



struc'tural

The Strength Behind the Structure,
More Than Concrete & Steel

Presented by: Alex Krom
Director of Sales

Today's Objectives:

1. Recognize weaknesses in structures **BEFORE** they fail
 2. Understand the signs of **DISTRESS**
 3. Plan a **SAFE** outcome
- What is reinforced concrete? Mild steel vs. PT vs. Precast
 - Types of loads and forces used in the design
 - Proper steel placement to resist these loads
 - How reinforced concrete fails
 - Typical construction defects...Cause and Effect
 - Signs of distress- **WHAT IS THAT CRACK TELLING US?**

Why do I need to know?



Honeycombed Concrete



Missing Reinforcement

STRUCTURAL COMPROMISE !

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Everything's fine, Right?



Low strength
concrete on column
7000 psi vs. 5000 psi

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New Penetrations



structural

For structural problems there are no such thing as a
“LITTLE MISTAKE”!



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What is Reinforced Concrete ?

*"I want to build a beam or slab that can **SPAN** 30 feet and can carry a 60psf **LOAD**"*

- There is an **ENGINEERING FORMULA** to design anything
- Basic engineering concepts are **NOT COMPLEX**
- BASIC MECHANICS** can explain most engineering concepts

Equilibrium
Section Properties

Moment

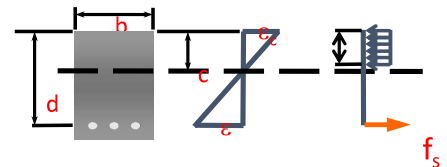
"Yield"

$$\Sigma f + 3\sigma$$

$$WL^2/24$$

π

Strain Compatibility



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Types of loads and safety factors in concrete design

Standard Live Loads:

Parking= 50psf

Condo = 60psf

Office = 100psf

Lobby = 100psf

Safety Factors:

$$1.6LL$$

$$+ 1.2DL$$

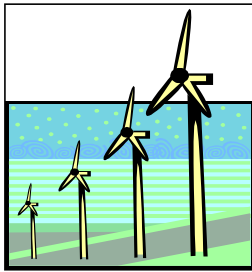
Ultimate Capacity

LIVE LOAD

DEAD LOAD

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Other types of loads



Wind



Seismic



Rain/Snow

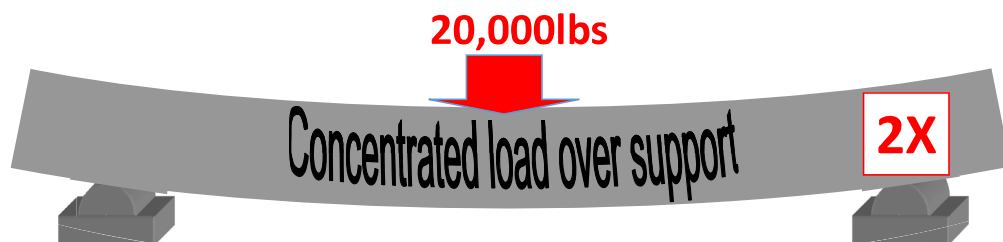


Blast

Environmental

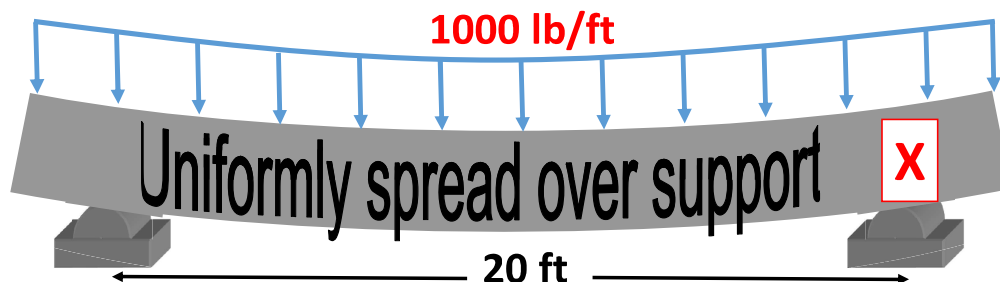
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Uniform Loads vs. Concentrated Loads



QUIZ

Which is worse?



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Loading Considerations During Construction

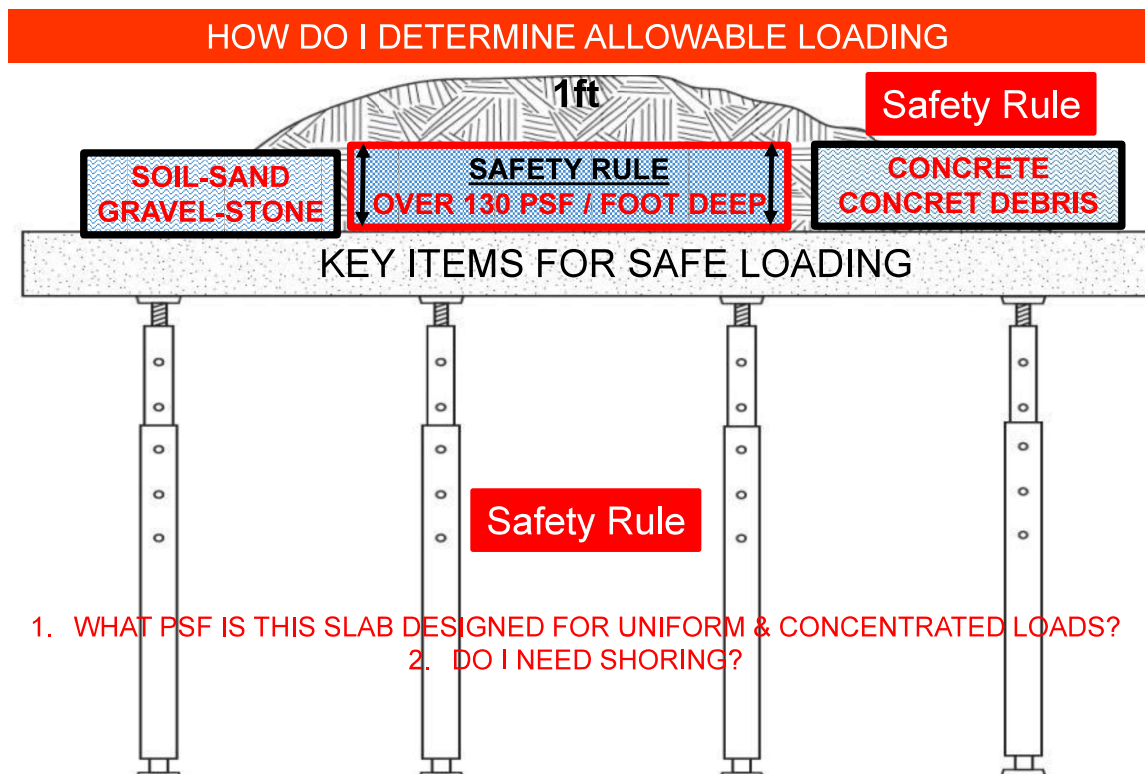


Uniform-1X



Concentrated- 2-3X+

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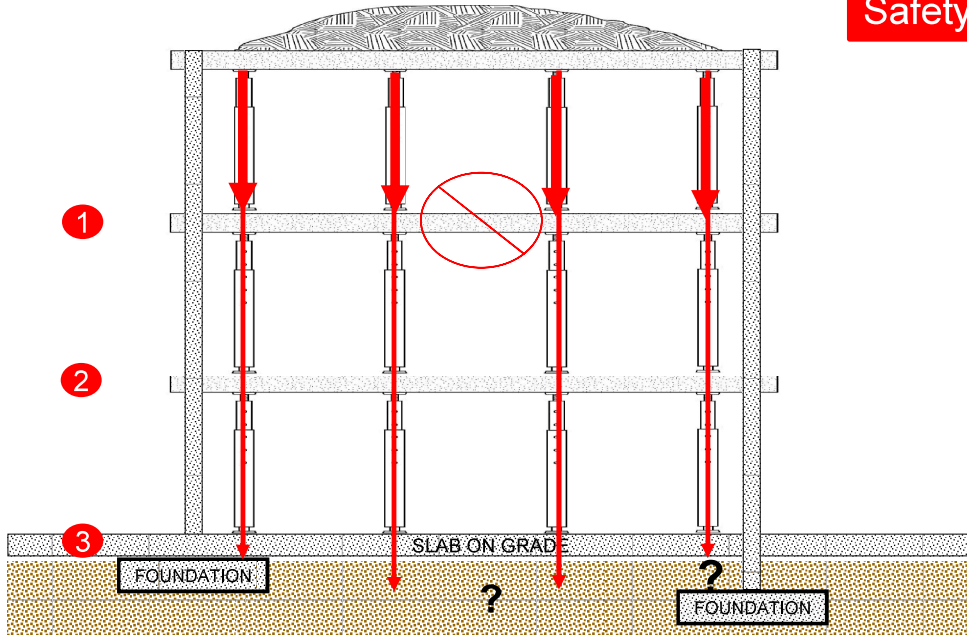
Construction Materials & Debris

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HOW DO I DETERMINE ALLOWABLE LOADING?

DO I NEED MULTIPLE LEVELS OF SHORING?

Safety Rule



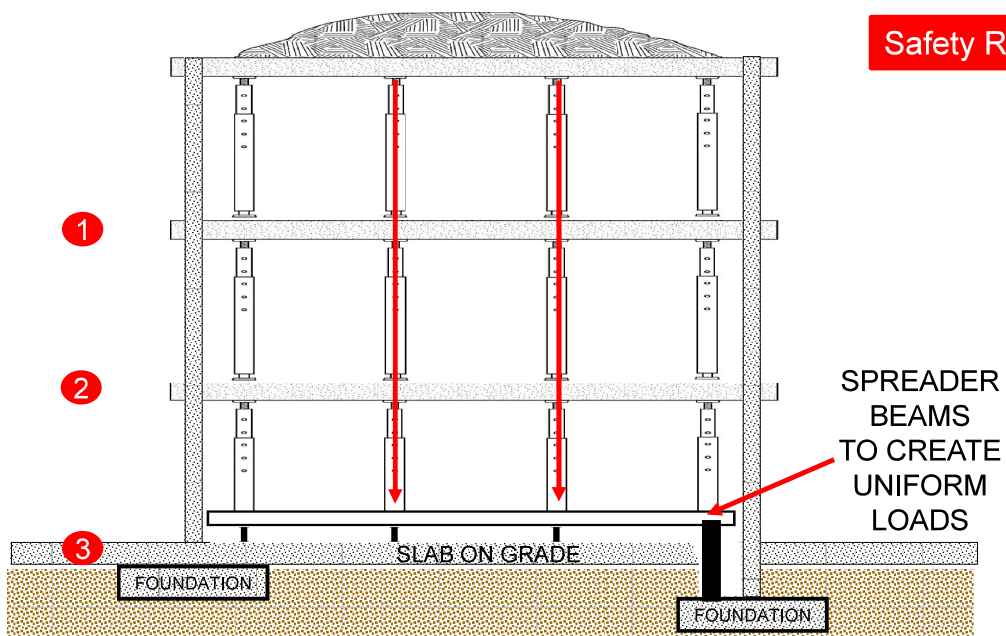
Construction Materials & Debris

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HOW DO I DETERMINE ALLOWABLE LOADING?

DO I NEED TO SPREAD THE LOAD OUT AT BOTTOM?

Safety Rule



Construction Materials & Debris

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2 Common Shoring Errors

1. EARLY REMOVAL and/or **2. EARLY LOADING OF SLABS**

Safety Rule

Construction Materials
>25-50PSF Construction Loading

COMPRESSIVE STRENGTH OK, STIFFNESS **"GREEN"**

REMOVE SHORING:
Compressive Strength Goal
OR
X Amount of Days

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How Much Deflection is OK?

STRING LINE

Max Deflection = Span in inches $\div$ 240

Deflection

Span

20ft span = 240 in $\div$ 240 = 1 inch deflection

If greater than 1 ½" Ask Questions!

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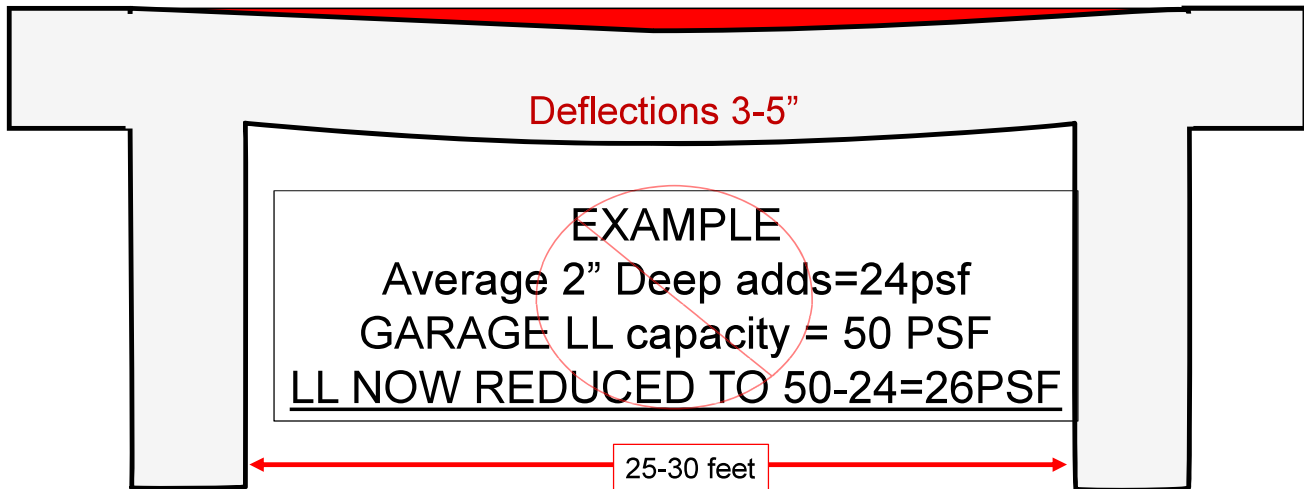
How Do I Fix This?

