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Russia's Sakhalin II Gravity Base Structures Stand As Triumph of International Cooperation

Vostochny Port, Primorsky Kray, Far East Russian Federation (June 5, 2005) -- Challenging the experts' position that mammoth oil and gas projects cannot be fast-tracked, an international construction team is nearing completion of the $1 billion Sakhalin II Phase 2 concrete gravity base structures (CGBS) near Vladivostok. The two offshore drilling and production structures, Russia's first, will be towed 1,000 miles across the Sea of Japan and installed nine miles off the northeast coast of Sakhalin Island in June and July, just fourteen months from initiation of construction.

With a total cost of $10 billion, Sakhalin II Phase 2 represents the largest foreign investment venture in Russia's history. It is also one of only three CGBS projects since the last of the Condeep North Sea platforms was completed 1993. The owner, Sakhalin Energy Investment Company (SEIC), is a venture of Dutch oil giant Shell and Japan manufacturers Mitsui and Mitsubishi. Reserves of approximately 1.2 billion barrels of oil and 20 trillion cubic feet of gas will be developed, primarily for the Asian Pacific market. Although 18 years in the making, the project and its investment reflect today's rising oil prices and rapidly growing demand for LNG worldwide. Many involved in its construction say it marks the beginning of resurgence in offshore developments reminiscent of the boom of the 1970s and '80s.

The overall project includes the construction and installation of the two new CGBS platforms, an onshore oil and gas processing plant, two 107-mile-long, 20-inch-diameter oil and gas pipelines from landfall to the plant, a 9.6 million-ton-per-year LNG plant and export terminal at the southern end of Sakhalin Island, and two 400-mile-long, 20-inch-diameter oil and gas pipelines connecting the onshore plant with the LNG terminal.

Norwegian contractor Aker Kvaerner Technology AS, Oslo, is providing design engineering and project management services for construction of the platforms' massive concrete caissons and asymmetrical four-legged support structures. The Aker Kvaerner project team consists of many key personnel from what was formerly Norwegian Contractors, the dominant designer and builder of offshore platforms from the 1970s through the early 1990s. Other major team members include QuattroGemini OY, an Espoo, Finland-based contractor with a strong Russian presence and history, mechanical outfitter RR Offshore OY, Ulvila, Finland, slipforming contractor Gleitbau Ges.m.b.H., Salzburg, Austria, and post-tensioning contractor Schwager Davis Inc., San Jose, California. According to several sources involved in the project, the overall teaming marks a reunion of hundreds of experienced key personnel from the frequently-referenced "Golden Days" of the North Sea Condeep accomplishments.

Long List of Challenges

Despite Aker Kvaerner's experience with CGBS projects in the North Sea and elsewhere, engineering and construction of the Sakhalin structures posed a number of challenges that required rethinking of conventional design. Each of the structures is designed specifically for the ocean current, seasonal icepack and seismic activity of the location in which it will be placed. "These structures are not of the tall, uniform Condeep design," explained Hans Hitz, former Norwegian Contractors engineer and current SDI post-tensioning project manager. "Sakhalin's are designed for shallow water depths, have no oil storage facilities and extremely heavy topsides. Plus they must withstand the region's seismic activity, large waves and flowing icepack that averages ten feet thick for six months of the year. So what you see are shorter, thicker, more angular tower shapes and overall structures that are heavily reinforced and post-tensioned to withstand the forces. Shorter, yes, but they are by no means small, or easier to build."

In the early phases, simply providing the optimal design proved challenging. "The heavy seismic and icepack conditions clearly pointed to a concrete gravity base solution," said Guido Schwager, SDI president. "However at first it was an uphill battle against the power of steel. The organized steel industry, whether local or worldwide, is much more influential than the relatively loose alliance of independent concrete contractors operating around the globe. But the means for concrete to provide the most Russian content tipped the scales in our favor."

According to Gleitbau project manager Vinzenz Fuchs, the unique design of the topside support towers entailed the most complex geometries ever achieved by the slipform method. "Inclination of the main axis of the shafts to more than 20 degrees from vertical, then transitioning back into vertical, localized blisters of wall-thickness varying from 27 inches to 7 feet over a given radius, and localized internal wall thickness increases from 27 inches to 19 feet and back have been the most challenging part," he stated. Our engineering team had to create the correct formwork adjustment list to accomplish those geometries and then it had to be performed precisely in the field."

