Rigging and Lifting Considerations for Precast Producers

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VP of Operations, Gainey's

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About me:

- Responsible for production, post production, shipping, receiving, and maintenance operations for Gainey's.
- NCCER certified advanced rigger
- NPCA certified Master Precaster
- NOT AN EXPERT!

The content I present in this course is not all inclusive. My knowledge comes from relevant experiences I have had within the past 7 years in this industry, lots of help from our suppliers and the NPCA, and my passion for this topic.

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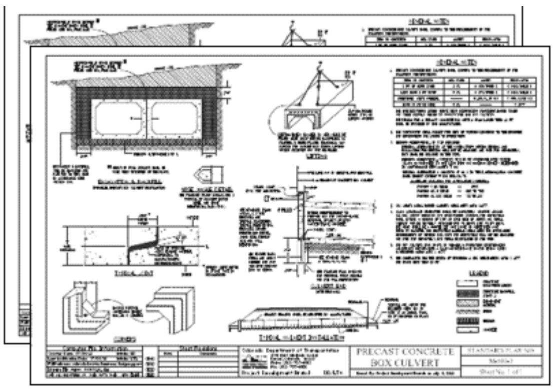
Recap from PQS II - Production

- Safe lifting and handling of precast concrete structures starts before any concrete is poured into the forms.



- Design
- Design relayed through production drawings
- Production and field drawings should always include the **weight of the structure, lift point location, and type of lifting anchors.**

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What design needs to determine:

- Weight of the structure
- Center of Gravity (CG) of the structure
- Lifting anchors – type, capacity, quantity, and location
- Minimum edge and anchor-to-anchor distance requirements
- Concrete strength **at the time of initial lift.**
- Is additional reinforcement needed to resist handling forces?
- Rigging required to equalize loading, lift, and rotate structure (if needed)

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Weight of the structure

- Weight will be the determining factor when selecting the anchor type, size, number of anchors, crane capacity and reach, and shipping requirements.
  - For most structures, estimate 150 lbs. per cubic foot.
  - For structures with dense reinforcing steel, I estimate 155 lbs. per cubic foot.

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Weight of the structure

This structure was 290 cubic feet of concrete with very dense steel reinforcement:

290 ft^3 x 155 Lbs./ft^3=

45,000 Lbs.

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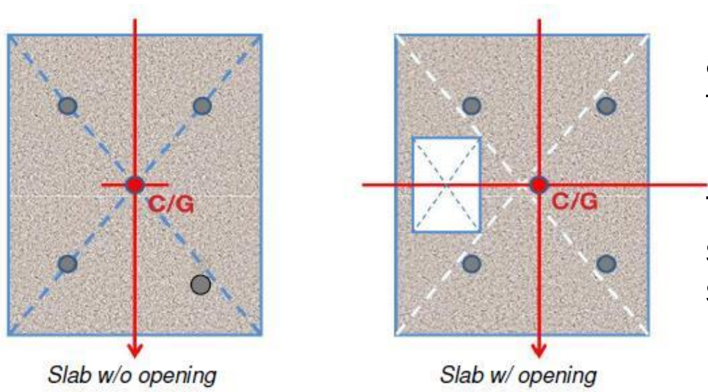
Center of gravity (CG)

- The location of the center of gravity will dictate where the lifting anchors should be placed.



Note that the lifting anchors are placed about the center of gravity.

This ensures the precast structure will remain stable and lift flat.

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Center of gravity (CG)

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Center of gravity (CG)

Minor adjustments can be made and should be communicated well with anyone who needs to lift this again in the future.

- Adjustable chains
- Adding shackles

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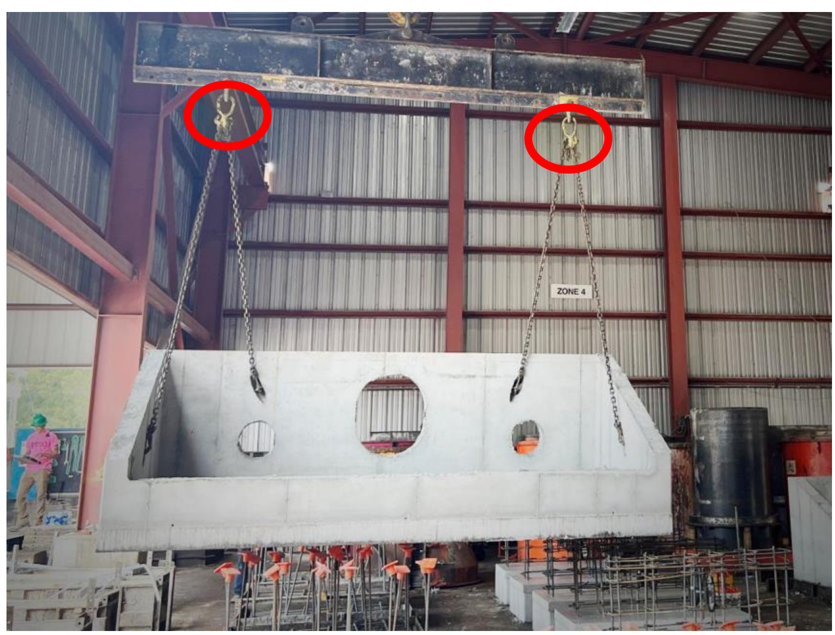
Center of gravity (CG)



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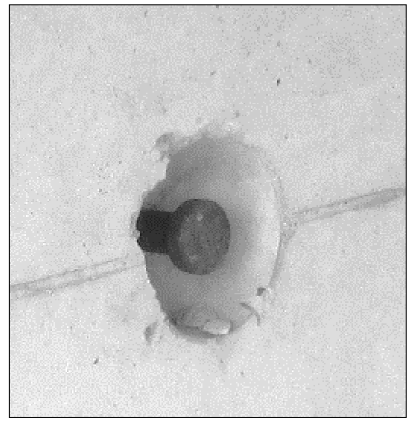
Type and number of lifting anchors



- There are many different types of lifting anchors on the market.
- Which anchor you select will depend on the application and preference.

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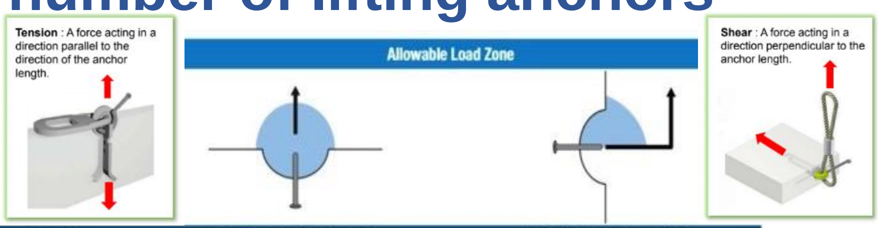
Type and number of lifting anchors



UTILITY LIFT ANCHOR LOAD CHART

Part #	Slab Min. Thickness	Edge Distance	4:1 SWL at 90° Tension (lbs)	4:1 SWL at 90° Shear (lbs)
LUA44G	4"	9"	3,200	5,800
LUA54G	5"	10"	3,860	7,710
LUA64G	5-5/8"	12"	4,460	9,460
LUA56G	5"	10"	4,560	8,430
LUA66G	5-5/8"	12"	7,320	15,780
LUA86G	7-5/8"	16"	10,830	18,850

Always refer to the data sheet for the anchor you plan to use

- Safe working load in the way you intend to lift
- Edge distance requirements

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Type & Number of Lifting Anchors

- This section of bridge arch had 8 anchors installed
- 4 were on the edge for the precaster to strip and load on the truck
- The contractor had to lift with the 4 edge lifters, then gradually shift to the face lifters to rotate the arch into position to be set.

- Anchor selection will sometimes depend on how the structure will need to be handled to install.

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Common precast lifting anchors

Lift Loops

Advantages:

- Cable is flexible and easy to work with
- Easy to engage / disengage lifting hooks
- Can be cut off and removed after use

Disadvantages:

- May rust when exposed to the elements
- Rusting will cause weakening of the core and surface wires, causing premature failure
- These are not ideal if the structure will sit for a substantial period of time before being set

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Common precast lifting anchors

Bent Rod anchors

Advantages:
- Easy to engage / disengage lifting hooks
- Recessed design can be grouted after lift is complete
- Excellent capacity in shear

Disadvantages:
- Using hooks that are too large could cause lever-arm failure
- Most shackles do not fit into recessed pockets
- Make sure customer's rigging fits into the recess before you schedule delivery!

