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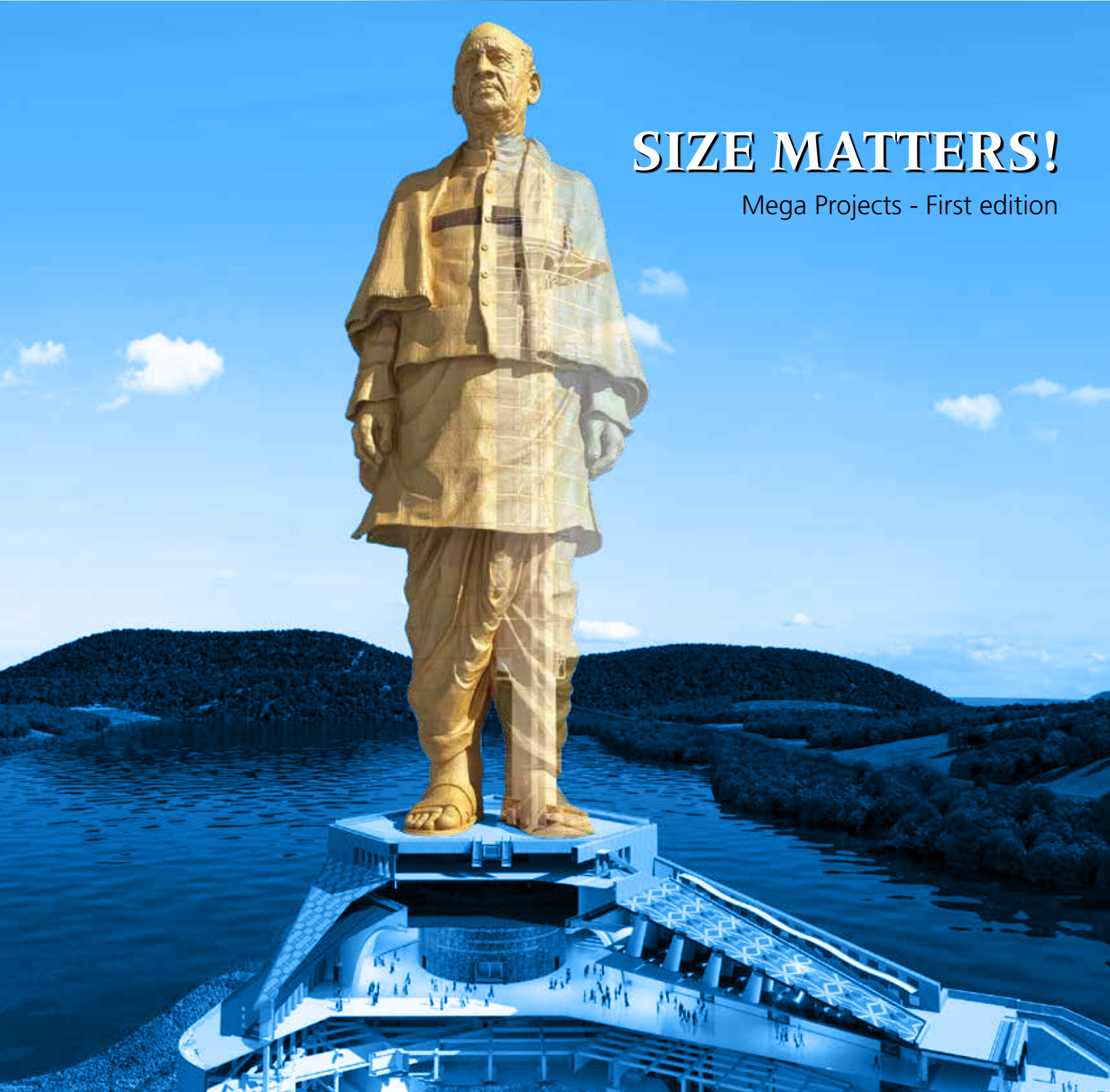
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SIZE MATTERS!

Mega Projects - First edition



From the EDITOR'S DESK

Size matters. In fact, size, scale and scope is the theme for this issue of ECC Concord for we have deep-dived into a clutch of mega projects that are unique as they are challenging; that are path-breaking as they are huge. SNS has gone on record that many of the mega projects that we have won in the recent past are going to define the future of L&T Construction and hence the successful completion of each of these projects are critical for all of us.

The claim to fame of the Statue of Unity project is that it is also our Prime Minister's pet project. Therefore, the attention and care that the B&F team needs to accord to its making is enormous and as the one of the managers at the site says with grim humor: "Some of the challenges we have to face and overcome are as tall as the statue itself!" Nature, work conditions, wild animals, ever-shifting workmen population, a tough demanding client are all aspects that this manager is referring to but once completed, in a year's time, the statue should stand as a tall testament to our prowess in construction.

The Al Wakrah team from TI IC is beating the heat and braving the harsh, Arabian dust to lay a road that will speed Qatar on the highway to growth while in the city of Doha, a Heavy Civil IC team is burrowing into the bowels of the city to pave the way for the Doha metro that will transform the way Doha commutes.

With farmers so much in the news these days, albeit for the wrong reasons, the Kharkai barrage that the WET IC has built will irrigate 24,388 hectares, meet the water requirements of the neighboring villages and industrial belts and, most importantly, bring cheer to the beleaguered farmers of Jharkhand. A team from PT&D, meanwhile, is helping to create a dedicated communications platform for the armed forces by laying an optic cable network of 17,000 km which will also be the country's largest intelligent communications network.

Last but not the least by any stretch of imagination, L&T's Metallurgical and Material Handling (MMH) Strategic Business Unit has executed a state-of-the-art 2.8 MPTA Blast Furnace (BF-8) complex which is also the country's largest free standing blast furnace at Bhilai. And, that too, right in the middle of a fully operational steel plant.

This is our first edition of a series of issues on Mega Projects.

Happy reading!

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It's all about Imagineering!



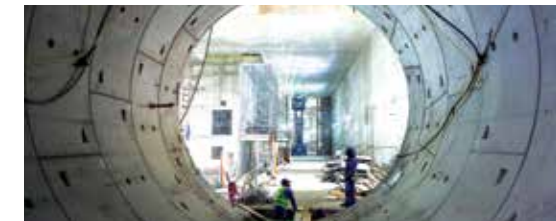
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Building a 182-m tall statute
to last a century!
It's all about Imagineering!



The view from the site office cabin of Mukesh Raval (MSR), Project Director, Statue of Unity, can take one's breath away. A profusion of green foliage fresh from the morning drenching rain leading away to rolling hills in the distance all capped with slowly moving cloud. MSR catches my look and smiles, "Sometimes I sit here and just take in this lovely sight." It is truly an awe-inspiring sight and perhaps, MSR is seeking inspiration to find solutions for the myriad problems he is wrestling with that gives him sleepless nights as the deadline to deliver the Statue of Unity hurtles closer; a deadline of October 2018 laid down by none other than the Prime Minister of India, Narendra Modi himself!

MSR brews himself a mug of green tea, takes his first swallow and then settles down to delve into the critical issues

surrounding this mega-project. "I gave a talk for 2 hours just a few days ago to our colleagues in Gandhinagar on this project," he laughs so I give him full rein to hold forth on this extremely demanding project that's driving him and his hardy team.

Facing an issue

The very first act in this challenging project was played out even before the first bit of excavation of the tough terrain had taken place. "Making the statue of a well-known political leader is tricky because everyone had an opinion of how Sardar Vallabhbhai Patel looked!" exclaims MSR. One big issue was that people who knew and interacted with Sardar Patel were old and hence all their contributions had to be corroborated. "We brought in historians, authorities on the Sardar, scoured through thousands of his photographs from

archives and had sketches ratified and re-ratified by people before we arrived at the final biometric of his face! It took months of hard labour for our team and Gopinath of EDRC in collaboration with Ram Sutar, the sculptor, but it was worth its while because there was no way we could engage with this kind of controversy once the statue was cast. We had to put this matter to rest," says MSR with a finality that is very typical of his character.

This fastidiousness about getting every contour, every wrinkle right is better understood when one comprehends the extent of magnification involved from an initial midget statue of 3 feet to almost 200 times of the prototype. The statue is going to be 100 times bigger than a man of average height of about 5 to 5 and a half feet! Precisely the statue with the pedestal will be 182M - roughly 600 feet tall.



"Most statues of the world in the league of SOU are tall figures standing straight or sitting giving them a wide base to transfer the load but in the case of SoU, the Sardar in a walking posture, as if he is about to step forward and that poses a peculiar engineering challenge!"



Getting the walk and dress right

Once the looks were decided and the aesthetics were put to rest, the difficult structural challenge began. "Most statues of the world in the league SOU are tall figures standing straight or sitting giving them a wide base to transfer the load - be it the Statue of Liberty, the Christ the Redeemer or some of the Buddha statues in China and Japan," informs MSR, "but SoU is of the Sardar in a walking posture, as if he is about to step forward. Hence, his left foot is placed slightly in front of the right." The attire of the Sardar was another important consideration which compounded the challenge. Coming from a peasant background, he wore a Dhoti in a manner that 'exposed' his ankles.

Both this aspects posed a couple of peculiar engineering challenges: it opened up a small gap between the two feet. 'Small' is relative because the gap is actually 6.4 meters for RCC cores which have to withstand the forces of wind of up to 180 kmph velocity.

To cater to this design requirement of immense stresses at the base of the cores (the leg cylinders) and to adhere to the proportions of human anatomy at the level of the feet, which is the portion of statue where a visitor will have closest access, was an engineering challenge for design.

The shape of the shawl and its fall caused several sleepless nights for the designers because of its uniqueness. The peasant background also dictated the texture of the Sardar's skin and MSR admits, "Ram Sutar has worked very hard, diligently and precisely to help us come as close to reality as possible with yet maintaining an artistic touch!" And there is a lot of skin to be textured, some 21,000 km of it in 1 m x 1 m panels!!

Why is he facing the Narmada dam that is 5 km upstream rather than the visitors who would be approaching from downstream? Simple! "The Sardar is facing that way because the dam was his vision!" informs MSR, adding that the dam has already proven to be a lifeline for Gujarat.

Finding a firm footing

While the Narmada dam was constructed, there were controversies about the same lying in a fault-zone, etc. The dam is standing tall with full reservoir and no dam induced seismic activity has been observed over the years proving that the geology of the region is quite stable. The statue on Sadhu Hill also has similar geological conditions and therefore it is not a concern, however the design takes care of any unexpected seismic forces.

"We conducted extensive geological investigations to address the issue of withstanding the impact of an earthquake if, God forbid, one occurred," shares MSR. "We also did hydrological model studies for 100 years flood cycles to understand flooding and its effects that helped us design and construct the bank protection work and foundations of the bridge."

"The statue is well grounded," smiles MSR, "practically in a more than 20 m deep pit with a raft of 3 m thickness." The simple raft is sufficient to take care of even the toppling force of design wind speed of 180 kmph.



Beating the sway

Standing atop a hill in the middle of a river at a height of 182 m or 597 feet, the forces of the wind on the statue can only be imagined. “Our studies of wind patterns over the years and the relevant codes applicable to the geographic location revealed that we had to be prepared for wind speeds of 39 m per second (roughly translated into 130 kmph buffeting the statue in a worst case scenario. The client however insisted to increase the tolerance to 50 m per second (i.e. 180 kmph). History does not show any such occurrence but then again, who has seen tomorrow in this rapidly changing environment?” We share a chuckle which is interrupted by a sweet little bird that daintily lands on the window. “A robin,” announces MSR and just as we watch the bird, the robin apparently unimpressed by the two occupants of the room takes flight leaving us to continue our chat.

