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Transforming cities into **METROS**



From the EDITOR'S DESK

In the age of specialization, this issue of ECC Concord reveals our specialization across varied business segments.

As the government's grand vision of creating 100 smart cities begins to realize, it is a matter of pride for all of us at L&T Construction that we are partners in creating India's first smart city – Jaipur. Working closely with the forward-looking Jaipur Development Authority, our colleagues from Smart World Communications have transformed the Pink City into a Smart, Connected City. Wide swathes of the city have been wifi-enabled and several historical monuments, hospitals and gardens are equipped with interactive, information kiosks while surveillance cameras have paved the way for more efficient governance. But more than Jaipur becoming a smart city what should cheers us is that we are helping to make the citizens of Jaipur smarter!

In the same city, we proved our engineering expertise by constructing the state-of-the-art Centre of Innovation and Technology for Hero Motors. We achieved the distinction of being perhaps the only company in the country and amongst the very few globally to construct a high speed parabolic test track using in-house equipment.

As cities struggle with the unbridled population growth of both people and vehicles, metro rail systems are increasingly being adopted by city after Indian city to ease traffic woes. It is not without reason that some of the toughest and most challenging stretches of the Delhi Metro have been awarded to us – true recognition of our preeminent status as the foremost builder of metro systems in the country. Perhaps, we are helping the people of Delhi to be more mobile! Overseas, too, we are expressing our expertise in building metros as we, along with a host of other global construction giants, are burrowing into the depths under the city of Doha to build the Doha Metro system, and setting a world record in tunneling along the way.

Our Water team has set another record by constructing Asia's first and largest Micro Filtration (MF) plant of 158 MLD for river water treatment as a part of the design-built 2X800 MW Yermarus Thermal Power Station near Raichur and by executing the complex long-span multi-voltage transmission line to evacuate power from NTPC's Kudgi Thermal Power Plant, our colleagues from PT&D continue to create corridors of power!

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Doha Metro

Setting a world record in tunneling



Not many pronounce Qatar as 'Kah-ter', the way it ought to be or are aware that this small gulf country that was virtually nonexistent on the global economic map has started making heads turn with its fast paced growth and infrastructural investments. Qatar enjoys a long coastline, thanks to its peninsular location in the Persian Gulf, which is why fishing and pearl gathering were its traditional sources of revenue until petroleum and natural gas reserves were identified and exploited to give the country's economy a major fillip. Most of Qatar's natural gas reserves that constitutes over 5% of the entire world's reserves are located in its offshore Northfield, an area almost as large as the nation itself. Therefore, not surprisingly, Qatar enjoys one of the highest per capita GDP globally.

Over the past few decades, the face of Qatar has transformed by an impressive

network of road infrastructure with over 1230 kilometers of roads linking the capital city of Doha to the major industrial and oil producing hubs of the country. The Hamad International Airport and four seaports are the country's gateways to the world. However, what the country sorely lacked was a rail network. A master plan was recently drawn up to develop a comprehensive railway network in the Greater Doha area and across the state. Consequently, Qatar Rail was given the mandate to design, develop and manage the country's rail network to enable a sustainable and efficient way of moving both people and freight around the country.

The Sultanate therefore went ahead full steam in building rail infrastructure. Investing in the ambitious 1940 km GCC rail network to connect with the six member states of Oman, UAE, Saudi

Arabia, Kuwait and Bahrain which was a significant step. This long distance passenger and freight rail will connect cities in the north and west of Qatar with Doha. Their second area of focus is a Light Rail Transit or a tram network that aims to provide a comfortable and convenient travel within the new city of Lusail. The third and the most significant of all is the Doha Metro - a largely underground rail network which will connect communities within Doha and its suburbs. Driven by the Qatar National Vision 2030, a guiding blueprint that aims to take the country from its current status quo as a hydrocarbon-dependent country to a diversified, pluralistic, and knowledge-based economy by 2030, the rail networks are expected to contribute strongly towards this projected growth. Once commissioned, all these three rail networks will be an integrated system, allowing passengers to easily transfer between them.

The master plan

Touted to be one of the most advanced mass rail transit systems, Doha expects to have its Phase - 1 Metro operational by the end of 2019 and Phase - 2 by 2026. Originally, the plan was to have it in place to host the 2016 Summer Olympics which was subsequently shifted to Rio de Janeiro. Doha, however, won the bid to host the 2022 FIFA World Cup for which the country is gearing up in full throttle.

The Doha Metro will serve both the capital region and suburbs through a predominantly underground network. Built in two phases, the first will cover the commissioning of three out of the four planned lines - Red, Gold, and Green measuring 75 km including 37 stations while the futuristic fourth, Blue Line will cover 130 km with 72 stations.



Concreting in progress



The stations will be designed on the lines of the traditional Bedouin tents, mimicking a 'vaulted space' concept that reflects the regional heritage with abundance of open spaces and a typical 'pearl-effect' in their tones. The exterior however, will be dhow-inspired reflecting the Qatari heritage. The largest station, Msheireb, considered the heart of the Doha Metro system, will be a confluence of all the lines.

ALYSJ - An integrated approach

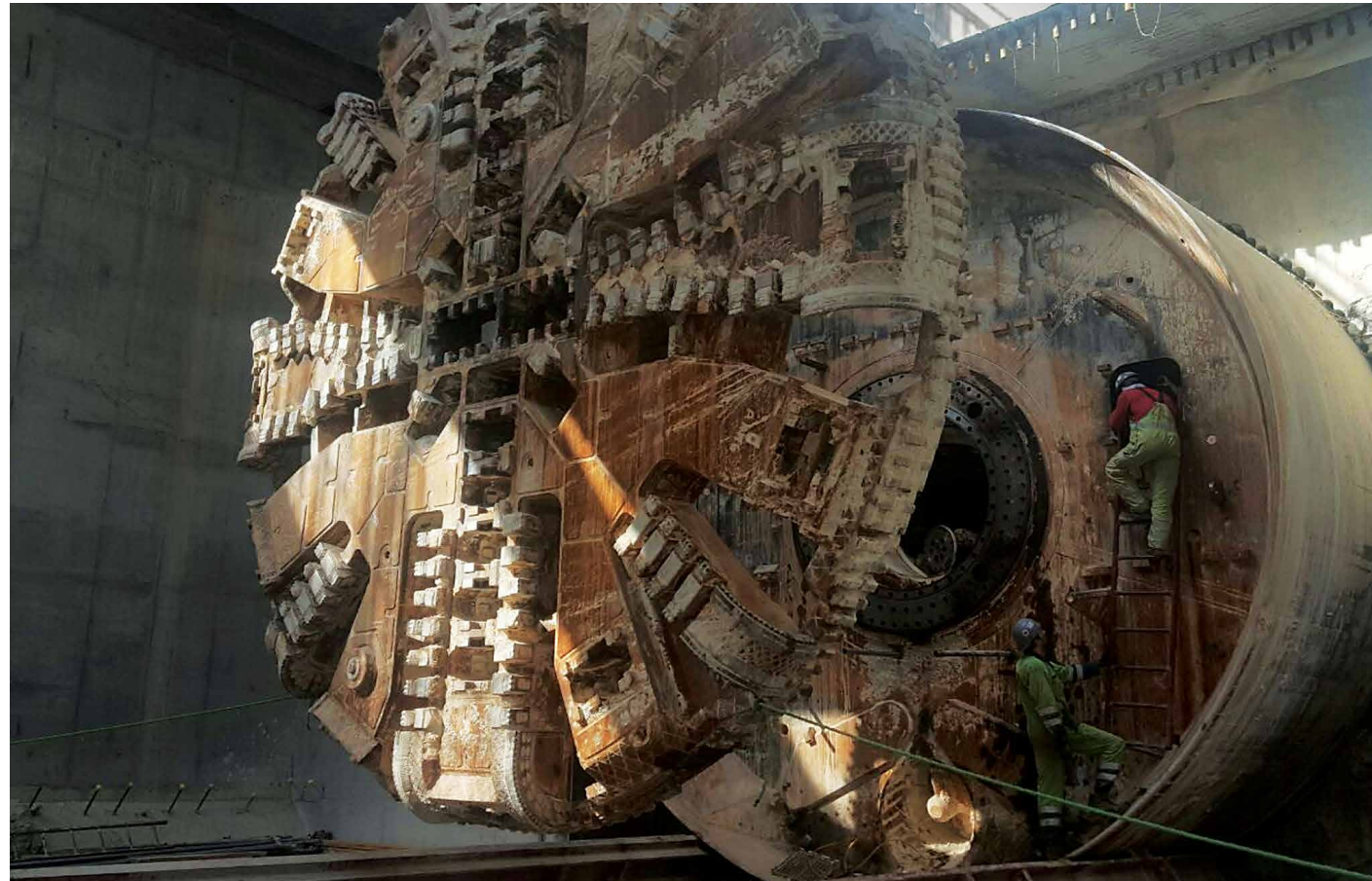
The ALYSJ or Aktor, (Greece) - L&T, (India) - Yapi Merkezi, (Turkey) - STFA, (Turkey) - Al Jaber Engineering, (Qatar), an integrated JV, bagged the mandate to build a significant section of the Gold line between the Ras Bu Abboud Station on the east and Al Aziziyah station on the west. The scope includes 11.68 km of twin bored tunnel passing through 10 underground stations with entry and exit structures, a couple of emergency exit shafts, a stabling yard, structures for switchboxes and two logistics

areas located about 15 km from the project command area. The scope also includes MEP and architectural works. What marks the package as unique is that despite being awarded almost a year and half after other packages, the ALYSJ JV has managed to complete the tunneling scope on time by deploying six state-of-the-art TBMs the world has on offer!

A boring business, as usual

Doha Metro has already achieved the unique status of being the largest metro projects in the world by deploying 21 Tunnel Boring Machines (TBMs) simultaneously across its lines. In fact Qatar Rail has set a Guinness World Record for operating the highest number of tunnel boring machines (20 as per Qatar Rail award certificate) in a single city, all at the same time.

As with any other underground metro, the lines will traverse under the city and significant structures and contractors had to deploy technology



One of the TBMs undergoing maintenance

that in no way disturbed life above. The ALYSJ JV deployed six TBMs to achieve its tunneling scope excavating a whopping 1 million cu.m of muck before lining the path to perfection with precast tunnel segments. The 6.17 m diameter tunnel stretch built by the JV consumed 1.34 lakh cu.m of concrete in the form of 15,555 rings and 24 cross passages.

The first two TBMs were to be assembled inside the launch shaft at Ras Bu Abboud station to its complete length of 120 m. Owing to the delay in constructing the station's base slab, the launching of these TBMs lay in abeyance. Not wanting to delay progress, the JV team thought on their feet and decided to assemble the entire TBM shield and back-up gantries above ground and truck it down to the launch pit through a backfilled earth ramp. Thereby, the entire shield weighing 460 t along with the 8 back-up gantries and 1 bridge section were assembled above ground and brought to the launch shaft 24m below the ground level. Totally, about 900 t of TBM parts

were lowered into position this way. The process broke all conventions proving to be a safe and time saving method.

While the original plan was to complete the tunnel drive and later construct the cross passages, delay in the award of the project saw the team staring at a schedule with some unrealistic milestone deadlines. Accordingly, an innovative approach of building the cross passages in tandem with ongoing tunneling works was drawn up. To enable the plan, eight 50 m long trolleys and California ramps were imported from Malaysia that made all the difference expediting progress that more than made up for the initial time loss.

The tunneling also witnessed other innovative methodologies that included the use of steel fiber in precast segments to increase productivity achieving three sets per day, per mould apart from the deployment of a flying bucket system to facilitate quick pour of concrete (only 30-60 seconds from the time concrete leaves the batching plant).

Another challenge the team faced was the process of TBM transfer at intermediate stations. Since a value engineering drive reduced the station width by almost a meter, the TBM team had to grapple with the situation to transfer it in a curved path. The team used a specially fabricated travelling trolley arrangement that overcame this hurdle successfully without any impact on the interim milestones at the planning stage itself

With no efforts barred, the assiduous tunneling team set their eyes with grit and determination on progress and started boring through the bowels of Doha city and achieved their first breakthrough on August 30, 2015 when TBM-3 a.k.a Al Sadd, reached the Joaan Station making its mark as the first among the six operational TBMs to achieve a breakthrough. It took the team about fifteen months to complete the entire tunneling scope at the Gold Line when the last of the six TBMs made its final breakthrough on 19th May 2016 at the Msheireb station

The network

The **Red Line**, also called Coast Line, will run between Al Khor city in the north and Mesaieed town in the south through Lusail and the Hamad International Airport. Divided into two major segments, the line will cover 40 km including 17 stations and 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**, also known as the Education Line will link the Education City with the heart of Doha. It will originate from the industrial area in the south and end at the Al Rayyan Stadium, covering 31 stations on a 65.3km stretch.

The **Gold** or Historic Line will connect Ras Bu Abboud on the east with Al Rayyan in the west covering 30.6 km with 20 stations.

