

# Evaluation of Embedded Wall Quoin Rehabilitation Methods

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# Ground rules

- ERDC funded to compare different methods for same problem for possible further application
- Compared methods NOT employees
- Document lessons learned for future
- Compare time and cost at end of job



# Quoin block function

- Bearing surface to transfer head differential load into the lock walls
- Alignment of the embedded quoin to the gate quoin is critical
- With proper adjustment the load is transferred to the wall quoin and not through the pintle

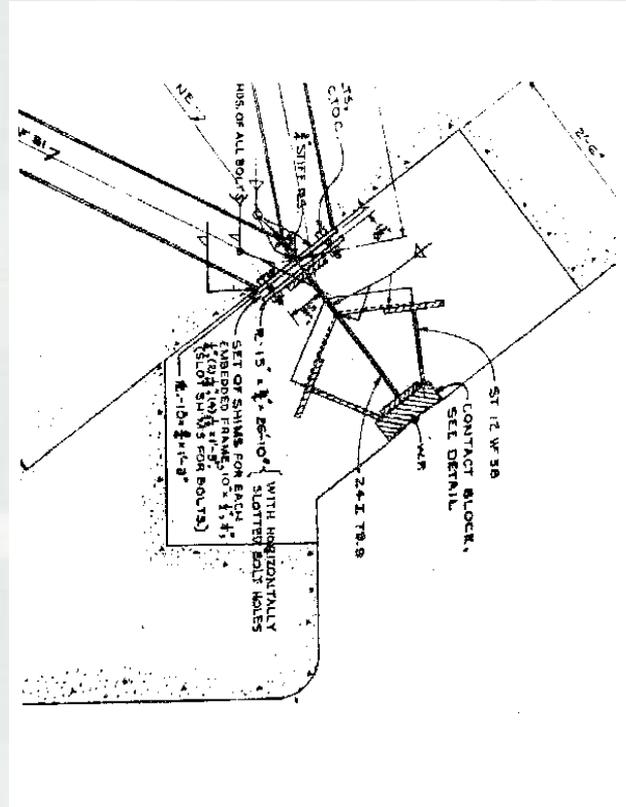


# Basic quoin block designs

- Bearing surface flush with concrete
- Bearing surface extends past concrete
- Quoin block replaceable
- Mainly used with horizontally framed gates



# Markland/Meldahl







# Common Problems

- Markland and Meldahl are projects with similar designs, similar ages, and similar levels of traffic.
- Wall quoins are embedded structural steel and flush with the surrounding second pour concrete. Non replaceable and not adjustable.
- The project design life was 50 years.
- They just hit the big five O.
- Repairs with epoxies have extended service life.



# Different Approaches

- At Markland the wall quoins were milled down for new removable replacement blocks. This required the purchase of two milling machines and replacement blocks.
- At Meldahl the second pour concrete was removed along with all the embedded steel. This required a contract for a large amount of concrete removal and the purchase of new embedded steel framing and new replaceable blocks.