ADDS

1 in. deep concrete ~ 12PSF
3 in ~ 36PSF

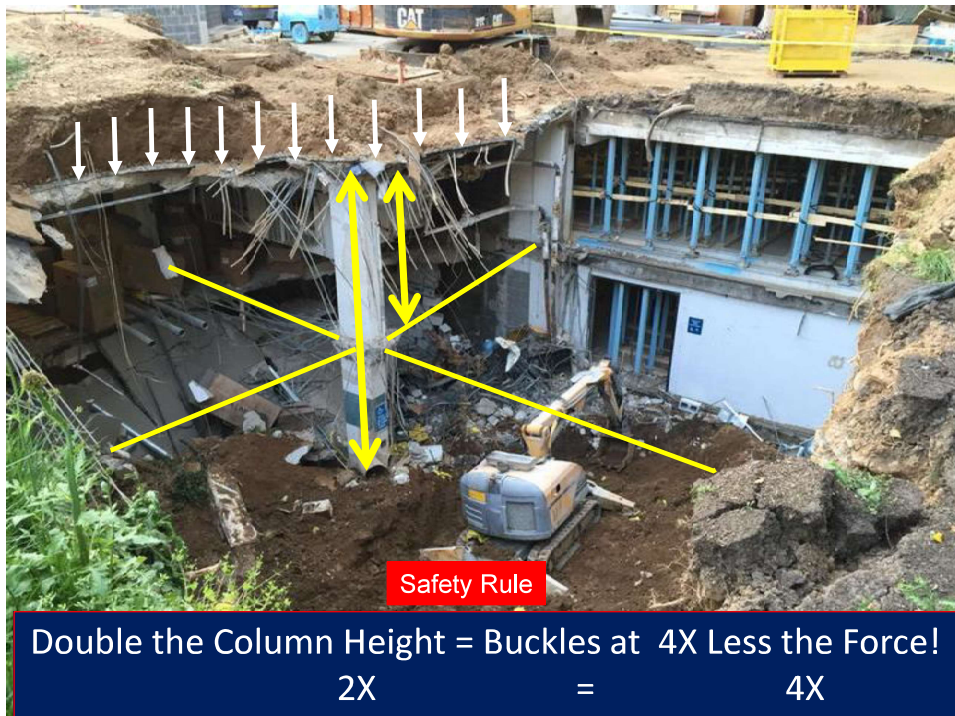
Safety Rule

Adds DEAD LOAD- REDUCES LIVE LOAD!

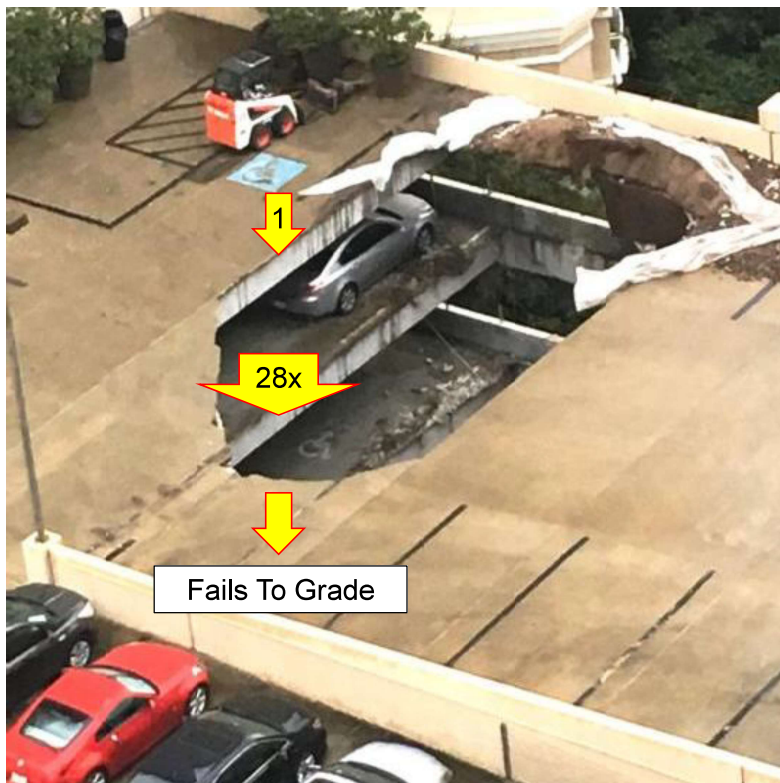


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Slab Overload Failures & Column Buckling



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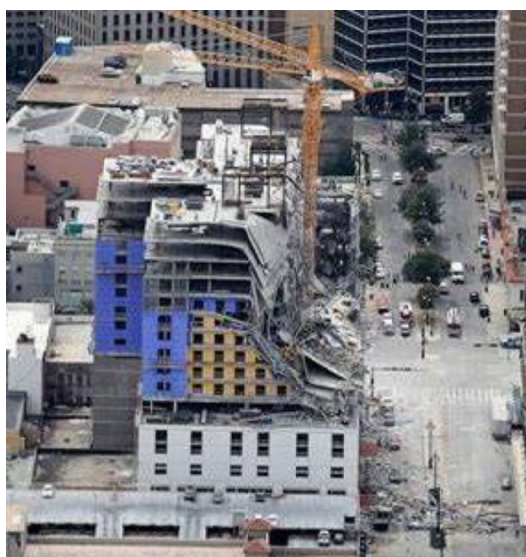


Construction
Overload

“Progressive
Collapse”

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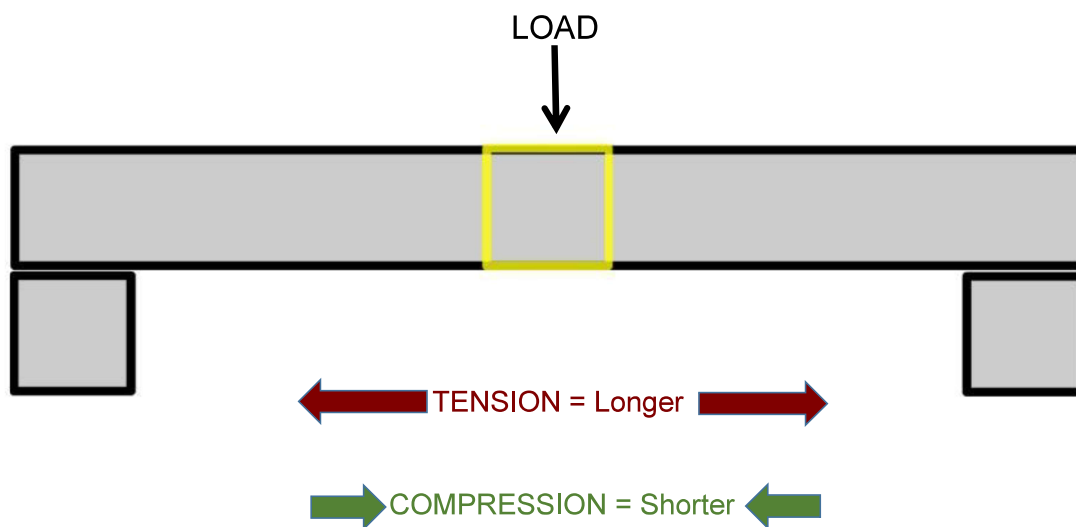
Progressive Collapse



 SEE SOMETHING – SAY SOMETHING

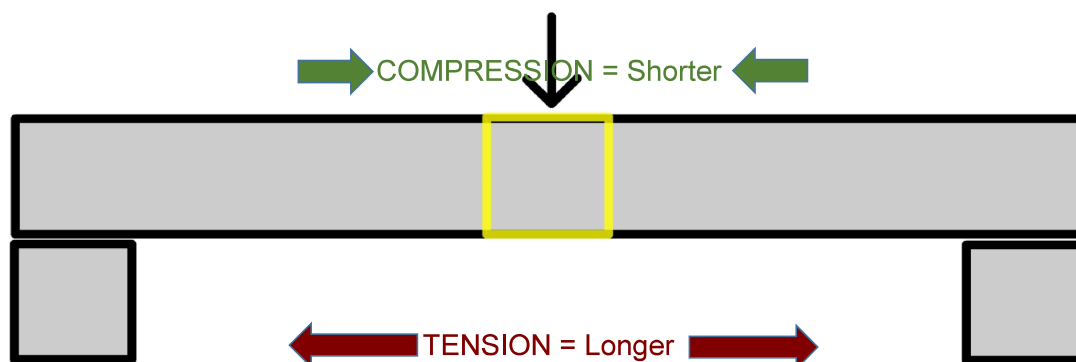
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Understanding Compression & Tension



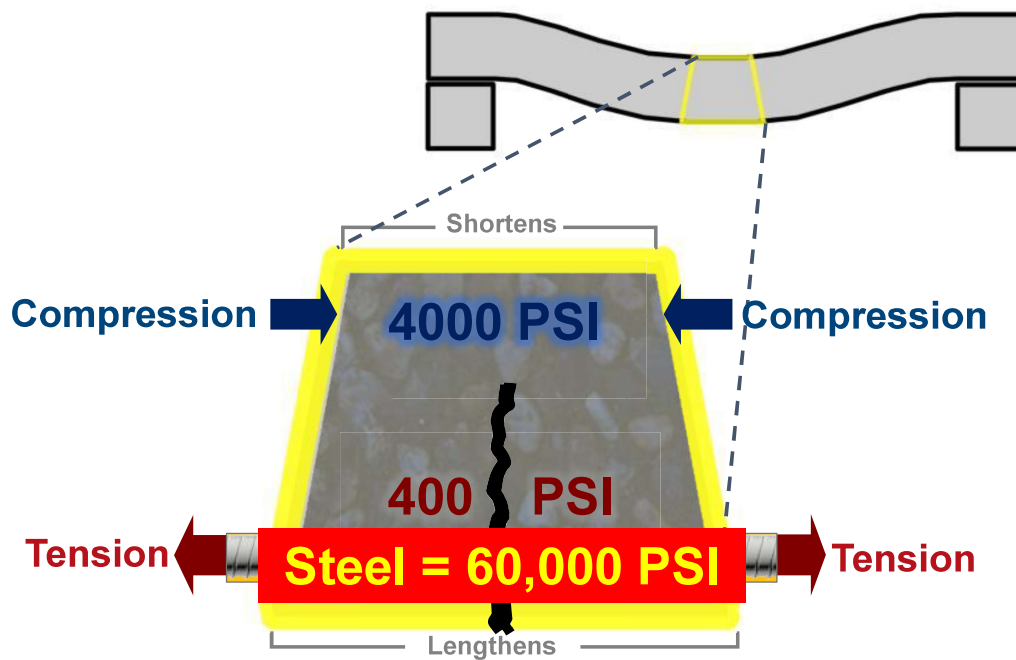
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Understanding Compression & Tension



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Understanding Compression & Tension



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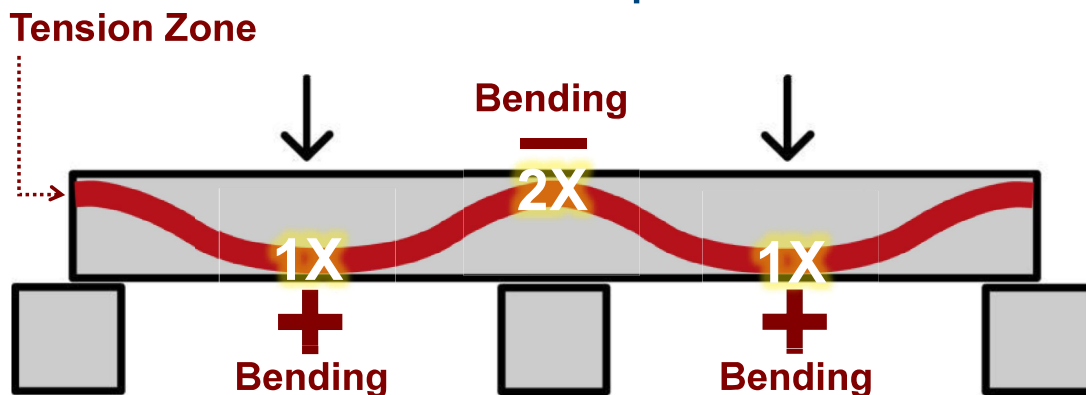


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Understanding bending forces

QUIZ:

Which area carries more stress?
Topside or bottom?



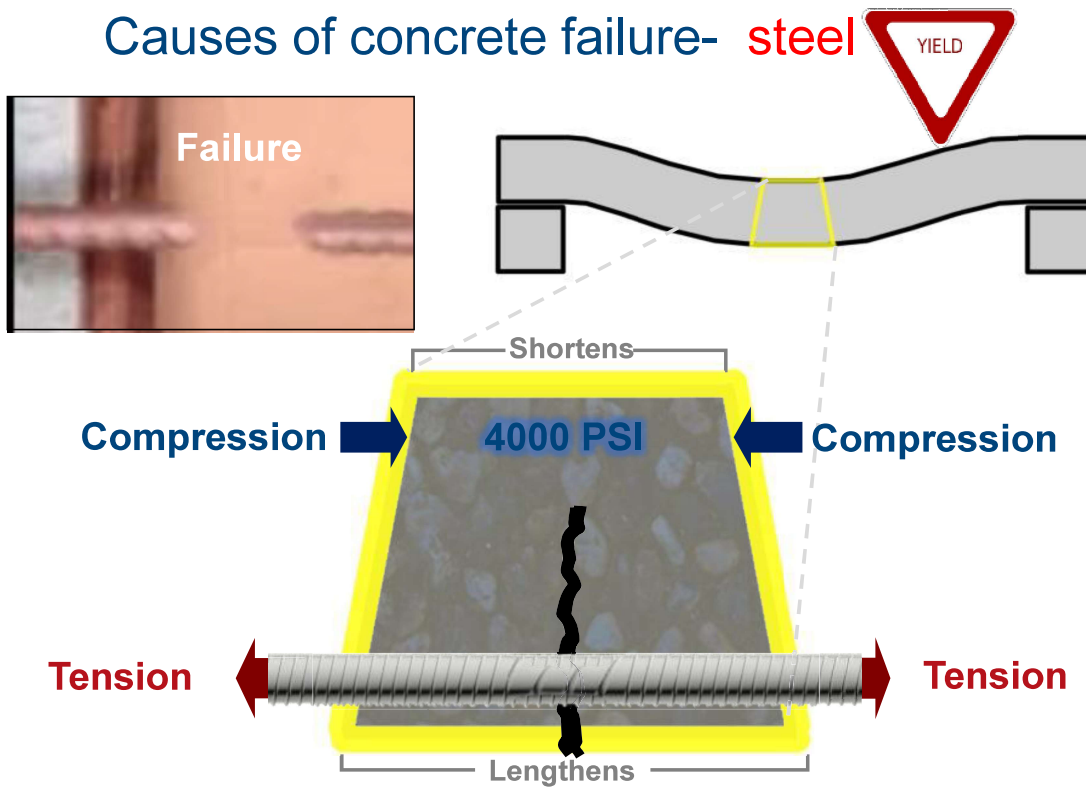
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Concrete failure modes



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Causes of concrete failure- steel



