# ECC CONCORD

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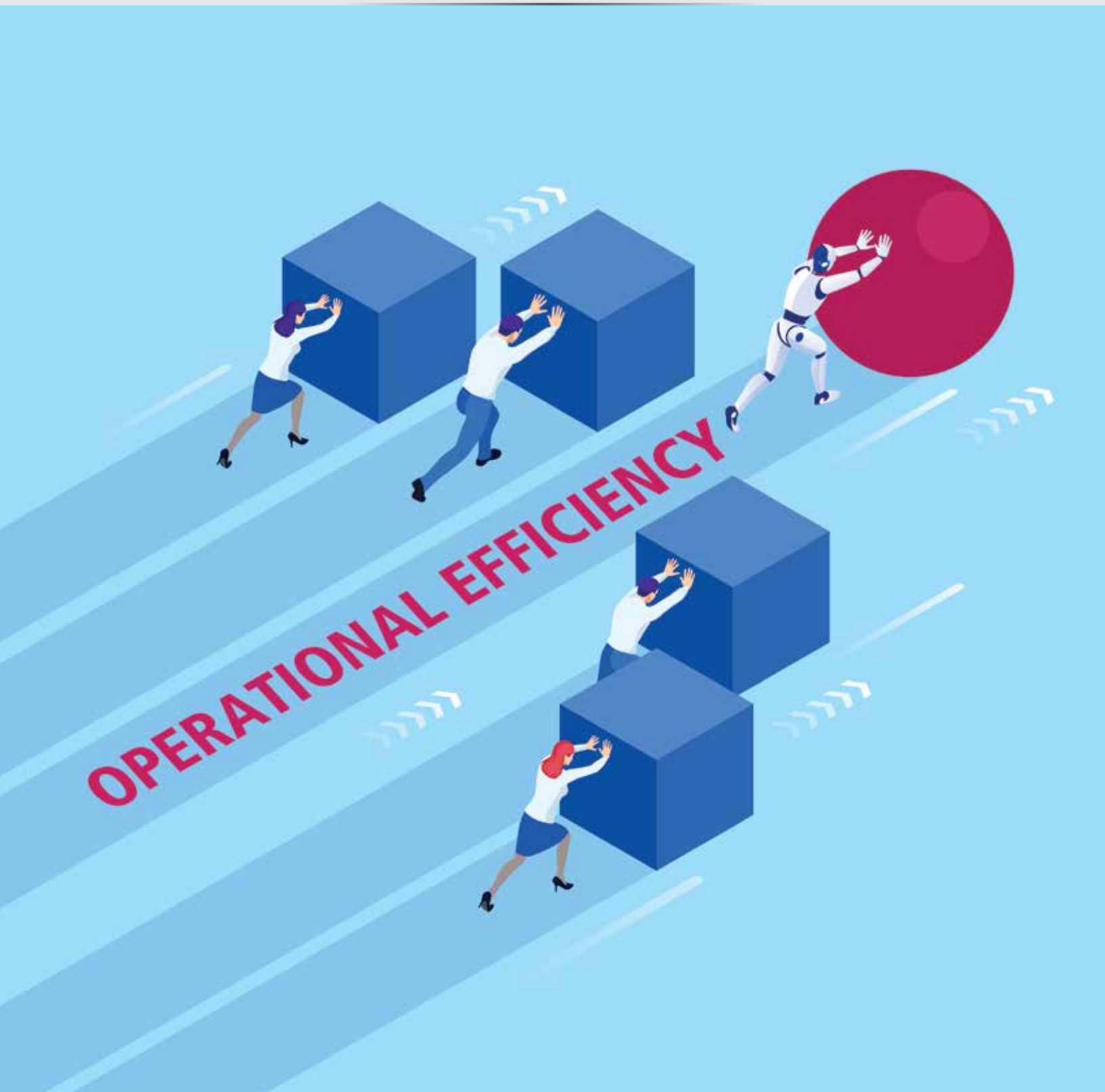

# CONTENTS




**Acknowledgements**

It would been well-nigh impossible for us to put together this issue of ECC Concord with such a comprehensive panorama of OPEX initiatives without the enormous help and support we received from several of our colleagues from across businesses. A big thank from us to all of them, a few of whom are named here in no real order: Pooja Agarwal, S P Rajan, Kiran Hasan Koramaddi, Debasis Roy, Hema Chandrasekaran, M P Rahul, S Jayachandran, A I Nachiappan, Sanjna Suresh, C V Bharadwaj, Akshara Asok, Nitin Shenoy, P T Selvam, Moinudeen Akbar, Anila Manoharan, G Srinivas, Vaibhav Kumar, V Kasiraja, Vijayalakshmi L ...

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LEADER SPEAK

## S.N. SUBRAHMANYAN

Chief Executive Officer & Managing Director, Larsen & Toubro

If there is one criterion that supersedes all other considerations in construction projects, it is timely delivery. Every effort of project leadership and teams are towards that one goal of being able to deliver as per the customer's requirements within the given timelines, abiding by the contractual obligations. The introduction of new construction methods and techniques and the advent of frontier technologies have given construction teams a much needed and critical 'help' to deliver their commitments.

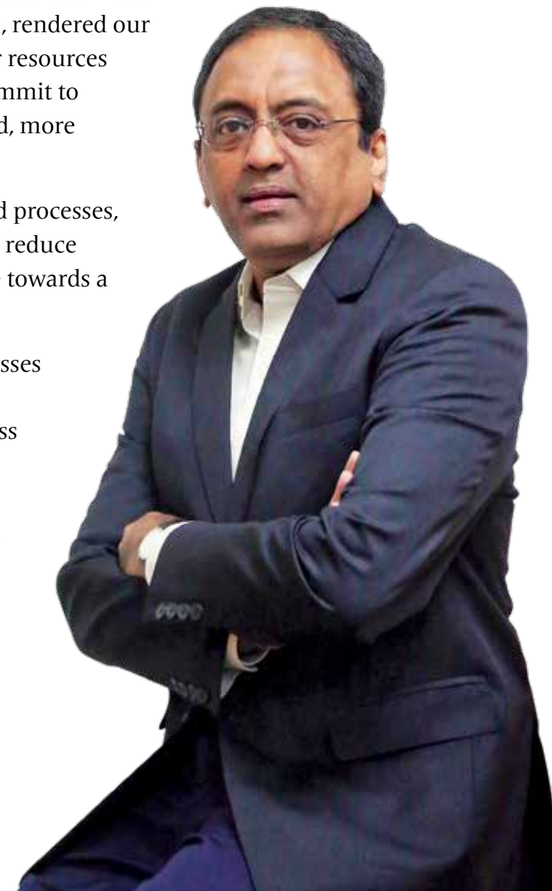
Across the entire spectrum of construction activities of project planning & management, procurement, finance, quality, safety, talent acquisition and retention, managing cash flows, vendor & supplier management, people are focused to deliver projects on time.

At L&T Construction, our concerted and sustained effort to go digital has driven us faster towards our goal by giving us a 'vision' of 'where and what' of projects that has sharpened our project monitoring, rendered our benchmarking more meaningful, helped us sweat our resources greater and more efficiently, and empowered us to commit to customers with greater confidence and conviction and, more importantly, deliver on our commitments.

In our quest for greater efficiencies in our systems and processes, we have succeeded to improve productivity, cut costs, reduce wastage, avoid rework, achieve zero defects and move towards a culture of getting it right first time always.

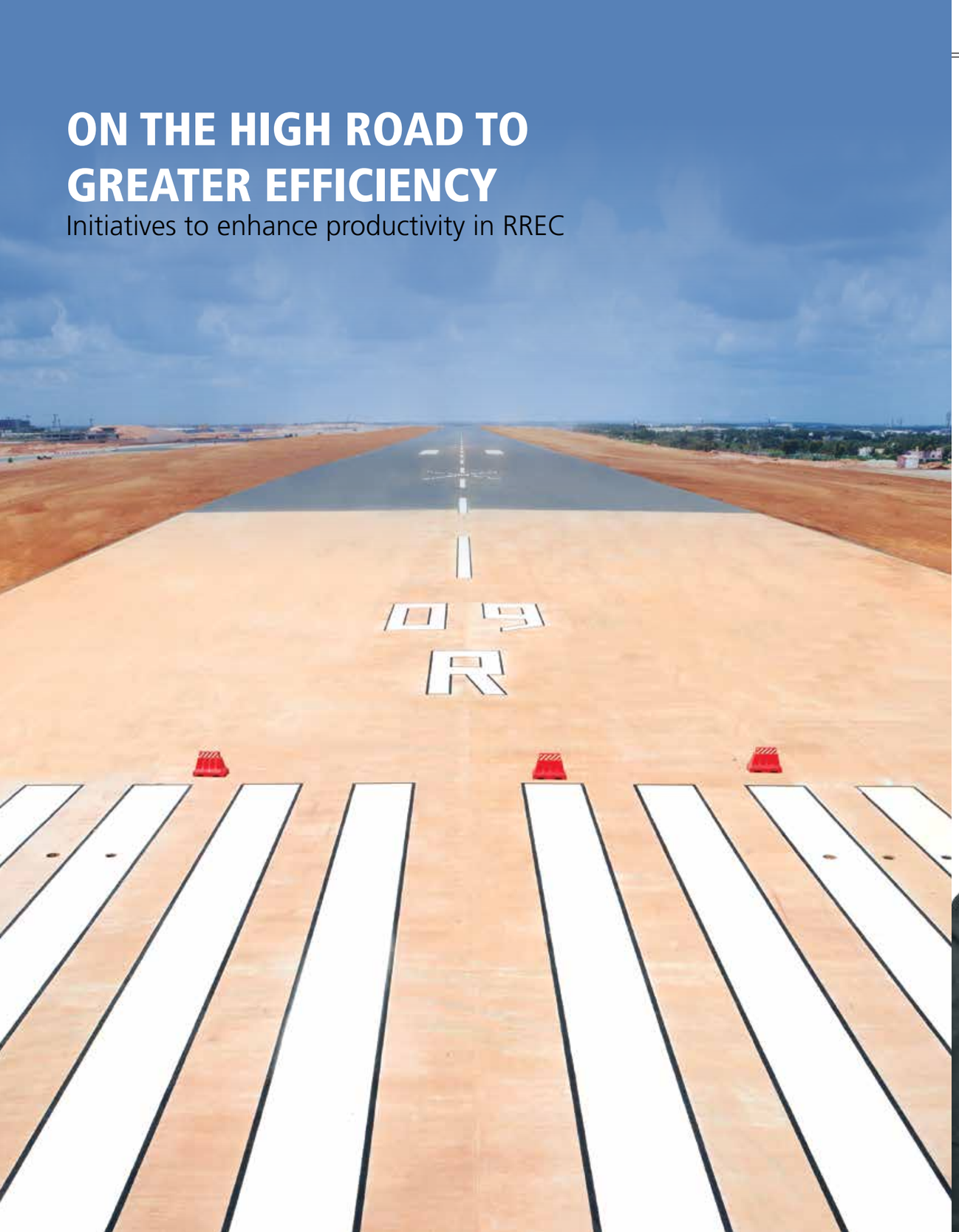
This issue of ECC Concord captures the thought processes of our leadership and the various initiatives taken by our businesses to achieve operational excellence across our different project sites and functions. These are extremely positive moves in the right direction; it is, however, critical for the momentum to continue with the same intensity and vigour.

All the best!



# ON THE HIGH ROAD TO GREATER EFFICIENCY

## Initiatives to enhance productivity in RREC



LEADER SPEAK

**D K SEN**
Whole Time Director & Senior Executive Vice President, Head – Infrastructure

Road infrastructure development is a key requisite for growth and the Government of India is focused on rapidly expanding the country's huge 143,000 kms of National Highway network. Statistics reveal that highway construction peaked at 10,800 km during 2018-19, an all-time high, reflecting a 30% growth and is expected to remain at similar levels in this fiscal too. The Government is now planning to expand the National Highway network to over 200,000 kms. In fact, the Bharatmala Pariyojana aims to build 66,100 km of economic corridors, border roads, coastal roads and expressways, to provide 4-lane connectivity to 550 districts, increase vehicular speed by 20-25% and reduce the logistics costs by 5-6%.

However, there are multiple challenges facing this program. There are headwinds in the form of funding issues, cost escalations, unfavourable payment schedules, delays in land acquisition, utility shifting, tree cutting, mining clearances among several others. The recent trend to award projects on PPP and HAM is unsuitable for us, shrinking our addressable market even further.

Against this scenario, we at RREC, have trained our focus inward to improve our systems and processes to increase productivity, reduce costs, cut out non-critical processes and thereby drive operational efficiency. The following major OPEX initiatives were taken after deep diving into various activities and implemented at ground level:

*Preconstruction Cell:* For extensive interaction between the client and other departments to expedite land acquisition and relocation of utilities obstructing highway projects.

*Road Finishing Activity Cell:* In every project, finishing activities are a bottleneck during project completion and this cell is to execute finishing activity in a focused manner.

*Engineering Project Control:* Quantity reconciliation before submitting designs and drawings to the consultant.

*Digital Monitoring:* Monitoring of productivity and dispenses of diesel through digital data.

*P&M Profit Centre:* Designed to accelerate P&M driven performance through digitalization, collaboration and advanced analytics; the P&M Profit Centre in RREC has contributed to benchmark productivity, asset deployment and energy efficiency in P&M Operations.

*B2B Subcontracting:* Major activities have started awarding to Sub contractors on a B2B basis to minimize risk.

*Smart Execution:* Invoiced based execution approach to monitor and improve cashflow.

*Finishing & Demobilisation of Project:* Co-ordinating with various internal departments to expedite and complete finishing works, including interaction with Consultants and Clients.

*Listing of Region Specific Sub-Contractors:* Discussion and enlistment of vendors in every region for common items such as survey, soil investigation, RE Wall, excavation, etc.

With strong leadership and efforts at sharper OPEX, planning and execution have started to bear fruit. These are initial steps, but we are convinced that we are moving in the right direction.

The transportation sector is arguably the backbone of the economy reflected in the announced outlay of INR 1,70,000 Crores for the sector in the Union Budget 2020. This special attention from the central government would pre-suppose a sector in high gear but the reality is slightly different as contractors face strong headwinds and uncertainties to succeed. Against a challenging backdrop, D K Sen, Whole Time Director & Senior Executive Vice President, Head – Infrastructure, L&T puts up a brave front: "While external factors are not within our control, I am driving my team to introspect and deep dive into our own systems and processes to evolve methods and kick start initiatives that can significantly improve our operational efficiencies. I am delighted that they have heeded my call and the RREC (Roads, Runways & Elevated Corridors) business have some encouraging results to show."

## Benchmarking for competitiveness

To remain competitive in the face of odds has been the dictate for the business as the 'headwinds' that DKS referred to are manifested in surreal forms. "With increased focus on projects in the HAM or PPP mode, our addressable market is shrinking," reminds DKS and hence the onus to improve internal efficiencies is even greater.

To drive operational efficiency, the RREC team has adopted a lean, integrated and design intent

VOICES FROM GROUND ZERO

**"We initiated internal technical audits to benchmark effectiveness, efficiency of operational processes and procedures with a complete review of the documentation, interactions with design, procurement, P&M, construction practices, planning and other critical functions."**

**G Shettar**
*Head – Quality, RREC*

*Infrastructure works for Dholera Smart City*

*Line drain work*

verified construction conforming to specified quality. "We initiated internal technical audits to benchmark effectiveness, efficiency of operational processes and procedures with a complete review of the documentation, interactions with design, procurement, P&M, construction practices, planning and other critical functions," shares G Shettar, Head – Quality, RREC. "To further strengthen quality checks at site, a dedicated Quality Assurance cross functional team has been deployed at a handful of pilot sites like Bangalore International Airport, Dholera Smart City, Delhi International Airport, Mumbai Nagpur Expressway & Mumbai Vadodara Expressway with encouraging results."

A robust system to finalize quarry sources has been developed and maintained as quantity of aggregates plays a vital role in the success of any project. Based on a thorough study of past performances, select suppliers of critical bulk materials like cement, fly ash, admixtures and agencies for critical work like RE wall construction, girder erections, road furniture works have been identified for better control.

A technical bulletin on critical activities, analysis of common and oft-repeated quality lapses, technical training programs featuring external industry experts specially on rigid pavement construction, best construction practices, Dos & Don'ts and learning from mistakes have significantly improved product quality and work efficiency.

An exclusive training programme titled 'Quality – The path to the excellence', focused on behavioural and attitudinal aspects was developed for senior employees. "Behaviour is a key determinant to achieve project quality," shares Shettar. "Just to quote an example: Honeycomb in concrete can be dealt with in two ways either by accepting it or by avoiding it but always remaining alert to it. In the former case, there are bound to be product quality lapses either due to ignorance or insufficient effort to solve issues. The training is to create this mindset of being always on the solution side."

## A P&M Profit Centre to drive excellence

Designed to accelerate performance, the P&M Profit Centre strives to streamline core processes, achieve optimal resource allocation, adopt a profit-oriented approach and inculcate greater accountability. "Value creation aims to optimize hiring charges by blending owned and hired equipment guided by productivity benchmarking, maximizing energy efficiency and


**"Value creation aims to optimize hiring charges by blending owned and hired equipment guided by productivity benchmarking, maximizing energy efficiency and responsive use of digital tools. Speed and time dictate modern-day construction and P&M is integrating solutions with a clear target to achieve operational excellence."**

**S P Rajan**
*Head – Plant & Machinery, RREC*

responsive use of digital tools," shares S P Rajan, Head – Plant & Machinery, RREC. "We have accepted an ambitious cost reduction target and aim to achieve it with a multi-dimensional approach to improve internal efficiency through collaborations, digitalization, advanced analytics, etc."

'Asset Insights' are mapping equipment across the Bangalore International Airport (BIAL) project to improve turnaround time and quicken movement of men and machinery. Machine automation in motor graders and excavators has helped BIAL achieve speed and accuracy, deploying lesser manpower while in house development of the mulching machine has obviated procurement time and cost. The Karodi Aurangabad Expressway project has consistently clocked more than 900 cu.m. per transit mixer per month despite operating in a rough terrain. Helwak Karad Road Project, Dholera Smart City, Delhi International Airport, Mumbai Vadodara Expressway projects meet their power requirement of plants and camps through a combination of Grid & Solar power, PNG.

A critical review of the business trained focus on the significance of balancing owned and leased equipment, equipment life-cycle management, skill upgradation and productive fleet management in tandem with project needs. "An integrated perspective on construction quality and P&M efficiency improvement is leading to improved construction productivity and business competitiveness in a market filled with new entrants," adds S P Rajan.

Apart from cultivating business acumen in the team, the model has introduced a cultural shift too that is helping RREC optimize solutions, increase team engagement, reduce costs like never before and create key differentiators through value creation. "Speed and time dictate modern-day construction," says S P Rajan, "and P&M is integrating solutions with a clear target to achieve operational excellence."

*Precast girders installed for fast tracking the construction of an elevated corridor*

## Reducing costs and rate contracts: imperatives for success

For DKS and team, the thrust to improve the bottom line is a continuous process, "for which we have planned strategic interventions, formed task forces and mandated SCM to re-negotiate all major existing contracts to reduce costs," shares DKS. Against an annual targeted spend base of INR 618 Crores, the initial internal target for re-negotiation was INR 30 Crores by Q3 of FY 20 but after presenting the plan to the management, the matter was referred to E&Y and target was revised to INR 100 Crores.

"Tough targets require tough strategies and equally tough actions to achieve them," smiles Sumit Bardhan Head – SCM, TI IC, who leads the initiative, "and therefore we carefully evolved our strategy looking at major spend areas like earthwork, transportation, aggregate procurement and production that were already on stream. We targeted sub-contracts that were above INR 10 Crores. In some subcontracts PBG, Retention Deposit and LD had a major impact on cost, partial relaxation aligned with risk profile of our business eased their cashflow so that they could pass one-time discount to us."

"Reorganising hiring contracts regionally and creating competition through reverse auction along with shifting to item rate contract for major equipment opened new avenues of cost along with shifting reduction. We involved PM & PDs too in the process, however foreign subcontracts were kept out of the ambit of this plan," he adds.

The team scrutinized work and purchase orders for all projects. Works orders included aggregate and concrete transportation, geo-composites, earthwork, quarrying & crushing works, pre-stressing and equipment hiring. Purchase orders included admixture, fly ash, GGBS, river & filling sand, GSB and aggregate procurement. "It was strenuous but with E&Y we aggressively followed our strategies and are confident to lock INR 51 Crores by March 2020 which will be a significant achievement," remarks Sumit, "but it is an on-going process so we cannot afford to rest on our laurels."


**"Tough targets require tough strategies and equally tough actions to achieve them and therefore we carefully evolved our strategy looking at major spend areas like earthwork, transportation, aggregate procurement and production that were already on stream."**

**Sumit Bardhan**
*Head – SCM, TI IC*

Close out of any project is a specialized activity that depends to a large extent on finishing items and the SCM set itself the task of enhancing the efficiency of project closeouts. “We therefore identified 16 finishing items that were required across all RREC projects but observed that the processes of RFQ, negotiations, approvals and agency selection were repeated over and over again,” shares Sumit. “To avoid this and reduce the time taken to finalize with agencies and/or suppliers, we decided to enter into rate contracts with shortlisted business partners that helped us lock rates for the project duration.” The items considered were MBCB, admixtures, PVC membranes, road markings, geo-composites, canopies, curing compounds, bus shelters, polysulfides, PGR, prefab structures, traffic signage, TMS, toll booths and such like. The results have been more than encouraging for the business with orders placed in advance at projects like Mumbai Nagpur Expressway, Mumbai Vadodara Expressway, Karodi Aurangabad Expressway, Veer Wadpale Bhogaon Khurd Road, Helwak Patan Karad Road, Dwarka Expressway and the Delhi International Airport.

## OPEX planning for better planning and execution

A pilot project is being implemented to achieve a superior rate of invoicing, keep costs under control and judiciously deploy fixed / variable resources by combining land map (obstruction management), engineering deliverables (engineering drawing management) and other related factors. “We identified 3 key areas – invoicing, planning and working capital,” reveals Manish Agarwal – Head Project Control RREC. Under ‘Invoicing’, the basis for analysis were one-on-one interactions, initial analysis of select projects, observations during visits and cross-functional discussions both at site and HQ. For planning, the criteria considered included one-on-one interactions, appreciation of execution processes and aligning P&M deployment, analysis of Schedule-H, prioritization of work and readiness of processes. First cut projections of Mumbai Nagpur Expressway formed the basis to analyse working capital.

The improvement opportunities for Manish Agarwal, and team are multi-fold. Under invoicing, there is greater focus on pre-construction activities like quarrying & crushing, burrow pits and land acquisition planning and to identify, prepare and prioritize invoice-able work unit packages. Work front availability is easier with better planning and stretch-wise planning considering LA mapping, economic stretches and prioritization of construction work. Rigour in village or stretch-specific execution and alignment of sub-cons with Schedule - H i.e. setting village specific targets have been achieved in the realm of working capital as seen in various expressway projects like Karodi Aurangabad, Dwarka, Mumbai-Vadodara and Mumbai Nagpur expressways.