- Height of the Statue - 182m from proposed ground level - (+58m RL to 240m RL) 187.5m from foundation bottom (PCC top +52.5m RL to statue top +240m RL)
- Weight / Load of Statue alone- Approx. 67,000 MT (Concrete - 53,000 MT, Rebar - 6,500 MT, Str. Steel - 5,000 MT, Bronze - 1,600 MT, Others - 900 MT)
- Formwork system being used for core walls - PERI Jump Form System
- Formwork system being used for bridge piers - Slip form System
- Skin/Bronze Cladding - Approx. 21,099 sq. m
- Concrete - Approx. 1,70,000 cu m (Approx. 21,300 cu. m for Statue alone)
- Reinforcement - Approx. 16,500 MT (approx. 6,500 MT for Statue alone)

“Oh yes,” he resumes, “one always forgets that the danger is not always from the wind blowing against the statue but the suction effect it creates at the leeward side of the statue which was revealed by the wind tunnel studies conducted by us. So the structural design was mainly governed by the forces on the leeward. We will also have two Tuned Mass Dampers of 250 tonnes each to cancel the large amplitudes of oscillation, if any.” What is the maximum tolerance even if there is some, I persist. “May be 300 to 450 mm at the max,” nods MSR, “but in any given situation, all the four corners of the base raft will remain rooted to the ground,” he adds reassuringly.

Impressing with size

The first thing that hits you about the project site is size. Everything is mammoth especially the two cylinders that already rise tall to a height of approximately 325 feet. “This has only reached to navel level,” chuckles Santhosh Bhasker, Head EHS, Project SoU, seeing my amazement. The 3,000-strong team of workmen around the huge structures seem like an army of ants in comparison, going about their industrious ways. “The two biggest challenges we face here,” continues Bhasker, “are of course the danger of working at huge heights and the fear of the unknown because everything we do here is new; we have no precedent to fall back upon so we have to be prepared for anything and everything,” he shares matter-of-factly.

“The real work is yet to start”

Cutting the hill, making the access and casting of raft foundation were initial challenges apart from others posed by all types wild life creatures like snakes, pythons and occasional visits of full grown crocodiles.

The construction of cylinders (cores) posed challenges of cycle time and concrete quality for unlike a



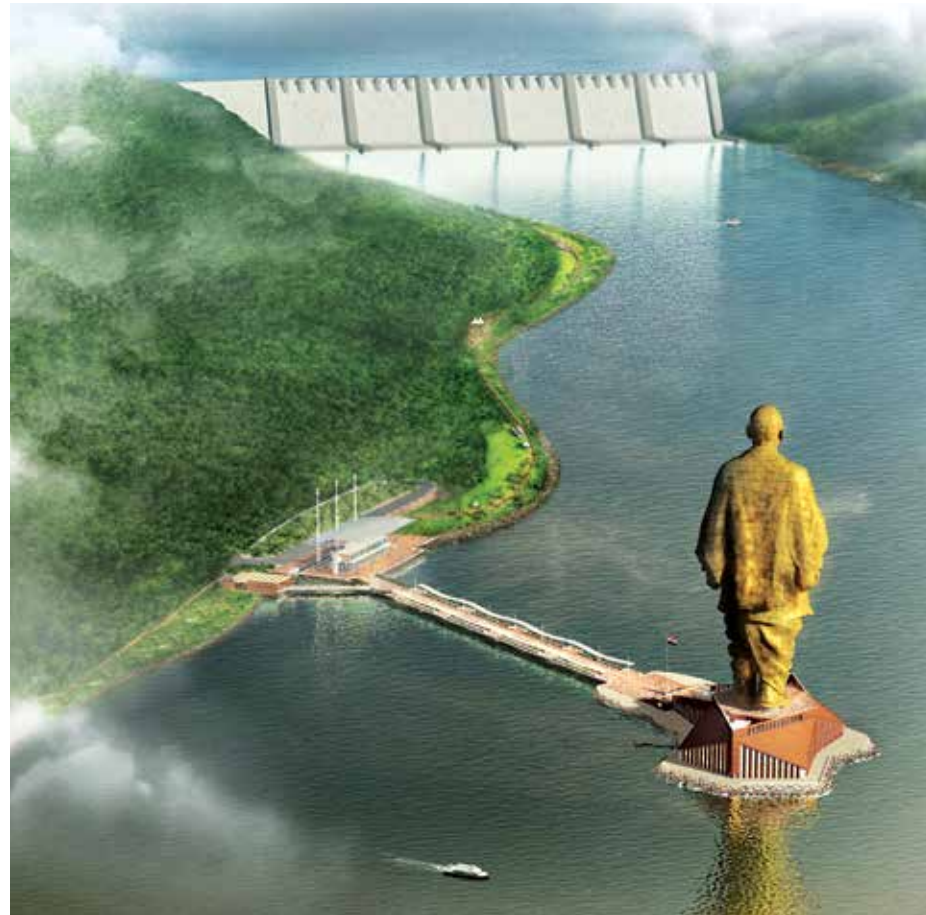
normal multi-storeyed building, the reinforcement density was almost four to six times per cubic meter and added to which was the placement of embed plates for the structural steel. “Our team of concrete experts put their heads together and overcome the issue of honeycombing by designing a recipe of M65 self-compacting concrete with 10 mm down aggregates,” reveals MSR. “The team of veterans led by Sekaran brought down the initial cycle time of concrete pour from almost 26 days to seven days in a very short time as the team gained experience!”

After having travelled for three years on this exacting project, I’m sure his heart must have sunk when MSR admits, “The real work is yet to start and the real challenge is when we start erecting the bronze panels!” And this fact is amplified by Santanu Chattopadhyay, Head Structural Steel & Cladding. “The key is coordination,”



Santanu Chattopadhyay
Head Structural Steel & Cladding

“The statue has to ‘age’ uniformly. At the end of a hundred years, the statue should be uniformly green like the Statue of Liberty but in the early years the aging or the ‘greening’ has to be uniform and that’s going to be one of our biggest challenges when the 15-year O&M period kicks in after handing over the statue.”



he says, “first between the sculptor, the other agencies involved and EDRC so that we arrive at the best possible solution. Thereafter, once we start casting the bronze panels we will have to maintain perfect synchronization between the concreting, structural steel and bronze teams. Not one of them can either go too fast or lag behind: it all has to be in perfect tandem!” He nods and looks out of the small window of his cabin almost imagining those tough days ahead.

“Another important consideration is that the statue has to ‘age’ uniformly,” says Santanu. “At the end of a hundred years, the statue should be uniformly green like the Statue of Liberty but in the early years the aging or the ‘greening’ has to be uniform and that’s going to be one of our biggest challenges when the 15-year O&M period kicks in after handing over the statue.”

The concrete internal structure in the form of two elliptical cylinders forms the main spine and over that steel trusses of 27 m each will be mounted like a skeleton on which will be bolted the bronze (skin) plates in modular form that have already arrived from the vendor’s foundry overseas. “We studied all the 300 odd foundries in the country including our own facilities but their cumulative capacities did not meet our requirements. In fact, they could not match our requirements neither in terms of quantity nor quality,” informs Santanu, “and hence we went to one of the two biggest foundries in the world who have expertise in this type of art casting,” putting to bed some murmurs that the company had looked beyond Indian shores for these panels. The precision casting of these panels has to be seen to be believed. I saw a little toe and it was at least half of my height! The big toe is seven foot high and add 3 feet of sole making it one storey tall!



S Sekaran
Deputy Project Director

“From a 20-day cycle time, we have brought it down to a 7-day cycle but to maintain it is tough for which I need my workforce to be adequate and available all 7 days of the week!”

For it to last a century, the quality of the material used for the statue has to be of a consistently superior quality which is the primary concern of M V Venkateshan (MVV), Head – Quality (Material). “The complexity and uniqueness of this project is best reflected in the nature and extent of casting involved. We are doing art casting where the challenge is to marry engineering and aesthetics,” he reveals. “Problem spotting requires domain knowledge experience which is what I am building here: a small mark on a cast item does not mean a flaw or a rupture. It has to be understood and explained.” Careful material handling, maintaining material compatibility since different kinds of metal and alloys are being used and problem resolution are all part of his mandate. “One recent issue has been that the client does not want the filler plates but we need them for stitching the two panels together.” An issue that requires resolution apart from a lot of such issues that are cropping up because MVV does not have any existing standards to resort to. “We have to create and establish the standard ourselves and then convince the client for a buy-in from them. We have also started 100% inspection of samples so that there is no variation in quality at all. After all, our reputation is on the line,” he smiles.

Riding the digitalization wave

The SoU project has been one site that has espoused digitalization discovering and investing in the obvious benefits of various digital initiatives. Apart from the extensive use of Geo Spatial technologies, BIM and other technologies, three new initiatives have been launched – tool tracking, RFID tracking of workmen and RFID tracking of the thousands of bronze panels. “Life will be so much easier because now we can easily find out which particular micro bronze panels put together will make a macro panel and where exactly they are stacked,” smiles a relieved Santanu. “A jigsaw puzzle has been solved for us,” he laughs out loud. On such a huge site, the tracking of workmen will help the process immensely too by not only ascertaining their whereabouts and safety but eventually also enhancing their productivity.

Tackling the softer issues

“From a 20-day cycle time, we have brought it down to a 7-day cycle but to maintain it is tough for which I need my workforce to be adequate and available all 7 days of the week,” declares S Sekaran, Deputy Project Director, SoU. “A high attrition rate among workmen is to be expected but it is even higher here at SoU which will become critical as we enter the slog overs.” He blinks rapidly before continuing, “With the deadline fast approaching, there is no way we can afford to lose even a day’s productivity,” says a worried-looking Sekaran. He welcomes the initiative of RFID tagging of workmen: “at least now I will know where the worker is,” he laughs.

The location is a big deterrent especially for youngsters. “We are 25-odd km from Rajapipla, the nearest town and that’s not much of a town to talk about,” says MSR with a shake of his head. Lack of connectivity is a big drawback for the younger generation who spend most



of their lives these days on Whatsapp, Twitter, Facebook and Instagram. Keeping the morale high and the team charged are high on the priority list for both MSR and Sekaran.

Perhaps, the other big consideration for MSR is the nature of the client. “The client has no experience of executing any project other than irrigation related projects and that too of long durations-like the dam and irrigation network which is under progress since the early eighties! Also, for someone having spent most of his life in fast track projects and in overseas where durations are counted in months or days, it was difficult to adjust to this scenario in the beginning laments MSR. “I had to also unlearn and re-learn many things like how to talk to them so late in my career,” he chuckles. His issues are not just about not being on the same wavelength. “Our payment process is quite something. The file has to pass through no less than 37 points

before our payments are cleared. And at each point, our intervention is required,” he pauses waiting for the import of the message to sink in. “But we have set a record that we got one of our payments cleared in 20 hours flat!” He grins at his and his team’s achievement.

Realizing a vision

The Statue of Unity, apart from being PM Modi’s pet project, is his vehicle to realize his vision for the development of the area. The 52-room, 3-star hotel, the bridges and the 4-laning of the roads by L&T apart from the Statue of Unity itself are all towards drawing more visitors to the dam and the statue and thereby give a huge fillip to the economy to the region. It’s a tall order, literally and figuratively, but achievable especially because the builders of nations are themselves involved in realizing that vision.

The path of change

Al Wakrah bypass road project, Doha



Qatar is one of the wealthiest countries in the Middle East with the 4th highest GDP in the world as of 2016, a wealth created almost entirely on the strength of its petroleum and natural gas resources. Though clouds have gathered over the horizon due to the steadily weakening crude oil prices and the recent sanctions placed on it by some of its neighboring Arab states, Qatar still shines like a diamond attracting expat talent with the promise of gainful employment and a vastly superior standard of living.

Impressive skylines and impeccable infrastructure including a road network of 10,000 odd kilometers are testimony to the fact that the Qatari government has not been shy of investing in infrastructural development. As the economy surges and commerce flourishes, the need for travel and therefore for world-class roads has also grown sharply.

The Doha Expressway, a high speed corridor that connects the north to the south and east to the west of Doha, has a special place in the hearts of the Qataris. Their only complaint being the congestion in the heart of the bustling city in response to which L&T was mandated to construct the Al Wakrah Bypass.

