

Bohai Shipyard Expansion *New Assembly Line or Nuclear Submarine Production?*



Christopher Carlson
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Bohai Shipyard Expansion

New Assembly Line or Nuclear Submarine Production?

- ◆ Since mid-August 2016, there have been numerous articles and webpage postings claiming the new assembly hall, built in record time at the Bohai Shipbuilding Heavy Industry Company (BSHIC) shipyard in Huludao, will produce the next generation of Chinese nuclear submarines – the Type 095 and 096.
- ◆ Many Chinese and Western writers have been quick to uncritically echo this claim and have aggressively pushed the issue in their articles/postings – essentially accepting the speculative assumption as true without doing any basic legwork to verify whether or not the claim is legitimate.
- ◆ This presentation will summarize the analysis of a review of Google Earth imagery taken over the course of the new assembly hall's construction to see if it indeed has the physical capability to build nuclear submarines as claimed.



Bohai Shipyard Expansion – In The Beginning



19 January 2014: At this time, the area of interest is part of Liaodong Bay in the Bohai Sea. Land reclamation and multiple sets of retaining walls begin construction by mid-2014 at the latest. The larger of the two 300,000 deadweight ton (DWT) graving docks was completed in early 2008, the smaller one with the adjacent shallow slipway was completed in late 2010.

Bohai Shipyard Expansion – Land Reclamation



12 December 2014: A considerable amount of new land has been added and the permanent retaining walls are under construction. Historically, Chinese engineers have used sand as the backfill material; usually dredged from the sea floor.

Bohai Shipyard Expansion – Land Reclamation



1 January 2015: The permanent retaining walls are finished and the last bit of the land reclamation effort is wrapping up. Construction equipment and some materials have been prepositioned.

Bohai Shipyard Expansion – Foundation Work



1 January 2015: Foundation work preliminaries. Pile drivers are to the northeast and northwest (out of view). To the south there is a large number of cube-shaped objects. The objects are about 1-meter square and could be individual reinforced concrete pile caps or pallets loaded with bags of concrete mix.

Bohai Shipyard Expansion – Foundation Work



- Preparations for foundation construction have been started on the newly placed dredged sand. There are potentially as many as 24 pile drivers in the vicinity of the build site. Tests runs may have been conducted as there appears to be broken piles to the east.

Bohai Shipyard Expansion – Foundation Work



- The piles appear to be made of concrete. They are about 15 meters in length and between 0.5 – 0.6 meters wide. These dimensions are consistent with Chinese manufactured reinforced concrete, solid square piles. Later imagery photos show the piles are square shaped. Estimated compressive strength is between 30 and 40 megapascals (4,350 to 6,000 psi) based on Chinese product information and published national standards. This very roughly equates to an axial load bearing capacity between 100 and 150 metric tons.

- Given the piles' rather short length, they are undoubtedly friction piles. That is they provide support to the foundation slab through friction forces with the soil – the piles don't rest on bedrock. The piles would also help to stabilize the newly reclaimed land as it is neither firm nor stable. As sand is a coarse grain, non-cohesive soil the use of friction piles is an accepted method of building a deep foundation. This type of pile is noted on Chinese product websites as having long life, good corrosion resistance, good performance in water and is well suited for use in industrial plants, embankment walls, bridges, port facilities and other coastal building projects.

Bohai Shipyard Expansion – Foundation Work



- The cube-shaped objects are about the right size, on the order of 1 meter square, to be pre-cast, reinforced concrete caps for individual piles.
- An alternative possibility is that the objects are a collection of pallets with concrete mix stacked on them to be used in the pouring of cast-in-place pile caps.
- Pallets of concrete is the preferred assessment as the deep footing pile caps were cast-in-place and it is more convenient and less expensive to do the same for the individual slab piles as well.
- Regardless, the timing of the disappearance of the objects indicates that they are related to the construction of the building's deep foundation.



Bohai Shipyard Expansion – Foundation Construction Begins



6 June 2015: Land reclamation completed. Piles for the slab foundations and support footings are in place. There is a significant reduction in the number of prepositioned objects – probably pallets of concrete mix – to the south. This indicates they are being used in the building of the deep foundation.