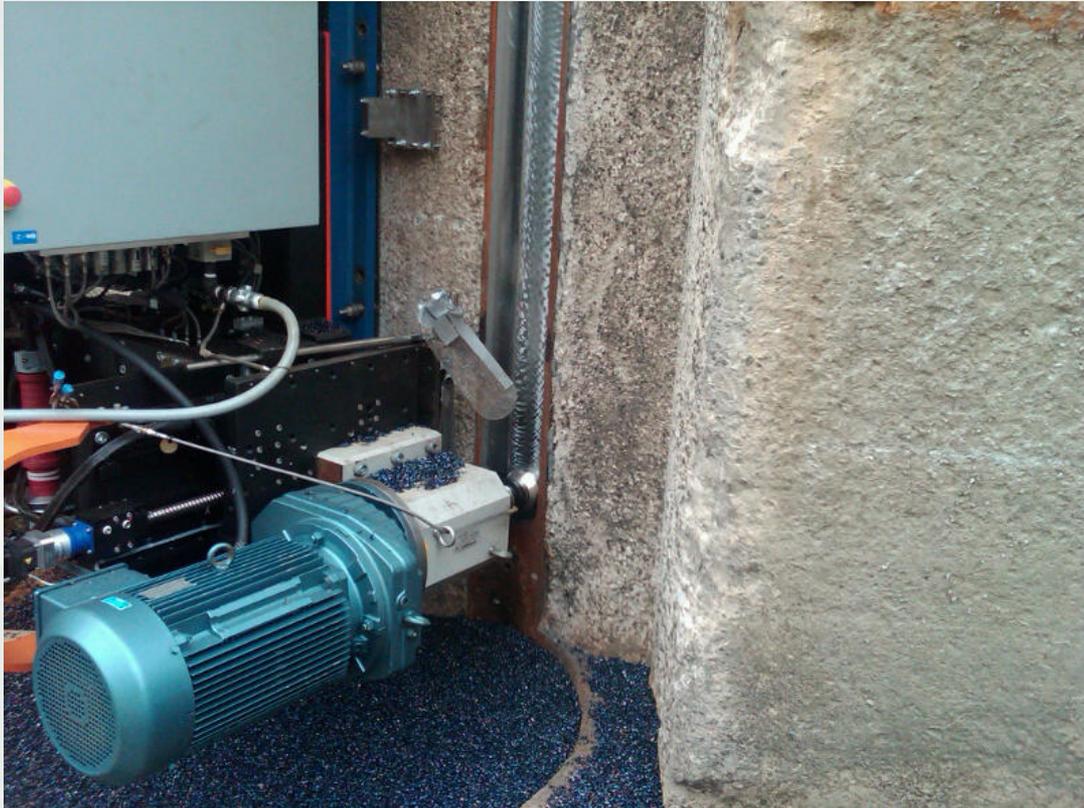


# End Result

- Both projects will have wall quoin blocks that are adjustable and replaceable in the future
- Markland's are stainless steel clad on the bearing surface and backed with epoxy
- Meldahl's are carbon steel and backed with zinc
- Both projects will have new miter gates
- Both projects will have new or refurbished anchorages
- Meldahl will now have horizontal seals



# Markland Milling



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# Wall Quoin Milling



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# Milling Complete



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# Finished Wall Quoin



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# Meldahl Concrete Removal



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# Removed Quoin Section



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# Concrete Removed



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# Finished Slot



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# New Meldahl wall quoin



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# Markland Anchorage Work

- Existing embedded anchorage reused
- Heavy riveted structure analyzed for fatigue by Louisville Engineering Division. No concerns or problems found.
- Anchorages were sandblasted, inspected for cracks and defects by NDT methods. Anchorages were painted and assembled using original style components but with improved material properties and inspection during fabrication.



# Refurbished Markland Anchorage



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# Meldahl Embedded Anchorage

- The existing concrete around the anchorage was removed and the existing structure was modified to accept a new style anchorage per Huntington District Engineering Division. This was in response to the anchor arm failure at Greenup lock.
- The anchorage at Meldahl was the same as Markland.



# Meldahl Anchorage



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# New Meldahl anchorage



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# Pintle Base Modifications

- Markland pintle bases were replaced to change to a fixed pintle and the existing bases were damaged when the gates fell.
- Meldahl bases were modified to make the pintles fixed.



# Markland Pintle Base



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# New Pintle Base



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# Meldahl Pintle Base Modification



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# Similarities

- The heavy lift crane Shreve was used to remove, transport, and install miter gates.
- Both jobs were suspended due to high water and were finished in the summer of 2012.



# Meldahl Advantages and Disadvantages

- A - Replaces all steel and permits extra rebar and structure
- A - Uses conventional equipment
- A - Contractor responsible for equipment
- D - Takes longer and dependant on contractor and procurement system
- D - Requires Corps support for contractor



# Markland Advantages and Disadvantages

- A - Milling is faster and retains existing embedded steel
- A - No contractor involvement or coordination
- D - Expensive and complicated machine to own/maintain and store
- D - Doesn't fix possible embedded issues



# Conclusions to wall quoin study

- After the winter and high water had past work resumed on the upper gates at Markland and Meldahl.
- For comparisons sake, the time required to modify the wall quoins does not include pump out or mobilization time.



# Greenup

- The Huntington District replaced the wall quoins and gates at Greenup in 2012. This is the same work done at Meldahl except with lessons learned from Meldahl. This project gives a better comparison of the time required for the two methods.



# Greenup time line

- 20 days to remove concrete by contractor with Corps assistance.
- 10 days to install embedded steel, replace concrete, install new wall quoin blocks, and pour zinc.
- The new gates were installed and adjusted after this.



# Markland time line

- Markland lower gates: set up milling machine, mill, drill, install new blocks, and remove machine took 18 days.
- Markland upper gates would have taken 14 days if the one milling machine had not gotten damaged.



# Milling machine “problem”

- At about 1 am the bolts attaching the milling machine to the vertical track broke and the machining head fell 60 ft to the bottom of the chamber and was destroyed. This resulted in a delay for investigating and to move the machine from the river wall to the middle wall.



# Milling machine “problem”

**Before**



**After**



# Final results

- There are advantages and disadvantages of each method, however, milling is faster and cheaper, based on a fleet cost of 40k per day. The replacement blocks and bolts for Markland cost \$53,000, the blocks and embedded steel for Greenup came with the new gate contract and was not priced as a separate item. I suspect over \$53k.



# Cost comparison

- Based on doing the job 10 days quicker the savings by milling would be \$400,000 per a set of gate leaves. The concrete removal cost for Greenup was \$474,000 including concrete removal for the anchorage mods. Assume half was for wall quoins, or \$237,000. The total savings would be \$637,000 by milling.



# Cost comparison (cont)

- The milling machines cost \$1.6 million to purchase. Assuming \$100,000 per year to store and repair the machines, using them on one job each year, they would pay for themselves in 4 years (two lock chambers) compared to removing the concrete. After that you still have a unique machine that can be a Corps asset.



# Other considerations

- If the milling machines were used in other Districts, there would be needed training of that Districts employees or would require setup and operation by Louisville workers.
- An accounting mechanism would need to be established. Transfer machines to PRIP? Currently owned by Markland.
- Close coordination of repair schedules.



# Questions?



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