Building the Ravenel Bridge

After all the photos I took, I've tried to arrange them in some order based on various topics I found interesting.

And a reminder from T.S. Eliot (East Coker from the Four Quartets (https://en.wikipedia.org/wiki/Four_Quartets))

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Old men ought to be explorers
Here and there does not matter
We must be still and still moving
Into another intensity
For a further union, a deeper communion
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February 11, 2005: The Freyssinet team building the last cable, 2 strands at a time

Today was a special day with Freyssinet and their magic for design, materials, installation and testing of stay cables: pulling the last strands of the last cable - Fini. For the super curious, how many cable stay strands are there in the 64 pipes supporting the New Cooper River Bridge? 6772 - and Oliver and his team counted every one of them as well as the 13544 wedges - one at a time as you will see below.

To produce such a result requires excellence. What is the first law of excellence? Anything is possible with a great team! High Steel has a great team and PBC has a great team. Here I present the great team of Freyssinet: Charleston

Looking west from the east deck (note the last floor girder, waiting for the final center edge girders to be installed) as we walked

to the east deck cable assembly area

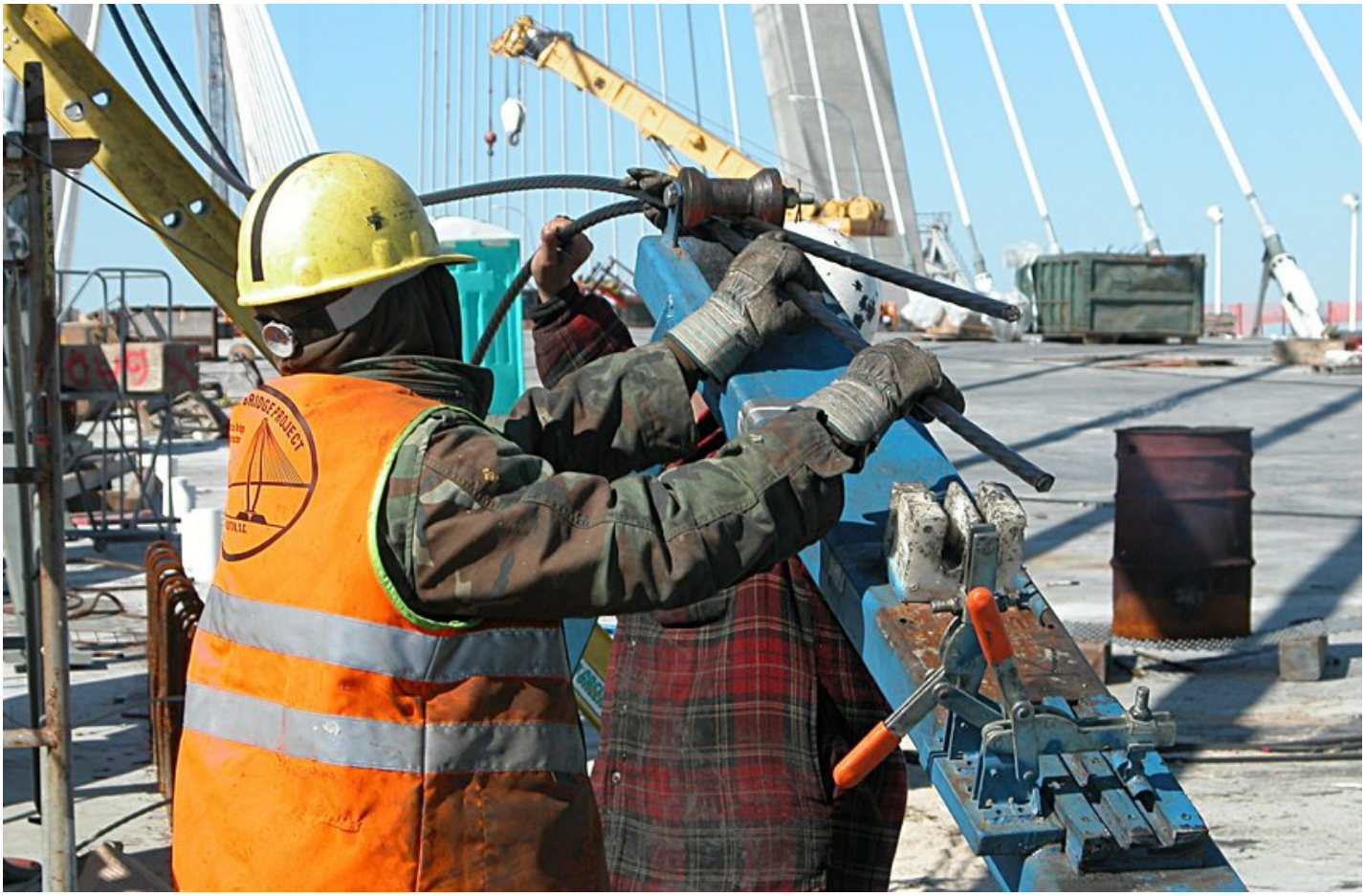
It all starts with the cable drums, from which each strand is unwound. Here is the team at work: Feeding the last two strands up the pipe

Outside the pylon, Cyril passes the cables to Cliff on the inside

Inside the pylon, Cliff works more magic and pulls the end of the cable through the anchor plate. (The hydraulic jack is seen under the cable array).

