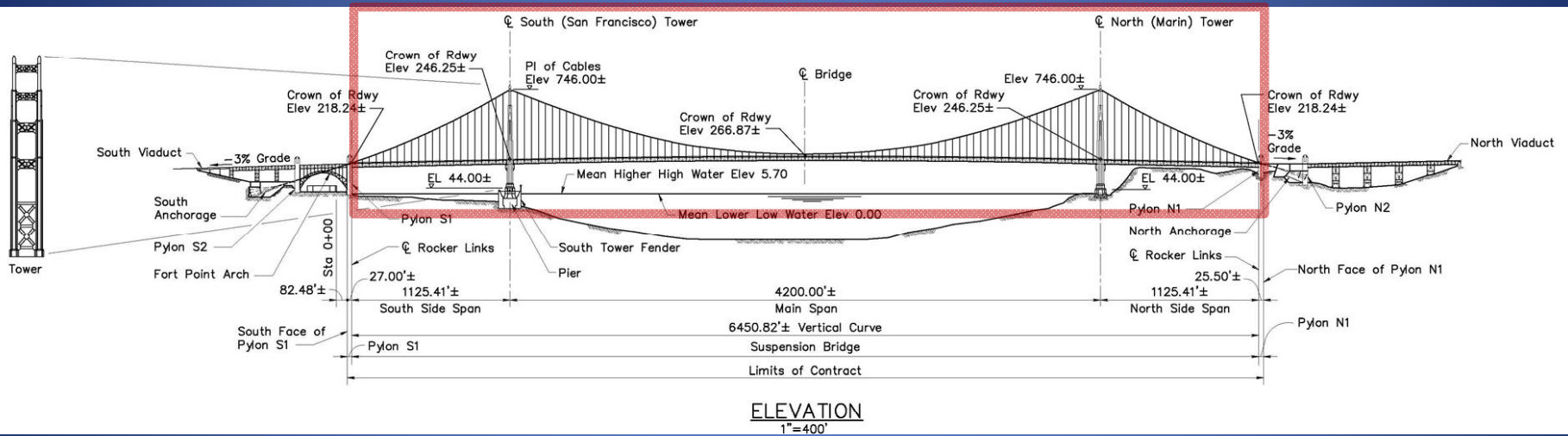


GGB Seismic Retrofit Phase IIIB Suspension Bridge



Energy Dissipation Device Testing



SEISMIC RETROFIT PROJECT PHASE IIIB – SUSPENSION BRIDGE

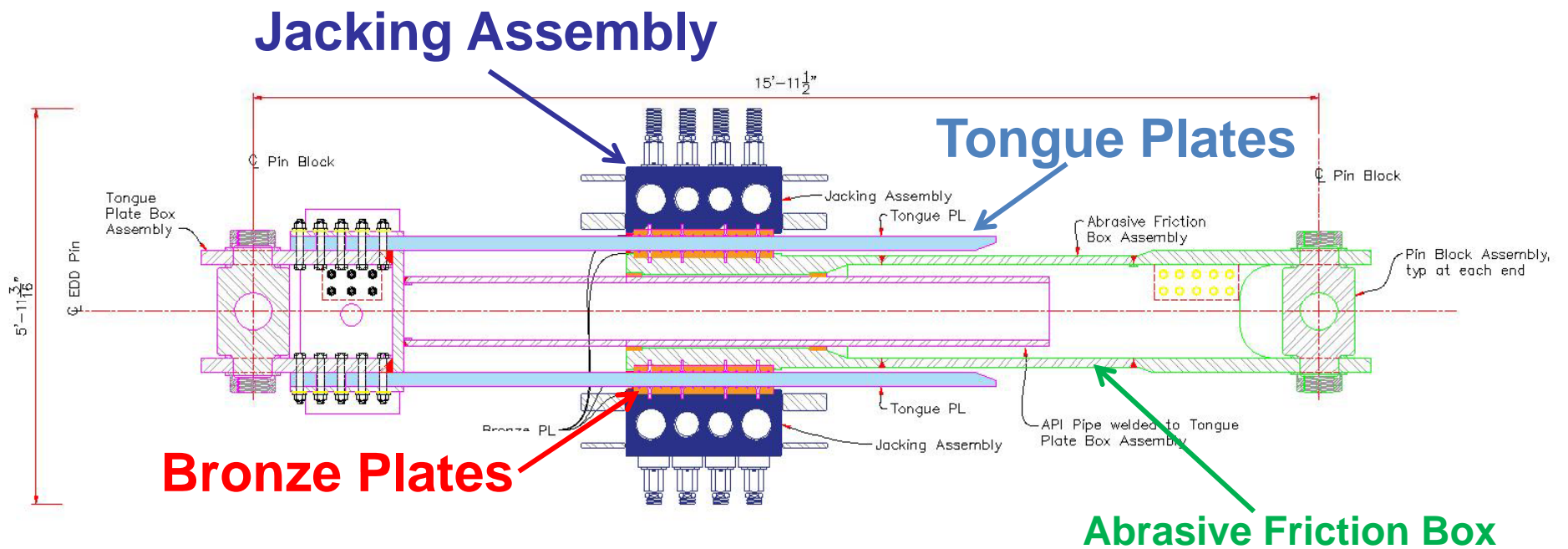
The Golden Gate Bridge Seismic Retrofit Strategy for the Suspension Bridge requires installation of energy dissipation devices (EDDs) to reduce seismic demand on the structural components.

The purpose of EDDs are:

- **to limit, through energy dissipation, the magnitude of forces imparted to the stiffening trusses**
- **to decrease differential displacements at the stiffening truss interfaces with the Main Towers and the South and North Pylons**

Energy dissipation in this EDD is achieved by utilizing abrasive shear friction occurring between the surface of stainless steel tongue plates sliding over the surface of tin bronze plates when the EDD is subjected to an earthquake.