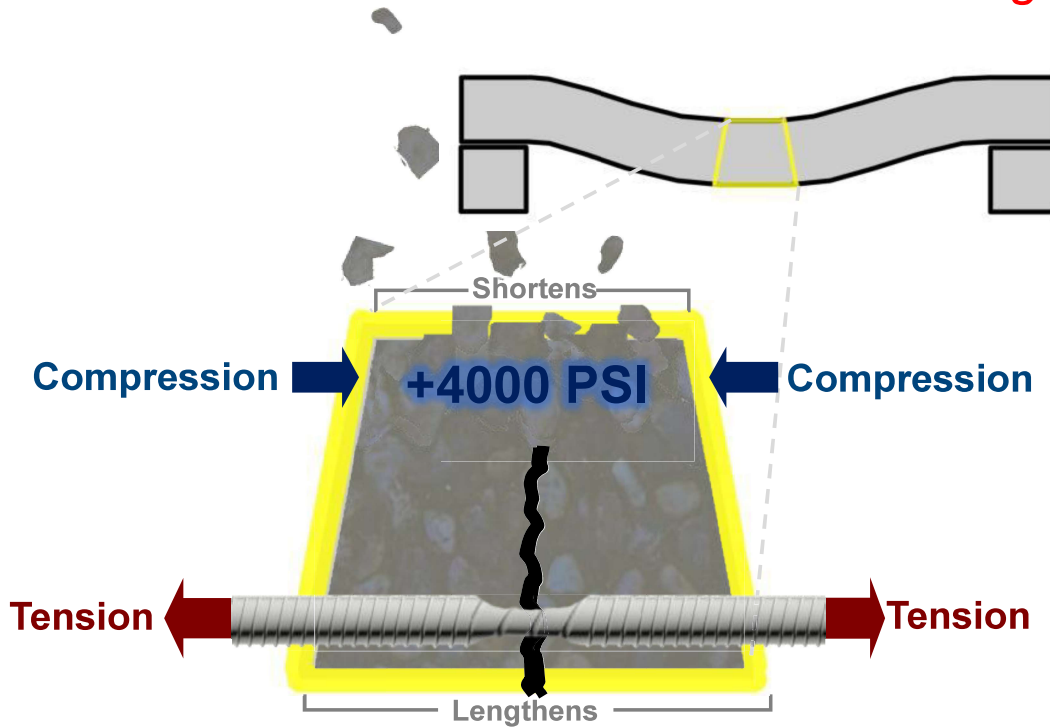
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Causes of concrete failure- Steel



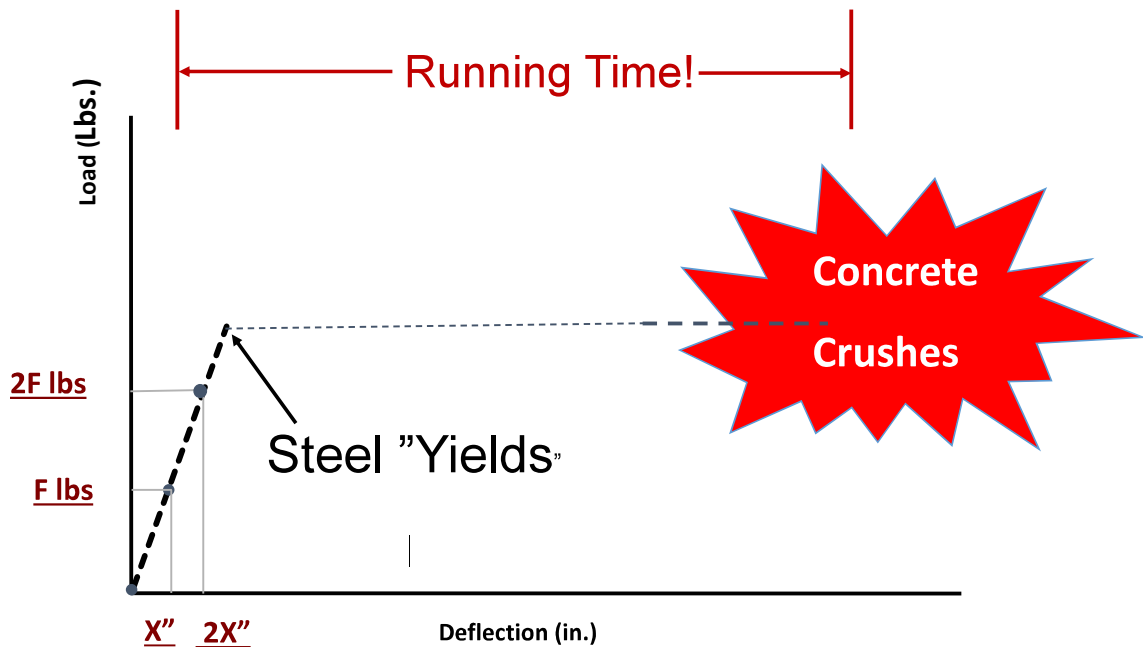
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Causes of concrete failure- concrete crushing



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Reinforced Concrete Failure



“Load- Deflection Curve”

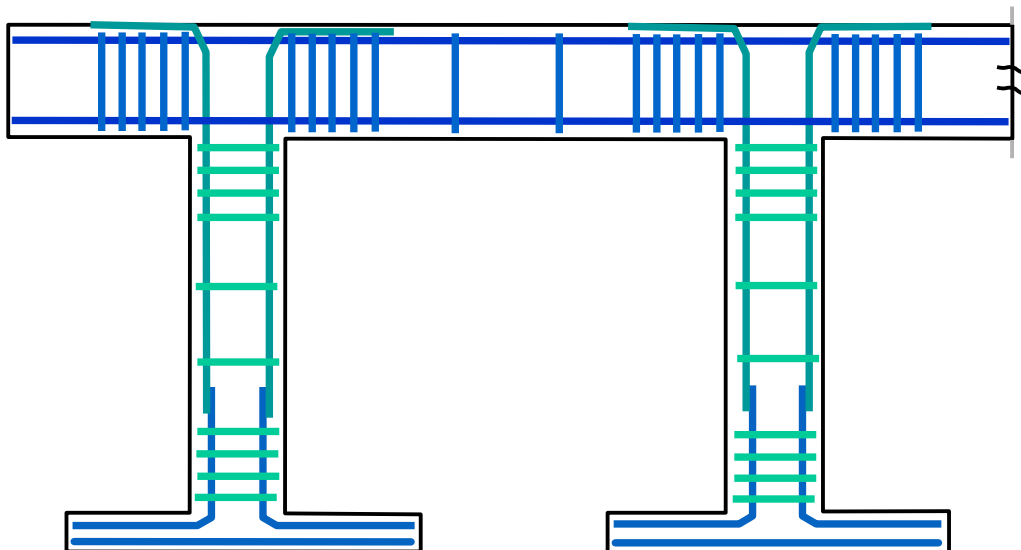
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Signs of structural distress



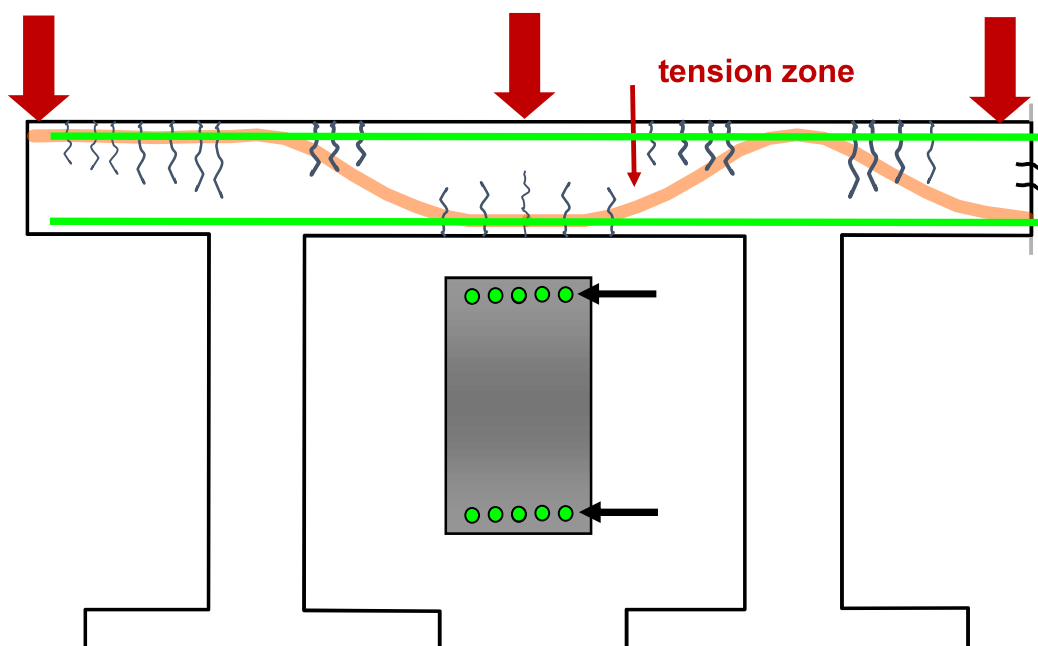
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Typical beam, slab and column steel placement



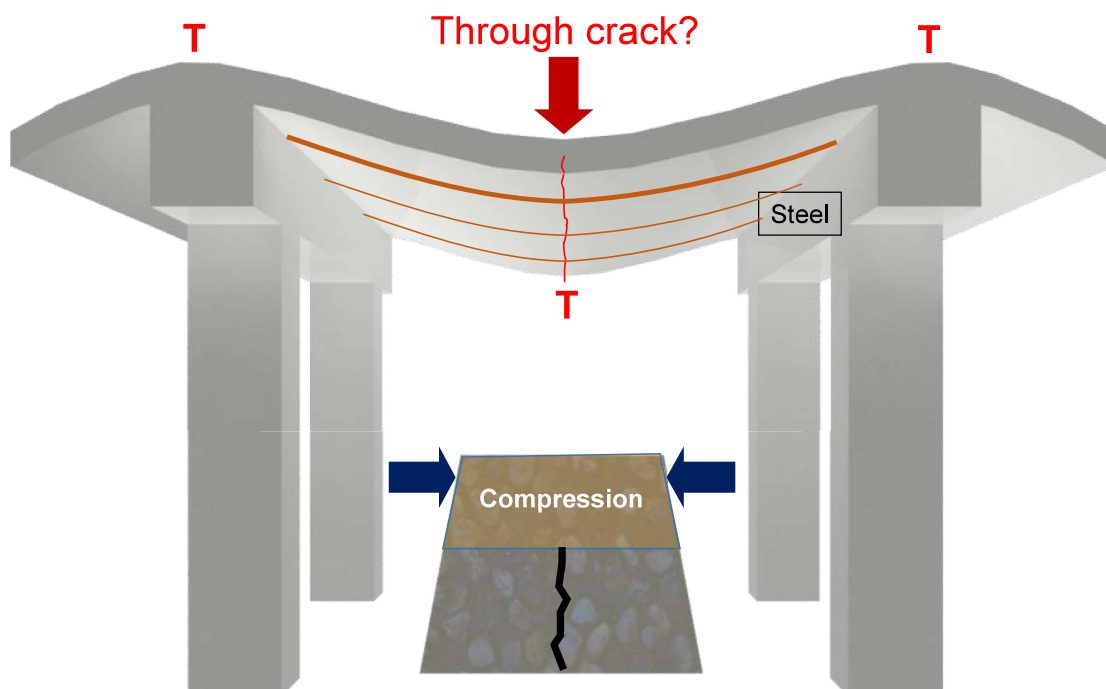
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Beam steel placement to resist bending forces



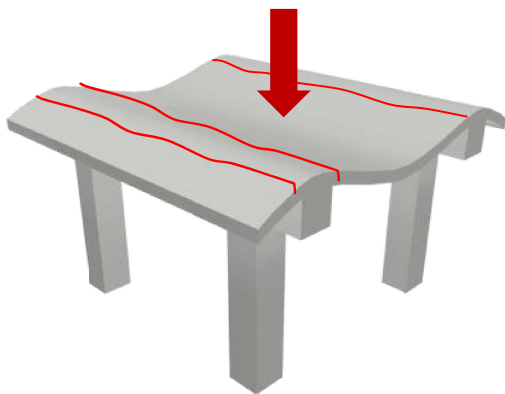
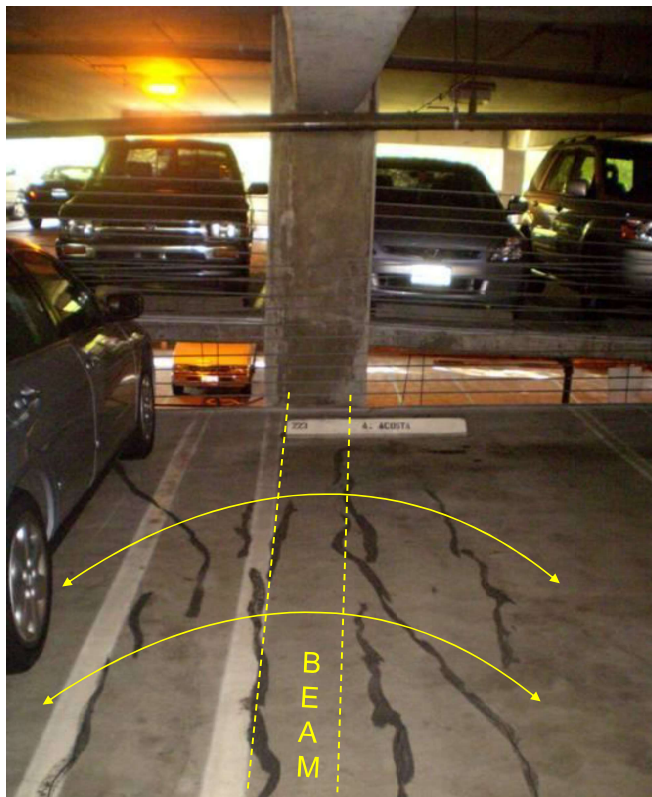
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Signs of distress: Cracks from bending (bottom)



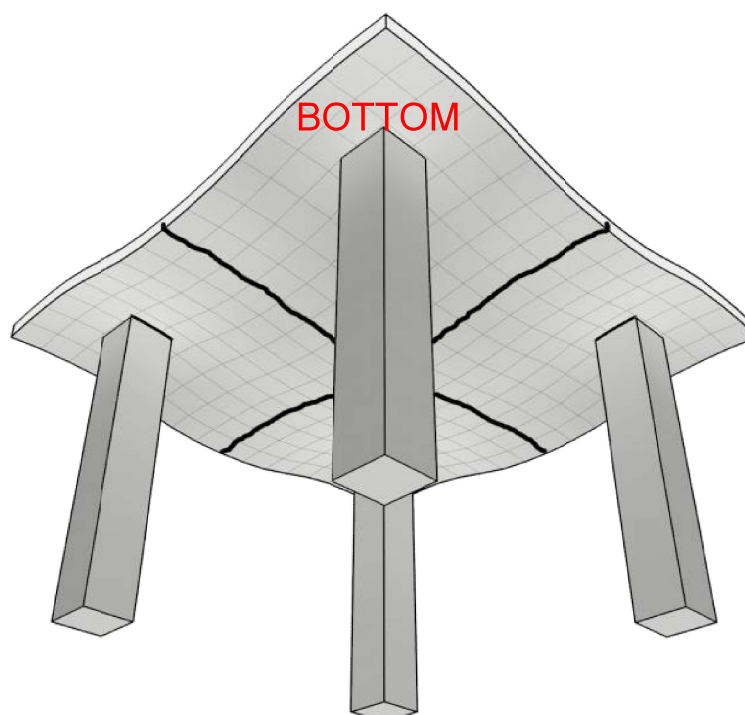
structural

Signs of distress: Cracks from bending (top)



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Signs of distress: **flexural** cracking 2 way slab-BOTTOM

