Tough projects
Tougher people
Decades ago, a famous adhesive brand ran a very popular outdoor ad campaign that showed a car stuck to the hoarding with a supporting line, ‘It also sticks handles to teapots.’ The creative expression beautifully captured the wide gamut of the product’s applications. Similarly, this ‘ECC Concord’ issue captures the huge range of capabilities that we possess as the leading creator of vital infrastructure. Right from the precision required in building hospital infrastructure to tackling the might of a fast-flowing river in the Himalayas, we can handle them all with verve and enthusiasm.

The hospital team of the B&F IC was faced with the stiff task of creating the truly world-class, super-specialty NMC Royal Hospital for a very demanding client in the exacting environment of the Middle East. Every step of the way was a stern examination of our project management capabilities and it is a matter of pride for all of us that the hospital is almost ready for commissioning, complete in every respect to the utmost satisfaction of the client.

The City of Joy is normally associated with India’s first metro system, Rabindra Sangeet, Eden Gardens and rosuggas but, like every other major metro, Kolkata has a seamier side and the traffic is on the brink of being unmanageable. Contrary to a widely held belief, the authorities are seized of such issues and are constantly seeking measures of mitigation. In this case, our TI IC won the mandate to build a cluster of road projects that will go a long way in easing Kolkata’s traffic woes.

India remains thirsty for power and despite the best efforts of the Power Grid Corporation of India (PGCIL), the Central Transmission Utility (CTU), the country is still struggling to see the light. A small but significant step in this big journey has been taken by our PT&D IC by stringing vital transmission lines and erecting towers over 320 km in the Varanasi-Kanpur corridor which is a strategic power link that interconnects Delhi with regions of Western UP.

If our hardy colleagues had to face Naxal threats when putting up power infrastructure, some of them from the Water IC had to work within the claustrophobic confines of an underground sump that had not been opened for over three decades among other challenges so that 40 lakh people in the national capital will not go thirsty. The Bhagirathi Water Treatment Plant is a truly a landmark project.

The Kingdom of Bhutan is a world away from the world nestling amidst the mighty Himalayas and our team from the HCI IC has found the courage to change the course of a swiftly flowing river and cut into a mountain to create an awe-inspiring hydroelectric power project. The challenges are Himalayan to say the very least and we feature a story of these wonderful, brave individuals who are soldering on to complete our mandate even in the face of fierce resistance … from nature!

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Building a world of WELLNESS
Healthcare, according to Forbes, is a trillion dollar industry in the making and the need for sophisticated health centers offering a wide range of health-care products and services is on the rise the world over. A growing consciousness towards better health on one hand coupled with changes in lifestyles, irregular and improper dietary habits and widespread pollution are opening huge opportunities in the healthcare space.

A paradigm shift

Hospital architecture and designs have transformed over time, from the once sterile white walls and stark decors to vibrant colors and use of eye-catching materials making it look more like a luxury hotel where the nonclinical experience matters twice as much as clinical reputation. One such integrated healthcare centre is the NMC Royal Hospital, in Abu Dhabi - Khalifa City A. Its construction contract was bagged by L&T Construction's B&F IC and the project commenced on January 27, 2013. With NMC Healthcare LLC being UAE’s largest private sector healthcare provider, the hospital offers specialized medical care encompassing emergency services, intensive care, pediatrics, cardiology, ophthalmology, orthopedics, urology, neurology, psychiatry, gastroenterology, nephrology, and oncology. The hospital accommodates 250 patient beds, 78 ICU/ NICU beds and will eventually feature 23 specialties with a capacity to park 630 vehicles.

Touching the lives of millions

L&T touches the lives of people in many ways and healthcare occupies a pre-eminent position amongst them all. The NMC Royal Hospital, a landmark structure, completed at breathtaking speed with quality conforming to international standards is the second largest private hospital in Abu Dhabi and also the fourth and largest integrated specialty hospital in UAE that will cater to the growing population of Abu Dhabi’s Khalifa City A, Khalifa City B, Al Raha, Mussafah, Mohammed bin Zayed City, Masdar City, Abu Dhabi International Airport, Shahama and Yas Island. It will soon make a big contribution to Abu Dhabi’s economy by offering state-of-the-art medical facilities employing highly trained medical professionals.