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Common precast lifting anchors

Lifting pin / "dogbone" anchors

Advantages:
- Fast to engage / disengage anchor
- Round recess and 360 degree lifting eye positioning
- **SWL applicable in any loading configuration!**

Disadvantages:
- Must have special clutches to engage each anchor

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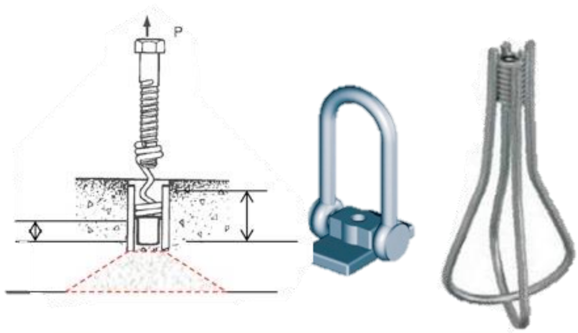
Common precast lifting anchors

Disclaimer – I do not have experience with these anchor systems contact your anchor supplier for more details

Coil inserts and bolts



Bar type anchors

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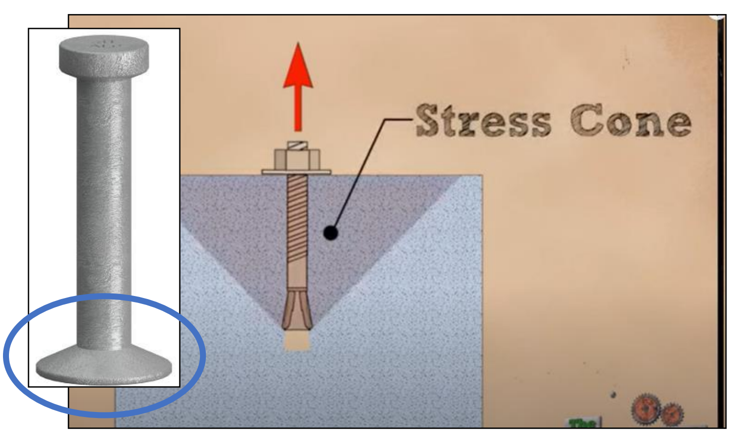
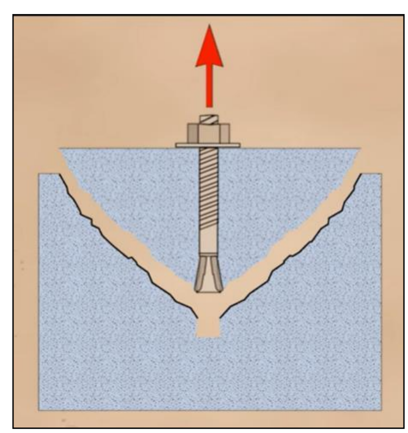
What is a shear cone?





Concrete anchors are held into the concrete by a bearing element on the anchor

- When the force exerted onto the anchor exceeds the shear resistance of the concrete, the concrete fails from the bearing member, at a predictable angle.

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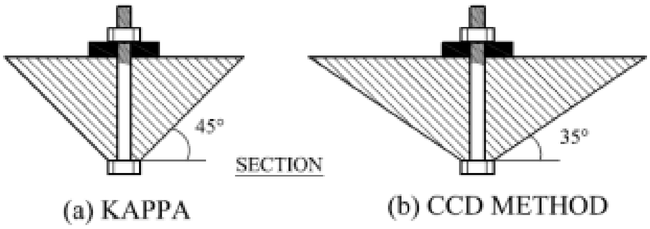
45 degrees or 35 degrees?



- The Kappa method resulted in an assumption that the failure cones in concrete were at a 45 degree angle.
- In the 1990s, further studies were conducted including one that would result in a method called the concrete capacity design or CCD (Fuchs et al. 1995)
- ACI compared the two methods and found that the CCD method gave a better prediction for anchor strength at a given embedment so they changed to the CCD method with the 35 degree angle.

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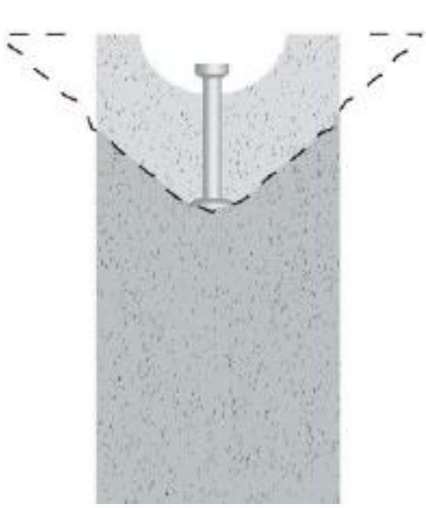
How shear cone affects anchor capacity



Anchor pullout capacity is a function of the shear strength of the concrete and the lateral surface area of the 35 degree failure cone.

Any factor that prevents the development of a full shear cone reduces the anchor capacity.

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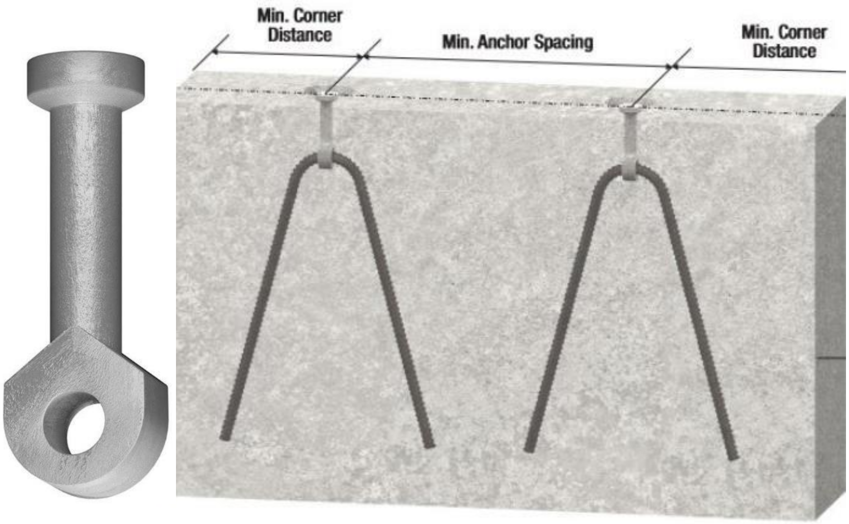
How shear cone affects anchor capacity



Some anchor styles can overcome the limitations of partial shear cones.

- Bent rebar transfers the tension loads deep into the concrete structure to produce high safe working loads in thin-wall sections.

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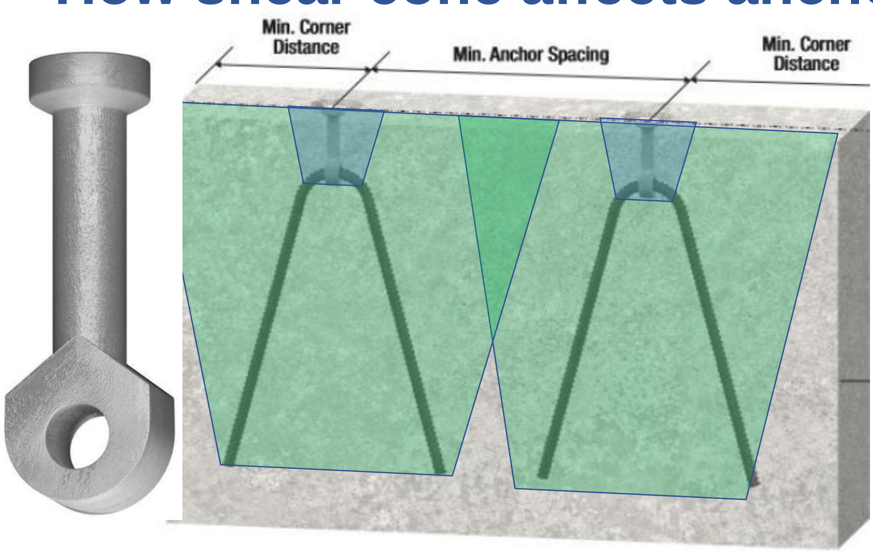
How shear cone affects anchor capacity



