THE UNIVERSITY OF ARIZONA

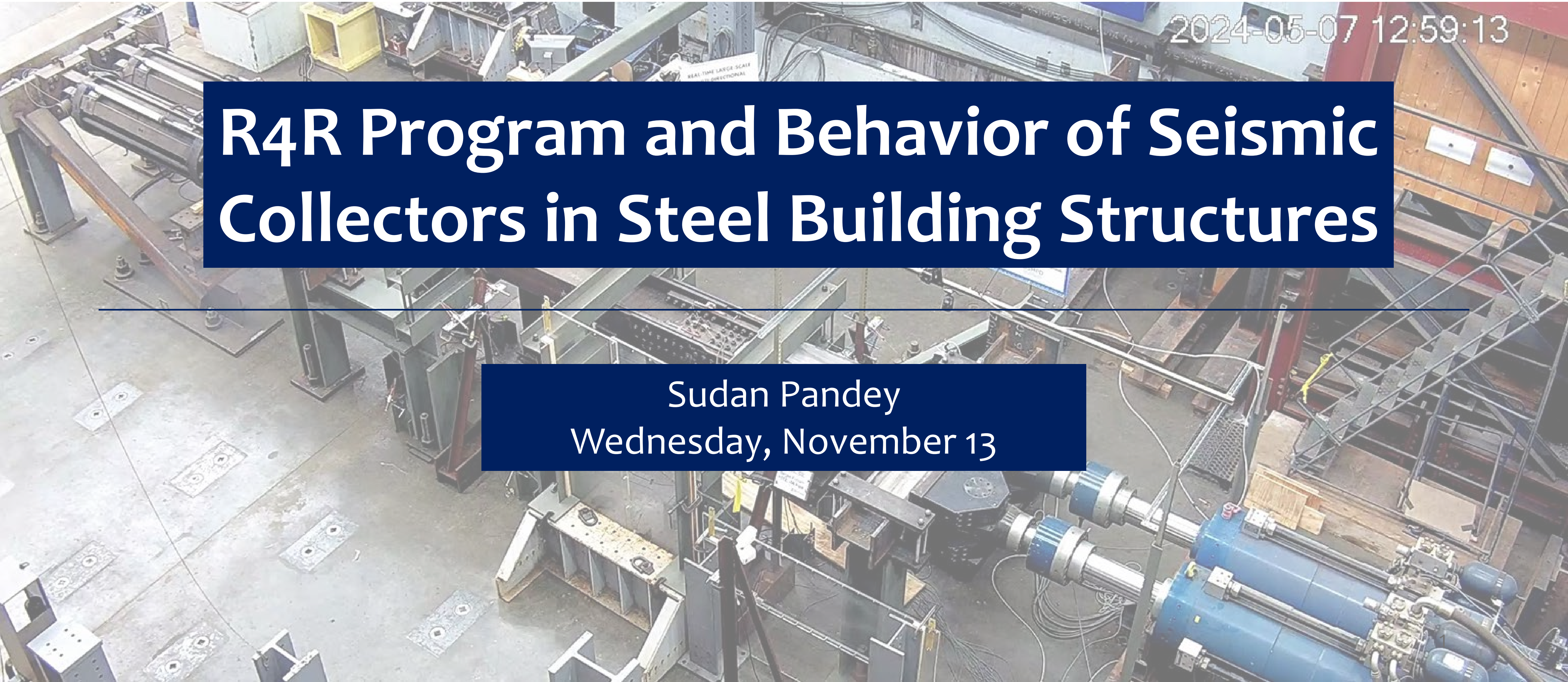
LEHIGH UNIVERSITY

UCSD

R4R Program and Behavior of Seismic Collectors in Steel Building Structures

Sudan Pandey

Wednesday, November 13



Presentation Outline

Roots for Resilience (R4R) Scholarship

- Program Overview

Behavior of Seismic Steel Collectors

- Background
- Experimental Study
- Test Data

Roots for Resilience (R4R)

The Roots for Resilience Program provides ***training*** *and* ***support*** *to select graduate students on* ***open, reproducible science and computational infrastructure*** *tools to enhance research focused on* ***resiliency*** *in the environment*

https://datascience.arizona.edu/r4r

Roots for Resilience (R4R)

- Led by the **Arizona Institute for Resilience** (AIR), **CyVerse**, and the **Data Science Institute** (DSI).
- **13 scholarships** awarded in Fall 2024 (typically one grad per department through nomination)
- **PhD candidates** who have completed qualifying exams. But others (including exceptional master's students)
- **$7,000** stipend awarded in two installments

R4R Goals

- *Develop data science capabilities.*
- *Accelerate research projects .*
- *Build professional networks for addressing large-scale challenges and research questions.*
- *Develop new interdisciplinary collaborations across AIR, DSI, CyVerse, and other academic units.*
- *Develop a cohort among participants.*

Program Schedule and Requirements

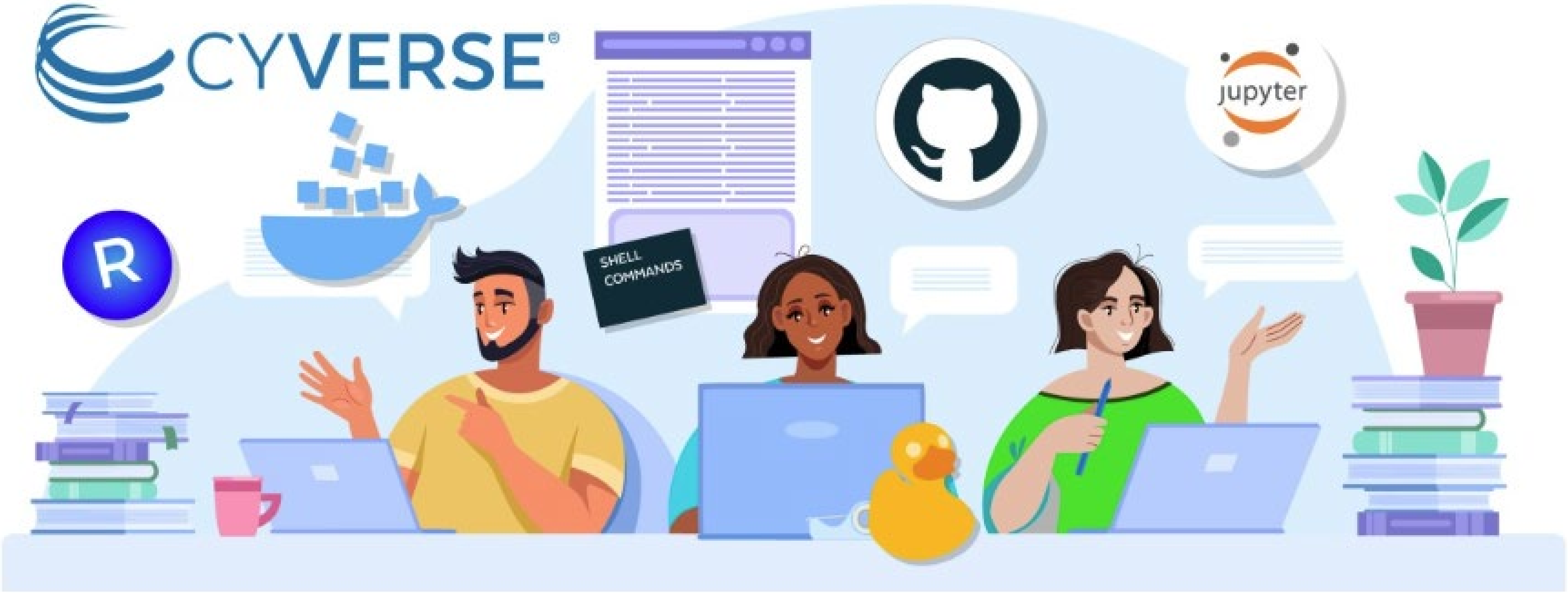
Schedule

- 2 hrs/week Foundation Open Science Skills workshop (online)
- 2 hrs/week In person cohort meetings

Requirements

- Weekly journal on GitHub
- Capstone Project (short presentation on two aspects learned from the program)
- Departmental presentation, Workshops etc.

Welcome to Foundational Open Science Skills (FOSS) Fall 2024!



FOSS SESSIONS

- Open Science
- Data Management
- **Documentation / Communication: GitHub Pages websites**
- How to Talk to Computers
- Version Control
- Reproducibility I:- Software Environments
- Reproducibility II:- Running Containers
- Reproducibility III:- Building Containers
- Remote Computing:- CyVerse
- **Remote Computing:- HPC**

https://foss.cyverse.org/schedule/#calendar

Creating a Website

HOME Publications Teaching Talks Portfolio CV

Sudan Pandey

Structural and Wind Engineer

- Tucson, AZ
- The University of Arizona
- Email
- Google Scholar
- ORCID
- Github
- LinkedIn

- Github
- Use of readily available templates
- Jekyll – Academic pages, Al-Folio
  - https://github.com/academicpages/academicpages.github.io
  - https://github.com/alshedivat/al-folio

https://pdy-sdn.github.io/pandeysudan.github.io/

Remote Computing with HPC

OPEN OnDemand

OnDemand provides an integrated, single access point for all of your HPC resources.

Pinned Apps A featured subset of all available apps

Abaqus GUI
System Installed App

Ansys Workbench GUI
System Installed App

Mathematica GUI
System Installed App

Matlab GUI
System Installed App

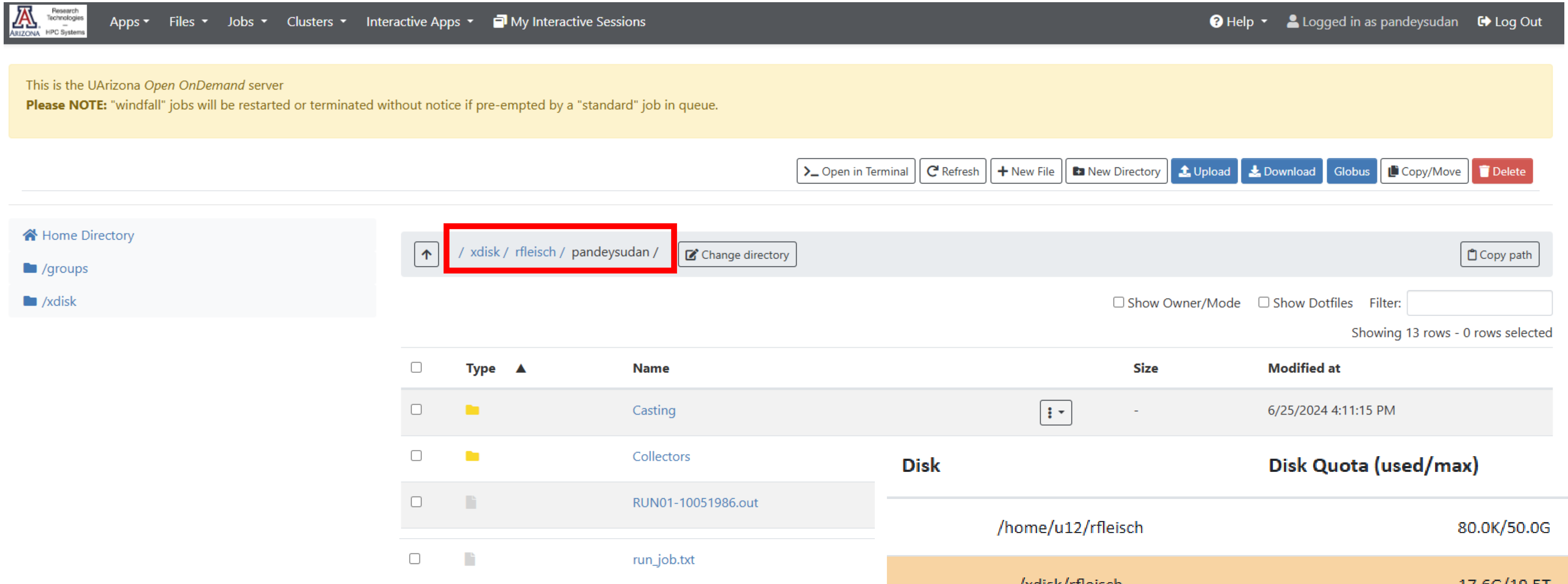
Stata GUI
System Installed App

VSCode GUI
System Installed App

Remote Computing with HPC

1. Home Directory for Open on-demand HPC portal:

https://ood.hpc.arizona.edu/pun/sys/dashboard/files/fs//home/u12/netid



Disk	Disk Quota (used/max)
/home/u12/rfleisch	80.0K/50.0G
/xdisk/rfleisch	17.6G/19.5T
/groups/rfleisch	104.4G/500.0G

Remote Computing with HPC

SLURM Script (run_slurm.txt)

```
#!/bin/bash
#SBATCH --job-name=TEST4
#SBATCH --output=%x-%j.out
#SBATCH --account=rfleisch
#SBATCH --mail-type=ALL
#SBATCH --mail-user=pandeysudan@arizona.edu
#SBATCH --partition=standard
### REQUIRED. Set the number of cores that will be used for this job.
#SBATCH --ntasks=94
### REQUIRED. Set the number of nodes
#SBATCH --nodes=1
### REQUIRED. Set the memory required for this job.
#SBATCH --mem-per-cpu=5gb
### REQUIRED. Specify the time required for this job, hhh:mm:ss
#SBATCH --time=5:00:00


# --------------------------------------------------------------
### PART 2: Executes bash commands to run your job
# --------------------------------------------------------------
### Load required modules/libraries if needed
###module load ansys
module purge
module unload gnu8 openmpi3
module load intel
module load ansys/21.1

### change to your script's directory
cd /xdisk/rfleisch/pandeysudan/Collectors/TEST4/RUN01

### Run your work
date

### GUI command line for linux
/usr/bin/time ansys211 -dis -np 94 -j AFW-RUN04 -b <HPC_PP.mac
date
```

slurm workload manager

To run this script:

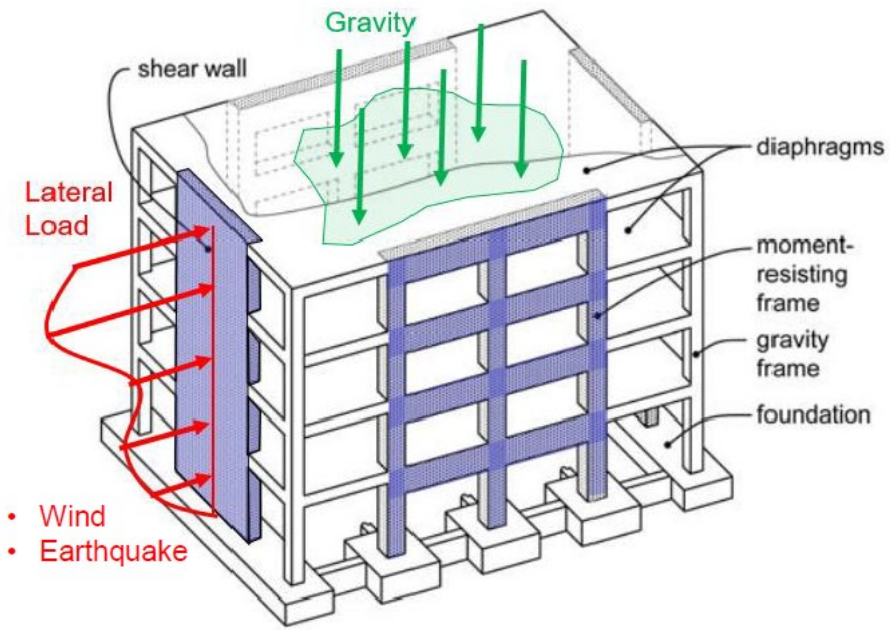
sbatch run_slurm.txt

Behavior of Seismic Collectors in Steel Building Structures

Sudan Pandey

Wednesday, November 13

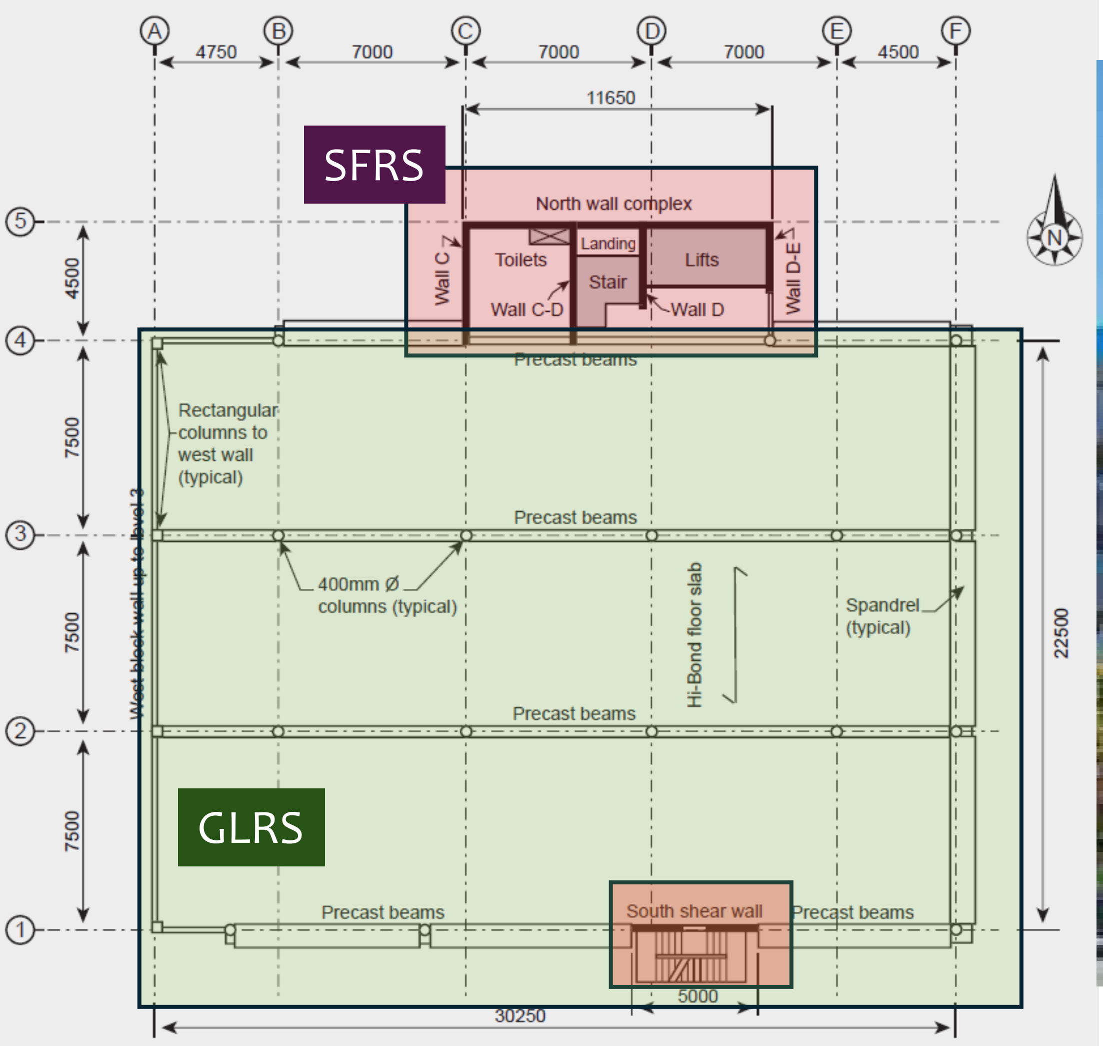
Lateral Load Resisting System



Systems	Types	Functions	Components
Gravity Load Resisting System (GLRS)	Vertical Elements	Support the gravity or vertical loads	Columns, etc.
	Horizontal Elements	Transfer gravity to vertical elements	Beams, Slabs, Deck
Lateral Force Resisting System (LFRS)	Vertical Elements	Transmit lateral forces from the upper levels to foundation	Columns, Bracing, Shear Walls.
	Horizontal Elements	Transfer lateral forces to vertical elements of the LFRS	Diaphragms, Collectors.

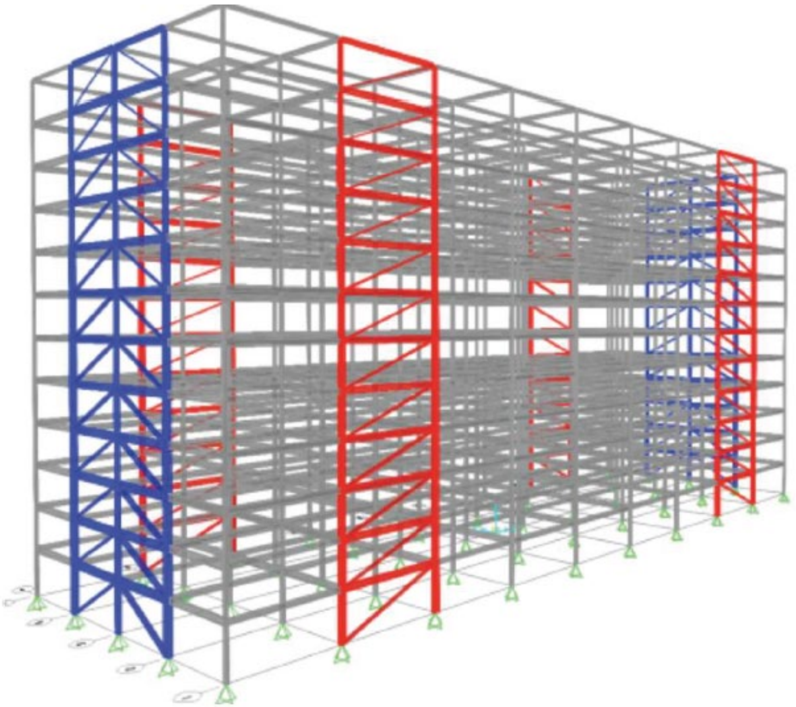
Loss Of Collectors

CTV Building, 2011 Christchurch Earthquake (New Zealand)



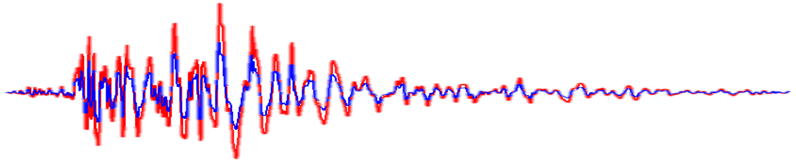
(Courtesy of CERC Report, Canterbury Earthquakes Royal Commission)

Collector Force



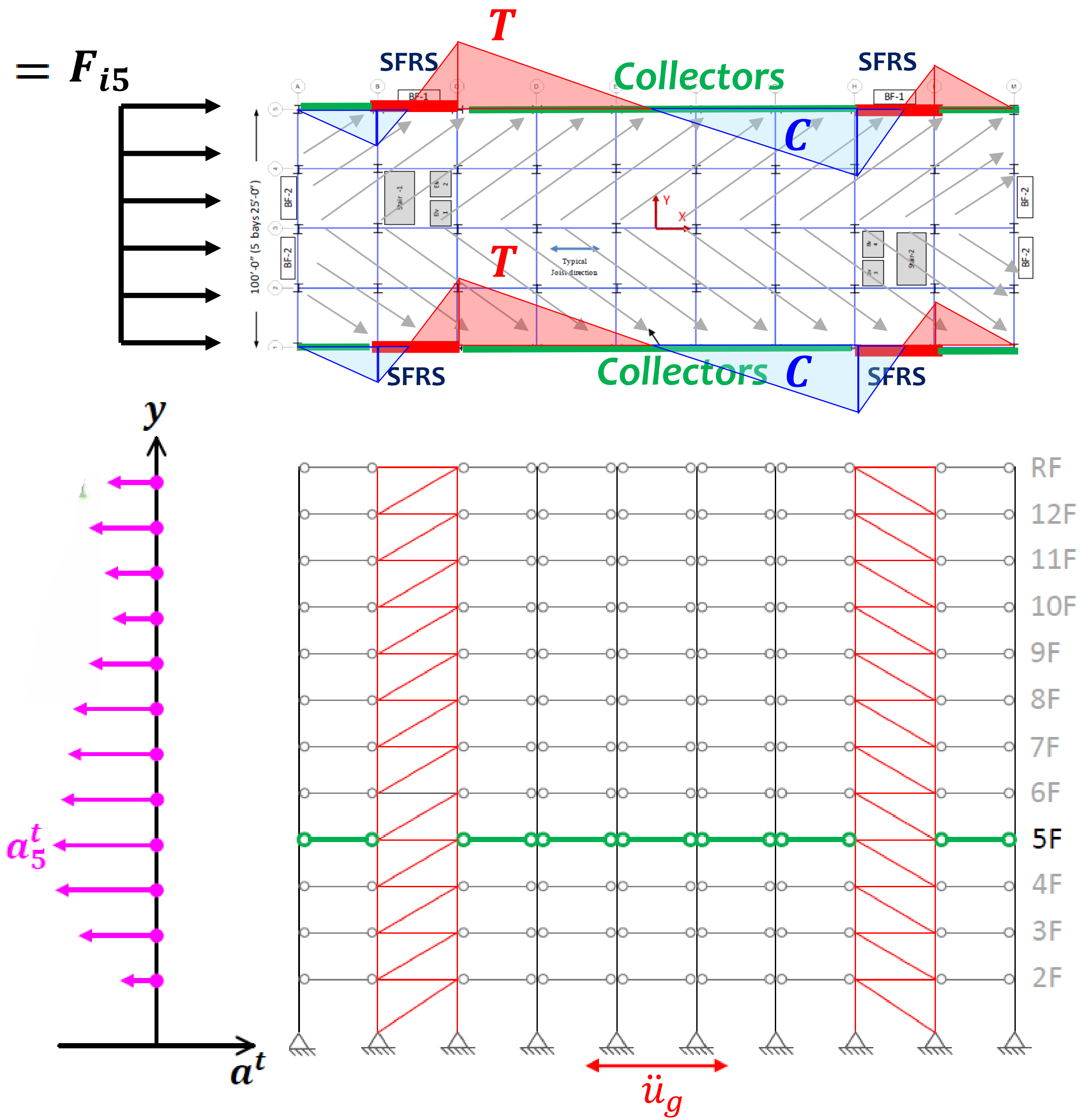
12-Story SDII Building

Courtesy of Steel Diaphragm Innovation Initiative (SDII)



Earthquake motion ($\ddot{u}_g$)

$$-M_5 a_5^t = F_{i5}$$

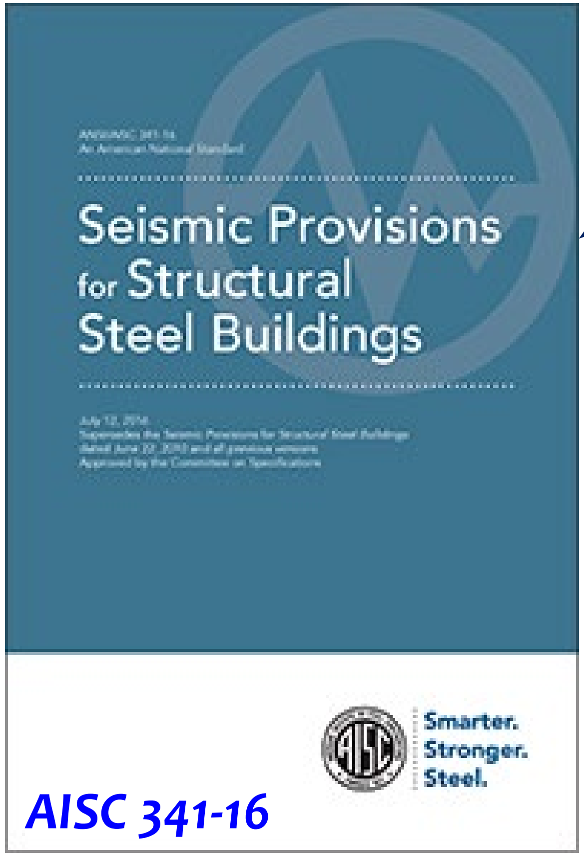


Collector Design

B5. DIAPHRAGMS, CHORDS AND COLLECTORS

1. General

Diaphragms and chords shall be designed for the loads and load combinations in the applicable building code. Collectors shall be designed for the load combinations in the applicable building code, including overstrength.