Translating ideas into reality

On a land area of 54,200 sq.m allotted to NMC by the Abu Dhabi Municipality, L&T set about constructing a structure that comprised a basement, ground plus three floors over a total built-up area of 71,765 sq.m with 2276 rooms including 76 ICUs & NICUs. The concept drawings of external consultants were developed into detailed working drawings by Team L&T to enhance value especially in the areas of interior fit-out and MEP services for seamless construction.

The low-rise, high-end hospital

The basement has a laundry area, kitchen, staff dining area, IT server room, pharmacy, medical record room, nuclear medicine room, sterile store CSSD, mortuary, medical equipment store, waste rooms and a car park.

The Out Patient Department, Pharmacy, Radiology, Laboratory, ENT, Ophthalmology, General Medicine, Neurology and Neurosurgery, General Surgery, Cardiology, Cardiothoracic and VIP Consultation sections, Cafeteria/Cafeteria, a gift and a flower shop are all on located the ground floor.

The first floor accommodates patient rooms, Paediatric Medicine, Dental, Obstetrics – Gynaecology, Dermatology, Orthopaedic, Oncology (Medicine & Surgery), Caesarean Operation Theatre, Labour Rooms, N.I.C.U, Paediatric (Specialized Medicine), Dialysis, Urology, Psychiatry, Gastroenterology, and Endoscopy sections. There are also doctors’ consultation rooms, treatment rooms, nurse stations, pantry, utility rooms and a reception area along with designated rooms for children’s play area.

The most critical entities of the hospital, the Intensive Care Unit, Paediatric Intensive Care Unit, Cardiac Thoracic Intensive Care Unit, Cardiac Coronary Intensive Care Unit, Operation Theatres and patient rooms are located on the second floor above which are located the Royal suite, office areas, a beauty salon, an internal pharmacy, burn units and rehabilitation centres.

The hospital accommodates a service block with UG sump, DG, boilers and transformers too. A mosque is also situated within the hospital premise.

Engineering that touches lives

Structural and architectural engineering

The scope for L&T included construction, completions of all related external services and enabling works that involved excavation, shoring, piling and dewatering and all associated works and in addition to providing building services, vertical transportation, and exterior curtain wall/cladding.

Construction involved structural and architectural works of providing vinyl and marble flooring, vitrified tiles, false ceiling with gypsum and aluminium tiles, glazing works, metal doors with wooden shutters and exterior cladding with glazing and artificial stones. Further enhancement sought was with
Mechanical engineering

The mechanical services installed comprise fire, drainage, water, HVAC & medical gas. The hospital is centrally cooled by chillers. Chilled water is pumped via primary and secondary pumps from the service block to the main building to serve air handling units and fan coil units (FCUs). While a variable air volume (VAV) system cools the majority of space in the main building, the service area is fitted with FCUs. Fresh air flows from roof mounted air handlers with an in-built heat recovery system while sub-grade levels are served by chillers. Chilled water is cooled by chillers. Chilled water is circulated around the building from a central clarifier's storage. A gravity drainage system connects to the external site sewage/waste water system while sub-grade levels are served by gravity drainage. The fire protection system features a fully protected sprinkler system of class III in association with NFPA 13. Smoke clearance is through roof mounted smoke extract fans, exhausted through the general extract system. All staircases are pressurized for emergency escape.

Electrical engineering

The main building is fed from a booster pump system with duty/standby pumps. Electric water clarifiers located in the basement generate hot water that is circulated around the building from a central clarifier's storage. A gravity drainage system connects to the external site sewage/waste water system while sub-grade levels are served by a pumped drainage system. The fire protection system features a fully protected sprinkler system of class III in association with NFPA 13. Smoke clearance is through roof mounted smoke extract fans, exhausted through the general extract system. All staircases are pressurized for emergency escape.