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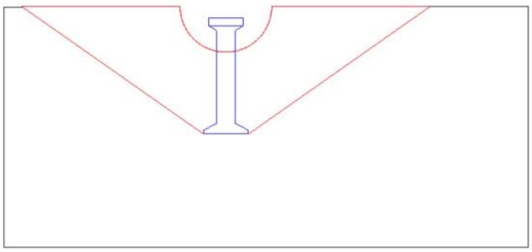
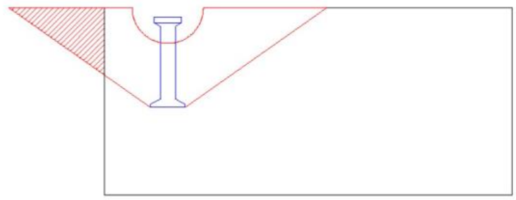
How edge distance affects anchor capacity



Full shear cone development



Missing part of shear cone

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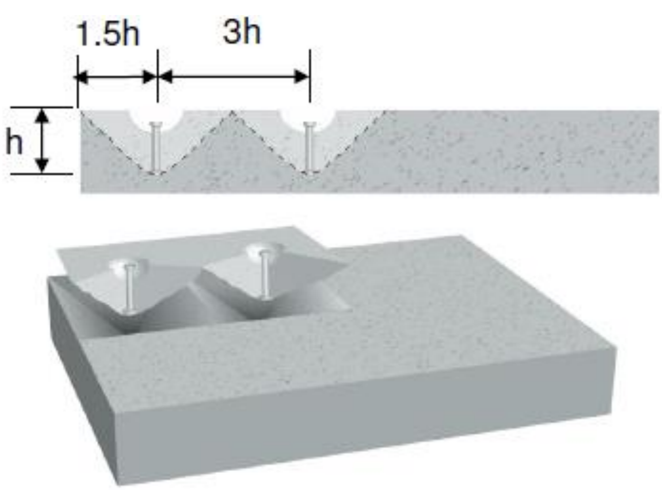
How edge distance affects anchor capacity



- Anchors should be spaced 1.5 times their height from any edges.
- 3 times their height from other anchors.

Check anchor data sheets!

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Concrete strength at time of INITIAL lift

Allowable Load Zone

4:1 SWL at 90° Tension (lbs)	4:1 SWL at 90° Shear (lbs)
3,200	5,800
3,860	7,710
4,460	9,460
4,560	8,430
7,320	15,780
10,830	18,850

- Table is based on 4,000 psi and 145 PCF concrete.

- The safe working loads listed on data sheets assume stated concrete strength (4,000 psi in this example).
- What is your minimum stripping strength?

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Concrete strength at time of INITIAL lift

Lifter Capacity at Stripping

	Concrete Strength			
Rated Lifter Capacity	**1500PSI***	**2000PSI**	**3000PSI**	**3500PSI**
1 TON	0.65TON	0.76TON	0.93TON	1TON
2 TON	1.31TON	1.51TON	1.85TON	2TON
4 TON	2.62TON	3.02TON	3.70TON	4TON
8 TON	5.24TON	6.05TON	7.41TON	8TON

* Minimum recommended PSI for handling

- At 1500 PSI the lifter is only able to lift 65% of its rated capacity
- At 2000 PSI it can lift 75% of its capacity
- At 3000 PSI it can lift 92% of its capacity
- At 3500 PSI the lifter has full capacity
- Higher Capacity lifters are needed for lower concrete strength at stripping.

- In most cases, precasters can not wait until products reach 4,000 psi to strip.

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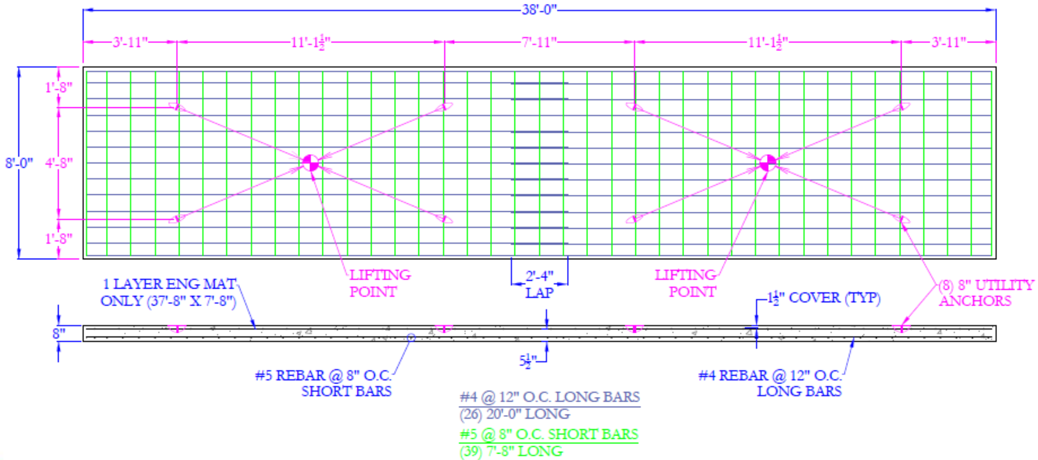
Handling reinforcement

- Reinforcement that is added only for the benefit of lifting and handling. It serves no purpose of the in-place structure.



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Safe lifting and rigging practices

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Taglines

- Taglines are used to safely control the load while keeping employees at a safe distance in case of rigging or equipment failure
- Never wrap hands in the tagline!
- Taglines should be long enough for employees to follow the 1 to 1 rule:

For every one foot the structure is raised vertically, stay at least that distance from it horizontally.

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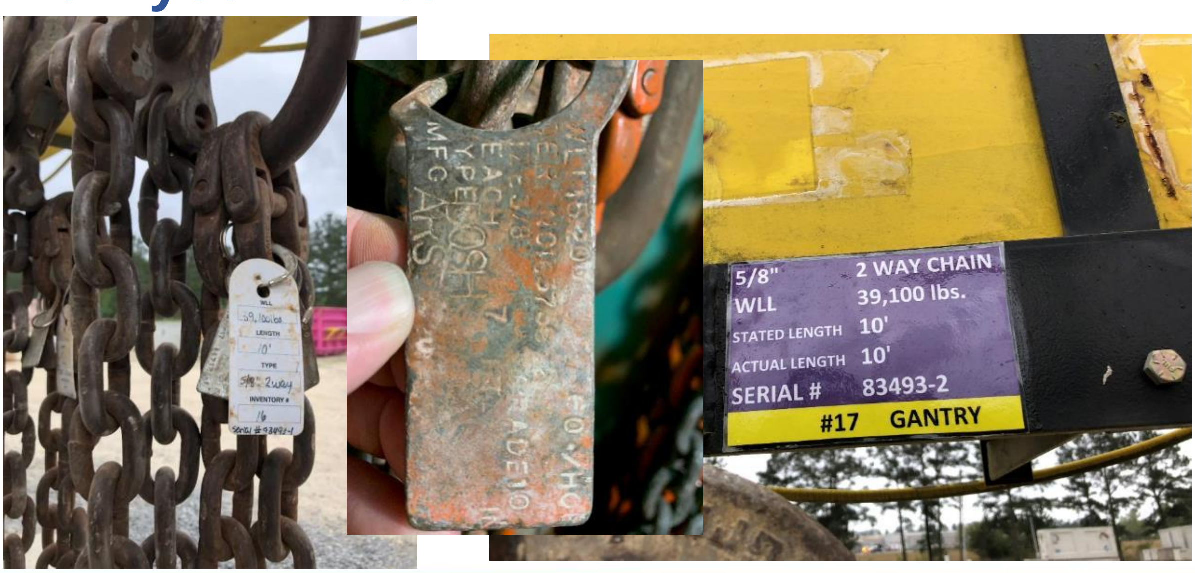
Know your limits!