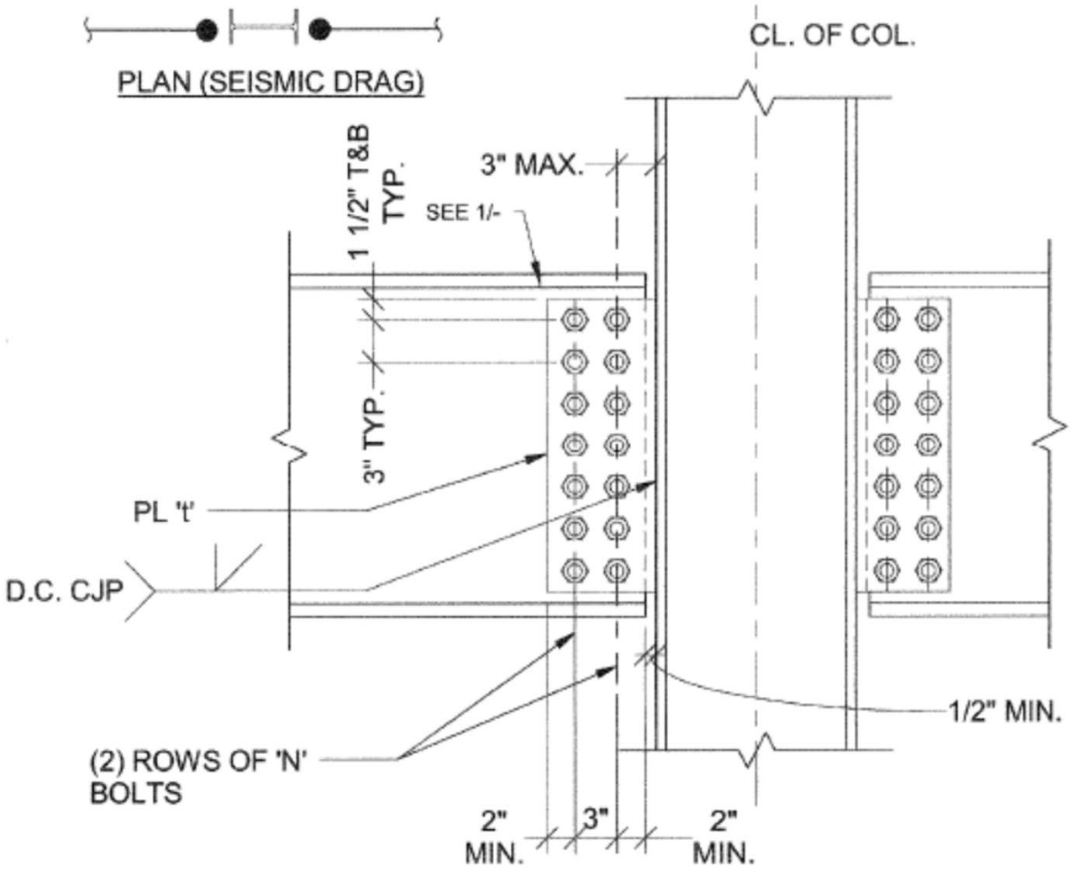


AISC 341-16

No Detailed Guidelines on Collector Connection!!

Collector Connection

Bolted Connection (Multiple rows of bolts)



(Courtesy of Herrick)

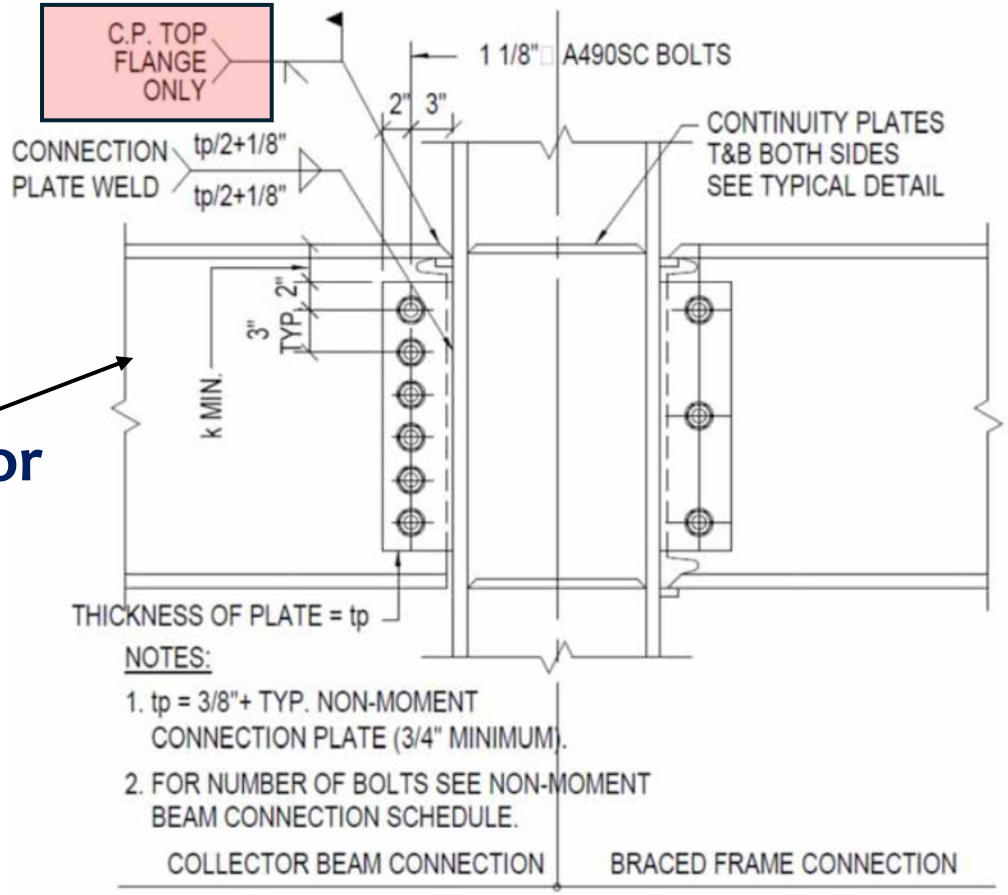
(Courtesy of Chao-Hsien Li)

Collector Connection

Top Flange Welded Connection (TFW)

SFRS

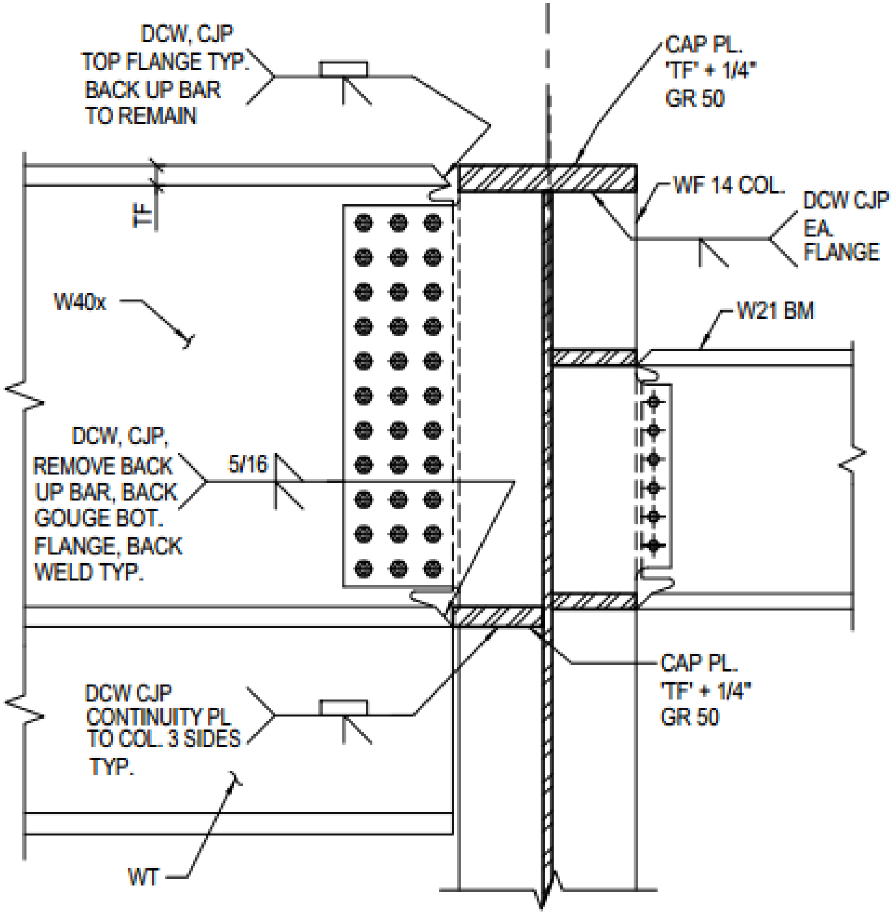
Collector



(Courtesy of Herrick)

Collector Connection

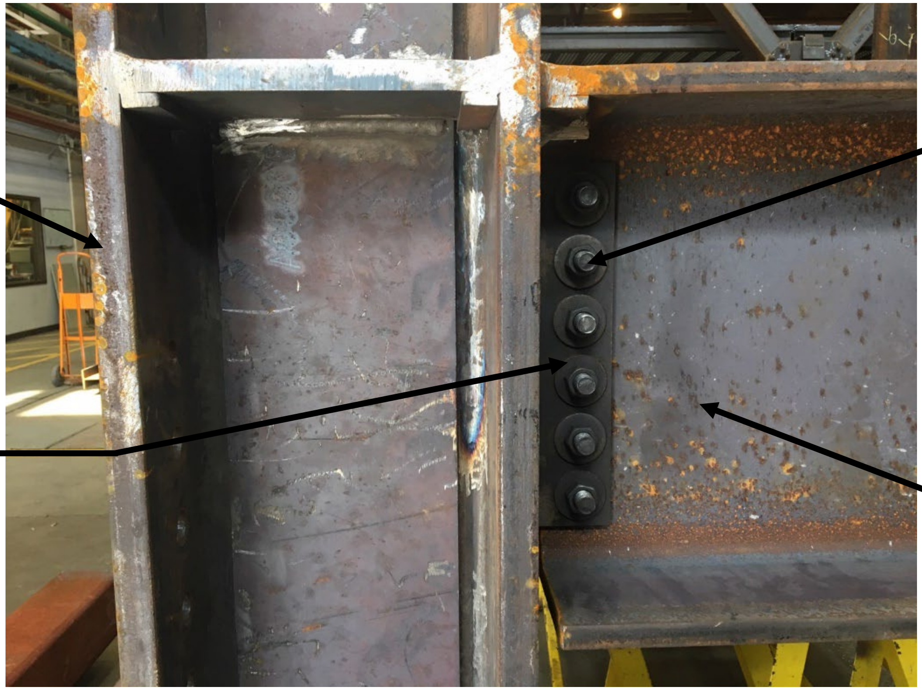
All Flange Welded Connection (AFW)



(Courtesy of Dr. Fleischman)