A large part of the network linking major parts of the city including the West Bay, Education City, Lusail, Doha Airport and the upcoming stadiums for the 2022 FIFA World Cup will run through underground tunnels though there will be a few stretches of at grade and on overhead corridors too.

Contracts for the first phase of the project were awarded in August 2012, with the ground breaking ceremony taking place in October 2012. Being one of the largest and the most advanced of its nature, Doha Metro employs talent from over 45 countries across the world making it one of the most sought after mega project for any discerning engineer. Global majors in the construction industry have bid and won packages to bring to reality one of the world's most advanced metro rail systems.



almost a month ahead of its projected master schedule!

The team won the admiration of all, including the client, by achieving timely completion with the best of quality and safety standards despite a delayed start compared to the other lines. As if that was not enough, the team also set several lofty records in the process which includes:

- Highest number of rings installed in a day by one TBM - 39 nos.
- Highest weekly production by 6 TBMs - 164 rings
- Highest monthly production by 6 TBMs- 491 rings

Stationed as numero uno

The ALYSJ JV has 10 underground stations to construct along with a stabling yard with switch box

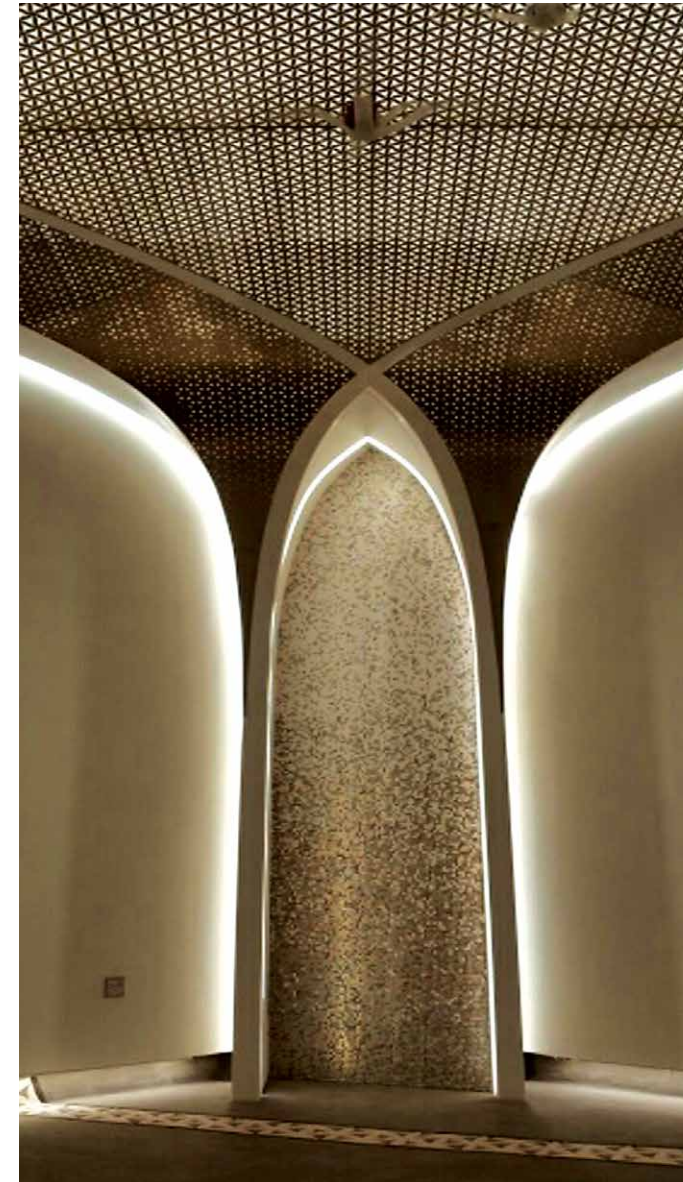
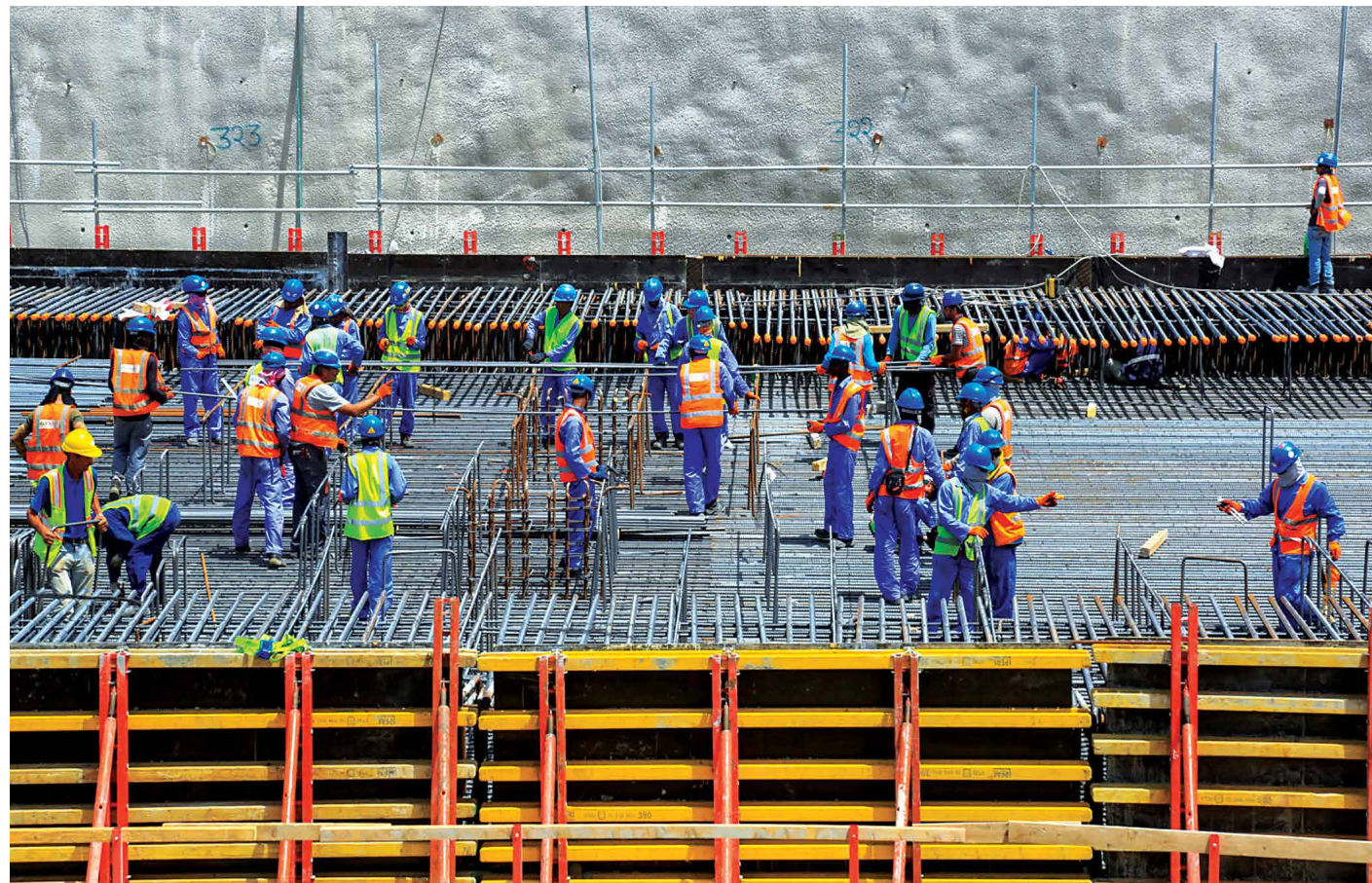
structure at Ras bu Abboud station and a switchbox structure each at Bin Mahmoud, Al Soudan and Sports City stations. With a generic station length of 178 m, each station varies in its platform level from 18 to 28m from ground level. While the basic structure has 3 levels covering under platform, platform and ticketing levels, some stations feature an intermediate floor for MEP sandwiched between the platform and ticketing levels. The station team has already

excavated a whopping 2.95 million cu.m of earth out of total scope of 3.5 million cu.m and has poured 4,50,000 cu.m of concrete of the total 10,04,332 cu.m scope to create the imposing stations including the entry/exit structures. The team is using the conventional bottom-up construction methodology with open excavation followed by shotcrete and soil anchoring for all station buildings except for one which features a diaphragm wall.

The quickest century

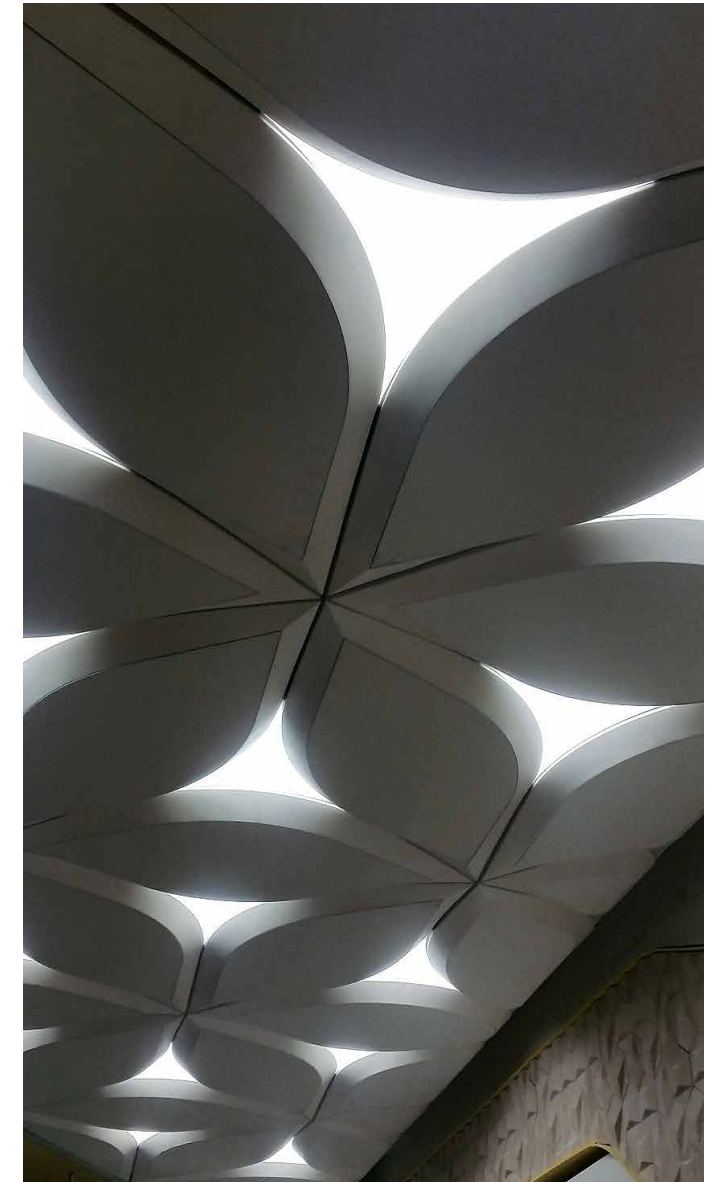
The tunneling milestone from ALYSJ JV team incidentally coincided with QRail announcing its major milestone of having completed 100 km of tunneling. Presently, 41% of the Doha Metro has been completed. The client also announced that 90 percent of the overall tunneling was completed with only 11km to achieve in the Red Line which is expected to be completed very soon.

With the completion of tunneling, contractors will now shift focus to the installation of tracks, power supply and signaling which will see milestone completions by the end of 2018 to make Phase-1 operational by 2019. The final architectural touches of the stations are also expected to be completed in tandem.



Finishing works at one of the stations

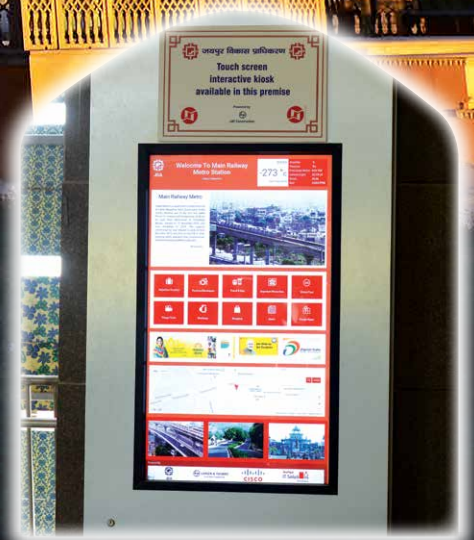
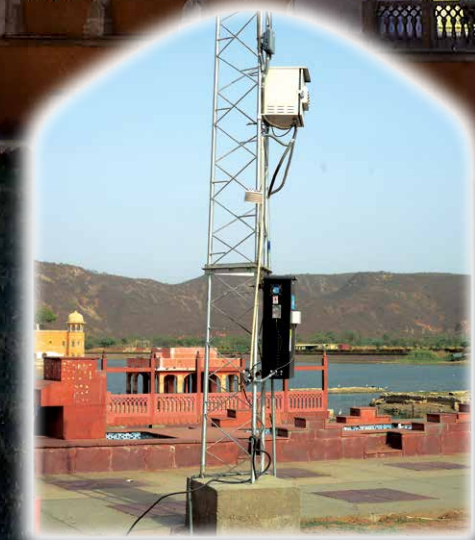
The team has had many surprises, some unpleasant, during excavation of the station boxes one of which was an aquifer. A bore hole installed for dewatering got connected to an aquifer due to soil movement and consequently water gushed out at enormous speeds inundated the entire station box to about 3m. Acting on a war footing, the team quickly lifted all the excavation equipment to the surface avoiding material damage. Precision drilling into the source and extensive cement grouting carried out for three days curbed the issue but the station depth was consequently reduced by 3 m due to this unforeseen natural challenge. This change in turn affected the vertical alignment between connecting tunnels at both ends of the station forcing the design team to make necessary alterations.