Connecting highways of growth

Doha is Qatar's capital city, its financial capital and also one of its most populous and fastest growing cities all of which have forced city planners to spread its limits horizontally to ease concentration and congestion. The New Hamad International Airport and the Doha Sea Port at Mesaieed have been planned by the government to give a fillip to the suburban area south of Doha, which is

also home to industries, factories and garages. This in turn has increased the need for a reliable and commutable road infrastructure connecting Doha to this throbbing hub of trade and commerce.

The Al Wakrah Bypass

The 11-kilometer freeway called the Al Wakrah Bypass was therefore envisaged as a continuation of the Doha Expressway and has been designed to connect the existing AI Wakrah-Mesaieed road, southwest of Wakrah. At its southern end, it will intersect the existing AI Wakrah-Mesaieed Road from where it forks off: one going south to the proposed Doha Sea Port and the other joining the existing AI Wakrah-Mesaieed Road and heading westward towards the Mesaieed industrial area. Citizens of Mesaieed and Wakra will thus be directly connected to Doha without the bother of traversing the bustling town of Al Wakrah. It will



Rangarajan Ramaswamy
Cluster Head – Qatar

“The Al-Wakrah bypass project came as a huge opening for L&T and it didn't come easy. In fact, we bagged it after a long struggle having bid for several other expressway projects in Doha. But it has given us recognition of being an active infrastructure player in the Gulf which should open doors for more mega road infrastructure orders in Oman and UAE.”



Qatar & L&T: An association that has traveled many miles and still going strong ...

L&T has been playing a crucial role in transforming the lives of the Qataris for several years, be it in the form of the innumerable transmission lines, power plants and substations that power Qatari homes and industries or the water treatment plants; be it the Metro that will soon snake under the belly of Doha or the expansive and hassle-free highway infrastructure; be it the multistoried residential and office complexes, or even the several stadia in which the country is soon to host the football extravaganza – FIFA 2022. L&T has indeed enjoyed an enduring partnership with Qatar to make life better with world-class construction solutions.

also connect the proposed Truck Orbital Road which in turn will be connected to the north and south in future.

This high-speed, free-flowing freeway is expected to ease traffic flow during construction of the proposed Al Wakrah Main Road, another significant project in the Government's Expressway Programme and, most pertinently, will be the key route to the up-and-coming Al Wakrah Stadium, a venue for the Soccer World Cup.

Consisting of 10 lanes (5 in each direction) with additional collector/distributor roads, frontage roads and ramps, the mainline section features a provision for adding two more lanes in each direction totaling to a whopping 14-lane mainline section. Once completed, the freeway will provide access to the existing and planned developments through the four proposed interchanges (IC-10, IC-11, IC-11A and IC-12).

- Structural concrete: 250,000 cu.m
- Embankment fills: 6,325,000 cu.m
- MSE wall: 170,000 sq.m
- Cement Treated Base Course : 689,000 t
- Asphalt: 670,000 t
- Safety barrier : 136 km
- TSE piping : 51 km
- Potable water piping : 9 km
- Fiber optic ducting : 150 km
- Electrical cabling : 236 km
- Street light poles : 3819 nos.
- Safety & decorative fencing : 45 km

Top-brass talk

“The Al-Wakrah bypass project came as a huge opening for L&T and it didn’t come easy,” says Rangarajan Ramaswamy, Cluster Head – Qatar. “In fact, we bagged it after a long struggle having bid for several other expressway projects in Doha. But it have given us recognition of being an active infrastructure player in the Gulf which should open doors for

more mega road infrastructure orders in Oman and UAE.” Rangarajan’s confidence is borne out by the steps taken thereafter. “Initially we focused on mobilizing a strong project team to work to the demands of the key stakeholders from various government authorities and later arrived at an aesthetically pleasing and functionally superior design. With material sourced from across the globe, we are now maximizing innovation and leveraging on digitalization to deliver a world-class road project which is a direct commitment of the 250-odd engineers and 4500-strong workforce,” adds Rangarajan.

Project Director, Adrian Brown’s advent to the project was not a calk walk. “When I joined the Project, I was confronted by many challenges both internally and externally with many of the several external stakeholders holding up progress. The key driver was to get the team to work together and make them believe that they could achieve what was a very significant

task. In addition, I had to get the Client on our side and I am proud to say that the whole team has excelled and demonstrated L&T’s professionalism to Ashghal. One of the most important aspects of infrastructure projects in Qatar is managing both the expectations of the Client together with the requirements of the other government and private stakeholders. These were achieved by delivering on all our commitments,” says Adrian with a sense of achievement.

“We focused entirely on creating a harmonized work culture through which we saw each other as team mates and not as departmentalized silos,” is how Deputy Project Director, K. Harikrishna puts it. “A customary routine was established by sharing best practices / creative and innovative ideas during review meetings for improved performance. Despite the cultural gaps of different nationalities we orchestrated our unified mantra - on time delivery with customer focus.”



Adrian Brown
Project Director

“One of the most important aspects of infrastructure projects in Qatar is managing both the expectations of the client together with the requirements of the other government and private stakeholders and these were achieved by delivering on all our commitments.”

The fact file

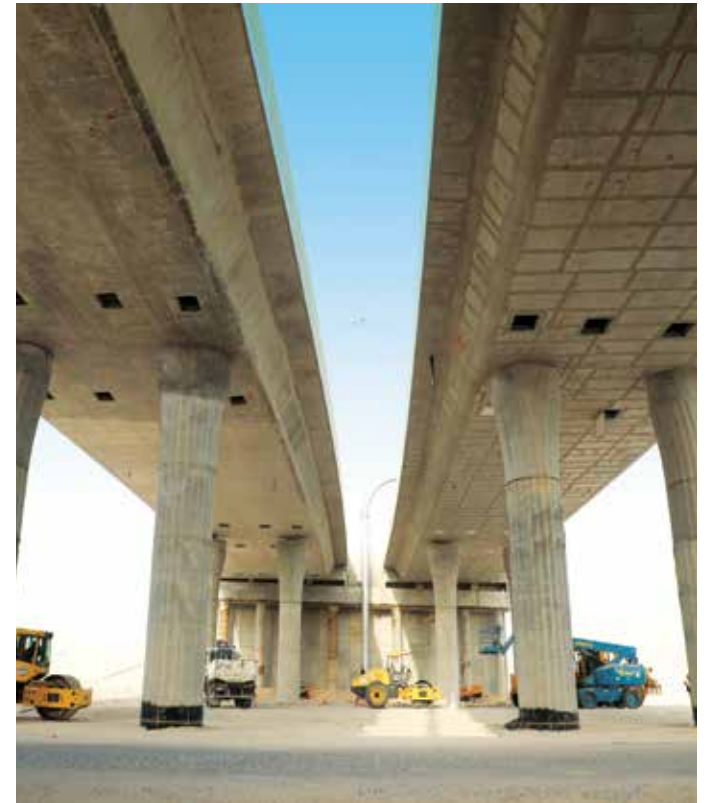
With 28 bridges, 24 cyclist tunnels, 8 underpasses apart from gigantic protection culverts for Qatar Petroleum, the project involves construction of 11 km (73 lane km) of expressway with safety furniture including guard rails, high containment barriers, intelligent traffic management systems with specially designed gantries and co-located gantries, concrete barriers, road markings, traffic signals, project sign gantries apart from decorative and chain link fencing. The project also includes 40 km of cycle track, footpaths and utilities such as lighting, storm water drainage system, complete water supply network, electrical and communication network and appropriate landscaping for aesthetics. To give the mega scope a perspective, hypothetically, if laid linear, the length of utilities and services alone will add up to a whopping 900 km!

The interchanges

Al Meshaf Interchange:
(aka IC10)

A 2-level grade separated the interchange providing connectivity to the G-ring road in the south and the





K. Harikrishna
Deputy Project Director

“We focused entirely on creating a harmonized work culture through which we saw each other as team mates and not as departmentalized silos. Despite the cultural gaps of different nationalities we orchestrated our unified mantra - on time delivery with customer focus.”

Al Meshaf residential area in the west comprising 3 crossing bridges, a couple of flyovers, loops, vehicular underpasses, 9 pedestrian/cycling underpasses and 4 Qatar Petroleum’s (QP) gas pipeline protection culverts.

“This section of the project was particularly challenging owing to the presence of the live gas lines about 3 m from the ground level,” shares Sujit Prakash, Head – Structures. “Qatar Petroleum only allowed any form of activity after procuring a daily work permit given exclusively to personnel who were specially trained by QP. Workmen had to therefore clear exams post QP training to get authorized which created a paucity of labour that consequently delayed progress. The bigger hurdle however, was the rule that only manual excavation was allowed. This meant that we had to resort to mere Jack Hammers and a fleet of compressors. Progress was painstakingly slow because the workforce could not operate for over one hour at a time through this strenuous method. Yet, we managed to excavate 10000 cu.m near

these live lines,” says Sujit, recalling the ordeal. “A person was dedicated exclusively to procure permits on a daily basis to fast track progress. Since night shifts were not allowed, construction was done only during daytime when it was not swelteringly hot,” adds Sujit. Since casting in-situ under such circumstances would be arduous, the team deployed precast beams which were later stitch concreted with heavy reinforcements. Thanks to the tough workforce from Ghana, albeit being labour intensive, the assiduous team pulled the task off with ease and elan.

Al Wukair Interchange: (aka IC11)

A 2-level grade separated interchange crossing the Al Wukair road at-grade forming a key access to the Al Wakrah Stadium. The project comprises two crossings and flyovers, loops, vehicular underpasses and pedestrian/cycling underpasses. The major challenge in

this section was the construction of four clover leaf bridges by diverting live traffic. A diversion road was required wide enough to cater to two way traffic. However, owing to non-availability of land the diversion road had to be developed between bridges which infringed upon activities affecting 110 m of the expressway.

The team also encountered an uncharted 66 kV cable passing right under the alignment where the bridges were to be constructed. On examination it was found that these cables, which were sourced from Egypt, were of old specifications and were no longer manufactured. Since Kaharamaa (General Electricity and Water Corporation) insisted on having the same cables for rerouting, the team had to wait for six months for the ‘made to order’ cables which were laid to a length of 11 km. Despite the delay caused by the presence of the utility, the team managed to complete the bridges on time by fast tracking the project on all other fronts.

The project also had to ‘go slow’ owing to the presence of a villa belonging to a sheikh who was part of the ruling family and a school in the vicinity. The team was careful not to cause any inconvenience to the community by installing tall boards to curb disturbances and noisy tasks were executed well after school hours. Use of proper nets ensured that the area remained dust-free.

Another seemingly simple task of demolishing a petrol station located in the project command area took an unbelievably long period of two years owing to regulations and procedures. The major hiccup was to prove that there was no soil contamination for which several core samples were tested. Once the team procured the necessary permit, the tanks were carefully dismantled and excavation commenced immediately for the ramps. The presence of utilities held up the construction of the cyclist’s tunnel too for which local solutions were explored and the issue mitigated.

A primary case of worry for Rangarajan was the frequent changes in specs “Originally we were planning for 14 m high mast lighting along the median, subsequently the client insisted on replacing them with 30 m high masts with 14 m posts along the shoulders. The final lighting effect was so phenomenally bright that we could have easily hosted football matches along our alignment,” he quips but the team took all these in their stride and delivered.

IC 11A Interchange:

A 2-level grade separated interchange with a table-top bridge apart from a couple of pedestrian/cycling tracks, vehicular underpasses and a vehicular tunnel of 700 m. Sujit Prakash faced some challenges here too: “Being a table top bridge, the key challenge was in executing the heavy cast in-situ box girder that demanded an innovative formwork scheme. We ultimately settled for Doka on account of faster staging progress and the whole structure was built in a record time of 14 months,” he says with a smile.



Waab Buhair Interchange: (aka IC11B):

A 2 level grade separated interchange with two crossing bridges, flyovers, loops, vehicular underpasses and seven pedestrian/cycling underpasses.

Waab Buhair Interchange (aka IC12):

A 2 level grade separated interchange with two crossing bridges, loops, four flyovers and pedestrian/cycling underpasses apart from a couple of Qatar Petroleum gas line protection culverts with vehicular access.

