

## Duplex stainless steel wire rope cable solution

### Member company

**Australian Stainless Steel  
Development Association**

### Challenge

ASSDA Member and Accredited Fabricator Arcus Wire Group delivered an innovative duplex stainless steel wire rope cable solution for a hydropower project in the Middle East.

The 344MW Kokhav Hayarden pumped storage hydropower plant is located 120km northeast of Tel Aviv. The project is the first and largest of its kind in Israel, as well as the lowest of its kind globally. The powerhouse lies 275m below sea level and features two 3.1 million m<sup>3</sup> reservoirs at different heights. Expected to be operational in the first half of 2023, the hydropower station is designed to provide

flexible backup power and stability to the national electricity grid of Israel.

Arcus Wire Group was engaged by GE Renewable Energy to manufacture and supply the cables to form part of a guiding system for the draft tube gates and stop logs for the lower surge shaft of the power station.

### Why?

The original project brief specified eight identical wire ropes approximately 110m in length with a diameter of 35mm constructed of a half-locked coil with an internal core of large diameter wire, capable of a permanently applied load of 100kN in an underwater application. A long working life was a critical requirement as maintenance of the cables was not an option once in place.

The initial consideration of materials in order of preference was carbon steel (heavy zinc coating), austenitic stainless steel, and duplex stainless steel. The water baseline data for the application during operating conditions was:

- pH value: Min 6.50 pH, max 9.00 pH
- Temperature: Min 2°C, max 33°C
- Total Dissolved Solids (TDS): Max 2,200mg/L
- Hardness: CaCO<sub>3</sub> Max 960mg/L
- Alkalinity: CaCO<sub>3</sub> Max 436mg/L
- Iron concentration: Max 320µg/L
- Chloride (Cl<sup>-</sup>) concentration: Max 1,000mg/L
- Sodium (Na<sup>+</sup>) concentration: Max 504mg/L
- Magnesium (Mg<sup>2+</sup>) concentration: Max 144mg/L
- Silica and other hard particles with hardness >5 Mhos:



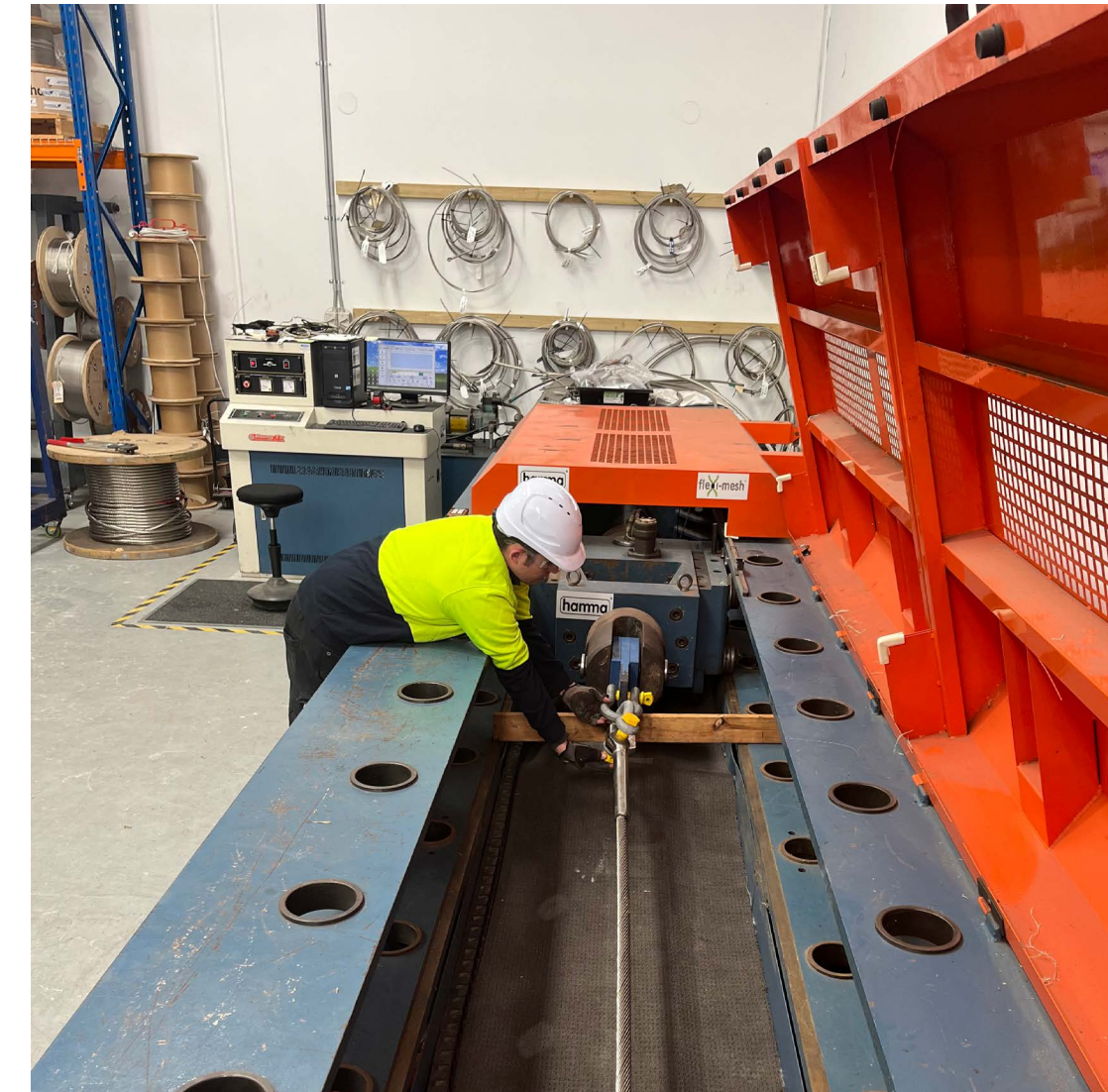
- Particle diameter  $>_{\sim} 50\mu\text{m}$ :  
Maximum concentration = 20mg/L
- Particle diameter  $>_{\sim} 1.5\mu\text{m}$ :  
Maximum concentration = 50mg/l