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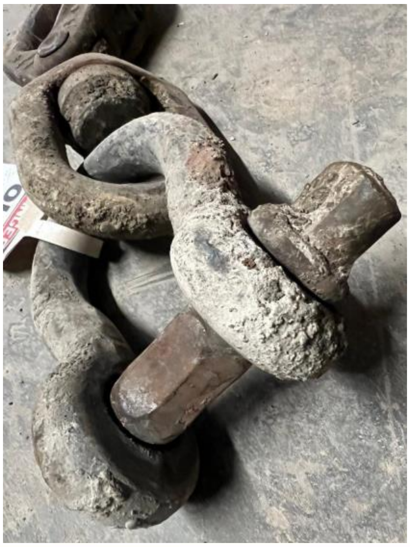
Rigging and hardware inspection



Per ASME B30.26:

- Visual inspection by user or designated person each day before use.
- Periodic inspection at least annually.
- Rejection criteria: a 10% or more reduction of the original dimension.

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Rigging and hardware inspection

Per ASME B30.26:

- Rejection criteria: Bent, twisted, distorted, stretched, elongated, cracked or broken load bearing components.
- Excessive nicks, gouges, pitting and corrosion.

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Rigging and hardware inspection

Per ASME B30.10 - hooks:

- Rejection criteria:

Any visibly apparent bend or twist from the plane of the unbent hook.

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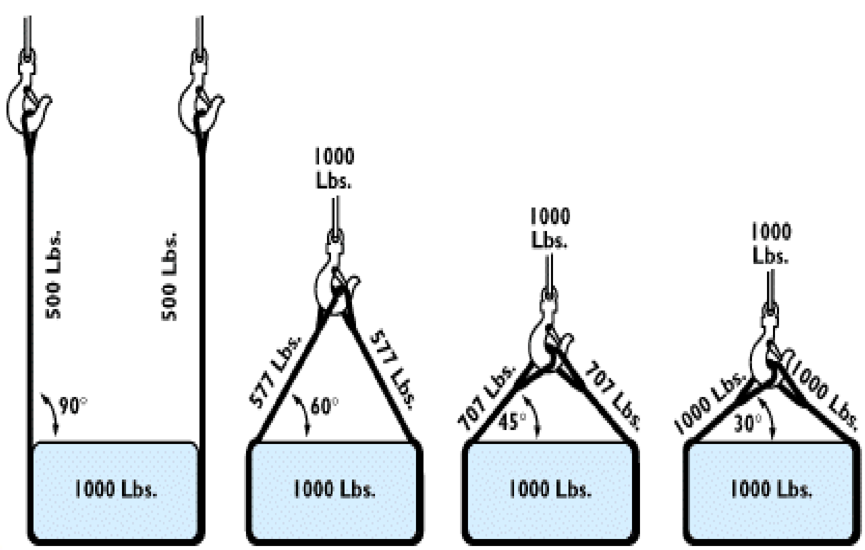
Sling length



- Sling length determines sling angle.
- Improper sling angle can overload anchors and slings.

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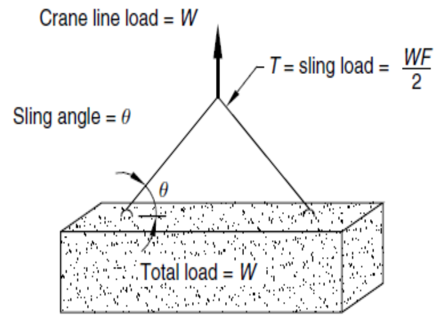
Sling angles

- An equilateral triangle has 60° angles.
- Sling length should be at least equal to the distance between anchors to ensure a sling angle of 60° or greater.



	Multiplication factor *F* for the total load on sling with a sling angle of θ				
θ	90°	75°	60°	45°	30°
F	1.00	1.04	1.16	1.41	2.00

Note: θ is usually not less then 60°. Check bi-directional sling angle. A 30° sling angle is not recommended.

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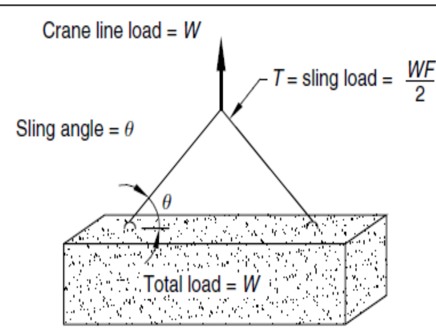
Sling angles

- A 30° Sling angle = twice the force of a 90° sling angle
- A Sling Angle of less than 60 ° is not recommended when lifting concrete structures



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F	1.00	1.04	1.16	1.41	2.00

Note: θ is usually not less then 60°. Check bi-directional sling angle. A 30° sling angle is not recommended.

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Sling angles

Sling angles that are too tight can cause several issues:

- Anchor failure
  - Forces exceed capacity
  - Extreme side loading
- Sling failure
- Structure failure

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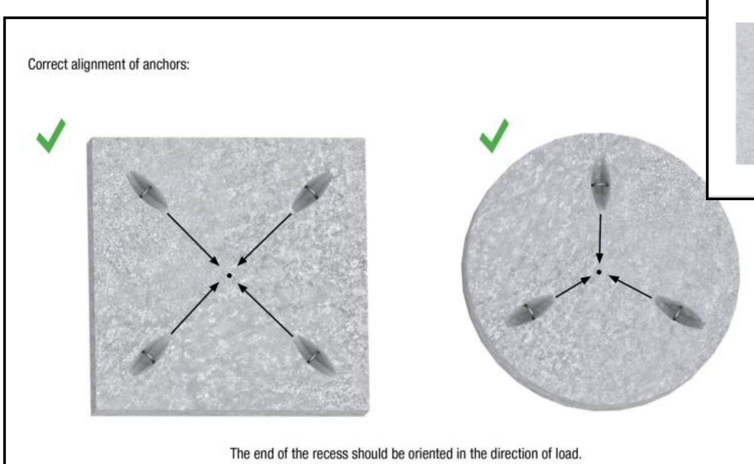
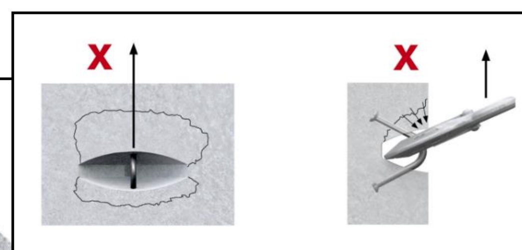
Proper use of lifting devices

Never side load anchors!





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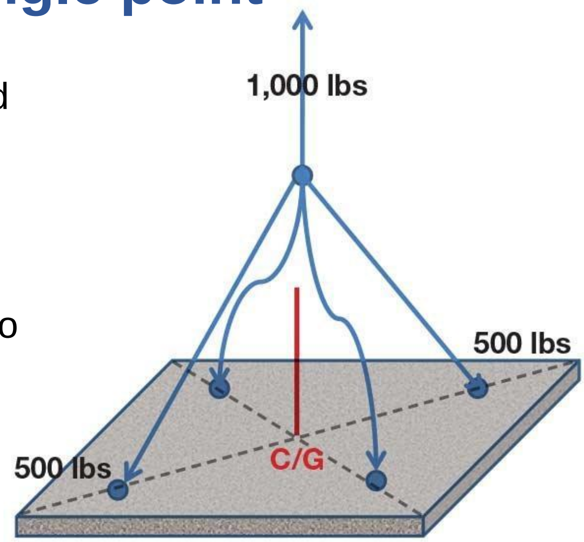
4-point pick from a single point

When using a 4-point pick suspended from a single point, only two of the slings and anchors will be loaded at any given time.

If the structure is designed around two anchors / slings having adequate capacity, this is okay.



