



## AISC Live Webinars

---

**Today's live webinar will begin shortly. Please stand by.**

Today's audio will be broadcast through the internet. Please be sure to turn up the volume on your speakers.

Please type any questions or comments in the Q&A window.



**Smarter.  
Stronger.  
SteelDay.**



## AISC Live Webinars

---

### AIA Credit

AISC is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES). Credit(s) earned on completion of this program will be reported to AIA/CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This program is registered with AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



Smarter.  
Stronger.  
SteelDay.

## AISC Live Webinars

---

### Copyright Materials

This presentation is protected by US and International Copyright laws. Reproduction, distribution, display and use of the presentation without written permission of AISC is prohibited.

© The American Institute of Steel Construction 2020

The information presented herein is based on recognized engineering principles and is for general information only. While it is believed to be accurate, this information should not be applied to any specific application without competent professional examination and verification by a licensed professional engineer. Anyone making use of this information assumes all liability arising from such use.



Smarter.  
Stronger.  
SteelDay.



## AISC Live Webinars

---

### Course Description

The Structural Stability Game Show!  
September 25, 2020

This webinar will feature a panel of engineers and academics, who will present their views on the root cause of three structural collapse case studies. The audience will then be given an opportunity to vote on which cause was most likely. Finally, the moderator will reveal and explain the true nature of the collapse.



Smarter.  
Stronger.  
SteelDay.

## AISC Live Webinars

---

### Learning Objectives

- Identify sources of instability for several structural configurations.
- Describe methods for how to approach stability analysis computationally and experimentally.
- Show how the structural factor of safety can be significantly impacted if one neglects considering stability.
- Explain the importance of communication during the design and construction of a project with case studies.



Smarter.  
Stronger.  
SteelDay.



## The Structural Stability Game Show!



Cliff D. Bishop  
*Exponent*



Patricia Clayton  
*UT Austin*



Larry Griffis  
*Walter P. Moore*



John D. Hooper  
*Magnusson Klemencic*



Ron Ziemian  
*Bucknell University*

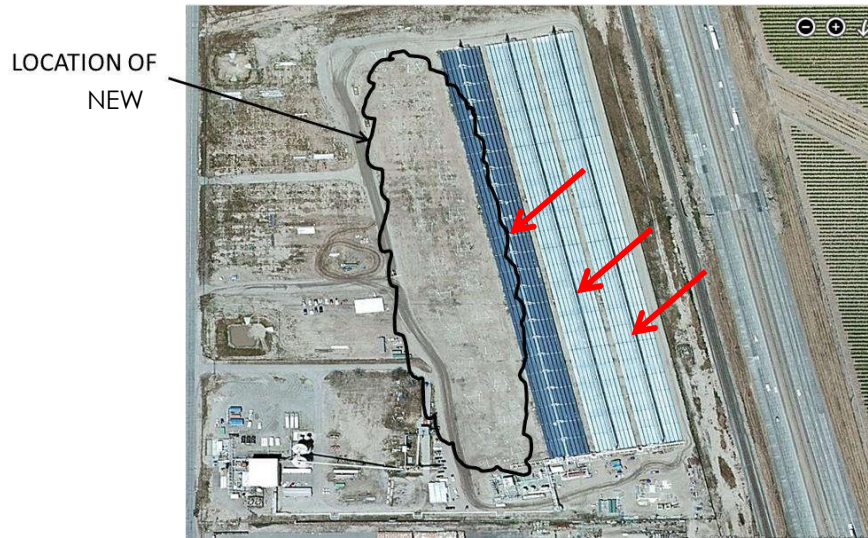
SteelDay  
Everywhere

September 25, 2020  
[aisc.org/steelday](https://aisc.org/steelday)