The best of the best

The ALYSJ-JV has been regarded as one of the best performers at Doha where work is progressing at a mindboggling pace to complete the infrastructure in time for the football fiesta. The project command area handled by the JV has also set a record of having a clean slate in receiving no complaints of public grievances. They have also clocked an impressive 11 million safe man hours till the end of March 2016. Cutting across cultural differences, members of the ALYSJ JV have joined as one to work with single-minded focus to achieve what was seemingly impossible. This hardy team is now gearing up to face fresh challenges that will certainly crop up in the process of execution and finally make its mark as being the best of the best when it comes to metro rail construction.

India's Pink City is also
India's first smart city



Though a late adaptor, India is leap-frogging ahead of others in the rapid implementation of intelligent infrastructure across some of its major cities. To begin with, some of the earliest smart technologies were integrated surveillance systems at select regions. The advantage of 360 degree command and control centers enabled administrators to monitor more effectively. Taking this cue, the government launched an ambitious smart vision programme which envisages building 100 smart cities in a phased manner with a range of real-time promises for a cross-section of stake holders.

Pink City raises the smart vision

From the master list, 33 urban regions have been earmarked under the phase I scheme and one of the first urban centers to take significant steps towards realizing this smart vision has

been Jaipur, India's most colorful and historically relevant metropolis. The Pink City's slew of heritage monuments attract hordes of tourists every year and hence the need was felt for enabling world-class digital facilities primarily targeted at the tourists. The Jaipur Development Authority (JDA), the nodal agency of the government of Rajasthan, was entrusted with the task to transform the city into a smart hub that would ensure 24/7 surveillance and facilitate on-line access to wide-ranging information about the city, its rich culture, historic locations, utility centers and e-Governance formalities at the click of a button.

A trailblazing venture

L&T's dedicated Smart World & Communication business are Master System Integrators offering the whole bouquet of smart offerings as security systems, smart communication and smart infrastructure. On the strength of

their credentials and past experience, they bagged the contract from Jaipur Development Authority (JDA) to integrate a range of smart technology components which were relatively new to the country in addition to surveillance systems within stringent timelines. The project was conceived to transform six major locations into smart zones within a span of one and a half months with the remaining locations to go smart in another 120 days.

Zoning information technology

Smart zoning divided the city into two distinct phases and the initial work was around 6 heritage monuments - Amber Fort, Jantar Mantar, Albert Hall, Ram Niwas Bagh, Jal Mahal and Hawa Mahal. Subsequent smart infrastructure works covered 9 metro stations, 5 hospitals and 9 gardens. The scope of work comprised a host

of smart solutions such as provision of WI-FI hotspots, interactive information kiosks, surveillance cameras, environmental sensors, parking information systems and remote kiosks with facility management services. The task called for quick integration of highly sensitive information and communication-based smart technology services. While working at sensitive locations the team had to ensure that the legacy of the historic structures remained intact as even a small damage could raise serious issues. Further, being an on-field project, there was always the influx of locals and international tourists across locations which needed carefully handling without hampering the progress of works. There were also innumerable on-field issues to be mitigated as the concept was new to the region and team L&T had to find ways to consider and address the concerns of the stake holders by highlighting the overall



Remote Expert Government Services Kiosk



Amber Fort

benefits of the project. The editorial team travelled to the smart zones of city to understand the technology and shares a vivid account of how team L&T integrated the various facets of high-end digital technology that is now a benchmark in the annals of the country's smart city projects.

Remote expert government services

Our first smart sighting is at one of the remote kiosks in an upfront market area. "There are two such e-Governance facilities across the city and based on the inputs from the citizens such models will be installed across various strategic market areas," informs Rahul Verma, O&M Engineer, who is taking us on a smart tour across the city. The compact prefabricated steel cabin is an elegant silver coloured steel enclosure with a sliding door. Taking us inside the kiosk, Rahul quickly connects through the DX 80 interactive screen on which we could

see the team at the JDA control centre. The O&M engineer briefs us that the facility is equipped with a document scanner which enables citizens to scan documents and submit on-line applications. An acknowledgment is generated once the process is done. Interactive guidance is also available in case the user seeks clarifications on issues while submitting.

While our photographer positions himself to take shots of the control centre team interfacing with the user end, Rahul steps outside the cabin and highlights, "It does look a simple installation, however, the concept was entirely new to the city and we had to change the location a couple of times as the locals were not convinced about its utility and foresaw it as some sort of government monitoring station. Finally it was through the intervention of the JDA that this location was allocated and the facility was quickly installed and put to test."



Interactive kiosk at one of the hospitals

Digital facilities at public hospitals

A visit to any one of the major government hospitals in Jaipur springs a pleasant surprise as the centre of attraction across the modest lobbies are the interactive kiosks that light up the surrounding. Stepping through the portals of Sawai Man Singh Hospital, one of the largest health care centres in Rajasthan, Rahul points the kiosk which is barely visible as it is surrounded by a group of people. Nonchalantly he relates, "With so much of information on board this has become a virtual crowd puller and doctors have acknowledged that there is never a dull moment around the kiosk." Getting closer to the display, we see locals surfing for a range of information with regard to health care, a doctor's availability and other amenities. Amazed at their familiarity, I quiz on how they could assimilate the facts as the display are in English. He reassures with a big smile, "The design of the kiosk

was done by the government with much care and the objective was to keep it as simple as possible so that it benefits both the locals and the tourists. Language is never a barrier while using such digital gizmos as navigation is predominately driven through images and icons that are user friendly."

A spread out WIFI canopy

One of the key factors that enliven smart zones is WIFI access and at Jaipur vast areas are covered under this ambit which includes public spaces, hospitals, heritage centres and metro rail stations. It is very evident that city administrators have reposed a lot of trust in L&T's digital integrating prowess as our guide leads us seamlessly across the monumental hotspots with the tag of 'WIFI Maintenance'. Driving past the city's largest garden, Rahul mentions that there were a lot of issues while routing the WIFI. "At Amber fort we had

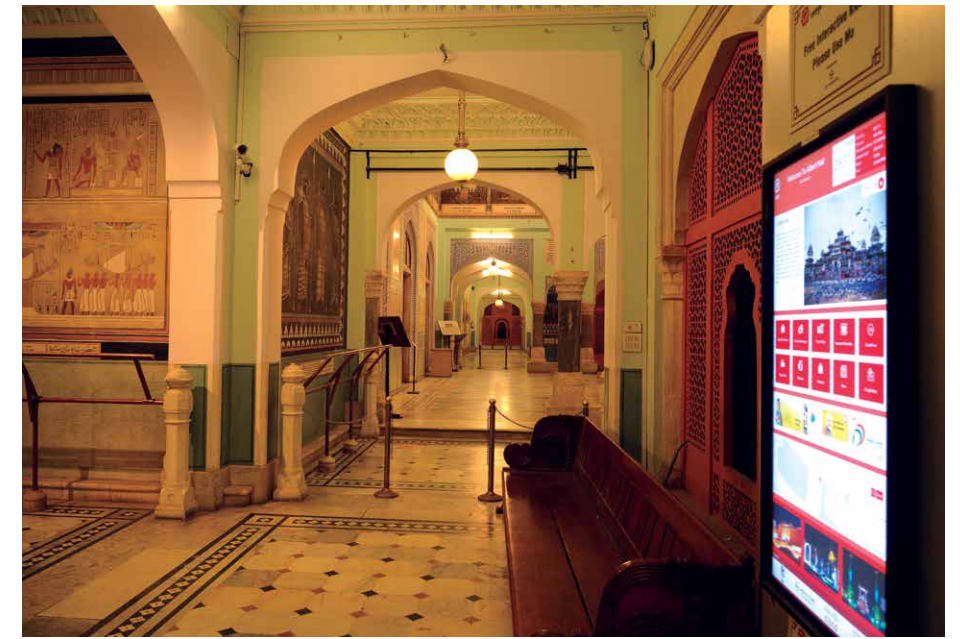
to stay put for more than two days to find out the delay in connectivity due to a third party fibre which was resolved at around 2 am at the office of the connectivity provider."

Sharing some of the challenges faced at other locations, Rahul relates: "Close to 3 km of cable had to be routed across the Ram Nivas park and as we were at the threshold of commissioning the connectivity, the local stakeholders hindered the provision of power supply as a result of which the entire cabling had to be reconfigured within 3 days and provisions were made to accommodate the UPS at an alternative location to ensure power backup."

We barely manage to cross the arterial road amidst peak traffic. Our guide then draws a parallel, "There is fibre optic cable across this road which was laid with precision detailing below an existing 12 inch Bisalpur-Jaipur water pipe line that connects the central museum. Though the client had unsuccessfully tried this

crossover on earlier occasions due to the confined below ground space and proximity of the water line. However we solved this checkmate by drawing references from L&T's track record of having executed the water pipeline job a few years ago and arrived at a breakthrough of maintaining a one foot gap below the pipeline and crossed over the cable safely."

Towards mid-noon with the mercury inching close to 50 degrees centigrade, we take a welcome break inside the air-conditioned ambience of an underground metro rail station. "L&T did the entire networking/WIFI for 9 metro stations out of which one is an underground structure. Working on operational stations called for a different time zone after the services were concluded between 10 pm to 5 am. Cable laying was critical as we had to lay them over the existing covered racks and for the underground section close to 250 m of cable was pulled via the under craft access way running right beneath



Surveillance system and interactive kiosk installed at Albert hall

the track. As most of the work was along the high tension lines it was mandatory to take up services only after the power was totally shutdown," he adds.

In total, close to 200 outdoor access points and 50 indoor points have been linked to the network which is controlled by wireless controller. In association with JDA, L&T provides an hour's/100 MB of free WIFI usage per person across locations which are then converted to a paid premium facility.

Internet ready interactive kiosks

Alighting near the zoo, we are led to a compact cabin inside which is positioned an interactive kiosk which displays basic information about the location. As we dabble with the kiosk, our guide mentions that finalising the location for this kiosk was a challenge and it was changed 5 times. "With innumerable visitors to the zoo, it was felt that positioning the facility at a distance would be ideal, however when team L&T got into execution mode it was decided to place the kiosk at the entrance." Unlike the kiosks at the hospitals, a compact cabin accommodates the kiosks in open areas as it needs protection from the vagaries of the weather.



One of the outdoor wifi access points



Internet ready interactive kiosk installed near the zoo

Entering the portals of the central museum which is popularly known as 'Albert Hall', we are drawn to the vibrant kiosk placed at the gateway. Visitors are interfacing with the digital appliance. The team engineer accompanying us briefs that such interactive kiosks have been installed across major heritage sites and metro rail stations. Drawing closer, we see a couple of youngsters indulging in a virtual tour of the 'Jantar Mantar'. This is certainly a great advantage for tourists who are always short of time. It also promotes virtual tourism which could be transformed into real visits in the near future.

The kiosks here are very different from the ones installed at the hospitals as these are tuned to guide the tourists, especially foreigners, to access utility details such as important phone

numbers, information on food and beverages, travel and stay; there are facilities to book hotels, airline and train tickets, access information about different modes of transport, check PNR status, book cabs, recharge mobiles, shop on-line, get news and current affairs and access google maps. Similarly the kiosks at the metro stations are designed to focus on transit schedules in addition to a host of other utilities.

The scenario at Amber fort showcased the many advantages of such a facility as tourists were seen getting familiar with the locale while the local guides lamented that this smart facility had reduced their relevance. Similar scenes were witnessed across all the monumental sites where the interactive displays were a huge draw.

Customizing display stands

The kiosks come in an array of sizes as the fit varies according to the location and LED screens. Briefing us about the customization, He says, "Doing the framework for the kiosk is a story in itself as we had to custom fit for each location which called for precision work. Initially it was intended to have a standard size LED screen but later it was found that our OEM provider could not deliver. A reliable local vendor was roped in to fabricate the frames with stainless steel. A single piece was installed at the Amber fort but the look and feel was not good and JDA insisted on an alternative model. Finally it was decided to opt for aluminium composite panels which were fabricated according to the sizes of the LED screens that ranged from 40 inches to 47 inches while the touch

panel was tested at site. Getting the sample frame to the Chief Minister's Office was another challenge as the final approval was given only after seeing the complete fitting."