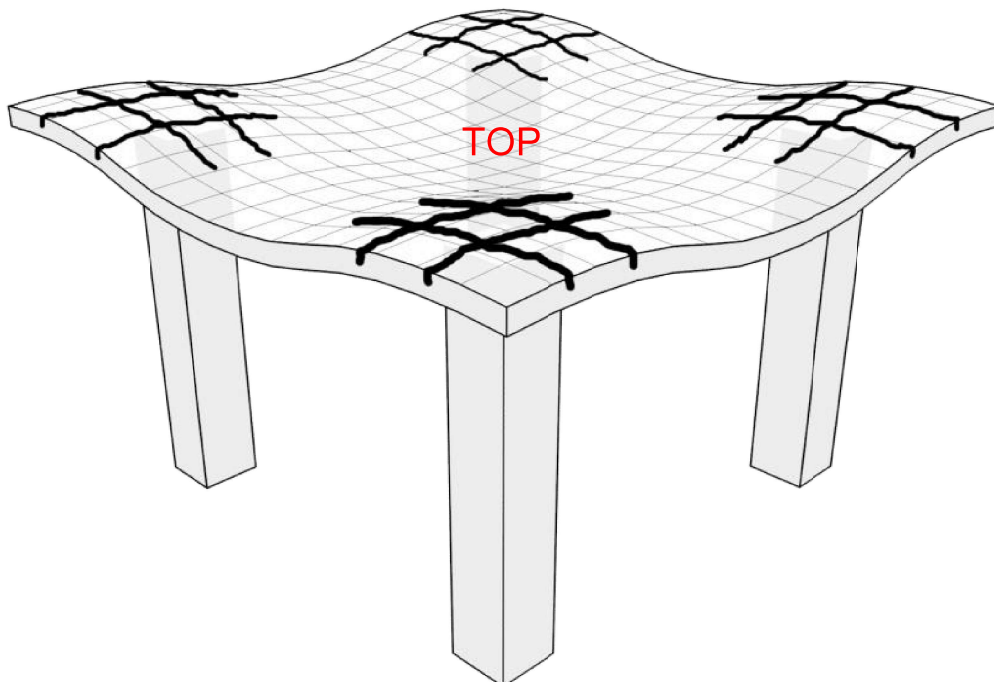


struc^{tu}ral

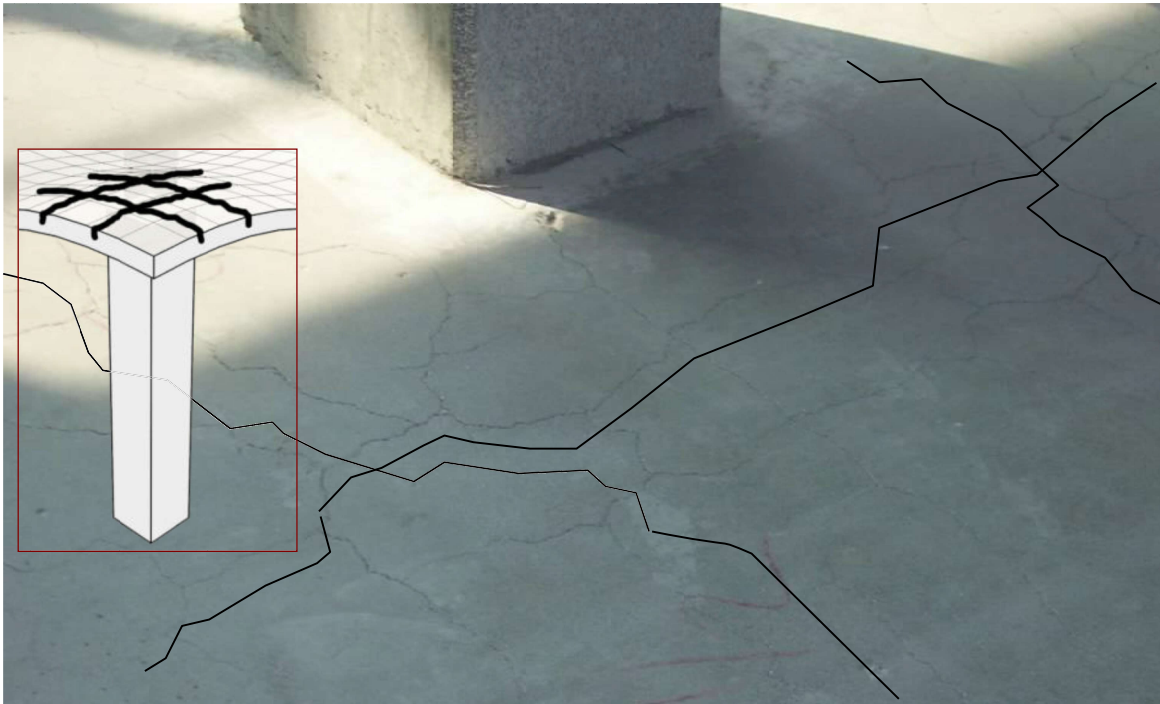
Signs of distress: **flexural** cracking 2 way slab-BOTTOM



Signs of distress: **flexural** cracking 2 way slab-TOP



Signs of distress: **flexural** cracking 2 way slab-TOP



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Signs of distress: beam **bending** cracks



structural

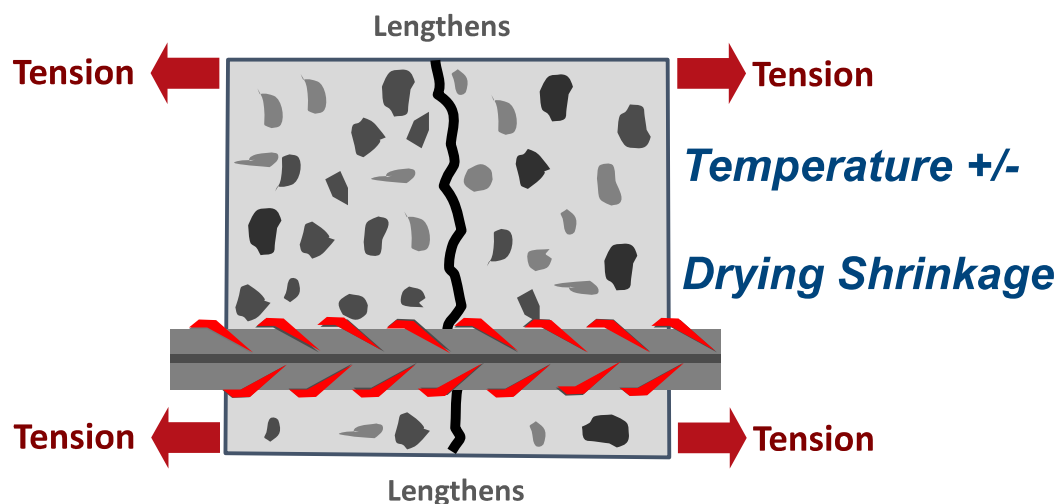
Signs of distress: **flexural** cracking slab on grade



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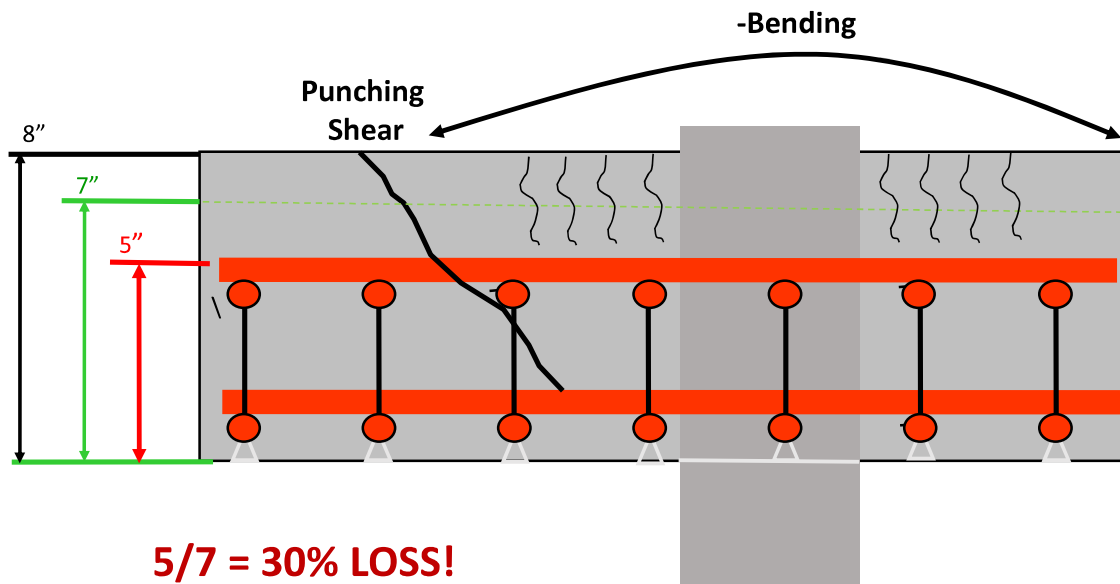
Signs of distress: slab **full depth** cracking

What could cause a Full Depth slab crack?



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What if the steel is set in the **wrong place?** **Too Deep**



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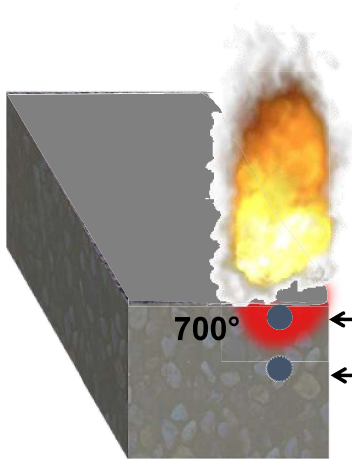
What if the steel is set in the **wrong place?** **Too Deep**



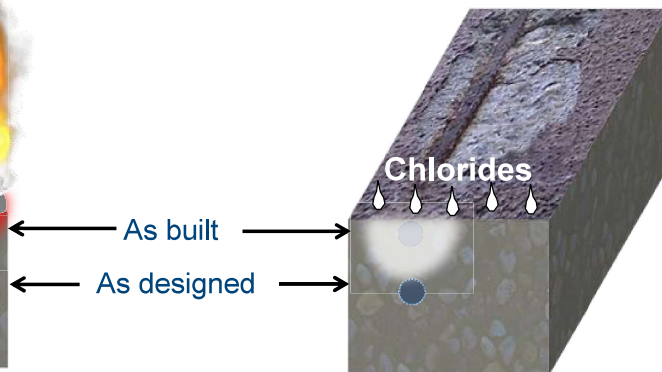
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What if the steel is set in the **wrong place**? Too Close to Surface- No Cover

Effect #1
REDUCED FIRE RATING



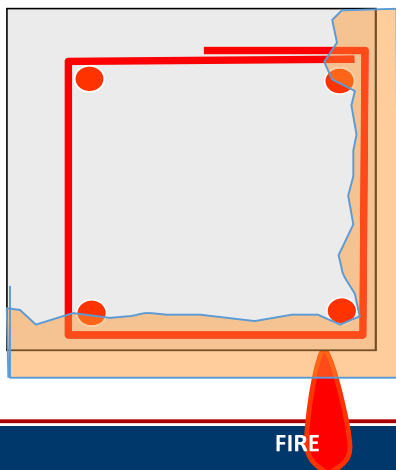
Effect #2
REDUCED CORROSION PROTECTION



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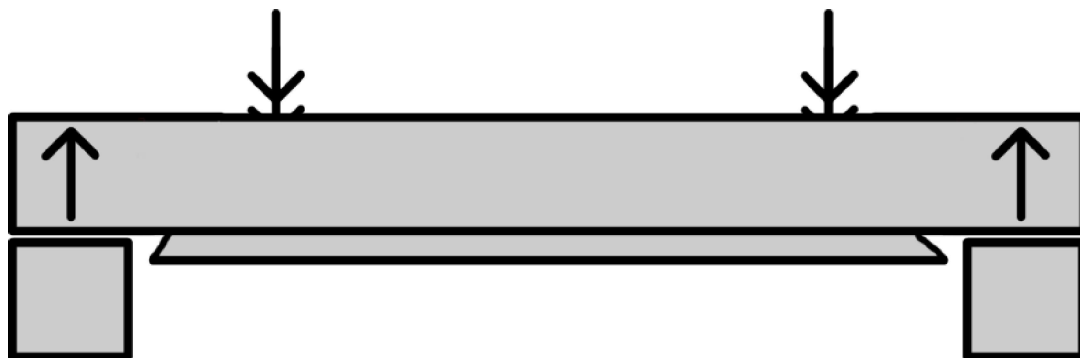
What if the steel is set in the **wrong place**? Too Close to Surface

No cover



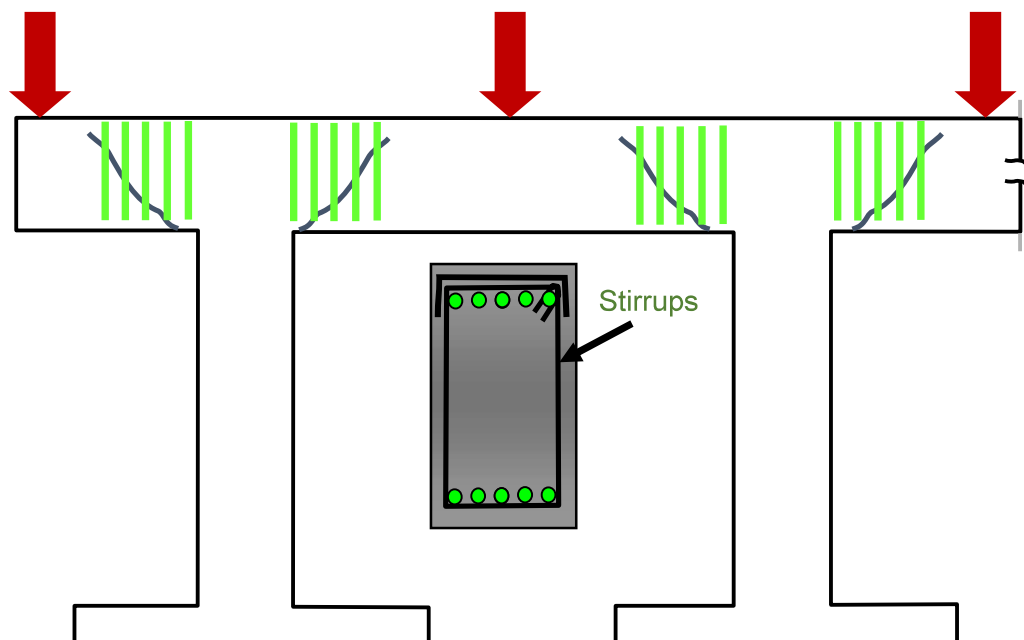
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Understanding beam shear forces



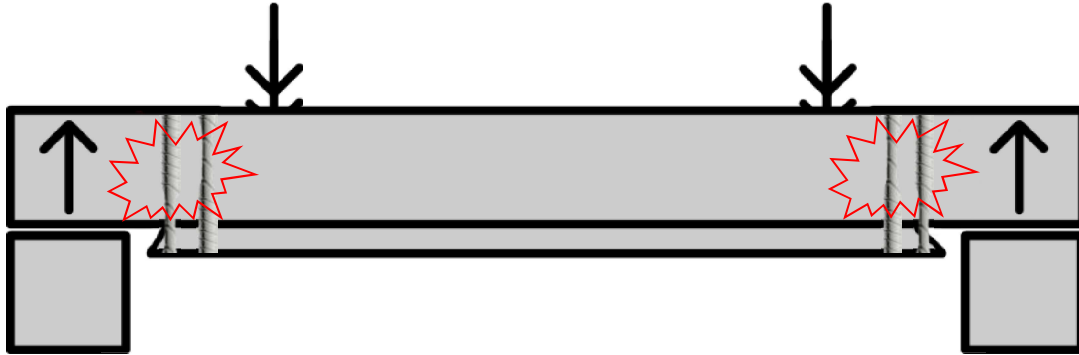
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Beam steel placement to resist shear forces