Bohai Shipyard Expansion – Foundation Construction



6 June 2015: Construction of a deep foundation with numerous concrete piles. This level of foundation support indicates the building is designed to bear at least moderate loads. The depth of the foundation's concrete slab doesn't appear to be very thick based on the height of the form and the lack of any excavation.

- The deep dug out areas are for footings for the building's structural support frames with pile caps at least a meter thick, if not two. The shallow dug out areas are for individual cast-in-place pile caps to support the foundation's slab and stabilize the new soil.

Bohai Shipyard Expansion – Foundation Slab Construction



- There are eight piles in each row, with the spacing between piles being about 4.5 meters. The spacing between rows is the same, although, some are closer. This spacing is consistent with compaction piles that are designed to densify and stabilize the soil. By keeping the piles at a distance of $6 - 8 \times s$ (where s is a square pile's side length or width) the areas of highly stress compacted soil generated by each pile do not overlap. This helps increase the load bearing capacity of the weak sandy soil while at the same time reduces uneven settling. However, as the piles are spaced rather far apart, the foundation will not be capable of supporting very heavy loads.
- Normally individual piles are not capped – capping is designed to help distribute compressive loads to multiple piles within a group. However, Chinese engineering texts suggest that capping individual piles has some benefit in areas with liquefiable soils and a history of seismic activity. Both of these conditions affect the reclaimed land this new assembly hall is built on.

Bohai Shipyard Expansion – Foundation Slab Construction



- By comparison, the deep footings for the structural supports also have eight piles but they are much closer to each other, about 2.5 meters apart. The distance between the piles is close to the minimum spacing requirement, $3.5 - 4.0 \times s$, specified in the Chinese standards for building pile foundations and is consistent with U.S. building practices. These piles are also grouped together and will be covered by one thick pile cap, indicating that they are designed to work together to support a very heavy load.

Bohai Shipyard Expansion – Foundation Slab Construction



12 July 2015: The foundation slabs for three production bays are well along. It appears that each slab is poured in two layers. Each production bay slab is about 276 meters long and 33 meters wide.

Bohai Shipyard Expansion – Foundation Slab Construction



- The slab foundation appears to be poured in two layers – a third thin finishing layer would be added after the exterior was completed. The total thickness of the slab is difficult to estimate, but it appears to be much less than one meter. The lack of any significant excavation, indeed fill material was brought in, and little to no shadow indicate the slab is near ground level.
- The deep footings for structural support frames at the east side of the building effectively block that end. Only relatively small items would be able to come through the possible 7 - 8 meter wide door way.

Bohai Shipyard Expansion – Building Construction



16 May 2015: Ten months later, work on the the building's exterior is progressing nicely and the interior gantry cranes have been installed in the three production bays. Gantry cranes would require the deep structural support footings seen earlier as the weight of the crane as well as its payload have to be borne by the building's frame.