Meanwhile, back on the deck, Bruno frees the last cable pair from the cable spools

Which makes two last ends



Which must be trimmed before back pulling into the anchor stay housing or pulling up the stay pipe

Which requires Bruno's magic touch, feeding the last leader up the pipe

Which requires another of Bruno's magic touch to pull the last leader with the attached cable down the pipe

Then pulling the cables through the anchor plate and placing the last wedge on the last cable

Then seating the last wedge

And here is a perfect result; every strand in its place - can you identify the master strand?

The static images capture only part of the story. Here are a few video segments (16 Mb, quicktime) that bring motion to feeding the strands up the pipe, trimming the ends of the strands and back-pulling the strands through the anchor plate.

- Feeding the last two strands up the stay pipe (https://s3.amazonaws.com/s3.ravenelbridge.net/video/feb_11_final_pull.mov)
- Cutting the last two strands (https://s3.amazonaws.com/s3.ravenelbridge.net/video/feb_11_last_cut.mov)
- Trimming the ends of the last two strands (https://s3.amazonaws.com/s3.ravenelbridge.net/video/feb_11_last_trim.mov)
- Back pulling the last two strands through the anchor assembly (https://s3.amazonaws.com/s3.ravenelbridge.net/video/feb_11_last_wedge.mov)

Meanwhile, the Cyril and Philiu are cleaning up their small nests

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_pylon_cleaning_up.jpg)

and finally the stay-cable ends are injected (Meanwhile, back on the west pylon, the week before)

March 22, 2005: West Pylon

Final injection of cable terminations

It all starts at the top - heating 55 gallon drums of wax to about 120 C and requiring 24 hours of heating. Its a rather big job requiring 32 drums per tower (West and East) or 1760 gallons of wax for the top anchorages of one tower. Here you can see the heating coils that have been working overtime since yesterday in order to convert solid wax into liquid wax.

Left is a view of cold wax while on the right is hot wax, ready for pumping

Here is the pump for passing the wax to the cable-stay stations below. The delivery hose is 155 feet long and imagine what happens when there is an internal block. Makes keeping coronary arteries clean seem pretty simple. But for homework, think about how to finish each day - primarily flushing the delivery tube so that when it cools, there is no wax inside to create an obstacle.

Here the bundle of strands is capped. The copper pipe at the top allows displaced air from inside the cap to escape. The lower snap-on connection is for attaching the wax delivery pipe. Crescencio is patiently waiting for the wax to start flowing. Prior to injecting the wax, the stuffing box for each anchorage is closed in order to prevent any leakage into the stay pipe.

and so we wait while approximately 100 L (depending on the number of strands in the cable) of wax is delivered.

When all is finished, the air pipe and injection point are removed and capped.

April 23, 2005

Its not all over until its over. Here is some finish work, that of building forms for the final anchors that anchor the anchor to the deck. As you can see, the steel fin that transfers stress from the cable anchor assembly to the edge girder is only a couple of inches thick. To add mass to the anchor assembly in order to further strengthen the cable anchor with respect to lateral stresses, a reinforced concrete box is added to the assembly. For cables close to the main pylons, there is less lateral stress than the stress associates with cable movement of the longer cables. Hence the further away from the pylon, the larger the stabilizing concrete support.

Initial rebar for a big anchor (left) and a small completed anchor (right)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/apr_23_stay_anchor_start.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/apr_23_stay_anchor_final.jpg)

Here is a completed form for one of the longer cables, ready for filling with concrete

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/apr_23_stay_anchor.jpg)

April 30, 2005

Some more finish work, that of building and pouring the anchor supports. Note also that the bicycle-motor barrier is complete.

Completed anchor structure

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/apr_30_stay_anchor.jpg)

Here is a initial rebar for the anchor structure, ready for enclosure.

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/apr_30_stay_anchor_rebar.jpg)

May 7, 2005: Installing cable dampers
These dampers absorb some of the stay pipe vibrational energy - a result of changes in wind load or load on the span.