Adding to the technical complexities are a host of unusual environmental, cultural and bureaucratic challenges. "The site in Siberia is about as close to the middle of nowhere that one would care to build in," observed Schwager. Winter temperatures can dip to -40°F at the site and the nearest city and commercial airport is three hours away in Vladivostok. "If you run out of duct tape, it will take at least ten days to get more so everything requires planning down to that level. Experience, communication and coordination between parties have to be exceptional, even though language barriers are everywhere. To successfully fast-track a project of this size in this location, with a ten-month non-stop concrete pour proceeding at forty below using unskilled Russian-speaking labor is more than impressive. I don't think it could be done by any team other than this one." Other parties agree that the project is no cakewalk. '"The familiar technical challenges of 'bigger, faster, cheaper, safer' - the more conventional issues of major offshore endeavors - are further compounded by local content requirements and contractual and regulatory regimes reflecting the industry's first big leap into Russia," said Roger Swaine, project manager for topside designer AMEC, London. "Everything … extrapolates existing design technology to well beyond existing limits."

In order to meet the required Russian content of 70% for material and man-hours, Russian labor subcontractors have been responsible for activities such as building the casting basin and site facilities, prefabrication of mechanical outfitting, concrete construction labor, rebar and post-tensioning labor, and material delivery including cement, steel, sand and aggregate. At its height in September 2004, the project workforce contained over 2,400 people. Currently, Sakhalin Energy executives state that 85% local content has been achieved.

Fast-Track from the Start

Following design and engineering throughout 2002 and most of 2003, QuattroGemini began work on the casting basin and site facilities in December of 2003. The casting basin required the excavation of 42.4 million cubic feet of mostly-frozen soil to accommodate the two structures. The basin, which is flooded upon completion to allow tow-out, measures 1,082 feet x 721 feet and was dug to a depth of 50 feet below sea level. Site facilities included hundreds of offices, a cafeteria for the 2,500-person labor force, medical clinic, social areas, a concrete batch plant and silos, prefabrication areas for rebar, post-tensioning and formwork, mechanical maintenance areas and warehousing. After only four months, the basin and facilities were complete and work began on the CGBS.

Although differing slightly in tower height and geometry, the two CGBSs – named LUN-A for the Lunskoye field and PA-B for Piltun-Astokhskoye field – are similar in shape and size. Both structures consist of a base caisson measuring approximately 300 feet square and 50 feet high that is heavily reinforced and post-tensioned, and four cylindrical, vertically post-tensioned concrete towers. The maximum diameter of the towers measures just over 65 feet. LUN-A has a maximum total height of 236 feet, while the height of PA-B tops out at 177 feet. The total weight of both structures is some 218,000 tons, utilizing 81,000 cubic yards of concrete and 32,500 tons of reinforcing steel.

Work on the two concrete caissons began in March of 2004 with the placement of the base slab rebar and formwork for the hundreds of internal cell walls necessary for controlled ballasting of the structures. Slipforming began the following May and required 3,300 lineal feet of formwork and 500 hydraulic jacks. The 50-foot- high walls were poured at a rate of four feet per 24 hours. The base caissons were completed in mid-November of 2004. As the caissons' top slabs were installed the much more complex slipforming of the eight support shafts commenced, beginning with the first in September of 2004.

To address the irregular, asymmetrical geometries of the topside support towers, slipforming contractor Gleitbau developed and supplied all-new formwork, utilizing a conventional yoke system along with the company's patented conical system. "For a good part of their lives these structures are ocean-going ships, and require similar licensing and insurance coverage", said Fuchs. "The structural requirements for ballasting make the concrete practices all the more demanding. Nothing less than a perfect monolithic structure is acceptable."

Slipforming of the caissons and eight tower shafts was complete in February 2005. The total formed area of the two CGBS exceeds 1.2 million square feet.

Post-Tensioning Operations

The massive compressive forces imparted by the post-tensioning of an offshore CGBS are vital to achieving the structural strength and watertight performance necessary for the ocean tow-out, ballasting and long-term service. Accordingly, the post-tensioning is always among the most scrutinized subcontracts for an offshore structure, while in the pt industry an offshore platform contract represents the pinnacle of qualification and achievement. For post-tensioning contractor Schwager Davis Inc. (SDI), San Jose, CA, it's been a quick ride to the top. The Sakhalin project is only the company's fifth post-tensioning contract, of five that it has bid, following its most recent for the San Francisco-Oakland Bay Bridge Skyway that ranks as the largest pt contract in U.S. history. Sakhalin has the distinction of being the first post-tensioning project in Russia to be performed by a U.S. firm.

According to SDI's Schwager, the key to the company's rapid rise is simple pencil sharpening, both on the drawing board and on the spreadsheet. "Smaller is better in the post-tensioning business", he said. "Smaller, lighter anchorages are easier to place, especially in areas of congested reinforcement, and also cost less. So we looked at today's high-strength concrete, designed a new and more compact anchorage system to take advantage of that, went through testing & approval and entered the market. Technically, I attribute our success to the fact that we were able to start from a blank sheet of paper and weren't saddled with a system that began its evolution forty years ago."