*Infrastructure works for Bidkin Smart City*

**A pilot project is being implemented to achieve a superior rate of invoicing, keep costs under control and judiciously deploy fixed / variable resources by combining land map (obstruction management), engineering deliverables (engineering drawing management) and other related factors.**

Manish explains the 5 high-level initiatives RREC has adopted to put this elaborate plan into action. **Integrated project planning** involves stretch prioritization, synergized P&M mobilization, execution planning (including last level) and daily management. **Pre-construction activities** entail land acquisitions and utilities status mapping before NTP, speed up timelines for quarrying, crushing, pit set-ups while the aspects under **Sub-contract management** are sub-contract management in line with Schedule – H, prioritization and cash management. He is confident that these initiatives will fetch huge benefits because, “there is better clarity and consistency of last level activities across all administrative levels, greater predictability about progression of physical work, financial impact and associated challenges.” There are gains of reduced costs due to improved operational discipline, improved assessment and mitigation of project risks and projects are geared up for quicker and more successful closures. At the end of the day, these initiatives maximise utilization of the critical period between LOI and NTP, speed up decision making across levels, improve P&M utilization and low productivity levels of the workforce and reduce mismatch between resource and front readiness.

## On the high road to adopting cutting-edge technologies

“Several of our equipment are now equipped with sensors that help achieve enhanced levels of efficiency,” says Utkarsh Desai, Digital Officer, TI IC, “In fact, currently we are using 3D Grade Control Systems for motor graders and expanding the technology to excavators and pavers.” BIM is being implemented at Delhi International Airport, Bangalore International Airport, Mumbai Nagpur Expressway,

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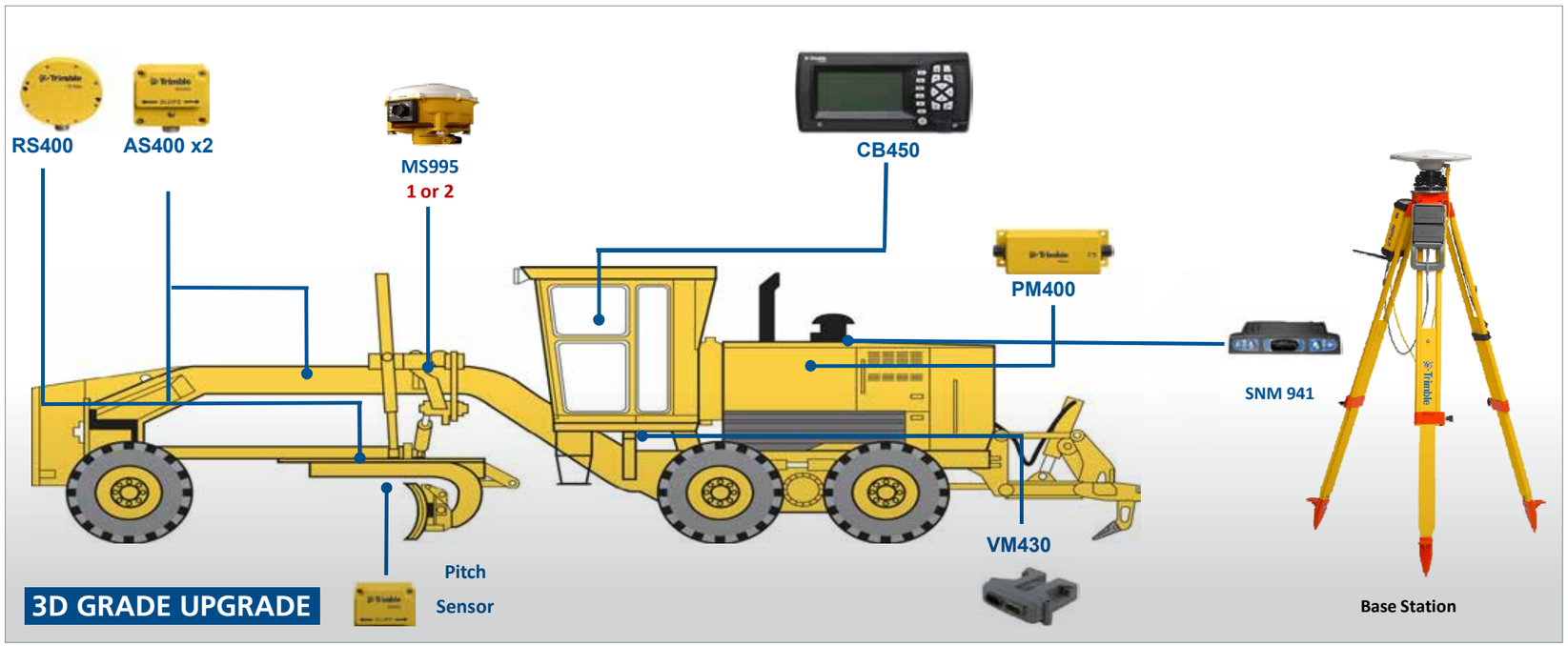
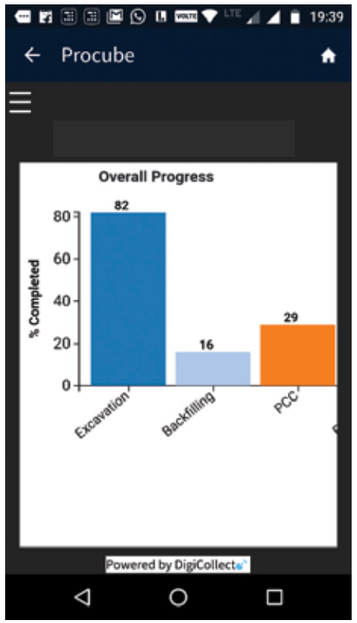



BIDKIN & Dholera Smart City Projects; Concrete Infilled Geocell System for lined drains at the Unnao-Lucknow Road project and Reclaimed Asphalt Layer introduced in road construction at the Kankatora Jharsugoda Road Project for the first time in India which is fast becoming a norm with other contractors.

Some of the digital initiatives include:

**TORQ** Tying Operations with Revenue & Quality integrates lab and on-field quality management, progress strip charts (from PROCUBE), creating and managing RFIs and link them to invoicing.

**EMTRACK** provides real time visibility of project progress, facilitates smooth return or transfer of material between projects/stores and helps reconcile


**"Several of our equipment are now equipped with sensors that help achieve enhanced levels of efficiency. In fact, currently we are using 3D Grade Control Systems for motor graders and expanding the technology to excavators and pavers."**

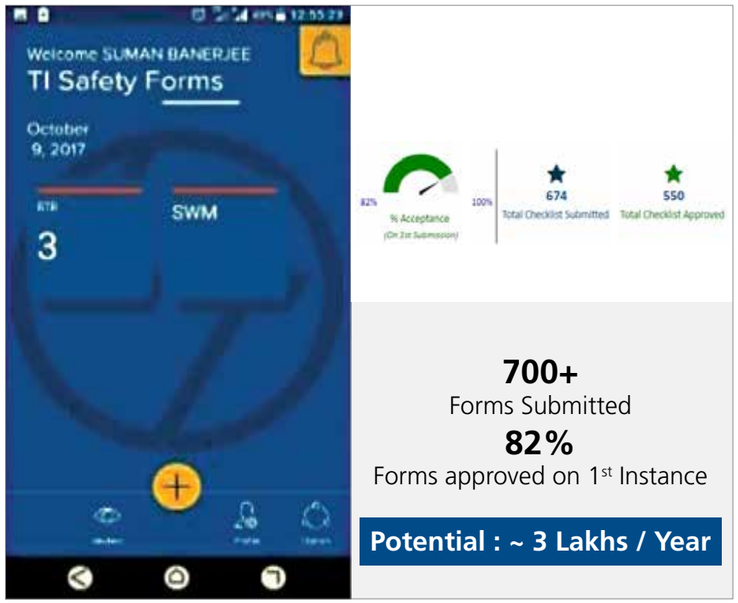
**Utkarsh Desai**
*Digital Officer, TI IC*

material issued to various sub-contractors and those being consumed against activities.

**Extracting greater value from motor graders:** Drawings are fed into the onboard computer that enables accurate GPS-aided positioning and automatic control of blades for accurate cut and fill.


**"Although the macroeconomic sentiment for Infrastructure remains sluggish with poor awarding and ambiguity of sources of funds, the underlying potential is huge. We have realigned the way we do business by improving the way we Plan, Design & Build to bring in significant improvement in our operations."**

**R K Bansal**
*Head – Roads & Runways*




**RtR Safety App:** Has been a boon to the RREC team that aids performance enhancements, triggers daily alerts to project, Cluster and SBG users, has ushered in all-new scoring parameters, allows for offline filling up of checklists and is replete with an updated mobile and web dashboard for the new scoring parameters.

"Although the macroeconomic sentiment for Infrastructure remains sluggish with poor awarding and ambiguity of sources of funds, the underlying potential is huge," opines R K Bansal (RKB), Head – Roads & Runways, "with the government planning major programmes like Bharatmala, Smart Cities and improved airport connectivity. We have realigned the way we do business by improving the way we Plan, Design & Build to bring in significant improvement in our operations. Today, we take up only large jobs above a certain threshold value making sure there is scale and we use our resources optimally in fewer projects to improve our top and bottom lines. We get our designs ready within 6 months from the date of NTP, we are already targeting for early completion of new projects and our dedicated preconstruction team works on all the utility shifting and hindrances to ensure that we sail through during the execution phase. We have a host of operational excellence initiatives to improve quarrying, machine & manpower productivity and diesel consumption."

In summation, RKB says, "we have taken a conscious effort to close all our old legacy projects by putting taskforces to quickly wind up jobs that are at finishing stage in all respects which will help the business to free valuable resources and utilize them in larger projects." ■

# THE MANY FACES OF OPERATIONAL EFFICIENCY AT B&F


LEADER SPEAK

**M V SATISH**
Whole Time Director & Senior Executive Vice President (Buildings, Minerals & Metals)

At B&F, we have driven operational efficiency through value engineering and adopting best practises to avoid rework, reduce repetitive work as well as cost for improved productivity. The advent and widespread adoption of precast engineering has brought with it several advantages including speedier execution, better standardization, reduced dependency on in-situ construction and better quality. The stadiums at both Al Rayyan and Motera are classic examples. Industrial prefabricated construction technology ensures 30-40% reduction in construction time and 10-15% reduction in cost apart from improving the workmen productivity in a factory environment by 40-50%.

A lot of our construction takes place at heights on high rises and to improve our efficiency at heights, we indigenously developed and implemented the Gallow ACS system, for the first time in the history of Indian construction, at the ICC Towers Project, Mumbai. This helped to optimise resource requirement and achieve a continuous cycle time of just 6 days. The use of travelling slab formwork for electrical trenching at Prestige Smart City, Bengaluru and aluminium slab formwork for the non-tower areas at Prestige Jindal City project, Bengaluru have both significantly reduced cycle time.

Digitalization has aided our journey to achieve operational efficiency. Our new P&M Central Monitoring Cell has facilitated the use of IoT for P&M strategic assets that drives P&M Life Cycle management by continuously tracking and analysing the data derived to improve overall P&M performance that has already accrued some handsome savings. Steps have also been initiated to reduce material wastages at site. While digital concrete requisition and engineer wise pour cards have reduced concrete wastage, a BBS automation tool to reduce and optimise offcuts have reduced rebar wastages.

Due importance has been given to improve workmen productivity at project sites. Continuous monitoring of the workmen biometry along with digital applications like WISA & Procube now track workmen availability at project locations and thereby improve their productivity.

Having said all that, operational efficiency is a continuous process and sky is the limit!

The unpredictability that is infrastructure projects was felt keenly by B&F's Al Rayyan project team when an adverse socio-political scenario forced them to alter operating procedures without the luxury of changing either the requirements or delivery schedules. "We had to immediately go into action-mode and literally push boundaries to quickly evolve alternate procurement strategies to source material from friendly countries that in many cases were new markets for us," shares Vijay Venkatesh, Head – Quality & EHS. "All our processes had to be remodelled to suit these fresh requirements and to ensure that our product specs were maintained. We introduced micro quality checks to achieve zero rejections and we succeeded!" His sense of triumph is obvious. Although this was a situation created by factors beyond their control, other B&F project teams across other geographies, are striving to improve productivity despite challenges to remain profitable.

## Precasting success

Like Al Rayyan, the Motera stadium, in Ahmedabad, that was recently in the news filled to the rafters for the 'Namaste Trump' event and already the world's largest cricket stadium, is another example of speedy execution using precast technology that has standardized delivery, enhanced quality, maintained aesthetics, improved safety and, in the process, achieved a high degree of operational efficiency.

*GY and HY precast columns erected at Motera Stadium*

The task of erecting the huge GY and HY columns with as many as 178 structural connections, was giving the Motera team sleepless days and nights with the added threat of a knock-on effect on the project's costs and delivery. Thinking out-of-the oval, as it were, Project Director, Subrata Dutta (SD) and his team evolved an engineering solution to erect these columns as single elements with special lifting arrangements. "Each of the HY columns was 36 m in height i.e. approximately as tall as a 12-storied building, 15 m wide, a metre in depth, weighing in excess of 250 tonnes," shares SD, "and these had to be first precast in steel moulds, then transported from the yard to site on self-propelled modular trailers with 3 sets of hydraulic axles, with a combined capacity of 400 MT." During transportation, turn table arrangements were used to negotiate sharp turns in Bolster mode. The team chose a main lifting point that was just 2 feet above the centre of gravity and the special lifting arrangement


VOICES FROM GROUND ZERO

**"We had to immediately go into action-mode and literally push boundaries to quickly evolve alternate procurement strategies to source material from friendly countries that in many cases were new markets for us. All our processes had to be remodelled to suit these fresh requirements and to ensure that our product specs were maintained. We introduced micro quality checks to achieve zero rejections and we succeeded!"**

**Vijay Venkatesh**
*Head – Quality & EHS, Al Rayyan Stadium*

included lifting clamps with a trunnion arrangement and a 'C' link. The expertise of N Srinivasan - Head Special Projects and his team was crucial in planning and executing the entire activity. "We were able to significantly reduce overall cycle time," smiles a satisfied SD through his trim goatee, "the GY column by 5 days that is about 42% and the HY column by 7 days or 38% and since we cast these huge columns in one piece we were saved the bother of several multiple tough lifts," he adds. There were more benefits that accrued to the team – reduced dependency on manpower, improved safe working conditions and a positive impact on cost, time and quality.

Elsewhere, 3 m wide and 2 m deep drains at the HST NATRAX project, drains, drain covers and manholes at both NATRAX and New Delhi's India International Convention & Expo Centre (IICC) project sites and bleachers for seating areas at IICC are all quickly and aesthetically taking shape thanks to precast technology.

**Precast wall panels for MEP shafts:** The usual practice is to construct a brick/block wall after installing the MEP services inside the shaft that usually take about 55 days in total for wall construction, curing, plastering, another round of curing, drying and painting. This does not allow plaster

*External wall robotic painting*

*Fly table erection*

*Rebar Reinforcement Cage*

VOICES FROM GROUND ZERO

**"We were able to significantly reduce overall cycle time of the GY column by 5 days that is about 42% and the HY column by 7 days or 38% and since we cast these huge columns in one piece we were saved the bother of several multiple tough lifts."**

**Subrata Dutta**
*Project Director*

and paint for the internal surface as there is no space to work. M Balasubramanian (Bala), Head – Quality, B&F shares that at the ITC Colombo site, the execution team used precast wall panels that were given a coat of paint prior to installation. "Once the MEP services were installed and the green signal was given for civil works, the team got cracking and completed the entire process in 12 days flat! If there is an example of improving operational efficiency, this is it!" says Bala with a thumbs up.

## Painting robotically

Efficiency in painting has risen several notches with the introduction of Robotic Painting, a revolutionary new painting technology as the S Vadivazhagan, Project Manager of Commerzone Raheja, in Chennai has found out to his delight. "Painting has suddenly become a far more controlled activity," he shares enthusiastically, "the robot precisely identifies the area to be painted, almost totally eliminates wastage and rework, and at the end of the day, our efficiency improves multi-fold."

## Digitally tracking aluminium formwork

Perhaps for the first time in L&T Construction, the CMPC Team of B&F's Residential Business Unit set out to find a digital solution to track aluminium formwork by eliminating human intervention as scheme preparation and data management were turning out to be far too time-consuming. The developed app helps to identify the usage pattern of panels thereby bringing in traceability and accountability at sites. It is now possible to record the physical stock available, the number of repetitions and the age of panels. The initiative is already 'live' across 17 project sites since August 2018.

## Improving efficiency at heights

As B&F's reputation of constructing high-rise towers grows and projects increase, project teams are constantly seeking construction methods to enhance productivity when working at heights. The Rebar Reinforcement Cage is one such that is helping their cause and a host of projects like DLF Crest, IKEA, DMIACC, CAPFIMS and Ford among others will vouch for it. "The advantages from rebar cages are manifold," shares Bala. "Enhanced construction sequence, improved manpower productivity, significantly reduced overall cycle time of achieving concrete works per floor and, most importantly, improved quality."

Reinforcement cages are prefabricated virtually like columns at site except that the stirrups are not tied at the lapping zone and since they are prefabricated, it reduces the need to issue separate material like straight bars, rings and stirrups onto the working platform that in turn reduces housekeeping headaches. "These cages provide an excellent guide system to accurately place concrete," says Santosh Kumar Shukla, Senior Construction Manager (QA/QC), DLF Crest project, "they are economical to use and have fewer labour requirements thereby positively impacting our project costs."

C Prasad, Head – Formwork Competence Cell, B&F IC shares about the innovative Gallow ACS system implemented perhaps for the first time in the history of Indian construction at the ICC Towers project in Mumbai. "The am was to optimise resource requirement and improve cycle time by creating a safe zone of working for the workmen at heights," he says and adds with a winning smile, "we have executed the project without a single incident." Prasad and team have also successfully worked at heights of up to 260 m with the Safety Screen system that was introduced to protect perimeters with an automatic climbing system that improved both labour productivity as workmen felt safe even at great heights.

## The efficiency of the Fly Table system

Project teams at BIAL and IKEA are singing praises of the simple but clever Fly Table system that has, according to Project Manager Jaydeep Sengupta, at the Ranchi Convention Centre project, helped us achieve a cycle time of 15 days from floor to floor of 5.5 m or above, has reduced our dependency on labour, reduced our rate of

VOICES FROM GROUND ZERO

**"Painting has suddenly become a far more controlled activity. The robot precisely identifies the area to be painted, almost totally eliminates wastage and rework, and at the end of the day, our efficiency improves multi-fold."**

**S Vadivazhagan**
*Project Manager of Commerzone Raheja*


**"The advantages from rebar cages are manifold. Enhanced construction sequence, improved manpower productivity, significantly reduced overall cycle time of achieving concrete works per floor and, most importantly, improved quality."**

**M Balasubramanian**
*Head – Quality, B&F*

shuttering and importantly increased our productivity from 2 sqm/md to a minimum of 8 sqm/md."

Prasad informs that the Large Area Table formwork system is used the world over for the flat slab format, "whereas in India we use the slab & beam combination in structural design, so we successfully modified the LAT system to suit our specific requirements and it has been hugely successful."

## Towards more efficient P&M Life Cycle management

J Raveendran (JR), Head – P&M, (CB&A), B&F IC has been busy setting up the P&M Central Monitoring Cell (CMC) to drive P&M Life Cycle management by, as he shares, "ensuring 100% digital implementation, continuously tracking data derived from IoT and analysing it to improve overall P&M performance. All the involved stakeholders connect every week to crunch the data to optimise performance and this initiative has already yielded us cost savings to the tune of INR 10 Crores by improving P&M productivity at sites, demobilizing hired equipment, reducing fuel and energy consumption." A satisfied JR adds, "during FY 19-20, the team has safely and successfully executed 1400+ critical activities."

## A bouquet of other initiatives driving productivity

**Speedier connect through mmGPS systems:** At the NATRAX project, mmGPS systems have increased the alignment between project site teams and the client across layers where previously the client had to check approximately 1,75,000 points. Now, through the mmGPS system, at least 5,000 points can be cross-checked by both the site team and the client in a single day that translates into huge saving of time and costs! Traditionally, this exercise would have taken at least five total stations and 5 auto level teams to complete revealing the efficiency of the system that has, at the same time, eliminated the possibility of human error during execution.

**Introducing efficiency to formwork material:** Formwork plays a key role at the IIT, Hyderabad project as most of the buildings have an Exposed Concrete Surface finish. After a detailed study, the project team identified the most optimal use of formwork material with maximum possible repetitions. Formwork movement was also effectively planned as per the building handing over dates. By using prefabricated or pre-erected scaffolds for columns, the team impressively saved on time, involved less labor, saved on costs and a Cup-lock system used for slabs proved faster and more productive than the conventional HD/flex systems.

*IKEA Retail Store Project, Mumbai*



*Government Medical College, Madhepur*


**"Fly Table System helped us achieve a cycle time of 15 days from floor to floor of 5.5 m or above, has reduced our dependency on labour, reduced our rate of shuttering and importantly increased our productivity from 2 sqm/md to a minimum of 8 sqm/md."**

**Jaydeep Sengupta**
*Project Manager - Ranchi Convention Centre*

**Reducing bulk material waste:** IIT Hyderabad was selected as a pilot project to implement Bulk Material Wastage (BMW) optimization by introducing the Real Cut 1D, a steel optimizer software, that automatically generates optimum cutting plans by ensuring the inventory of offcuts to be used and updating the inventory before running a fresh cutting plan. "As part of this initiative, a user form was shared along with the pour card that automatically calculates wastage according to the mode of concreting," shares Project Manager H.S.P. Shukla. The software gives the site engineer the option to choose the quantity against the theoretical quantity of his/her pour. "Although, the analysis is still manual, the reduction in wastage has been very significant," Shukla shares with a thumbs up.

**Use of Plywood Arrangement Scheme Drawings:** is an initiative by the Government Medical College & Hospital Project team in Madhepura, Bihar to use a plywood arrangement scheme drawing for the plywood used for slab shuttering. It involves placing the plywood as per the arrangement used in the previous slab to avoid cutting plywood pieces, increasing the repetition of plywood, reducing scrap and thereby saving plywood cost. This practice is recommended for all sites to dramatically reduce the cost of plywood.

**Use of shuttering oil sprayer:** Instead of the conventional method of applying shuttering oil on the plywood surface with a waste cloth or paint brush, the project team at the Government Medical College & Hospital project introduced a shuttering oil sprayer. The area of coverage has increased dramatically from around 8-10 SqM/litre to a whooping 40-45 SqM/Litre.