“Of all the interchanges, the construction of IC 11 and 12 the toughest,” remarks Adrian Brown. “These were built on live roads amidst heavy traffic which had to be diverted in two phases with an enabling infrastructure of a 2 km asphalt paved road (2 carriageway x 2 lanes). Even these temporary diversion roads were audited by external road safety

authorities who were very impressed on its ride quality and safety,” beams Adrian Brown.

The interchange from design to delivery

This complex mega project links several highways and it is only understandable that bringing to reality what was conceptualized warranted impeccable coordination between the design and the execution teams. Both these teams integrated all the wish lists of the stakeholders that kept altering the project from time to time. Thanks to digitalization, the team was on top of everything despite several uncertainties. Seamless app-based project monitoring eschewed delays on several factors including those from multi-level design approvals. “Our graders were GPS-based and leveling was done automatically through sensors which gave us flawless results saving both resources and time,” shares Thejas H K, the Planning Manager. “Being on the same page fostered a culture of transparency and immediacy and whenever we noticed on the dashboard that some of our colleagues needed help, the team reached out mutually to each other.”

“We caught up with delays from land acquisition, permits and approvals with extended work hours to achieve our milestones, shares a relieved Sujit Prakash. “It was with diligence, commitment and persistence that the team was able to overcome all the obstacles many of which were totally unanticipated.”

With shortage of raw material such as earth, bitumen and gabbro for asphalt works, the team relooked at areas of pavement design by introducing CTBC (Cement Treated Base Course) using limestone (a locally available natural resource) apart from reducing the pavement thickness. This consequently lowered dependency on the exotic raw material which anyway was a nightmare to procure owing to the sanctions imposed on the country.



Sanish Edathodiyal who heads Road Works reminisces that balancing supply vs demand for borrow earth and maintaining adequate stock was the mainstay in achieving the main carriage completion. He also recalls that conforming to set standards which was periodically audited by third party testing teams warranted a high level of competence.

“Earth for embankment was a very precious resource that needed constant monitoring. With mega projects happening across the country, earth was in acute shortage leading even to pilferages and theft if left unchecked. Digital technology helped alleviate this concern as the team installed weigh bridges along with IP cameras to closely monitor material movement apart from installing microchips in the fuel tanks of all vehicles to prevent theft of fuel.

Delays were also the case of headache for Procurement Head, Omprakash Shrivastava. “Imports of pipes and major

fittings from Europe were complicated and delayed owing to clearance issues at port which became increasingly more acute following the sanctions as some of the shipments got stuck at Jebel Ali Port. Playing it by ear, the procurement team forwarded the shipment to Oman and onward to Qatar smartly mitigating the situation,” shares Shrivastava.

The promise

L&T has been a symbol of reliability, promising and delivering projects to exacting standards set by the Qataris who are sticklers to perfection. The Al Wakrah bypass project has been no exception and the team has wowed the client, by opening to beneficial use, a section of the main carriageway, three months ahead of schedule! With construction still in full swing, the team is sure to pave the path for on-time delivery of this mega project that will forever change the way traffic moves between the most important cities of Qatar!

A metro on the fast track

Metro rail project, Doha



A 11,500 sq. km peninsular position in the Gulf region, marked by an impressive 563 km of uninterrupted coastline has been the backbone of Qatar's economy, be it for their long-lost, yet traditional fishing and pearl gathering occupations or the northern oil and gas fields which fuel the nation to be one of the wealthiest members of the six Gulf Cooperation Council (GCC). With over 5% of the entire world's reserves of natural gas spread out almost as large as the nation itself, Qatar enjoys one of the highest per capita GDP globally and the Government invests heavily in creating world-class transportation infrastructure to ensure safety and comfort to the citizens.

This desert nation's transport infrastructure has predominantly been its expansive road networks, about

10000 km of which links the capital city of Doha to the major oil producing hubs and other industrial areas. The Hamad International airport and the four sea ports serve as the gateways to the rest of the world.

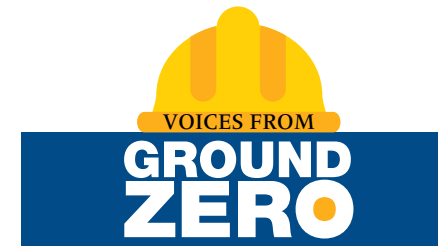
Qatar now aspires to transform itself from a hydrocarbon - dependent country to a diversified, pluralistic and knowledge-based economy. A dream that has been outlined in the ambitious Qatar National Vision 2030. Building rail networks was a major part of this vision and consequently Qatar Rail was formed and mandated to design, develop and manage rail networks to provide a sustainable means of transport for both passengers and freight.

Apart from partnering the efforts of building the ambitious 1940 km GCC

rail network to connect the six member states, Qatar Rail is also building a Light Rail Transit system or a tram network in the new city of Lusail. The most significant of the rail projects, however, is the Doha Metro - a largely underground rail network that promises to make commute within the congested city of Doha easy and sustainable. The grand masterplan is to merge these three rail networks together as a smart and integrated system, allowing passengers to transfer between them offering absolute convenience as a country-wide rail network!

The thrill in the kicks

Doha is presently perhaps the most happening place in the world, not merely because of its rapidly increasing GDP or infrastructural projects that power



A.L. Sekar
Senior Vice President
Special Projects - International

"Operating multiple TBMs under the JV requires impeccable project planning backed with contingency measures to ensure that not even a single day is lost. We are racing against time."



it, but the excitement around the FIFA World Cup 2022 slated to be held here. A soccer-crazy nation, this footballing fiesta is sure to set the stage on fire and the country is gearing up for it and how!

Swanky hotel citadels, well paved pathways, impressive stadiums and a host of other smart infrastructure are transforming Doha. However, Doha also aspires to fast track and strengthen its guts with a robust and secure metro rail system right under its belly to tackle the millions who would be commuting frequently during this mega event.

Connecting the dots

The **Red Line**, or Coast Line, will connect Lusail city in the north with Al Wakrah in the south and passes through the Hamad International Airport. Divided into two major segments, the line will cover 40 km including 17 stations. This line is expected to reduce travel time from the airport through the heart of the city to Lusail by 36 minutes from the usual hour and a half during peak traffic.

The **Green Line**, or the Education Line will link Education City to Doha. It will originate from the industrial area in the south and end at the Al Rayyan Stadium, covering 31 stations on a 65.3 km stretch.

The **Gold** or Historic Line will connect Ras Bu Abboud on the east with Al Aziziyah in the west covering 25 km with 10 stations.

Much of these networks run through underground tunnels in central Doha and are either at-grade or elevated in some suburban stretches.

ALYSJ JV

The Gold Line was awarded to AYSJ Joint Venture consortium including Aktor (Greece) - Larsen & Toubro Limited (India) - Yapi Merkezi (Turkey) - STFA (Turkey) - Al Jaber Engineering LLC (Qatar) with the following scope:

- Civil/structural work for 10 stations which include 3.7 million cu.m of excavation, 1 million cu.m of structural concrete and 1.1 million precast segments for tunneling



- 25 km of tunnel executed through TBMs
- Cut and cover method for station construction
- 24 cross tunnels and 1 emergency exit
- Mechanical, Electrical and Plumbing (MEP) and architectural works for all stations

While tunneling posed its own challenges, construction of stations was more complicated with some of the three levels structures reaching excavation depths of 35 m making disposal of excavated muck cumbersome. "Operating multiple TBMs under the JV requires impeccable project planning backed with contingency measures to ensure that not even a single day is lost. We are racing against time," shares Mr. A. L. Sekar, Senior Vice President as he shifts impatiently on his feet.

"We set-up a dedicated team exclusively to liaise with the external stakeholders so that the execution guys

could focus entirely on achieving their targets. We were thus able to increase productivity and overcome hurdles and, in the process, impress the client



with many ahead of schedule deliveries and impressive safety records," explains Mr. Jens Huckfeldt, Chief Executive – Qatar.

Managing more than a project

Converging the work culture of 44 Nationals into a five member Joint Venture environment that is charged with asking rates and striking a balance between commercial interests and project progress is indeed a challenging tough ask. "Concluding an Islamic banking syndication was a first of its kind initiative at L&T involving four banks. Providing consistent banking support for project execution gives a sense of satisfaction as an individual," shares Mr. Ramkumar Nagarajan, Chief Financial Officer, ALYSJ JV. "We have an energetic team of domain experts who ensure that Internal Controls and L&T's value system reflects in an International Joint Venture project environment" he beams.

Never a dull day for the team

Doha metro holds the Guinness World Record for operating the highest number of tunnel boring machines (TBMs) in a single city! Of the 21 massive TBMs steadily digging underground, 6 were from the ALYSJ JV engaged in creating the Gold Line. "These advanced TBMs use Earth Pressure Balance (EPB) technology where a circular cutting ring breaks into underground surfaces creating cylindrical cavities for tunnels and the excavated debris from this process is transferred through the tunnel to a dish," explains Mr. Alope Kumar Dey, Project Manager, ALYSJ JV adding that precast segments are placed as liners along the tunnel walls to stabilize it instantly. "In this advanced construction method, tunnels are created at unbelievably fast rates in the safest possible manner without causing any harm to above ground structures."



Stations backed by BACS

“Most station buildings feature a generic length of 178 m with a three level structure of under platform, platform and ticketing levels while some also have an intermediate floor to house the MEP services between the platform and the ticketing levels,” shares Vivek Maruti Pai, Station Manager – Qatar National Museum - talking about the gigantic stations. “Ours was a bottom-up method and we are excavating 3.7 million cu.m of earth and will pour 1 million cu.m of concrete. That’s actually the easy part,” he quips, adding that all this hard labour was carried out in extremely congested urban areas where logistics was a nightmare. Barricading the work area appropriately along with smart traffic management helped accomplish this daunting task.



Jens Huckfeldt
Chief Executive - Qatar

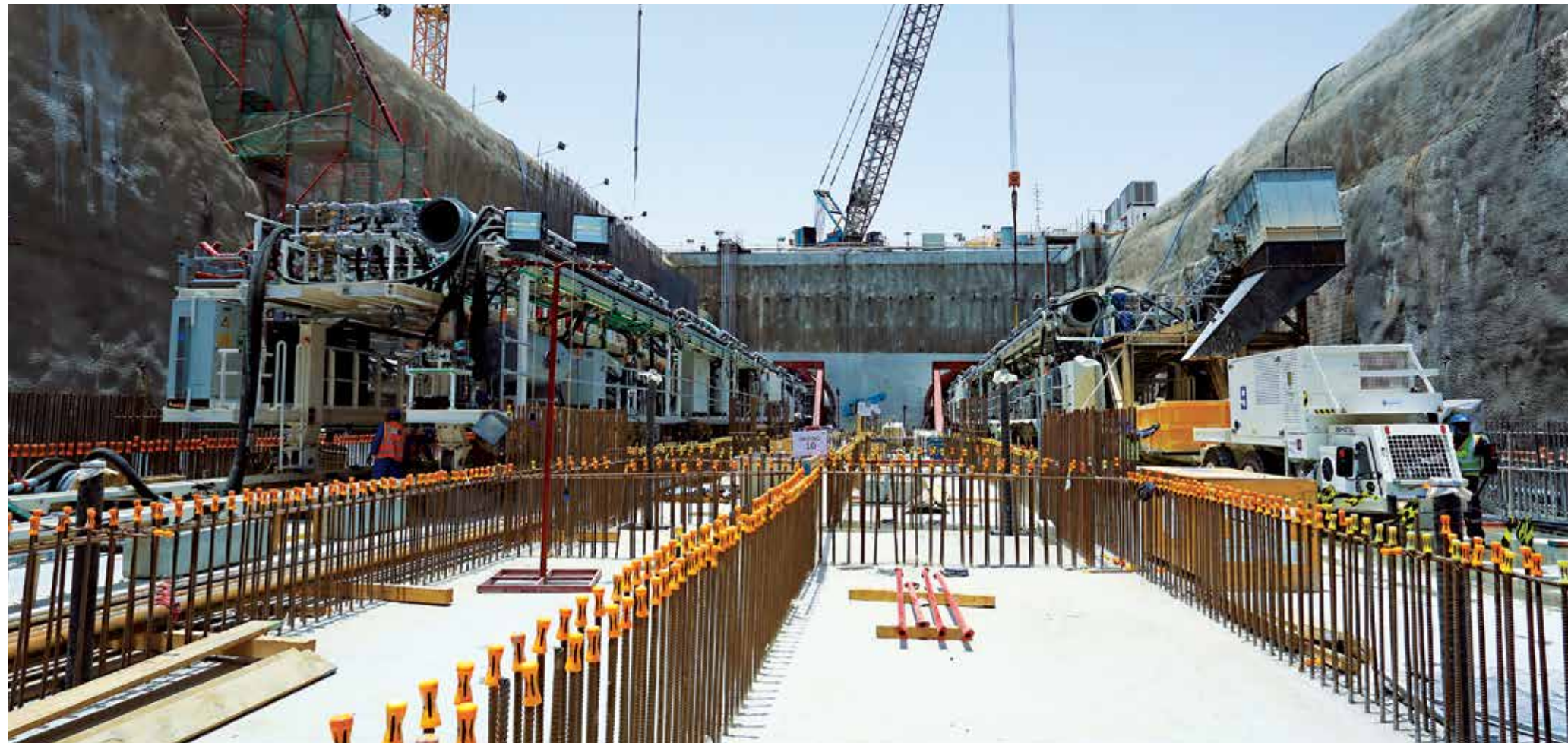
“We set-up a dedicated team exclusively to liaise with the external stakeholders so that the execution guys could focus entirely on achieving their targets. We were thus able to increase productivity and overcome hurdles and, in the process, impress the client with many ahead of schedule deliveries and impressive safety records”