Energy Dissipation Device



EDD TESTING PROGRAM :

- **Phase I –Tests of the abrasive friction components using a scaled EDD specimen**
 - **Dimensions = 6' long x 2' high**
 - **Weight = 1,000 pounds**

- **Phase II –Tests of a full size complete EDD Unit**
 - **Dimensions = 22' long x 4.5' high**
 - **Weight = 26,000 pounds**

- **Designer:**
HDR Engineering, Inc./Thomas Jee and Associates
- **Manufacturer of test specimens:**
G&G Steel , Russellville, Alabama
- **Phase I Testing Laboratory:**
**The State University of New York at Buffalo,
Structural Engineering and Earthquake Simulation
Laboratory (SEESL)**
- **Phase II Testing Laboratory:**
**UC San Diego, Caltrans Seismic Response
Modification Device (SRMD) Test Facility**

EDD TESTING PHASE I

**June 1 - December 8, 2015
over 270 tests**

OBJECTIVES OF THE PHASE I TESTS:

- **To determine best material and surface finish of the abrasive friction components that yield desired energy dissipation**
- **To obtain information on performance of the EDD under dynamic loading and to determine changes to its structure to improve its performance**

PHASE I – TESTED EDD PARAMETERS:

- **Different types of friction materials**
- **Different contact surface finish and roughness of friction materials**
- **Effects on the friction components of**
 - **velocity**
 - **clamping force**
 - **dynamic seismic loading**
 - **rising temperature due to heat dissipation**

➤ Different types of friction materials

Tongue Plates:

- carbon steel
- stainless steel

Friction Plates:

- aluminum bronze
- tin bronze
- Midwest Material HFRP-10 (Midwest)
- Scan Pac Gatke Material No. 397 (Scan-Pac)

➤ **Different contact surface roughness of friction materials**

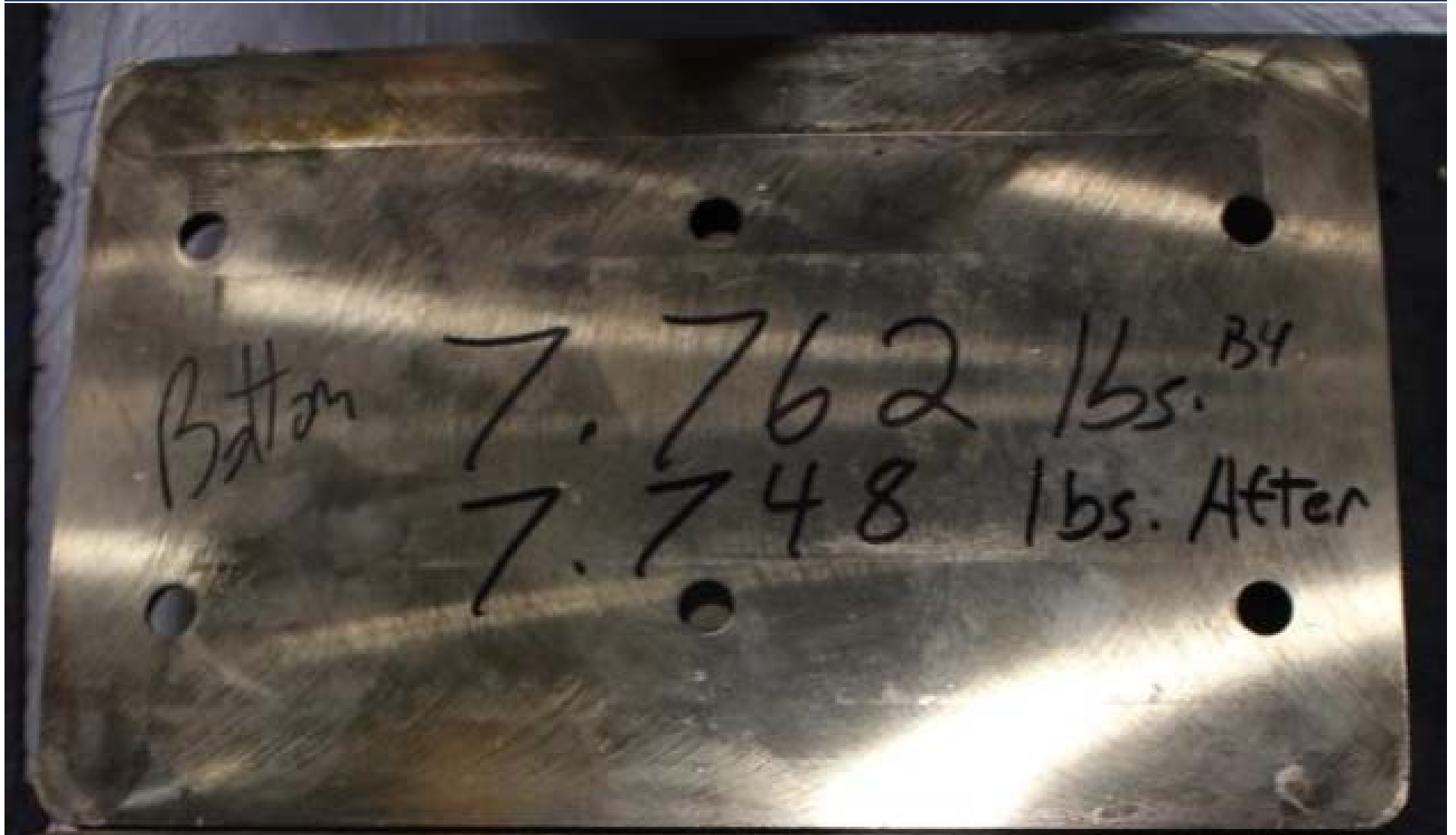
Tongue Plates:

- **painted**
- **smooth**
- **sandblasted**

Friction Bronze Plates:

- **smooth**
- **machined grooves – square pattern**
- **machined grooves – diamond pattern**

Smooth Bronze Plate – Pre-Test



**Bronze Plate with Machined Grooves
Square Pattern
Pre-Test**



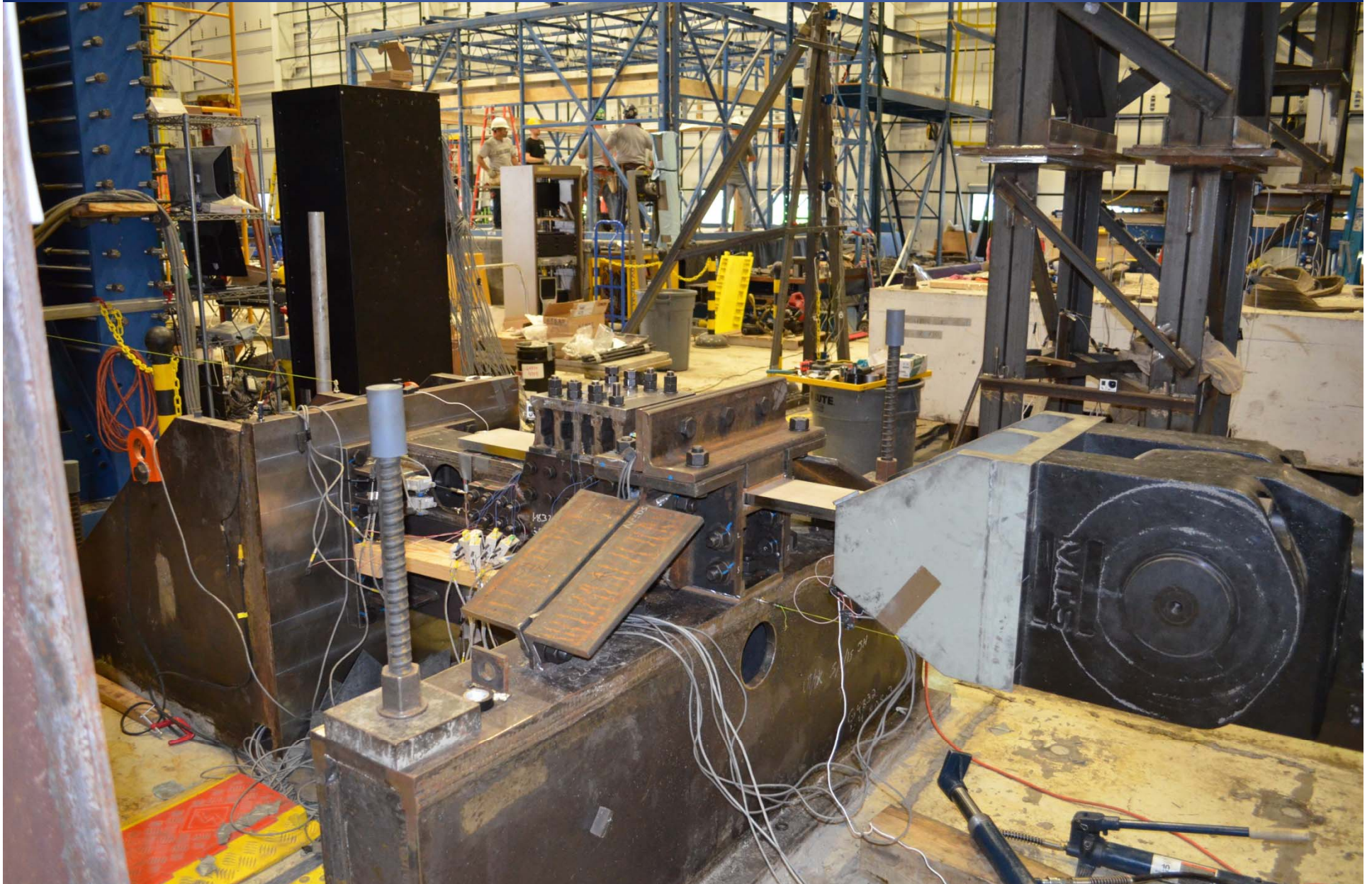
Bronze Plate with Machined Grooves Diamond Pattern Pre-Test