All flange welded

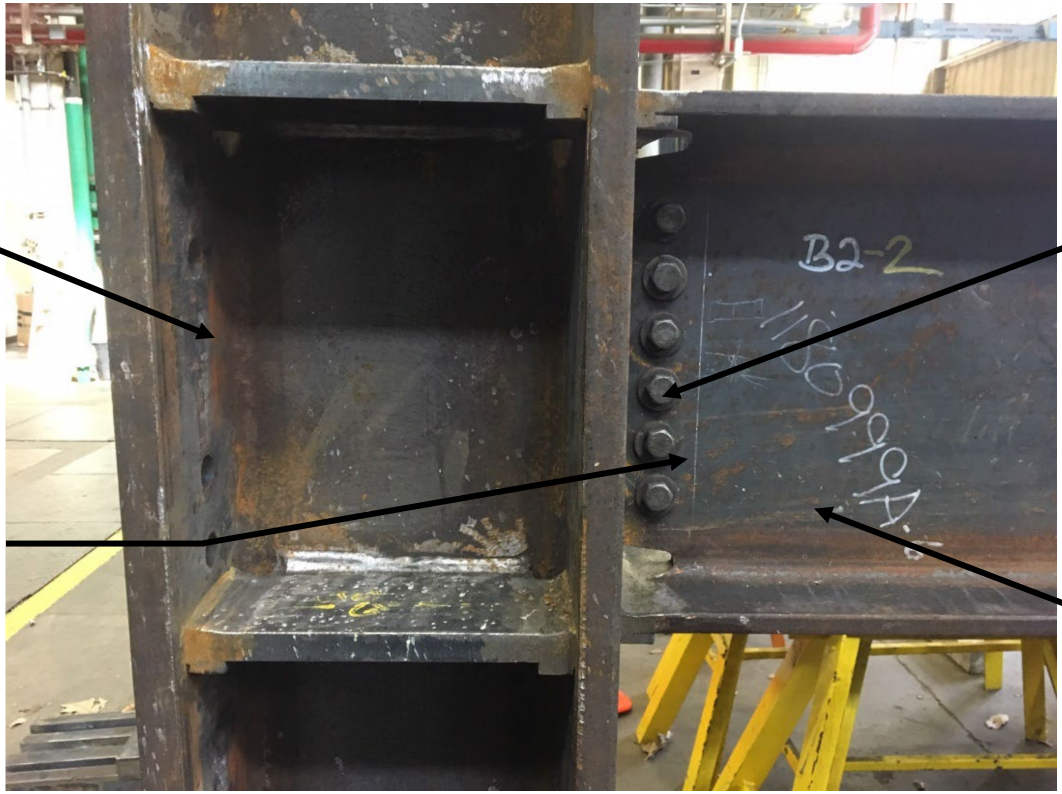
Fabricated Specimen: Top Flange Weld (TFW)



The TFW is a 3/4-scale test specimen based on a Full-Scale Prototype

Scale	Section	Length	Shear Tab (H x W x t)	Bolt Dia	# of bolts	Factored Strength	Maximum Exp. Axial Capacity
		ft	*in x in x in*	*in*		*k*	*k*
1.0	W24X162	30	18 x 4.5 x 1/2	1.00	6	714	1499
0.75	W18x97	20	13.75 x 3.25 x 3/8	0.750	6	435	940

Fabricated Specimen: All Flange Weld (AFW)



W12x136 Column

11.8”x3.25”x3/8” Shear Tab

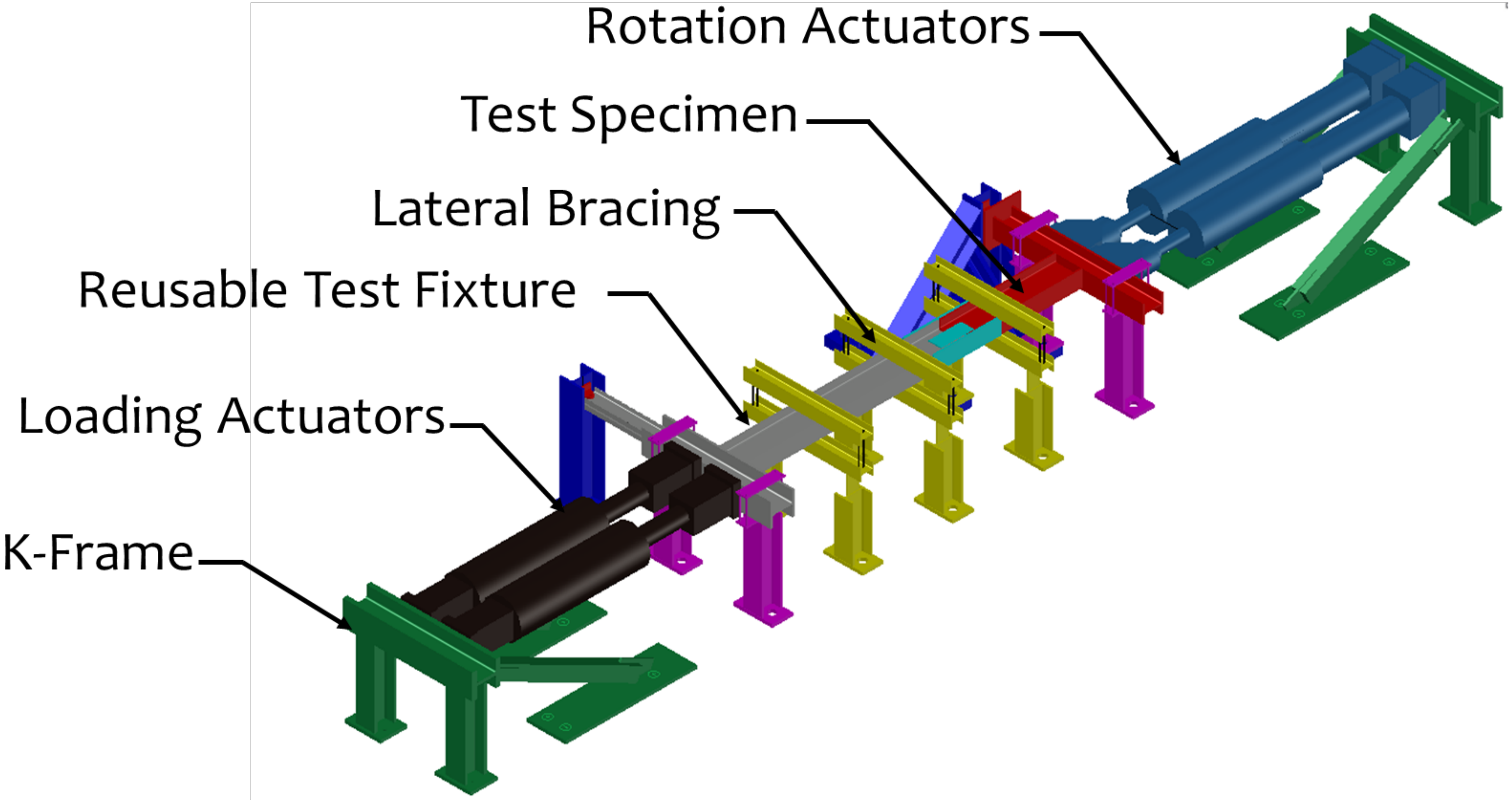
6 – 5/8” dia. A325 Snug tight bolts

W16x57 Collector

The AFW is a 2/3-scale test specimen based on a Full-Scale Prototype

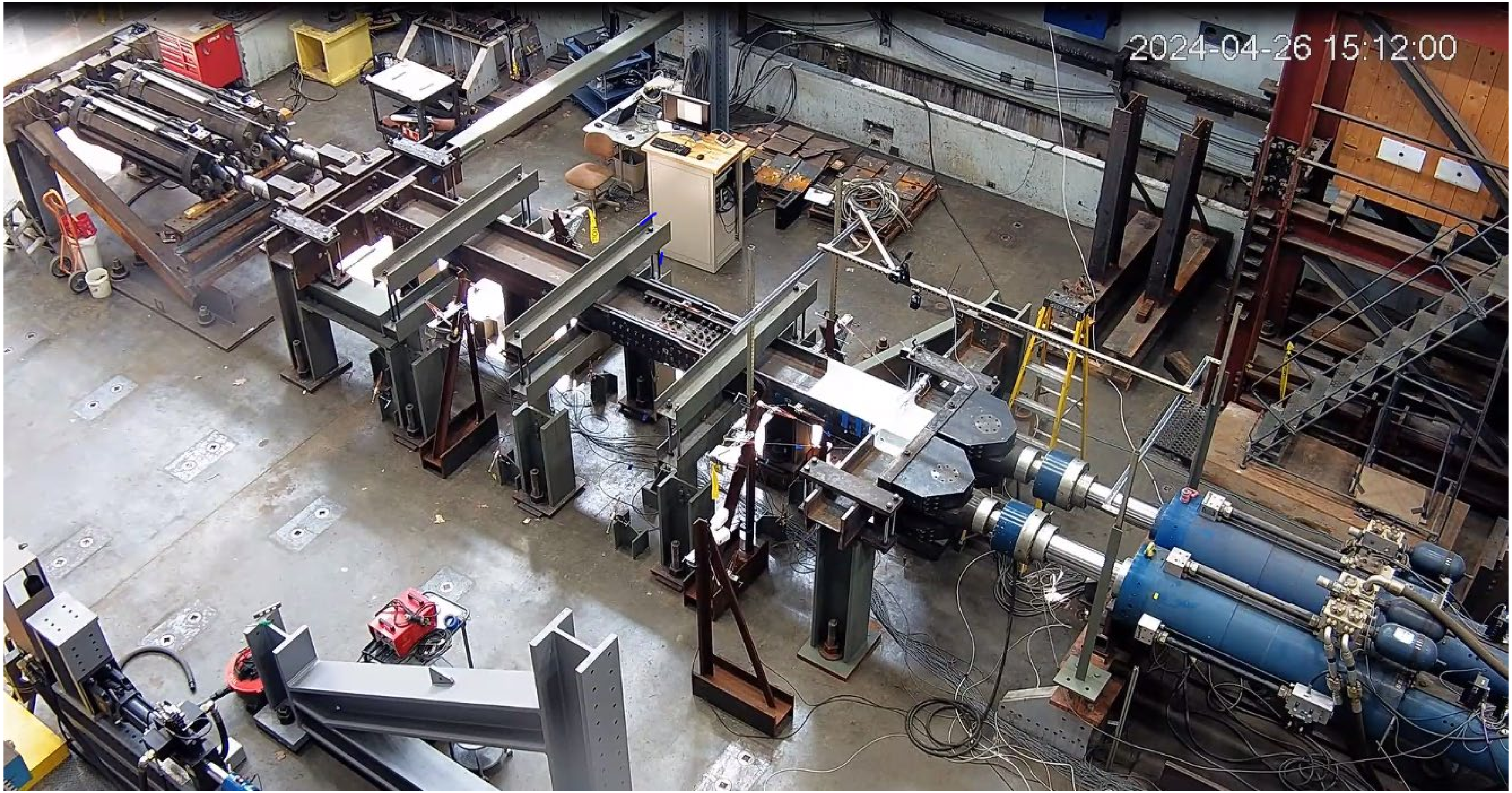
Scale	Section	Length	Shear Tab (H x W x t)	Bolt Dia	# of bolts	Factored Strength	Maximum Exp. Axial Capacity
		ft	*in*	*in*		*k*	*k*
1.0	W24X162	30	18 x 4.5 x 1/2	1.00	6	1427	2633
0.67	W16x57	20	11.8 x 3.25 x 3/8	0.625	6	458	978

Experimental Verification



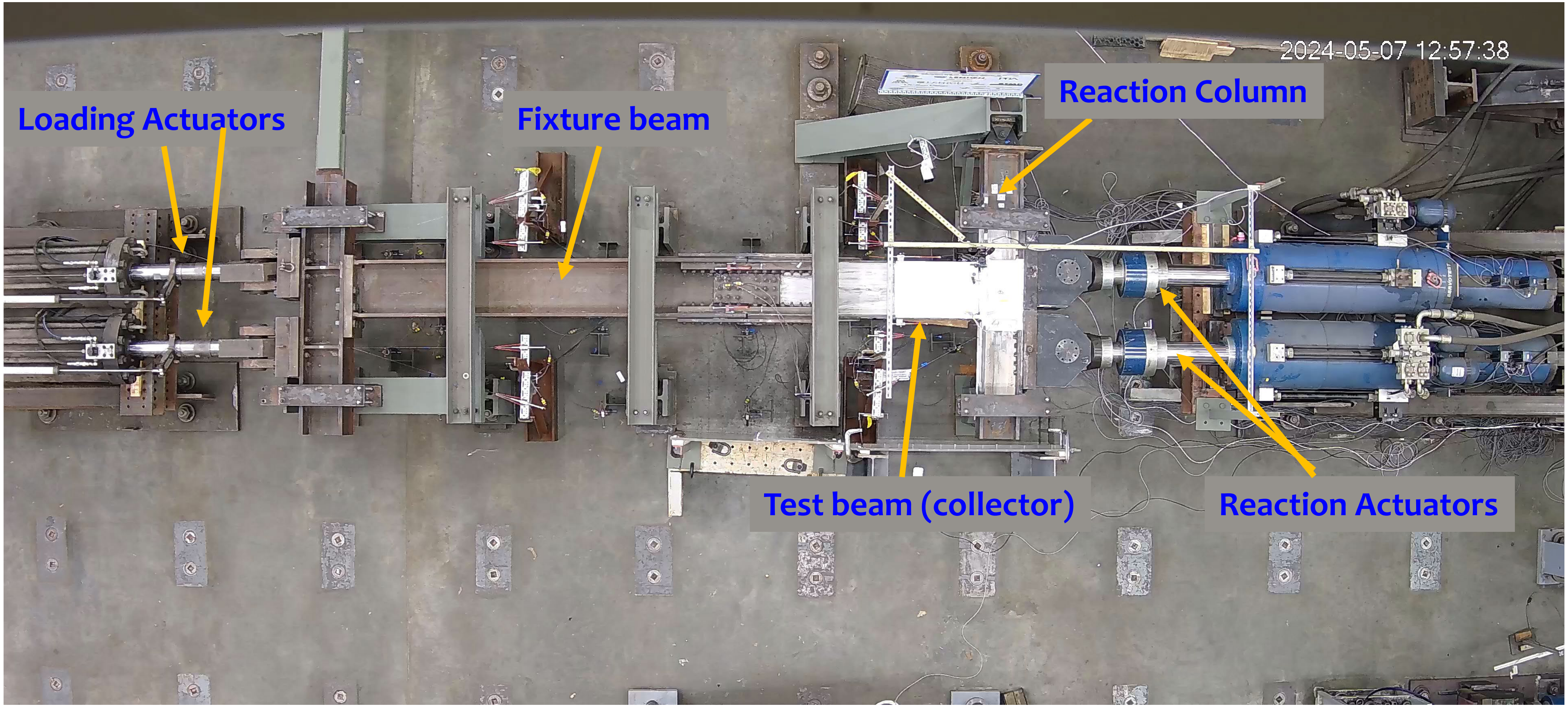
(Jessica Duke, 2021)

