Profile

Laura Legnani was told at the start of her career not to worry about what she didn't know, but to go and find out. From an airport roof, to tidal stream power, to residential towers, it is advice that has underpinned her approach to her work, she tells Jackie Whitelaw.

After six years with Robert Bird Group (RBG), Laura Legnani is back where she started, working in the firm's Advanced Technical Services (ATS) team. This time, though, she's not the graduate engineer but the team leader, able to use her reputation, gained from experience on some of the most challenging structural projects in an engineer's repertoire, to develop the unit.

The ATS team takes on projects where standard design and construction approaches won't suffice and combines them with the company's stated speciality of being able to work out how to build the most complex of structures.

Legnani was involved in cutting-edge work from her first days at RBG, which she joined in 2013 following a master's degree in earthquake engineering from Imperial College London. The first project was the construction sequence for the central processor roof for the Midfield Terminal Building at Abu Dhabi International Airport.

The 300m wide by 400m long structure is a steel grillage with fabricated girders supported on 18 inclined arches, which are leaned in pairs but don't touch. RBG was commissioned by the main contractor to carry out a numerical analysis of the erection sequence that would validate the structural stability of the roof during construction.

Legnani's job was the erection stress analysis of the steel roof, with particular focus on the automation process that was developed at RBG to analyse the complex structure during the 200 critical stages of its construction, which resulted in more than 10M checks on the steel elements.

'The permanent design for the Midfield roof was amazing, but it was a challenge in terms of getting it built,' Legnani says. 'The contractor brought us onboard to help it understand what to do, and advise on an achievable construction sequence. In terms of a first project, it was a great place to start.'

Midfield was followed by the first phase of the MeyGen tidal turbine scheme. This is the world's largest tidal stream array and has been described as 'Britain's moonshot' in terms of how far at the edge of human understanding it is.

Legnani was part of the team establishing the design and construction approach for the first four of potentially hundreds of turbines operating at a depth of 31m beneath the seas, off the northeast tip of Scotland (Box 1).

This was an opportunity to be at the forefront of a completely new industry. The scheme won the Award for Structures in Extreme Conditions at the Structural Awards 2017.

Classical inspiration

Legnani has been fascinated

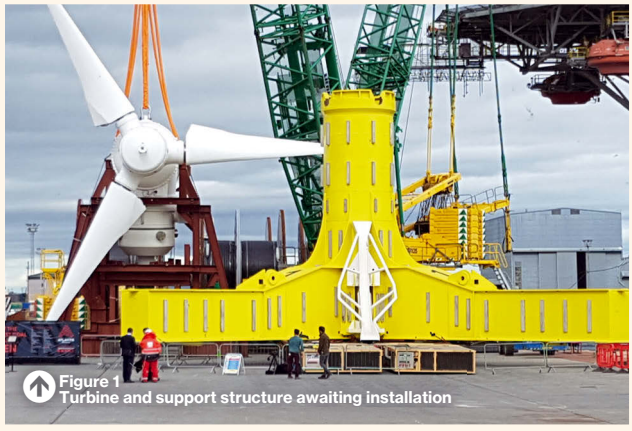

Figure 1
Turbine and support structure awaiting installation

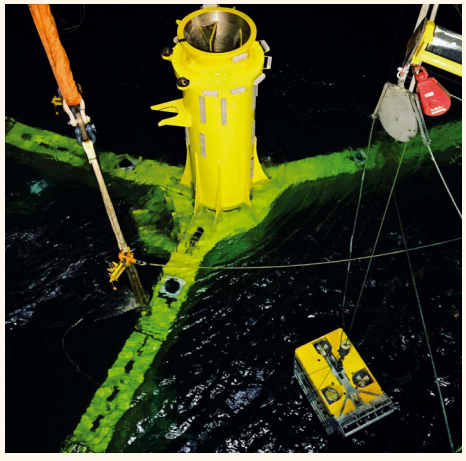

Figure 2
Tripod incudes articulated feet with spherical bearings to allow self-levelling and lifting eye for installation

Figure 3
Installation of tripod from barge

for a long time by the early engineering pioneers such as Florence Cathedral dome designer Filippo Brunelleschi, who in the 1400s took on what was considered impossible to build – and did it anyway. It was that spirit which she took into the MeyGen scheme, supported by RBG director John Ward, along with advice from former team leader Jonathan Chadwick, 'who taught me not to worry about not knowing; just find a way to learn it'.

Legnani's appreciation of Brunelleschi is no surprise. She too is Italian and admired the skills of the ancients from her schooldays where her education included a healthy amount of Latin and Greek. Nevertheless, it was her love of maths and physics that drove her when looking for a career.

'I wasn't patient enough to study mathematics or physics alone. And I wanted to see and touch the results of my work.

"FROM THE OUTSIDE, SOMETHING MAY APPEAR TO BE AN EASY BIT OF ENGINEERING, BUT IN REALITY THERE IS A LOT OF SKILL NEEDED TO MAKE IT LOOK THAT SIMPLE"

Engineering was the obvious choice,' she says. 'I had a friend who was studying civil engineering and he took me to a couple of his lectures and I loved them.'

Legnani, now 29, was born and brought up in Bologna and went to the university there, studying for three years as an undergraduate. She then selected a two-year master's degree with the option of taking the final year in England.