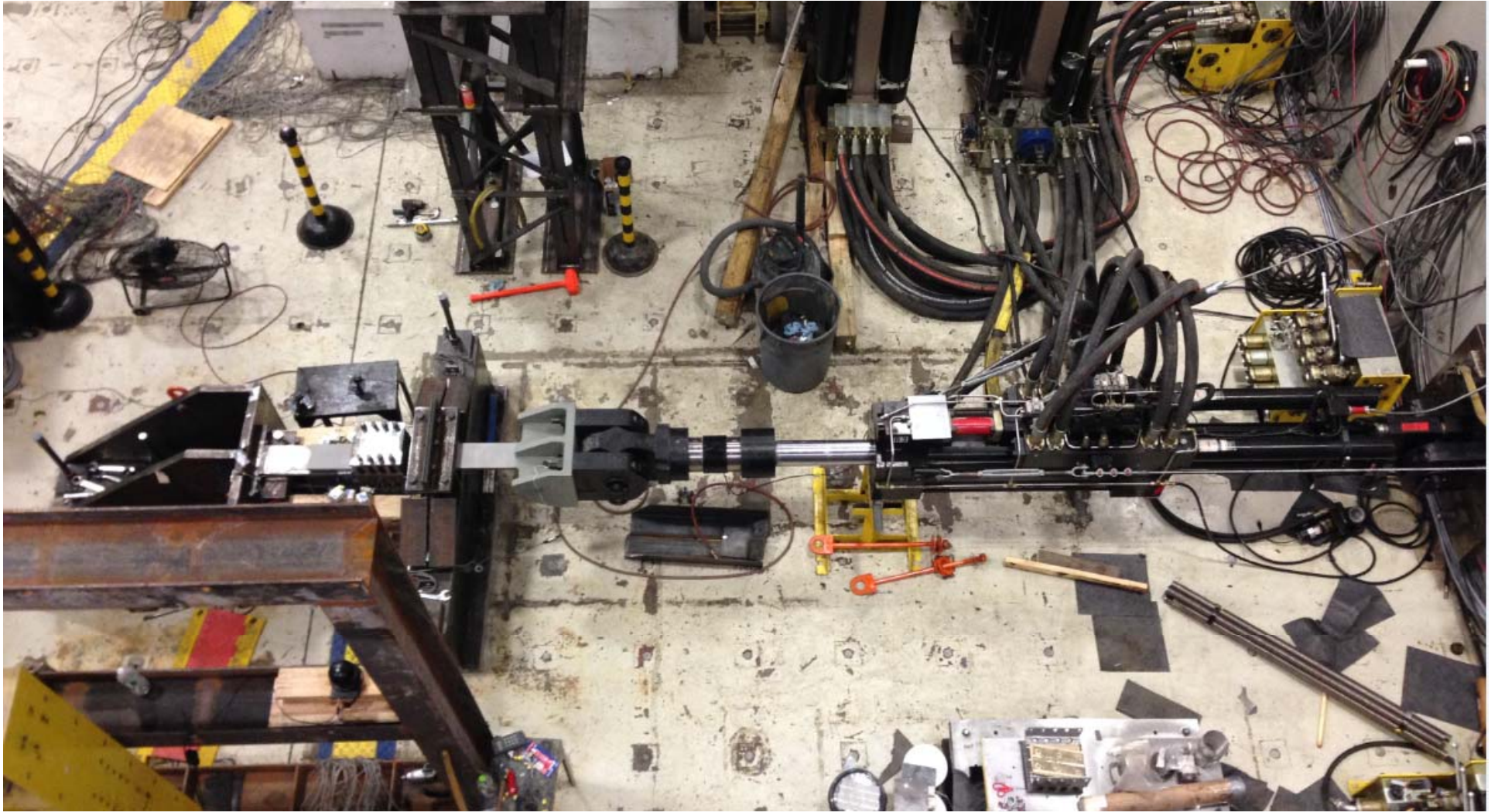
Steel Tongue Plates



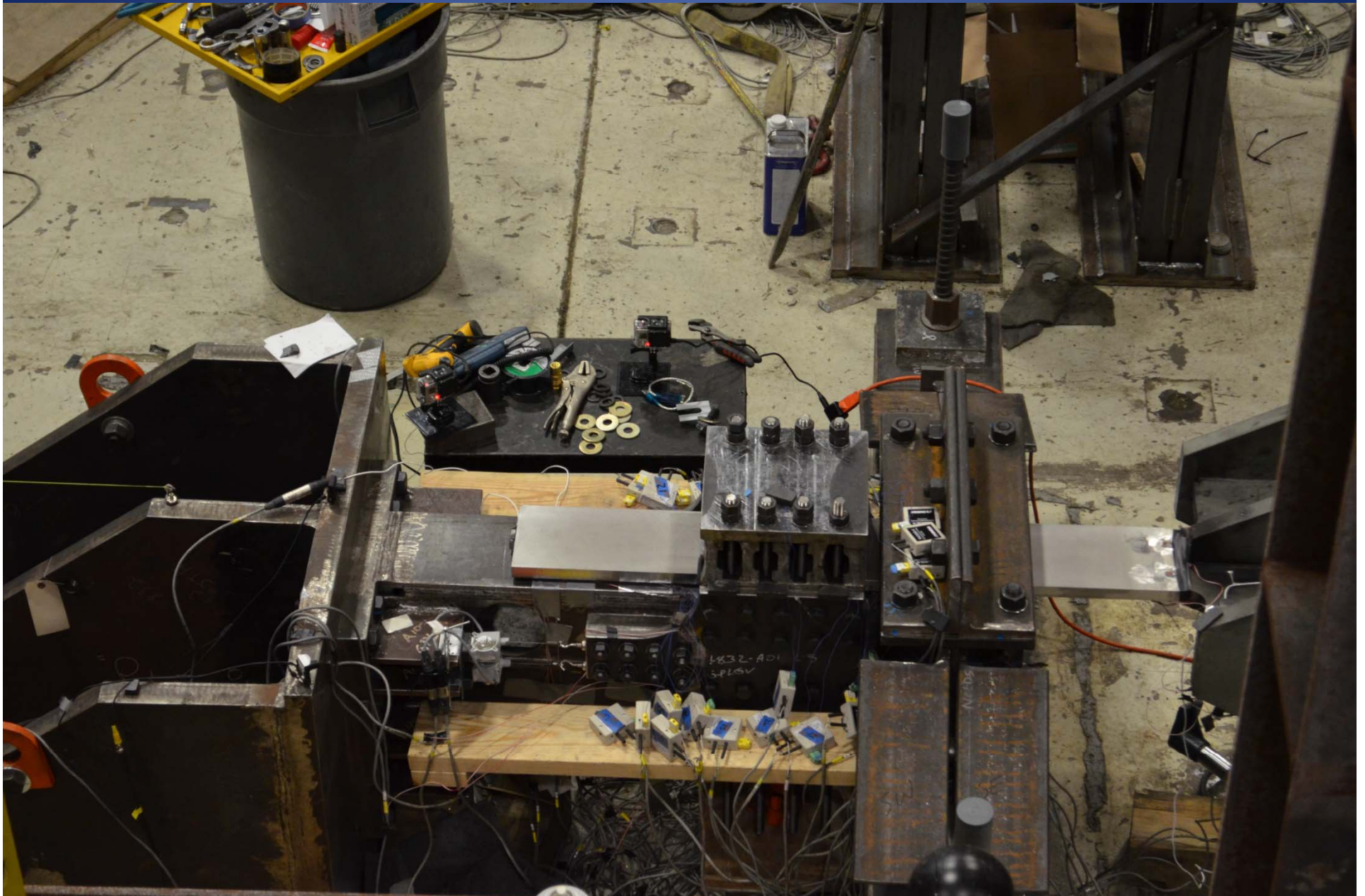
Structural Engineering and Earthquake Simulation Laboratory at the State University of New York Buffalo