The cable guiding system required one part of the wire rope to be attached to an anchor embedded in concrete and permanently submerged in water exposed to highly corrosive conditions. The top part of the cable is connected to a post-tensioned wire located above ground and exposed to air, with temperatures at a maximum of 45 degrees Celsius and humidity of up to 75%. Post-installation, the wire rope cables will not be accessible for maintenance for up to 30 years.



### Needed action

ASSDA was consulted during the design phase, and as the specification evolved, the client identified stainless steel as a more suitable and sustainable option than carbon steel wire ropes for the submerged application. Considering the maximum temperature and minimum pH level, grade 316 stainless steel would be at its limits, particularly with the crevices



that are characteristic of wire rope. 2205 duplex stainless steel was recommended and ultimately chosen as the material of construction to reduce the risk of pitting and crevice corrosion, in addition to its tensile strength, longevity and life-cycle cost-effectiveness.

The final design specification delivered alloy grades 1.4362, 1.4462 and 1.4501 duplex stainless steel wire rope cables, half-locked coil with an internal core of large diameter wires and a 30-year lifetime warranty.

The terminations proposed and subsequently selected for use were grade 2205 duplex stainless steel swage forks. They were designed specifically by the Arcus Wire Group team for the 26mm wire rope and a pin diameter of 40mm to allow connection for the anchor at the bottom of the post-tensioning system at the top.

### Action review

*Specific:* Arcus Wire Group worked with its mill and manufacturing partners to produce and fabricate 970m of 26mm diameter 6x19 SL and IWRC construction 2205 duplex stainless steel wire rope and



20 units of 2205 duplex stainless steel fittings. Seale construction (SL) is a wire rope construction that offers excellent breaking load characteristics. It is used in a wide variety of applications and is resistant to wear and abrasion due to its larger outer wires. An independent wire rope core (IWRC) adds strength to the total length of the rope and reduced the amount of stretch during service.

*Measurable:* Material testing was

performed on the wire rope cables. This included destruction testing of a 3m sample cable to measure the breaking strain (breaking at 456.061kN as tested on a horizontal tensile testing machine calibrated to AS 2193: Calibration and classification of force-measuring systems), 10 rounds of cyclic loading up to 100kN and unloading to 1kN of an 11m sample cable and loading up to 1.8 times the maximum working load of 180kN to determine elongation under the various conditions. All cables delivered conformed to EN 12 385-4: Steel wire rope; EN 13411-8 Terminations for steel wire ropes – Safety – Part 8: Swage terminals and swaging; and EN 10088-3: Stainless steels – Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, section and bright products of corrosion resisting steels for general purposes.

*Achievable:* Achieved! Carbon steel was the preferred material of choice, but ultimately, duplex stainless steel was chosen to deliver the exacting demands of the project specification. Delivery of technical information and expertise was critical to the outcome, and all parties involved in executing the final product. This will open doors for new applications where stainless steel, and specifically duplex stainless steel wire rope cables may not have previously been considered. In this particular project, maintenance is not an option and is an excellent life-cycle costing example.

*Realistic:* Collaboration is key. The execution and successful outcome of this project would not have been possible without the expertise and contribution of all stakeholders involved. Arcus Wire Group worked closely with its client to

understand their requirements and deliver the ultimate materials solution with design and technical support provided by ASSDA. They also worked closely with mill and manufacturing partners to develop the final products specifically designed and produced for the project.

*Time-bound:* The duplex stainless steel wire cables were assembled, swaged, tested and quality certified at Arcus Wire Group's facility on the Gold Coast, Queensland, Australia, and shipped over 14,000km to the project site in Israel. The final delivery included 8 x hamma® 26mm diameter 2205 duplex stainless steel wire cables measuring 111.4m and weighing over 325kg each. Due to strict timelines enforced for the project air freight was necessary. The heavy weight (more than 2.5 tonnes overall) and reduced availability of flights caused by COVID-19,

made scheduling the delivery logistically challenging, however, the project timelines were achieved and delivered on time.

### Horizontal Expansion Capability

Yes – there has been a lot of interest in this project and application as one of the first examples globally of a duplex stainless steel wire rope cable solution. Stainless steel delivers a sustainable material solution for applications in aggressive environments, and this particular solution has already been considered to support another project application here in Australia (construction of 30m high ‘wind fences’ in Port Hedland to reduce dust emissions and withstand cyclonic weather). In a world that is working towards a sustainable future and a circular economy, we need to promote these types of projects and solutions to grow the market and the use of stainless steel. It also highlights the emergence of duplex

stainless steel in new applications.

### Other comments

This project was the 2022 winner of ASSDA’s Australian Industry Stainless Steel Fabricator Awards in the Architecture, Building and Construction category. Arcus Wire Group delivered Australian stainless steel innovation and service delivery at its best with the supply of its wire rope cable solution meeting the exacting demands, life-cycle and performance expectations of Israel’s new hydropower station.

Arcus Wire Group was also invited to speak about this project at the following events:

- Stainless Steel World Asia Expo & Conference 2022 (Singapore, 26-27 October 2022)
- Stainless Steel World Duplex Seminar & Summit 2022 (Rotterdam, 1-2 November 2022)