Building experience

At Imperial she applied to join RBG after meeting them at a careers fair. The UK office of the international firm is now 200 strong, 'but at the time I joined there were between 50 and 60 people and the company had very interesting projects. I could see lots of potential and knew I would not just be a number, but could connect with people in the business and with clients and, most importantly, learn'.

She joined as one of two graduate engineers, the other being her partner, Francesco, and while he was assigned to the building team, she found herself in ATS. Despite the innovative projects, there came a point when, to meet her ambition of becoming chartered with the Institution, she needed some experience of conventional buildings. So, Legnani switched horses in 2016 to a building team and chartered two years later.

She has enjoyed the building work. 'Buildings give you a lot in terms of challenge, interest and innovation,' she says. 'I really like the coordination and communication part. There may not always be the big engineering issues, but there are always some very detailed elements that you need to employ all your talents on. From the outside, something may appear to be an easy bit of engineering, but in reality there is a lot of skill needed to make it look that simple.

'And there are challenges that come from how you put the building together on site; how you interact with others. It is often working in combination with different disciplines that you find the right solution.

'I've also enjoyed the feeling of ownership that working on

BOX 1. WORKING ON BRITAIN'S 'MOONSHOT'

The MeyGen site in the fast-flowing waters of a 2km channel between the northeast tip of Scotland and the island of Stroma had a storm surge current that could reach 5.2m/s, with wave heights up to 15m.

'The challenge was to work in what is considered quite shallow water, where waves produce strong reactions,' Legnani says. 'We were at the breaking depth of waves from the Atlantic.'

The chosen concept for the first phase of MeyGen (Phase 1A) project was a gravity-based structure comprising a 190t fabricated steel tripod weighted down by two 200t steel ballast blocks per leg. A 15m high pylon then supports the 100t turbine above the seabed (Figure 1).

The turbine is designed to yaw about the pylon to align its rotor blades with the tidal flow. By careful consideration of the prevailing tidal streams and most onerous wave directions, an isosceles tripod configuration was chosen with the longest leg facing west.

RBG worked with Imperial College and the Danish Hydraulic Institute in the early project stages to better understand the turbine hydrodynamics and oceanic interaction. Based on research and first-principle studies, in-depth dynamic analysis procedures were developed, including multi-axial fatigue analysis to efficiently design the structure, along with behavioural assessment of the combined substructure-turbine system under dynamic loading. Bespoke software tools were developed and validated by the team to support the work.

'As it was the world's first turbine array, many design aspects lay outside existing codes. In particular, the behaviour of structures in marine environments with large waves and strong currents was not fully understood and was poorly documented,' Legnani says.

A 1:36 scaled tank test was performed at the HR Wallingford fast-flow facility to calibrate the basis of hydrodynamic loading assumptions. And the design and installation concepts were field tested at the European Marine Energy Centre test site in Orkney.

'The typical solution for a fixed marine structure is a tubular jacket, but in such relatively shallow water it would have interfered with the turbine operation and attracted significant drag,' Legnani says. 'We developed an alternative low-profile structural form to enable development of the shallow-water MeyGen site. This low-profile form also minimises frontal area that is exposed to environmental drag, thereby reducing the size of ballast required and enabling the turbine to be placed in a high-tidal-energy region.'

Articulated feet with spherical bearings were developed to allow the tripod base to self-level on the irregular seabed. Ballast blocks for the tripod legs were stressed together, with the lifting eye for installation welded to the connecting pin, which, as well as holding together the plates, also transferred lifting loads (Figure 2).

Buildability and turbine maintenance were a major focus of the design. 'The combination of depth and strong currents meant it was not safe for divers to go so deep, and we had only a 40-minute operating window to work in during neap tides only, when the waves were no more than 2m,' Legnani explains.

'For construction, we largely removed the need for humans, though for maintenance it is possible for divers to work on the turbines which are only 16m down.'

Remote-operating autonomous vehicles (ROAVs) were the answer for overseeing assembly of each unit, with everything placed from a barge (Figure 3). 'The ROAV went down with the tripod first, watching where it landed. One leg was put down, then the second, then the third. The ballast blocks were shaped to slot in over the legs.

'In the next tide window, the turbine was then dropped in from the surface to automatically wet-mate with the pylon, with the ROAV giving the crane operator line of sight.'

Figure 4
Design work at Elephant and Castle in London includes two 11-storey mansion blocks

buildings gives you – you can see them through from start to finish.'

Leading the show

With her new change of role, Legnani is able to have the best of both worlds – at least for a while. She is just finishing the designs for Elephant Park Masterplan Phase 4, one part of the redevelopment of Elephant and Castle in London. This involves the design of two towers – one 19 and one 25 storeys high – and two 11-storey mansion blocks (Figure 4).

Legnani has been involved in the project from the early stages. She was responsible for the conceptual and developed design of the buildings and an alternative concept design using modular construction.

'I feel I can't let go until the design is complete in November,' she says.

At the same time, however, she is conscious of the responsibility she has been given to build up the ATS team, and that her past experience is very much a selling point for the group that she has been charged with developing.

'The directors get the leads and can let clients know our capabilities. But we are the show. And I'm looking forward to proving what we can do.'

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