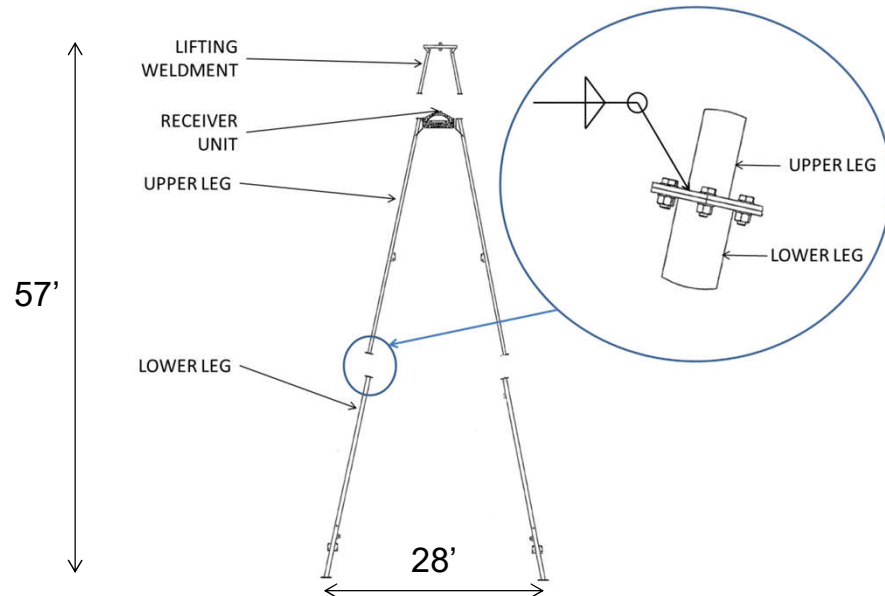
### Case 1: Solar power support structure



## Background – Site and Structure



## Background – Site and Structure



## Background – Erection Process



11

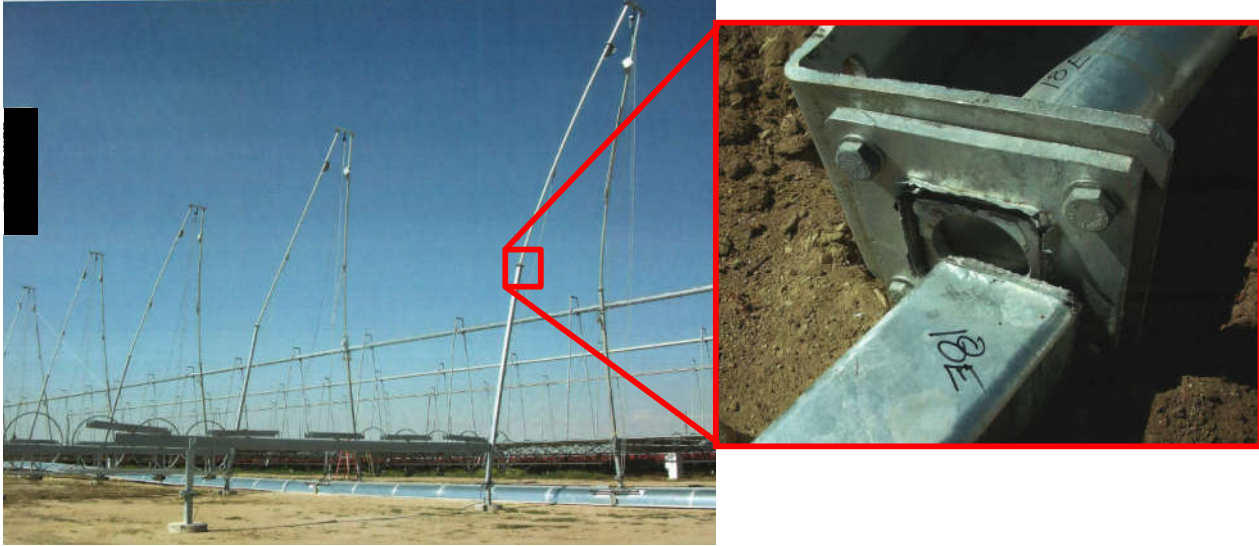
## Background – The Failure



12



## Background – The Failure



13

## Contestants' discussion of root cause



14



## Contestants' discussion of root cause

A. Weld failure



15

## Contestants' discussion of root cause

A. Weld failure



B. Inadequate design



16



## Contestants' discussion of root cause

A. Weld failure



B. Inadequate design



C. Poor construction sequencing



17

## Contestants' discussion of root cause

A. Weld failure



B. Inadequate design



C. Poor construction sequencing



D. Extreme weather



18



## What was the root cause?

A. Weld failure



B. Inadequate design



C. Poor construction sequencing



D. Extreme weather



Time  
to  
Vote!



19

## What was the root cause?

A. Weld failure



B. Inadequate design



C. Poor construction sequencing



D. Extreme weather



Select  
your  
answer!