"Value engineering is nothing but analyzing your construction methods to find new, better and more efficient ways to build," shares M V Satish, Whole Time Director & Senior Executive Vice President (Buildings, Minerals & Metals) and Head B&F IC. "I am delighted that a number of teams have successfully introduced so many efficiency enhancing initiatives but there is still a long way and I urge all to continue this process, to keep thinking out of the box because ultimately all these will work best for our wonderful organization," he concludes with a positive air. ■

**"Value engineering is nothing but analyzing your construction methods to find new, better and more efficient ways to build. I am delighted that a number of teams have successfully introduced so many efficiency enhancing initiatives but there is still a long way and I urge all to continue this process, to keep thinking out of the box because ultimately all these will work best for our wonderful organization.**

**M V Satish**
*Whole Time Director & Senior Executive Vice President (Buildings, Minerals & Metals)*

# SOUTH ASIA'S LARGEST, 2000 MT SKY BRIDGE LIFTED TO 95M

## at ITC One Colombo Project

Colombo's Galle beach skyline was transformed on 15th December 2019, when a spectacular sky bridge 'Ahasa One' ('Sky' in Sinhalese), weighing 2000 MT, measuring 55 m longitudinally and 18 m transversely, was raised to a height of 95 m by L&T at the ITC One Project. The bridge features a restaurant and a jazz bar with two infinity pools on the top overlooking the Indian Ocean on one side and Beira Lake, on the other, and is the high point of Colombo's Galle beach face where the President of Sri Lanka hoists the National flag every year on Independence Day.

## Enabling constructability with value engineering

Tracing the making of this milestone, Kasiraja, General Manager, Special Projects & Construction Methods (SPCM), highlights, "Considering the span, the ITC Project and SPCM teams worked out a phased fabrication schedule starting from October 2018 at L&T's LTEW Workshop in Kancheepuram. The connection of the main spine, which was proposed as a welded connection, was converted to an 100% bolted one for easy assembly and dismantling during load test and final assembly at project site."
A modular production scheme was lined up to fabricate the steel elements considering the transportable size from Kanchipuram to Colombo and the assembly crane available at Sri Lanka.

"The fabrication involved critical welding of plates and sections up to a thickness of 150 mm in a restrained environment," shares P. Dinesh Kumar Head – LTEW- Kancheepuram Works. "We ensured that all the components including the splice plates were properly tagged during despatch for ease of erection at site." A total of 17,800 fasteners was used to connect about 1300 components. Top-notch fabrication at LTEW ensured seamless integration of the elements with the joints and quick assembly at project site, "as we couldn't afford the risk of even a minor misfit," adds Dinesh.


**"Considering the span, the ITC Project and SPCM teams worked out a phased fabrication schedule starting from October 2018 at L&T's LTEW Workshop in Kancheepuram. The connection of the main spine, which was proposed as a welded connection, was converted to an 100% bolted one for easy assembly and dismantling during load test and final assembly at project site."**

**Kasiraja**
*General Manager, Special Projects & Construction Methods (SPCM)*

## Guaranteeing the performance of the Skybridge

A load test of this magnitude and scale had never been attempted at L&T and with seemingly no other alternative, the challenge for Kasiraja and team were to try and accomplish the impossible. "An innovative load test method was developed by the SPCM team to support the 3000 MT bridge at two ends with the available loading facilities at Kancheepuram - two 50 MT gantry cranes, without any heavy lift cranes," he explains. "We opted for a secure ground level test in line with the overall requirement of 3000 MT to ascertain the amount of deflection without any lifting system." The load spread for 1500 MT on each supporting end was distributed by placing the available steel mats on top of the shop floor of the fabrication yard, which had a SBC of 20 MT per sqm. After a successful load test, the bridge elements were dismantled and transported to Colombo by ship with the maximum weight of a single element being 100 MT.

## Piecing together the elements

On site, the components of the skybridge were preassembled at ground level in an open space in front of the podium building, some 40 m from the final lift-off location. Effortless movement of the skybridge spine assembly was possible by deploying an indigenously developed skidding system taking advantage of a low coefficient of friction between the stainless steel and the Teflon-coated launch pads. Automated remote-controlled push pull jacks were used for this movement. On reaching the final lift-off position, the spine assembly was hooked-up to the strand jacks and subsequently, the skybridge attachments were loaded in five stages with the skybridge hanging from the strand jacks all the time. The strand jacks were supported by a temporary RCC deep wall between the 24$^{th}$ and 25$^{th}$ floors simulating the final structural support requirements between the 20$^{th}$ and 21$^{st}$ floors, that resulted in substantial savings in the cost of structural steel. A thorough survey was also conducted to decide the positioning of the jacks as the operating space for the jacks to raise the bridge between the towers on either side was only about 50 mm.


**"The fabrication involved critical welding of plates and sections up to a thickness of 150 mm in a restrained environment. We ensured that all the components including the splice plates were properly tagged during despatch for ease of erection at site."**

**P. Dinesh Kumar**
*Head - LTEW - Kancheepuram Works*




**"From the initial 750 MT, the weight of the sky bridge increased in phases, reaching its maximum load of 2000 MT with the addition of elements such as the concrete of three floors, facades, bearings, resting brackets ACP & BMU."**

**N. Srinivasan**
*VP & Head - P&M and SPCM*

## Raising the bar

Heavy lifts are always critical, exclaims N. Srinivasan, VP & Head -P&M and SPCM and when it is dynamic as in this case, it is all the more complex, "From the initial 750 MT, the weight of the sky bridge increased in phases, reaching its maximum load of 2000 MT with the addition of elements such as the concrete of three floors, facades, bearings, resting brackets ACP & BMU."

Sunday. 5.20 am. Even before the sun had risen, the lifting process commenced after a traditional pooja and reached its final position at 1:25 pm, smoothly and safely negotiating 95 m in approximately 8 hours. The fully dressed sky bridge module was lifted using 8 strand jacks, each with a capacity of 300 MT, mounted at the 25th floor level and operated in a synchronized manner. The whole process that was digitally controlled using a customized Smart Computer Control System, was carefully planned and executed as the sky bridge structure was not symmetrical and curved on all three axis, and precise alignment of strand jacks position was critical for the lift to succeed.

## A triumph of collaboration

"In every challenge, the team work among the various stake holders beyond their roles made all the difference. For the first time the client openly appreciated the efforts by LTSP," says Natarajan Namachivayam, Project Director.

Sri Lanka's entire engineering fraternity were present at the grand heavy lift event. The clients and consultants were unequivocal in their praise for L&T's innovative first-of-its-kind method that was the project's 5th critical milestone. There are two more remaining.
For team L&T, it was a triumph of collaboration, a feat executed entirely in-house, involving the B&F IC's project team, EDRC, L&T Engineering Works, Kanchipuram and L&T Special Projects & Construction Methods department of Divisional Corporate. ■


**"Team work among the various stake holders beyond their roles made all the difference. For the first time the client openly appreciated the efforts by LTSP."**

**Natarajan Namachivayam**
*Project Director*

# MASSIVE ROOF STRUCTURE ERECTED

## at Hyderabad International Airport Project

A massive roof trust spanning 70x77 m (equivalent to the size of a football ground) and weighing 450 t was erected at the Hyderabad International Airport through a strand jack system on 6th Jan 2020. Being a brown field project, this remarkable achievement was engineered by the Special Projects & Construction Methods Department of Divisional Corporate along with the HIAL project team.

The lifting system comprised ten 185 t strand jacks mounted on portals supported by Doka towers on one side and a permanent column on the other. The consumption of enabling steel was kept to the bare minimum and reusable for subsequent roof modules at HIAL.

The roof module was lifted above the 17 m tall column from the assembly level and skidded 1500 mm diagonally to reach the final installation position. Hollow hydraulic jacks with mac-alloy bars were used for horizontal skidding. ■

# INNOVATIONS THAT BRIDGE THE FUTURE

## Achieving operational efficiency at Heavy Civil

LEADER SPEAK

**S V DESAI**
Senior Vice President & Head Heavy Civil IC

If the Heavy Civil IC has been successfuly delivering mega projects to quality, safety and timelines, it has been largely thanks to our ability to provide 'tailor-made' solutions to suit the specific requirements of our customers which presupposes a clear understanding of customer requirements and expectations. Often, the challenges we face at our various sites are unique, without precedent that calls for quick appreciation of ground realities, understanding the true nature of the issue at hand and thinking on one's feet to evolve mitigation strategies. We, as a team, have been able to think out-of-the-box to overcome many of these challenges.

Be it massive concrete pour record of 16,722 cum in a single day at Medigadda Barrage project, or launching girders cycle time of 2 days per span at Riyadh metro, or record casting a 16 m tall RCC wall in a single pour using system formwork, or custom P&M solutions to meet stringent environmental requirements such as Rock Splitters and Hydraulic Auger cleaners at Mumbai Metro UGC-01 project, Innovation, has been one of the chief enablers to achieve these benchmarks that are on par with international norms.

In addition, our digitally 'connected sites' supported by various applications help us monitor the projects closely and ensure optimal use of 3M (Materials, Machine & Men) at every step of the progress enabling continuous improvement and setting productivity benchmarks.

Innovations can be big or small but our focus, as a team, will always remain to constantly seek ways to enhance productivity, improve cycle times, reduce execution time, cut costs that will, at the end of the day, translate into superior operational efficiency and more satisfied customers.

Perhaps, the most defining aspect of the Heavy Civil IC has been, as the name suggests, constructing projects of huge size and scale and as projects become bigger and more complex, the need for best practices and more efficient construction methods to enhance overall efficiencies and complete projects within stipulated timelines is greater.

## Introducing some chief enablers

Enabling structures are the lifeline of Heavy Civil projects, to build imposing and permanent structures that are interdependent, as their design and details govern that of permanent structures and vice versa. The construction methodology decided during the tender stage, can have major consequences if changed mid-way through the project. Right selection, effective planning, design and operation of enabling structures are imperatives for success.

**Launching Girders:** With pre-casting technologies dominating the construction industry, precast segment erection has formed the backbone of infrastructure projects that are more equipment intensive than labour driven. In this realm, the Launching Girder (LG) has assumed prime importance. Huge precast segments were erected in challenging projects like the Hyderabad Metro by purpose-made erection machines called '1st Gen LGs.' These 2-lane LGs are designed considering sharp curvatures in the alignment, capable of achieving a cycle time of 3 days per segment and a lifting capacity of 520 MT. Other types of LGs deployed at the Hyderabad Metro project included the underslung, the movable winch and the hinged LGs, all improvements on the 2-lane LG. Hinged LGs are preferred in the confined spaces of congested cities as these can be scaled to erect spans ranging from 19 m to 31 m with 128 m Radius of Curvature and a lifting capacity of 450 MT to achieve cycle times of 6 days per span. "The Movable Winch LG was developed to address the sharp curvatures of Hyderabad's roads," elaborates T Vijayakumar, Head – CPMC, Heavy Civil, "that were designed to erect spans of 31 m and 34 m with a Radii of Curvature of 128.1 m and 150.2m respectively with a rear segment feeding provision. The Hyderabad Metro project holds the record for the highest productivity in India in the erection of box girder superstructures (15 spans / LG month) as published in www.ice.org.uk," he mentions proudly,

*Hyderabad Metro Rail*

VOICES FROM GROUND ZERO

**"The Hyderabad Metro project holds the record for the highest productivity in India in the erection of box girder superstructures (15 spans / LG month) as published in www.ice.org.uk."**

**T Vijayakumar**
*Head – CPMC, Heavy Civil*

*Launching girders at Mandovi Bridge Project*

*Semi automated mould, Barapullah*

The capability and productivity of LGs were further enhanced in the construction of Goa's 3rd Mandovi Bridge with the design and development of the Twin Box Launching Gantry to leverage hydraulic power. Hydraulic circuit systems were developed and deployed to improve operations, such as the remote operated segment positioning system, semi-automated side shifting system, and the support shifting system with a lifting capacity of 1500 MT that helped achieve cycle times of 6-10 days per span compared to other launching girders and, as a competitor to international brands.

**Bridge Builders:** Segments weighing up to 65 MT can now be erected using winches for erection and hydraulic jacks for movement with the specially designed, semi-automatic Bridge Builders (BB) that have revolutionized ROB construction. 'Weighing about 120 MT, a pair of BBs can erect straight segments as well those with sharp curvatures of up to 128 m radius," explains TVK, "and with a lifting capacity of 60 MT, we can achieve a cycle time of 2 days per segment." First engineered for the Hyderabad Metro, BB set a world record for the fastest segmental span erection at Mandovi Bridge and an Indian record by constructing a 30 m span of the Malakpet ROB in just 25 days. BBs have accelerated the progress of special bridge projects as well like the 3rd Narmada Bridge, 3rd Mandovi Bridge, the Barapullah Extra Dosed Bridge, and the Durgam Cheruvu Bridge. "BBs have positively impacted productivity, cost, delivery, safety, quality and improved cycle times," vouches V R Saravanakumar, Project Manager, HMRL.

VOICES FROM GROUND ZERO



**"Our initiative to cast the full height of the wall from raft, top to bottom of the roof slab in a single pour with the L&T formwork system addressed the lack of skilled manpower and shortage of trade workers in carpentry."**

**Roy George**
*Head – Formwork, Heavy Civil*



**Form travellers:** Designed for cantilevered concrete girder construction at the Lucknow Metro project, each form traveller can cast 12 segments with an average cycle time of 12 days per segment against the industry norm of 16 days. "In fact, this special cantilever bridge holds the record for the fastest balanced cantilever construction in India," enthuses Sanjay Singh Gangwar, Project Manager, Lucknow Metro.

**Semi-Automated Short Line Moulds:** were used for the segment casting at the Barapullah Extradosed Bridge project. The hydraulically controlled operations in an automated mould set a record in the casting schedule achieving 3.5 days per segment to match international standards. "The compact, scalable, and versatile system suits all blisters, eliminating human intervention and hydraulics improves accuracy, quality of segment profile and finish," shares Shubendhu Bose, the Project Manager.

**Casting Gantry:** was designed to cast I-Girders on a large scale that reduced the total time required for casting I-Girders at the Ishwar Gupta Project from 836 man-hours to just 514 man-hours! "A moving frame to carry and guide the formwork during moulding and de-moulding operations was certainly a leap towards automation," says an excited Sandip De, Project Manager, Iswar Gupta Setu.

**Marine construction:** CMPC had the opportunity to prove their mettle in marine constructions by designing a 5-span, continuous (9.6 m per span) Temporary Modular Access (TAB) bridge at the Mumbai Trans Harbour Link Project, Package-1 suitable to march 150 MT capacity crawler cranes of 8 m width, floating batching plants, material barges, storage barges (aggregate, cement & reinforcement) etc., that has enabled round the clock operations.

## Larger pour, Lesser resources, Higher productivity

The KKNPP–HTS Phase II project achieved a milestone in the Construction Industry by casting a 16 m high RCC wall concreting in a single pour using a 16-meter tall Formwork System. Head – Formwork, Heavy Civil, Roy George explains, "Our initiative to cast the full height of the wall from raft, top to bottom of the roof slab in a single pour with the L&T formwork system addressed the lack of skilled manpower and shortage of trade workers in carpentry."

Shutter panels weighing about 3.5 MT were handled using heavy duty tower cranes to cover the work area of the pump house. Adopting the tremie method, concreting was planned to reach the bottom level with two intermediate platforms positioned at 5 & 10 m levels to carry out the concreting and vibration works. "Special mechanisms were designed and used to lift and tilt the shutter panels to either position them on the raft or move them safely from one place to other," explains Anup Kumar Anupam, DGM, Formwork – KKNPP HTS Phase II Project. Shutter panels were so designed that the alignment and erection required minimum manpower and less time with the shuttering crew engaged on both sides of the walls to continuously monitor and record the supports, tie rods and maintain verticality of the shutters during concreting. The mechanical crew were also vigilant to monitor the displacement of embedded parts during concreting. The initiative was appreciated by the client, NPCIL, who acknowledged it as a one-of-its-kind in their history.

*16-meter tall formwork system for Kudankulam Nuclear Power Plant*

## Vizag Vessels Project – a hot bed of innovations

While this naval project is veiled in secrecy due to obvious reasons, there are several interesting snippets that have emerged that reveal the agile, active, engineering minds working on this project.

**Mating the parts to make a whole:** In vessel construction, mating two mammoth sections involves huge labour, time and cost and is traditionally carried out by a trial and rectification method, entirely dependent on the skill sets of the workmen involved, resources available, accuracy of inspections at every stage, etc.

In addition, several repeated activities adversely impact manpower productivity and resources. Erstwhile, the process involved shifting the sections to site, aligning them on the saddle post, two sets of trials followed by green trimming and WEP of the sections before final set up. The attendant hazards were many: multiple erection and removal of scaffolds, working at heights, crane availability for repeated trials, movement of the CMM (Coordinate Measuring Machine) while taking profile readings, multiple movements of sections via trolleys amongst others.

"To reduce cycle time and increase productivity, we brainstormed and came up with a digital solution to introduce a FARO Laser Tracker," shares E Kranthi Kumar Reddy (Senior Engineer, Vizag Vessel IV), "that digitally captures profile readings, superimposes the readings after taking a common reference point, analyses the data to arrive at the green trim line and projects it onto both sections."

The result was better than the team anticipated: significant reduction in hazard levels, reduction of cycle time from 21 to 9 days (!) along with huge saving in time, cost and labour.

*Girder erection at Hyderabad Metro Rail Project*

**4D modelling using Synchro:** Manual project monitoring involves engineers forced to spend lots of their precious time to complete a host of non-value-adding activities which Raaj Kumar G (Senior Engineer, Vizag Vessel III) and team wanted to eliminate to improve productivity and quality of the project.

"The answer lay in introducing 4D Modelling using the Synchro BIM 360 software platform," he shares, "that drastically reduced manual work, saved time, made monitoring, tracking of the entire project life cycle, material tracking and reconciliation simple and easy!"

4D BIM includes project schedule, costing and with the data posted on cloud, it can be accessed by all concerned anytime, anywhere, that helps the team keep track of progress, closely monitor critical paths, detect clashes, manage payments, avoid rework, evaluate different scenarios, derive insights and compare & contrast alternative construction strategies. Certainly, a great asset for Raaj Kumar and team.

**Passing the hydro pressure and leak tests with flying colours:** M Arun Kumar (Engineer – Mech, Vizag Vessel) and team, in normal course conduct hydro pressure tests (1.5 times of working pressure) on more than 10,000 spools and leak tests (1.25 times of working pressure) on 25,000 spools of detachable joints. During the process, leaks occur invariably due to hoses and adaptors and the time spent to check, detect and rectify these leaks, a drain on the project. "In fact, our FTR (First Time Right) was below 60%," laments Arun Kumar, "primarily because of improper tightening, frequent opening and tightening of the hoses and lack of standard enabling items."

To address these issues, the team introduced a Quick Release Coupling that cut the time to make one connection from 5 minutes to just 15 seconds, reduced wear and tear, the chances of thread misalignment and eliminated failures in the Go/No Go gauge tests. "Our FTR has jumped to 92%!" rejoices Arun Kumar.

**Moving from 2D to 3D to improve productivity:** Laying cables in extremely confined spaces is one of the biggest challenges for teams working on vessels and Pritam Bose (Construction Manager, Vizag Vessel III) and team had only about 15,000 of them to lay maintaining stringent quality norms without interfering with other adjacent elements like pipes, internal structures, equipment, etc.

"It was a tedious process as we had to keep referring back time and again to the drawings and spec sheets to match them to the actual situation at site," he explains. "Chances of errors were high as every change conducted, big or small had to be captured."

By replacing all 2D auto cad drawings and spec sheets with a single 3D PDF, life has changed dramatically for Pritam. "It has improved our productivity, we enjoy better visualization, there is less rework, we are able to manage change better and, most importantly, it has improved our FTRC (First Time Right Clearance)," he grins happily.

VOICES FROM GROUND ZERO

**"With Electronic Document Management System, we can track activities real time starting with the procurement plan, updates of various procurement packages, identify bottlenecks, target dates, people responsible and the like."**

**Prasanta Gupta**
*Head – SCM, Heavy Civil IC*

## Towards operational efficiency in Supply Chain Management

Creating a SOP for SCM was a revolutionary first step taken by the team that captures all the systems, processes and digital initiatives being followed making it easy for even a novice to hit the board running. Big data and analytics are the new order and the introduction of 'Lattice', a module to manage data in the EDMS (Electronic Document Management System) has been a huge step in the right direction. "We can track activities real time," shares Prasanta Gupta, Head – SCM, Heavy Civil IC, "starting with the procurement plan, updates of various procurement packages, identify bottlenecks, target dates, people responsible and the like. Monthly activity progress keeps us abreast of savings over ACE/ JCR/ baseline costing, cycle time, vendor database, locators and cost sheets are readily available to refer saving us lots of time." 'Lattice' has made everything paperless including new vendor registrations, RFQs, offer documents, comparison statements, scrap declarations and e-auctions.

**"The Mumbai Metro project won the 1st Prize for Lean Implementation at the 'Lean Construction Training and Implementation Programme 2018' organized jointly by IIT-M, IIT-B and ILCE (Institute for Lean Construction Excellence) after 9 months of continuous evaluation."**

**Jayarama H**
*Project Director, MMRC UGC-07*

**Skill set mapping to specific categories:** Based on spend trends over the past 3 years, 63 major categories have been identified and mapped with the skill sets of team members to ensure that the right person is assigned the right procurement as category specialist.

**Creating healthy competition to improve performance:** The **PUGH Matrix** decision making tool is one such idea that is handy when several parameters are not at par and it has paid rich dividends for the organization in the use of TBM at the Bengaluru Metro project.

## Innovations at the front line

**Operational Efficiency through Lean techniques:** Lean Construction Methodology has sharpened day to day tracking, smoothened work planning, improved standards of house-keeping and reduced cycle time of activities for the Mumbai Metro UGC-07 project team. Value adding and non-value adding activities have been identified with efforts taken to eliminate non-value adding tasks. The lean tools implemented are the last planner system, work sampling, value stream mapping, 5S, BIM Big Room Meeting, WS, VSM and LBMS.

"The project won the 1st Prize for Lean Implementation at the 'Lean Construction Training and Implementation Programme 2018' organized jointly by IIT-M, IIT-B and ILCE (Institute for Lean Construction Excellence) after 9 months of continuous evaluation," shares a proud Jayarama H, Project Director, MMRC UGC-07. The award was won against tough competition among 8 sites

*Bridging the sea at the Mumbai Trans-Harbour Link project*



*Spider boom placer*

(3 from L&T Construction and 5 from other companies).

**P&M Innovations:** The P&M team of the MMRC UGC-01 project innovated a **'Spider Boom Placer,'** a smaller version of the boom placer with automatic boom extension and swinging operation. "When using conventional concrete pumps in concreting works, our main concern was the enormous amount of time taken and manpower required to fix pipeline works apart from the delay in clearing the concrete from the choked pipes," points out Avdhesh Kumar Mishra, P&M – MMRC UGC-01. "For a mere INR 4 lakhs, we developed the Spider Boom Placer that is smaller, more economical than other boom placers commercially available with OEMs that carry a tag of approximately INR 40 Lakhs plus."


*One of the underground tunnels for Mumbai Metro*

With the hard rock ground strata at UGC-01 impeding excavation productivity, the P&M team innovated two solutions to address the issue. **Rock Splitter:** that works on the hydraulic principle and depending on the rock strength, applies 60-100 MT load on the wedge which when inserted into the pre-drilled hole of suitable diameter, splits the rock which is then easily removed by excavators. **Rock Buster:** is a compact and user-friendly hydraulic device in which the drilled holes in rock are expanded and pushed outwards towards free face by applying 70-150 MT load directly on the rock surface.