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4-point pick from a single point

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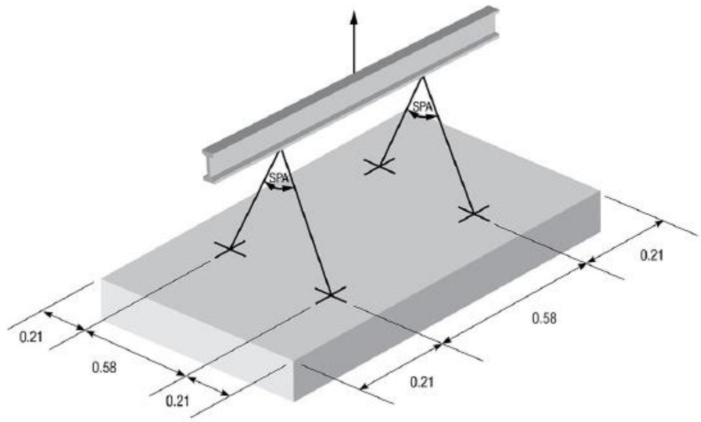
4-point pick using a spreader beam



All four anchors and slings are equally loaded.

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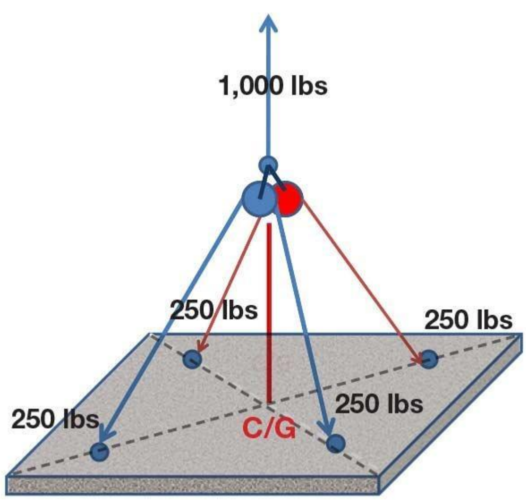
4-point pick using roller blocks



All four anchors and slings are equally loaded.

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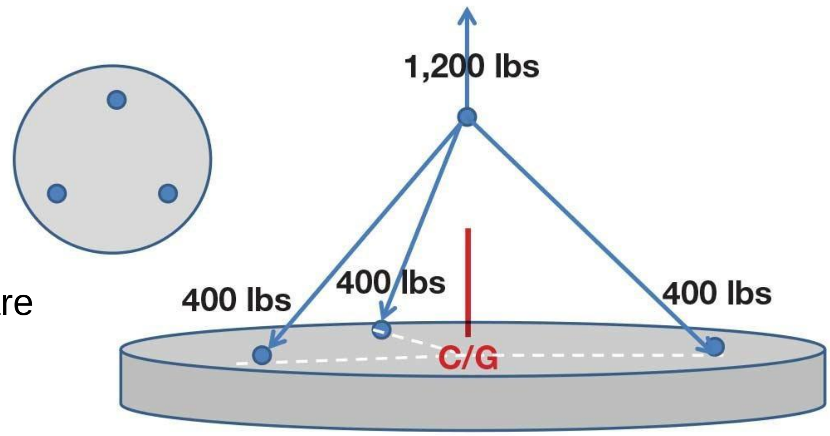
3-point pick from a single point

All anchors and slings are equally loaded



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3-point pick from a single point

When practical, consider designing around 3-point picks to minimize rigging and anchors being loaded unequally.

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Critical lift planning – Cradle to Grave

Define a critical lift for your operation.

- At Gainey's, anything that weighs more than 30,000 Lbs. or has unique circumstances is designated as a critical lift.

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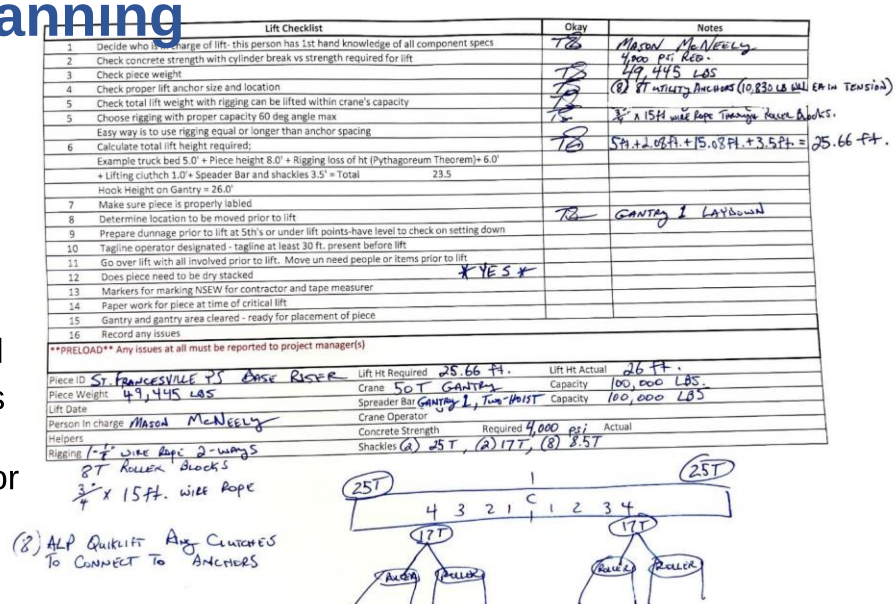
Critical lift planning

How we prepare:

- Lift plan written by qualified person
- Structure weight calculated
- Exact rigging and configuration specified
- Verify crane capacities and hook height
- Important reminders for the lift date



	Lift Checklist	Okay	Notes
1	Decide who is in charge of lift- this person has 1st hand knowledge of all component specs	[illegible]	Mason McNeely
2	Check concrete strength with cylinder break vs strength required for lift		4,000 psi Req.
3	Check piece weight	[illegible]	49,445 lbs
4	Check proper lift anchor size and location	[illegible]	(8) 8T utility anchors (10,830 lb WLL ea in tension)
5	Check total lift weight with rigging can be lifted within crane's capacity	[illegible]	
5	Choose rigging with proper capacity 60 deg angle max	[illegible]	3/4" x 15ft wire rope through roller blocks.
	Easy way is to use rigging equal or longer than anchor spacing		
6	Calculate total lift height required;	[illegible]	5ft.+2.08ft.+15.08ft.+3.5ft. = 25.66 ft.
	Example truck bed 5.0' + Piece height 8.0' + Rigging loss of ht (Pythagoreum Theorem)+ 6.0'		
	+ Lifting cluthch 1.0'+ Speader Bar and shackles 3.5' = Total 23.5		
	Hook Height on Gantry = 26.0'		
7	Make sure piece is properly labled		
8	Determine location to be moved prior to lift	[illegible]	Gantry 1 Laydown
9	Prepare dunnage prior to lift at 5th's or under lift points-have level to check on setting down		
10	Tagline operator designated - tagline at least 30 ft. present before lift		
11	Go over lift with all involved prior to lift. Move un need people or items prior to lift		
12	Does piece need to be dry stacked *YES*		
13	Markers for marking NSEW for contractor and tape measurer		
14	Paper work for piece at time of critical lift		
15	Gantry and gantry area cleared - ready for placement of piece		
16	Record any issues		

PRELOAD Any issues at all must be reported to project manager(s)

Piece ID: St. Francesville PS Base Riser	Lift Ht Required: 25.66 ft.	Lift Ht Actual: 26 ft.	
Piece Weight: 49,445 lbs	Crane: 50T Gantry	Capacity: 100,000 lbs.	
Lift Date	Spreader Bar: Gantry 1, Two-Hoist	Capacity: 100,000 lbs	
Person In charge: Mason McNeely	Crane Operator		
Helpers	Concrete Strength	Required: 4,000 psi	Actual
Rigging: 1-1/2" wire rope 2-ways	Shackles: (2) 25T, (2) 17T, (8) 8.5T		

8T Roller Blocks
3/4" x 15ft. wire rope
(8) ALP Quiklift Any Clutches To Connect To Anchors

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Critical lift planning

	Lift Checklist	Okay	Notes
1	Decide who is in charge of lift- this person has 1st hand knowledge of all component specs	TB	MASON McNEELY
2	Check concrete strength with cylinder break vs strength required for lift		4,000 PSI REQ.
3	Check piece weight	TB	49,445 LBS

1. The person in charge of the lift should have extensive experience working with lifting equipment and rigging knowledge.
   - Must be trusted to follow lift plan exactly or halt the lift to discuss discrepancies.
2. Concrete strength – Set minimum requirement based on datasheets from anchor supplier for anchors used.
   - Verify actual prior to the lift.
3. Check structure weight – Manually calculate to independently verify!