Low voltage electrical services
- Voice and data/telecommunication
- Fiber optic network
- Music sound, audio – visual
- Public address and paging systems
- Fire detection and fire voice alarm systems
- CATV and SMATV systems
- An Audio-Video intercom system
- Security systems including CCTV, access control systems, barrier gates, guard booths and a central security management system
- Other specialized building services
  - Pneumatic Tube System
  - Hybrid Operation and Robotic Operation Theatres
  - Kitchen Equipment
  - Laundry Equipment including Boilers
  - Heat Pumps
  - Isolated Power Supply
  - Nurse Call System
  - Bed Head Units and Pendants

An innovative approach to healthcare infrastructure

True to its reputation as a leader in the construction of healthcare projects, L&T adopted several innovations for speedy and high-end completion.

- Polyolefin Elastomeric XLPE
  Insulation was used for HVAC ducts and chilled water pipes that reduced the work to a single stage against the conventional two stage method that resulted in a 30% saving in labour cost.
- Dry wall cladding on blockwork: The Fermacell gypsum fiber boards used for wall cladding offered all the benefits of a wet plastered wall with the speed and flexibility of a drywall, combined with improved impact, acoustic, fire, moisture and load bearing properties. Environmentally friendly, it took only half the time to execute compared to wet plastering.
- Window frame waterproofing: Bituminous waterproofing membrane used with silicone for window frames made them water resistant.

Spacious lobby and lift areas

high end interior fit out works – marble flooring, carpet wall finishes with glass mosaic tiles, wall paper wooden veneer, stainless steel false ceiling with mineral fibre ceiling and a combination of aluminium tiles with gypsum.

Vibrant rooms for the children on the first floor

Rest rooms at the Royal suite
• **Split steel frame:** The flexible telescopic design of the split steel frame used for doors that were powder coated and re-finished at site itself speeded up installation and at the same time reduced cost and time.

**Concreting milestone**

Concreting the raft foundation of the NMC Royal hospital was done in record time with the project achieving 25,084 cu.m of concrete from a total of 53,500 cu.m in 6 months. The process was divided into six pours and each horizontal concrete pour i.e. Pile caps and Grade Slab required time-consuming approvals from the Abu Dhabi Municipality as per the norms. However, despite the challenge, the structure was ready 7 days ahead of schedule.

**Converting a hospital building into a high-end specialty facility**

The most challenging aspect of hospital construction is the installation of medical equipment which makes the hospital facility truly world-class. At NMC, L&T astutely planned and executed all the pre-installation works including power and service provisions required for equipment, structural steel supports for lead line of the rooms, supply and installation of lead lined glass panels and the final finishing of the rooms. Many machines demanded modifications in the HVAC design and additional HEPA filters, and separate exhaust systems had to be introduced. Subsequently, the electrical load and other provisions had to be provided. The 3 Tesla capacity MRI machines demanded installation of 12" diameter stainless steel pipes for the emergency Helium Quench Discharge system to a height of approximately 30 meters. All of this involved extensive co-ordination among the various services, suppliers and the site team and engineering detailed drawings for the pre-installation of these highly advanced devices. Thanks to L&T’s domain knowledge and micro-detailing specialization, the project management team successfully aided equipment installation.

**Pneumatic Tube System (PTS) - The high speed missile that saves lives**

A state-of-the-art pneumatic tube system was installed for fast, efficient and reliable transport of lab samples, pharmaceuticals, patient documents, small parts and countless other applications securely using advanced technology. There are 9 front loading end stations, 28 front loading pass through stations, 20 diverters-3 way, 2 special multi station units for the laboratory and a linear transfer unit with provisions for 6 lines. There is also a central control unit and blowers with blower controller units.
Royal suite

The hospital's luxurious royal suite sprawls across a massive area of 5,000 square feet and is appointed with a deluxe patient room, a sitting room, an attendant's room, a Majlis, a dining room and a servant's room all with attached wash areas.

The master bedroom is fully equipped with facilities such as oxygen and suction, an electric bed, a big closet, a special table to serve food for the patient, a luxurious bathroom and a satellite TV. Along with a modern kitchen, separate entrance and nursing facilities, the Royal Suite also has a fully equipped business desk with private fax, telephone and laptop.