20

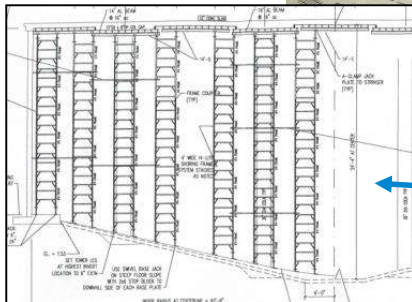
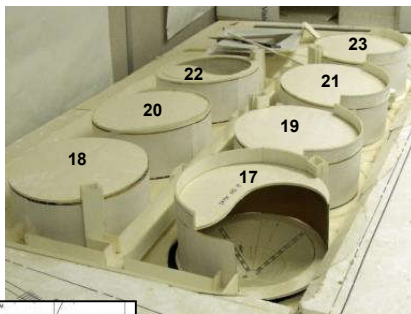


## Case 2: Dome scaffolding collapse



28

## Background



- Project required construction of 7 digester tanks
- Tanks were numbered from 17 to 23
- Dimensions
  - 125-ft diameter concrete tank
  - 50-ft tall
  - 1-ft thick wall and slab
- Base of tanks slopes down towards center
- Aluminum falsework used to support formwork and deck pour

29



## Background



### At the Time of the Accident:

- Tanks 17 and 18 had already been constructed; roof decks poured without incident
- Tank 19 was ready for concrete deck pour
- Tanks 20 and 21 had the falsework almost fully installed

30

## Background



### At the Time of the Accident:

- Concrete roof was being placed in Tank 19, moving south to north
- A little over half of the concrete had been placed

31

## The failure



32

## The Failure

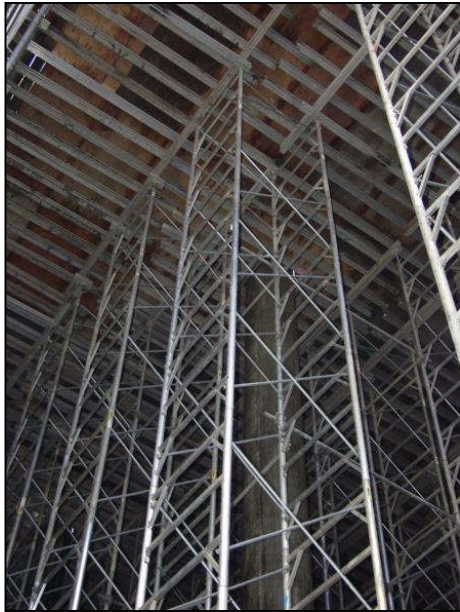


- Falsework supporting the plywood in Tank 19 collapsed
- 29 persons on the roof deck
- 14 workers injured; 4 serious; **none** fatally injured
- Tanks 19, 20, and 21 were immediately put under Cal OSHA Order to Preserve, pending investigation

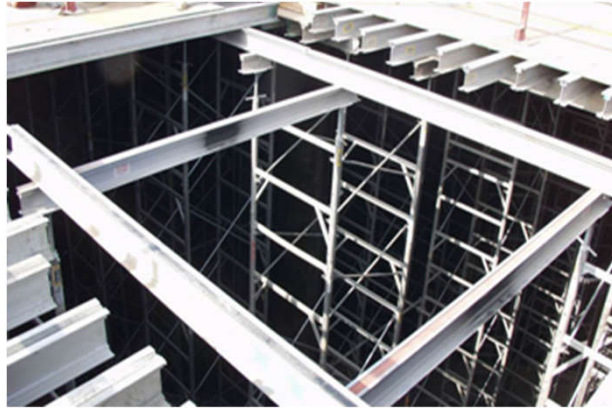
33



## Scaffold Layout



- Plywood formwork for concrete deck was supported on aluminum beams
- Layers of aluminum beams supported on aluminum shoring towers

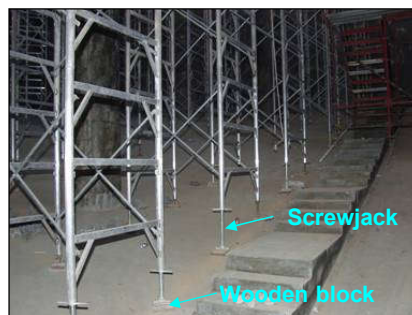


34

## Scaffold Layout



- Top and bottom of the towers had screwjacks for adjustable extension
- Many of the towers also had 12-inch or 16-inch long sub-stringers at the top



35



## Scaffold Layout



36

## Observations – Tank 19



So... What caused the failure?

37



## Contestants' discussion of root cause



38

## Contestants' discussion of root cause

A. Stringer web buckling



39



## Contestants' discussion of root cause

A. Stringer web buckling



B. Screwjack extensions



40

## Contestants' discussion of root cause

A. Stringer web buckling



B. Screwjack extensions



C. Inadequate bracing




41




## Contestants' discussion of root cause

A. Stringer web buckling 

B. Screwjack extensions 

C. Inadequate bracing 

D. Too much concrete 




42

## What was the root cause?

A. Stringer web buckling 

B. Screwjack extensions 

C. Inadequate bracing 

D. Too much concrete 

Time  
to  
Vote!