Third eye dynamics

Team L&T installed the surveillance system comprising 100 fixed and 50 PTZ cameras across the major hubs of the city in a phased manner. This system is equipped with a leased line connectivity having minimum 2.1Mbps bandwidth per camera and is designed to pick up specific intrusions. Our colleague elaborates on the fundamentals of the execution, "We had to ensure that the walls and outer surfaces where the cables/cameras were earmarked for installation were carefully grooved as it was mandatory to match the patchwork with the existing archaic surface colour and in most cases we took the help of local masons as they were adept in such restoration works. The scale of the project called for an integrated safe work strategy which was put in place to carry out the critical tasks such as excavation



Interactive kiosk at one of the underground metro stations



Video surveillance through PTZ camera at Jantar Mantar



Parking information system

and pole erections during night time and workmen were given special on-job orientation about outdoor risks.”

Parking information system

An insight into the working of the smart parking systems at the upfront GT area and Crystal court showcased how technology bridges gaps. Vehicles on course to the malls are guided through the Variable Message Signs (VMS) deployed at strategic locations and based on the availability the driver can access the nearest parking destination. IR based sensors facilitate the counting of vehicles and update the LED counters at the respective malls. Recounting the rigours at work, our guide highlights that this technology is entirely different when compared to the other smart offerings. “Initially, we assimilated the

tasks as independent parking zones and went ahead with the works such as developing the VMS, installation of the sensors and cameras. Fortunately

during a client visit, JDA insisted that it had to be an integrated facility which meant that we had to combine the feeds across the 5 locations including JDA's



office. It was subsequently found that the camera-based counting of vehicles was not feasible and we convinced the client to go in for IR based sensors while assuring that the cameras would be retained for surveillance. The counting has been customized in such a way that even if a vehicle enters through an exit route it is considered in the counting. In addition, the information is also integrated with the city infrastructure management platform.

Keeping track of the weather

From any of the kiosks one can get real-time weather reports as environmental sensors have been installed across key locations and integrated with the displays. Alighting at the Jal Mahal, we approach one of the sensors that resemble a miniature telecom tower programmed to measure temperature, humidity, noise, pressure, ambient light and particulate matter. Our guide informs us that the output feed is integrated with the JDA control room and relayed back at the user interface end. The system also has provision for CIM integration for analysing historical data over a period of time so that it can be forecast in case of adverse weather.

Network operation centre

A state-of-the-art Network Operating Centre (NOC) established inside the JDA office smartly monitors the major hubs of the city. Major components installed at the centre include 2 IBM servers which are designed to cater to high availability and a range of storage accessories, UPS, routers along with power back-up equipment. The centre is equipped with 2 four-frame LED screens which are linked to the monitoring desktops to view live feed. At any point of time, the proportion of the display matrix can be enhanced to include more windows. A fully integrated software application 'CISCO SASDA Advanced Player' provides easy-to-use and highly flexible management tools for multi-site



Environmental sensor



Command and control centre

monitoring from the control centre. It enables the operator to survey infringements such as zone intrusions, lifting of objects at monuments and line crossings by sending alarms and pop-ups on a regular basis. The data is stored for 30 days and in case of an incident it is passed on to the police officials for further scrutiny.

Providing unstinted O&M support

Having accomplished the smart technology integration, team L&T has positioned a lean crew to manage the Operations & Maintenance (O&M) at the JDA office for a period of 5 years. And with the client gung-ho on stepping up the smart make over across larger areas of the city, L&T is poised to integrate a range of futuristic solutions and build the country's next gen cities to enhance the quality of urban life across the country.

Hero Moto Corp Ltd, Jaipur

A giant stride in technology



'We make things that make India proud' has been L&T's mantra for over seven decades and the world-class Global Centre of Innovation and Technology (CIT) constructed for Hero Moto Corp Ltd, the world's largest two-wheeler manufacturer, is a true reflection of that mantra.

According to SIAM (Society of Indian Automobile Manufacturers) India saw the influx of 4 million vehicles in 2015 to add to the existing millions! Safety becomes a key area of concern and if the Indian roads have to be safer, all these vehicles need to be tested and reliability checked for which controlled simulated tracks are imperative. This is why the CIT is a landmark mark project both for Hero Motors as well as L&T.

Everything under one roof

B&F IC has been involved in the construction of this world-class

infrastructure, a one-of-its-kind facility, housing all aspects of Research and Development under one roof – R&D Labs, Administration buildings, Test Tracks with 40 different types of surfaces including self-sufficient facilities for New Product Design, Prototype Manufacturing, Testing and Validation.

Inside Hero's new 247-acre R&D facility

The Project Director Mr. Ch. Rajendra Prasad has a lot to say about this project referring to it as "a milestone in the Indian construction industry" and that has exceeded client expectations. Rajendra Prasad details L&T's scope of work: 9 R&D labs G + 1 floor with 2000 sq.m each, an Administration Building of G + 11 + Helipad with varying floor areas and orientation, a Cafeteria Building (G + 2) with a 6m wide cantilever path around it and the admin tower till the 4th floor for vehicular movement. There is a

Boulevard Area with three structural bridges connecting the labs with the cafeteria and the Iconic Tower and a space frame structure of almost 2000 sq.m area and 12 m height, 4 Utility buildings of 8000 sq.m each, a combined basement of 18000 sq.m and a one km long retaining wall.

The construction of the Test Tracks was crucial with its 40 different surfaces to simulate real world road conditions, both Indian and global. The patterns vary from concrete surfaces to potholes, railway crossings to mud roads.

True to L&T's commitment of creating a sustainable future, the CIT has advanced green technologies imbibed into its design and construction, ensuring eco-friendly operations. Testament of these efforts is the Platinum rating granted to the Centre by the Indian Green Building Council (IGBC) with a rating of 91 points, making it the highest rated facility in India's manufacturing sector.



Aerial view of the HMCL Innovation Design Centre

The iconic tower - where designs are created

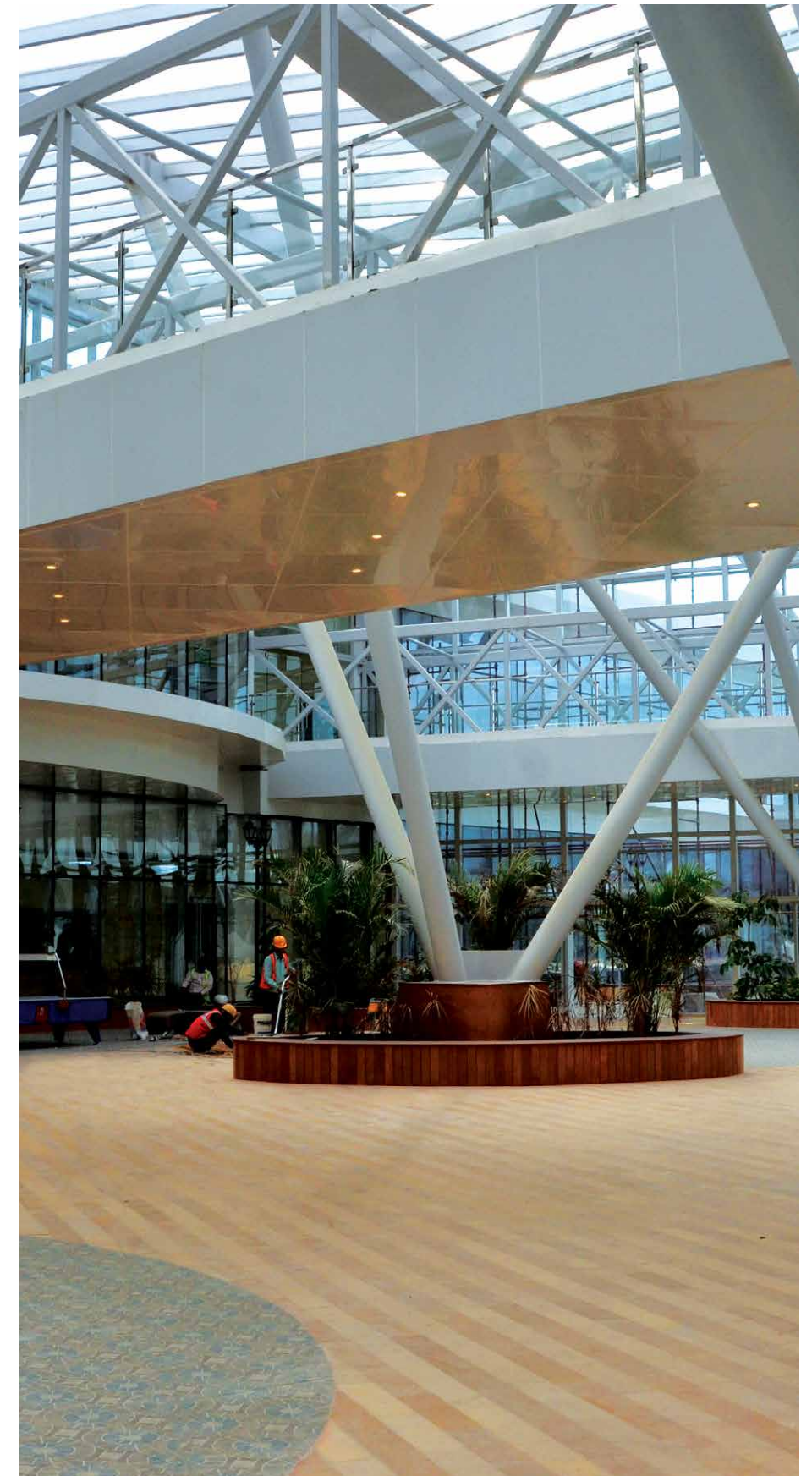
The main 11-story, 12000 sq.m building with raft foundation, radial beams, slabs with varying floor areas & alignment, brickwork and plastering, houses the brains behind the designs and is aptly named the Iconic Tower. Spider and structural glazing and ACP cladding cover the façade sitting on top of which is a heat resistant ceiling. The tower accommodates around 500 engineers, including 12 top professionals from across the world, who work on areas like engine development, vehicle development and chassis design. The crowning piece of the tower is a helipad.

There are 9 state-of-the-art Lab Buildings (33600 sq.m) – G + 1 floor with isolated footings, brickwork, internal plastering, flooring and façade works with aluminum windows, structural glazing and ACP along with terrace waterproofing.

The 2400 sq.m Cafeteria Building provides an unwinding experience for the techies with its G + 2 floor structure. It involves a combined foundation, radial beams, slabs with varying floor areas & alignment, structural steel based skylight and façade works – structural glazing and ACP.

There are four G +1 floor Utility Buildings of 8000 sq.m each with isolated footings, VDF flooring, brickwork, plaster, puff panel cladding and aluminum windows.

The campus has an exclusive 2000 sq.m Boulevard area of structural steel space frame with 3 structural steel bridges that are piped with Special Flex underground, to reduce the load on the cooling systems.



Boulevard

Test track – where the actual spinning takes place

The test track spreads over 100 acres that comprises 15 main tracks with 40 different surfaces and several micro testing tracks spanning a length of 16 km. The various corners are inspired from several famous tracks across the world and will soon be named accordingly.

The complexity of design, layout, gradient and different surfaces on the proving ground posed the team with several construction challenges:

- Requirement of excellent surface drainage system in conjunction with construction
- Traffic management all around the proving ground during and after construction
- Usage of highly specialized equipment for minimized tolerances
- Usage of specialized materials of defined characteristics in pre-designed specifications with strict quality control measures
- Technical coordination for planning, execution and quality control
- Highly skilled workmen
- Specialized construction equipment
- Specialized testing equipment

- High precision survey equipment
- Flexible approach towards construction due to varying geographical conditions
- Sustainable construction to reduce carbon footprint
- Although the roads are designed for movement of lightweight vehicles, during construction, 40 MT dumpers also moved around. Hence special care during preconstruction design and execution phase was taken by the engineering team to avoid any damage or undulation to the surface

Efficient project management and close coordination with the architects, contractors and the client to specify the content and layout of multiple proving grounds played an important role in successful completion.