"Since the size of projects we execute are so huge, the challenges we face are just as huge that call for innovative and out-of-the-box thinking at almost every step," says SVD. "In fact, our very survival depends on our ability to stay ahead of the curve and we are committed to do so," he sums up confidently. ■

# 4 HOURS TO BUILD A RAILWAY BRIDGE OVER FOUR 'LIVE' RAILWAY LINES

## A milestone for L&T; a 'first' for the Indian Railways

On a cold and foggy night in New Delhi on January 26th, when the country was still awake to welcome India's 71st Republic Day, two L&T teams, one from the WDFCC CTP 15 C project of Nuclear & Special Bridges BU, Heavy Civil IC led by Project Manager, M Kannan and the Special Projects & Construction Methods (SPCM) team, attached to Divisional Corporate were in the last stages of preparations to launch one of the two steel girders weighing 160 MT across a 48.5 m span over four 'live' lines on the busy New Delhi-Mathura sector, at Asoati in Palwal near Faridabad.

"Normally, we would have used the 'push launch' method for such an erection," points out V Kasiraja, General Manager, SPCM who was one of the prime movers of this operation. "We would have done it in stages with supports, a long-drawn process that would have taken at least a month, and when the work was in progress, the trains would have to move slowly which was not acceptable to the Indian Railways." That prompted the team to develop an innovative method to launch the long span girders from one end of the RFO using crawler cranes in tandem. "The bridges were handled below the centre of gravity since the cross girder of the bottom chord was stronger, the rigging gears were designed accordingly to ensure stability. For us it was a normal erection but for them," chuckles Kasiraja, "Rapid bridge construction."

## Preparing the ground for launch

Preparation is key to the success of such an operation. "Tougher than the actual erection was convincing the authorities at the Indian Railways that what we were suggesting was feasible because they had not seen anything like this before," shares Kasiraja. "In fact, our approval sheet carries 30 signatures of various railway officials!" To address their reservations, a mock lift was arranged and executed post which the teams were given the go ahead.

Their first task was to literally prepare the ground for the launch. With paddy fields adjoining the tracks where the super heavy-duty crawler cranes had to be positioned, the project team had to 'borrow' the land from the owners, prepare hard stands and lay steel mats on which the cranes were placed.

Although only two cranes were used for the erection, another 3 were on standby.

All the elements of the bridge were first assembled on the ground that comprised of two Open Web Structural Steel Girders of 48.5 m span with 7.0 m x 10.9 m cross sections weighing 160 MT each. After assembly, they were torqued, painted and then with the cranes and the super lift counterweights ready, the team waited for the go ahead from the railway authorities to commence operations.

## Get. Set. Push …

They received the green signal at 12.40 am and had a tight 4-hour window till 4.40 am to complete the erection. It was therefore all systems go.

The bridge was first lifted from the assembly bed with two 600 MT capacity Demag CC2800-1 cranes. While the rear crane marched the entire length of the bridge, the front crane marched only till the railway line barricading and since further movement was not possible, super lift counterweights of 250 MT were added to enhance the capacity before lowering and reaching the other end (radius of 40 m).

**"The complete launching activity was executed in a best-of-class manner that is chiefly attributable to the meticulous planning and coordination between DFCCIL, Indian Railways, PMC-2R and L&T.**

**Anurag Sachan**
*Managing Director, DFCCIL*

VOICES FROM GROUND ZERO

**"Tougher than the actual erection was convincing the authorities at the Indian Railways that what we were suggesting was feasible because they had not seen anything like this before. Our approval sheet carries 30 signatures of various railway officials!"**

**V Kasiraja**
*General Manager, SPCM*

VOICES FROM GROUND ZERO

**"Our method has now been adopted by the Indian Railways as a standard operating procedure for all such erections!."**

**M. Kannan**
*Project Manager*

The erection was successfully completed almost an hour before the cut off time to the delight of the railway officials in attendance, watching the entire exercise with bated breath, that included Mr. Anurag Sachan, Managing Director, DFCCIL, who was effusive in his praise of the operation in a letter to Mr. S N Subrahmanyan, CEO & Managing Director, L&T. "The complete launching activity was executed in a best-of-class manner that is chiefly attributable to the meticulous planning and coordination between DFCCIL, Indian Railways, PMC-2R and L&T," he wrote, further expressing his appreciation of the team's precautionary and emergency standby arrangements and for maintaining the highest levels of safety throughout the operation.

Having perfected the act, the teams launched the second girder on the night of January 28th with equal alacrity, efficiency and success. For Kasiraja and team, the success is even more satisfying because as Kannan remarks with pride, "our method has now been adopted by the Indian Railways as a standard operating procedure for all such erections!" ■

# RIYADH METRO – BUILDING VIADUCTS EFFICIENTLY!

6 lines, 176 kms long Riyadh Metro network is being built by some of the biggest names in the global construction industry. 41 km of Line 3 is being constructed by L&T as a major partner in the ArRiyadh New Mobility consortium. Running from west to east, 25.7 km of the line is elevated, with underground sections in the middle and the remaining portion at grade. The line features 20 stations, 2 iconic stations and 2 depots at either end.

**Shaping the Viaduct:** The viaduct has been designed to optimally accommodate a double track and a maintenance/emergency steel walkway on both sides that also carry the cables trays throughout the route. The structural arrangement is a 3 celled box girder with a sleek, aerodynamic fish belly bottom. For greater efficiency, the entire elevated portion is precast, executed as precast segmental decks with match-cast segments. The deck is supported over a single pier located over the central median for most of the stretches. There are over portals straddling the road when the alignment is away from the central median.

**Standardisation is key:** Though there are varying requirements for changing the superstructure, the profile is standardised to fit the basic fish belly shape to give a uniform band across the entire viaduct.

To accommodate road crossings of up to 50 m, 3-span continuous hyperstatic superstructures have been adopted with the same standard profile. A similar continuous superstructure arrangement is used to deal with sharp curvatures of up to 150 m and steep gradients of up to 5.5%. For larger road crossing spans (maximum is 95 m), the central cell depth alone is increased gradually from the centre to the supports, maintaining the end cell shape and the uniform band effect and constructed using balanced cantilever construction techniques.

**Station in the stride:** Completing the stations was a huge bottle neck in the construction of the elevated metro. At stations, in addition to the tracks, platforms need to be incorporated. Conventionally, the station spans are constructed either in-situ or with a different erection technique which interrupts the erection methodology of the viaducts. To overcome this delay, the team came up with a brilliant idea to integrate the viaduct with the platform and precast 17 m wide structures and erected them continuously thus taking station construction in their stride using the same launching girders.

**Enter the versatile Universal Launching Girder (ULG):** Considering the variety of the construction involved – typical, continuous and stations spans – and the tight schedule, the team decided to deploy 7 ULGs that were versatile enough to handle the different size of spans, dimensions and weights. To use the same launching gantry, continuous spans were carried out in two phases – first the mini cantilever portions near the central piers and then the infills and end spans. The station segments were different, 17 m in width (wider because of the innovative design), 3 m long and weighing up to 130 tons. As the station and continuous spans were designed with precast segments to be erected by the ULG, the erection of the viaduct and station spans / continuous spans could continue uninterrupted without dismantling and re-erecting the ULG near stations.

*Riyadh Metro Tunnel*

## Challenges & solutions

There were challenges for superstructure erection pertaining to terrain, alignment and traffic diversions but these were pre-empted and considered when finalizing the specifications for the ULG with respect to loads and the design.

| Vital statistics of the ULG | |
|---|---|
| Max. Span | - 37 m span |
| Max. Span load | - 600 Ton |
| Max. Longitudinal Slope | - 6 % |
| Min. Horizontal Radius | - 150 m |
| Max. Winch Capacity | - 145 Ton |
| Average cycle time | - 2 days |
| Best cycle time | - 24 hours |


*Launching Girder*

VOICES FROM GROUND ZERO

**"Meticulous planning, precise detailing of construction stages and design enabling structures helped us to deliver. There were about 58 stages (584 steps) required to complete this complex erection activity and each stage was analysed, and detailed drawings prepared."**

**K. Senthilnathan**
*Design Head*



VOICES FROM GROUND ZERO

**"Literally, thinking on our feet, we devised a new plan to advance the construction of superstructure as a tie element by integrating the inclined pier to provide a robust structural connection by introducing a closed frame action. The LG was moved over the station in 3 days and we achieved it with detailed construction method planning, immense design support and perfect logistic coordination between the 5 stakeholders involved."**

**G. Vinod**
*Head Elevated Section*

**Speeding across an expressway:** The ULG successfully launched a particularly challenging span with a sharp curvature of 150 m radius and a high gradient of 5.6% over the Jeddah Road, one of the busiest expressways, with only a small window of time open for erection. Not once but twice across the expressway to accommodate a station across the other side of expressway.

"Meticulous planning, precise detailing of construction stages and design enabling structures helped us to deliver," explains Design Head, K. Senthilnathan (KSN). "There were about 58 stages (584 steps) required to complete this complex erection activity and each stage was analysed, and detailed drawings prepared. Our team from the technical office monitored the stages at site to ensure that the erection was safely carried out across the expressway with heavy traffic running all the while below."

For G. Vinod, Head Elevated Section, this was the first major challenge to prove the efficacy of the launching girders of handling erection over a live expressway within a very restricted four hour window per night. "We had to move the elements and lift them," he shares enthusiastically, "but this is a major milestone receiving continuous accolades from both client and consultants."

**Straddling the hurdle:** MVS Rao, Viaduct Head, recalls that a huge challenge for his team was to lift the ULG above the architectural piers supporting the sprawling iconic landmark station. KSN points out, "Designing these piers to support the launching girder was both costly and risky as the height of the piers from the station basement is approximately 20 m plus there were the sharp 150 m curvatures of the approach spans to consider that required special tie-downs." Since the station platform was not being erected by a launching girder, the original plan was to dismantle and re-erect the LG at location that would interrupt work on the station. "Literally, thinking on our feet, we devised a new plan to advance the construction of superstructure as a tie element by integrating the inclined pier to provide a robust structural connection by introducing a closed frame action," recounts G Vinod. The entire system was conceptualized and devised in-house by the technical department and the detailed design verification was carried out by the design consultant, without any major modification to the available design and in very quick time. "Finally, the LG was moved over the station in 3 days," says an extremely satisfied G. Vinod, "and we achieved it with detailed construction method planning, immense design support and perfect logistic coordination between the 5 stakeholders involved."

**Client appreciation for Line-3 Viaduct is a testimony of our team efforts, and credit goes to the entire team for their efforts to leave a legacy viaduct structure in Riyadh and build L&T's brand image in the Kingdom of Saudi Arabia.**

**T. Srinivasan**
*Head Riyadh Metro*

"Client appreciation for Line-3 Viaduct is a testimony of our team efforts," T. Srinivasan, Head Riyadh Metro summarises, "and credit goes to the entire team for their efforts to leave a legacy viaduct structure in Riyadh and build L&T's brand image in the Kingdom of Saudi Arabia." ■

# SCALING NEW LEVELS OF EFFICIENCY

## Charting OPEX processes across WET IC

LEADER SPEAK

**S. RAJAVEL**
Senior, Vice President & Head, Water, Smart World & Communication

At WET, we have a two-pronged approach to operational efficiency with the initial focus to maximise project delivery and the other being seamless O&M management, pivotal for most water infrastructure projects. Over the years, we have consolidated and enhanced these two approaches with resounding success.

Today, our OPEX initiatives are giving us a head start in all projects. Survey is no longer a time-consuming activity as a range of digital and geospatial tools help to firm up alignments even as the scale of our jobs is becoming larger and more complex. With sustainable water management becoming the need of the hour, it's imperative that we prep up execution with the right kind of technology through smart engineering initiatives like micro tunnelling and Dusk to Dawn (D2D) construction that are now our signatures of excellence across the industry.

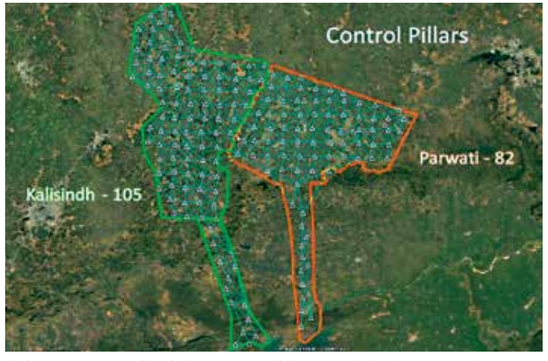
Taking a cue from BIM, we have established a dedicated BIM hub, 'PratiBIMb', equipped with advanced clash analysis software for virtual construction that has significantly improved productivity with better cost control and precision. Digital tools like e-Pragati and PEARL are redefining the way we review projects to keep projects on track with a 360-degree forward vision. With a computerized maintenance management system, we now have the advantage of predictive maintenance with in-depth information to streamline and automate processes that are benefiting the industry at large.

In all our excellence initiatives, people have been our prime movers and our larger vision is to nurture an innovative culture with employees as process owners in our quest towards outgrowing our potential.

LEADER SPEAK

**K. ASOK KUMAR**
Executive Vice President & Head Water & Effluent Treatment

Water & Effluent Treatment (WET) IC has been in the thick of the action, engineering a slew of world-class infrastructure projects for water and wastewater treatment across India and in select overseas geographies. The good work has enabled us to record a CAGR of more than 25% in the last 5 years, and most remarkable about this achievement is that our success has been largely attributable to our continuous focus on and commitment towards OPEX initiatives.




*Helicopter-mounted Light Detection and Ranging (LiDAR) survey at Parwati and Kalisindh micro lift irrigation projects*

In today's water starved world, the future hinges on sustainability. In fact, all that glitters is not only gold but every drop of water. Though countries like Singapore are far advanced in the realm of water sustainability, India has been making rapid strides by building new-age water infrastructure and implementing sustainable technologies to meet the government's promise to deliver piped water to all rural homes by 2024.

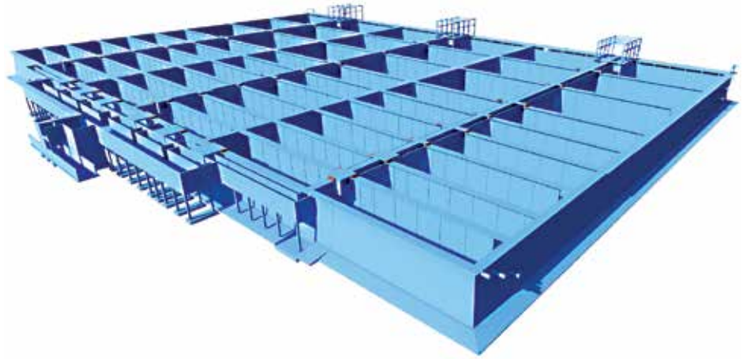
"Water & Effluent Treatment (WET) IC has been in the thick of the action, engineering a slew of world-class infrastructure projects for water and wastewater treatment across India and in select overseas geographies. The good work has enabled us to record a CAGR of more than 25% in the last 5 years," shares K. Asok Kumar (KAK), Executive Vice President & Head Water & Effluent Treatment, "and most remarkable about this achievement is that our success has been largely attributable to our continuous focus on and commitment towards OPEX initiatives."

## Giving wings to survey

As the scale of projects become larger, the need to add value to project execution has assumed greater importance with innovative execution methods to accomplish both initial and long-term milestones "To a large extent, we have succeeded in eliminating elaborate manual processes that had extremely long lead times," shares G.Balasubramanian, Head Corporate Center, "and likewise enhance productivity and monitor progress, all thanks to several in-house developed digital applications. With much of our work happening below ground, it is always a challenge to make headway as there are no records available of the existing underground utilities.

Geospatial technologies have literally given us an x-ray vision to see what lies beneath the surface before we start work as was done in the case of the integrated sewer and water distribution system in Pali, Rajasthan, where GNSSbased surveys helped us immensely.""

After the success at Pali, geospatial technologies have been generously deployed across WET projects, to fast track execution. More innovation has driven digital surveys even further at the Parwati and Kalisindh Micro Lift Irrigation Schemes where an area of more than 4,500 sq. km was surveyed within two months against the normal time of 8 months using helicopter-mounted Light Detection and Ranging (LiDAR) technology. The precise levels of the survey provide scope for digital terrain and surface modelling, design of various structures and pipeline routes, finalisation of locations of important structures, right of way and the number of trees to cut to clear forests. Close to 8000 t of steel scope was avoided by optimizing the route.



*Design customization of the bioreactor at the Coronation Pillar Project*

VOICES FROM GROUND ZERO

> **"To a large extent, we have succeeded in eliminating elaborate manual processes that had extremely long lead times."**
>
> **G. Balasubramanian**
> *Head Corporate Center, WET IC*

## BIM resolves project clashes

The entry of Building Information Modelling (BIM) has made life easier for engineers with prompt clash detection, analysis and resolution. With BIM, the geometric interference of elements can be immediately identified and resolved at the mere click of a button. A dedicated BIM hub, 'PratiBIMb', is equipped with advanced clash analyses software for virtual construction that improves productivity with better cost control, quantifies accurately, dynamically uploads construction documents and enables WEB-ex training. "We have resolved over 15000 clashes, reduced 4000 manhours and made substantial savings in cost," says Arun Venkatesh, Head BIM, WET IC.

A standout feature of BIM is its capability to change project scenarios as was the case at the Coronation Pillar site. "We addressed a last-minute client requirement to scale up the size of the bioreactor after most of the surrounding infrastructure was completed by proposing feasible options in a couple of days that would have normally taken two months to develop," adds Arun.

VOICES FROM GROUND ZERO

> **"We have resolved over 15000 clashes, reduced 4000 manhours and made substantial savings in cost."**
>
> **Arun Venkatesh**
> *Head BIM, WET IC*

## Design automation

The construction of storage tanks and elevated reservoirs though largely repetitive yet important calls for a lot of detailing. An OPEX initiative has automated the design for such work through visual basis/google earth and autolisp applications along with parametric modelling through BIM based on multiple parameters that have improved efficiency and saved costs by a whopping 33% and 30% respectively, the latter thanks to GA drawing preparation instead of manual drafting.

## It pays more to work at night

A novel scheme developed by the Wastewater BU, the 'Dusk to Dawn' concept is a first-of-its-kind in the construction industry according to which a specific portion of the alignment is earmarked for sewer network construction after the evening peak hours to be completed by dawn. V Dakshinamurthy, In-charge Operations Support, shares how he and his team started with a 100 m stretch at Jhunjhunu in Rajasthan. "It is a unique service as various digital and process improvement techniques are amalgamated including a remotely operated time lapse camera for real time monitoring and laser level monitoring with a Geo-tag enabled GIS App." He recounts how they took up a busy section of the road on 3rd October 2019 to try out the initiative for the first time. "We started the initiative at 8 pm and despite challenges, like a sudden rain that lashed for over 90 minutes and undocumented buried utilities in our way, we still completed the task on time i.e., by 8 am, the next day, thanks to our preparedness."

Having tasted success, the initiative then took flight and has been implemented across 10 wastewater projects and "and with every succeeding project, our insights have got deeper," adds Dakshinamurthy. "Eventually, we should be able to stretch pipelines up to 200 m." The plaudits from customers and the public have been overwhelming proving without doubt the runaway success of dusk-to-dawn construction.

VOICES FROM GROUND ZERO

> **"We opted for micro-tunnelling technology, deploying three types of micro tunnelling machines depending on the size of the pipes and terrain."**
>
> **K. Hariharan**
> *Cluster Head, WET IC*



*Winch and trolley system for shifting and laying MS pipes at Alirajpur MLIS Project*

## Tunnelling made more efficient

A landmark project is being executed by the Wastewater BU at Cuttack that will be certainly the largest sewer network construction in India and therefore, unsurprisingly, extremely challenging. A feasibility study of the predominately high-water table revealed that conventional trenching was possible only in certain portions. "After deep analysis, we opted for micro-tunnelling technology," informs K. Hariharan, Cluster Head, "deploying three types of micro tunnelling machines depending on the size of the pipes and terrain. For smaller dia pipes, a compact pit launcher was installed in a manhole or a launch cradle to link the works." For slightly larger pipes, a pilot tube machine was deployed, the pipes precisely aligned with a monitor installed inside the shaft with a theodolite. For larger cross overs, the Akkerman slurry type machine was pressed into service. "Thanks to micro tunnelling, we have successfully fast-tracked execution, project management has been quicker and easier, and efficiencies have improved immeasurably." Hariharan is a mighty pleased man.

A winch and trolley system devised by the project team at Alirajpur MLIS to shift and lay MS pipes across hills has fast-tracked execution and ensured safety. The combined casting of conical frames and integrating the SFRC frame portion within the precast segment across 110 villages saved close to 17,000 man-days for the Bommanhalli Wastewater project team, again speeding up execution and maintaining safety standards. Allu Screener is a new age machine for backfilling that is being extensively deployed especially by the Surya WSS project team, who are enjoying the benefits of completing backfilling of large trenches in double quick time.

## GIS progress monitoring

A GIS progress monitoring system, implemented to lay pipes and keep track of the pipeline network, picks up visual images of the alignment with differentiated colour coding that keeps the client abreast of progress. Gaps are highlighted and ROU availability linked with the activities.

## Thirsting for success

The entire IC was keen to succeed at the Jebel Ali STP project, the IC's largest international project and hence it merited a tailor-made OPEX plan that combined a slew of initiatives such as the 5S method for productivity, last planer system for critical works, make-ready meetings, bar coding systems and a computerized maintenance management system. "We zoned the entire project into 7 control areas by breaking down the construction activities to align each activity with individual targets that were monitored daily through the Time Quality Report (TQR)," shares Project Director, Syed Abdul Noor. To construct complex structures like the anaerobic digesters, an automatic climbing scaffolding system with three hanging platforms for the different layers of work was deployed. While the topmost platform catered to the reinforcement work, the middle focussed on continuous concreting and the bottom bench on finishing. "This way, we achieved phase wise finishing by putting close to 150 workmen per shift and completing the entire activity in just about 5 days with utmost safety." Process innovation was required for the 3-level tertiary filter beds too. "It was extremely risky at the lower levels because of the confined space," Noor points out, "so we used a thermocol block as a dead bed for the base slab to align the sequence of works as per the schedule."

## e-Pragati keeps projects on track

As the quantum of their jobs leapt, the onus to plan, schedule, control and track projects increased and the answer was an in-house developed, web-based, project management platform - 'ePragati' – for efficient project progress monitoring. It typically follows a quantity-based scheduling to facilitate effective planning of works for extensive linear jobs spread across huge areas of 3000 sq. m, at an average.

The project engineer must feed in daily progress in terms of quantity of work executed and manpower employed. e-Pragati juxtaposes the actual progress vis-à-vis plan to highlight variance (viz. lead or lag) based on which, it triggers an alert in case of lag to the appropriate hierarchy in the management to initiate necessary action to bring projects back on track.