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Causes of concrete failure- beam shear

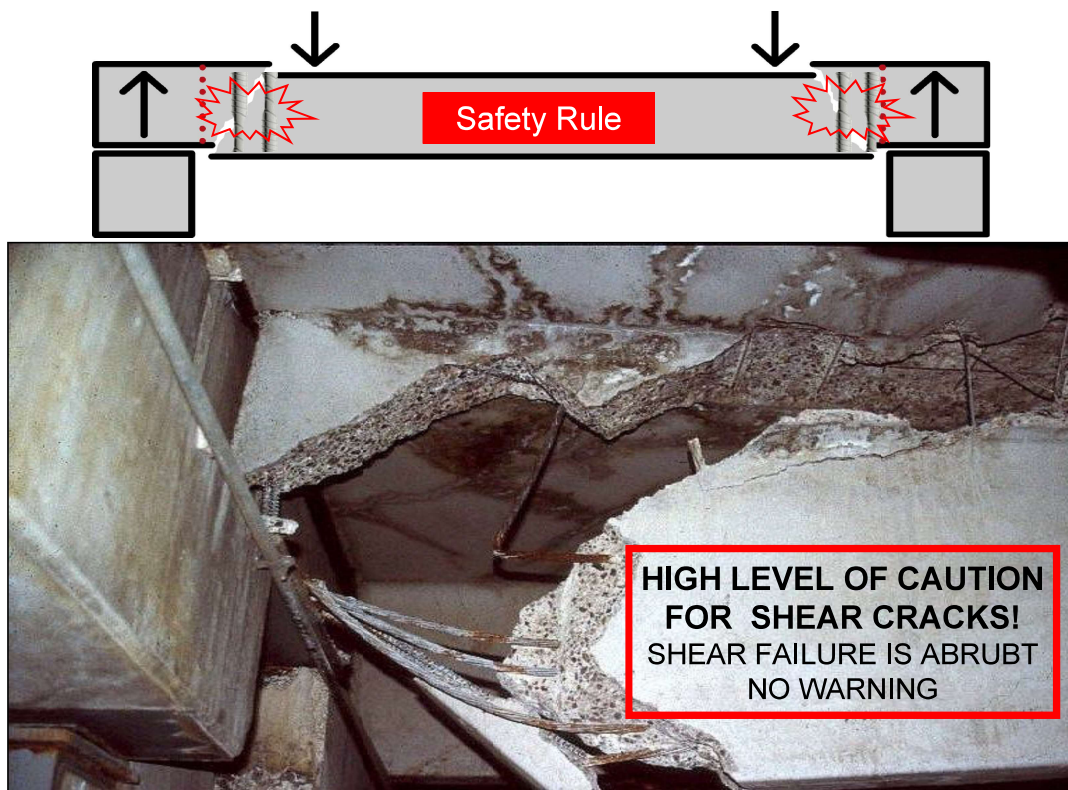


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Signs of distress: beam shear cracking

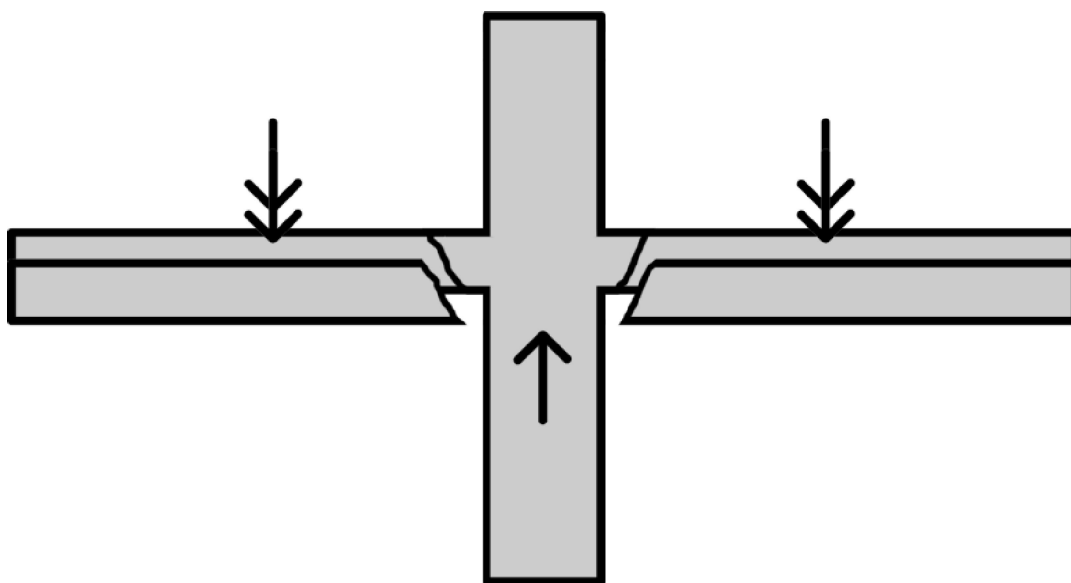


structural



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Understanding slab punching shear forces



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Signs of distress: progressive slab punching shear failure



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Signs of distress: slab punching shear failure



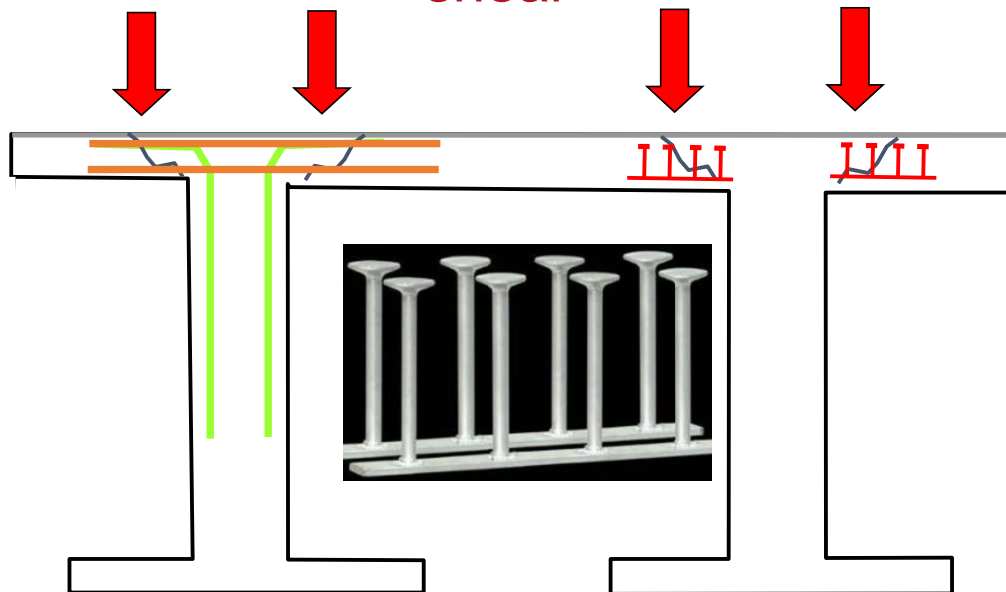
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Signs of distress: abrupt slab punching shear failure



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Slab steel placement to resist punching shear



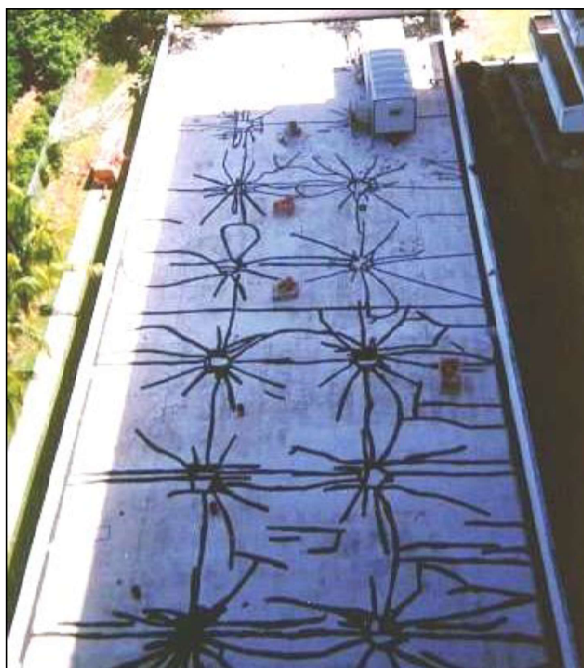
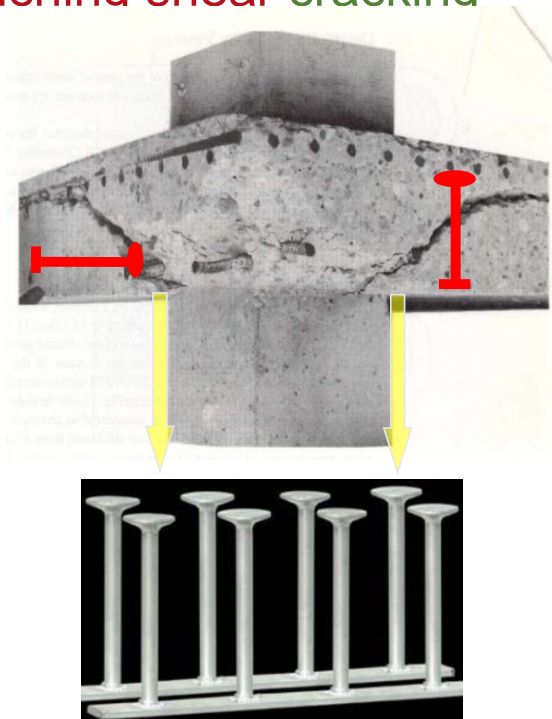
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Typical Steel Placement-Punching Shear



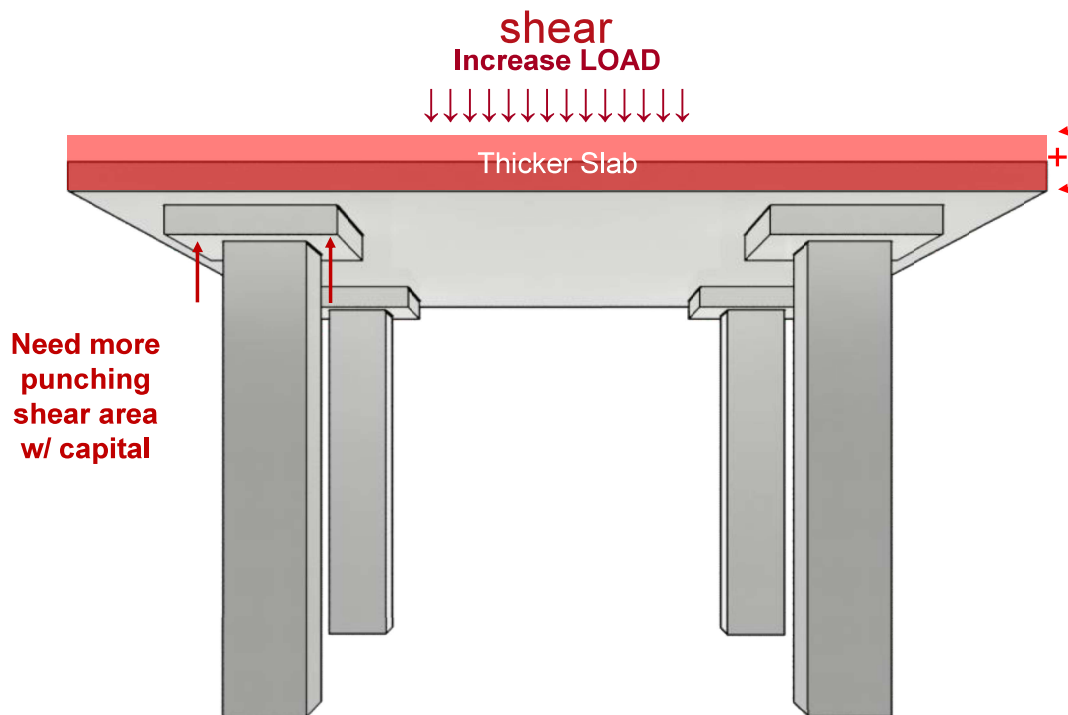
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Signs of distress: slab punching shear cracking



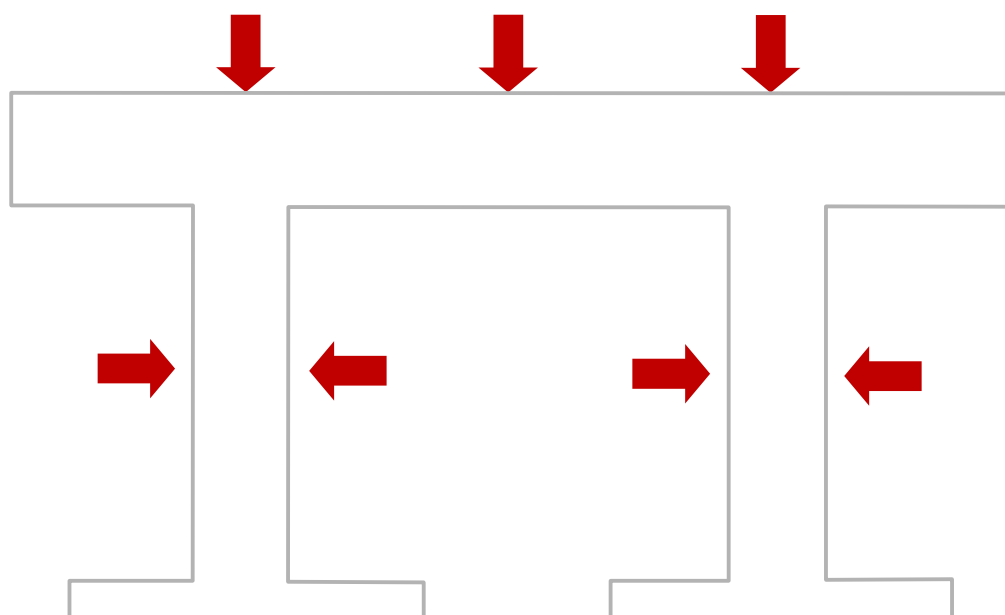
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Shear Heads or Column Capitals to resist punching