Types of test tracks

- High Speed Track (Speed)
- Steering Track (High speed steering)
- Wet Braking Track (friction)
- Test Hill (Traction)
- External noise/ISO Track (Sound emission)
- Accelerated Fatigue Track (Fatigue)
- Water Wade Track (Performance at water surface)
- Dirt Track (Village road condition)



Handling tracks



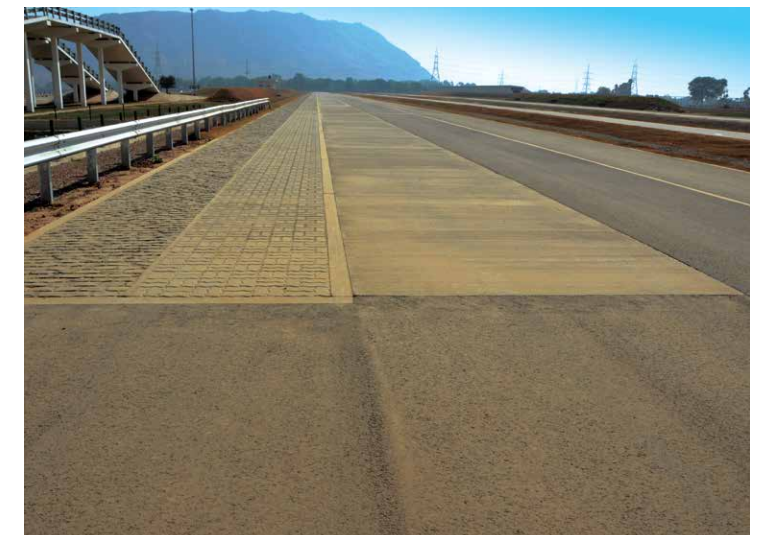
High speed track



Over bridge



Test hill



Comfort surfaces

- NVH Track (Noise, vibration and harshness)
- Handling Track (Handling at sharp curves)
- Highway/sustainability Track (Highway performance)
- Endurance/Durability Track (Durability at extreme road conditions)
- Comfort tracks (Rider comfort)
- Dust Tunnel (Performance in dusty condition)
- Rain Water Simulator Track (Performance in rainy conditions)

L&T, first in India and fifth in the world to construct a high speed parabolic test track

A high-speed parabolic track is one of the most technically challenging of constructions due to the complexities

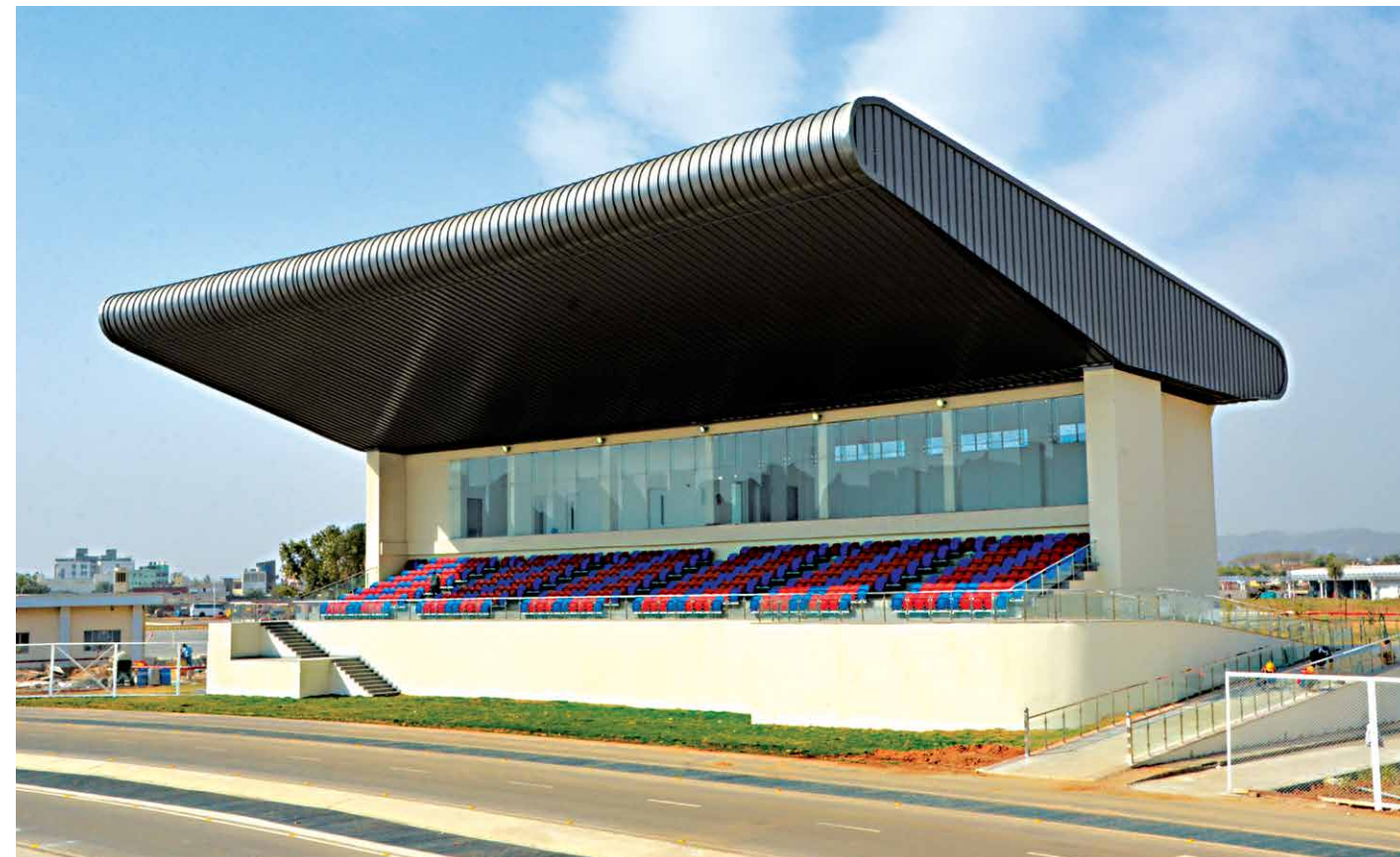
involved and the requirement of special equipment like paver with parabolic screed, specially designed static rollers and holders for all the paving equipment. Very few companies in the world possess the requisite capability to attempt such projects primarily because none of this equipment are manufactured by any OEM today and the contractors who do have them do not share the technology for modification. Hence, the construction cost is exorbitant. When B&F IC was awarded the contract, the biggest challenge was to scout for specialized equipment. While a Japanese contractor matched spec expectations, the cost did not. This is when the P&M team rose to the occasion with a decision to conceptualize and develop equipment in-house.

To realize the goal of developing the equipment, a paver manufacturer in Ahmedabad was roped in and the concept was detailed to the vendor. With close monitoring, regular on-site

visits and extensive research, the P&M Team developed a Parabolic Profile Paver with parabolic screed and PLC controlled. However, the challenge was not only the paver, but also the rollers along with holding arrangements for all the paving chain. L&T Case 450 rollers were modified by reducing the drum width, so that the profile of pavement was not disturbed during compaction. The pipe layers that were idling with L&T's Hydrocarbon Division at the yard were loaned and modified with hydraulic controlled holding arrangement. After a lot of site trials, the project was successfully completed on 9th November 2015. L&T thus emerged as the 5th company in the world and the first one in India to indigenously build a parabolic profile road using in-house equipment.

Team P&M stands tall

The P&M department played a major role in the day to day functioning and



Grand stand



Dust tunnel

supported the execution team with a number of initiatives to increase speed and productivity of construction. Right from installation and commissioning of the batching plant to the erection of the tower crane, creating inroads and sourcing of construction equipment, conceptualizing and developing the Parabolic Profile Paver and optimizing the utilization of the existing equipment, the P&M team significantly value-added to the project.

Appreciating the efforts of Team L&T in the construction, technology usage, quality, safety and speed the CMD & CEO-Hero Moto Corp Ltd, Mr. Pawan Munjal stated that the testament of these efforts is the Platinum rating granted to the centre by Indian Green Building Council. "Designed by the International architects and design consortium, the CIT maintains Hero's highest ecological standards. The 11 storey Iconic Tower or the green building is designed in a manner that each floor plate orientation is different to have maximum view and light. We have ensured water and energy optimization through design innovations. Moreover, the orientation of the buildings is aligned with the wind direction, thus ensuring natural ventilation and reduced load in cooling system. Thanks to L&T's efforts in making our dream a reality."

Truly world-class

At some point during graduation years, every engineer-to-be dreams of cracking



Control tower

a research and development job at an automobile company. Though I was never able to have that privilege, it was surely a surreal experience to talk to the team and get an exclusive sneak peek into this state-of-the-art R&D facility set up on the outskirts of Jaipur at Kukas.



Delhi Metro

Zip, zap and
zoom on the Metro

Be it the elevated corridors snaking along the highway or the inconspicuous underground tunnels traversing underneath modern cities, the Metro rail systems never fail to awe as modern marvels of infrastructure. They stand testimony to the minds, money, machinery and muscle that go into creating this fast, reliable and sustainable transit system that allow us to simply zip, zap and zoom across crowded cities. While the concrete structures and tunnels reveal telltale stories of the trials and tribulations the team would have faced creating this infrastructure, the various systems such as Ballastless Trackwork, Traction and Signalling & Telecom (S&T) are actually the lifeline of the Metro System.

L&T's Railway Business holds the unique distinction of having energized major trunk routes in the Indian Railway network since 1981 with

its turnkey capabilities in overhead catenary systems, traction substations and switching stations. The domain of signalling and telecommunication services have seen several innovations to provide state-of-the-art system engineering for automatic train control, supervision, protection and operation including electronic interlocking. With the advent of the Metro and Monorail transit systems, L&T has been at the forefront as one of the leading contractors for Ballastless Trackwork, Traction and S&T packages in Urban Transit Systems as well

The association that L&T enjoys with the Delhi Metro is long and illustrious. Being a significant part of every single Phase of DMRC, L&T has created some of the most challenging metro viaducts, tunnels and stations including complete and comprehensive solutions for Traction and S&T. Under Phase 3 which

is presently under commissioning, L&T is involved in three major packages, CE-07, CE-08 and CT-11.

Smooth and silent sail

Piggy could have never broken his bones even if he tried to on a Metro track! Firstly, getting on to the tracks without being noticed by the surveillance system or not being stopped by the guards is impossible. Even if he did manage to get on to the tracks, there would be no stones to pick up!

The ballast or more commonly, 'stones' as we know it, that cushion the conventional tracks have been replaced with the ballastless track technology that uses specially designed concrete plinths/slabs that don't just bear the weight of the passing Metro rakes, but also reduce consequent vibrations and noise levels which explain the silent

and smooth sail of the Metro rail despite its higher torques and speeds. DMRC specifically included a design clause for the track structure and the fastening system to minimize noise and vibration generated by moving trains. Team L&T therefore ingeniously developed the use of a mass spring system as a mitigation methodology which worked wonders and will soon become a standard of methodology.

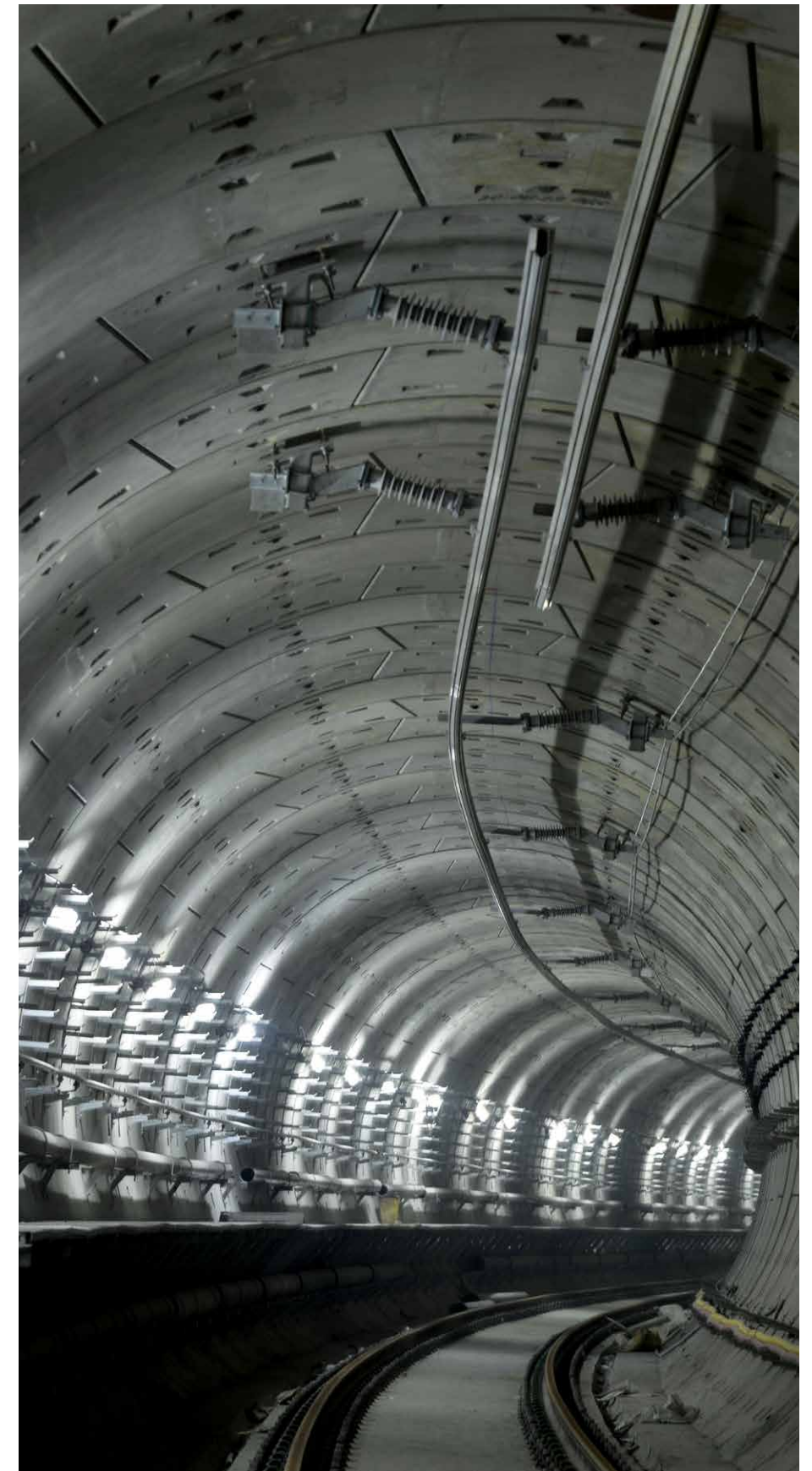
The track work team at CT-11 package built and commissioned ballastless track of standard gauge along the additional corridors of Mundka – Bahadurgarh (Line – 5 extn.) and between Dwarka – Najafgarh sections including elevated and underground sections along with a combination of ballasted/ballastless tracks. The scope also included tracks for depots at Bahadurgarh and Najafgarh regions.

