TRANSPORTING A STEEL GRAVITY STRUCTURE BY SEA

Simulating ocean wave exposure for transportation of a large platform substructure

Chevron needed to transport their prefabricated 36,000 tonne steel gravity structure (SGS) from South Korea to Australia – a distance of more than 7,000 km – using a heavy lift vessel (HLV). To confirm the integrity of the chosen transport method, Chevron asked us to carry out physical model tests in our ocean basin. We found that the seakeeping characteristics of the HLV were excellent with a satisfactory margin of safety against SGS overturning, wave slam, and loads experienced by the SGS and vessel during their long journey through the Pacific Ocean.

MOVING A 36,000 TONNE STRUCTURE

Chevron needed to transport its 36,000 tonne steel gravity structure (SGS) from South Korea to its Wheatstone development site in Australia. The 24-day journey through the Pacific Ocean could potentially expose the SGS to rough conditions, including typhoons.

Chevron requested that we fabricate and equip with instruments a scale model of the Wheatstone substructure and its heavy lift vessel, and subject the combination to extreme environmental wave conditions associated with transportation from South Korea to Western Australia's North West Shelf. This was in order to confirm the performance parameters of motion, acceleration, inertial load, interface loads, slamming load, slamming pressure on various components of the system as well as to quantify the non-linear response due to effects such as water on deck and cargo intermittent immersion.

The steel gravity structure after installation in August 2014. ©Chevron Australia Pty Ltd

CLIENT

Chevron Australia Pty Ltd

CHALLENGE

Need to properly assess the global transportation performance of transporting a steel gravity structure (SGS) by seas to the Wheatstone Field using a heavy lift vessel (HLV)

SOLUTION

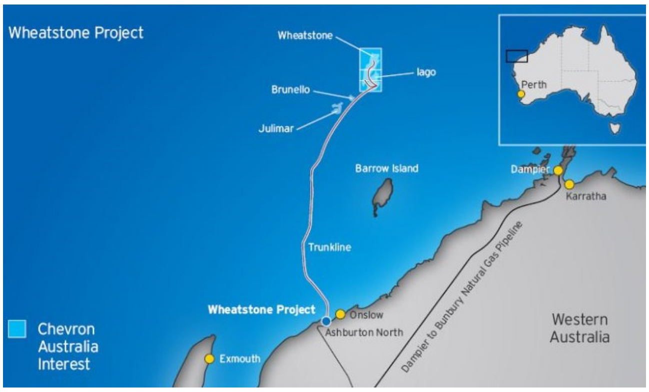
Conducting SGS transportation physical model tests with multi-directional waves in our 20 x 30 metre ocean basin

VALUE

Confirmed the transport integrity for key performance parameters

LOCATION

Indian Ocean off the coast of Western Australia, Australia



Location of Wheatstone development off the coast of Australia. ©Chevron Australia Pty Ltd

MODEL SETUP AND INSTRUMENTATION

We constructed models of the HLV and the SGS at 1:60 scale – together the models weighed 340 kg with an overall dimension of 3.4 m long by 1.4 m wide. In order to obtain the correct centres of gravity and radii of gyration, both individually and for the assembled model, we carefully balanced the models.

For this purpose, a new swing was constructed with adequate dimensions for adjusting both transverse and longitudinal parameters. Strict compliance with full-scale data is a necessity to obtain a realistic response to wave action in the model basin. This is particularly important when the roll period is close to the peak wave period.

We installed the SGS on four three-component force gauges embedded in the deck of the HLV model. The tolerances for elevation of the SGS's overhanging pods were very fine since the potential wave slamming on the base of the pods had to be measured. We measured the slamming loads on well-defined sections cut-out of the base slabs and mounted on force sensors.

Joint heavy lift vessel and steel gravity structure model undergoing swing tests for transverse load characteristics. ©DHI

Using a Qualisys tracking system, which tracks a number of reflective markers on the floating structure, we measured the overall motions. The marker tracks were converted to six degrees of freedom motions with respect to the centre of gravity as well as to other specified positions.

In addition to the direct motion measurements, we also measured accelerations at two locations on the SGS. The freeboard of the HLV was small and water was constantly washing across the deck during the severe wave conditions tested. Wave gauges were mounted on either side of the SGS to record the air gap and submersion of the overhanging pods of the structure.

Testing the steel gravity structure transport in head sea. ©DHI

TEST PROGRAMME

The test programme comprised regular and irregular long-crested waves and multi-directional waves, with the specified wave conditions correspond to expected maximum conditions from South Korea to Australia. We set up the HLV in four different orientations: head sea, beam sea, and fore and aft quartering sea in order to determine the response even under the worst possible scenario.

Our test results proved that the HLV's seakeeping characteristics were excellent, with an overall maximum roll angle of about 10 degrees. In all cases, the margin of safety against overturning the SGS was found to be satisfactory.

OUR OCEAN BASIN

Ocean transports of large prefabricated structures are common for the global offshore industry. At 30 x 20 metre with a water depth of 3 metre and a 60-paddle multi-directional wave generator, our ocean basin is ideal for testing floating units with relatively small horizontal extension. It can also be used to simulate transport at low speeds as the softly moored model maintains its average orientation when exposed to waves.

CLIENT TESTIMONIAL

> *The DHI team responded to our request with a rapid mobilisation of personnel and equipment. They managed to carry out a complex instrumentation of a dynamic system and provided a detailed and continuous feedback of performance during the fabrication, instrumentation, calibration and testing.*
>
> *John Davis—Transport & Installation Naval Architect—Chevron Australia*

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