Bohai Shipyard Expansion – New Assembly Hall Near Completion



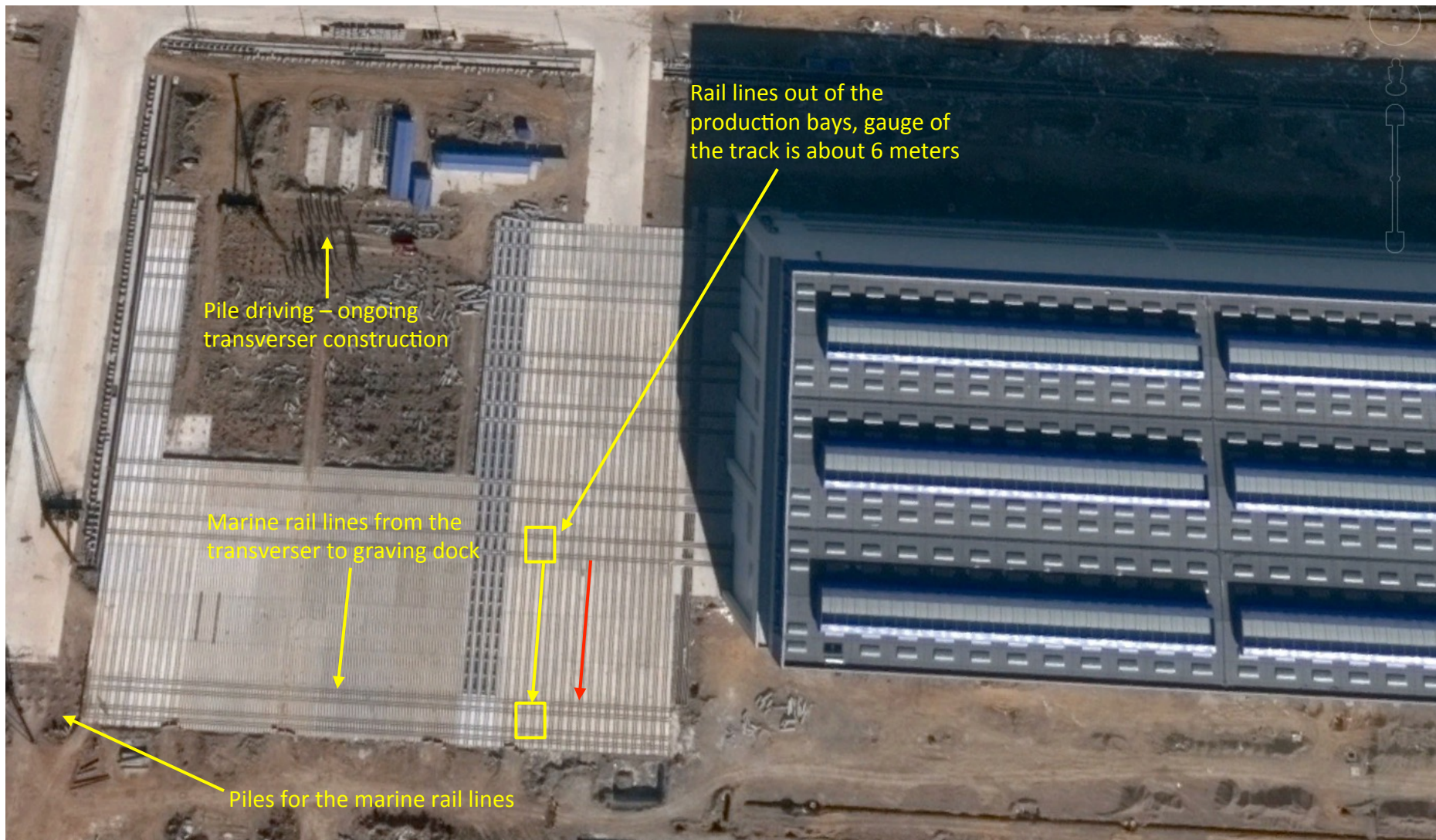
18 June 2016: The new assembly hall is nearly completed; there is still work to be done on the roof. Construction of a rail-based transverser system has begun. The transverser's deep foundation appears to be the same as the production bays; meaning the transverser will have the same overall load bearing capacity. There are two rail lines coming out of each production bay on the west side of the building.

Bohai Shipyard Expansion – New Assembly Hall Traverser



5 February 2017: The new hall's exterior looks completed. A second new building is well into the framing stage. Of note, there was no evidence of a deep foundation for this building – no piles other than those in the structural support footings. This suggests a shallow raft type foundation, or even just a concrete slab on grade, and will not be able to support the same loads as the assembly hall. Two sets of rail lines lead from the transverser to the graving dock, construction of these rail lines was noted beginning on 16 May 2016 imagery. The 500 meter length of the marine railway to the graving dock is quite long.