With progress and manpower consumption data recorded on a daily basis, the leads generated are helpful to perform big data analytics to ascertain productivity norms for major execution activities; projects can also be monitored on a regular basis to tap the unlockable potential for productivity improvement.

e-Pragati captures a project at its lowest level thus enabling monitoring of project progress with respect to its financials, as each level of work is mapped with its corresponding unit cost. It is integrated with several modules of the Enterprise Resource Portal to measure works, generate subcontractor bills and calculate the budget on completion.

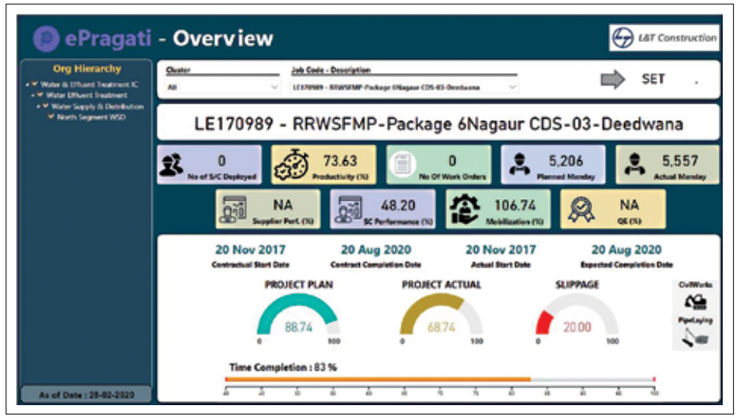
## Using a PEARL of wisdom

Productivity Excellence, Analysis & Realization League (PEARL) is a gamification platform with weighted average scores (60% to productivity and 40% to baseline improvement) assigned to each project site. The present productivity data (weighted by mandays) is compared with its historic productivity data and any improvement in productivity fetches points for baseline improvement. Piloted across 7 projects, the initiative created substantial cost savings from workforce productivity enhancement within 13 weeks that prompted PEARL to be rolled out across projects under different leader boards where each league houses projects based on similar scope of work. On the safety front, Apps such as 'SWADESH' and 'ViewEHS' have brought in unprecedented transparency in overall site EHS assessment," shares K.S. Sudeesh Kumar, Head, EHS. "We have already submitted 6,23,656 forms, 1,47, 892 SECs involving 3478 users and considerably brought down the severity frequency."

VOICES FROM GROUND ZERO

**"We have enhanced productivity with less manpower, possess the know-how of predictive maintenance for quick breakdown resolutions while effectively scheduling tasks for 100% achievement of contractual parameters."**

**Rajmohan**
*Head O&M*




## Computerized Maintenance Management System

WET IC constructs defining water infrastructure and are now being increasingly called to operate and maintain structures that led to the setting up of the O&M Department in FY 17 to provide scientific management of the various water and wastewater assets. However, achieving contractual parameters in terms of quality, quantity and safety was a challenge due to the absence of an integrated maintenance management system. To effectively bridge strategic management and operational layers, an in-house Computerized Maintenance Management System (CMMS) was developed that translates goals into operational metrics while automating the hitherto fragmented maintenance information for better information processing and actionable insights. More than 35 projects are presently being monitored through CMMS giving WET IC a sustainable competitive edge.

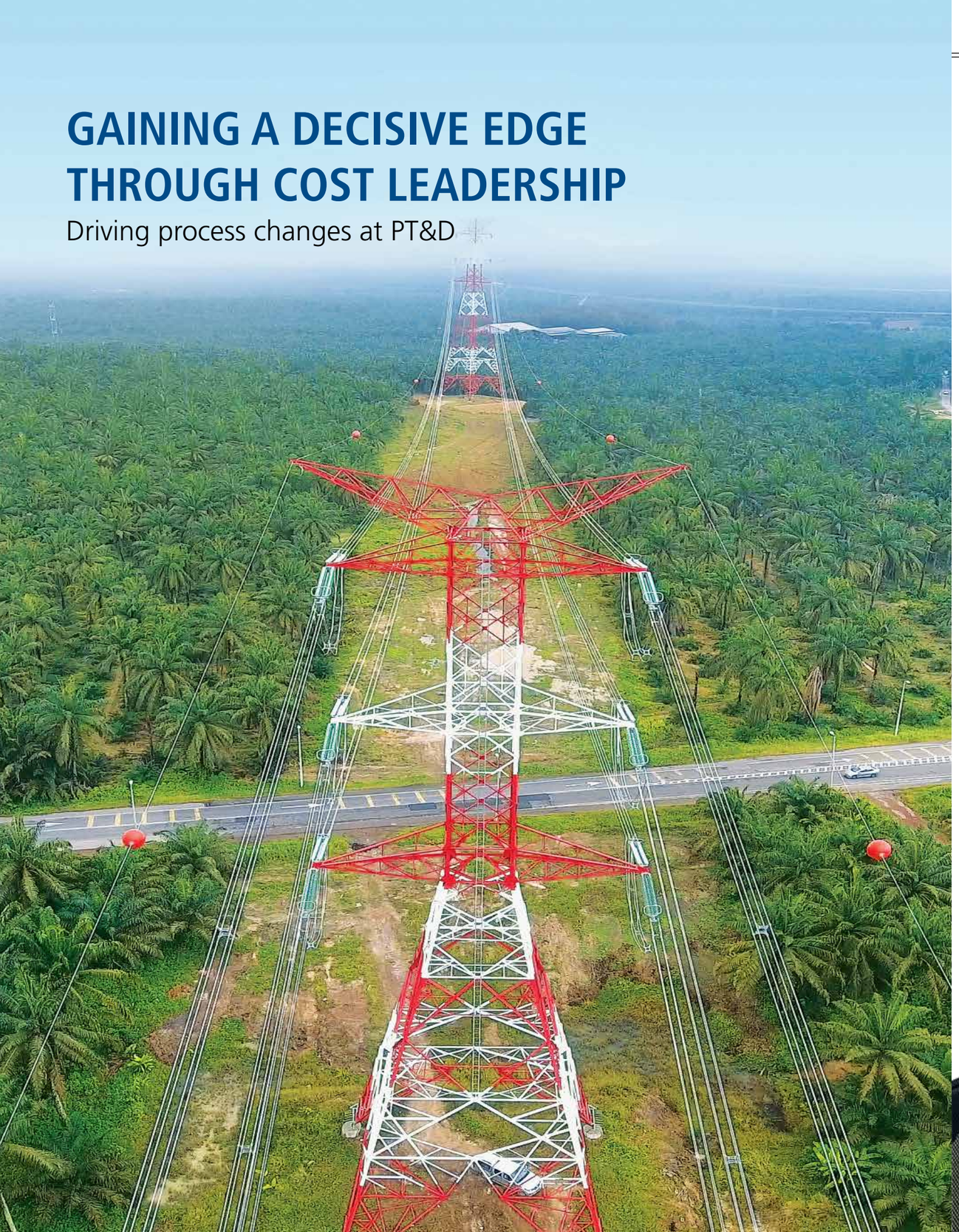
Rajmohan, Head O&M explains its advantages, "Our earlier practice for pump over hauling was based on elapsed time but condition monitoring has helped us analyse the critical parameters and pump performance thereby postponing the overhaul has resulted in substantial cost savings. Elsewhere, a timely alert on the higher vibration of a motor avoided a costly breakdown. Today, we have enhanced productivity with less manpower, possess the know-how of predictive maintenance for quick breakdown resolutions while effectively scheduling tasks for 100% achievement of contractual parameters."

## People are our excellence movers

"All our processes and improvements are driven by our people," asserts SRV, "and with more than 5000+ plus employees engaged across various phases of OPEX, the idea is to nurture an open and innovative culture across levels that is already reaping us rich rewards and is sure to stand us in excellent stead as we explore new horizons and take up challenging projects." ■

# GAINING A DECISIVE EDGE THROUGH COST LEADERSHIP

## Driving process changes at PT&D



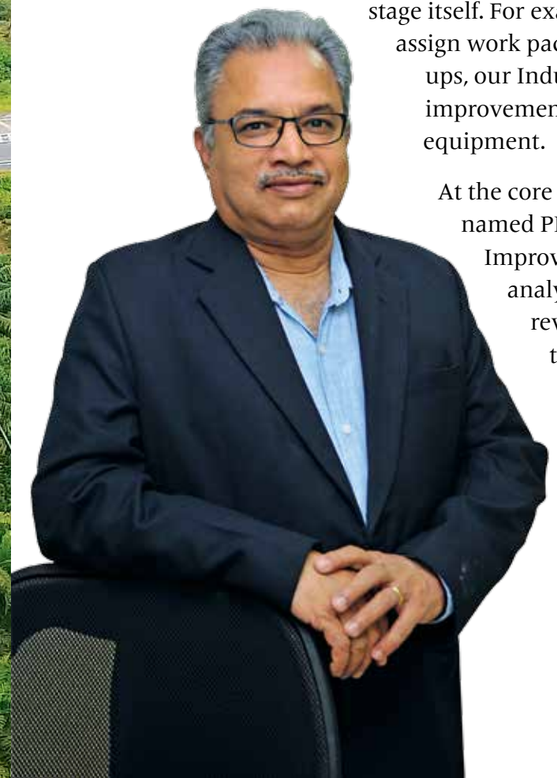
LEADER SPEAK

**T. MADHAVA DAS**
Senior Vice President & Head, PT&D IC

At a recent meeting with a developer, their CEO shared a critical piece of their interesting strategy that they endeavour to discover the lowest possible cost for all their inputs, irrespective of market pricing, by working out specific, best-fit, technically optimized solutions every time. Such a strategy has given them a success rate of two out of three tenders. Being an EPC contractor, we can truly add value to our customers not only by demanding lowest possible cost for our own inputs with our partners and giving technically optimized solutions but also by excelling in our operations.

Our predictive abilities make our plans robust that gives us an edge to manage risks better and achieve speed and scale. Thanks to our vast experience and spread, we are blessed with a huge amount of data and knowledge. We, at PT&D IC, are on a journey through a specific OPEX initiative to orchestrate the data captured by digital means and articulate organizational wisdom in a replicable manner.

We have reaped the benefits of modularization improvised to suit our own business needs, for instance, in the kitting of tower components or remote electrification items.



In our projects, the elimination of inefficiency starts early at the planning stage itself. For example, in the way we sequence our project tasks and assign work packages for our subcontractors. At our manufacturing set ups, our Industry 4.0 journey has gained momentum with marked improvement in the Overall Equipment Efficiency (OEE) of our equipment.

At the core of such initiatives is the centralized facilitator set up named PRAPTI – Planning, Reviewing and Assisting Projects to Improve – that equips the site team with the requisite tools and analytics to improve productivity. Productivity improvement reveals itself in project duration, like in the reduction of the number of days for our civil works to achieve clean room access in GIS projects. Be aware that timely completion is a panacea this will ultimately reflect in our profitability.

Finally, process simplification needs no emphasis. As Tiger Woods put it, “There is always stuff to work on. You’re never there.”

By getting better each day, we ensure a greater tomorrow for all of us!

For a business that operates across multiple geographies and in some of the harshest terrains, the Power Transmission & Distribution (PT&D) IC has always banked on robust processes to achieve excellence across its operations both at sites and production centres. In recent years, the IC has successfully executed mega power transmission and distribution projects within stringent timelines thanks largely to its Operational Excellence (OPEX) initiatives.

"We have driven OPEX with the primary focus on Cost Leadership across all operations," declares T. Madhava Das (TMD), Senior Vice President & Head, PT&D IC. "Our success factor is attributable to the total commitment of our senior management to continuously drive the change process, to evolve solutions best suited to cross-country/geographically widespread projects where execution is always a challenge and to monitor remote locations where accessibility is an issue."

## In sync with LAKSHYA goals

Aligned to the business goals and LAKSHYA 2021 plans, the OPEX initiatives are focused on Productivity Improvement, Cost Optimization and Process Time Reduction to gain a competitive advantage in the industry, reveals TMD, "to achieve which, we introduced various initiatives at the functional level driven directly by the BU heads through specific OPEX coordinators and Cluster Operating heads to effectively implement across factories and sites. Each OPEX initiative is driven by an OPEX Champion, supported by a small team working in close coordination with the OPEX team at L&T Powai to monitor, review and provide the necessary push to speed up implementation.

> **We have driven OPEX with the primary focus on Cost Leadership across all operations, focused on Productivity Improvement, Cost Optimization and Process Time Reduction to gain a competitive advantage in the industry.**
>
> **T. Madhava Das**
> *Senior Vice President & Head, PT&D IC*

Subsequently, as the initiatives have gained momentum, we have institutionalized them across functional levels as Standard Operating Procedures."

*765 kV GIS at Varanasi*

## Realtime monitoring through PRAPTI


Time has always been critical for any infrastructure construction contract. However, understanding delays, determining critical tasks and forecasting completion dates have always been challenging, even more so considering the span and tough terrains of PT&D projects.

The need of the hour was a platform with the right insights to mitigate time variations and cost claims. A 4-member task force team worked with a stringent timeline of one year to develop and implement a first-of-its-kind digital tool in the construction industry for Planning, Reviewing and Assisting Projects to Improve. "Called 'PRAPTI', we developed this digital intervention," shares Jerome Johnson, one of the digital champions, "to integrate a real time decision support system that uses a detailed integrated plan, by involving all the disciplines (Engineering, Procurement & Construction) in a single schedule to subsequently, with the help of analytics models, indicate the department or discipline that is delaying a project."

"PRAPTI is extremely useful during the closing stages of a project too," adds Jerome, "when we are dealing with variation claims as delays not attributable to the contractor can be highlighted and made eligible for scope variation with the client or get additional Extension of Time (EoT) and thereby avoid legal problems."

The team of Siva Sankaran, Vijay and Sumit briefs the editorial team on a gamut of information and about the physical progress of a transmission line project in Malaysia on an applications dashboard. Thanks to the inbuilt virtual workspace feature, an impromptu meeting is called with the stakeholders of the site team. Impressed by the insight, we quiz them about the software dynamics and are briefed that project management solutions such as EIP Execution Plan, Primavera P6, Nadhi (ALIGN), Building Information Modelling (BIM) and Geospatial technologies have been integrated into PRAPTI.

A Central Planning Cell (CPC) streamlines the plan of the respective stakeholders and establishes a consolidated base to schedule resource allocation, enable lean construction, integrate procurement and track material with all activities tagged to specific project coordinates.

## Strategizing execution

To transit seamlessly from strategy to execution, PT&D has adopted a fundamentally strong, workable approach. "Our core initiatives are focused on improving execution methodologies, introducing process improvements, enhancing production capabilities, digitalization, engineering standardization, time saving and sustainable growth, that have ultimately led to customer satisfaction," shares Deepak Nayak, Head Corporate Centre. About 26 major OPEX initiatives have given the IC comprehensive benefits across its various business.

## REVIEWING PROJECT SCHEDULING

When a project to electrify 96 villages across an area of more than 47, 800 km across 9 Districts in Western Odisha was undertaken within a stringent timeline, the stakes were high for PT&D's Utility Power Distribution Business. Especially, with a ton of challenges to be mitigated that included negotiating the elephant corridors of Sundergarh, hilly terrains of Deogarh, mines of Jharsuguda, submerged areas of Sambalpur, cultivation lands of Bargarh, tribal habitats of Nuapada, Maoist regions of Kalahandi and the searing heat of Bolangir. A detailed survey revealed that 36 out of the total 96 villages were in the vicinity of dense forests where the scope involved electrifying 1392 households ranging from 4 to 208 with an average of 36 households per village. Power had to be transmitted through 192 km of aerial bunched cables strung on 4880 steel tubular poles. 65 distribution transformers with ratings of 25 kVA, 63 kVA & 100 kVA had to be installed too.

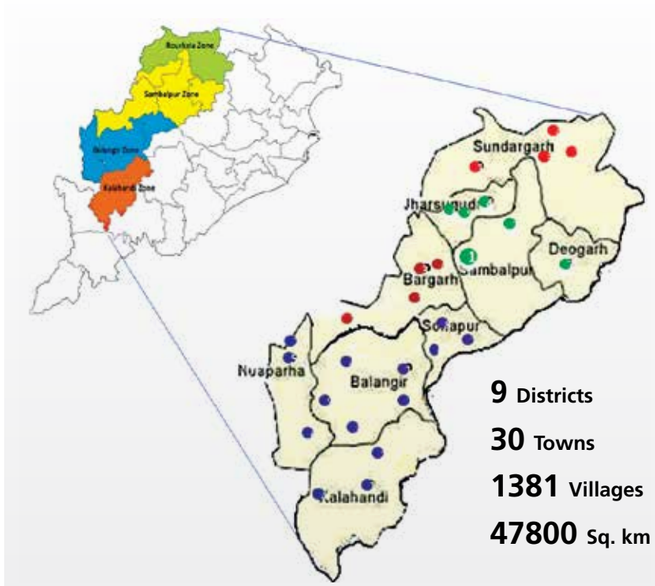
Based on initial linear scheduling, work commenced but soon the project team encountered various issues like changing customer priorities, Right of Way issues, third party delays in approval and the like that required continuous rescheduling of order of preference of villages and reallocation of resources. After carefully analyzing all the factors affecting the deployment of resources, the core project team realized that four major factors held the key to determine the project schedule – Order of Preference of Villages/Works, Customer & Political priorities, Contractor & Work Front Availability, Complexity in Materials and Accessibility. Based on this success, this approach was implemented across DDUGY and IPDS works covering 1381 villages.

VOICES FROM GROUND ZERO

**"Our core initiatives are focused on improving execution methodologies, introducing process improvements, enhancing production capabilities, digitalization, engineering standardization, time saving and sustainable growth, that have ultimately led to customer satisfaction."**

**Deepak Nayak**
*Head Corporate Centre*

### TOPSIS APPROACH IMPLEMENTED ON A LARGER SCALE

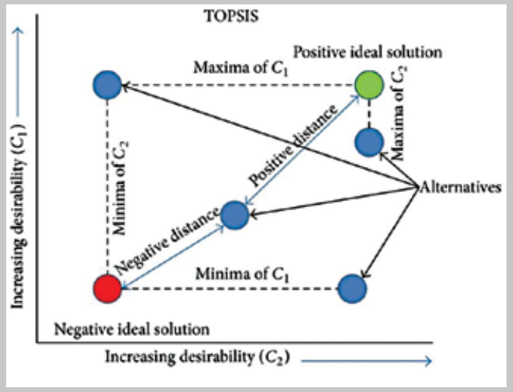



**9** Districts
**30** Towns
**1381** Villages
**47800** Sq. km

| DDUGJY & IPDS Works | |
|---|---|
| 33kV New Lines **213 ckt km** | 11kV Aug. Lines **1188 ckt km** |
| 11kV New Lines **1086 ckt km** | DTR Aug. **570 Nos** |
| DTR New **776 Nos** | LT Aug. Lines **210 ckt km** |
| LT New Lines **490 ckt km** | 33/11kV New SS **9 Nos** |
| 33kV Aug. Lines **593 ckt km** | 33/11kV Aug. SS **43 Nos** |



**Technique for Order of Preference by Similarity to Ideal Solution**




The chosen alternative should have the shortest geometric distance from the positive ideal solution (PIS) and the longest geometric distance from the negative ideal solution (NIS)

**Best Alternative : Positive Ideal Solution (PIS)**
**Worst Alternative : Negative Ideal Solution (NIS)**

VOICES FROM GROUND ZERO

**"We iterated the TOPSIS approach thrice i.e. in March, June & September 2018, assigning different weightages to various criteria."**

**G Karthik**
*Project Manager*
*DDUGJY*

## Aligning with the TOPSIS approach

For the core team of Karthik, Sandeep, Karthikeyan, Ravitej and Sahil Kumar, it was time to shift gears, and they opted for a novel scheme - Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a multi-criteria decision analysis method based on the concept that the chosen alternative should have the shortest geometric (Euclidian) distance from the Positive Ideal Solution (PIS) and the farthest geometric (Euclidian) distance from the Negative Ideal Solution (NIS). For instance, PIS maximizes benefit and minimizes cost, whereas the NIS maximizes cost and minimizes benefit assuming that each criterion needs to be either maximized or minimized. A simple and useful technique, TOPSIS ranks multiple possible alternatives according to closeness to the ideal solution. "After working out the mathematical functionality, the decision matrix was derived and then the order of preference arrived at," elaborates Karthik. Therefore, instead of starting with 16 villages in April as originally planned, the team started with a different set of 9 villages in April and another 9 in May as per the revised schedule; the execution of 10 villages was brought forward to start in the 1st quarter that were originally scheduled for the 2nd and 3rd quarters.

## Keeping tabs on influencing factors

With the schedule spread over nine months, quarterly revisions to the weightages were made considering the dynamic nature of the influencing factors. "We iterated the TOPSIS approach thrice i.e. in March, June & September 2018, assigning different weightages to various criteria," says Karthik, with each succeeding iteration excluding the villages that were started earlier. During the initial phase of the project, i.e. March to June, there was a compulsion to start and complete those villages under the SAGY scheme and directly monitored by the local Members of Parliament. With the customer having his own list of villages to be taken up on priority basis, the criterion of 'Customer or Political Priority' was given more weightage during March 18 and reduced in the subsequent months. As accessibility to several of the villages reduced with the onset of monsoon during July - September, the 'Accessibility' criterion was given preference while the 'Complexity in Material' criterion gained precedence during March & September due to the limitations in procurement of the specialized structures used specifically for the UE execution works.

The gains for the project team by adopting the project schedule based on the TOPSIS approach were manifold: reduction in average cycle time to electrify villages, reduction of schedule overruns, reduction in supervision costs, improved monitoring and implementation of quality and safety resulting in lesser working capital requirements that thrilled the stake holders. After the successful implementation of the pilot project in 36 UE villages in the Sambalpur District, the scheduling approach has been applied for the entire works.

## SURVEYING MADE SIMPLE


There were instances especially in UPD projects where for a 24-month project, surveying alone used to take close to 4 months. Hence there was a dire need to make surveys more efficient especially for long span projects. A 4-member task force team at UPD's HQ office was mandated to design and develop a GIS based solution to reduce survey time and improve data collection at sites during survey and execution stages.

Within a year's time, the team came up with 'LMNoP+Dhruv', a unique digital solution that combines mobile application to collect and map all equipment at field level and the web application to review and finalize field data to submit to client. The application works through a Trimble catalyst device which is a lightweight antenna that plugs directly into an Android phone or a tablet's USB port to take measurements.

Elaborating on the simplification of the process, the development team comprising Charan, Ajay, Kaustav and Dileep take us through the paces. The surveyor at site has only to upload the data from the catalyst device following which automatic BOM generation location wise and auto survey drawings are generated with conductor/cable lengths finalized. 'LMNoP+Dhruv' has enhanced productivity and improved workflow that ensures faster delivery of the final survey outputs and less chances of any cost escalation. Across UPD projects, the average cycle time for conducting surveys has reduced from 4 months to just 2.5 months!

Similar digital surveys have now become the order of the day at other projects too. At the 400 kV Chimuara -Nacala Transmission Line project in Mozambique, LiDAR was used to complete the 370 km topographical survey, where close to 100 km of the alignment passed through dense forests. Apart from time and cost savings, the crew's safety was ensured. The site team is also using drones to capture data from various locations.