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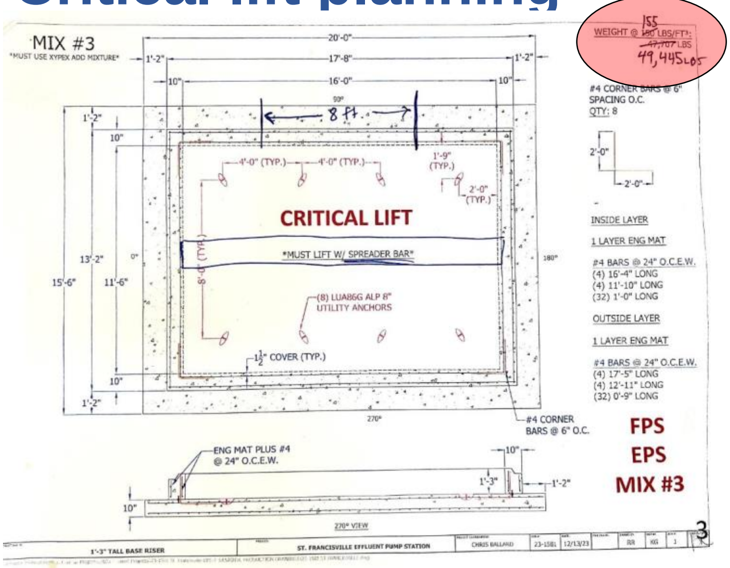
Critical lift planning



Weight calculation:

- Extended base – volume
  - 15.5' X 20' X 0.833' = 258 ft^3
- Riser – volume
  - (13.167' X 17.667' X 1.25') – (11.5' X 16' X 1.25') = 61 ft^3
- Total volume = 319 ft^3
- This structure has double layer of WWR with supplemental rebar so I estimate total density at 155 lbs per cubic foot.
- 319 ft^3 X 155 lbs/ft^3 = 49,445 Lbs.

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Critical lift planning

3	Check piece weight	TB	49,445 LBS
4	Check proper lift anchor size and location	TB	(8) 8T UTILITY ANCHORS (10,830 LB WLL EA IN TENSION)
5	Check total lift weight with rigging can be lifted within crane's capacity	TB	

Anchor selection considerations:

- Customer did not want anchors that required special clutches.
- The 10" thick base excluded another style utility anchor we use that has 12T capacity.
- The riser walls were too short to use utility anchors in shear where they have greater capacity.
- We designed around an 8-point pick using anchors with a SWL of 10,830 lbs each.

ALP SUPPLY

Allowable Load Zone

UTILITY LIFT ANCHOR LOAD CHART

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LUA86G	7-5/8"	16"	10,830	18,850

- Safe Working Load provides a factor of safety of approximately 4:1.
- Table is based on 4,000 psi and 145 PCF concrete.
- Published load capacity cannot be adjusted for higher concrete strength.
- Above capacities are based upon mechanical testing and available industry data.
- For use as a pulling iron, higher allowable loads can be determined by the design engineer by selecting the appropriate factor of safety.

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Critical lift planning

5	Choose rigging with proper capacity 60 deg angle max	TB	3/4" x 15ft wire rope through Racer Blocks.
	Easy way is to use rigging equal or longer than anchor spacing		
6	Calculate total lift height required;	TB	5ft.+2.08ft.+15.08ft.+3.5ft. = 25.66 ft.
	Example truck bed 5.0' + Piece height 8.0' + Rigging loss of ht (Pythagoreum Theorem)+ 6.0'		
	+ Lifting cluthch 1.0'+ Speader Bar and shackles 3.5' = Total 23.5		
	Hook Height on Gantry = 26.0'		

Rigging selection:

- Based on the needs of each unique critical lift.
- Should be selected to ensure more than 60 degree sling angle using Trigonometric functions.

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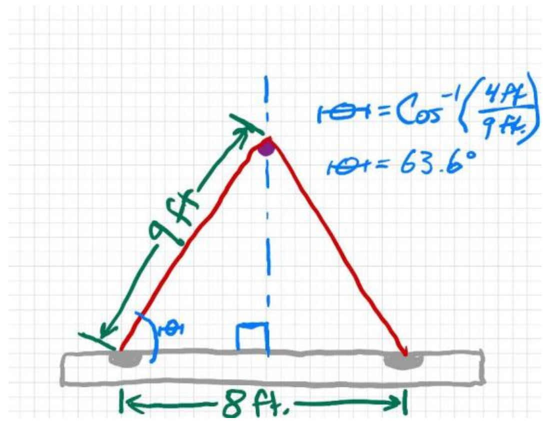
Critical lift planning

Rigging selection:

- Should be selected to ensure more than 60 degree sling angle using Trigonometric functions.



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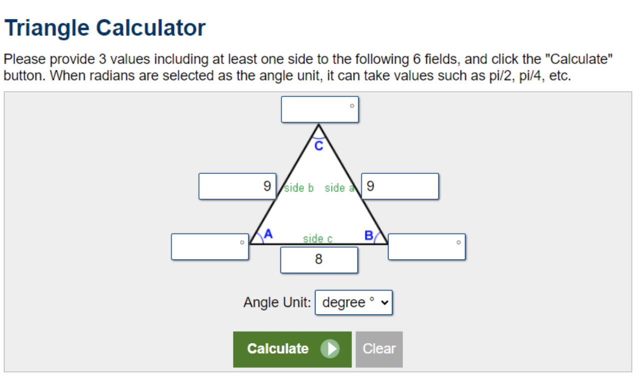
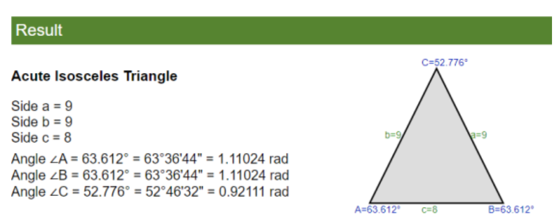
Critical lift planning

Rigging selection:

- OR – use a triangle calculator to verify sling angle
- There are many free versions available online





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Critical lift planning

Having a database with rigging inventory, WLL, and exact lengths **REALLY HELPS!**

Gantry Crane										
Gantry Crane	Rigging	Type	Serial No.	WLL Capacity (Lbs)	Stated Length (Ft)	Actual Length (Ft)	Common Anchor Size	Load Test Date	Inspection Date	Labeling
	3/4" Wire Rope	Single	9540-5	11,200 vertical 8,200 choke 15,800 basket	3	3.792	≥ 8 T	5/9/2011	7/1/2023	
	3/4" Wire Rope	Single	9540-4	11,200 vertical 8,200 choke 15,800 basket	3	3.792	≥ 8 T	5/18/2011	7/1/2023	
	7/8" wire rope	Single	445084	15,000	3	3.58		8/17/2020	7/1/2023	
	7/8" wire rope	Single	445085	15,000	3	3.58		8/17/2020	7/1/2023	
	5/8"	2 way chain	83493-1	39,100	10	10.16	12 T	11/6/2017	7/1/2023	
			83493-2	39,100	10	10.16		7/21/2021	7/1/2023	
			484348	39,100	12	12.33		8/28/2018	7/1/2023	
			114232-2	45,200	12	12.33		8/28/2018	7/1/2023	
	1/2"	2 way chain	92737-1	26,000	10	10.16	≥ 8 T	6/27/2017	7/1/2023	
			92737-2		10	10.16	≥ 8 T		7/1/2023	

Accessories						
	Accessories	Type	WLL Capacity (Lbs)	Actual Length	Diameter of Pin	Pin Type
Qty. 2	Shackles	1.5" Steel	34,000	0.479	1.63"	screw
Qty. 2	Shackles	1.75" Steel	50,000	0.583	2.04"	screw
Qty. 2	Shackles	1.25" Steel	24,000	0.375	1.00"	screw w/ nut

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Critical lift planning

5	Check total lift weight with rigging can be lifted within crane's capacity		
5	Choose rigging with proper capacity 60 deg angle max	[illegible]	3/4" x 15ft wire rope Through Racer Blocks.
	Easy way is to use rigging equal or longer than anchor spacing		
6	Calculate total lift height required;	[illegible]	5ft.+2.08ft.+15.08ft.+3.5ft. = 25.66 ft.
	Example truck bed 5.0' + Piece height 8.0' + Rigging loss of ht (Pythagoreum Theorem)+ 6.0'		
	+ Lifting cluthch 1.0'+ Speader Bar and shackles 3.5' = Total 23.5		
	Hook Height on Gantry = 26.0'		

Calculate total height required:

- Add the known height-loss variables
  - Truck bed (5') + Structure height (2.08') + Spreader bar and shackles (3.5') = 10.58'
- Use Pythagorian Theorem to calculate rigging height loss.
- Add all height loss and verify that the crane used will have sufficient hook height.