The station buildings feature BACS (Building Automation and Control System) energy and smoke management systems which are based on programmable microprocessor controllers. These advanced safety controllers can operate in a stand-alone mode even in the case of a communication failure with the central servers apart from being seamlessly calibrated to optimize the energy efficiency of the MEP equipment. The system, that makes data real time, can be operated either remotely using SCADA or as a stand-alone module from the station control room. The scope was extensive and it kept changing often with additions and modifications, yet the tenacious team slogged it out to create one of the world’s most intelligent and smart metro station buildings from a MEP perspective.

Escape to safety

A part of the Gold Line team handled a unique challenge of digging down vertically towards the metro tunnels! The ‘Emergency exit shaft’ as it is technically known is a 30 m deep tunnel connecting both the Gold and the Blue Lines with an above ground interconnected structure that includes a power station to ensure sufficiency of energy at all times. This shaft serves as an evacuation exit from the metro tunnels in case of emergencies.

The first challenge that presented itself was in the form of uncharted live optic fibre cables heading to the Hamad International Airport. Shifting such crucial utilities presents its own delays and challenges owing to permits and clearances. At the same time, there was constant pressure from the client on



timely completion. Playing off the front foot, the team resorted to carefully digging out the cables and slewing them just outside the alignment and further, as a contingency, the newly laid cables were sheathed in concrete for added protection.

“We had to continuously dewater as we went deeper. The proximity to the coastline and the deep excavation forced us to ‘literally’ think out of the box to secure the workspaces and make them safe, waterproof and sealed,” shares Mr. Pakki Jagadeeswara Rao, Construction Manager – Souq Waqif Station. “We also had to bear in mind the long term reliability, given that this infrastructure will be used to save human lives during eventualities - exactly why we did extensive grouting to exacting standards.”

The digital thrust

Live IP cameras helped monitor activities across project locations and offered the convenience of logging in from anywhere. Armed with state-of-the-art Building Information Modelling (BIM) solutions, the model-based

construction process constantly added value across the entire lifecycle of the structures. While the Aconex software powered documentation, SnagR proved immensely useful in recording, monitoring, escalating and resolving snags, especially on architectural finishes.

Where blue and white merge to create gold

Blazing heat, freezing nights, frenzied pace of work and a persevering focus on targets – life has indeed become a roller coaster ride for the team building the Gold line of Doha Metro. With families back home thousands of miles away, these brave-hearts have quickly adapted making Doha their new home and are adjusting to the local traditions, culinary flavors, dress codes and even their idea of leisure! The project is enormous, complex and demanding - completing it on time and to the utmost quality is the singular objective that drives this team of engineers and workmen who are engaged in the process of creating history!

Strengthening the sinews of the nation

Blast Furnace (BF-8) at Bhilai



There is more than a bit of steel in everybody's lives

Did you know that there is a little bit of iron in all our bodies? Close to 3 grams has been apportioned across key functional areas that is essential for survival. Steel is also an irreplaceable part of our daily lives due to its wide range of applications in almost everything we do. Be it the transport we use, the homes we live in, the offices we work or a host of other essentials. Steel is woven into the very fabric of life.

From a larger perspective, the steel industry plays a vital role in the economic development of the country being integral to infrastructure development. India, with its rich source of iron ore is a global hub for steel production. Just recently, India has emerged as one of

the world's three top steel producers having achieved an all-time high production of 100 t. India's steel sector is dominated by a handful of public and private sector players among which the Steel Authority of India (SAIL) holds lion share of the market operating and owning 5 integrated and 3 special steel plants. As part of its expansion drive, SAIL has embarked on an ambitious path to scale up its production to 50 MTPA by 2025 by enhancing capacities which includes setting up one of the biggest blast furnaces in the country at its flagship plant in Bhilai.

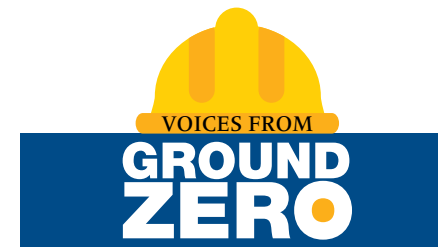
Reinforcing partnerships

L&T's Metallurgical and Material Handling (MMH) Strategic Business Unit which has forged steely bonds with all the steel majors by pioneering the construction of modern plants and now having built a slew of them, was

roped in to build a state-of-the-art 2.8 MPTA Blast Furnace (BF-8) complex for SAIL at Bhilai. The project kicked off in 2010 after the consortium of L&T and Paul Wurth Italia bagged the EPC order which stipulated that while technology, basic engineering, supply of proprietary equipment and performance guarantees came under Paul Wurth's scope, L&T's onus included detailed engineering, architectural, MEP, HVAC, road works, supply, erection and commissioning of mechanical, electrical and instrumentation systems along with site services comprising civil & structural and sheeting works.

Making ground within an operational plant

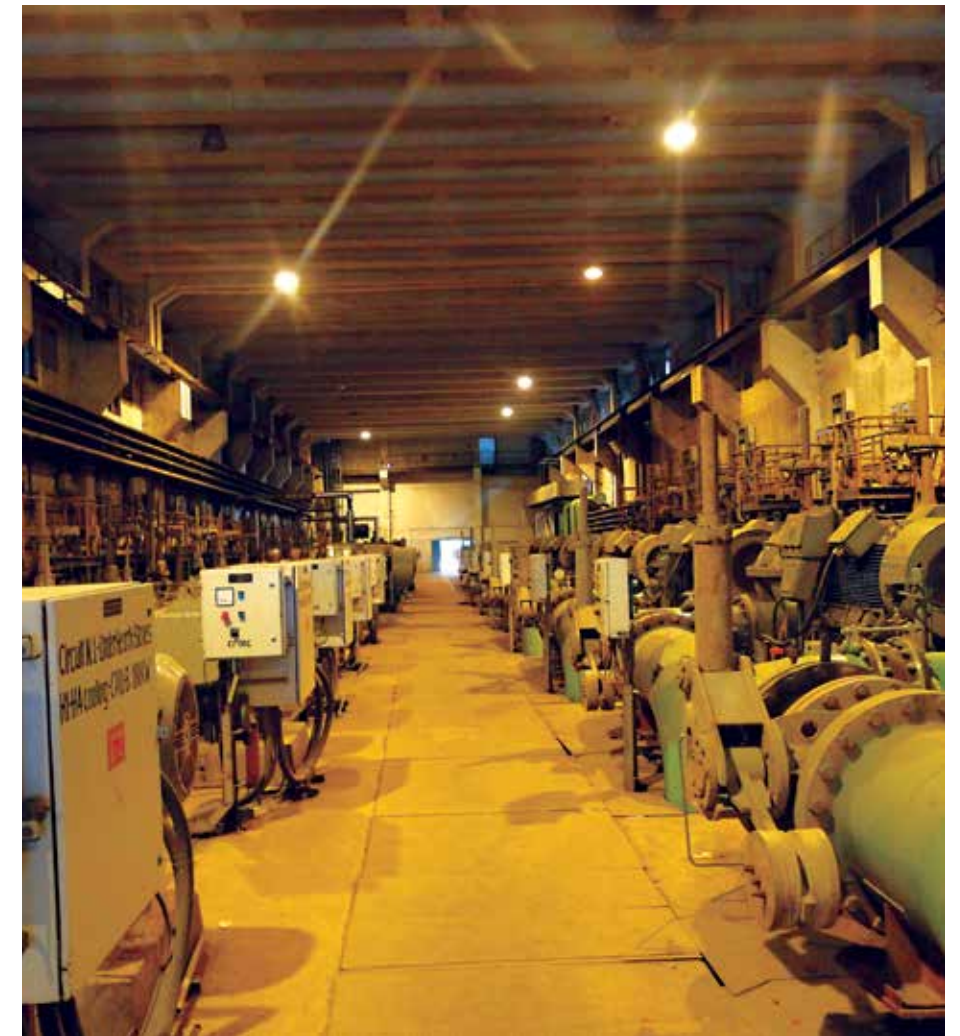
One of their first challenges for the team was the vast area involved for execution spread over a 7 km radius



Pranab Saha
Project Director

"For team MMH, delivering a project of such complexity was no mean task but what kept us in the race and enabled to finish the milestones, one after another, was the implementation of a range of value additions and sustainable construction initiatives."

"With the trail runs successfully conducted and approvals in place, the blast furnace is on the verge of commissioning with all systems under operation and the blow is expected to be achieved as the final stabilization of the incoming gas lines from the battery limits are nearing completion. The system is also being re-run continuously to give enhanced confidence to all operating agencies till the blow in is achieved."



within an operational plant premises starting right from the stock house up to the slag disposal conveyors. "Apart from the huge capacity, the furnace is conceived as one of the most advanced plants in the country with environment friendly designs and is equipped with modern features such as top recovery turbine, waste heat recovery system, energy efficient equipment and pollution control measures," mentions Pranab Saha, Project Director. One of the foremost tasks for the team was to plan a secure demolition programme taking into consideration the operational factors inside a running plant. "A whopping 15000 cu.m of demolition had to be done to clear the various fronts" reveals Saha. "This included existing client owned buildings,

underground RCC structures, and utility & communication systems. While the task of removing the existing equipment was relatively easy, the challenge was in bringing down the larger facilities such as the stock house, stock house de-dusting and the gas cleaning plant areas. Dismantling the slag conveyor system called for precision detailing and a secure execution strategy as this mammoth structure spanned over 3.5 km running across operating units, office buildings and even overlapped with road crossings and a hot metal railway track system. There was an instance when one of the structural supports for the conveyor had to be re-engineered due to the non-availability of fronts. But the diligence and hard work of the team ensured the structures were brought

down with minimum hindrance to the daily operations of the existing plant," shares Saha proudly.

Mitigating on-field challenges

Apart from the physical deterrents there were a multitude of other challenges that needed to be addressed on a daily basis such as the management of critical resources, space constraint for assembling and storage of materials, adherence to bureaucratic procedures and submission of technical requirements at every stage of the project. Security was another grave concern, informs Sandeep Kaul, Planning Manager, "As the site was situated close to Maoist areas, it



was important to thoroughly verify workmen details before engaging them and ensure that the colonies were put across safe zones for the close to 4000 workmen engaged at site during peak operations.”