Test Setup



(Alia Amer, 2024)

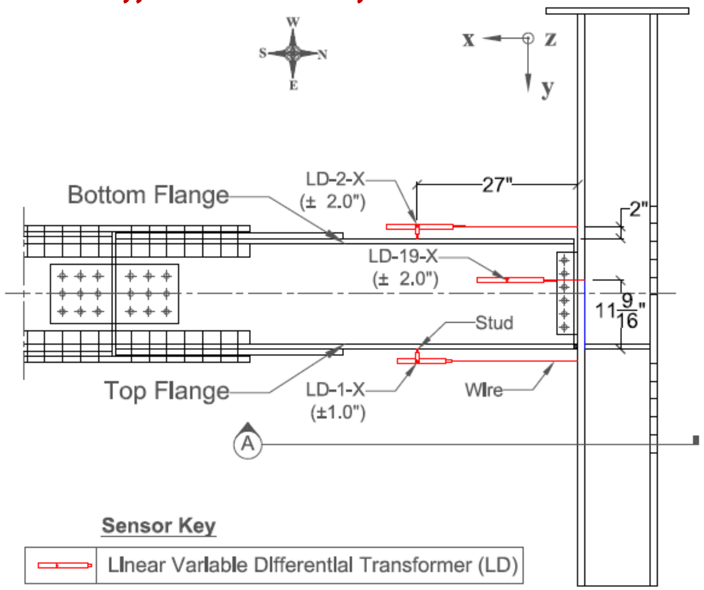
Test Setup



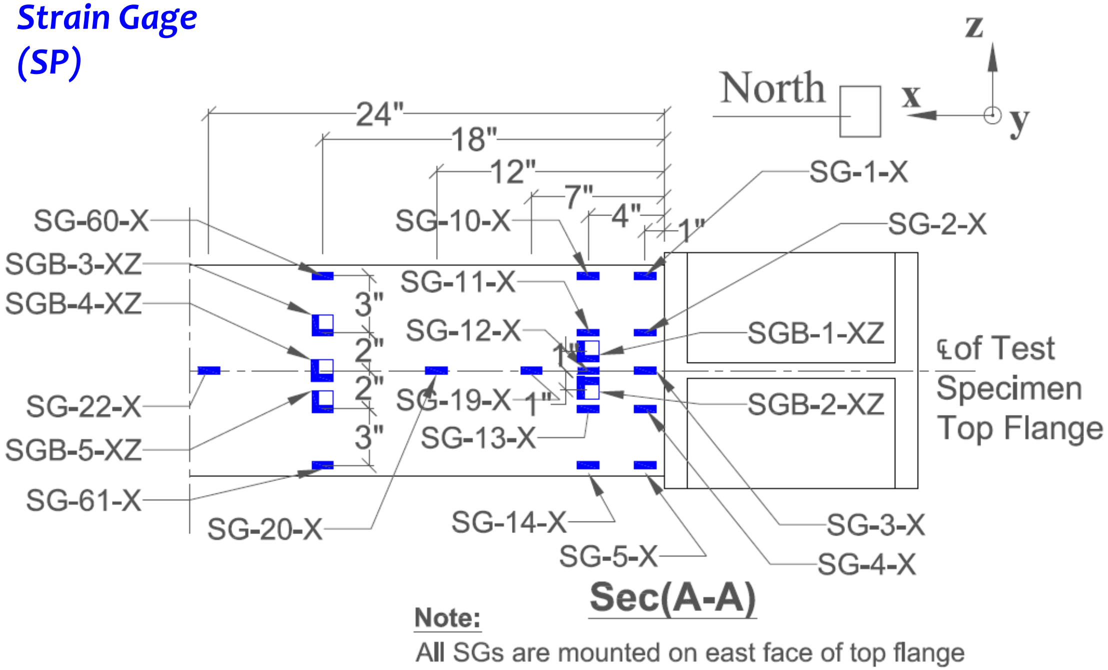
2024-05-07 12:57:38
Loading Actuators
Fixture beam
Reaction Column
Test beam (collector)
Reaction Actuators

Instrumentation

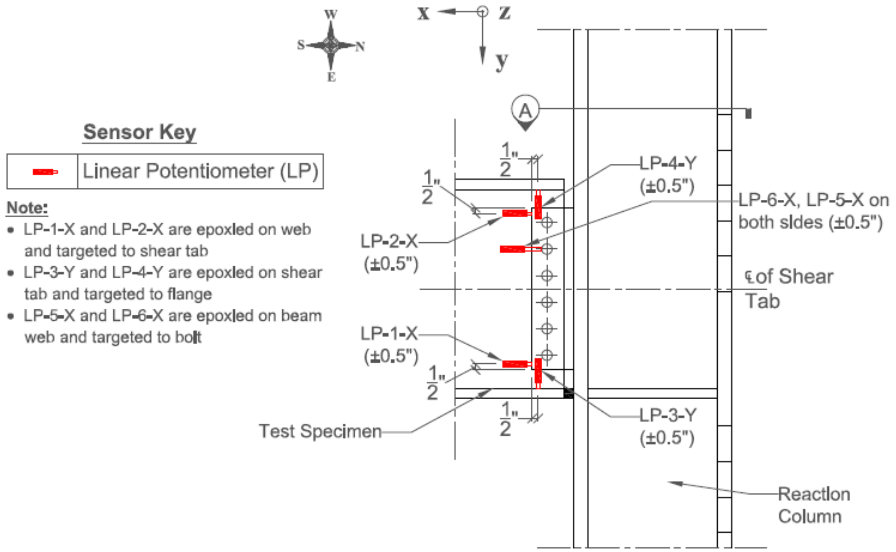
Linear variable differential transformer (LVDT)



Strain Gage (SP)

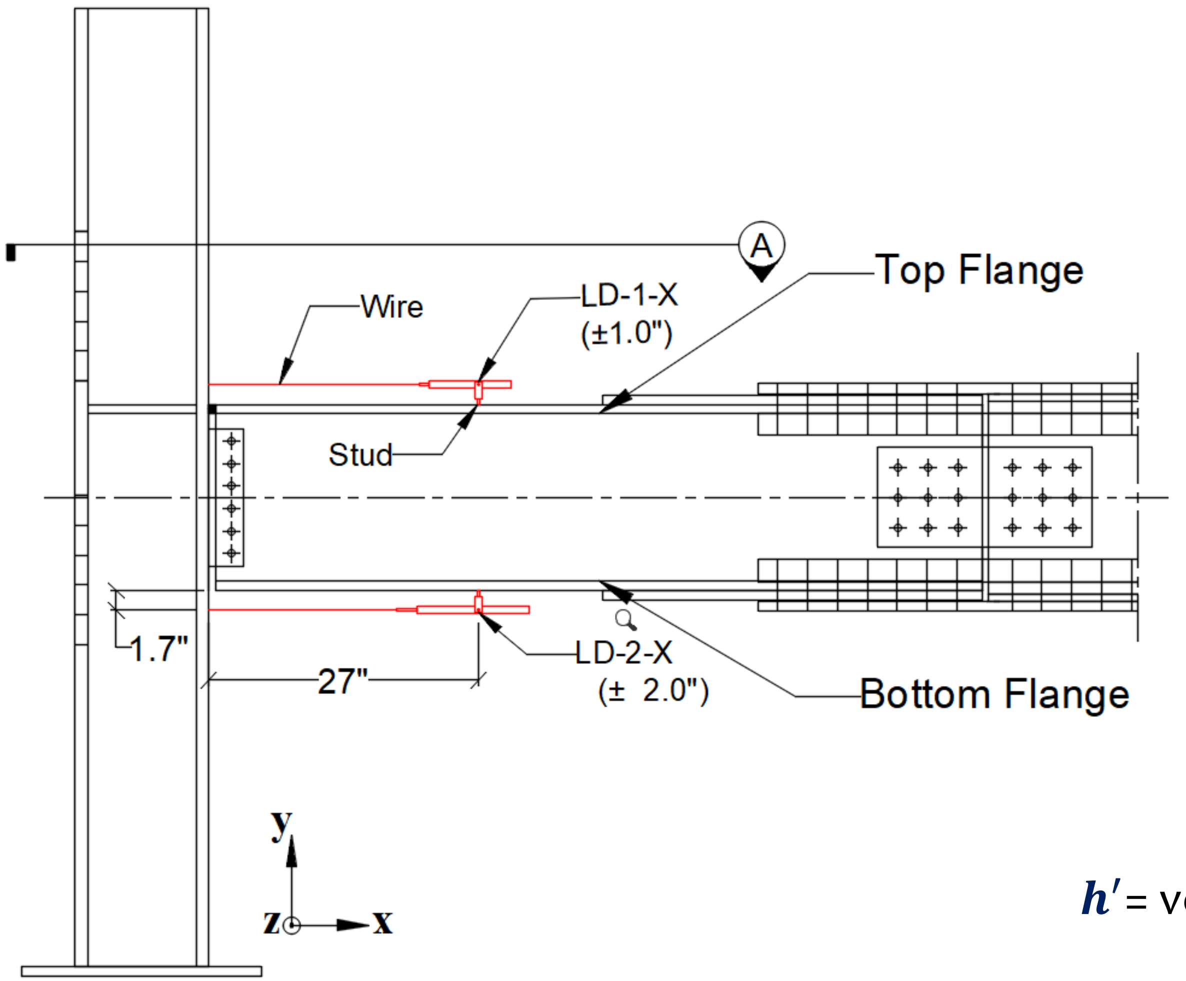


Linear potentiometer (LP)



Instrument	Count
LVDT	*33*
LP	*7*
Axial strain gage	*55*
Rosette gage	*5*
Biaxial gage	*6*