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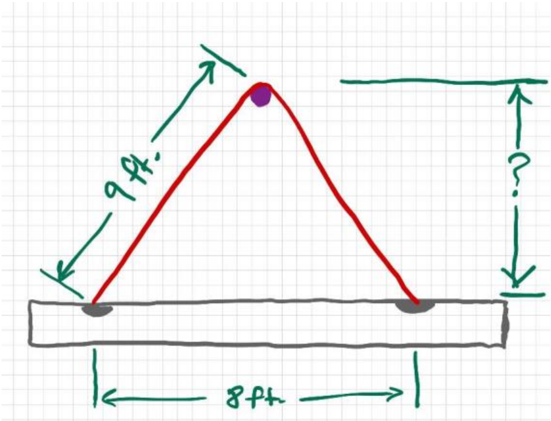
Critical lift planning

Calculate total height required:

- Use Pythagorian Theorem to calculate rigging height loss.



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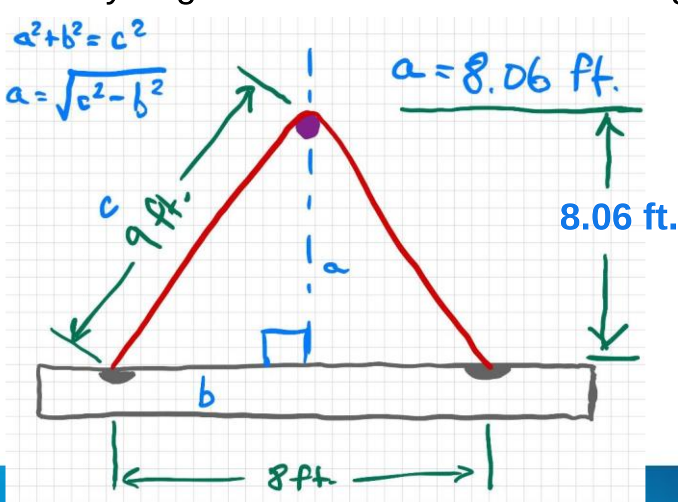
Critical lift planning

Calculate total height required:

- Use Pythagorian Theorem to calculate rigging height loss.



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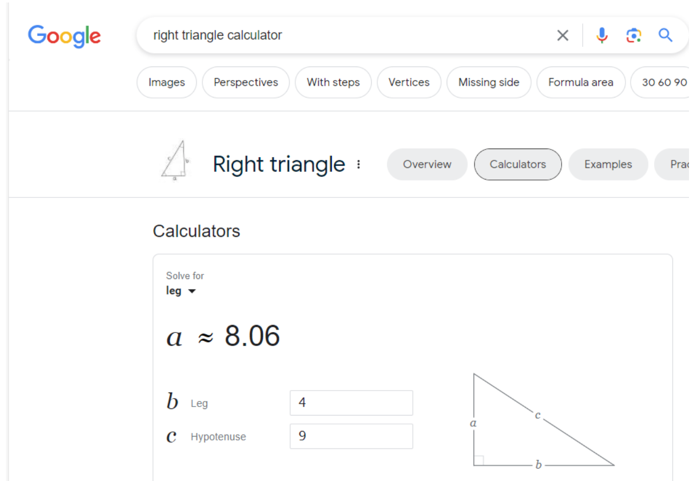
Critical lift planning

Calculate total height required:

- OR – Use a triangle calculator



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Critical lift planning

Calculate total height required:

Gainey's Rigging Inventory & Inspection

General Overview

Over-Head Crane Information		Hook Heights	Capacity (lbs.)	Trailers	Height	Length	Width	Payload
Crane	Inspection Date							
Gantry	4/22/2017	26	100,000	GCP Old Flat Bed (Plant)	4.58	39.5	8.0	50,000
25 Ton	6/17/2017	25	50,000	(#24) Freightliner Truck + #35 Flat Trailer	4.5	46	8.5	31,280
15 Ton	6/17/2017	22	30,000	(#21) Sterling Crane Trk	4.33	18.25	8.5	20,000
10 Ton	6/17/2017	22	20,000	(#34) Tag Along w/ #21 Truck	3	27.0	8.5	36,000
				(#23) Sterling Crane Trk	4.3	18.0	8	23,000
				(#37) Tag Along w/ #23 Truck	3	20.3	8.5	43,000
				(#24) FL Truck + #39 Lowboy Trailer	5' F / 4' 3" B	9' F / 28' 6" B	8.5	81,100

Spreader Bars

Spreader Bars	Type	Serial No.	Mfg Date		WLL Capacity (Lbs)	Weight	Actual Length (Ft)	Lift Height Loss (Ft)	Labeling
Black	W- 18 x 97		9/20/2016				43.92	3.5	Black
Pink	W- 16 x 50						24.12	2.62	Pink

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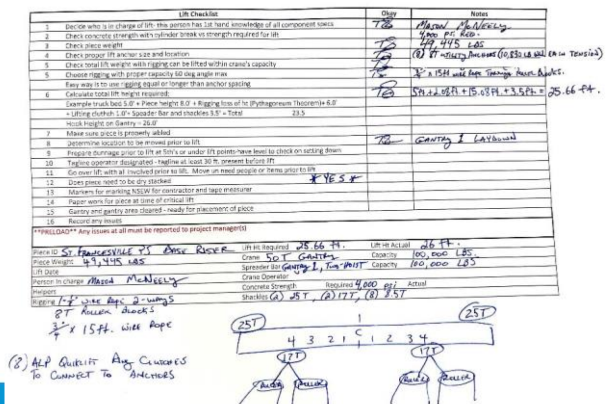
Critical lift planning

Putting it all together:

- All paperwork required at time of lift
- Cautiously share with customers

“This is how we lifted it safely”



Lift Checklist		Okay	Notes
1	Decide who is in charge of lift- this person has 1st hand knowledge of all component specs	TB	Mason McNeely
2	Check concrete strength with cylinder break vs strength required for lift		4,000 psi Req.
3	Check piece weight	TB	49,445 LBS
4	Check proper lift anchor size and location	TB	(8) 8T utility anchors (10,830 LB [illegible] each tension)
5	Check total lift weight with rigging can be lifted within crane's capacity	TB	
5	Choose rigging with proper capacity 60 deg angle max	TB	3/4" x 15ft wire rope through roller blocks.
	Easy way is to use rigging equal or longer than anchor spacing		
6	Calculate total lift height required:	TB	5ft + 2.08ft + 15.08ft + 3.5ft = 25.66 ft.
	Example truck bed 5.0' + Piece height 8.0' + Rigging loss of ht (Pythagoreum Theorem)+ 6.0'		
	+ Lifting cluthch 1.0'+ Spoader Bar and shackles 3.5' = Total 23.5		
	Hook Height on Gantry = 26.0'		
7	Make sure piece is properly labled		
8	Determine location to be moved prior to lift	TB	Gantry 1 Laydown
9	Prepare dunnage prior to lift at 5th's or under lift points-have level to check on setting down		
10	Tagline operator designated - tagline at least 30 ft. present before lift		
11	Go over lift with all involved prior to lift. Move un need people or items prior to lift		
12	Does piece need to be dry stacked *YES*		
13	Markers for marking NSEW for contractor and tape measurer		
14	Paper work for piece at time of critical lift		
15	Gantry and gantry area cleared - ready for placement of piece		
16	Record any issues		