Bohai Shipyard Expansion – New Assembly Hall Traverser



5 February 2017: Transverser construction is ongoing. There are two rail lines for each production bay. Completed objects will be rolled out and then “transversed” or rolled sideways along the perpendicular rails. Each production bay has two sets of rails, but only one set can access the transverser at a time due to the bay door’s construction. A single production bay rail line has a gauge of about 6 meters. This matches the inner two of the four rails heading to the graving dock. The outer rails are probably for prime movers that will push structural cradles on wheeled bogies carrying completed objects to the graving dock.

Bohai Shipyard Expansion – Rail Lines to Dry Dock



- Once a completed item reaches the 300,000 DWT dry dock, it will have to be physically lifted off the structural cradle and placed in the graving dock itself or in the adjacent slipway by the gantry crane. The approximate 6 meter thick reinforced concrete graving dock wall completely blocks direct access to the slipway and thus, the graving dock.

Bohai Shipyard Expansion – Slipway



- The lack of rail lines in the slipway itself indicates that completed items weren't intended to be rolled directly from the assembly hall into the slipway. In addition, the depth of the slipway is very shallow. The graving dock itself has a depth of 12.75 meters based on information on the BSHIC webpage. Comparing the two in satellite imagery shows the slipway has a maximum depth of 3.5 to 4 meters – far too shallow to float a submarine off of its support cradles. Without a dedicated path to transfer a completed vessel from the marine rail line to the graving dock, the only way in is by the gantry crane – and then only up to the crane's lifting capacity of 600 tons. This means only sections of a large ship's hull, or grand blocks, can be moved into the dock.

Bohai Shipyard Expansion – Is this a Submarine Construction Hall?

- ◆ The analysis of satellite imagery evidence available on Google Earth argues strongly *against* this new construction hall having a role in nuclear submarine production.
 - The foundation of the new building is insufficient to support the weight of a completed nuclear submarine
 - The foundation's pile configuration is designed primarily to stabilize the newly placed dredged sand to improve its load bearing capability and to mitigate uneven settlement.
 - The foundation slab is also rather thin for supporting the weight of a large, heavy vessel. A thickness of a meter, or more, is usually needed to bear such a huge load.
 - *The design of this foundation can support objects that weigh several hundred tons, but not several thousand tons*
 - The marine rail line foundation is constructed similarly to the assembly hall and would be unable to support the weight of a completed submarine.
 - The lack of access to the slipway at the other end of the marine rail line precludes a large completed vessel from being transferred to the graving dock – only hull sections, or grand blocks, up to a maximum of 600 tons can be moved by the gantry crane from the marine rail line to the construction graving dock.
 - The ≈6 meter thick reinforced concrete graving dock wall at the end of the marine rail line completely blocks direct access.
 - The lack of rails and the shallow depth of the slipway make it impossible to transfer a submarine to the graving dock.
 - BSHIC's current submarine assembly hall across the bay has a 50,000 DWT capable lifting dry dock that has been used to launch nuclear submarines since the first Type 091 Han class was launched in 1970. A similar arrangement would be necessary for the new assembly hall to produce submarines.



Bohai Shipyard Expansion – What is this Assembly Hall for??



17 August 2016 Press Release



BSHIC Production Capacity Webpage

- ◆ This new building is most likely a block assembly hall for large high-tech, high value added merchant ships, such as high TEU container ships, LPG and LNG tankers, etc., and is part of BSHIC's strategy to implement the Medium and Long Term Development Plan for Shipbuilding Industry 2006-2015
- ◆ Numerous Chinese websites like to compare a photo from the August 2016 press release of one of the new assembly hall bays with a Western submarine production hall; with the posters claiming that they look identical.
- ◆ Truth be told, an assembly hall looks pretty much the same on the inside regardless of what is built in it. A better comparison, however, would be to show the new assembly hall alongside a current BSHIC facility that produces hull block sections for large bulk cargo merchant ships and VLCC tankers.
- ◆ The new assembly hall differs from the one completed in 2008 in that the former has to use a marine railway to transport the grand blocks due to the unusually long distance to the 300,000 DWT graving dock.

Bohai Shipyard Expansion – Possible High Value Ship Work Flow



Panel Fabrication

Steel Plate Pretreatment

Block Transfer

Hull Assembly

Block Assembly