Collector Local Behavior Measurement



LVDT's to measure the deformation

Axial Deformation at girder centroid

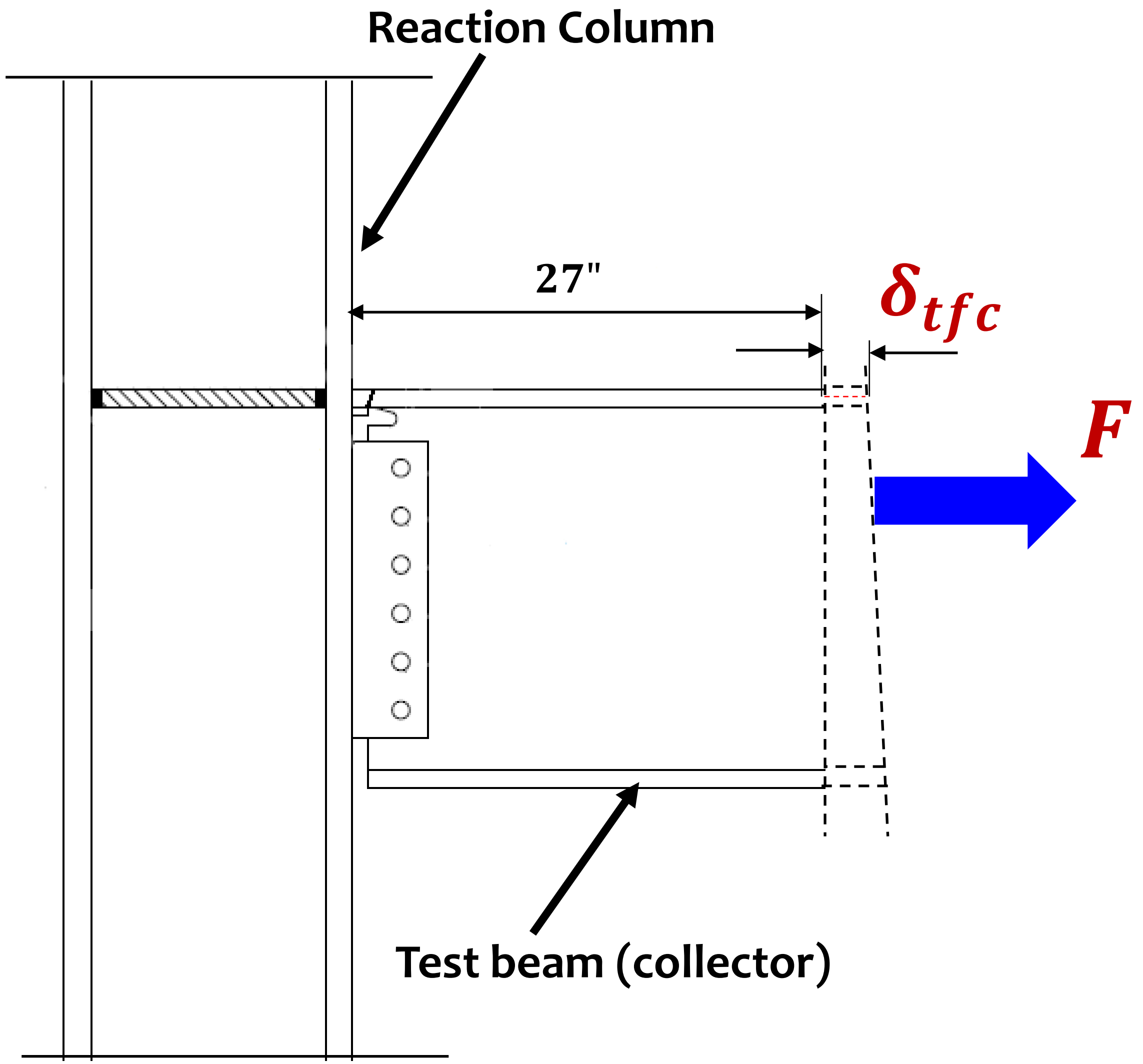
$$\delta_c = \frac{LD1_X + LD2_X}{2}$$

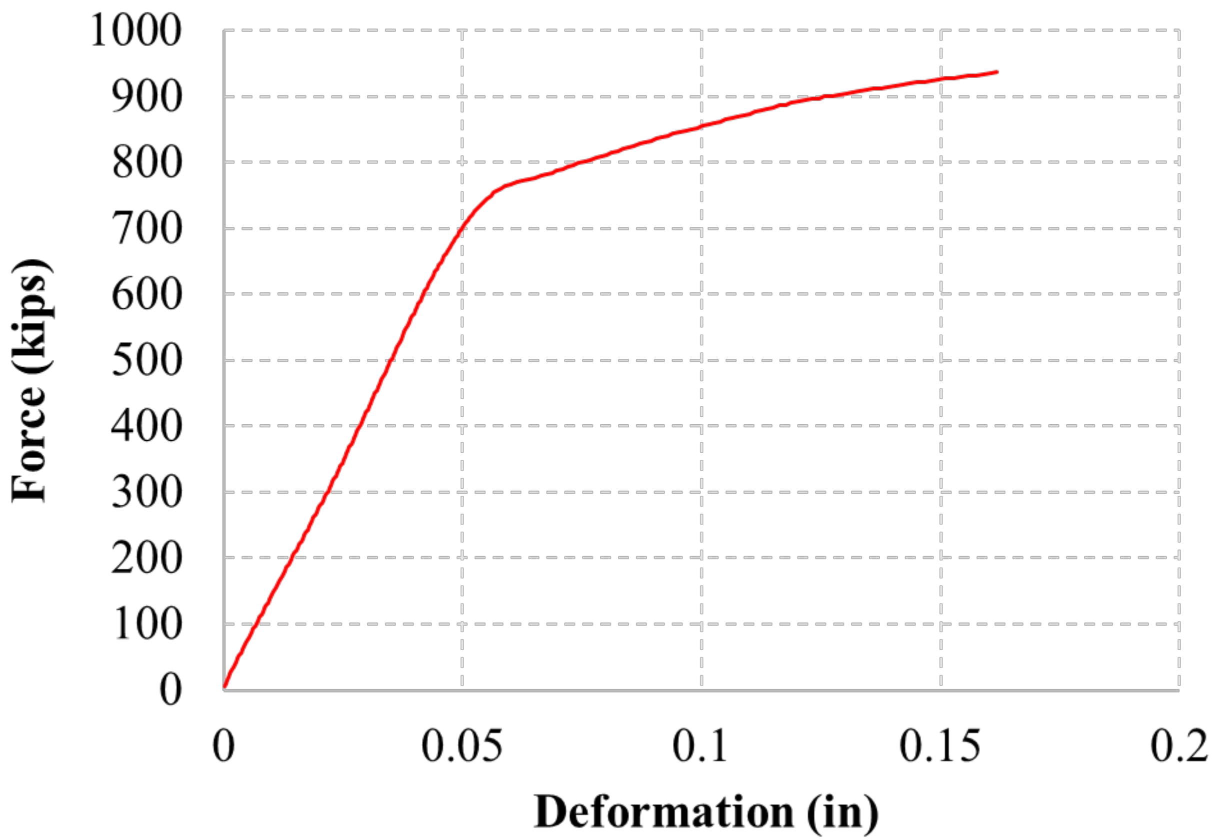
Rotation of the girder cross section (positive when bottom flange open)

$$\theta_c = \frac{LD2_X - LD1_X}{h'}$$

h' = vertical distance between LD 1-X and LD 2-X = 18.6 +1.7*2 = 22"

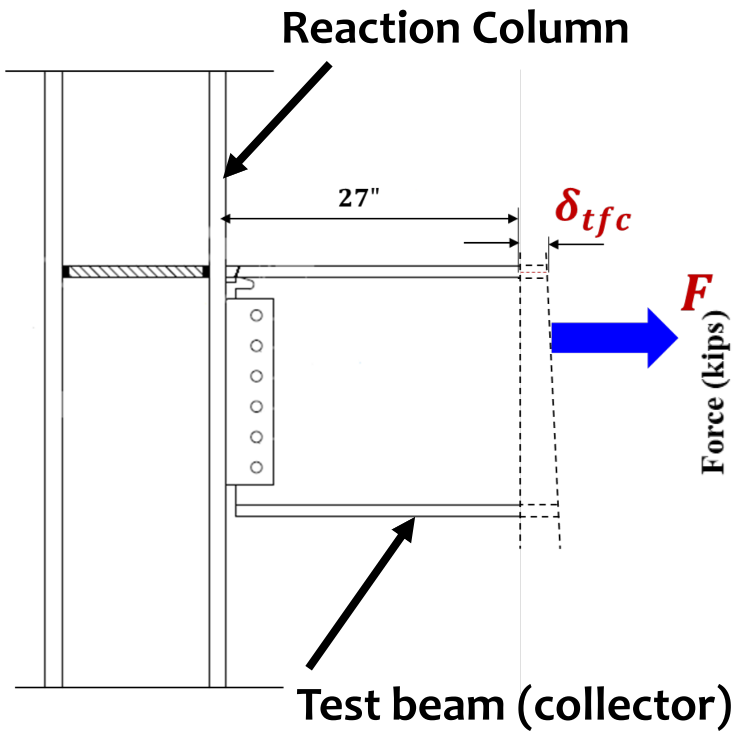
Collector Local Behavior Measurement

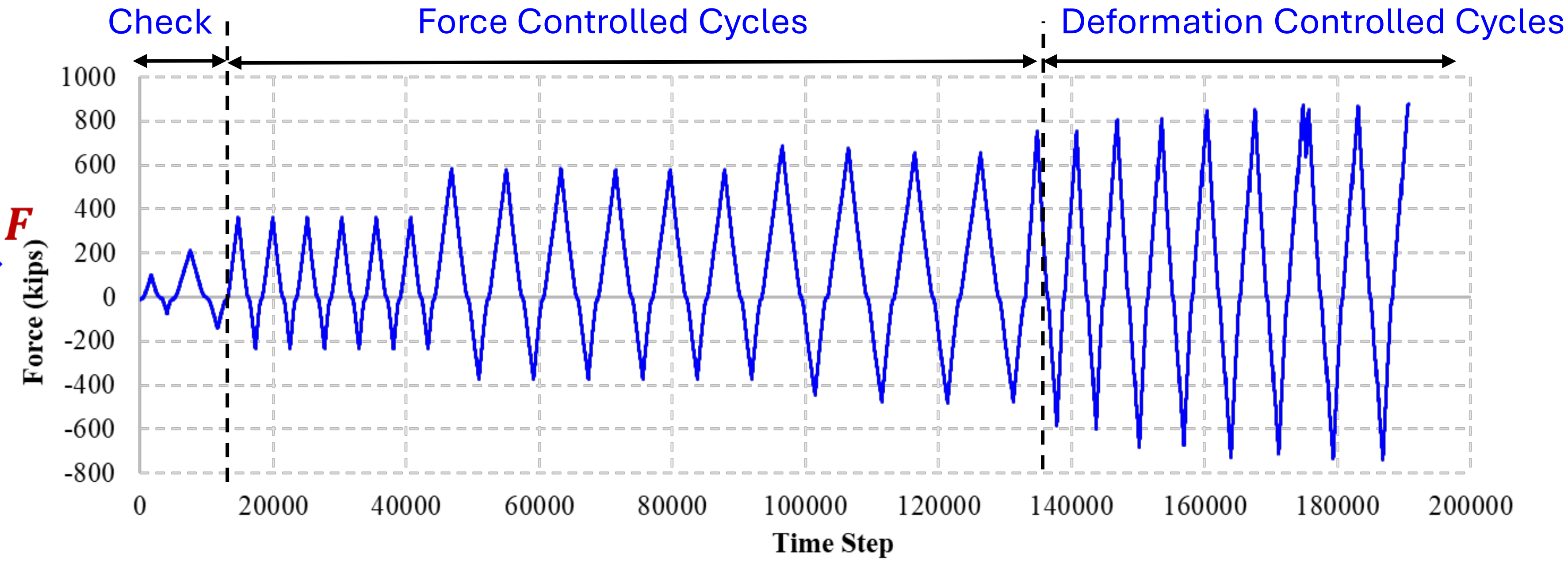




Loading Protocol: Cyclic Axial Loading

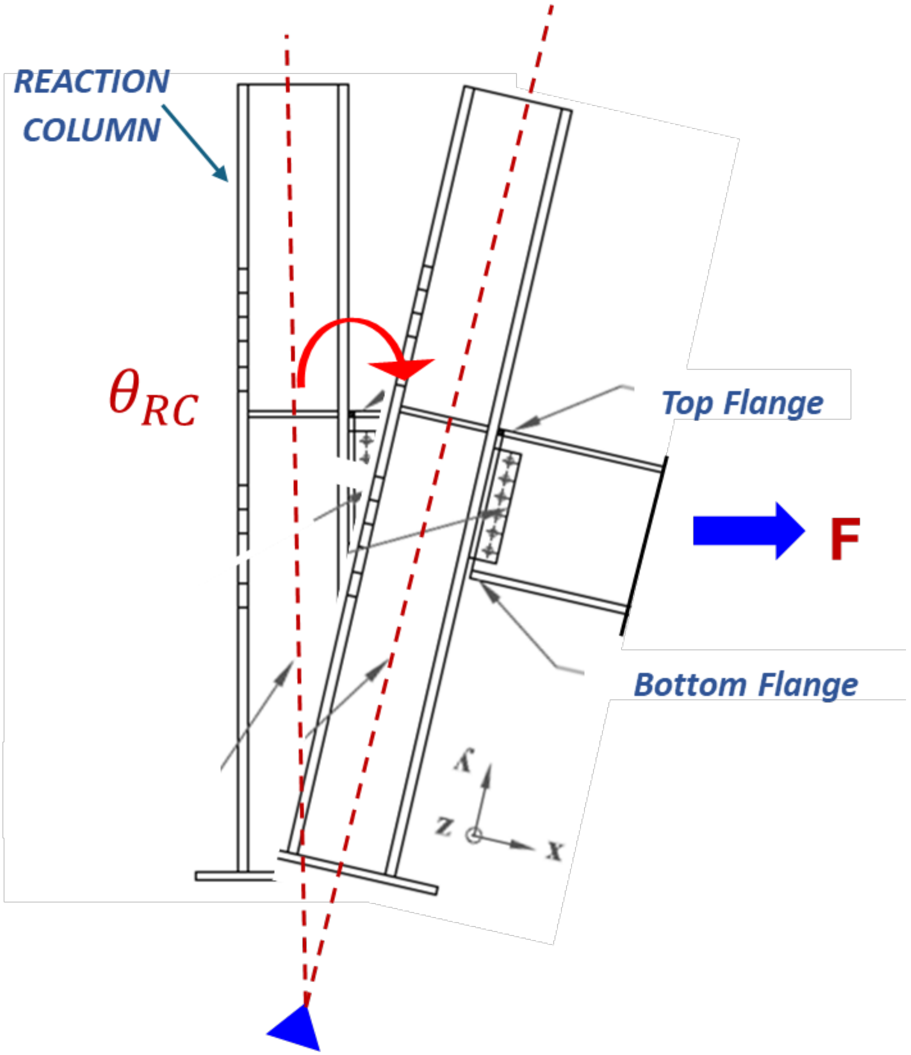
Test 1: TFW3
Loading: Cyclic Axial
Rotation: No