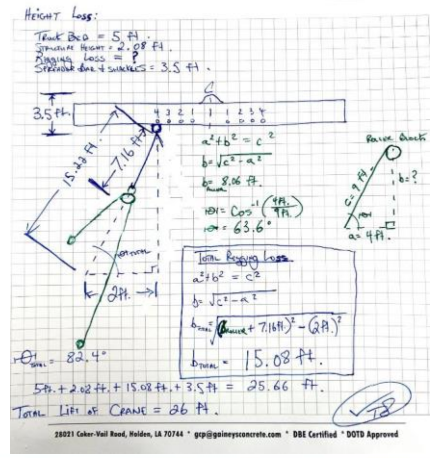
PRELOAD Any issues at all must be reported to project manager(s)

Piece ID St. Francesville PS Base Riser	Lift Ht Required 25.66 ft.	Lift Ht Actual 26 ft.	
Piece Weight 49,445 LBS	Crane 50T Gantry	Capacity 100,000 LBS.	
Lift Date	Spreader Bar Gantry 1, Two-Hoist	Capacity 100,000 LBS	
Person In charge Mason McNeely	Crane Operator		
Helpers	Concrete Strength	Required 4,000 psi	Actual
Rigging 1-3/4" wire rope 2-ways	Shackles (2) 25T, (2) 17T, (8) 8.5T		

8T Roller Blocks

3/4" x 15ft. wire rope

(8) ALP Quiklift Anchor Clutches To Connect To Anchors



Case studies – when it went wrong

I added this section to help drive home the point that any component of a lift can fail at any time.

What went wrong here?

Case studies – when it went wrong

- The wire rope broke, which sent the block and spreader bar to the ground.
- The cause was attributed to double blocking the crane.
- The upper limit switch failed sometime between the morning inspection and when this accident happened, and the operator was relying on that upper limit switch instead of watching the load with his eyes.

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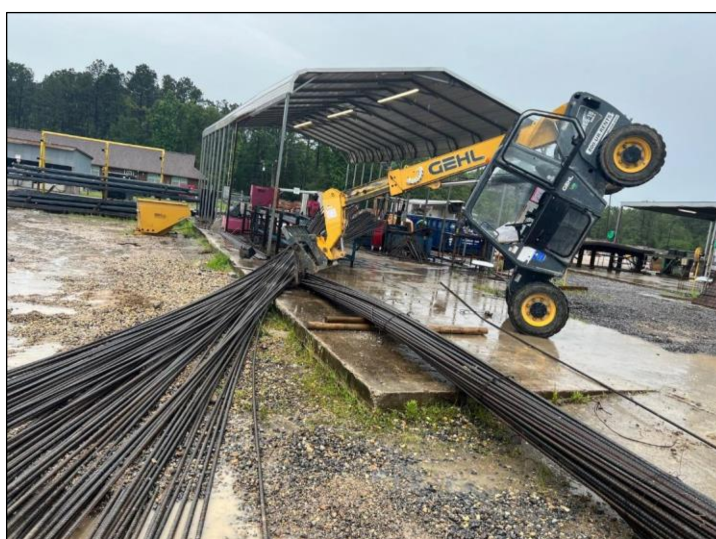
Case studies – when it went wrong

What went wrong here?



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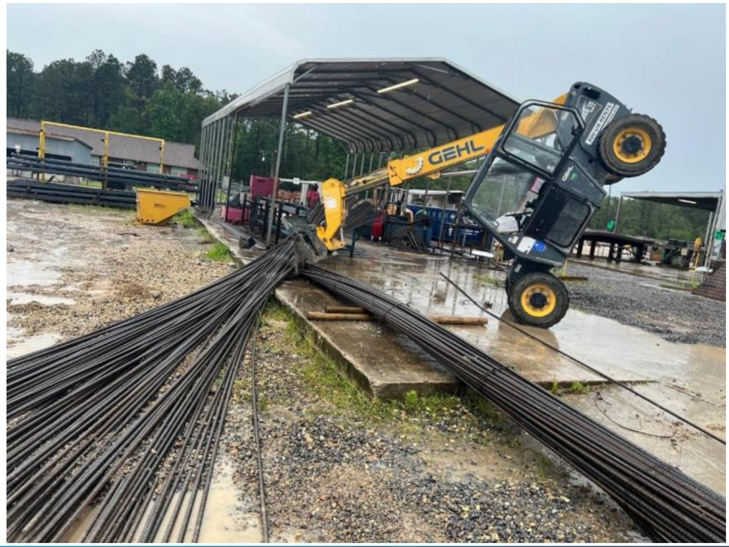
Case studies – when it went wrong

- Operator failed to know the weight of his load.
  - It exceeded the forklift before extending.
- The operator did not understand how to read a load chart.



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Case studies – when it went wrong

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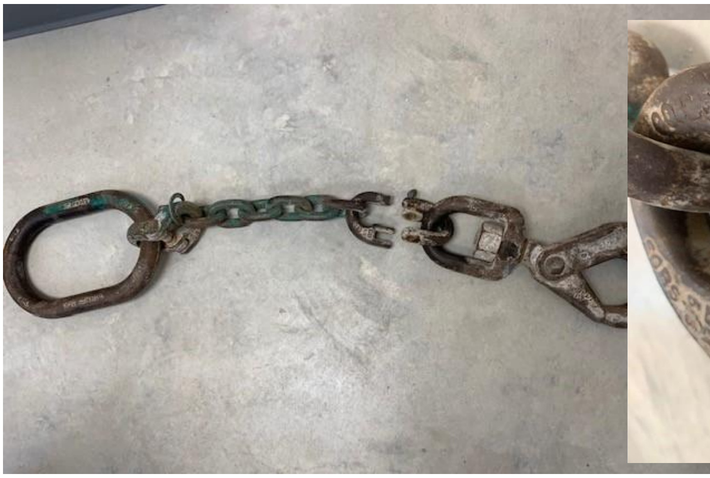
Case studies – when it went wrong



The pin holding the connecting link together sheared.

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Case studies – when it went wrong

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Case studies – when it went wrong

The anchors had minimum edge distance when originally placed, however, when the hole was cored, they lost a significant portion of their shear cone.

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Case studies – when it went wrong

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Case studies – when it went wrong

We were using shackles for this lift and our rigger didn't realize that the "ear" of the bolt was caught in between the concrete and the anchor

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Case studies – when it went wrong

What went wrong here?

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Case studies – when it went wrong

- The lifting anchors were not placed in the correct position, which led to too much tension on one anchor.
  - When one anchor pulled out, it overloaded the other anchors.

- The person who shared this said

"I'll NEVER forget hearing it hit the ground."

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Case studies – when it went wrong

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Case studies – when it went wrong

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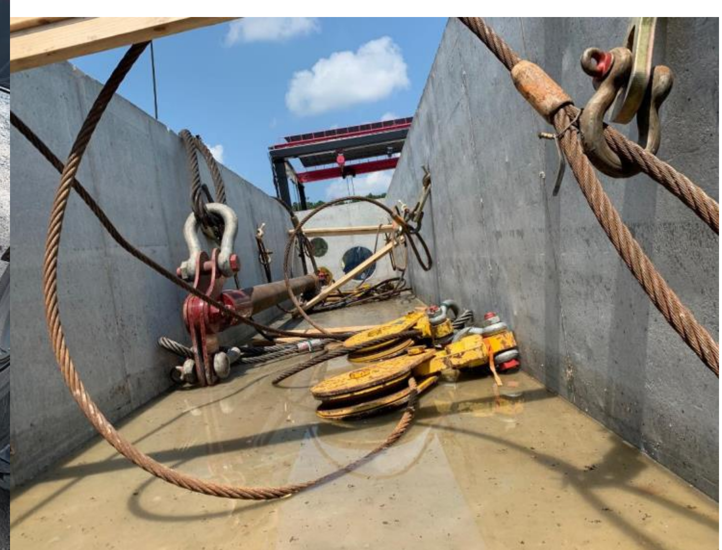
Case studies – when it went wrong



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Rigging and Lifting Considerations for Precast Producers

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