## Pre-task Plans

Tower erection and stringing call for comprehensive safety and quality guidelines in transmission line projects. Though secure methods were in place, the risk of a tower collapse had to be completely removed for which a Pre-task Plan (PTP) was initiated that involved implementing motorized double-capstan winches for tower erection and aluminium final sagging bridges for final sagging activities for control and safety of workmen.

Through a centralized approach, the process at each location was defined highlighting the potential hazards that included stringing across different stretches to prevent tower collapse. Conductor drum scheduling further minimized wastages. To enhance the process, workmen gangs were oriented with activity training programmes and procedures for using winches and sag bridges safely.

At the 500 kV DC TL stringing activities in Malaysia that had close to 160 plus towers with an average height of 60 meters running for most part of the alignment, the sag bridge played a pivotal role to ensure safety and productivity. "Introduced in West Malaysia, the sag bridge was placed parallel with the rough sag of the conductor as a platform for fitters to carry out the final works completely eliminating the hazards of working at height," informs T.R. Ravichandran, Project Manager. Sag bridges can be customized as per the tower specifications as was the case in this project where a 20 m sag bridge was used to accommodate 5 m platforms in 4 parts with all tools required for final sagging placed on the bridge.

*A safe platform on sag bridges for transmission tower erections*

The success of sag bridges is translating into numbers: 15% increase in tower erection, 26.86% reduction in tools and tackles inventory, reduction of manpower by 35% during the final sagging activities and an overall reduction in the incident and fatality rates to 9.87% and 8.56% respectively during 2018-19.

*Tagging of transmission tower members*

*Workmen orientation*

*Workmen on lifelines to raise the steely tower members*

*Stringing over a railway line*

# EXPERTLY MOVING MOUNTAINS

*Safely moving hulking transformers to Wangtoo and Sarawak Substations*

VOICES FROM GROUND ZERO

**"The transportation system was reconfigured with variable load distribution and simulated to reciprocate with the IRC Standard of the vehicle to transport without either strengthening or modifying the existing bridge."**

**Sivakumar**
*Planning Engineer*

Transporting huge, heavy-duty transformers, veritably a project within a project, have been successfully accomplished at Wangtoo in Himachal Pradesh and Sarawak in Malaysia that involved a cross-section of on-field tasks. At Wangtoo, the Special Projects and Construction Methods team stepped in to expertly move 9 of these hulking monsters across the Solding Khad and Jaypee Bailey bridges, that were the only link to the districts of Kinnaur and Lahal Spiti that are critical for army movement to the border areas. After a thorough analysis of the bridges, a customized solution was developed by reducing the self-weight of the system (without puller and trailers) and 'skidding' the transformers across. "To meet the bridge design requirements, the lattice girder system configuration was devised as an easy assembly and dismantlable pin connection," shares Sivakumar, the Planning Engineer. "The transportation system was reconfigured with variable load distribution and simulated to reciprocate with the IRC Standard of the vehicle to transport without either strengthening or modifying the existing bridge."

At Sarawak, two 240 MVA Auto transformers with a freight weight of 143 tonnes, comprising mainly of a tank that was 9.5 meters long, 4 meters wide and 4.5 meters tall, had to be supplied to the Marudi Junction 275/132 kV substation project. It was a two-day journey from the Bintulu port to the site, the cargo moving at speeds of 5 to 20 kmph accompanied by escort vehicles. At site, the issue was to position the transformer to its plinth area along the live substation without a crane due to space constraints. "We introduced the hydraulic jacking and skidding technique for the first time in this region for the installation," informs Mohana Dayalan, the Project Manager, and it took just 2 hours to position the transformer from the road to the plinth, perhaps the fastest and most effective skidding/Jacking method executed in this region.

## ENHANCING DELIVERY COMMITMENTS

Across PT&D's factories in Pithampur and Puducherry, the process of production is driven through an internally developed, customized 'PDSS 4.0 TL Tower Factory ERP' software that monitors a range of tasks like BOM preparation, material requirement planning, cutting optimization, production planning, vendor planning, process control, QC checks, panel wise bundling and despatch. At the shop floor, the Theory of Constraint (TOC) approach is implemented to identify bottlenecks in the supply chain to streamline production processes. Considerable improvements have been made across various lines including galvanizing, beam production, fabrication of tower parts with reduced delivery lead times. Wastages in zine and binding wire consumption have also reduced. With tower wise despatches to sites, on-field teams have lead time, and cost and time are saved as there is no need for any segregation at site.

The demoulding time to produce precast poles in power distribution jobs has been brought down from 72 to 24 hours by changing the M40 mix design of concrete through admixtures that has also increased productivity and sales of poles.

Another process innovation at the 500 kV Chom-Bung Bang-Saphan 2 site in Malaysia has been a three-check point QR code that tracks elements from the factory, to the store and thence to the site through which likely shortages are immediately addressed, can be accessed any time and one can compare scope verses actually supplied tower elements.

*TLT factory Puducherry*

*One of India's largest floating solar plants, Tirupati*

*Single axis tracker block and single row tracker variants*

*Solar automatic cleaning system*

## Ready for Commissioning Cell

Functioning as a nodal agency, an exclusive Ready for Commissioning (ROC) cell has been empowered to act and take decisions outside of the project team regarding any critical evaluation that calls for updates before issues are raised by the customer. Since this is an upfront evaluation before the client evaluates, the down time due to punch points have dropped drastically by 20%.

## PATENTING TECHNOLOGY

Several technological innovations have seen light of day in solar tracker and battery energy storage systems. One of the biggest by the Solar BU has been the indigenous development of the Automatic Single Axis Horizontal Bifacial Tracker with Specular Reflective Elements. "This is a high energy yielding platform with 18% more output than the horizontal single

VOICES FROM GROUND ZERO

**"The L&T SAHBT tracker is designed with higher structural stability and is easy to handle, assemble and maintain while its automatic, remotely controllable and unmanned operation makes it a safe solar installation."**

**Shaji John**
*Head - Business Development & Proposals*

axis monofacial tracker," mentions Shaji John, Head Solar BU. "The L&T SAHBT tracker is designed with higher structural stability and is easy to handle, assemble and maintain while its automatic, remotely controllable and unmanned operation makes it a safe solar installation."

Since backend service is just as important in product development, the Solar BU has developed an automatic module cleaning system that reduces water and manpower requirement by a whopping 70 to 80% while increasing energy generation by 2 to 5% in comparison to conventional methods. With the technology patents to be formalised shortly, these products will be a shot in the arm and a decisive competitive edge for the Solar BU when tapping global markets.

## Championing OPEX

The future is all about how the OPEX initiatives are championed by bringing technology to the fore and automating processes to ultimately give customers greater value and timely delivery. "As the 'Columbus' of L&T and as we make inroads into newer geographies, scaling up OPEX initiatives is the way forward to achieve operational excellence," rounds off TMD. ■

# LAYING TRACKS OF GROWTH … EFFICIENTLY!

The Railway SBG story …

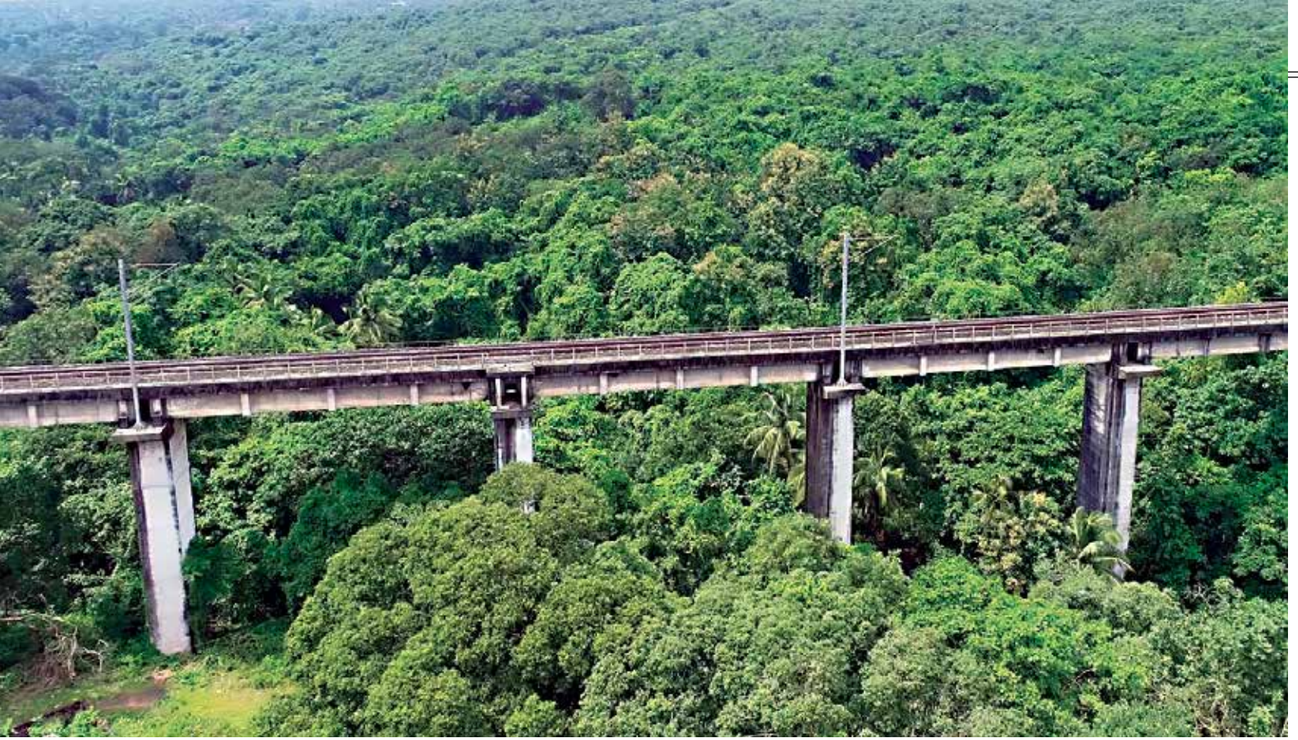
LEADER SPEAK

**RAJEEV JYOTI**
Chief Executive, Railways SBG

Railway Projects are unique in many ways. Our focus on improving operational efficiency involves a multi-faceted approach that involves a combination of strategic initiatives, expert project planning, and innovative methods to execute speedily and cost-effectively.

Some of the these aspects include :

- Large scale deployment of mechanized construction techniques for rapid progress of both Trackwork and OHE projects and monitoring of turnaround time of all P&M through GPS based digital technologies. This includes New Track Construction (NTC) machines for trackwork along with a multitude of other track finishing machines. On the OHE front, besides mechanized OHE wiring, multiple mechanized methods are followed for Cylindrical Auger foundations and OHE mast erection as well.
- Our pioneering venture to implement Linear Project Management tools like 'TILOS' is to effectively visualize and plan mega linear projects across domains.
- We are harnessing Digital technology for Supply Chain Management by developing various apps that drive 'Store to Site' planning in OHE and S&T works.
- Leveraging strengths on the Design and Engineering fronts across multiple domains like track alignment, traction power simulations, interface design, ballastless track works, signaling design through state-of-the-art design software and BIM.
- Strong focus on safe work practices leveraged through digital technologies viz;  Virtual Reality based training for workmen to emphasize the criticality of working along 'live' tracks.
- Nurturing an innovative culture for Operational Efficiency through institution of awards - Digital implementation, Energy Optimization, Large Scale Reuse of / Waste, Time Reduction, Advancements (DELTA Awards)



> **Apart from a paradigm shift in our execution, our focus has been to improve our operational efficiency through a combination of strategic initiatives, expert project planning, innovative methods to execute speedily and cost-effectively, but what has really helped us is a culture of efficiency that we have created and perpetuated within our business.**
>
> **Rajeev Jyoti**
> *Chief Executive, Railways SBG*

The Railways business is unique and railway projects are unique in many ways. A case in point is a major project in the Western Ghats that requires OHE installations in 70+ tunnels and 125 bridges over a stretch of 428 km, 90% of which is single line. A project of this complexity throws up a welter of challenges: of working amidst highly restrictive 'block sections' involving significant material handling and extraordinary erection methodologies. Unique challenges require unique solutions, like in this case, installing OHE using gantry structures without impeding normal train movements, with minimal dependence on 'traffic block', developing 'quick transfer containers' to shift OHE foundation material to difficult locations and such like. This ability to think on their feet and evolve clever strategies, has transformed the Railway business from a simple EPC player into a large-scale Rail Systems Integrator. Proof of pudding is an order book that has grown 5 times along with revenues and profits.

"Apart from a paradigm shift in our execution, our focus has been to improve our operational efficiency through a combination of strategic initiatives, expert project planning, innovative methods to execute speedily and cost-effectively," shares Rajeev Jyoti, Chief Executive, Railways SBG, "but what has really helped us is a culture of efficiency that we have created and perpetuated within our business."

The Dedicated Freight Corridor (DFC) projects have radically changed the way the Indian Railways approach projects and, at the same time, as rail systems integrators, the Railways business has continuously morphed itself to meet new and more exacting demands.

## Stretching efficiency over hundreds of kms

DFC projects are primarily mega civil & track works involving multiple linear activities spread across hundreds of km featuring numerous minor and major bridges. These require location design and construction activities that must be visualized and conceptualized in planning to optimally utilize resources and movement of heavy track equipment like the NTC machines and tamping and ballast regulating machines. In response, the SBG was amongst the first to introduce Linear Project Management tools like 'TILOS' – to effectively visualize and plan mega linear projects across domains. Driven by a dedicated 'Track Planning Cell', this strategic initiative facilitates centralized planning of not only civil & track projects but mega OHE projects as well.

## Excellence in logistics and P&M turnaround time

The NTC machine is truly a workhorse for DFC projects. This 'over a km long machine train' carries about 2,000 pre-cast sleepers and 250 m long welded rail panels to lay 1.5 tkm. "We need to optimize the movement of the NTC machine as it spreads the sleepers and lays tracks at the rate of some 2 km a day," says S.Ramkumar – VP & Head Mainline BU, "of course there are issues to be solved," he adds, "RoW and incomplete sections can seriously impact productivity but through TILOS we are able to visualize the overall project in a snapshot and plan critical activities like NTC machine movement months ahead." Timely refurbishment of rakes carrying sleepers and rails is yet another logistic challenge the team faces to ensure that the NTC machine functions optimally. Besides, a large battery of Ballast hoppers is digitally monitored to optimize 'Hopper Turnaround' time.

On the OHE front, simultaneous stringing of contact wire and catenaries under tension reduce both operational costs and execution time.

Besides wiring, multiple mechanized methods are followed for Cylindrical Auger foundations based on site conditions that includes Auger on Crawler based RRV and tractor/trolley mounted Auger. A similar multi-pronged approach is followed for mast erection as well.

## Self Sufficiency in OHE structures

"Our association with the Railways has leapt from about 7,500 tkm of OHE a decade ago to over 16,000 tkm now with the advent of the DFC and other large EPC projects from the Indian Railways mainline," points out Rajeev that has, at the same time, increased his requirement for OHE structures including 13 m high rise masts for double stack containers. Managing the existing vendor base and insulating the business from price spikes are critical considerations for Rajeev that has led to the establishment of a new OHE

VOICES FROM GROUND ZERO

> **"We need to optimize the movement of the NTC machine as it spreads the sleepers and lays tracks at the rate of some 2 km a day. Through TILOS we are able to visualize the overall project in a snapshot and plan critical activities like NTC machine movement months ahead."**
>
> **S. Ramkumar**
> *VP & Head Mainline BU*

*Riyadh metro track work*

*New track construction machine*

*OHE fabrication and galvanizing facility at TL factory, Pithampur*

VOICES FROM GROUND ZERO

**"Safety is a critical consideration and more so in linear railway projects, for which we have been leveraging digital technologies viz; Virtual Reality based training for workmen to emphasize the criticality of working along 'live' tracks."**

**Alok Sharma**
*Head Safety*



fabrication and galvanizing facility at TL factory, Pithampura with a capacity of 36,000 MT/annum. "Our sense of urgency is reflected in the fact that the fabrication facility was set up and fully functional in double quick time," smiles Ramkumar

## Driving efficiency along several tracks

A first-of-its-kind GPS-based 'Central Command Centre' was deployed by the WDFC project team to monitor and track a multitude of high value and specialized track and OHE construction machines, provide track linking completion status updates, trigger collision warning alerts to both the driver and LC gate operator when approaching LC gates.

'eM Track' drives 'Store to Site' planning and is specific to OHE and S&T works. With numerous components involved, the non-availability of even one component can throw productivity off the rails. By promoting inter store and store-site interaction, 'eM Track' significantly reduces working capital requirements without compromising project progress and since railway activities are linear, most of these applications are mobile based.

## Making the engine room more efficient

On the engineering and design fronts, the business has assimilated in house talent across multiple railway domains like track alignment, traction power simulations, interface design, ballastless track works, signalling design and much more. "For Track and OHE designs, we use advanced design software like Bentley; STAAD Pro to generate Alignment Designs, Engineering Scale Plans, Layout Plans (LoP), and Signal Interlock Plans (SIP) to name a few," informs Shiv Gupta – Head EDRC Railway SBG , 'and we are moving towards simultaneous linking of track ESP (Engineering Scale Plan) with LoP and SIP leading to BIM."

## Harnessing the benefits of digitalization across domains

"Safety is a critical consideration and more so in linear railway projects," says Alok Sharma – Head Safety, "for which we have been leveraging digital technologies viz; Virtual Reality based training for workmen to emphasize the criticality of working along 'live' tracks."

The implementation of PROCUBE across all railway projects has given top management comprehensive daily overview snapshots of projects, supported by periodic drone-based video capture. SPEED is another initiative to improve **S**ite **P**roductivity **E**fficiency and **E**xcellence through **D**igital means while 'Asset Insight' tracks and efficiently monitors P&M.

"We have developed and implemented a QR Code system at site for effective control of drawings," adds Shiv Gupta. An app-based solution to raise, approve and monitor RFIs (Request for Inspection) too.

RACE initiatives have been adopted to benchmark cost and a structured process to benchmark suppliers on multiple parameters has already resulted in significant savings on big-ticket system vendors. RACE has ushered in a greater degree of understanding that has triggered the creation of a significant database and increased partnership with specific stake holders both locally and globally.

## Enhancing skilled manpower base

More 'Front Line Supervisors' are coming through the Competency

**The business is extremely challenging and very often we are treading challenging terrains, but I guess that is the thrill of meeting these challenges head on and driving the business forward to new frontiers.**

**Rajeev Jyoti**
*Chief Executive, Railways SBG*

Centre in Kanchipuram, one of the finest and first amongst Indian private companies to train manpower in the railway domain, with the requisite theoretical and practical on-the-job training to address Track and OHE requirements.

## Nurturing an innovative culture for Operational Efficiency

At the end of the day, for Rajeev and his senior management team to drive productivity, it is imperative to create and nurture an innovative culture and one step in that direction has been the institution of the DELTA Awards - **D**igital implementation, **E**nergy Optimization, **L**arge Scale Reuse of / Waste, **T**ime Reduction, **A**dvancements (Innovation) Awards that attracted as many as 89 implemented entries from across the Railway SBG.

"The business is extremely challenging and very often we are treading challenging terrains," says Rajeev with a serious and piercing look, "but I guess that is the thrill of meeting these challenges head on and driving the business forward to new frontiers." ■

# DIGGING DEEP TO MINE GREATER VALUE

## Driving operational efficiencies at L&T GeoStructure

LEADER SPEAK

**S. KANAPPAN**
Chief Executive, L&T GeoStructure

Being a specialized business, operational efficiency for us at L&T GeoStructure has a lot to do with smart customer relationship management. First and foremost, it is imperative to have 360-degree data about our key stakeholders. For this, we draw up a list of all our current and past projects, understand our clients/customers, identify their key decision makers, analyse our own bid strategy, identify the key marine P&M owners/ hirers, specialist sub-contractors and competent partners/associates. We prepare ourselves with a database of emerging or forthcoming projects for various customers so that we can provide techno-commercial and robust conceptual designs at the drawing board itself to partner them throughout the life cycle of the project.

To improve our strike rate, we appreciate the importance of educating and enlightening our customers about our specialized offerings and the advantages of EPC solutions to create innovative designs and engineer cost-effective execution strategies by leveraging our strong in-house design and engineering team to reduce competition and increase our hit rate. Even after either a win or loss, we conduct a threadbare post bid analysis to arrive at appropriate counter strategies vis-à-vis that of our competitors.

Last, but not the least, success in our field has a lot to do with retaining our customers by constantly staying in touch with the key decision makers, proffering help to resolve operational or contractual conflicts to sustain and nurture relationships and thereby win repeat orders.

"To have an operationally consistent and sustainable business, it is imperative to have an inclusive strategy," declares S Kanappan (SK), Chief Executive, L&T GeoStructure, "whereby inputs are gathered, discussions conducted, strategies evolved, decisions taken and initiatives adopted with the buy-in of everyone involved." During the execution of a project, it pays to involve all the departments to consider innovative ideas and options, discuss and decide on them only after carrying out due diligence. "We adopt a holistic approach, studying the different components and provisions of the project as a whole, analysing both the engineering and commercial aspects before taking a final call."

## Inclusive strategy translated into action

The earlier the involvement, better the cohesion and results, which is why general arrangement drawings are regularly updated and shared with the Construction Methodology and Planning Cell (CMPC) and Formwork teams at the planning and design stage itself, to take on board valid suggestions from the perspective of constructability that saves time, rework, redesign and helps procure timely approvals. For concrete structures, the choice of precast and/or cast in situ construction methodologies are decided at the design stage that improves efficiency and flexibility in material allocation and manpower planning. "We are able to speedily resolve issues at site or promptly address customer or consultant queries by deputing designers to site," explains Amit Mishra, Head – Planning. "Issues are resolved quicker with face-to-face technical discussions and by being at the centre of action, they are able to continuously interact with onsite personnel to modify methods or even experiment to enhance efficiencies that are immediately communicated with the PMC or client to highlight the resultant change in scope vis-a-vis the tender and the accruing cost benefits."

"We always seek to value-add to client proposals by following a process of consultative selling," shares SK, "and it is a win-win situation in which the client enjoys a more efficient process and we gain with additional scope of work." A case in point is the Uppur Project, where the advantages of the Cathodic Protection Systems were recommended to the owner to increase the durability of marine structures that were readily accepted and are now acknowledged as best industry practices. Faced with certain execution issues for curved rectangular precast girders in the BHEL Project at Ennore, the team recommended straight, smaller, rectangular girders fixed on a chord to achieve the curve. The client accepted the recommendations and the girders were executed with only a modification to the pier cap dimensions. In the IndusInd Project too, a 'D-Wall' was proposed instead of sheet pile excavation that even the client recognized as a more viable, feasible and modern solution.