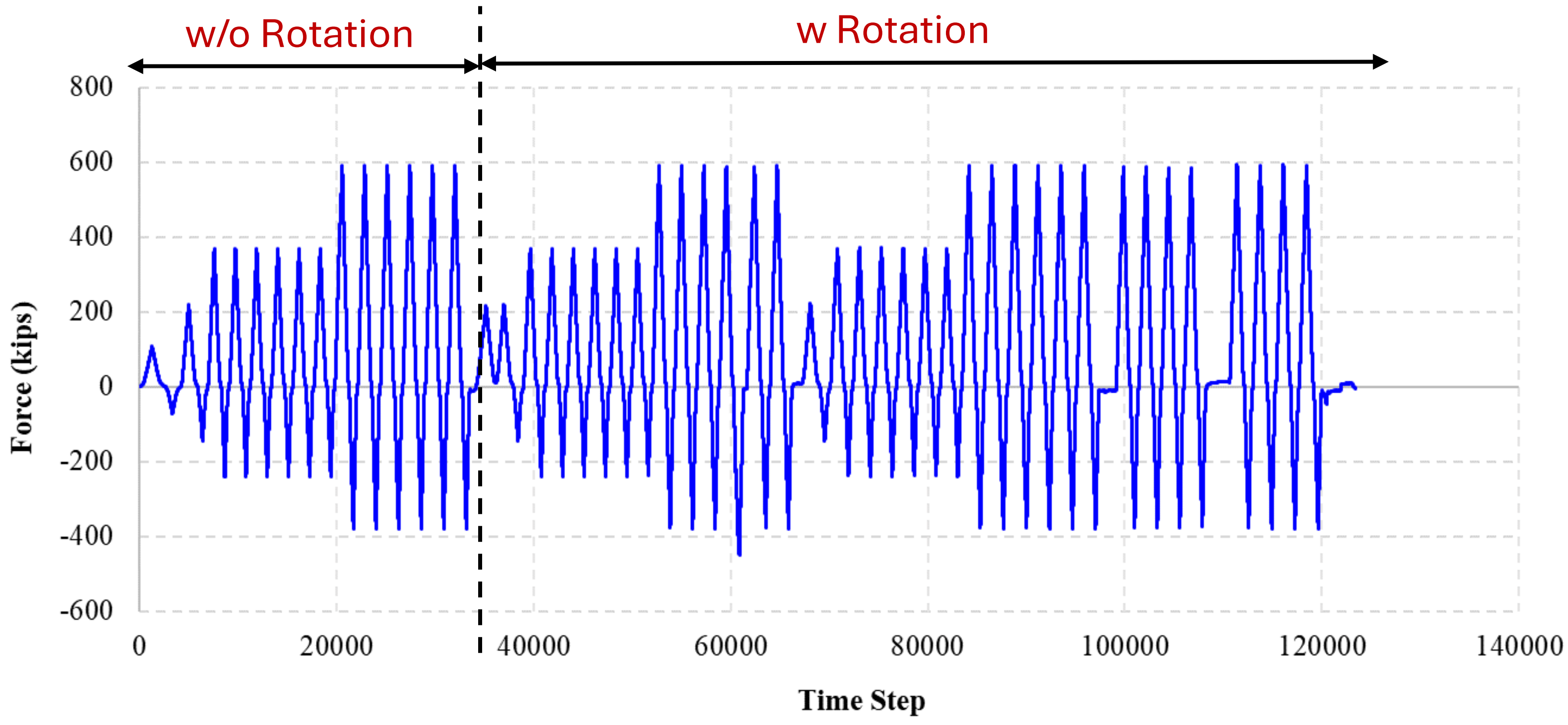




Loading Protocol: Rotation and Cyclic Axial Loading

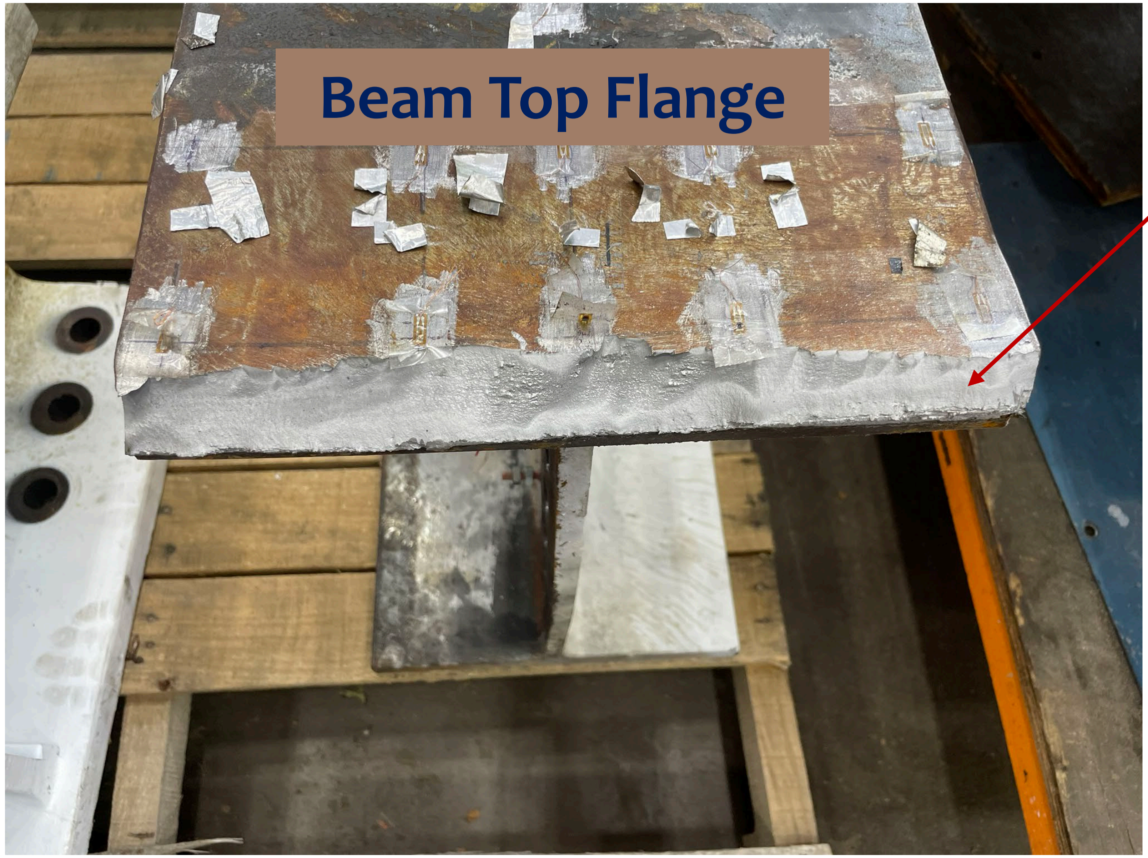
Test 2: TFW1
Loading: Cyclic Axial
Rotation: Yes





Applied Rotation (rad): +/- 0.005, +/-0.0075, +/-0.01, +/- 0.02, +/-0.03, +/-0.04, +/-0.05