Being one of the pioneers in the construction of Direct Fixation Resilient Track Systems (plinth/slab type) which is a cast in-situ, top-down method of construction and having been associated in Chennai, Hyderabad and recently in Riyadh (line 1 & 2) for metro rail construction, the team made great headway at Delhi Metro and took ballastless track work construction to a new high with speed and sophistication.

Typically, once the viaduct is done along with parapet walls, the track team conducts a detailed survey. Following this, the centre line is marked along with the plinth position on the alignment. Meanwhile, 18m long head hardened rails are stacked on the viaduct. Multiple such rails are welded together to form a Rail panel measuring up to 180m using a specialised welding technique called 'Flash Butt Welding'. A pair of these rail panels are positioned over a 'Gauge Supporting Frame' (GSF) and secured into position using a push pull bar. Further to conducting a gross alignment using 'Total Station', anchor bolts are fastened to hold the resilient rail fasteners in place using temporary supports called 'Dummy Plates'. Thereafter they are flanked by formwork



Conductor Rail installation works in progress



Completed ROCS in a tunnel section



Flash Butt Welding of tracks in progress



Control panels being installed at one of the stations

which will enable a sandwich of dense reinforcement to get embedded in the concrete and give the plinth the desired flexural strength.

Following a regimented curing period, the tracks are removed from the concreted plinth and resilient rail fasteners get inserted on the anchor bolts that are now embedded securely in the plinth. The plinth is also cleaned thoroughly to enhance finish and is now ready for checking the final parameters using gadgets such as the 'Track Master' that compares the alignment vis-à-vis the design parameters to an accuracy of 1mm. The joints between the 180m rail panels are further welded to enable a seamless continuous track which is finally de-stressed before it becomes ready to handle the innumerable trips the metro rail rakes will make. Apart from the usual challenges that include lifting the heavy track sections to the heights of the viaduct or the lowering of equipment such as truck mounted flash butt welding machines to the depths of a tunnel face, it was an uphill task for the team to interface not only with different vendors, but also other contractors who were going about their unfinished jobs on the viaducts and tunnel sections.

Powered with determination

At the CE07 package, team, L&T commissioned 25 kV overhead equipment including switching equipment, cabling and auxiliary sub stations. The team had to work on five different lines at various locations to cover about 150 track km (tkm) that formed the scope of the project. While originally the project schedule was spread over seven months, delay in handing over the work front forced the team to crash the timeline to only three months. Working against stiff deadlines, the team even managed to complete one of the lines in time for inauguration by the Hon'ble Prime Minister of India, much to the client's delight.



Revenue operation started in Line 6 (Badarpur – YMCA Chauk, 28 tkm) on September 6, 2015

The first process in the sequence of commissioning the overhead catenary system is to erect the heavy masts using derricks. With live traffic below, the process was executed with care and caution. Thanks to a world-class safety system, the team could breathe easy as every single risk was carefully analysed and mitigated. Using a ladder and a rope pulley system the team fits the cantilever assembly following which the guy rod is fixed along with a turnbuckle adjustment to set right the sag as well as to prevent the mast from leaning owing to the line tension. Following the laying of the RC and OPC cables (ensuring a termination tension of 400 N & 500 N respectively) the catenary and contact stringing is done using a specially fabricated road and rail vehicle to clamp in place the wires ensuring a 1200 N tension. Tightness is taken care with the use of counterweights and a dropper is erected at all the marked positions. PSI equipment such as interrupters, isolators and voltage transformers are

erected as per drawing using the trifor-sling arrangement.

For the first time in DMRC, L&T introduced aluminum based single insulator type cantilever which is widely used for high-speed rail in Europe that offer the benefits of being lightweight, anti-corrosive and maintenance free. Even the counter weights were designed to fit into a smaller area taking into consideration the expansion allowances owing to wide variations in the Delhi temperatures. Other innovations included modifying the design of road cum rail vehicle to increase productivity and reduction of human intervention both of which directly resulted in substantial savings. The team also introduced an extendable and adjustable working platform which was suitable for both pre and post wiring activities.

Under the CE 08 package, team L&T installed 49 tkm of ROCS (Rigid Overhead Catenary System - a 25kV

overhead system that powers the rolling stock) working at constrained spaces through tunnels and underground stations. The scope was primarily divided into pre and post track activities. Work such as centre line and template marking along with fixing of anchor bolts (the fasteners of which are tested for a load of a whopping 1.2 t to assure complete safety) are covered under the pre track scope. The fixing of brackets that will support the conductor also falls under the pre track scope. Once the tracks are laid, all the cables including the conductor, contact wire, RC, OPC and TEW are installed and clamped securely to propel the metro rail.

Being track and traction works, these projects mark the successful completion of this phase of Delhi Metro and this dedicated team can sit back with satisfaction after having toiled strenuously to put on tracks the Metro rail system that is already easing the city's traffic woes and improving the air that the people of Delhi breathe.

Transmission Line, Kudgi

Integrating the arteries of power evacuation systems





A stretch of the alignment passing through a hilly terrain

For India which depends on a mix of energy generation sources that are spread unevenly across select regions, power evacuation is as important as energy generation. With more and more powerhouses coming up at remote locations, long distance integrated transmission systems are seen as the way forward to transmit power to a cross-section of distribution networks. L&T's Power Transmission & Distribution business has been giving shape to the country's powerful dreams by partnering major power developers and integrating a slew of high voltage marathon transmission networks. One such benchmark is the execution of an extensive multi-voltage transmission line for NPTC's Kudgi Super Thermal Power Plant in Bijapur, Karnataka.

The plant is a super critical thermal power facility which is being developed in two stages with the first phase having capacities of 2400 MW (3x800 MW) and 1600 MW (2x800 MW) respectively. NTPC's first 800 MW power generation venture, the electricity generated from it will be supplied to states of Karnataka, Andhra Pradesh, Tamil Nadu and Kerala.

A maiden power transmission PPP project for L&T IDPL

L&T's Infrastructure Development Projects Limited (IDPL), a pioneer in developing landmark infrastructure, has for the first time ventured into the power transmission business and bagged this project through a Public-Private-Partnership (PPP) in August 2013. It

was awarded by REC Transmission Projects Company Limited (Bid Process Coordinator) on a Tariff based Competitive Bidding (TBCB) mechanism for developing the transmission line on Design, Build, Own and Operate and Maintain basis to evacuate power from NTPC's Kudgi Thermal Power Plant. The scope of work comprised detailed engineering, survey, civil works, installation, testing and commissioning of interconnected power transmission lines that covered two 400 kV D/C lines from Kudgi to Narendra (New SS) across 18 km, a 765 kV D/C line from Narendra (New SS) to Madhugiri across 376 km and a 400 kV D/C line from Madhugiri to Bidadi across 93 km. The project was scheduled to be completed in 22 months through Kudgi Transmission Limited, a Special Purpose Vehicle, with a concession period of 35 years.

four store yards were set up at the respective sites to facilitate seamless access to resources and materials.

Fast-tracking from a delayed start

To begin with, the first leg of the project across the Hungund section involved the construction of two transmission lines of 400 kV over a short span of 18 km. However, the works were held up for nearly 10 months because of several ROW issues. IDPL and PT&D IC joined forces to resolve the stalemate and a renewed schedule was fixed to complete the works by March 2015. The scope for the 400 kV line involved raising 47 towers and dedicated teams were deployed to lay the foundation, install the towers and string the lines thanks to which the task was completed in a record time of 48 days by adhering to an internal milestone of raising a tower a day.

The other portion involving the 765 kV D/C line alignment was mostly across fields but access for foundation and tower works was not allowed by the farmers during June to December as

it was the farming season. Moreover the alignment had a slew of critical crossovers over powerlines, river and highways. Two stringing teams were formed to handle the works stage wise. Appropriate shutdown procedures were followed by seeking prior approvals from the power authorities and within a stringent timeframe the segment of 90 km was completed by December 2015.

Holding together the mid-way section

Having streamlined the early phase of the project, it was time for team L&T to innovate on the process as the going got tough over the Hospet region which spanned 133 km with 297 towers of 765 kV D/C voltage. The alignment passed through a series of crossings out of which the most challenging was the Tungabhadra river crossing. Planning was crucial at this stage as it was necessary to route the alignment away from the forest and hilly terrains to raise the towers. Following a thorough survey, a secure alignment was finalized without any major impact on the cost of the project while cautious headway

Plotting the 500 km corridor

PT&D IC was entrusted the task of executing this project on an Engineering, Procurement and Construction basis by L&T IDPL. With the alignment spread over a vast area that included major crossings over rivers, railway lines, highways and other power lines, a lot of ground work was required especially in resource planning while securing the Right of Way (ROW). Owing to its size and scale, the project was divided into 4 strategic phases - Hungund region over 108 km, Hospet area over 133 km, Chellakere segment over 157 km and Magadi division over 93 km. The main site office was established at a mid-point to coordinate the works while





was completed in just about 12 months making this the fastest completed section.

Making an all-out effort

The final phase stretched over the Magadi section for close to 93 Km with 256 towers of 400 kV D/C voltage. Challenges were plenty in this alignment as the line passed through farm lands, intersected along the urban areas, involved hot line crossings, railway crossings and spanned over the waters of Manchanabele dam. Team L&T raised the bar by coming up with a slew of smart work strategies to mitigate each hurdle.

The live line crossing was executed with the help of drones - an interesting and safe execution strategy involving a high D-electric 16 mm Plateena rope tied to the drone and guided over to the new tower location where it is fixed by a fitter while maintaining minimum sag at the desired locations between

was made while executing the stringing works especially during the river and farm land crossings. For a length of 9.5 km which was across fruit bearing trees, the process of stringing was customized with the stringing platforms mounted on the towers and winches used to execute the final sag on the tower itself.