Establishing firm footings

In line with the design of putting up one of the largest free standing blast furnaces in the country, the foundation works were scheduled over three stages. Stage 1 involved establishing a firm footing for a large girth that formed the base of BF-8 which was accomplished within three and half days. However, the challenge here was not the ordinary concreting but the pouring of the heat resistant concrete which formed a vital component that too during May in the height of summer, indicates Saha. “The methodology was finalized after a lot of

brain storming and the entire process was firmed up after many trail runs estimating the time taken to transport the ice from close to 100 factories around the Bhilai belt, calibration of batching plants for precision pour and lining up other associate concreting equipment.” Stage 2 involved around 1030 cu.m of concreting for shaping the rectangular structure of 23 x 21 x 2.131 m size with two CP 30 batching plants achieving an average of 30 cu.m/hour output. The pour was done with a boom placer and a static pump within two days. The final phase of works was across the circular 17.35 m dia pedestal of the blast furnace that involved around 632 cu.m of concreting and was accomplished within 42 hours.

Raising a free standing structure

Most critical for a blast furnace are the sturdy shells. Usually, these are

supplied by the client but in this case it was assigned to L&T, mentions Saha, “The task was spread out across phases involving fabrication, assembly and erection of the lower, middle and upper parts of the structure. Special 100 mm thick plates imported from China were customized at our workshop in Kancheepuram through a state-of-the-art automatic bending machine with the entire control assembly done at the fabrication shop to facilitate seamless integration at site. The segments were transported on trailers and assembled as circular rings weighing close to 1030 t at the pre-setup assembly beds close to the furnace location and subsequently made into sub modules and lifted using a 600 t heavy duty crane.”

Saha continues with a sigh, “The huge base plate of the structure with a girth of more than 210 mm had to be machined and fabricated only at site which meant that we had to devise

innovative means to process this critical task. Precision welding was the need of the hour for which we had to pre-heat the plate to more than 150 degrees so that the welding was securely done and free from stress.” The team came up with a proposal of placing electrical coils all around the plate thereby ensuring that the required amount of heating was done for taking up the welding works.

Having lined up the structure, the team had another daunting task. “As there was a delay from the consortium partner in supplying the Bolt Together Hopper, a portion of the heavy erection works was revised since the earmarked heavy duty crane had to be released to another site. This critical task of putting in a place two 62 t hoppers at a height of 60 m was accomplished with a 50 t outrigger crane by precisely calculating the additional load capacity as well as by reducing some weight by removing the manhole covers, enablers, etc. while ensuring all safety parameters were adhered to,” avers Saha.

Banking on inherent strengths

Team MMH made extensive use of L&T’s in-house formwork systems to customize the framework for a range of civil structures noteworthy among which is the construction of the Emergency Overhead Tank at a height of 70 m. “The shell portion of the tank which is up to 60 m high was constructed through slip formwork to accommodate 3 independent tanks at different elevations (+ 25 m, +40 m and + 51 m) respectively,” informs Saha. “While the top slab was constructed using rebar couplers, the support for the tank’s base slab was provided through a temporary structural platform fitted on the stack wall. The top dome portion spanning + 60 m height to + 70 m height was executed using conventional formwork system.” On the whole, close to 57220 sq.m of formwork materials were used for foundation works, 56003 sq.m for walls, 51603 for columns, 95303 sq.m for slabs and 15000 sq.m for slip formwork.



Breathing life into the system

An array of electrical and instrumentation fixtures powers the functioning of the various systems in the plant with 24 core transformers feeding power to the 12 plant control centres which are also secured with an emergency back up provided by 8 UPS. "This is first time that MMH has executed the entire electrical, instrumentation and automation works for the entire furnace and integrating a composite power network was instrumental to the success of this project," acknowledges Saha, "Especially the automation of the plant involved a range of meticulous tasks for lining up the 16 programmable logical controllers which remotely control the 56 remote input output panels."

Implementing a feasible heating system

As per contractual norms, the heating of the stoves of the furnace was scheduled to be done with diesel which is predominately the way SAIL does across its others plants however at BF-8, L&T convinced both the consortium partner and the client to opt for the coke oven method of heating thereby eliminating fuel cost. The process involves heating the hot stove chimney along with the hot blast main and bustle pipe for about 7 days following which the stoves start getting heated. The stoves are designed to provide hot blasts at 1250 °C at a blast volume of 6125 Nm³/Min to the furnace. The hot stove system is also equipped with a waste gas heat recovery system that consists of heat exchangers which are

used to recover the heat from the waste gas leaving the stoves thus enhancing the efficiency of the operation. The cooling system of the furnace includes the main pump house that houses 143 HT and LT motors, a cooling tower and a state of the art 2500 cu.m emergency overhead tank. It is estimated that the furnace can churn out close to 8030 t of hot metal on a daily basis.

Ensuring a foolproof environment

Saha indicates that a range of secure systems have been implemented across the plant to arrest any unlikely emergency situations. "This is the first blast furnace to use an Inergen Suppression System which is strategically installed across the major hubs of the plant and is also backed by an unique Foundation



Field Communication System which monitors plant operations on a 24/7 basis. While most of the instrumentation engineering has been done by the technology providers, L&T had the onus of the detailing the access way for this myriad network."

Good practices that reaped rich rewards

For team MMH, delivering a project of such complexity was no mean task but what kept them in the race and enabled them to finish the milestones, one after another, was the implementation of a range of value additions and sustainable construction initiatives. These included streamlining work processes by using readily available materials such as slag cement and locally available fly ash bricks for soling, diversion of construction debris, construction of open vats for faster curing, installation of an Enhanced Dust Control System along with a range of monitoring equipment to

assess the various compounds generated across the plant. By adhering to the SOP and Quality standards, L&T was able to bag a slew of domestic and international awards which included the Best Safety Performing Agency, RoSPA Gold award and National Safety Council of India accreditations.

Well on course towards successful commissioning

With the trial runs successfully conducted and approvals in place, Saha is visibly delighted, "The blast furnace is on the verge of commissioning with all systems under operation and the blow is expected to be achieved within a month as the final stabilization of the incoming gas lines from the battery limits are nearing completion. The system is also being re-run continuously to give enhanced confidence to all operating agencies till the blow in is achieved which in itself is the best way to have a hands-on un-simulated experience."

Ringling in a green future for farmers

Kharkai barrage project



A 32-year-old project gets a new lease of life

Every year, India reveals her diversity with several areas getting heavy rainfall resulting in extensive flooding while may other parts battle with severe drought conditions. While a lot of hope is riding on the take off and success of the interstate river linking scheme, there have been other projects modelled to bridge the demand-supply gap in water. One such mega scheme is the Subarnarekha Multipurpose Project (SMP) announced way back in the '80s which benefits the three states of Odisha, Jharkhand (formerly undivided Bihar) and Bengal by sharing of waters from the Subarnarekha River for irrigation and industrial use. However, due to strategic reasons, a significant portion of this scheme involving the construction of a barrage at Kharkai that had been

shelved for many years was finally brought to life in 2013 after almost 32 years.

Taking over the construction of a maiden barrage project

L&T Construction's Water & Effluent Treatment (WET) business which has been in the forefront executing vital lift irrigation projects across the country added one more milestone to its list of benchmark projects by stepping into Jharkhand for the first time to take forward the construction of this barrage along with its allied works including civil, mechanical, electrical & SCADA system.

Farmers of the region have lots to smile about as the scheme was envisioned to feed 18 cum/sec of water to the right

bank canal which in turn would be utilized for irrigating 24,388 hectares and also recharge the nearby Sitarampur reservoir to meet the drinking water requirement of the people of Adityapur area and also supply water to the major industrial units along the Jharkhand belt.

Stepping over the initial setbacks

Dinesh Kharbanda, Project Manager, has a lot to share on the vague beginnings of this project, "Initially when the work was awarded there was a lot of agitation from the local villagers due to land issues and being a tribal area it was an uphill task to convince them that this scheme was ultimately going to benefit the community in the long run. Although providing encumbrance free land for

work was under the client's scope, the onus shifted to L&T as we had to make a beginning and hence we initiated talks with the villagers even before stepping onto the site by roping in the local bodies and highlighting the major gains for them like perennial availability of water for irrigation and a permanent bridge on the top of the barrage connecting villages across both the banks. Further, we also encouraged them to form a village committee 'Ganjia Ekta Manch' to share the common benefits such as allowing the locals to make use of the site approach road as there was no approach way earlier while also engaging local resources wherever possible." To speed up the groundwork, "We joined hands with the client by engaging our survey team and fast-tracked the preparation of land records for taking up the tasks at site"



Coffer dam work in progress



Excavation for left abutment

Being on field after a hiatus of close to three months meant that the team was visibly charged. "We plunged into action straight away and took up the core drilling works for assessing ground conditions which was originally in the client's scope. We provided the samples to the Geological Survey of India, Kolkata, in January 2014, following which the soil investigation report was submitted to the Central Water Commissions (CWC) Department in May 2014. Based on the CWC report, the first set of civil drawings including the excavation layout was finalized on 22nd May 2014."

Evolving a feasible tactic

Most of the tasks were lined up after we did a detailed sequencing of the various activities taking into consideration the seasonal factor which governs the flow of water, mentions Ashish Singhal, Planning Manager, "When the base schedule was prepared, the whole barrage was divided into two parts from the center,



Dinesh Kharbanda
Project Manager

"We were spot on in ensuring that safety and quality were stringently adhered to at site by having two construction managers assigned across both banks with another senior construction manager exclusively reviewing the entire activities through daily and weekly meetings with the on-field teams. A slew of safe work methods such as work permit system, breath detectors for night shift workmen and use of PPEs were implemented at site along with motivational schemes which enabled the site to clock more than 4 million safe man-hours."



Reinforcement for pier footing

left and right banks, and the initial plan was to do the entire course of works in four phases aligning to the seasons so that working in the river would not be a challenge. However, with a delayed start, it was evident that this approach would not work and hence we shifted gears to take up simultaneous fronts along both banks by channelizing a narrow passage way for diverting the water to facilitate works with the conviction that being a non-perennial river, the water level in the stream would considerably reduce during the summer months thereby giving us the advantage to open more fronts to cater to the increase in the volume of works as we surged ahead."

Perfecting 63 precision blasts

As a large part of the terrain was rocky, excavation was carried out in a mixed manner indicates Dinesh, "Work commenced on 27th January 2014 and we quickly ascertained

that blasting was essential to gain momentum. However, the challenge here was in securing the safety of local communities living in close proximity to the site while limiting the frequent movement of men and cattle across the site. A dedicated crew comprising safety in-charge, construction managers and engineers was formed to look into the entire blasting process while creating continuous awareness in the nearby areas a day prior to the activity which was slotted strategically during the lean movement hours between 12.30 pm and 2 pm. During the blasts, the whole team was divided into four groups with two units deployed to block any unlikely movement 500 m before the site area on both the sides, while the other teams carried out the risk inspection works across the entire site area. Continuous sirens were played for 15 minutes before the start of the activity and proper coordination was ensured for safely carrying out the blasts. We were able to do 63 successful blasts using 84 t explosives," beams Dinesh.

Realigning to the design changes

Having paved the way for the core works, the team was surging forward to begin the concreting works but Dinesh was faced with fresh challenges as design changes proposed by the client necessitated a realignment. "There were many changes in the construction drawings issued by the CWC when compared to the study drawings released during the tender especially with regard to the left abutment, foot width of which was increased from 10 m to 23 m. As a result of all these changes there was huge increase in the quantum of works. An entire deviation statement was prepared and submitted to client for approval with extra time also requested for."

Lining up a slew of concrete solutions

Concreting formed the bulk of the works comprising close to 227,000,



Staging for deck slab

cu.m along with associated tasks such as 109,000 sq.m of shuttering and 5800 t of reinforcement. This was not a plain pour forward task, reveals Ashish, "Only 8 to 9 months was available in a year to be utilized as we were working in the middle of a flowing river and our asking rate for concreting was more than 10,000 cum per month. To cater to such a high volume, only two feasible options were available i.e. install our own batching plant at site or deliver through ready mix transit mixers. After comparing the cost of both options, we decided to install a M1 plant along with a CP30 plant each on both sides of the river."