Fracture Surface: Test-1

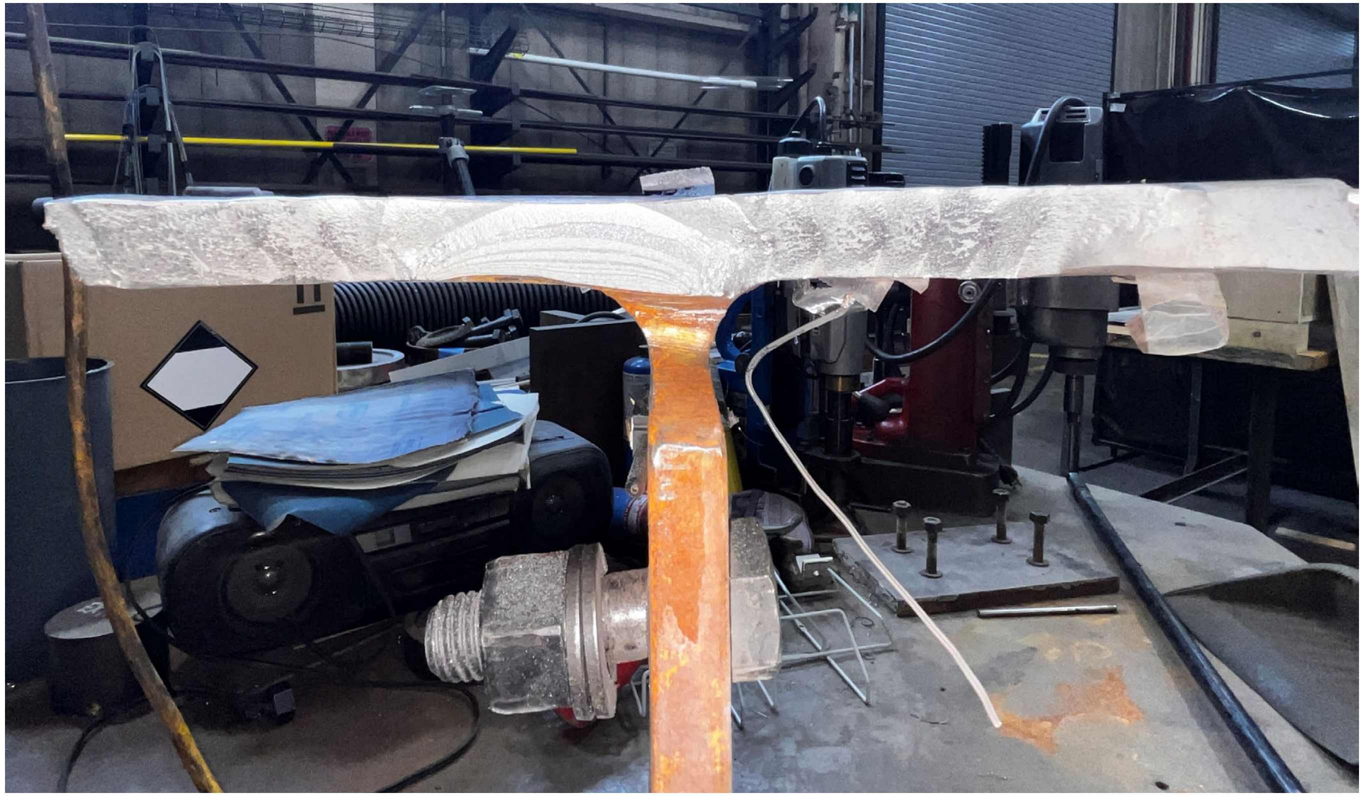


Top Flange Fracture Surface

Brittle Failure

Fracture Surface: Test-2

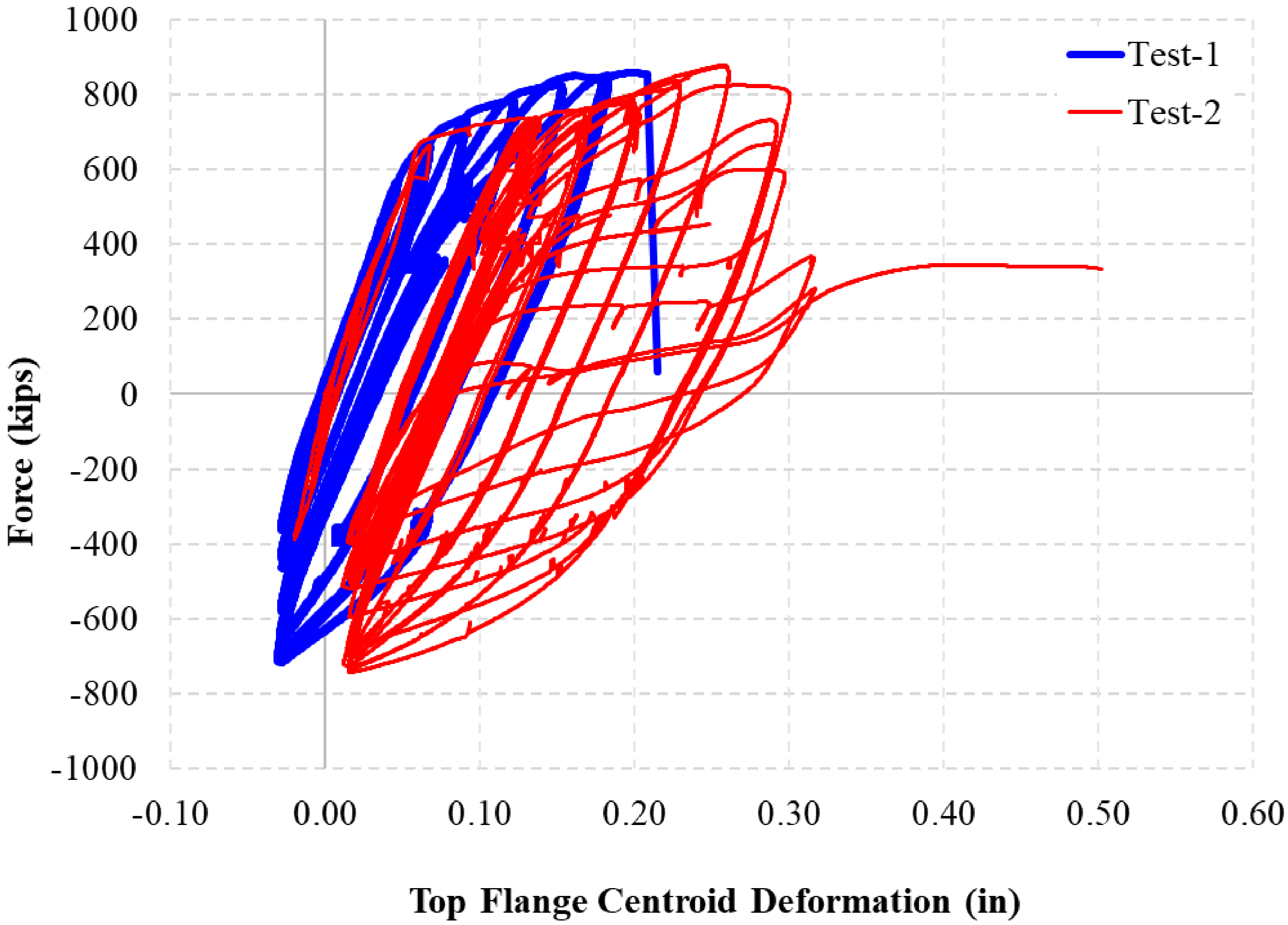
Beam Cross Section View



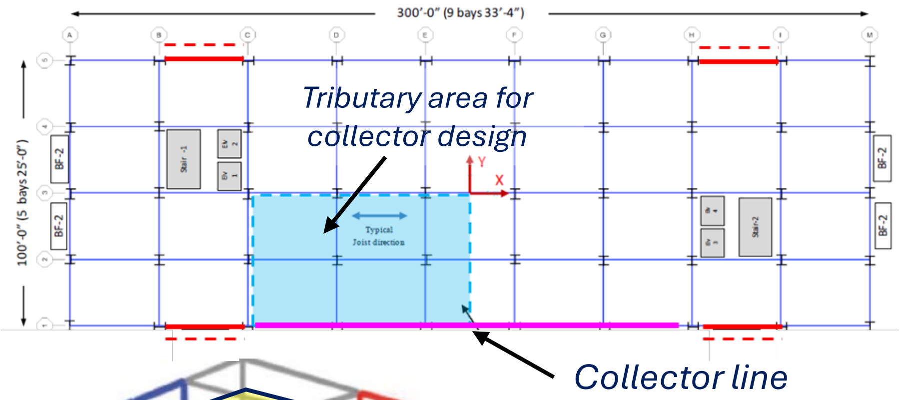
Beam Top View

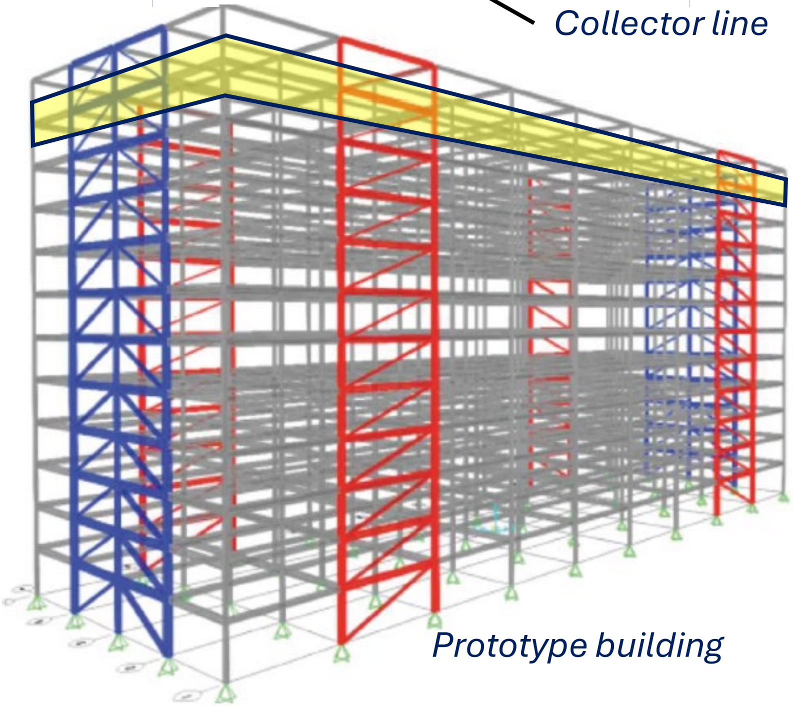
Ductile Failure

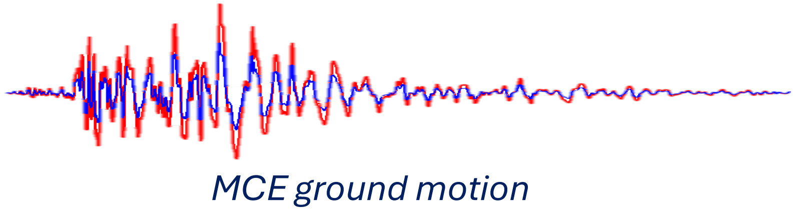
Collector Connection Behavior

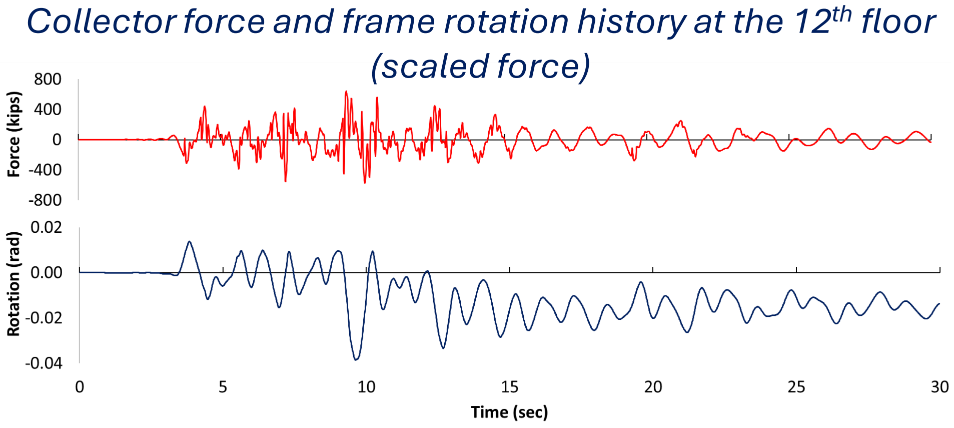


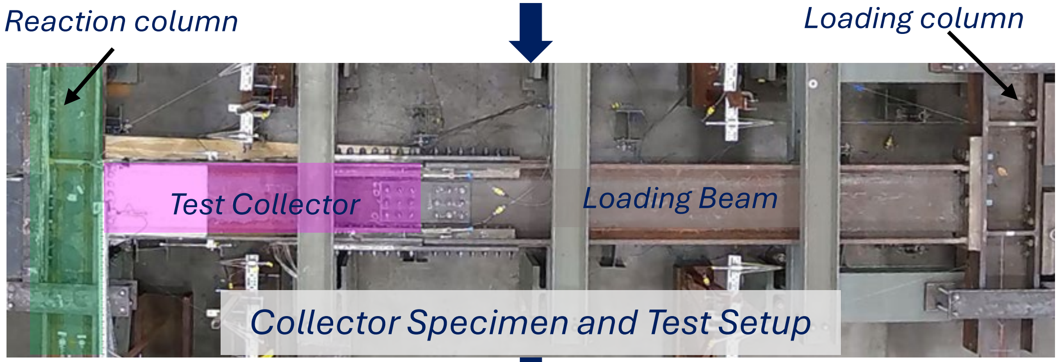
Test-3

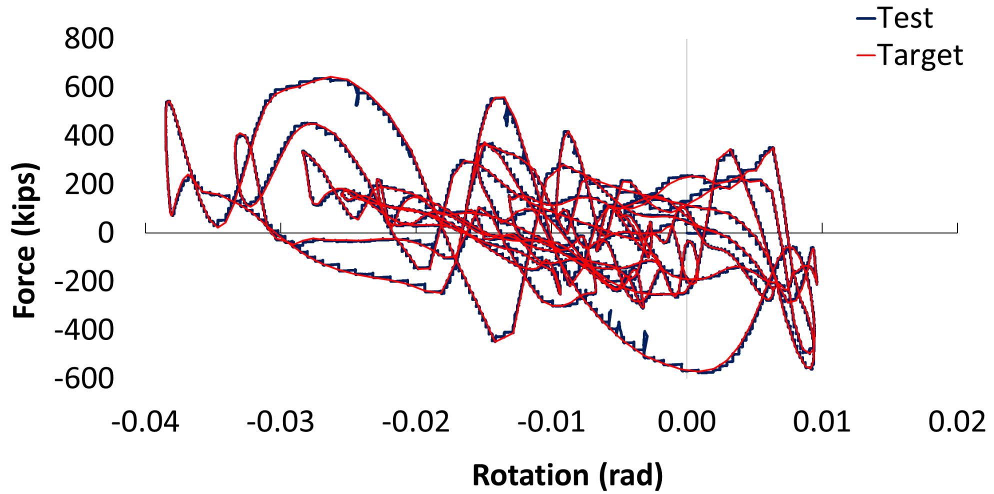

300'-0" (9 bays 33'-4")
100'-0" (5 bays 25'-0")
Tributary area for collector design
Typical Joist direction
Collector line


Prototype building

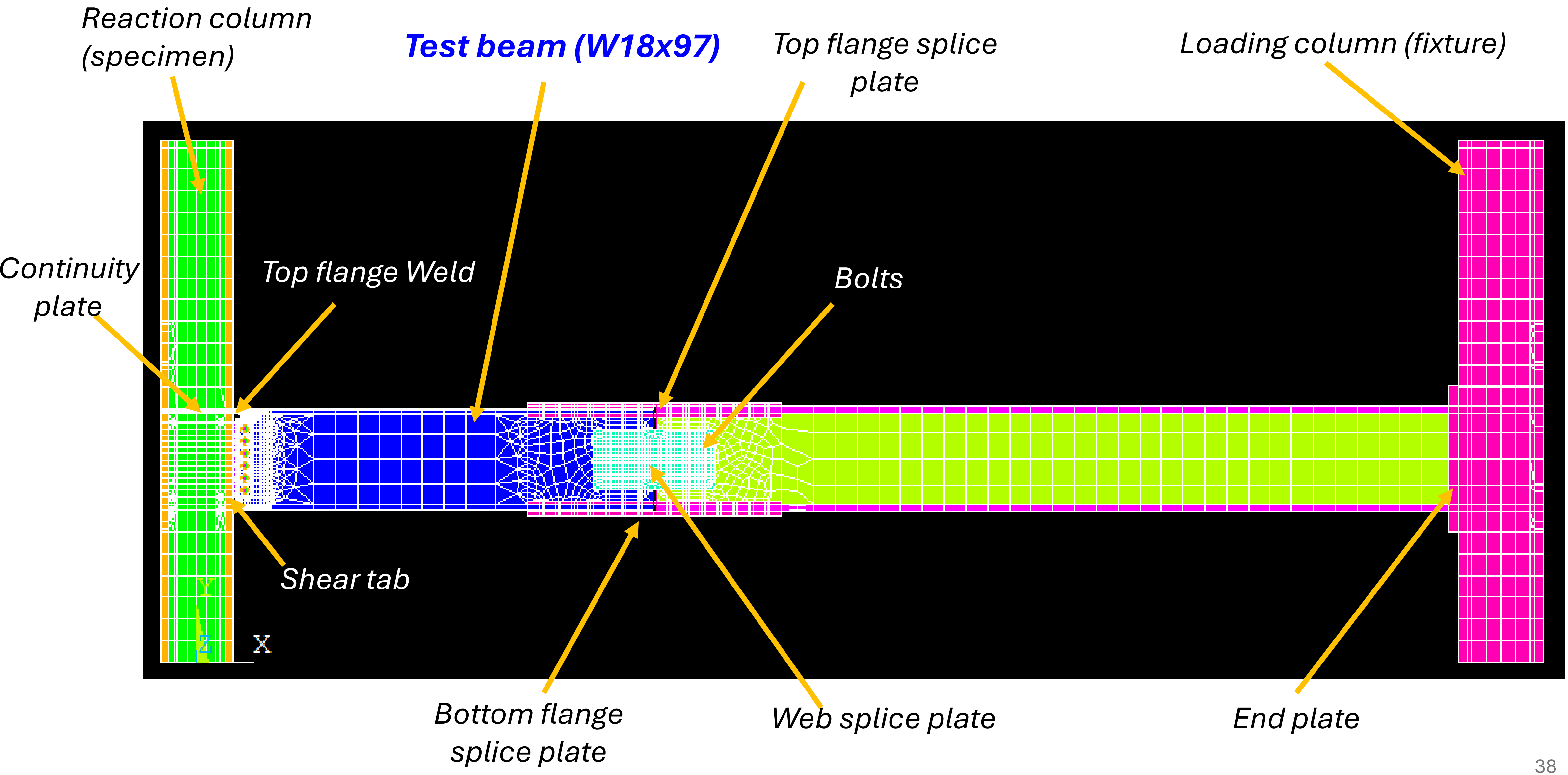

MCE ground motion


Collector force and frame rotation history at the 12th floor (scaled force)
Force (kips)
800
400
0
-400
-800
Rotation (rad)
0.02
0.00
-0.02
-0.04
0
5
10
15
20
25
30
Time (sec)


Reaction column
Loading column
Test Collector
Loading Beam
Collector Specimen and Test Setup


Test
Target
Force (kips)
800
600
400
200
0
-200
-400
-600
-0.04
-0.03
-0.02
-0.01
0.00
0.01
0.02
Rotation (rad)

Finite Element Model



(Sudan Pandey, 2024)

Acknowledgment

- Dr. Lansey, Dr. Fleischman, and Dr. Boccelli for the Nomination.
- Jeff, Michele, Tina Johnson , Tina Lee from R4R program.

- NSF
- ATLSS Center, Lehigh
- Thomas Marullo, Dr. Richard Sause, Dr. Jim Ricles, and Dr. Alia Amer from Lehigh University
- Dr. Chao-Hsien Li, Dr. Chia-Ming Uang from UCSD

pandeysudan@arizona.edu

github.com/pdy-sdn