43



## What was the root cause?

A. Stringer web buckling



B. Screwjack extensions



C. Inadequate bracing



D. Too much concrete



**Select**  
**your**  
**answer!**



44

## Case 3: Building roof collapse



56



## Background



57

## The Failure



58

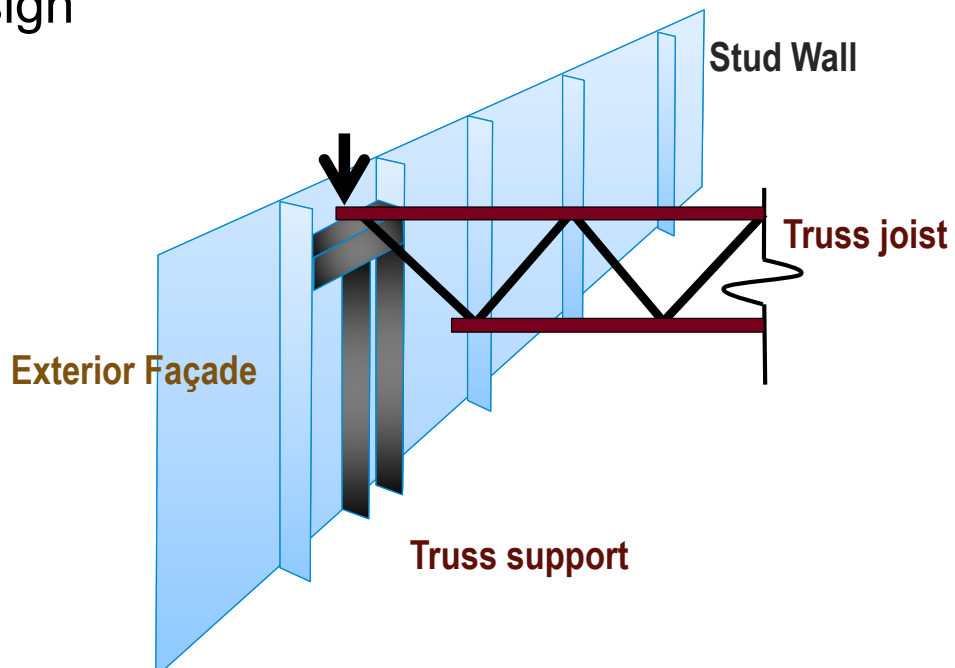


## The Failure



59

## Design



60



## As-Built



61

## The Failure



62



## Contestants' discussion of root cause



63

## Contestants' discussion of root cause

A. Freak storm (overload)



64



## Contestants' discussion of root cause

A. Freak storm (overload)



B. Missing support (improper construction)



65

## Contestants' discussion of root cause

A. Freak storm (overload)



B. Missing support (improper construction)







C. Local member effects



66







## Contestants' discussion of root cause

- A. Freak storm (overload) 
- B. Missing support (improper construction) 
- C. Local member effects 
- D. Improper design 



67

## What was the root cause?

- A. Freak storm (overload) 
  - B. Missing support (improper construction) 
  - C. Local member effects 
  - D. Improper design 
- Time  
to  
Vote!**



68



## What was the root cause?

A. Freak storm (overload)



B. Missing support (improper construction)



C. Local member effects



D. Improper design



**Select  
your  
answer!**



69

“For since the fabric of the universe is most perfect, and is the work of a most wise Creator, nothing whatsoever takes place in the universe in which some relation of maximum and minimum does not appear.”

Leonhard Euler in *Lineas Curvas (Elastic Curves)*, 1744

Thank you for your participation!

Exponent®



# The Structural Stability Game Show!



Cliff D. Bishop  
*Exponent*



Patricia Clayton  
*UT Austin*



Larry Griffis  
*Walter P. Moore*



John D. Hooper  
*Magnusson Klemencic*



Ron Ziemian  
*Bucknell University*

SteelDay  
Everywhere

September 25, 2020  
[aisc.org/steelday](http://aisc.org/steelday)

**AISC** | Questions?



## PDH Certificates

---

- You will receive an email on how to report attendance from: [registration@aisc.org](mailto:registration@aisc.org).
- Be on the lookout: Check your spam filter! Check your junk folder!
- Completely fill out online form. Don't forget to check the boxes next to each attendee's name!



## PDH Certificates

---

- Reporting site (URL will be provided in the forthcoming email).
- Username: Same as AISC website username.
- Password: Same as AISC website password.





**AISC** | Thank you