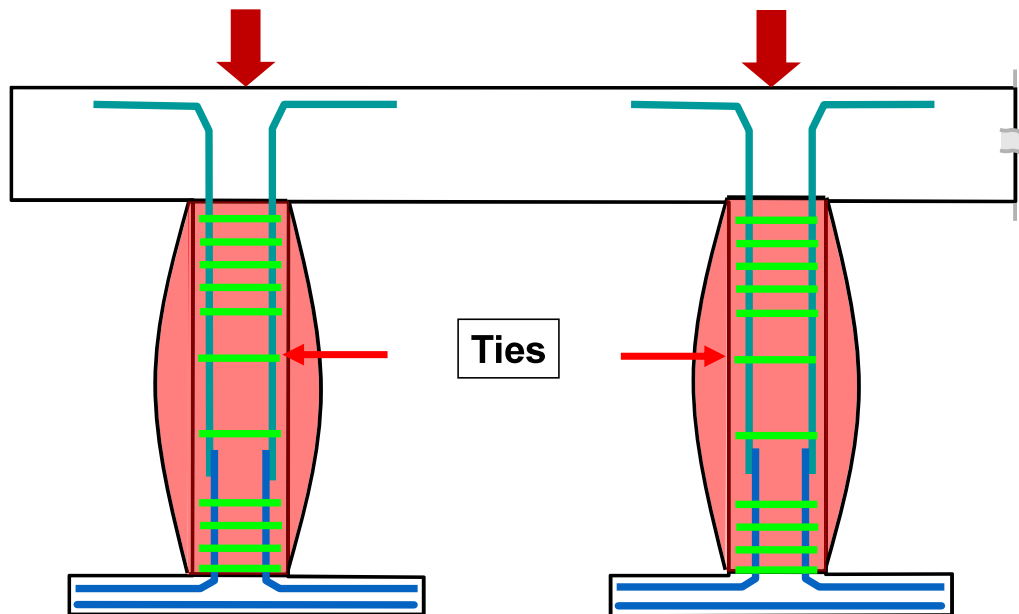
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Loads & forces on COLUMNS



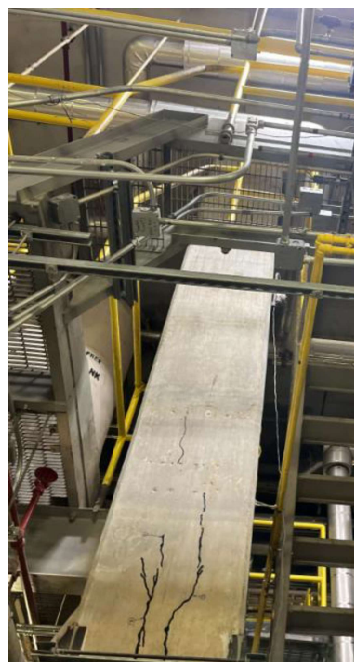
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Column steel placement to resist VERTICAL forces

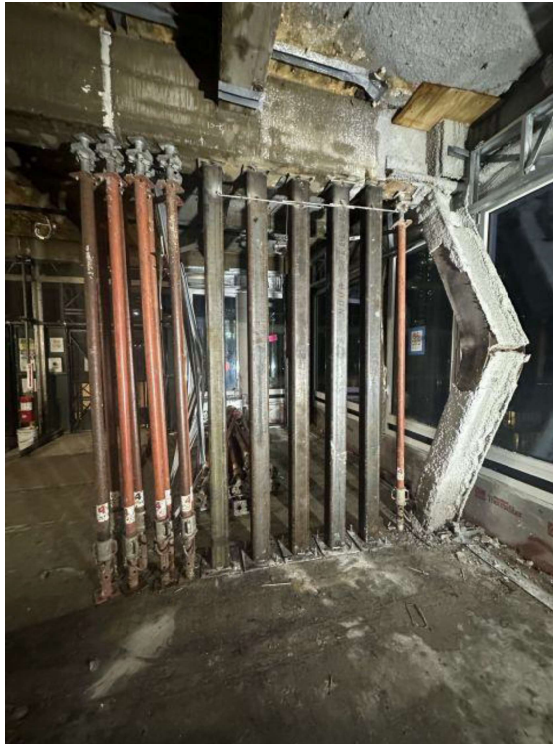
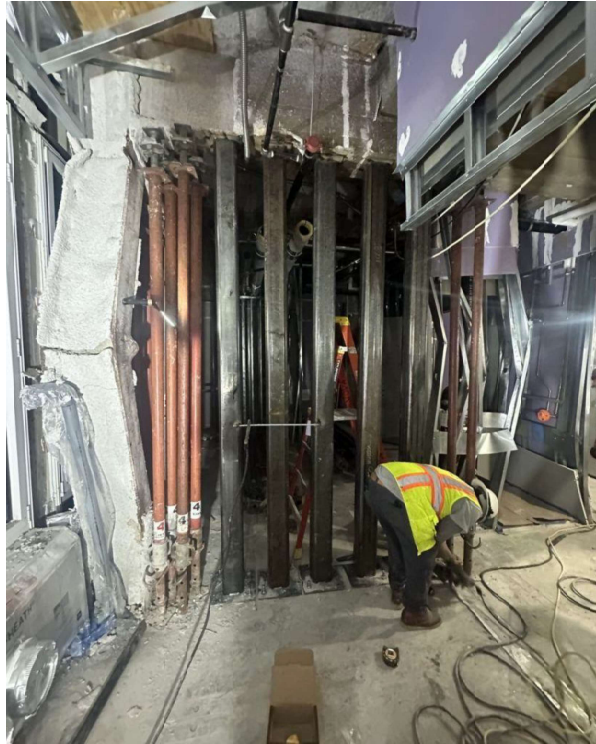


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Signs of distress: column bending force cracking

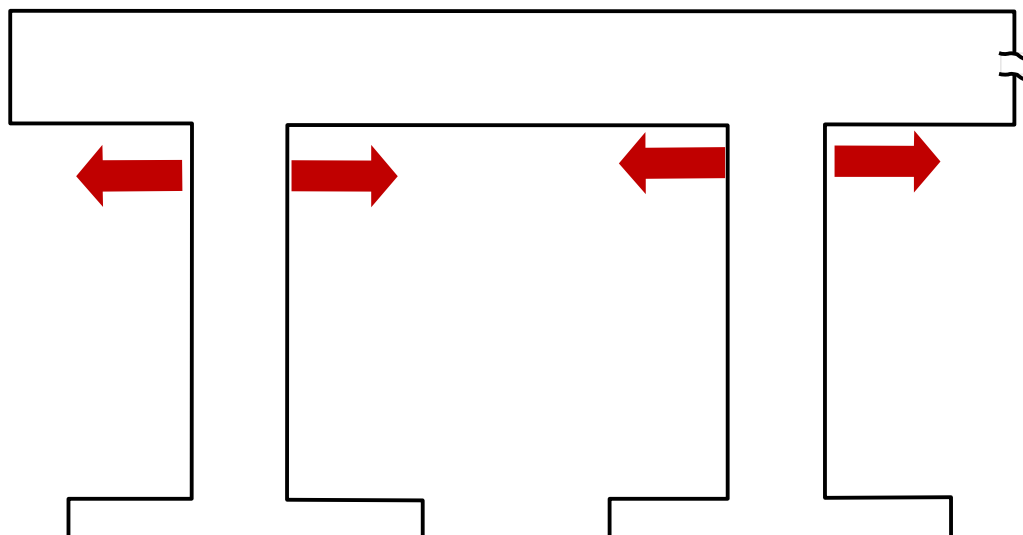


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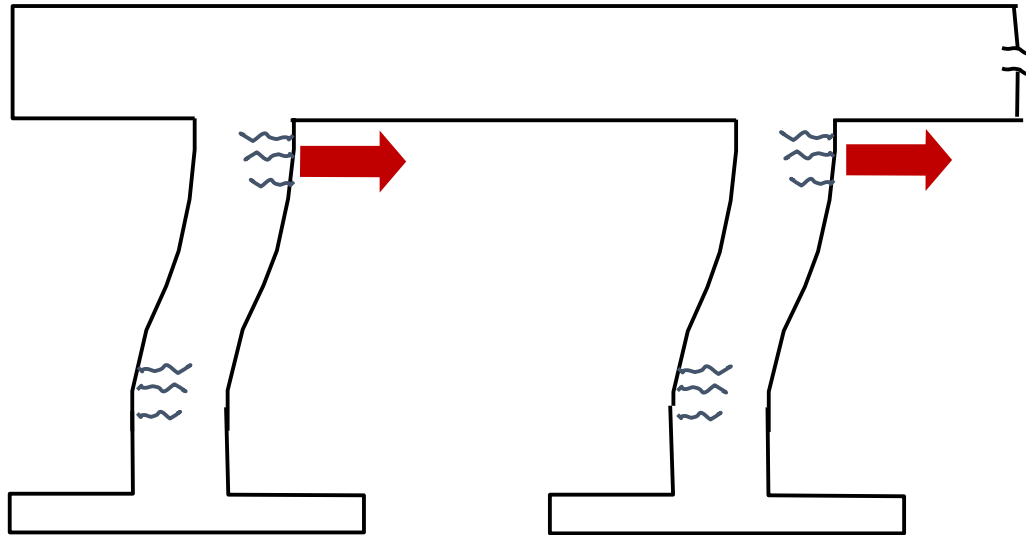
Column steel placement to resist **LATERAL** forces
Wind or Seismic



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Column steel placement to resist LATERAL forces

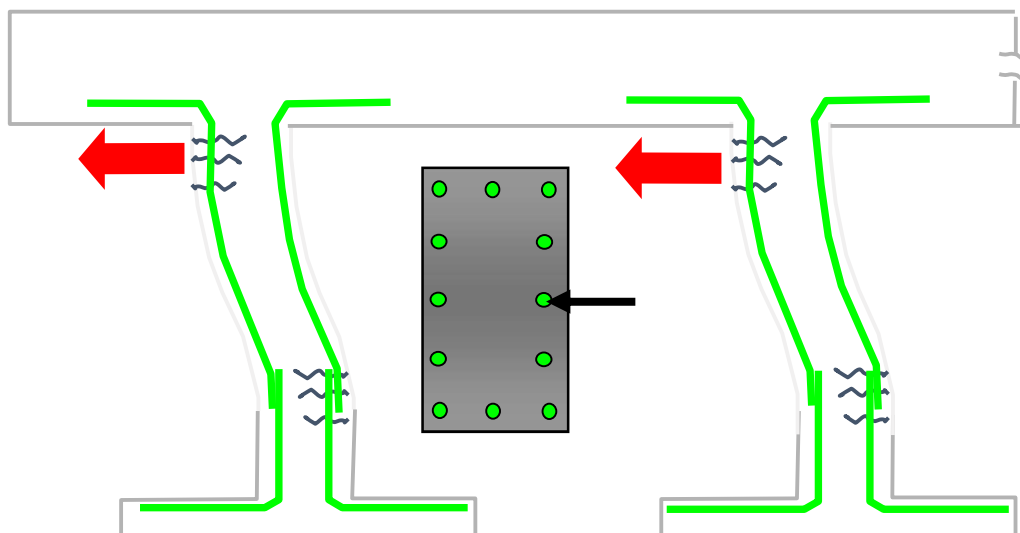
Wind or Seismic



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Column steel placement to resist LATERAL forces

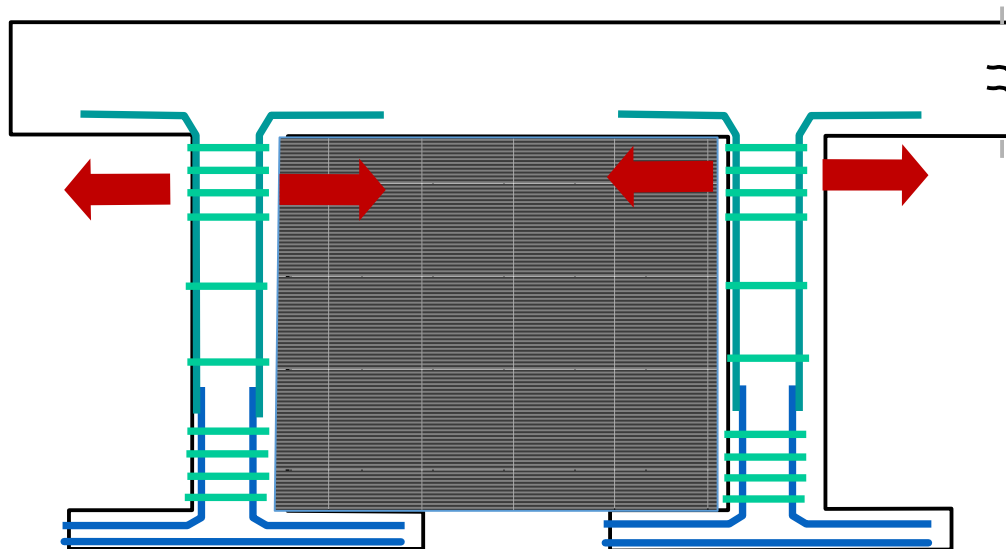
Bending



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Shear walls to resist LATERAL forces

Shear Walls



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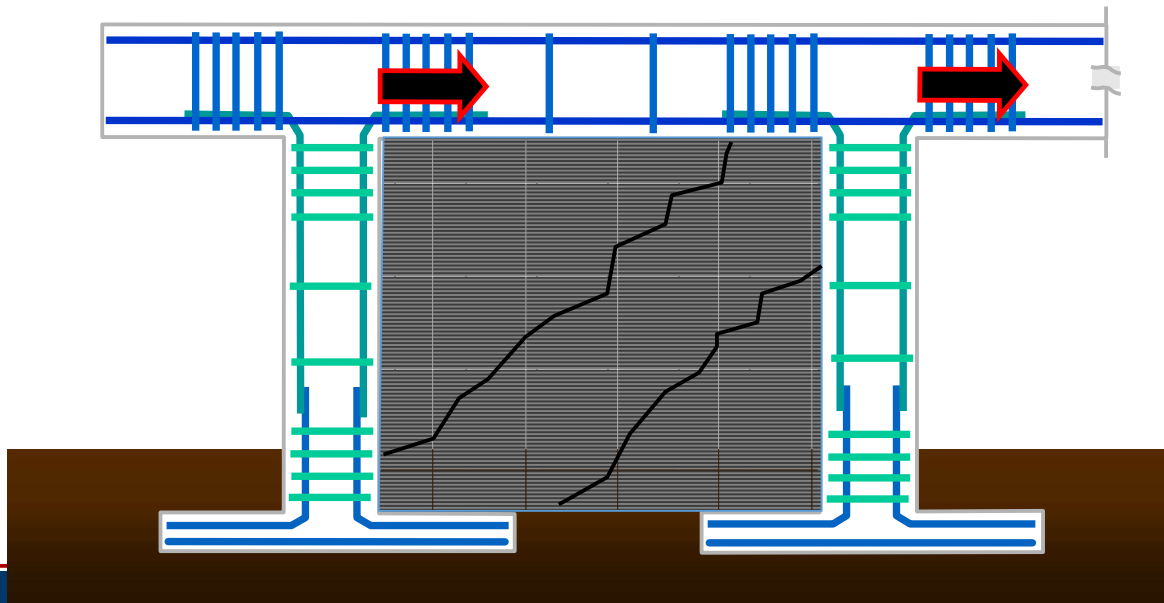
Typical Steel Placement- Shear walls