*Multi modal terminal at Sahibganj, Jharkhand*

*Coal terminal at Paradip, Odisha*

**We always seek to value-add to client proposals by following a process of consultative selling, A case in point is the Uppur Project, where the advantages of the Cathodic Protection Systems were recommended to the owner to increase the durability of marine structures that were readily accepted and are now acknowledged as best industry practices.**

**S Kanappan**
*Chief Executive, L&T GeoStructure*

## Recognizing the key roles of CMPC & formwork teams

The role of the CMPC and formwork teams is vital from day one of a project especially in the choice of the construction methodology, its planning, testing and constant improvisation with the available material to speed up execution. "We analyse various equipment positions in the process," shares E. Sathish Kumar, Head – CMPC, L&T GeoStructure, "prepare and share sequenced drawings with the site for easier comprehension." Geotechnical test setups and schemes are recommended based on experience, ease of execution and site safety like 3D models for formwork and shuttering that were prepared for the BHEL and


*Diaphragm wall works for a project in Chennai*

*Innovative movement of consignment through water way*

*Trench cutter in action*




**"The process called for high precision, because as the raker piles go below the soil stratum, the possibility of clashes is huge but as we had modelled the whole piling sequence and arrangement in BIM by calculating the exact coordinates, we were able to execute flawlessly."**

**M. Kumaran**
*Head - Engineering*

Runj Projects or the piling sequence modelling for clash detection developed for the IOLPL Project.

## Making 3D models at home near the sea

In marine works, the most common equipment for pile driving offshore work is a jack-up barge (also known as a self-elevating platform) with 400 MT payload capacity equipped with a driving setup of two cranes and material handling barges to shift piles and precast members. A 250 MT crane is positioned over the jack-up barge to drive the raker and vertical steel piles while a 300 MT crane handles the piles and other precast elements in both the travel barges. A hydraulic pile guide system mounted on the jack-up barge guides the pile at the required angle.

The process involves a Vibro hammer pile-driving to the required penetration based on the soil condition, ensuring that the pile centre does not shift by more than D/10 (where D indicates the diameter of the pile) from the drawing coordinate and the deviation in verticality does not exceed 1.5%. On attaining the desired depth, the hydraulic impact hammer is lifted by the 250 MT crane. "The process called for high precision," says M. Kumaran – Head - Engineering, "because as the raker piles go below the soil stratum, the possibility of clashes is huge but as we had modelled the whole piling sequence and arrangement in BIM by calculating the exact coordinates, we were able to execute flawlessly." At the IWT Sahibganj project, gantry piling that is easy to assemble, operate, detach and reuse, was efficiently deployed. Project Manager, Samir Sarkar, shares that they were equipped with and guided by all the necessary calculations and sequence drawings for every movement of the gantry. "What's more, we could operate the gantry smoothly and safely even in bad weather."

## Enjoying the fruits of collaborative working

In most projects, the selection of construction methodologies is based on a multi-disciplinary analysis; the more realistic and reliable the analysis, the better the choice of methodologies and excavation techniques. Six basements were planned at the IndusInd Project, a diaphragm wall with four level struts and a waler system (excavation shoring system) to demolish the existing structure. The team resorted to the Plaxis 2D software to model the soil structure interaction, using a finite element method for a 2-dimensional analysis of deformation and stability that optimized the design solution for excavation and ensured stability during construction. The Plaxis 2D software was used similarly by the Uppur Project team to successfully construct an offshore intake well.

## Achieving operational excellence at the Sahibganj Project

The IWAI-IWT Project at Sahibganj in Jharkhand is part of the Indian Government's Sagarmala Project to improve waterways along the river Ganges. The project warranted the deployment of a mobile harbor crane that had to be transported from the Kolkata Port to the project site – a tall order considering that the consignment comprised 34 packages, weighing all of 244 MT. Transit of such a huge consignment 472 km by road to a remote, not-too-well-connected site was a non-starter. Instead, the team decided to transport it on a barge via the NW 1 Inland Waterway to be unloaded directly at the IWT Sahibganj terminal. "We had a deadline to deliver the cargo before 26 February 2019," points out Balaji Sree Ranganatharao P, Head – Logistics, "and to plan this time-bound exercise we had to consider a number of aspects like custom clearance, material handling, lashing, choking, river transit, Farakka Lock Gate permission and a lot more." They managed them all and against an estimated transit time of 21 days, the consignment was delivered right on schedule in 8 days. "The last package was unloaded bang on dot on 26 February," exults Balaji, "and in the process we managed to save 10% in costs and 13-man days!"




**"Our Quality Management System is in line with the requirements of ISO 9001:2015, and we believe that the capability of an organization is directly related to the capabilities of the people employed: obviously better the people, better the productivity. Therefore, training and development are the focus areas for us in QMS."**

**S.N. Rajan**
*Head – QMS, L&T GeoStructure*

## Using quality to drive efficiency

"Our Quality Management System is in line with the requirements of ISO 9001:2015," says S.N. Rajan, Head – QMS, L&T GeoStructure, "and we believe that the capability of an organization is directly related to the capabilities of the people employed: obviously better the people, better the productivity. Therefore, training and development are the focus areas for us in QMS." Strategic planning and risk management are two other areas under QMS. Under risk


**"17 out of our total 18 sites performed without LTIs. The National Safety Council of India recognized our efforts at the IWT Sahibganj site and two of our clients – VIH Stone Column Work, Vizag and Nabinagar Super Thermal Power Plant awarded the EHSOs for their sterling performances."**

**K P Ravinath**
*Head – EHS, L&T GeoStructure*

management, potential risks and possible variabilities from anticipated conditions are analyzed and captured. Allowance for these risks during the pre-tender and operational stages avoids delays or cost variations. "Our Quality Assurance Plan for specific activities defines work method statements, inspection test plans and checklists," adds Rajan. Routine, periodical checks and inspections of processes, materials and products improve the quality of construction and, at the same time, substantially reduce the chances of potential liability and rework.

For SK, better quality management results in delighted customers who open the door for future business. "While customer feedback is a valuable input for improvement, continual self-driven improvement is just as important," he stresses.

## EHS – an important determinant of efficiency

On K P Ravinath's (KPRn), Head – EHS, L&T GeoStructure shoulders, rest the responsibility of ensuring that a positive safety culture prevails. "17 out of our total 18 sites performed without LTIs," he shares with a sense of achievement. "The National Safety Council of India recognized our efforts at the IWT Sahibganj site and two of our clients – VIH Stone Column Work, Vizag and Nabinagar Super Thermal Power Plant awarded the EHSOs for their sterling performances." Apart from employee engagement, rewards and recognition, sub-contractor management is another focus area for KPRn. "Sub-contractors are assessed and evaluated on their previous safety performance prior to engagement at our projects," he says, "and their EHS performance is continuously assessed. We use the carrot and stick approach," he grins, "support them when required, but reprimand when necessary, with the threat of dire consequences if they do not follow our EHS requirements." Involvement and demonstration of EHS by the leadership goes a long way to create

**Our theme of 3G3 is to grow 3 times in 3 years, and to achieve this ambitious target, we must keep raising the operational efficiency bar, which we are sure to.**

**S Kanappan**
*Chief Executive, L&T GeoStructure*


**"We achieved operational efficiency by tapping the right talent at the required time, with substantial savings on cost of talent acquisition. We tapped 85% of our candidates through a strong external and internal network domain."**

**Bino Mathew Jose**
*Head – HR, L&T GeoStructure*

and sustain a positive EHS culture and one of KPRn's mandates is to see that leadership is visibly driving EHS at sites.

## The right person for the right job

For Bino Mathew Jose, Head – HR, L&T GeoStructure and team, talent acquisition is all about hiring special talent for extremely niche areas like building marine structures, construction of dams, barrages, diaphragm walls, lift irrigation projects, piling, ground improvement works, Reverse Circulation Drilling (RCD) and the like. "We achieved operational efficiency by tapping the right talent at the required time," he points out, "with substantial savings on cost of talent acquisition. We tapped 85% of our candidates through a strong external and internal network domain." Understanding the available skillsets is an imperative to leverage human capital and fill gaps. "Skill gap analysis and expertise mapping have helped us fill various key positions in Engineering Design," says Bino. "In terms of operational efficiency, this has helped us leverage the available talent pool from a short- and long-term strategic perspective."

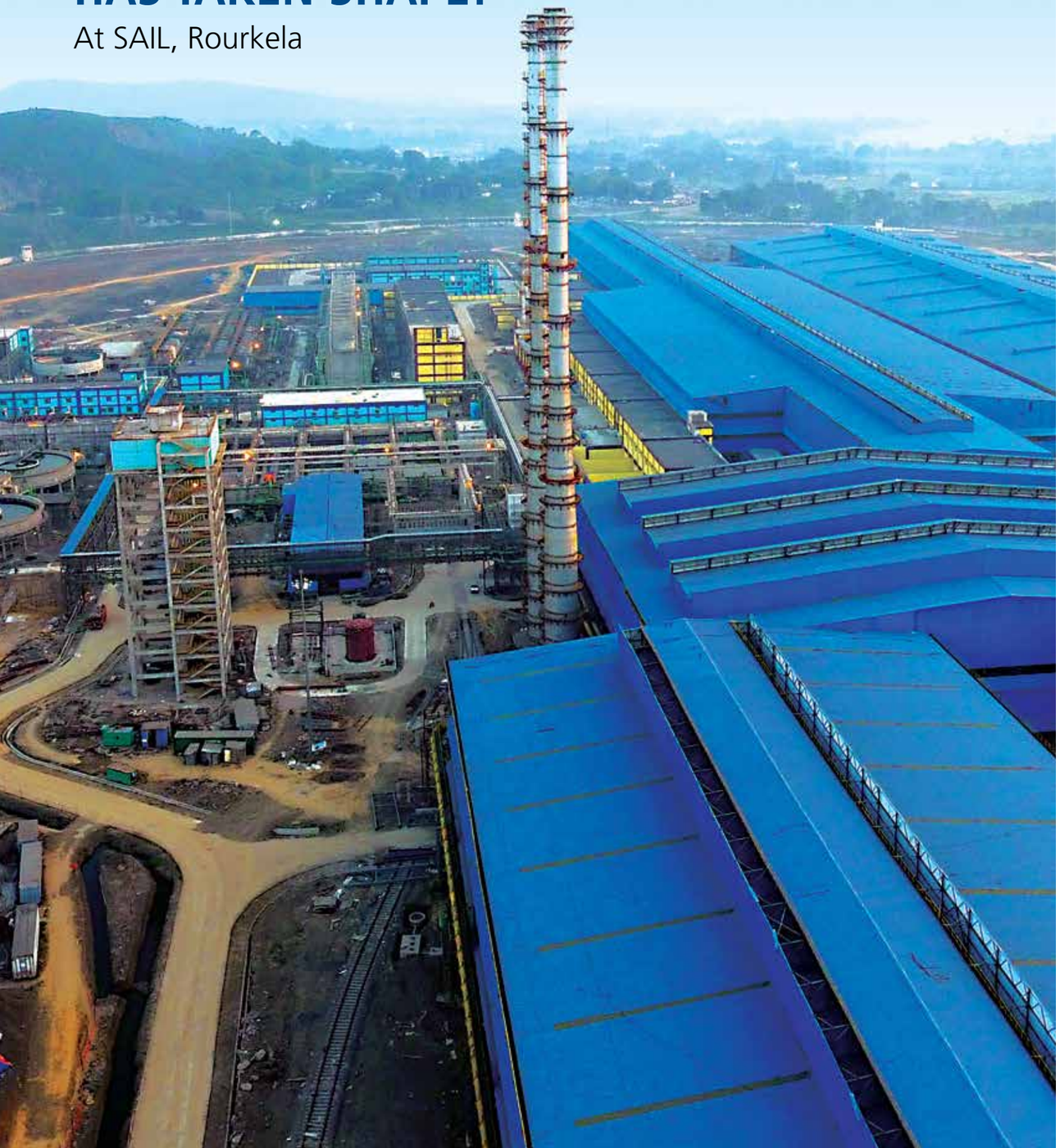
Planning was identified for skill development for which the HR team initiated the Planning Engineers Programme, an 8-month long exercise, to train and develop a bunch of strong planning engineers. Recognized as the Best Skill Development Programme, the initiative won the Golden Category HR Award presented by Tata Institute of Social Sciences & LeapVault CLO (Chief Learning Officers) in 2019 while L&T GeoStructure had won the Golden Category HR Award for Best On-the-job Training in 2018.

"Our theme of 3G3 is to grow 3 times in 3 years," affirms SK, "and to achieve this ambitious target, we must keep raising the operational efficiency bar, which we are sure to," he signs off confidently! ■

*Sea water intake and outfall structure at Uppur, Tamil Nadu*

# A BEST-IN-CLASS HOT STRIP MILL HAS TAKEN SHAPE!

At SAIL, Rourkela



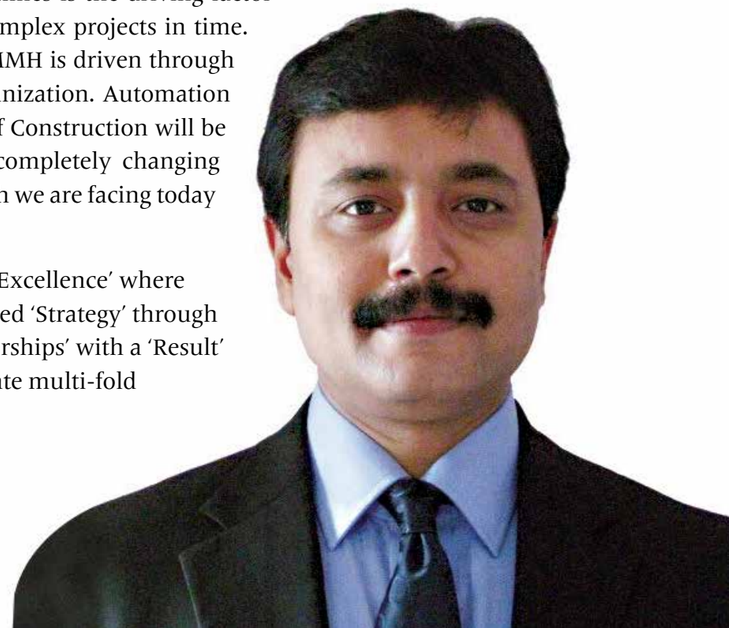
LEADER SPEAK

**ANUPAM KUMAR**
Vice President & Head (Metallurgical & Material Handling - SBG)

The ever-growing demand in EPC projects is for speed and scale, which calls for enhanced operational efficiency to deliver quality products at right time and right value. The expectations of stakeholders can be addressed by embracing digital advancements and quickly adopting to new and faster techniques, duly complemented by advanced mechanization. At MMH, operational efficiency is close interaction right from inception stage, i.e. design and detail engineering wherein the issues related to constructability are debated and duly incorporated for faster and smoother execution. The procurement process is fully digitized and synchronized with the project requirements to enable selection of the right product, undertake inhouse manufacturing and onboarding the right vendor. In execution, MMH has institutionalized several processes with the sole purpose of transforming the site activities into a safer and more productive environment thus adding value to the product being delivered.

We always endeavour improved performance across departments at micro-level, robust interface & resolution management. Coupled with this internal process efficiency, the focused efforts for external stakeholder management, involving a multitude of customers, consultants, vendors, subcontractors and workmen at various levels and locations in these challenging times is the driving factor to execute process intensive complex projects in time. The operational excellence at MMH is driven through People, Processes and the Organization. Automation of Design and Mechanization of Construction will be the growth drivers for MMH completely changing the competitive dynamics which we are facing today to enable us to grow globally.

MMH is focussing on 'Business Excellence' where the 'Leadership' is driving focused 'Strategy' through its 'People', 'Process' and 'Partnerships' with a 'Result' oriented approach that will create multi-fold value to all its stakeholders.



The Consortium of L&T's Metallurgical & Material Handling (MMH) SBG and Mitsubishi Corporation, Japan, were contracted by Steel Authority of India Limited to build a 3 MPTA Hot Strip Mill (HSM) along with a 0.4 MPTA sheet shearing line on turnkey basis at Rourkela, with technology from Primetals and Hitachi of Japan. Spread over an area of 86.56 acres, the scope of this EPC project, a first for MMH, was huge: design & engineering, civil engineering work, fabrication & supply of steel structures, manufacture & supply of plant and equipment, manufacture & supply of refractories, intermediate storage, insurance & handling, erection, testing, pre-commissioning, start-up & commissioning and demonstration & establishment of performance guarantee parameters of the facilities. Critical equipment like roller tables, shearing lines, chock extractors, transfer and pallet cars were manufactured at L&T's Kansbahal works in sync with the 'Make in India' theme.

*Roughing mill*




**"We had to overcome several challenges before successfully rolling out the first coil, within two days of the start of hot commissioning. Now, we are concentrating on fully commissioning the project for 66% of the guaranteed production capacity as per the terms of the contract."**

**R Umasathiyan**
*Project Manager*

After manufacturing 390 distinct pieces of equipment, buying out 3,979 distinct items procured from 155 local and overseas suppliers, 200+ customer inspections and some 40,000 inspection documents, the mill, one of the largest of its kind in India, was commissioned in January, 2020 and rolled out its first HR coil within two days of the commencement of hot trials. It is already being recognized as best-in-class and will roll out Carbon Structural Steel, HSLA, High Carbon Steel, LPG Cylinder Steel, Low Alloy Steel, API (up to X100) Pipe Steel and Auto-grade steel, to cater to high-end market segments.

## Demystifying an HSM

Quite simply, a hot strip mill produces hot rolled coils from steel slabs that are in turn produced through a continuous casting route of charging in a reheating furnace to temperatures of up to 1,250$^{0}$C. Thereafter, the reheated slabs are sprayed with high pressure water in a descaling unit to remove the scales and then put through a roughing mill stand to reduce their thickness and correct their edges for further processing downstream. In a crop shear, their heads and tails are squared, divided into 7 numbers that in a finishing mill are converted into strips with precise 1.2 mm thickness and 25 mm flatness and then cooled to recover their steel mechanical properties. Finally, the strips are formed into two down coilers, paint marked, strapped online and transported to the coil yard via a pellet conveyor. The sheet shearing line cuts these strips into the desired lengths. The annual capacity of the shearing line is 400,000 tons capable of shearing strips of thickness ranging from 5 to 25 mm and widths ranging from 1000 to 2150 mm. The sheet bundles vary in length from 4 to 13 m and weigh up to 10 tons.

## It took a lot of doing

6000 piles, 15 lakh cum of earthwork, 2.3 lakh cum of concreting, fabrication & erection of 24000 MT structures, installation of 26,000 MT mechanical equipment, 10 lakh inch-meter of piping comprising of mixed gas, water, nitrogen, steam, hydraulics & lubrication, compressed/instrument/dry air, oxygen, steam, fuel oil, LPG, furnace oil, firefighting system. 4000 MT of refractory work, 4.2 km & 8.8 km 220kV double circuit transmission line from Tarkera grid to MSDS VII and NSPCL grid to MSDS VII of HSM respectively, 1.8km EHV cable laying, 2 km of railway track laying, 2,200 km of power/control/communication cables, HT/LT electrical panels including 220kV & 33kV GIS and 90 transformers. The HSM certainly took a lot of doing.

*Hot slab being passed through the roughing mill*

Other challenges were that it was being constructed on a solidified slag filled area in which structures had to go 23 m underground, with the perennial riverbed of the river Brahmani and a high water table in close proximity. "I'm proud to have lead the team to execute this project that faced several challenges since inception, but due to the combined efforts of the entire team, we were able to overcome them to successful roll out the first coil within two days from the start of hot commissioning," says R Umasathiyan, Project Manager, New Hot Strip Mill Project. With an adrenaline rush, he adds, "Now, we are concentrating on fully commissioning the project for 66% of the guaranteed production capacity as per the terms of the contract."




**"We had to negotiate and deal with as many as 550 equipment suppliers and another 145 specialized vendors for the electrical and automation works, but we managed them well."**

**R. Suresh Kumar**
*Head – Operations, Minerals and Metals BU*

## Improving efficiencies

**Perfect coordination:** To execute a project of such complexity and scale, perfect co-ordination between Engineering, Procurement and Construction and across all disciplines like civil & structural, mechanical, electrical and automation was an imperative. "The good news is that all our teams worked in tandem," shares T. Kumaresan, Head – Minerals and Metals BU, "information was readily shared and we seamlessly coordinated during the design and execution stages which is primarily why we were able to deliver the project against an extremely aggressive time line." Dealing with vendors and suppliers is normally a tall order but at this project it was even taller. "We had to negotiate and deal with as many as 550 equipment suppliers and another 145 specialized vendors for the electrical and automation works," shares R. Suresh Kumar, Head – Operations, Minerals and Metals BU, "but we managed them well!" His smile tells a tale of success.




**"The good news is that all our teams worked in tandem. Information was readily shared and we had seamless coordination during the design and execution stages which is primarily why we were able to deliver the project against an extremely aggressive time line."**

**T. Kumaresan**
*Head – Minerals and Metals BU*

**Going digital:** "With Procube, our project progress monitoring was spot on," shares Anton Jayanth, Digital Officer – MMH. "Our Safety app was the reason we were able to clock 38.4 million safe man hours thus far but the real digital success was the RFID system monitoring our 1,500-strong work force that significantly improved our human productivity quotient." Supply materials were tracked through the SLIM (Smart and Liver Inventory Management) application while concrete pour cards generated using the Conquer app hastened clearances to speed up execution. All vehicles at site were tracked while the stores were always under the lens of CCTV surveillance cameras.

**Mechanisation:** Compensating the limited availability of skilled manpower, the project team implemented several mechanisation initiatives. "With great learnings through cross cultural interaction with foreign experts from Japan and Europe, we were able to explore various innovative approaches like the usage of a skidding arrangement to install heavy equipment like Mill Housing weighing 165 MT each, 9.5 MW Motors and levellers. This eliminated the involvement of high capacity cranes for multiple handling," says Suman Mukherjee, Project Coordinator and Mechanical In charge "Erecting structures in modular form improved resource productivity. By applying ceramic back strap with adhesive tape inside the buffer tank and two 112 m tall steel chimneys before welding joints cut both cost and time." The chimneys were assembled with 500 MT Demag cranes on ground with refractories and erected after which the refractory lining was done with specialized platforms and hoists designed by CMPC.

**Exclusivity:** "For the first time in MMH, we installed and commissioned 220 kV and 33 kV Gas Insulated Substations and 12 Mbps network speed for profibus network," informs a delighted N Jothi Ramalingam, Incharge – Electrical, Instrumentation and Automation. "In fact, the 33 kV GIS is India's 2nd largest single board GIS with one Sectionaliser, 2 bus couplers and 37 bays. The 12Mbps network line is exclusively used for communication of heavy-duty mill motors (IGBT drives). The plant is fully automated with complete Fibre Optics backbone catering to different sections of the plant such as the mill bay, coil storage bay, roll shop, reheating furnace, water treatment plant, MSDS VII, etc."

*First coil produced at the down coiler*

**Auxiliaries:** The Hot Strip Mill features vast utility systems and the water system handles 25,554 cum/hr of cooling water by three water circuits: an indirect cooling water system, a direct cooling water system and a laminar cooling system for control of metallurgical process as well as dissipation of unutilized heat. To conserve precious fresh water, water re-circulation systems recycle and reuse discharges from the mill equipment with the help of a filtration plant, thickener and filter press. These systems are also used to collect and convey scales, for drinking, sanitation, firefighting, condenser cooling of chiller units and other miscellaneous purposes.