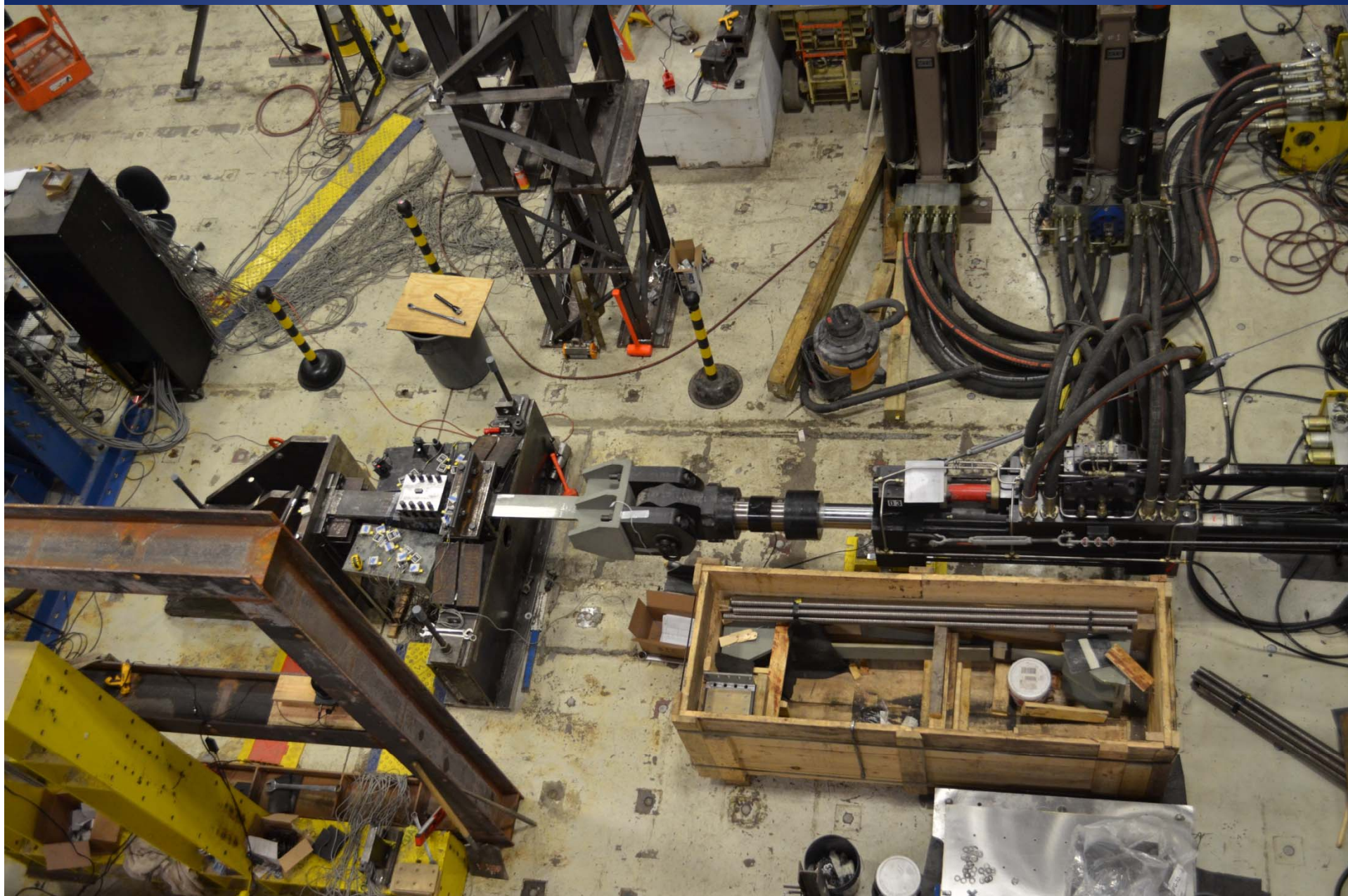
Aerial View of the Phase I Test Setup



Aerial View of the Phase I Test Setup



Phase I Test Video



CONCLUSION

Based on the results of Phase I tests, Phase II test specimen utilized

- **stainless steel smooth tongue plates**
- **tin bronze plates with diamond groove pattern**
- **cast jacking box**

**EDD TESTING
PHASE II**

**September 12 - 28, 2016
23 tests**

OBJECTIVES OF THE PHASE II TESTS:

- **Determine the amount of energy dissipation under dynamic loading**
- **Determine the value of slip force that would prevent engagement of the EDD below the desired level of dynamic loading**
- **Verify structural integrity of the EDD under dynamic loading**

PHASE II – TESTED EDD PARAMETERS:

- **clamping force – calibration tests**
- **slip force (coefficient of friction) - wear-in tests**
- **EDD's ability to sustain service load vibrations – vibration test**
- **EDD performance and energy dissipation under dynamic/seismic loading – dynamic tests**
- **EDD's resistance to buckling under extreme forces – compression test**