"With the day time temperature hovering around 48° C it was critical to effectively bond the concrete because at such high temperatures, the top layer dries much faster than the bottom resulting in shrinking leading to cracks in the surface," says a worried Dinesh and to avoid such excessive hydration, a concreting chilling plant was also installed at site for producing pre-cooled concrete (max 21° C) during summer when the temperature rose above 35° C.



Reinforcement for deck slab

Further insulation was provided to the produced concrete by transferring it to site through transit mixers covered with wet hessian cloth."

Integrating the steely components

The mechanical works included fabrication of more than 3000 t which comprised various components of the barrage such as vertical gates, stop-log gates, hoist supporting structures, rope drums and head regulator gates. We took up the heavy tasks right at the nascent stage itself as the scope involved a lot of precision detailing, details Dinesh, "A separate fabrication yard on one side of the project site with three working platforms was set up with both the civil and mechanical works being individually executed. Further, for critical works, a unique rolling shed with an adjustable roof was built to facilitate work even during adverse weather conditions. The process of

mechanical installation was precisely corroborated with a detailed review of the required condition at site before the casting of every concrete lift as the tolerance limit for displacement of the mechanical parts was negligible. The erection of the first stage of embedded parts was done across a span of two to three days subsequent to which the final combined inspection was done to clear the front for concreting."

Surging ahead with process innovations

Having streamlined the early phase of the project, it was time for team L&T to innovate on the critical processes as the going got tough, mentions Dinesh. "Ascertaining a suitable formwork scheme for constructing the flared out wall spanning 80 m to 90 m long and 18.5 high across upstream and downstream along both banks of the barrage was a challenge due to the varying slope ranging between 90

degree at start with to 26 degree at the end point. As close to 30 percent of the total concrete work was in this section, a novel formwork scheme for hinging the structure from the inside was developed using the reinforcement and only the working platform was provided from the outside."

For lifting the piers and abutment, Dinesh adds, "A triangular shaped 1.5 m long climbing bracket system was used at site which was fixed to the bottom of the pier lift above which the lifting was done. The entire shuttering formwork was placed over this climbing bracket system and fastened from inside using tie rods with supports also provided from the outside. Adopting the bracket system instead of the conventional staging prolonged the working season and also mitigated risk of flash floods during the pre-monsoon period."

Similarly for putting together the critical heavy components, a slew of safe measures were devised, shares Ashish,

"We convinced the vendor to supply a 13.2 m MS plates against the conventional size of 12 m for the barrage gate thereby eliminating the fabrication scope and saving precious time. The hoist support structure, weighing close to 7 t to a height of 15 m, was erected from the adjacent concrete deck due to the monsoon after carefully ascertaining the load chart calculations with a 60 t hydraulic crane."

Playing it straight and safe

Team L&T has been spot on in ensuring that safety and quality were stringently adhered to at site. "We had two construction managers assigned across both banks with another senior construction manager exclusively reviewing the entire activities through daily and weekly meetings with the on-field teams," shares Dinesh. A slew of safe work methods such as work permit system, breath detectors for night shift workmen and use



Aerial view of barrage



Right bank upstream view of Kharkai barrage

of PPEs were implemented at site along with motivational schemes which enabled the site to clock more than 4 million safe man-hours thereby fetching the prestigious British Safety Council award.

To facilitate precision delivery across concreting and mechanical works, a fully equipped field lab was set up at site where regular stage testing of the materials and concrete was done while third party testing was certified through NIT Jamshedpur. "The good work practices has been acknowledged by the client with 10 appreciation certifications," shares Dinesh proudly.

Balancing the cash flow

Sounding like a true Project Director, Dinesh says, "At the end of day it is all about managing costs. With around close to Rs.10 crore of monthly invoicing during the peak period, it was important

to ensure timely collection from the client and also make payments to the subcontractors. Therefore we convinced the client for a fortnightly billing cycle during the working months which helped maintain a positive cash flow all along."

Closing in with a clean image

So far so good exclaims Dinesh with Ashish beaming, "Though the job is still under progress, we are on the verge of completion with the client expressing satisfaction on the delivery schedules. An added bonus is the good will we have garnered from the locals who now acknowledge that their quality of life has undergone a transformation for the better with this project. From the team's side, there is feel good factor of having achieved a milestone for the organization and also making a difference to the lives of many in this remote region."

Integrating India's largest intelligent communication network

Network for Spectrum
Optic Fibre Cable (NFS OFC) scheme



Realizing a spectrum of opportunities

Communicating in today's scenario is literally child's play, thanks to digital technology and smart hand-sets that have simplified sharing of information through a range of high-tech platforms exclusively driven through select electromagnetic waves known as spectrum bands. While many of us are familiar with 3G and 4G networks, there is far greater significance to these frequency bands as they form the crux upon which all formats of commercial and sensitive communication are channelized.

Initially and for long, spectrum bands were predominately reserved for government agencies with the Defence Services holding a major share of

them. The privatization of the telecom sector and the need for additional spectrum bands led to the auctioning off of the first bands of telecom spectrum to deploy the 2G networks in the 90s. Today, the spectrum is divided between different types of technology: AM and FM radio channels operate in the 100 MHz-200 MHz range while the telecom spectrum commences from 800 MHz and goes up to 2300 MHz beyond which are unlicensed bands for technology for Wi-Fi, Bluetooth and such like. The transition to 3G and 4G spectrums owes a lot to the mobile phone revolution. As the share of civilian communication sky-rocketed, the government was forced to enhance the bandwidth of private telecom operators and at the same time plan for an exclusive communication network for the Defence Services.

High-tech communication for the forces

To meet this new requirement from the Defence forces, a mega 57000 km Network for Spectrum Optic Fibre Cable (NFS OFC) scheme, which is also India's largest & longest intelligent communication network project, was conceived by the government to provide reliable gigabits of bandwidth to the nodes of Tri-services located across India. The project is considered as an important milestone in enhancing the communication capabilities of the forces in terms of advanced voice, data and real time video services.

L&T, which has been at forefront of designing, developing and

manufacturing weapon systems of highest quality across chosen Defence segments that have reinforced its credentials as 'protectors of the nation,' pitched in to execute this mega communication network scheme through its Power Transmission & Distribution (PT&D) business vertical and was successful in bagging two significant packages from M/s Bharat Sanchar Nigam Limited (BSNL), the nodal agency nominated by the Defence Services for this project.

PT&D's scope covered a span of 17000 km involving supply, survey, trenching, laying, installation, testing & commissioning and maintenance of an fiber optic cable network across the Western States under Package D and Southern States under Package E with a stringent execution schedule of just about two and half years.



Gearing up for unique cross-terrain challenges

For team PT&D, this was a unique project as it marked L&T's return to the OFC segment after many years, points out G.Kesavan, Task Force Leader, "As a turnkey assignment, we had a long list of tasks to be streamlined even before taking up the works across the 9 states as this was a one-of-a-kind project extending across a cross-section of terrains." The scope covered planning OF links for connecting the nodes of Tri-services across states, surveying to identify the most feasible and economical routes, applying and getting the Right of Use (commonly termed as RoW) from various central, state and local authorities, trenching and ducting, blowing of the OF cable, splicing, providing joint manholes, route/joint markers, installation of the Fibre Distribution Management Systems at the terminal buildings, completing the civil works, acceptance testing and cable acceptance testing, preparation of 'As Built Drawings' to centimeter accuracy to the complete satisfaction of BSNL and Defence authorities.

Strategizing a two-way progress approach

Initially the client insisted on a plan based on the priorities as per the contract, i.e., prioritizing every 1000 km stretch, but on-ground, the project team found that it was not feasible to make progress due to RoW issues and hence it was decided to open up parallel fronts to facilitate works. This, however, called for a calculated approach as opening up several fronts meant making huge volume of RoW payments which also could not be reversed if the particular link was not commissioned due to non-availability of RoW even for 100 m, mentions Kesavan. "It was after a lot of deliberation that a balanced approach was finalized to take up the fronts with two separate project units formed for the Package D and E backed up by a Task Force Team at HQ, Chennai, for interfacing with the BSNL and Defence HQs at Delhi." As much of the challenges lay in dealing with the local environment, the onus was especially on the two project directors



G. Kesavan
Task Force Leader

"There were many testing moments for the team as they closed in on the milestones and also actual tests to pass at every level from BSNL and the specially formed Project Implementation Core Group (PICG) which comprised technical members from the Tri-services. Importantly, as the project is directly monitored by the Prime Minister's Office, a detailed review schedule had to be prepared before closing in on each activity. Further, BSNL's quality wing conducted surprise checks to ascertain the accuracy of the coordinates which was precisely plotted by the site team through GPS."



- V. Padmanabhan for Package 'E' and A. A. Mogal for Package 'D' to firm up experienced sub-contractors to clear the way forward. While the on-ground formalities were taken care by the sub-contractors, L&T had to step in when dealing with the higher authorities of the various states.

Routing with an eye for detail

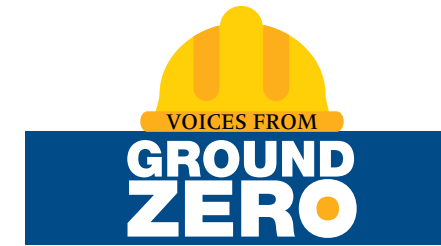
Charting out the alignment was a rudimentary task but doing it across such a vast span posed multiple challenges, acknowledge Padmanabhan and Mogal, the project directors, "However, firming up experienced sub-contractors proved handy as most of them were familiar with the local terrain and possessed good network with the people that guided us on the alignment especially across densely populated areas where we had to be extra careful not to disturb the existing utilities." Though the ground works were executed through various sub-contractors, tuning them to align with L&T standards was a great challenge.

Spreading out the material handling hubs

One of the first tasks that the project team did was to line up a slew of strategic material handling hubs across locations in each state. "The task was a humongous one" indicates Kesavan, "Since the job was more of a cross-country nature, we planned at least one store location based on the link concentration and at times established additional open stores for reaching the materials across larger states as most of them were underground materials that could withstand the vagaries of the weather." The OFC cable, HDPE ducts, FDMS and other passive components were specially procured as per the client's requirement while the other components included protection material, joint closers and chambers.

Taking stock of the RoW issues

Channelizing the RoW is always a sensitive task reveals Padmanabhan "As it determines the progress of work and is crucial for achieving the various milestones but here it was an especially uphill task due to the vast alignment that passed through a cross-section of rural and urban areas with the cable routing aligned across National and State Highways, villages, towns, cities, metros, railway lines, gas pipelines, public works lines, forests and national parks." Citing a specific section, Padmanabhan points out that the longest link between Bengaluru and Secundrabad covers a distance of 640 km, "Every time the RoW processes were raised, the file had to pass through various government departments before the final consent was secured. And if it involved a forest region, sanctuary or national park, the task was more difficult as it calls for stringent guidelines as per the Supreme



V. Padmanabhan
Project Director Package 'E'

"We have worked in the most serene zones and also in some of the most densely populated areas across the country with unique RoW mitigation proposals. Whether it was the Sagar Tiger Reserve forest or Pasuvemula Reserve, Satpura Reserve, Narasingarh Sanctuary or metros, our way of handling RoW issues was the most important success factor for realizing this mega network scheme."

Court of India and requires approvals from Senior Administrative/Forest Service officials across more than fifteen levels and could be cleared only by the Chief Minister of the respective state. Further, the request will be forwarded to NWLB and based on the project's merits the final permission is granted or rejected!" He shakes his head.

L&T has three such cases pending before NWLB in package 'E' and 'D' each, even after couple of years after filing the initial applications, exclaims Kesavan while reassuring, "They are of course in the final phases of clearance and we should be closing in on the routing as quickly as possible."