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_07_damper.jpg)

May 14, 2005 Continuing installation of the external dampers

North side of the west span

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_damper_north.jpg)

South side of the west span

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_damper_south.jpg)

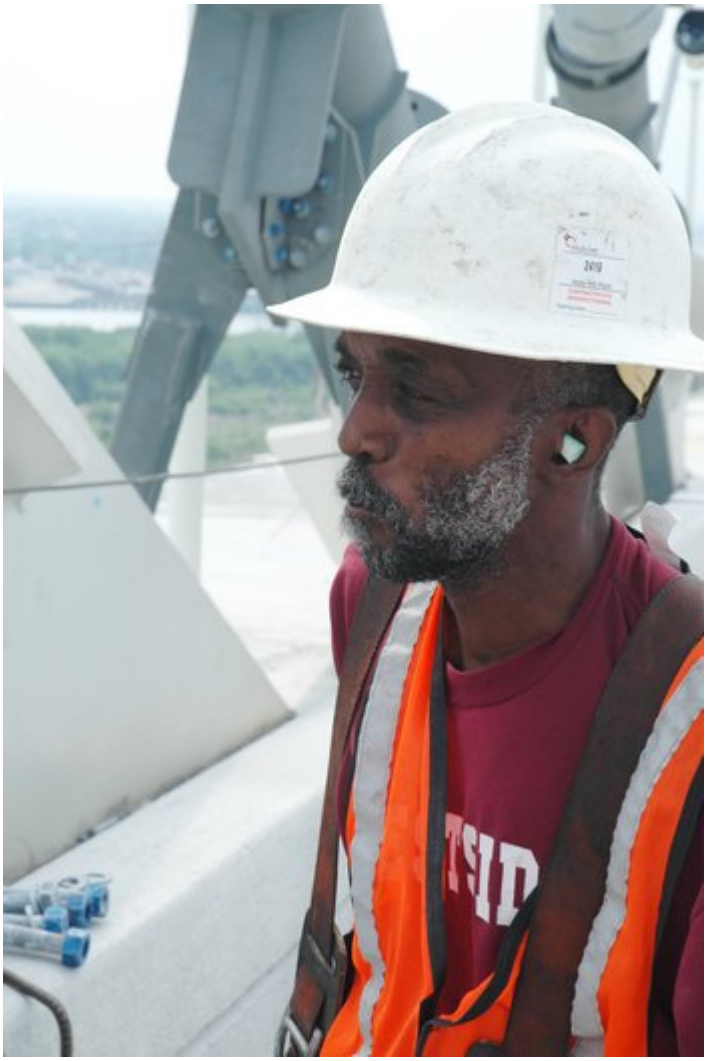
May 14, 2005

Drilling holes to anchor the base of the stay cable anchor support

Wilbur never ceases to susprise me. This afternoon when I visited the bridge, Wilbur hollered at me. Walking over, I saw that today, he was not Wilbur, the iron worker, not Wilbur the hydraulic man, not Wilbur the forklift driver, but here was Wilbur the hole driller. I had watched the High Steel guys drill and ream the bolt holes for coupling the center edge girder to the east and west span edge girders. Here, Wilbur and his coworkers were drilling holes to anchor the stay pipes. I asked how the bolts would be stabilized in these holes - and Wilbur's answer - we use red epoxy - so I made a photo of this also.

Here is Wilbur and one of his coworkers

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_wilbur.jpg)



(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_wilbur_worker.jpg)

Here is another coworker and Wilbur making holes under the footing of the stay cable support.

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_wilbur_drilling.jpg)

Here is Wilbur - and a view (right) of the stay pipe stabilizer

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_wilbur_working.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_damper_all.jpg)

And here is shown the red epoxy used to bond the bolts to the concrete wall of the holes that Wilbur drilled.

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_14_red_epoxy.jpg)

May 20, 2005: External dampers finished

North side

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_20_damper_north.jpg)

South side

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/may_20_damper_south.jpg)

June 10, 2005: Final touches - painting the anchor assembly

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/jun_10_anchor_painting.jpg)

Now for some of the team members

Cliff, the inside man in the pylon, works with his magic tensioning machine while the outside team on the deck works their magic

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_pylon_team.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_deck_team.jpg)

Eduardo and Louis

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_eduardo.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_louis.jpg)

Crescencio and Cliff

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_crescencio.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_cliff.jpg)

Philou and Nico

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_philou.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_niko.jpg)

Oliver and Pavel

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_oliver.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_pavel.jpg)

Fernando and Bruno with Nico

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_fernando.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_bruno.jpg)

David and Jose' with Yolanda

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_david.jpg)

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_true_love.jpg)

A PBC guy, Philou, Yolanda, Fernando and Bruno

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_group.jpg)

And another taste of the greatest guys

(https://s3.amazonaws.com/s3.ravenelbridge.net/large/feb_11_team.jpg)

And a taste of Charleston: a view from the top

And a view of where I work: MUSC

And a view of the SC Aquarium and where I record my bridge data each weekend

And a taste of the bridge (February 11) from the top of the east pylon, looking west

And a better taste 6 weeks later (March 29), from the top of the east pylon. No gap, no west tower crane - just a continuous structure.

C. Frank Starmer

_ (http://butterfat.net/mySiteMaker/html_resources_ravenel_search.html)