EDD Assembly at G&G Steel, Alabama



EDD Leaving Alabama for UCSD

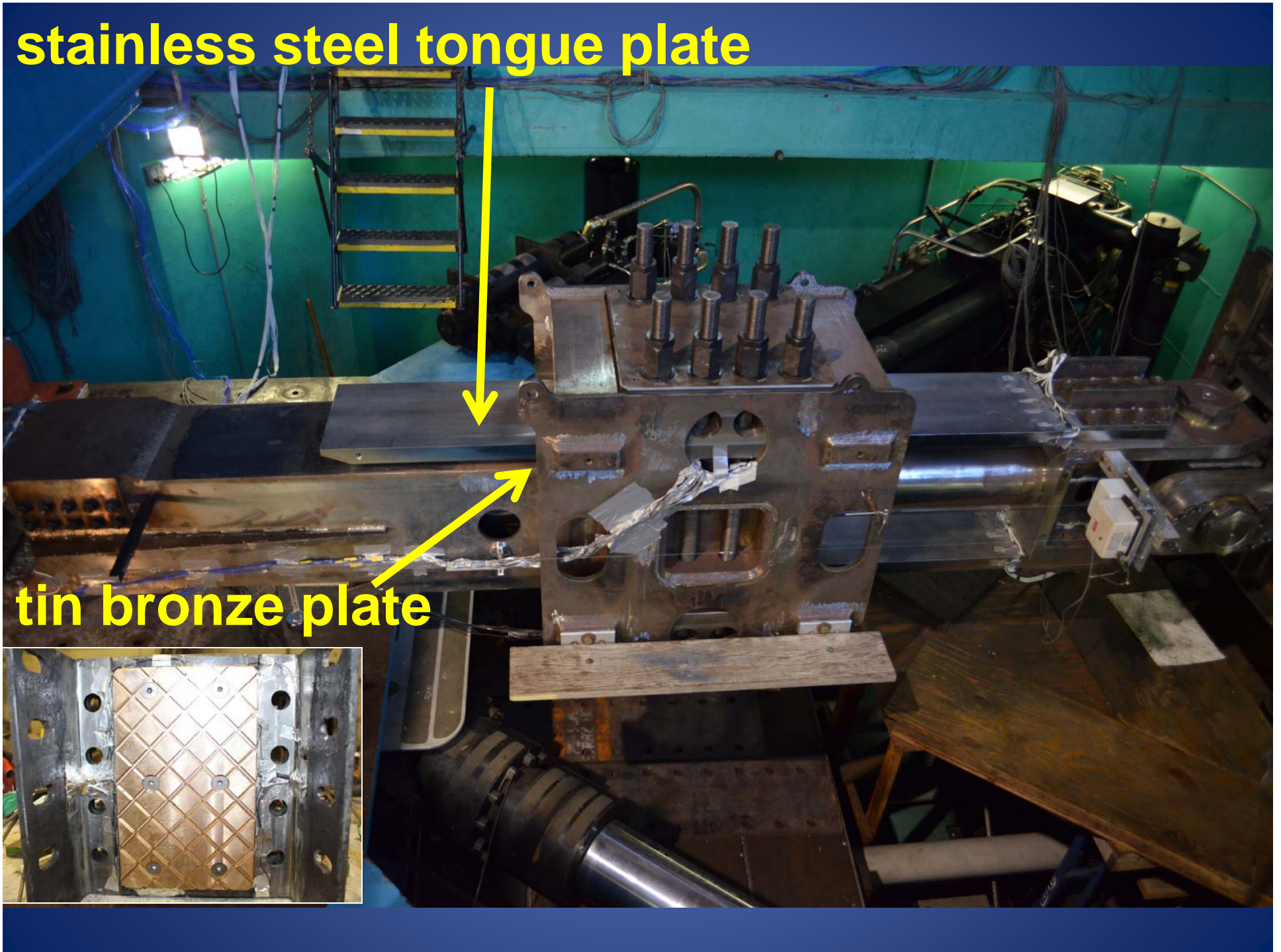
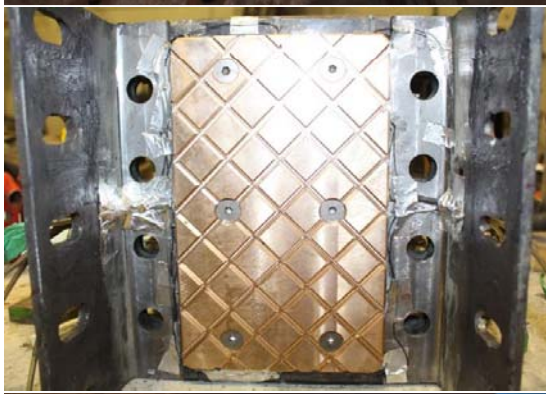