Going ahead with ease

When compared to the previous two sectors, the Chellakere section was relatively easier though it spanned 133 km and comprised 363 towers of 765 kV D/C voltage. A peculiar feature of this section was that it passed through a complex network of transmission lines of various voltage levels ranging from 11 kV to 400 kV. While the stringing works were carried out only during the shutdown period, the process was made further fool proof by routing the live power network temporarily through underground cables till the tower works were completed. Over 286 Km of 765 kV and 76 Km of 400 kV the stringing



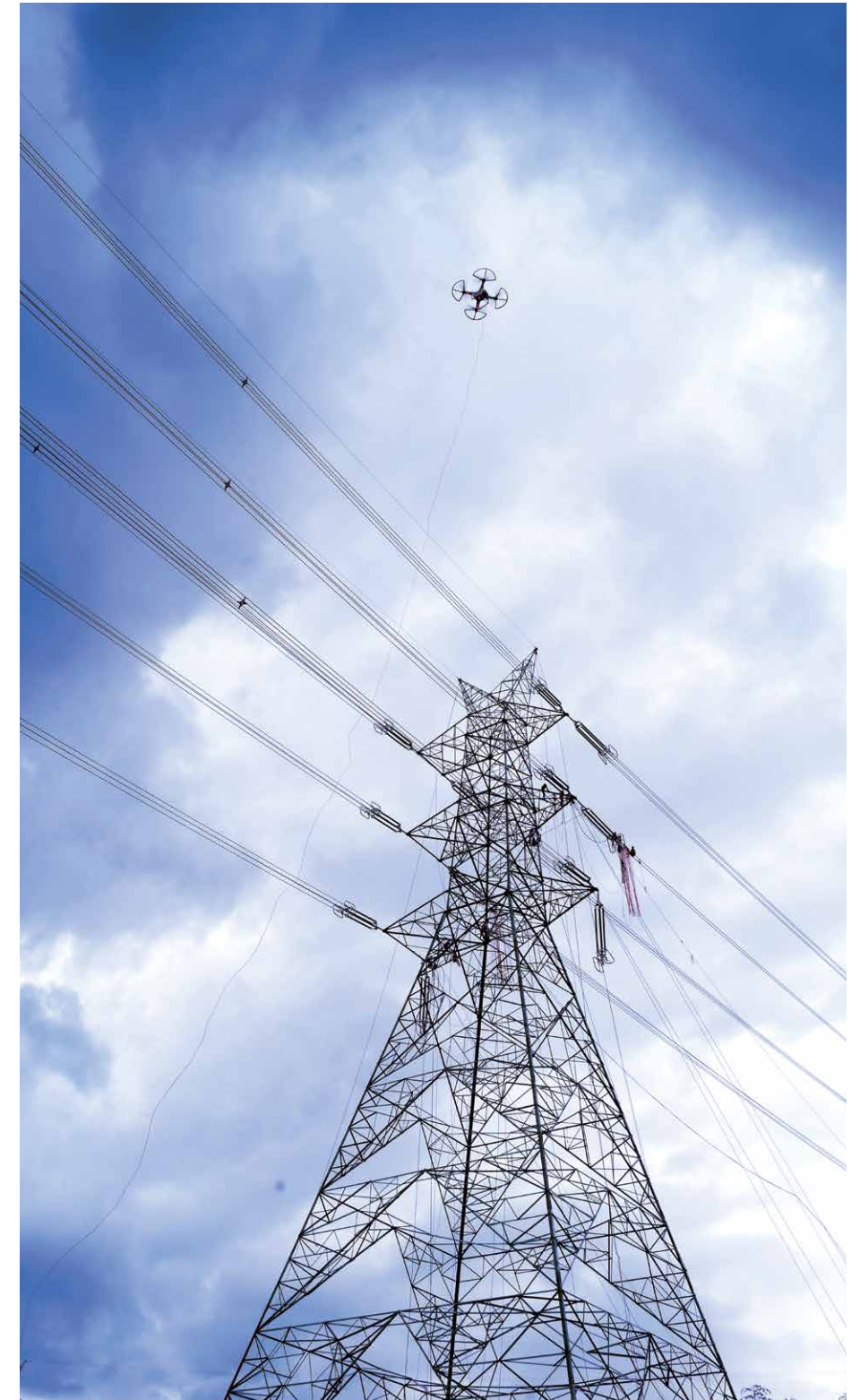
Drone technology deployed to cross over live line

the two new towers. The cross arms hole to distance is measured through a total station theodolite while the actual length of the conductor and sag is computed and dead end connections are made at the ground level. Hot line hanging rollers are passed through the Plateena ropes which carry the conductors and a spacing of 10 to 12 meters in between the hanging rollers is ensured so that there is no sag during the process. While one conductor is passed over the energized line, dead end cone fixing is done at the other end to string the insulator hardware. The conductor on the other tower is pulled with the help of come-along clamps/pull-lift and connected with the dead end cone to the second side of the string insulator. The final sagging of the conductor is done keeping the conductor inside the hanging rollers after which the rollers are removed.

There were also large areas in this section across hilly regions with limited access way which required manual loading and close to 200 workmen were engaged in this herculean task. The tower foundation works around the Manchanabele dam needed a thorough review as the soil had high water content. A detour of the route unfortunately was not feasible due to the adjoining forest area. After consultations with the Engineering Design and Research Centre, the team opted for a deep well dewatering system that was designed to withstand the soil collapse under water logged conditions while stabilizing the tower foundations.

Good practices that bridged the span

For team L&T delivering a project of such a vast span 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. At the design stage, the edge was provided to facilitate execution by opting for specialized foundations and tower schemes with



longer span of 500 m (DS type tower) that minimized raising towers. While on-field strategies such as use of mobile crane for tower erection, motorized

winches for stringing final sag work, installation of sagging bridge during conductor stringing streamlined the execution process.



Plant water system for 2X800 MW
Yermarus thermal power station

Optimizing technology for
recovering resources

More than 70% of India's electricity demand is met through the country's vast coal reserves especially from thermal power plants. Unlike the renewable energy generation sources such as hydel, wind and solar which are self-sustaining, traditional plants require large volumes of fresh water for cooling during the energy generation process. According to a report by The Energy and Resource Institute (TERI), thermal power plants account for 88% of water consumed across all industry sectors put together. With rapid increase in India's thermal power generation capacities in recent years, not only the consumption of water by these plants has gone up but their expenditure on water related charges has also risen considerably. As the water-power nexus is becoming increasingly critical, modern plant water systems are being constructed with

advanced technologies to minimize the use of water and effectively manage the treatment processes.

Banking on innovative process systems

The state of Karnataka which has a rich history in power generation has been over the past few decades facing acute power and water shortages. To mitigate this grim scenario, the state government is roping in private investors to join hands to develop sustainable power generation plants to bridge the gap between rising demand for electricity and limited resources. The 2X800 MW Yermarus Thermal Power Station (YTPS) developed by Karnataka Power Corporation Limited near Raichur is one such coal-based modern plant which is replete with a slew of advanced water treatment systems that

enhances effective water management and distribution by using water and coal optimally. Needless to say, it also produces a higher amount of electricity.

A high-tech guarantee that tilted the scales

As forerunners in building world-class water infrastructure, L&T's Water & Effluent Treatment IC bagged this high-tech contract which involved the construction of Asia first and largest Micro Filtration (MF) plant of 158 MLD for river water treatment along with an ash water recovery system, effluent treatment plant, sewage treatment plant, mechanical equipment erection and associated electrical & instrumentation works. Apart from being the lowest bidder, what tilted the scales in favor of L&T was a technical guarantee assuring the client of arriving at a lower discharge

pressure for the micro filtration pump against the MF supplier's requirement of 2.6 kg/cm². L&T's Engineering Design and Research Centre team at Chennai worked on designing the hydraulic system with less frictional loss and low differential pressure to arrive at a maximum pump discharge pressure of 2 kg/cm² which proved to be the key differentiator from the offerings of other competitors. The calculations were ratified by the client through the Indian Institute of Science, Bengaluru and approved the pump to implement the technology.

The heart of the filtration system

Micro filtration is the heart of the plant water system which operates through proprietary Poly-Vinylidene-Fluoride (PVDF) hollow fiber membrane



Micro filtration unit in operation



Micro filtration building

technology and is designed to produce consistent quality of water irrespective of seasonal and/or weather related variations in the source of raw water. This filtration system advantageously occupies a reduced footprint as the technology to be installed is a single unit when compared to the conventional plants with several treatment processes. Further, the process is cost effective, filters river water without any pretreatment and limits the use of chemicals during the treatment process as the pathogens and other inorganic substances are directly removed through the filtration process thereby ensures protection of the downstream systems, reduces downtime, maintenance costs and enhances service life. To top it all, the filtered water has less than 2 units of Nephelometric turbidity while the recovery of water from waste streams is close to 95%.

Making a conscious start

One of the first priorities for the team was to access the earmarked location to streamline works at site. However,

a change in the overall plant layout delayed land acquisition. The team quickly resolved the stalemate by convincing the client to shift the earmarked area to a nearby available location without compromising on the hydraulic requirements of the system. On-ground challenges were plenty as the strata was a mix of black cotton soil and hard rock which called for a secure excavation strategy that involved the removal of 1m to 1.5m of surface level earth followed by 7000cu.m of controlled blasting. At locations which had a range of activities and excessive labor movement, the team deployed crews to break down the rocks through chiseling which though laborious was foolproof.

Unloading the microza microfiltration modules

The 1456 microza microfiltration modules, each weighing close to 32kg, 165mm in dia and 2160mm in length resemble a series of elegant hollow pipes. The entire consignment was shipped from the US and arrived at site on containers. Stacking the modules at site

called for some deft handling as it was mandatory to store them in an enclosed area with no exposure to direct sunlight with the temperature maintained well below 40° C by continuously operating air coolers till they were moved for erection onto the rack inside the MF building.

Integrating the MF system

Team L&T, in consultation with the membrane supplier, designed a staging system that comprised 16 racks with a provision for 2 standby units. Each rack consisted of 91 modules and 5 spaces were allocated as additional provision along with a skid frame, skid valves, instruments and necessary piping to hold the modules. The site team assembled the modules in a particular sequence inside the MF building and erected them with top and bottom coupling joints. The inlet and outlet header pipes were

clamped with the bottom and top frames in such a way that the vertical distance/alignment of the nozzle matched with the length of the modules. The hose pipe connections were Victaulic couplings. For connecting the inlet, outlet and reverse filtration of all the racks, HDPE pipes of 90mm to 350mm were used which called for executing close to 1250m of piping works with 1076 joints in confined places. Further, each rack is provided with 9 pneumatic valves for inlet/outlet/reverse filtration/drain/excess re-circulation and chemical cleaning. Post erection, the modules were flushed with clean water to wash out the preservatives. The specialty of this system is that the entire filtration operation is carried out from the PLC / SCADA through the Festo block installed on each rack. Two air compressors along with associated instruments are provided for scrubbing the modules with air /water during the backwashing of modules.

Ash water recovery system

Close to 3300 m³/h of ash water is recovered from the ash water recovery system, a state-of-the-art plant that processes through a 61m dia clariflocculator. Apart from the construction of the entire plant, the scope involved installation of fire and dust suppression pumps for the coal handling plant. During execution, the team discovered that top soil was black cotton in nature up to 2m while the base raft of the clarifier was much lower. To overcome the uplift pressure, a sandwich type of slab was employed. Other challenges involved maintaining the radius of the outer wall and slope of the flooring. An innovative method was evolved to install the new clarifier bridge that weighed close to 15 t by fabricating and erecting a special derrick to facilitate positioning of the bridge components that resulted in



Ash water clarifier

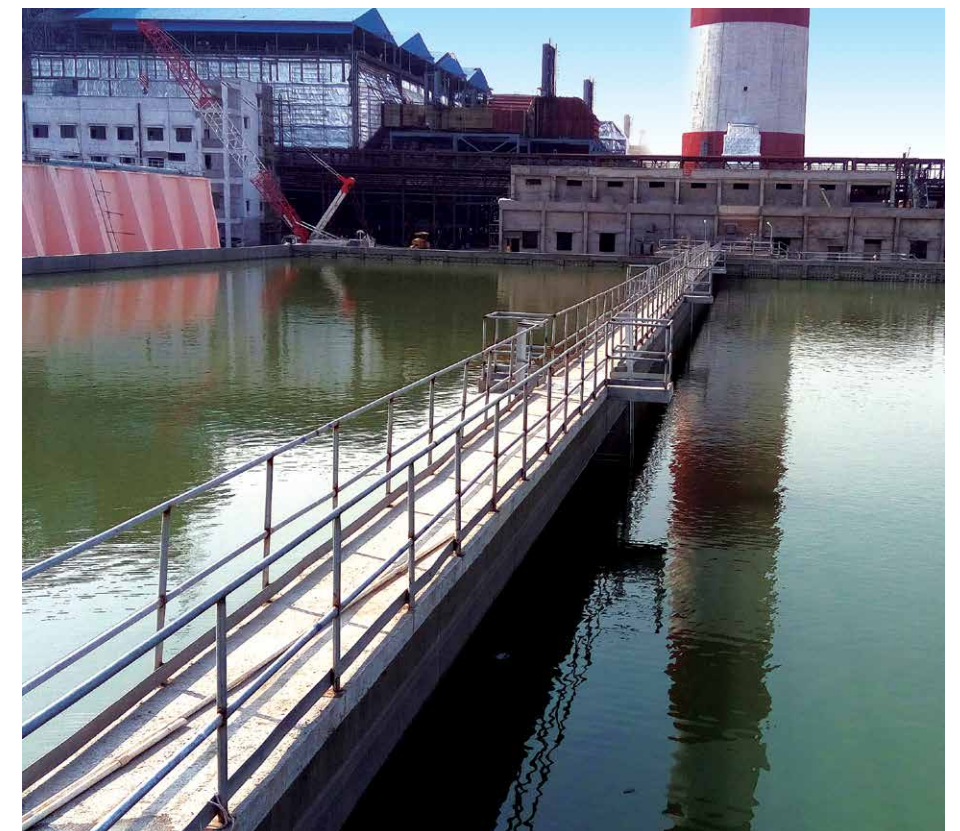
huge savings on cost and time. The plant is built to take up flocculation and sedimentation in a single unit and ensures less than 25 units of Nephelometric turbidity.