Crossings that really mattered

While the arduous process of making headway was meticulously planned, what really mattered were the critical cross-overs involving multiple stake holders. Being a network





oriented project, the links are always interdependent, hints Kesavan, “The Godavari section had a total link length of 350 km against which 343 km was completed and due to RoW issues across 7 Km, the entire commissioning was held up; similarly a 2.7 km problematic stretch across the Pamban river deterred the commissioning of links across 44 km for nearly an year.” With a sigh, Kesavan mentions that the rigors are still not over. “In the Mudumalai Wild Life Sanctuary, we are pursuing the clearance for a strategic section due to which links across 197 km is held up even after the work was completed long ago.” Certainly we have gained the expertise to create a master for all types of RoWs, beams Mogal, “We have worked in the most serene zones and also in some of the most densely populated areas across the country with unique RoW mitigation proposals. Whether it was the Sagar Tiger Reserve forest or Pasuvemula Reserve, Satpura Reserve, Narasingarh Sanctuary or metros, our way of handling RoW issues was the most important success factor for realizing this mega network scheme.”

Apart from the environment sensitive zones, there was large section of the alignment running through densely populated areas in metro cities across the Western and Southern regions which included Mumbai, Pune, Bhopal, Ahmedabad, Chennai, Bengaluru, Hyderabad, Trivandrum to name a few. As most of the existing utilities were underground, the task of trenching and cable laying was done with precision deploying state-of-the-art sensor tools and ground drilling equipment.

Trenching & Ducting

A large part of the manual works comprised trenching and ducting which was again a tough task considering the rocky nature of the terrain across both the packages. “The tender specification warranted a depth of 165 cm even across solid / hard rock terrains and the scope covered major metros amidst densely populated regions. Most of the underground paving works especially



A. A. Mogal
Project Director Package 'D'

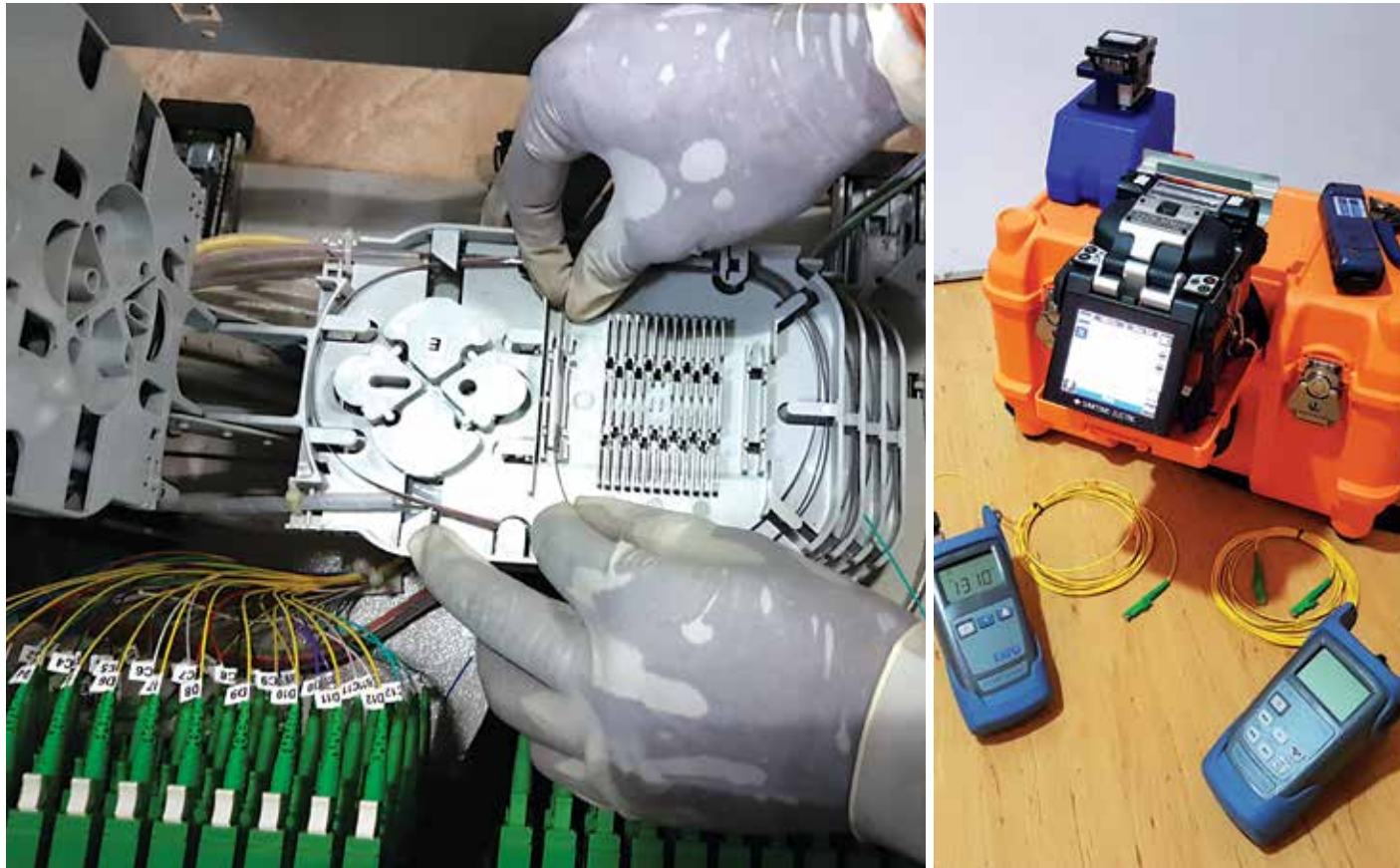
“Modern digital tools like LIDAR enabled the team to do the entire mapping of the cable positioning with indexing symbols which were duly approved by the Ministry of Defence for the entire package. Going forward, the entire network can be controlled through a state-of-the-art network management system which can ascertain unlikely disruptions based on the elaborate mapping done by L&T.”

across critical junctions where a host of utilities interspersed was done by horizontal drilling machines. Further, in areas where open trenching was done, daily approvals were obtained from the traffic police for specific works across city limit roads.” L&T has completed around 98% of trenching & ducting works in package 'E' with 92% of the links commissioned and across package 'D', 7764 km has been closed in thereby achieving 88.5% trenching, ducting and backfilling.

Safely traversing 17000 km

Team L&T took a broad stand while going about implementing a safe operating method across both the packages which Kesavan elaborately describes, “The project had many deviations and we were prepared to handle all situations at work by adhering to our safe work method guidelines. We also made extensive use of underground utility detectors and ground mapping radars to locate critical utilities before taking





up the trenching works. While working across hilly terrains, especially in the ghat regions, heavy equipment was deployed to cut through the rocks and in cases where further thrust was required, controlled and chemical blasting was done which enabled the team to close in 14900 km without any untoward incident. All the hard and safe work paid rich dividends as we have clocked more than 15.97 million safe man-hours thereby topping the safety milestone in our IC, while also bagging a slew of domestic and international safety awards in the process."

Passing the test of acceptance

There were many testing moments for the team as they closed in on the milestones and also actual tests to pass at every level from BSNL and the specially formed Project Implementation Core Group (PICG)

which comprised technical members from the Tri-services. Importantly, as the project is directly monitored by the Prime Minister's Office, a detailed review schedule had to be prepared before closing in on each activity. Further, BSNL's quality wing conducted surprise checks to ascertain the accuracy of the coordinates which was precisely plotted by the site team through GPS at intervals of every 100 m and again reconfirmed for any unlikely offsets at every 200 m where both the RCC Route Marker and Electronic Marker were installed. Modern digital tools like LIDAR enabled the team to do the entire mapping of the cable positioning with indexing symbols which were duly approved by the Ministry of Defence for the entire package. Going forward, the entire network can be controlled through a state-of-the-art network management system which can ascertain unlikely disruptions based on the elaborate mapping done by L&T.

At the heart of modern communication

Kesavan and team are now a happy lot as most of the ground work is done and the client is looking forward for operation & maintenance support which will be over a period of the next 3 years. "We have already formed the maintenance units, finalized the 'Service Level Agreement' for achieving the specified targets of 'Mean Time To Recover' and reduction in cable cuts by route patrolling which will be followed by a 7 year AMC." However post commissioning, we have a huge onus mentions Kesavan, "There are stringent limits for repair time after fault, number of cuts permissible per annum and periodic test schedules and as custodians of this first-of-its-kind communication network in Asia, we have a commitment to ensure that its efficiency ably supports the communication needs of our Defence Forces."

A power packed performance

The Power Transmission and Distribution business won the single largest order in the Middle East from 'KAHRAMAA' - Qatar General Electricity & Water Corporation to expand the existing power transmission network. This EPC order will involve 30 new Gas Insulated Substations of varying voltage levels and 560 km of 132 kV and 66 kV underground cables.

For the Power Grid Corporation of India Ltd., PT&D will be executing ± 200 MVAR STATCOM each at Hyderabad, Udumalpet and Trichy apart from a transmission line order to build a section in the ± 800 kV HVDC bipole link between the Western and Southern Regions.

On implementation of mini and micro grid solutions, the business secured orders from Bihar Discoms to provide electricity to over 36,000 households in 214 villages spread across 12 districts of Bihar. This project involves turnkey construction of solar photovoltaic plants with associated battery storage and power conditioning units. Another EPC contract was bagged from NHPC Ltd. for the development of a 50MW Grid Connected Solar PV project including evacuation arrangements, in the Theni and Dindigul districts of Tamil Nadu.

For the Water & Effluent Treatment orders flowed in from Narmada Water Resource Water Supply and Kalpsar Department, for Kakrapar - Gordha - Vad Lift Irrigation, Kadana - Patadungri Lift Irrigation and Sauni Yojana Link-2 Package where the scope includes design and construction of a pumping station, substations, transformers along with MS pipeline rising mains, an underground pipeline distribution network and other allied electro-mechanical works.

The business also secured orders from Krishna Bhagya Jala Nigam Limited, Karnataka for Nandawadagi Lift Irrigation project, from Mumbai Metropolitan Region Development Authority for implementation of Surya Regional Bulk Water Supply Scheme for Western Sub Region of Mumbai and the mandate to execute a dedicated water supply project for Erode Corporation in Tamilnadu that involves creation of a complete distribution system.

The Smart World business received an order from Greater Vishakhapatnam Smart City Corporation Limited as Systems Integrator to implement smart city solutions; another mandate was bagged from Rajasthan Raja Vidyut Prasaran Nigam Ltd. to build Information and Communication Technology (ICT) infrastructure.

The Transportation Infrastructure & Water Effluent Treatment businesses have jointly bagged an EPC order from Aurangabad Industrial Township Limited (AITL) for construction of roads, drains, bridges, potable water network, sewage and common effluent treatment plants, sewerage and recycled water network, firefighting system and power distribution system including GIS substation, in the Bidkin industrial area of Aurangabad, Maharashtra.

On the road infrastructure front, the Company bagged an order from the Ministry of Road Transport & Highways (MoRTH) for two laning (48 km of two lane carriageway) of the Helwak Karad Section of NH-166E in Maharashtra.

The Buildings & Factories business will construct residential towers in Kolkata where the scope of works include entire civil, electrical and finishing works for four residential towers varying from 30 to 47 floors apart from a turnkey order from Andhra Pradesh Township Infrastructure Development Corporation Ltd. for the construction of residential buildings in the West Godavari District of Andhra Pradesh. The scope of work includes construction of around 22,000 residential units on a fast track mode for the weaker sections of the society.

The Metallurgical and Material Handling Business bagged a prestigious order from Hindustan Zinc Limited for their 1.5 MTPA Lead-Zinc Beneficiation Plant Phase III at S K Mines, Rajasthan. This repeat order reaffirms L&T's engineering and project execution capability in delivering EPC solutions in the beneficiation sector.

Celebrating Two Knights of Honor!



Mr. S.N. Subrahmanyan stepped into his role as CEO & Managing Director of Larsen & Toubro on July 1, 2017. AMN presented SNS with a Sword of Honour stating, "This is a sword of defence, the ammunition to help you protect L&T!"