**Enormity:** The project team built 7 major substations and 100 small buildings with all finishing works, MEP and 2.5 lakh inch-meter embedded conduits. The foundations had to be precise to cater to critical tolerance levels required for mill equipment. All major external plastering works were carried out with plaster spraying machines by a specially trained CSTI team. The plant is connected by 8 km of RCC pavements; it has a 16 km long drainage system too. "A reflection of our commitment to faster execution is that we poured more than 10,000 cum of concrete per month consecutively for 3 months with placement in 26 multiple locations with exacting quality requirements meeting the precise tolerance limits under stringent environment conditions across varying elevation from (-)23 m depth to 48 m height ", says C V Nagaraju , Incharge – Civil works.

**Every project is a fresh experience. It was no different with this one and it is kudos to our team for having pulled off such a wonderful project though the bigger concern for me was to live up to the expectations and trust reposed in us by SAIL, a long time customer of L&T, and I am delighted that we have delighted them.**

**Anupam Kumar**
*Head – MMH*

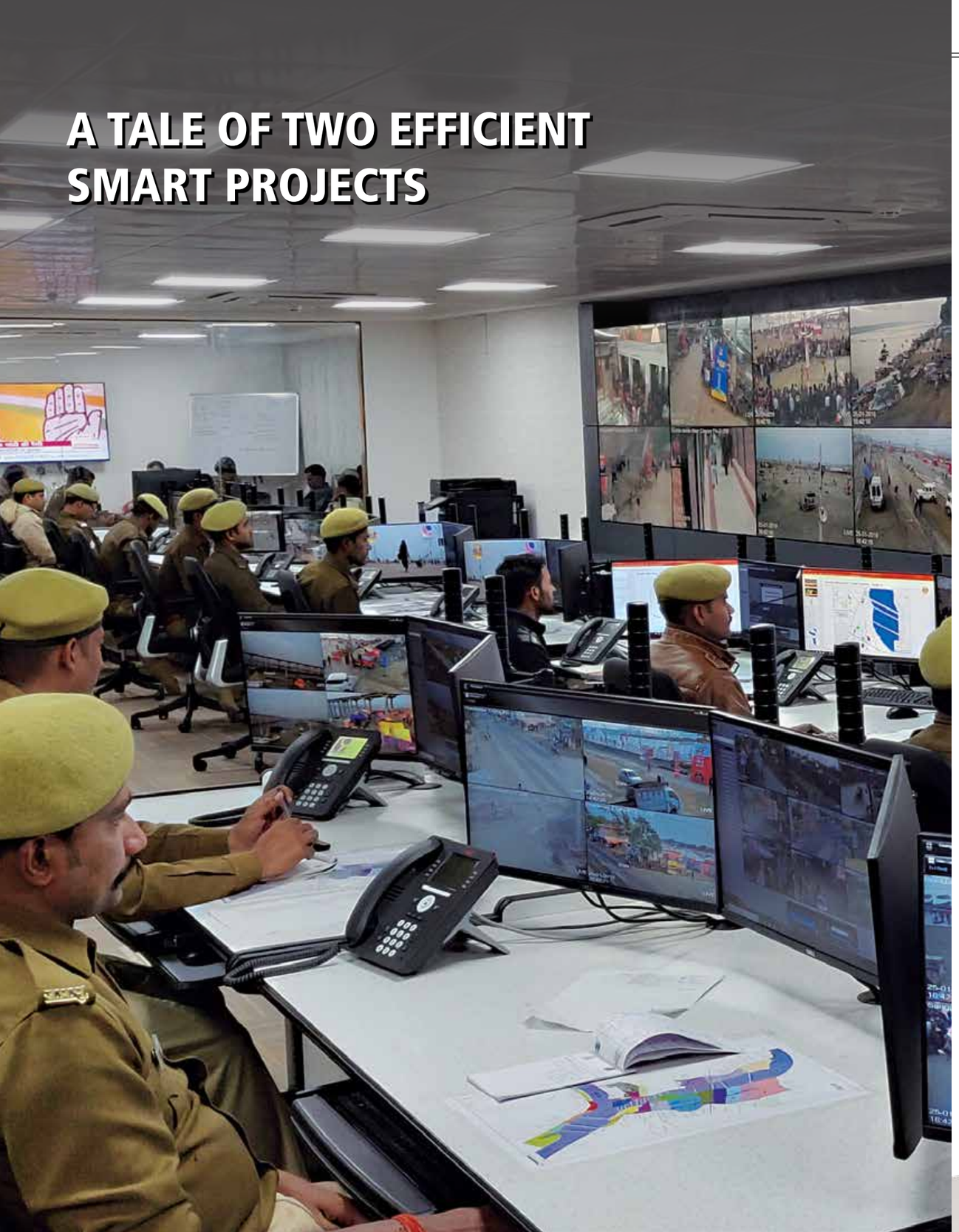
*Finishing mill*


**"With Procube, our project progress monitoring was spot on and the Safety app was the reason why we have been able to clock 38.4 million safe man hours thus far but our real digital success was the RFID system that monitored the 1,500-strong work force that significantly improved our human productivity quotient."**

**Anton Jayanth**
*Digital Officer – MMH*

For Anupam Kumar, Head – MMH, the Rourkela HSM has been yet another opportunity to prove the SBG's mettle to execute large scale EPC projects across metallurgical units. "Every project is a fresh experience. This one was no different and kudos to our team for having pulled off such a wonderful project though the bigger concern for me was to live up to the expectations and trust reposed in us by SAIL, a long-time customer of L&T, and I am delighted that we have delighted them," he concludes with a grin and a thumbs up, relishing the pride of L&T being the sole EPC company to have executed the majority of hot strip mills in the country. ■

# A TALE OF TWO EFFICIENT SMART PROJECTS



LEADER SPEAK

**R. SRINIVASAN**
Executive Vice President & Head, Smart World & Communication

Our Smart World business, since inception has been operating, in most cases, in unchartered territories with no precedence or pre-set benchmarks both domestically and Internationally to fall back on.

The business solutions include use cases to enable and ultimately improve the quality of life of citizens. The whole business involves citizen centric solutions in crowded urban environments with very limited timeframes. These compulsions make operational excellence a prerogative part of all our projects.

In some of our projects, the eco system we address involves several initiatives to build broad consensus with citizens and corporations for effective understanding and delivery, which is usually not part of our regular EPC projects. Each of our project solution is unique and customised to meet the distinct challenge faced, including several innovative and customised solutions, most cost-effectively.

Being first-of-their-kind solutions in many projects, bringing the right software and integrating them on a single interface has always been an amazing challenge, and our Technology team, carved out with talent from across the world, has always raised to the occasion to deliver.

We have delivered in our short journey of 4 years, the country's largest surveillance network in Mumbai, smart solutions to monitor crowds of over 25 Crore people, at the world's largest religious gathering for the Kumbh Mela in Prayagraj, an automated system to usher in a cop less culture in Hyderabad, an Early Warning Dissemination System (EWDS) in Odisha to have practically zero incident during cyclones, digitally connected 6000 schools across Tamil Nadu including managing content, digitized smart meters in 17 districts in the states of Uttar Pradesh, Haryana and New Delhi, and have in the process successfully emerged as a Master System Integrator with multiple domain expertise as a first mover.

Several of our projects are like an open-heart surgery, working in the midst of bustling cities, where creating work fronts have always been a challenge with the added pressure of a limited time window. We have had to work pro-actively with utmost safety and quality procedures and in several cases, work only at nights, to achieve our targets.

At our Technology Innovation Centre (TIC) at Chennai, all the project solutions are first tested in our own campus, which is another unique way of achieving operational excellence. In Smart Cities, proactive positioning is critical for success and through our TIC, we can identify various solutions to problems of cities and showcase them to our stakeholders how quality of life can improve through digital interventions. This positions us better than most other System Integrators.

We have implemented various digital solutions internally and the solution - SWIFT stands out, with which the entire procurement process end-to-end has become online and approvals are happening at 25% better time efficiency.

I am also happy to share that L&T Fusion, a smart solution platform, under development by our in-house team, was recently utilized in Telangana for crowd management of 1.5 Crore people at the Medram Jatara as a POC. L&T Fusion will take us a long way to develop better and smart solutions and create value propositions.

As we move forward, we will continue our journey of Customer First Approach with innovation, advanced solutions, pro-active planning and remain focused to deliver by continuously re-writing the rules of the game.

For a business that has been a trailblazer in setting up smart infrastructure across the country, L&T's Smart World & Communication (SWC) has been raising the bar and defining the way with first-of-its-kind projects in India. "An operation excellence charter gives us insights but largely smart projects have a lot of on-field customization which we have been successful in achieving, all thanks to our domain expertise as a Master System Integrator," highlights R. Srinivasan, Executive Vice President & Head, Smart World & Communication.

In recent times, Phase 1 of two mega projects were delivered by the business within a short period of time: one that safely managed the world's largest gathering of people for the Kumbh Mela while the other involved the installation and digitalization of smart meters in 54 cities across Uttar Pradesh, Haryana and New Delhi. In terms of scale and execution, both projects were unique and called for some innovative operational strategies to achieve various challenging milestones.

# MAKING PRAYAGRAJ KUMBH READY



> **An operation excellence charter gives us insights but largely smart projects have a lot of on-field customization which we have been successful in achieving, all thanks to our domain expertise as a Master System Integrator.**
>
> **R. Srinivasan**
> *Executive Vice President & Head, Smart World & Communication*

## Value additions make the vital difference

How do you go about a project the sole objective of which was to effectively manage more than 25 crore people at the world's largest spiritual congregation? You need ideas and plans, lots of them, to figure out out-of-the-box approaches. That's what the SWC team at Prayagraj achieved. While a lot has already been spoken about the Prayagraj smart infrastructure project, Jigesh Dubey, Project Manager and his team proudly share some hard-core L&T project management techniques that went a long way to deliver the tough project.

"At the Kumbh Mela, our mandate was to implement the project in three stages involving first, the setting up of smart infrastructure for the Kumbh area, taking up remaining works after the mega event and finally ensuring smart governance of Prayagraj," shares Jignesh. The overall project timeline was approximately 5 months but with the client finalizing the locations for Kumbh area only after the monsoon, the timeline for the first milestone was crashed to 3 months. "It was like a project within a project," exclaims Jignesh.

## Setting up the Prayagraj Command & Control Centre

As Prayagraj Smart City combined the Kumbh Mela operations along with smart city infrastructure development works, one of the first priorities for the project team was to establish a state-of-the-art command & control centre to monitor the massive gatherings. However, the task was a race against time having to roll out in just 5.5 months against the normal time frame of 6 to 9 months. The challenges involved multi-agency coordination, substantial work on the streets especially in conjunction with other development tasks, establishing connectivity and finally sensor integration to the command centre.

"Successful convergence of cyber-physical infrastructure is important for all smart city projects, here the case more pressing considering the timelines. We adopted our proprietary Smart City Agile Development Methodology, L&T-SCAD, for parallel execution of digital and physical solutions," highlights Jignesh. "Within a record-time of 3 months, one large command & control centre and a data centre were made operational to cater to the needs of the Kumbh Authority, City Govt. Authorities and the police." While the L&T-SCAD strategy gave the much-needed edge, the project team initiated a series of process enhancements to fast track execution across fronts. "We Identified and trained operators during project execution to document the process with help of multi-agency coordination, leveraged reusable and proven smart city solution architecture and detailed design to avoid last minute integration challenges, streamlined approvals for resource mobilization, organized daily and weekly stake holder consultation to resolve minor and major issues, formed a dedicated task force team to accelerate and customize material procurement for just-in-time delivery of materials."

VOICES FROM GROUND ZERO

> **"At the Kumbh Mela, our mandate was to implement the project in three stages involving first, the setting up of smart infrastructure for the Kumbh area, taking up remaining works after the mega event and finally ensuring smart governance."**
>
> **Jigesh Dubey**
> *Project Manager*

## Understanding the dynamics

As working out the infrastructure around the Kumbh area was unique, to evolve practical solutions especially for activities that included power setup and other associated works, the team roped in local past masters who were well aware of the nitty gritty. And, it was quite a number, even if for a temporary set up as it included some 450 poles and an equal number of UPS, fibre cable laying and installing 20 variable message displays, lining up all these elements even in the fastest mode would have normally taken around 4 months. Team SWC however achieved the setup in just a month's time.

## Ploy for poles

A strategy to source the CCTV poles was critical as the OEM had a minimum delivery timeline of 2 months which the project couldn't afford. A dedicated team was deputed to directly oversee the production and quality at the OEM's factory that conveyed the urgency; parallelly some quantities were drawn


*Crowd density estimation at strategic locations*

from the orders of other projects. "This was more of an internal understanding and it worked well as the momentum was critical for the Kumbh event."

## Precast lifting tackle

Almost every project site across L&T has a precast success story and Prayagraj is no different. "The CCTV poles weighed close to 4 to 5 tonnes with an average height of 2.5 m," informs Jignesh. "Definitely not an easy piece to shift along the banks where the wind speed was a major factor. We came up with a timely precast lifting tackle innovation that ensured that the job was done with utmost safety with considerable savings in time and cost." By precasting, removing them after the Kumbh event was a whole lot easier.

## Gaining insights with crowd management

Arriving at a world-class AI-driven solution for crowd management needed a lot of study, remarks Jignesh. "We went through pre-recorded videos of such events and took the help of professors from the Motilal Nehru National Institute of Technology who were already doing research on crowd modeling to enable us deliver the solution as per customer requirement." None of us at L&T had any idea about the outcome of such an event, exclaims the Planning Engineer. "The first congregation on 15th January 2019 was an experience to see around 2 crore people gather," he adds. "Our AI was 75% tuned and from the insights gained it gradually evolved as a comprehensive platform." Further, for every team member, the congregations were testing times as it ensured a 36-hour monitoring shift with 12 different teams zoning across various locations.

## Shifting gears

A whopping 90 km of underground cabling to be completed in just 3 months was a tough ask, mentions Jignesh. "The only way we could gain ground was through overhead cabling which was not the norm but typical of L&T's innovative thinking, we initiated a proposal for a dark fibre set up and convinced the client to opt for it." Though it was at an additional effort, Jignesh affirms that it was well worth in terms of catching up with the critical timelines as they were able to create the backbone for the smart infrastructure across the Kumbh area.

## Banking on inherent strengths

Capex resources were extensively used to achieve the various milestones with in-house teams addressing the commissioning of the command and control centres to bring substantial savings. "Wherever possible, other smart city project team members were sourced temporarily, including CSTI trainees, and we had a separate O&M team for service level agreement management while the local team was deployed for field O&M activities." With a zero-incident record, team SW&C has not only delivered a project of huge stature but, in the course, enhanced its inherent strengths with every team member gaining invaluable insights.



# MAKING 5 MILLION HOUSEHOLDS ENERGY EFFICIENT

## Engineering Advanced Metering Infrastructure

Advanced Metering Infrastructure (AMI), an offshoot of Smart Grid infrastructure, is all set to transform the management of the electricity ecosystem across the country with the Ministry of Power fast-tracking the installation of smart meters. L&T's SWC business was entrusted the task of installing more than 5 million smart meters in 54 cities across Uttar Pradesh, Haryana and New Delhi.

## Strategizing solutions for India's largest smart meter roll-out

Being a first-time implementation of the AMI solution on such a massive scale in the country, challenges were inevitable to meet the speed of smart meter installation and devise scalable and reliable solutions for the load envisaged. Since chosen domain applications were not pre-tested for this scale especially in multi-meter vendor environment and concurrency, arriving at the right solution was vital to meet the tall requirement.


VOICES FROM GROUND ZERO

**"With the help of our Technology Innovation Centre in Chennai, we carried out PoCs for faster solution roll out as the system was expected to be live right from the first meter roll out."**

**M.S. Krishna Kumar**
*DGM - Security Solutions Initiatives*

To overcome the challenges, the team did multiple Proof of Concepts (PoCs) to choose the best fit global technology solutions and partners which included Head End System, Meter Data Management, Connectivity Provider and Cloud provider. SW&C onboarded LTI to leverage their global expertise in Oracle utility products and domain expertise in Meter Data Management.

We initiated a series of measures for this massive roll out shares, M.S. Krishna Kumar, DGM - Security Solutions Initiatives, "With the help of our Technology Innovation Centre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> **Shashikant Agarwal**
> *Project Director*

in Chennai, we carried out PoCs for faster solution roll out as the system was expected to be live right from the first meter roll out, stitched solutions for scaling infrastructure incrementally for every 5 lakh meters so as to keep the cost within control while meeting business objectives. We opted for loosely coupled architecture for independent rollouts, enabled proactive coordination to receive customer load profiles and customization and set up dedicated UAT teams to coordinate and accomplish UAT by EESL and DISCOMS."

## Multisite management

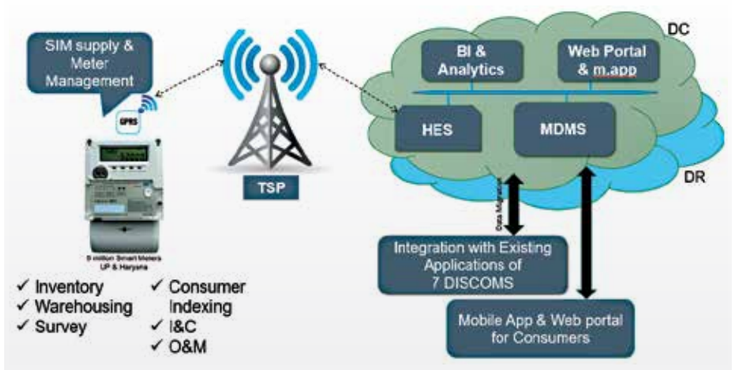
Considering the volume of 5 million households and multiple DISCOMS/ cities, meter installation in coordination with local DISCOMS and households was the biggest challenge and called for a proactive approach across various phases. Planning comprised setting up of zonal leads followed by city and division leads with clearly defined targets and schedule. A common SOP for consumer indexing, meter replacement and management was followed with multiple teams deployed across the states to complete the various milestones.

Digital interventions included inductions and video-based trainings to workmen, a work WhatsApp group to address common multisite issues and facilitate communication. Further, the local subcontractors and workmen registration processes were centralised to track their performance. A dedicated helpdesk was integrated with the existing system to address grievances along with ticketing and a SLA monitoring system.

## Inside out approach

The smart meter team went through the workings of the existing billing system to find out the root cause for inefficiencies.

**AMI System Architecture**




"We based our study on the Ishiwakawa or fishbone approach that outlined the various delay elements across constant factors covering machines, methods and material on one side of the scale compared with environment, measurement and workmen on the other side," highlights Shashikant Agarwal, Project Director. "The results exposed the poor productivity among some sub-contractors with less than 5 meters per manday that also contributed to below 60% billing efficiency."

## Driving automation

As the project was spread across 54 cities in 3 states, implementation was monitored online real time. A dedicated team led by U. Udhaya Kumar, Senior Manager, Digital, was quickly put together to develop a unique project monitoring application. "With just about 36 months in hand, we had a humongous task of developing a mobile app which tracks movement of 10 million meters, collecting data on the field, stores it in cloud, presents real-time dashboards to all stakeholders, facilitates multiple access points across mobile and desktop." Overall, this was a comprehensive solutions architecture where the application was structured with the data flow. As there is a central repository of data that everyone could access, there was no duplication/ corruption/ loss of information. It was a reliable system where every bit of data stored was authentic, valid and safe.

"We identified the operational gaps and fixed them one by one such as the bar code-based tracking of old meters. The old meters had to be handed over to DISCOMS on a periodic basis," elaborates Udhaya Kumar. The project involved handling 10 million meters, new and old, inventorying them and identifying the installed ones later for maintenance. When a field engineer removed old meters from across locations, there would have been no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> *Senior Manager, Digital*

track of which meter belonged to which consumer and subsequently handing over to the DISCOMS would have been even more complex. "Hence a system was evolved wherein the old meters were barcoded (randomly generated), that was captured in the mobile app and linked to the consumers. When placing the new meters, the old meter barcode was entered to track the consumer location before installing the new meter to simplify the process," highlights Krishna Kumar.

Further, the data from DISCOMS was scattered that increased the complexity in execution. To streamline the process, a common area wise identity was created with specific allocations with consumers in their respective areas that was available to all the field engineers in that area. The engineers were given a colour tag which had to be placed in consumer locations to indicate that a consumer had been attended and data verified. This was done in addition to the updation in the mobile application that avoided duplication and enabled complete utilization of field forces thereby improving productivity and reducing unnecessary travel.

## SIM-Meter mapping

For seamless integration of meter with the HES & MDMS, uninterrupted communication is the key. The team faced initial challenges in meter and SIM IP mapping, however, a quick decision was taken to fix the SIMs at the vendors' factory. A dedicated team was stationed at the meter manufacturer factory for installation, communication testing and mapping. The SIMs are QR coded to capture the SIM number automatically and mapped with meter numbers. For issues related to SIM, a centralised SIM and communication management portal was created to monitor the status of communication and SIM on-field activation "On the whole, we eliminated manual activities and rework as the mapping data was accessed through 'L&T Consumer Indexing / Meter Installation' portal," highlights Udhaya Kumar.

## Shrinking timelines

The AMI App comes with a range of benefits for the client as well as the end user, shares Pratik, Senior Engineer, Digital. "For the first time, people were empowered to efficiently manage power as the user-friendly application ensured higher reliability with information at fingertips to track and control energy usage. The earlier cumulative bill cycle of around 30 days was brought down to 10 days while the days spent in the process of advising meters was reduced from 26 days to just 6 days." A radical shift in the meter registration process in the Head End System was achieved with installation productivity improving to 7 meters per day along with a billing efficiency of more than 90%.


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> **Dharmapal Sahadeo Wankhede**
> *Head O&M*

## Forging bonds of trust

With Operations & Maintenance being an integral part of SW&C projects, nurturing a healthy relationship with the client is critical especially for additional leads, mentions Dharmapal Sahadeo Wankhede, Head O&M. "Add-on sales is one such lead and at SW&C, projects like Mumbai CCTV are testimony to this, while there are also projects where a model is shared to improve profitability of a single service partner when working on multiple jobs for the same client which is again value addition. From the execution point of view, the O&M Department has centralized some of the significant initiatives such as integrated operation for project management, centralized technical expert cell for taking up data centres and network operation works by creating an expert talent pool across projects to work in virtual NOC concept so that the dependency on OEM is reduced," he adds.

## Partnering excellence

By delivering a premium solutions architecture for the smart meter project, team SW&C has upped the ante, making it a win-win situation both for client and L&T while reinforcing the fact that operational excellence is all about successful project management and achieving customer satisfaction. ■

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*It was game on at the world's largest cricket stadium at Motera that opened its gates to host one lakh plus spectators to witness the 'Namaste Trump' event on February 24th, 2020. At the end of the huge event, as one L&T engineer quipped, "full load tested!"*

*Edited by Mr. Vinod Jacob Chacko for L&T Construction from L&T Construction Headquarters, Manapakkam, Chennai - 600 089. The views expressed in this magazine are not necessarily those of the Management.* 