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Signs of Distress-

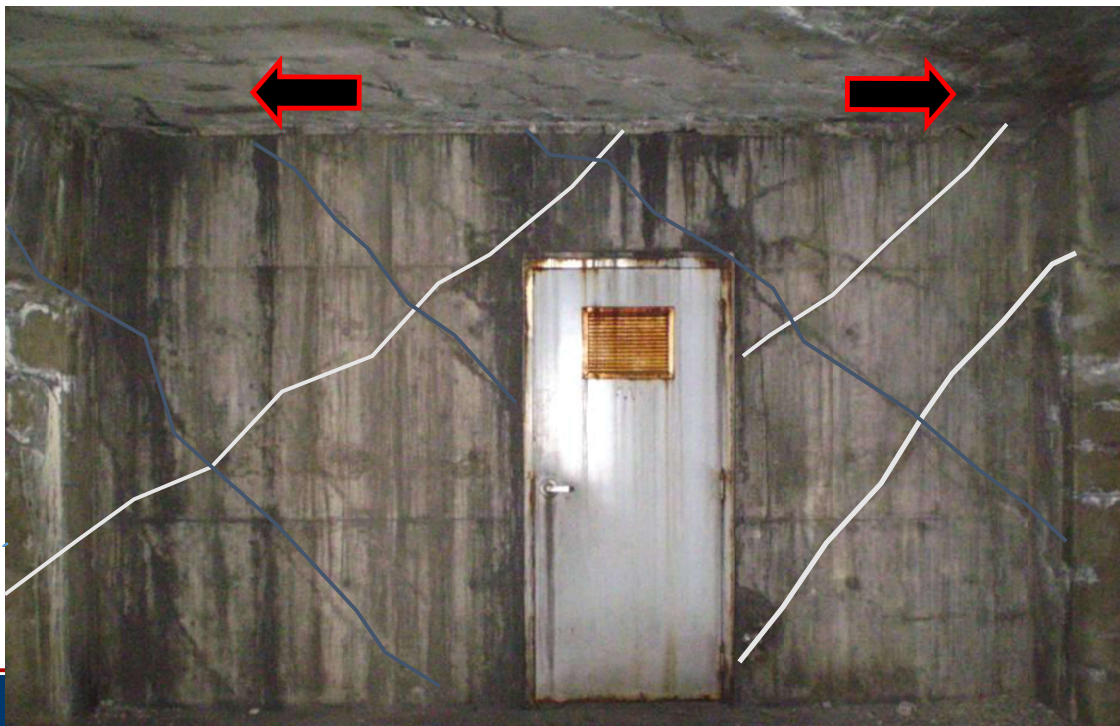
Shear walls



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Signs of Distress-

Shear walls



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Signs of Distress- Cantilever Slab Cracking

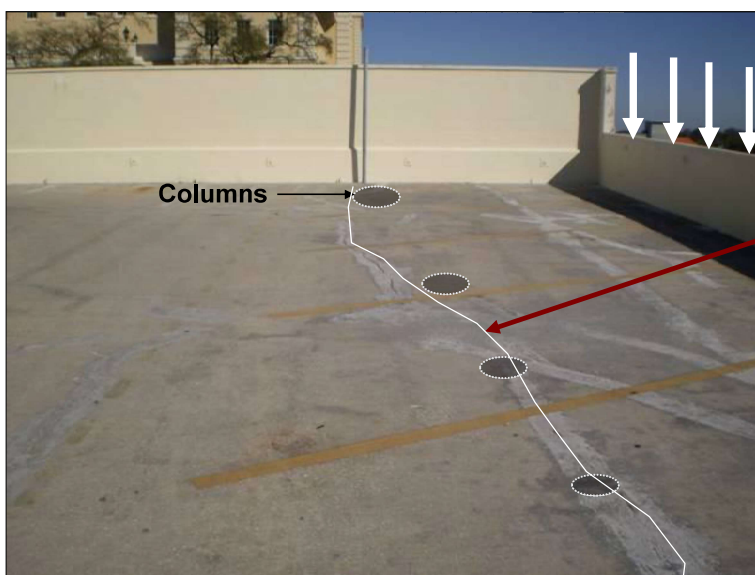
WHAT HAPPENED?



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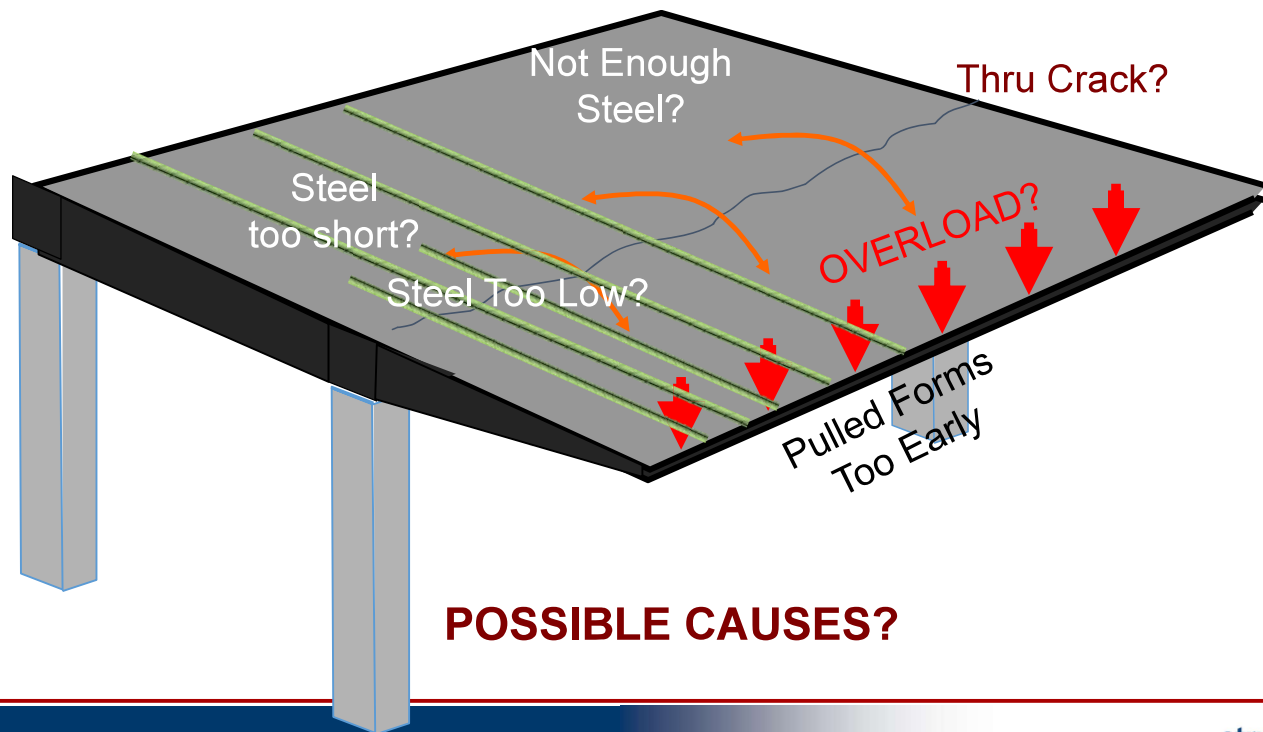
Signs of Distress- Cantilever Slab Cracking

WHAT HAPPENED?



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QUIZ- *WHAT COULD HAVE HAPPENED?*



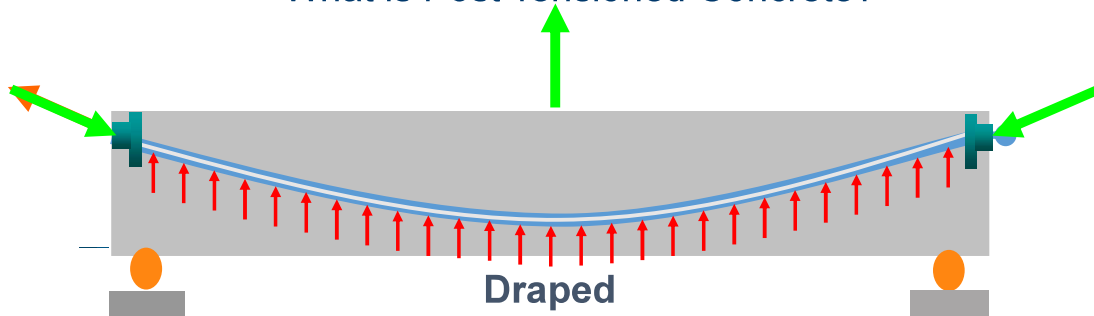
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What is Post Tensioned Concrete?



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What is Post Tensioned Concrete?



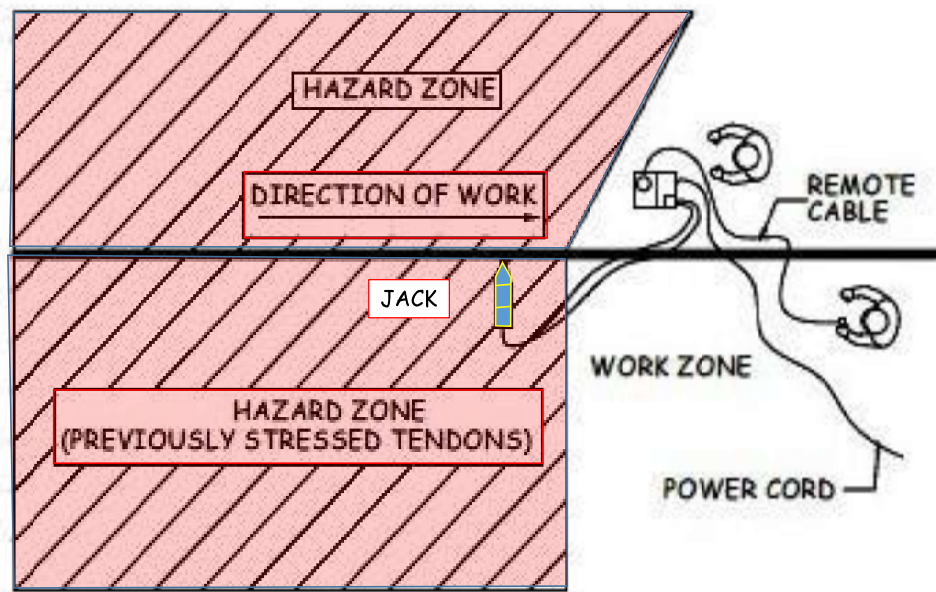
Advantages:

- Thinner slab-smaller beam
- Lighter structure
- Longer spans- less columns
- Minimum cracking
- More durable against corrosion

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Post Tension Safety Considerations

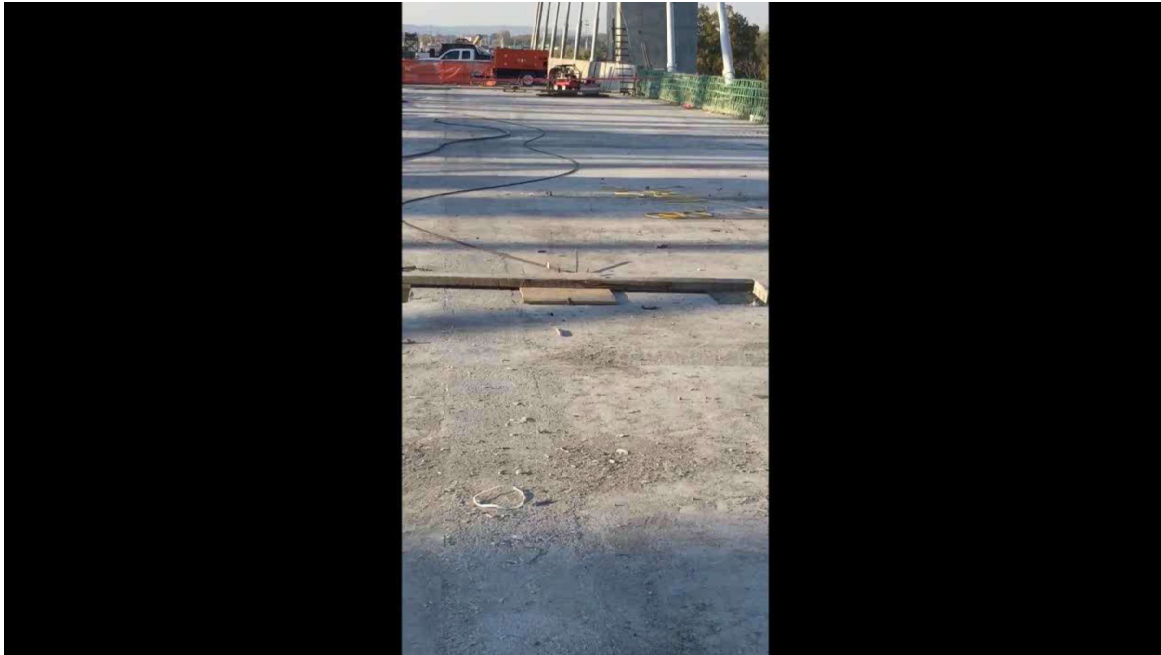
STRESSING SAFETY GUIDELINES (PTI)- Line of Fire Rule



1
51

STRESSING SAFETY DETAIL
(NTS)

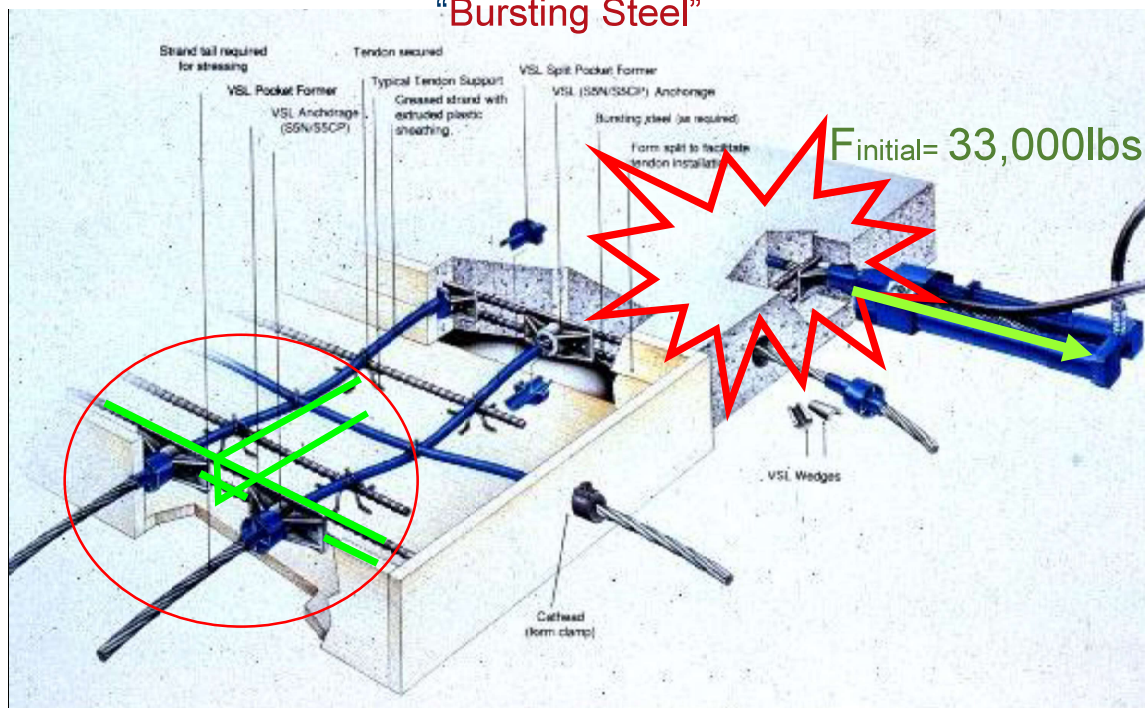
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Post Tension anchorage zone reinforcement details