Post-tensioning of the Sakhalin structures required a total of 2,100 tons of steel, using tendons made up of bundles of 0.6-inch diameter high-strength steel strand and SDI's new bearing plate and anchor head. The slabs of the caissons were post-tensioned in both directions using a total of 376 19-strand tendons with an average length of 330 feet. The tendons were assembled by pushing individual strands through galvanized duct that was placed inside the slabs prior to concreting. Due to their long lengths, the tendons were stressed from live anchorages at both ends using 600-ton capacity hydraulic jacks. The maximum stressing load is 3,775 kN. All tendons were installed, stressed and grouted in a period of only one month for each structure, finishing in December of 2004.

The eight hollow-core support towers are currently being vertically post-tensioned by a total of 800 site-fabricated tendons, each made up of bundles of twenty-two 0.6-inch strands. The pre-assembled tendons are hoisted by tower cranes and then fed down into the galvanized steel duct embedded in the tower walls. Unlike the slab tendons that contain live stressing anchors at both ends, the vertical tendons, averaging 193 feet in length, are configured like rock anchors – the strand tails are first bonded inside the duct for a length of ten feet at the lower end to create a dead-end anchorage. After the lower grouted zone achieves a strength of 60 MPa, the tendons are stressed from the top anchor head to a maximum load of 4,466 kN. Operations for installation, stressing and final grouting of the vertical tendons began in

February and are currently on track for early completion in late May. SDI reports that to-date all tendons have been stressed without a single broken strand or lost time incident.

According to SDI's site manager Hans Hitz, the post-tensioning operations have proven to be the most difficult of all the CGBS projects in his experience, which includes 17 platforms over the past 25 years. "It's not that they're so technically challenging," he said, "it's the working environment – the isolated location, extreme cold, Russian regulations, and relative unavailability of materials, equipment and skilled labor – that has made it tough. Still, there's no room for error or delays, so you have to rely on planning and assemble an experienced supervisory team that knows exactly what to expect and do in any given situation. Going in, most referred to this project as a 'Mission Impossible.' We proved them wrong by meeting every milestone." SDI's performance, currently on track for completion three weeks ahead of schedule, earned the company an SEIC Subcontractor Award for Excellence in December of 2003.

Preparing for Tow-Out

As final post-tensioning and mechanical outfitting activities are proceeding, preparations are underway for the 1,000-mile, 18-day tow-outs to the Sakhalin Island fields. Aker Marine Contractors AS, Oslo, will perform the transport services and will also ballast and install the structures onto prepared drilling templates on the seabed. The casting basin was partially flooded on April 16 by pumping water into the basin. After leak testing and float-up procedures are complete, the final 15 feet of water will be pumped into the casting basin and the bund wall between the basin and the sea will be removed. Dredging of a 1.5-mile-long, 850-foot-wide channel from the basin to the entrance of the Sea of Japan was completed last December. Removal of the bund wall and dredging of the channel require the handling of 38 million cubic feet of material.

Tow-out of the first CGBS is scheduled to commence on June 1. Aker Marine will use three 150-ton ocean tugs for the transport, with one additional tug providing backup and the control system for the ballasting operations. The flotilla will proceed northeast across the Sea of Japan (East Sea), then pass the southern tip of Sakhalin Island into the Sea of Okhost and continue north along the eastern coast of the island to the fields. Once above the wellhead, the CGBS will be ballasted using the inclined descent method. The floating structure will be moored to tugs at both ends to control and maintain proper GPS-monitored position, and then seawater will be sluiced into successive ballast compartments in a precisely-controlled operation that gradually lowers one side of the platform to a maximum angle of approximately 30°. Once the lower edge of the CGBS touches down on the seafloor and a ground reaction force is established, the compartments are flooded successively upward and the structure is lowered until it rests evenly on the prepared floor. Then all the caisson cell walls are filled to their remaining capacity, followed by flooding of the tower interiors. The ballasting operation is performed from a central control room on the support tug, with an emergency backup control area located on the top of one of the platforms' shafts. Transport and installation of the second platform is scheduled to begin July 1.

Topping Off

Manufacture of the two topside derricks is underway at the Geoje Island yard of Samsung Heavy Industries, Seoul, Korea. With weights of 28,000 and 35,000 tons, both are destined to become the heaviest such facilities to be installed by float over. The smaller of the two, LUN-A, measures 132 ft. x 269 ft. x 131 ft. high and includes a processing facility for gas and some associated oil. The PA-B topside, measuring 228 ft. x 277 ft. x 164 ft. high, will extract oil and some associated gas. Presently, Samsung is proceeding with construction at a rate of 10,000 man-hours per day. The company reports that to date it has achieved a safety record of five million man-hours without a lost time incident on the projects.

A new custom-designed vessel will transport and place the topsides on the CGBS as part of the installation contract with Saipem, S.p.A., Milan, Italy. The LUN-A facility is scheduled for installation this summer, and, after hookup, testing and commissioning, is expected to go onstream in early 2006. PA-B will follow in the summer of 2006, duly taking its place as the largest installed by float-over, and is scheduled to begin operation in 2007.

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