Effluent Treatment Plant

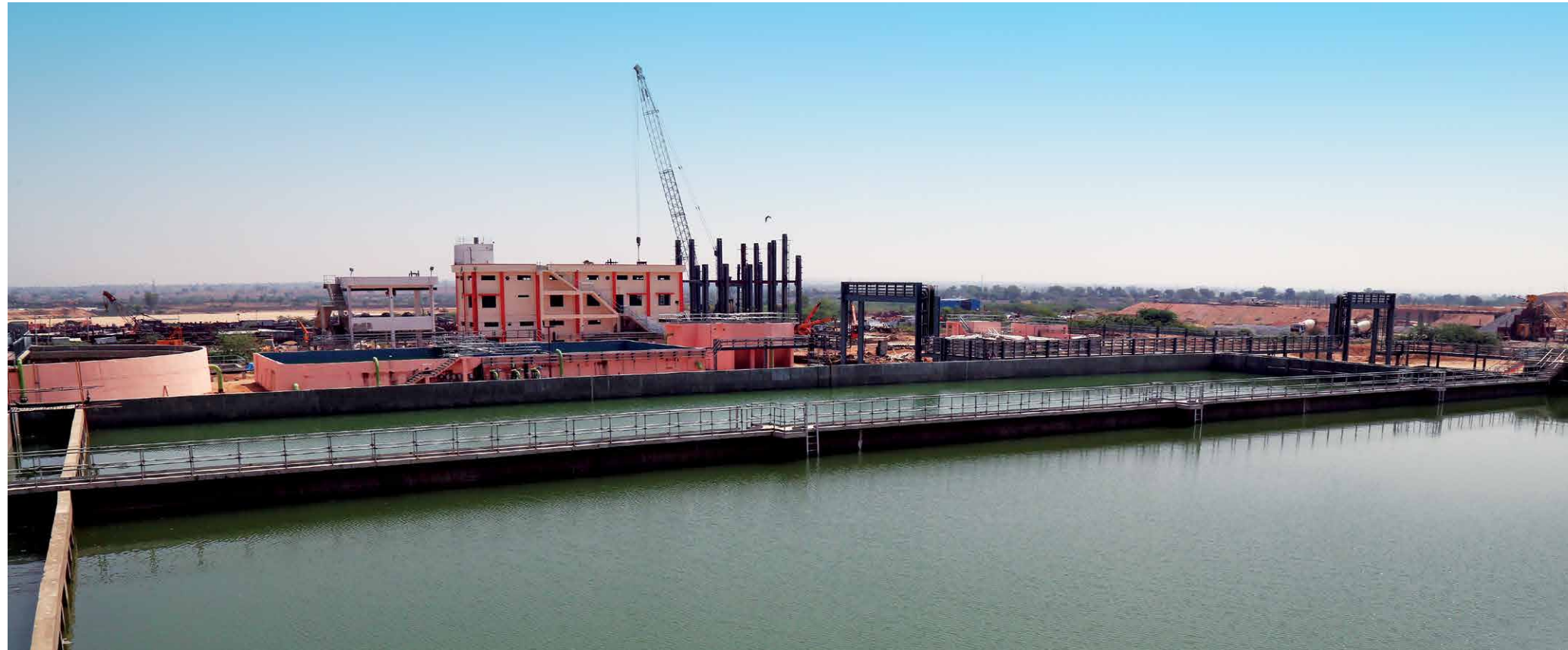
Establishing the piping for the Effluent Treatment Plant (ETP) was a critical task as more than 2 km of pipeline had to be routed inside the boiler area of the running plant while the effluents were collected from 5 different locations to a common point. The pipeline was laid on pipe racks with the help of a rope and chain pulley so that it did not hamper other agency works. Raising the civil structure called for deft review during construction as it was an above ground plant with three distinct zones for oil and grease separator, flocculation and clarification. The bottom slab inclination along with the cross wall dimensions was cross-checked at regular intervals so that the zones were in position. Putting together the lamella clarifier was a herculean task as it comprised 7600 tube deck plates in honey comb shape at a 60 degree inclination. The task was accomplished by grouping the plates in batches of 380 for easy handling and positioning with the help of a crane. Around 225 m³/h of effluent was treated as per discharge standards set by the client while the sludge generated from the ETP was treated through the thickener and centrifuge thereby recovering a reasonable quantity of water. The treated effluent from the ETP is pumped to the ash slurry sump and recovered for gardening after neutralization with acid and alkali in the central monitoring basin.

Sewage Treatment Plant

The 60 m³/d Sewage Treatment Plant (STP) plays an important role in recovering treated sewage water for low end reuse and involves a biological treatment in a moving



Settling tank



Settling tank with sludge handling system



Main control room

bed bio-reactor while the tertiary treatment comprises chlorination followed by new generation multi-grade and activated carbon filtration. The final step of treatment is through UV disinfection which ensures that the treated sewage water is completely sterilized. L&T scope of work covered a mix of civil and mechanical works that included construction of the screen, equalization tank, aeration tank, tube settler, new generation multi-grade filter, new generation activated carbon filter with final treatment of UV disinfection. The UV disinfected sewage water is used for gardening inside the plant and the sludge generated is being handled with the filter press. The recovered water from the filter press is recycled back to the equalization tank. The main challenge for the team was to ensure that the associated civil works were done with care as the clarifier zone was a FRP prefabricated material.



Filter water storage tank

Raising critical support structures

Three filtered water storage tanks, a settling tank, pump house and the MF building were the main civil structures erected. While most of the structures were modest, construction of the tanks was a challenge as it was designed with 3 compartments and was to be raised above ground. The execution was planned compartment wise with each section divided into 4 parts. Since the middle compartment was bigger and needed more focus, resources were allocated to speed up the works for which certain areas of compartment 1 were held back to create an approach way for boom placers and transit mixers to do the concreting for parts 1 and 2. A similar approach was followed to complete the remaining phases. With the walls of the tanks tapering from 550mm to 200mm at the top along with

counterfort at 4m intervals, columns were proposed at every 3.5m in both directions to support the roof of the tank. L&T's expertise in formwork and staging came in handy to complete this task safely.

The chemical house was another structure that needed precision planning during construction as it comprised RCC chemical tanks inside the first floor which was taken up only after completing the entire structure and roof works. Special care was taken to insulate the floor and tank with acid resistance tiles as the UPVC pipeline carries the chemical up to the stilling chamber, CMB ETP and centrifuge.

Supervisory Control and Data Acquisition (SCADA) System

Putting together the SCADA system

with inputs of field equipment was another critical task as the entire microfiltration processes depended on precise settings for smooth operation. A stage wise approach was planned that involved connecting the individual racks of the MF to a Festo system and interconnecting the other MF racks via Ethernet into a ring system operation thereby ensuring redundancy of the system without affecting the filtration process. In the second stage, the field equipment serving MF was rescaled and the corresponding high and low alarm limit values fed to the SCADA. In the third stage, the individual equipment feedback between the field to SCADA and the main equipment was checked to enable the operation.

The SCADA system is designed to operate on auto and manual modes of control. The auto mode takes the field value from the instruments while the



MF Feed pump house



MF Dyke area

manual option allows the operator to set a value within the process range. The intent of the manual mode is to allow the operator to set the value of the Programmable Logic Controller (PLC) which allows the code to function in the event of an instrument failure thereby ensuring that the microfiltration functions without inconsistencies.

Handing over a hassle free system

The final phase of the project called for a range of pre-commissioning checks and the filtration system was put to a dynamic test involving the client and the membrane supplier. To ensure that process was foolproof, several tests were conducted to assess the functioning of various facets such as PLC/SCADA, electrical distribution and utilities. The MF system comes with a 10 year warranty and envisages a minimum output of 150 MLD of filtered water with a turbidity of 0.01 NTU which is well below industry standards. As a fully automated plant there are no shutdowns while the cleaning in place is conducted by re-circulating chemicals and water at high velocities and temperature. However, since this technology is new to India, a crew has been based at site to oversee the operations and maintenance for a period of 5 years. And with the future hinging on sustainability, L&T's Water business is well poised to take forward the concept of water sustainability across industries.

New orders kick in along with a major win to build a stadium to host FIFA 2022

L&T Construction, along with its JV partner in Qatar, Al Balagh Trading & Contracting, has bagged the mandate to build a 40,000 seater stadium, as part of the sports infrastructure being readied by the Emirate in preparation of the 2022 FIFA World Cup. Inspired by local patterns and dune-like structures, the Al Rayyan stadium and its precinct design will resemble the sand dunes that surround the traditional desert tents. A landmark in the making, the Al Rayyan stadium will be one of the most significant stadiums slated to host games up to the quarter-finals in the much awaited 2022 FIFA World Cup.

On the domestic front, the Buildings & Factories business is building a prestigious high rise residential project in Mumbai that will feature two residential towers, each having 3 basements, 7 podiums and 66 floors among other ancillary buildings. The business is also set to build a mid-rise residential project in Mumbai apart from a win to construct a mixed use development (MUD) project for a renowned customer in Kolkata.

The Transportation Infrastructure business won an EPC order from NHAI for four-laning the Addahole (Gundya) to Bantwal cross of NH-75 (Old NH no. 48) in the state of Karnataka. Scheduled to be completed in 30 months, the project involves two flyovers, two major bridges, 14 minor bridges, nine underpasses and one toll plaza. The order book for highways also includes a win for four-laning of the Mukkola junction to Kerala/Tamil Nadu border of NH-47 (new NH-66) under NHDP phase-III in the state of Kerala.

The railway business in concert with Instalaciones Inabensa, S.A., Spain, has won a major design & build job from Dedicated Freight Corridor Corporation of India Limited (DFCCIL) for the electrification works of 417 km section of the Eastern Dedicated Freight Corridor from Mughalsarai to New Bhaupur in the state of Uttar Pradesh.

Significant EPC orders have been won by the Power Transmission and Distribution business both in the international and domestic markets. In the Middle East, the business is to construct a medium voltage overhead line which will enhance the reliability of the existing network. L&T Saudi Arabia LLC, a fully owned

subsidiary of L&T, has bagged a contract from Saudi Electricity Company for the engineering, procurement and construction of 132 kV overhead transmission lines and cabling works in Artawyah and Zulfi areas in the Central Operating Area (COA) in Saudi Arabia.

On the domestic front, orders have been received from Paschimanchal Vidyut Vitaran Nigam Limited (PVVNL) in Uttar Pradesh for the construction of 33 kV substations and associated lines in Ghaziabad apart from orders from Power Grid Corporation of India Limited for the construction of a 400 kV double circuit transmission line package from Tumkur to Hiriyur in Karnataka and construction of a new 400/220 kV AIS substation in Tumkur, Karnataka. The business has also bagged a mandate from Karnataka Solar Power Development Corporation Limited for the construction of 220/66 kV substations along with an associated transmission line network. This project will be instrumental in power evacuation from the proposed 2000 MW Pavagada Solar Park in Tumkur district.

The Smart World business is making major inroads in its domain with orders from RajCOMP Info Services Limited, a government of Rajasthan undertaking, for establishing and commissioning command & control centres at Bikaner, Bharatpur and Jodhpur under the Surveillance and Incident Response Project apart from another major win which involves design and implementation of safe cities using integrated security systems and intelligent & integrated traffic management systems.

An order from Gujarat Water Infrastructure Limited marks the inflow for the Water & Effluent Treatment business the scope of which involves design and construction of approximately 146 km of mild steel pipelines and 26 km of ductile iron pipelines. Another mandate has been won from Rajasthan Urban Drinking Water, Sewerage & Infrastructure Corporation Limited (RUDSICO) for the design, construction and commissioning of Sewage Treatment Plants (STPs) and Sewage Pumping Stations (SPS) along with sewer networks in Alwar, Sikar and Bhiwadi towns of Rajasthan.

A clutch of MEED quality awards endorse L&T's project excellence



Some of L&T's most prestigious projects in the GCC received the region's top honors for project excellence at the MEED Quality Awards for Projects held in association with Mashreq in Dubai on May 25, 2016. The MEED Quality Award that aims to raise standards through benchmarking the best practices specified in the project brief and excellence provided in the project delivery is distinguished from other awards programs because it evaluates the outcome of the construction process, rather than the process itself.



The Lamar Bausher Project (Muttawar Residential) of LTO-B&F was the National Winner under the category "Residential Project of the Year" and Darsait - Al Wadikabir Flyover Project of LTO-TI was National Winner and GCC Winner under the category "Road and Bridge Project of the Year". Water and Effluent Treatment IC's Doha South Sewage Treatment Works project was adjudged as Qatar's National Winner in Power & Water Sector for 2016.



The awards were received by Mr. G.R. Ranganath, Chief Executive, L&T Oman along with Mr. Srinath Rao, Vice President & Head - Transportation BU (Middle East), Infrastructure Gulf, Mr. D.D.Khot, Head - TI IC, LTO, Mr. Shyam Sundar, VP & Head - Building BU (Middle East), Mr. G. Ramasubbu, Cluster Project Manager - B&F IC LTO, Mr. Roy Saldanha - Project Director, Doha South Sewage Treatment Works project and other members from team L&T.