Aerial View of Phase II Test Setup



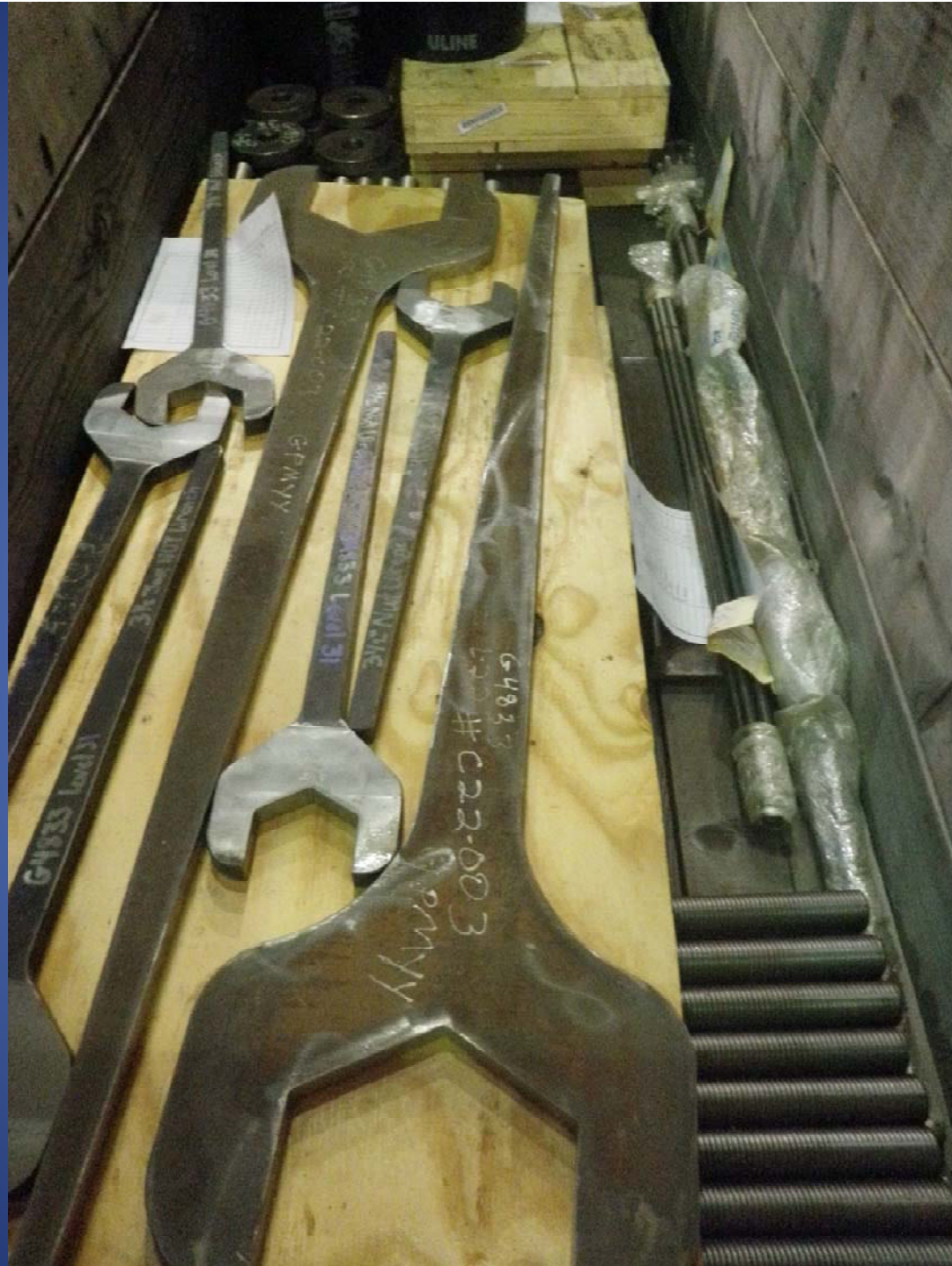
stainless steel tongue plate

tin bronze plate



Phase II – Wear-In Test



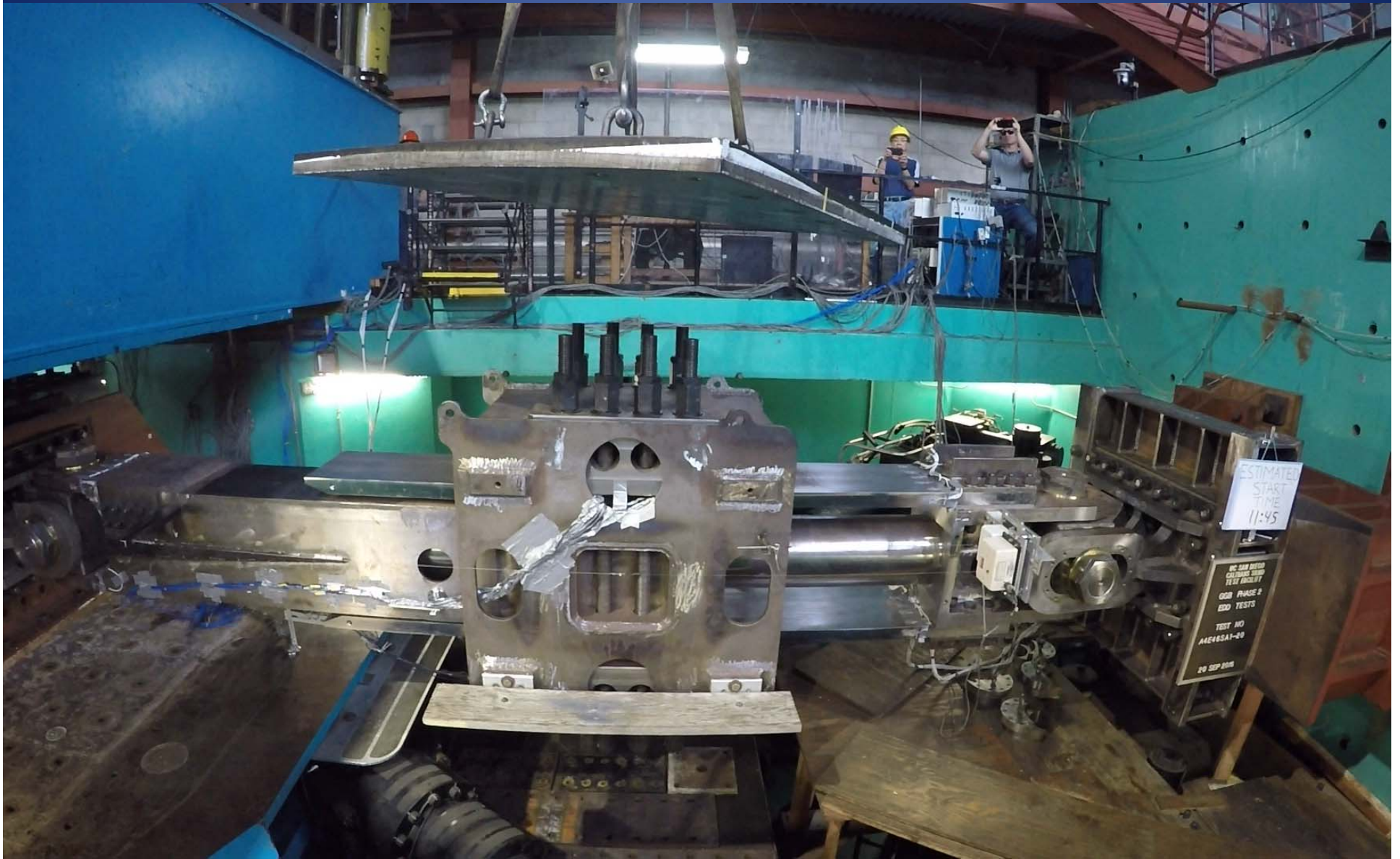


Phase II Test Setup – Releasing the Pin



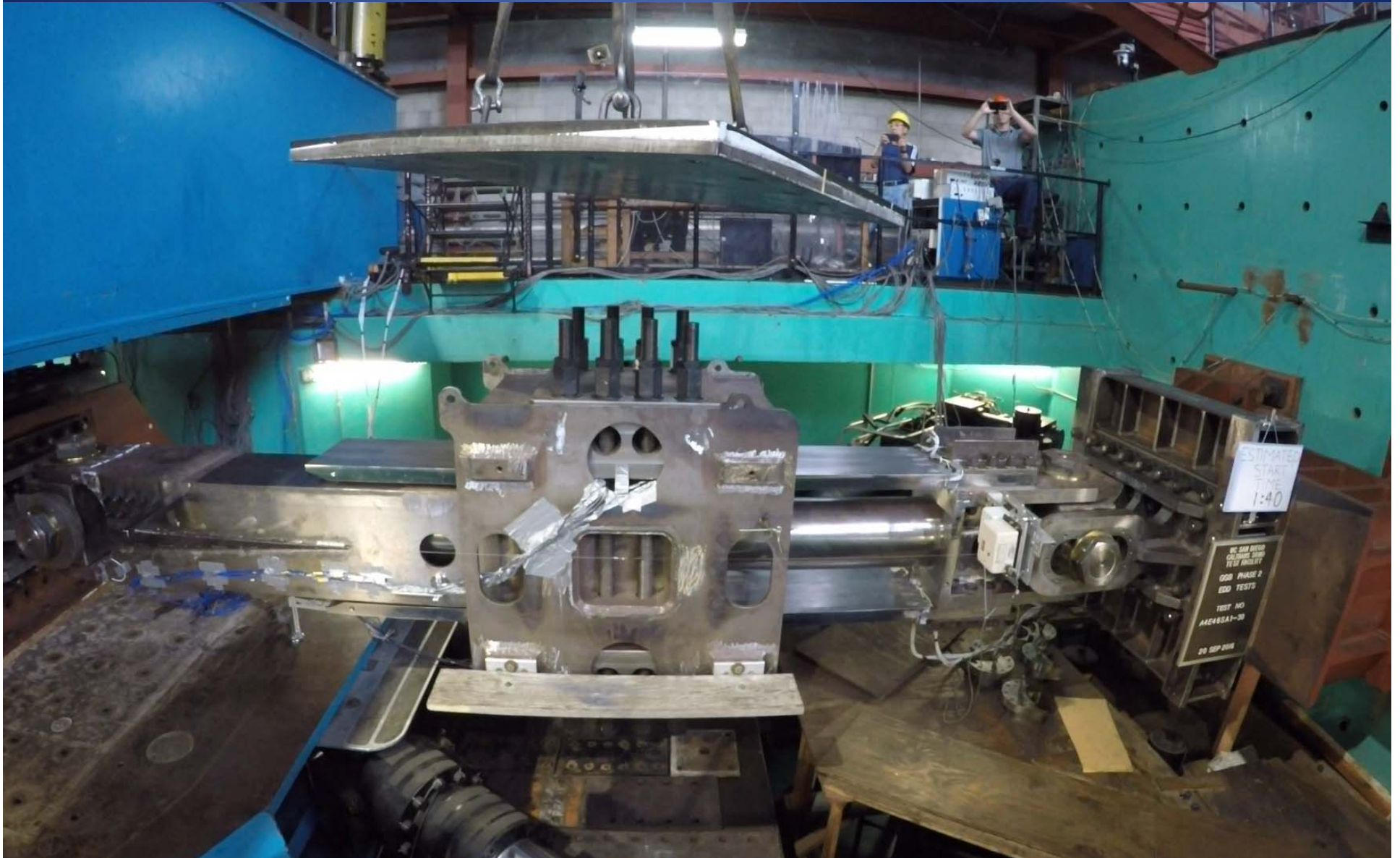
Phase II – Dynamic/Seismic Test (20in/sec)

Phase II – Dynamic/Seismic Test (20in/sec)



Phase II – Dynamic/Seismic Test (30in/sec)

Phase II – Dynamic/Seismic Test (30in/sec)



CONCLUSION

EDD performed as predicted:

- **provides reliable and consistent energy dissipation at predicted level**
- **can, without engaging friction components, accommodate vibrations and movements due to temperature and wind**
- **is very sound structurally; can withstand extreme loading**

GGB Seismic Retrofit Phase IIIB Suspension Bridge



Energy Dissipation Device Testing