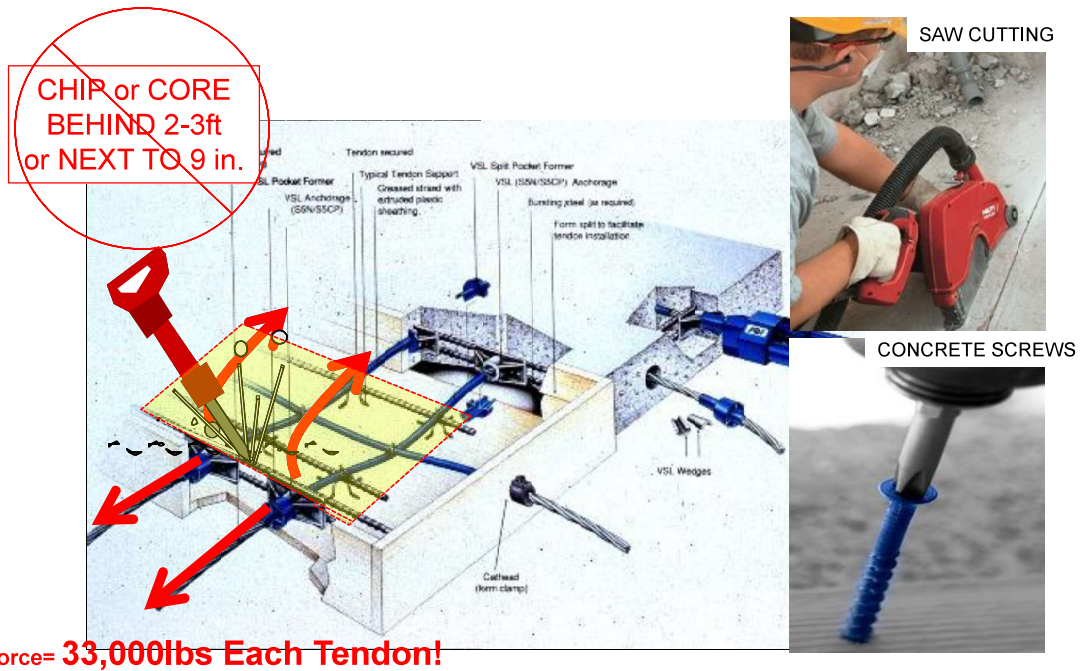
“Bursting Steel”



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Post Tension **SAFETY RULE**

Hazards during field investigations, repairs, saw cutting & drilling



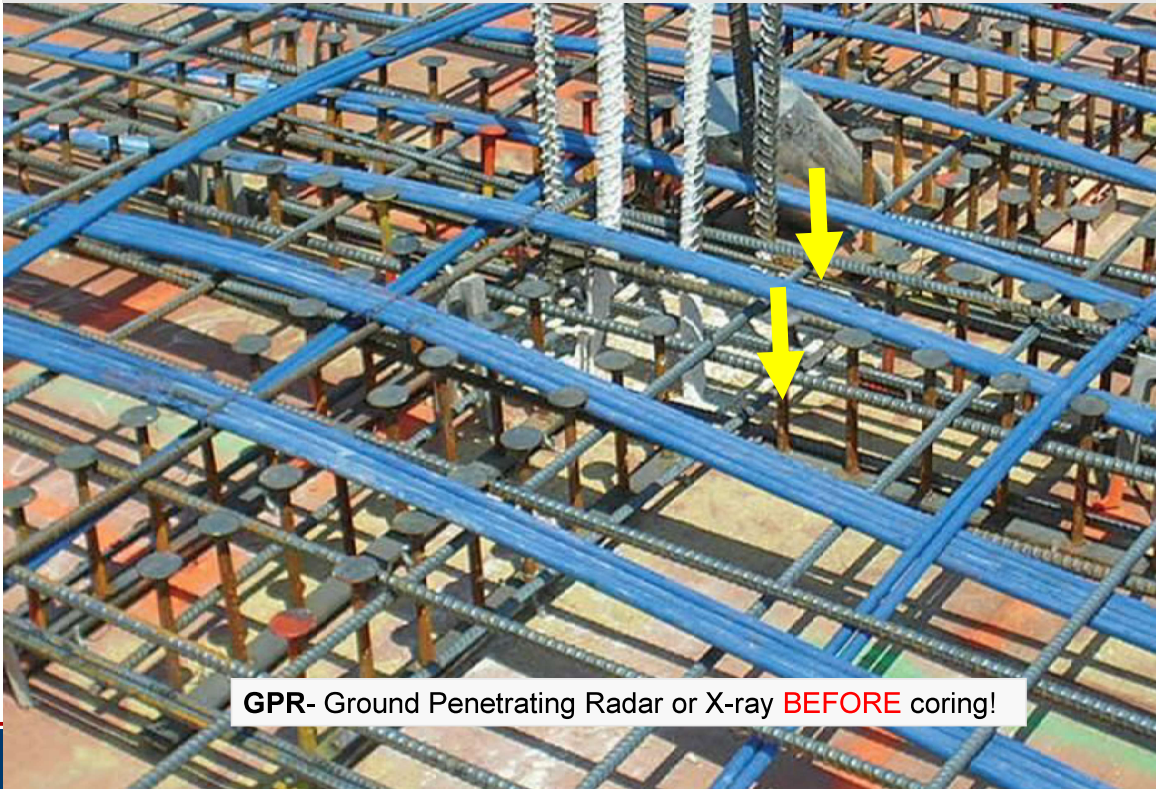
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Post Tension **SAFETY CONSIDERATIONS**

During stressing



Post Tension Reinforcement Concepts



GPR- Ground Penetrating Radar or X-ray **BEFORE** coring!

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GPR vs. X-Ray

	X-Ray	GPR
Cost	High	Low
Access	2 sided	1 sided
Set Up Time	Long	5 minutes
Data Collection Speed	1 film/time	4sf / 8 min.
License Required	Yes	No
Hazardous/Evacuation Req'd	Yes	No
Immediate Results	No	Yes
Can determine depth	No	Yes
Slab on Grade	No	Yes
Consumables	Film	No

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PT Tendon Damage- Core Drilling



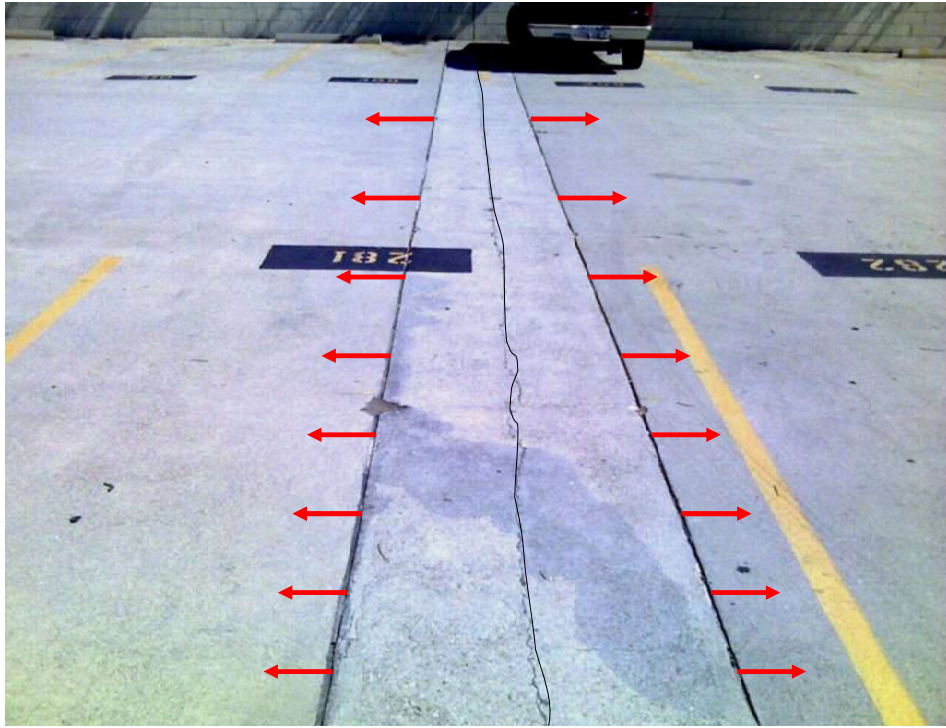
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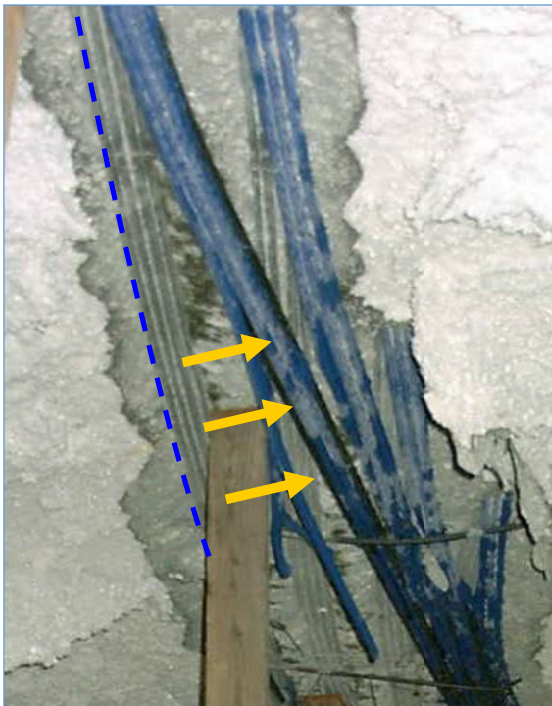
Top

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Post Tension Reinforcement Concepts- Pour Strip cast too early



PT Concepts



Post Tensioned or Prestressed Cracking

Flexural Crack in PT Beam



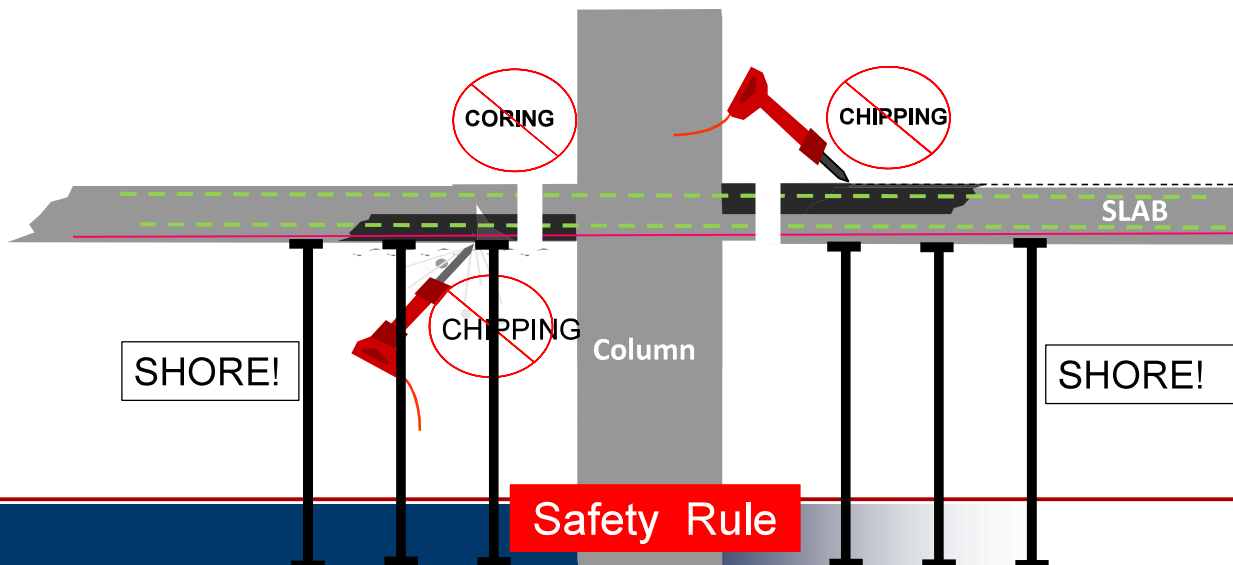
If structural crack
in PT/PS...
80% of Ultimate!

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WHAT ARE THE CONSIDERATIONS
BEFORE CHIPPING, CORING, ETC...

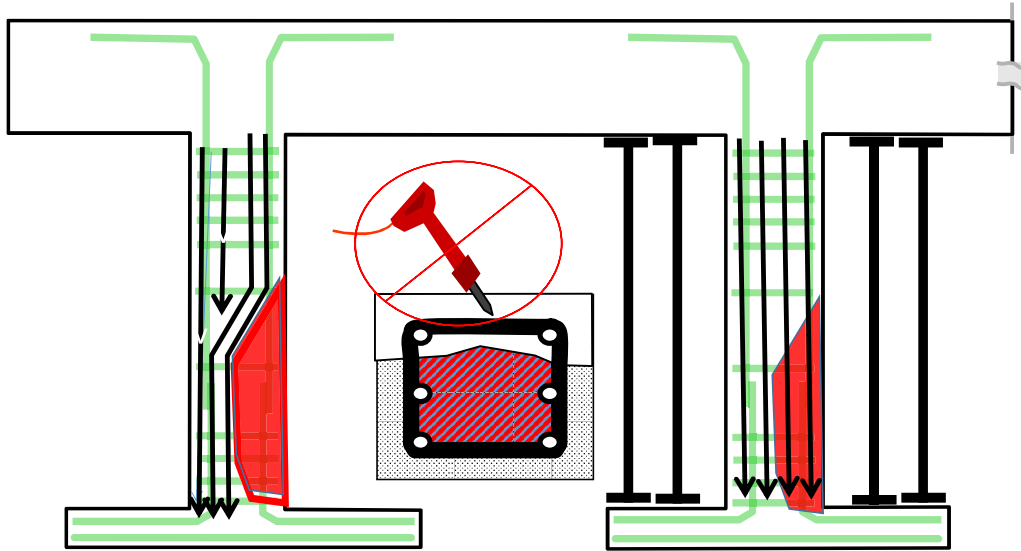
1. WHERE IS THE STEEL & 2. DO I NEED TO SHORE?

CAUTION! Slab areas around columns are heavily reinforced and have high punching shear & tension forces.



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*WHAT ARE THE CONSIDERATIONS
BEFORE CHIPPING & CORING SHEAR WALL OR COLUMN
1. WHERE IS THE REBAR 2. DO I NEED TO SHORE?*



Safety Rule- NEVER CHIP INSIDE STR. CORE!

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How did we do?

Today's Objectives:

1. Recognize weaknesses in structures **BEFORE** they fail
2. Understand the signs of **DISTRESS**
3. Plan a **SAFE** outcome

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Thanks Very Much!

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