Hybrid Operation Theatres

For the extremely complex working environment of the hybrid operating room equipped with advanced medical imaging devices that enable minimal-invasive surgery, special wall substructures have been created that are capable of accommodating gas supply systems, water pipes, electricity and IT cables, air supply and exhaust equipment in line with the requirements of the equipment supplier Philips Allura Xper FD20 and meet all construction requirements in terms of fire, radiation and sound insulation.

A reflected ceiling plan has been drafted and a substructure capable of accommodating ceiling supply units, room lights, surgical lights, ventilation, cables and gas supply systems was constructed. The infrastructure required for digital OR-Integration and room control is installed, and the operating room's IT solutions are hooked up to the hospital's network, RIS and PACS. This Hybrid OR will be the first-of-its-kind in the Middle East.

A Robotic Operation Theatre features robots that aid surgeons in minimal invasive operations and ensure greater accuracy. These devices were pre-installed using a high-end network.

Four electrically heated calorifiers (3 working + 1 standby) generate hot water with the electrical load for each of 165 kW and a total electrical load for the 3 working calorifiers of 495 kW. At the client's request, L&T proposed heat pumps for hot water generation that were approved by the consultants and helped save about 218 kW electrical load.

Green features for a sustainable future

Water efficiency

Water usage in sanitary applications has been reduced up to 30% by installing low flow taps and sensor operated taps and the aerators in the wash basin mixers are compliant with ESTIDAMA Pearl 1 rating. The hospital uses other eco-friendly medical equipment like water saving sterilisers and washers (Getinge Eco system) which saves up to 75 % water.
Energy efficiency

Several energy efficient practices have been implemented for optimization of resources like the BMS (Building Management Systems) that helps maximize energy performance with lesser dependence on manpower. High efficiency heating & cooling equipment, heat recovery systems in air conditioning, natural ventilation and passive cooling, central lighting control system with motion sensors and dimming control systems, high efficiency switch gears, lights, appliances and intelligently planned and fixed fixtures all contribute to save energy.

Enhanced refrigerant management through the use of non CFC refrigerant which has low global warming and ozone depletion potential and cooling chillers, RAHUs and FAHU’s with ozone depletion potential and fitting through the use of non CFC refrigerant Enhanced refrigerant management to save energy.

and fixed fixtures all contribute to Energy efficiency

Power consumption by reducing the adopted that help save 25% in the total efficiency are some of the best practices variable speed controls for high chillers, RAHUs and FAHU’s with

ozone depletion potential and fitting through the use of non CFC refrigerant

Energy efficiency

Resource management

The site administration played a major role in establishing an affable work environment in a foreign territory. Some of the best practices followed include:

- Arrangement of visas for 318 direct workmen and 112 employees along with medical insurance facilities.
- On-time wages as per the norms of UAE Ministry of Labour using EIP workforce management module.
- Stringent scrutiny of documents of the subcontractor’s workmen while entering site premises. Registration of subcontractor agreement under the Ministry of Labour.
- Public interfacing and traffic management to resolve issues which occurred due to the location of the project in a residential area where vehicle movement was restricted and limited space for working and stocking of construction material.
- The administration team was instrumental in carrying the Good Samaritan image of L&T across workmen and the public at large. The project employed over 350 workmen from India and Pakistan and accommodation for these workmen was located far away from site making daily commuting a hassle. The site team not only organized conveyance but also provided food, laundry and recreation facilities for the workmen and appointed a manager in the workmen camp to monitor housekeeping and to check on food quality and quantity.

Playing it safe

With safety as one of the key criteria for international clients, the safety management at the NMC Royal construction was of the highest order. The project’s EHS management system was in line with the Abu Dhabi Environmental, Health and Safety Management System’s Regulatory Framework work version 2.0 Feb 2012 and compiled with the UAE Federal Law 1980. An index of the safe work culture was the clocking of 4.4 million safe man-hours without any time lost due to injury.

Leading from the front in quality

QMS is integral to every project and it was so in this project too. Every construction material was reviewed by an internal QA team and every activity was measured for its conformance and duly certified by the consultant. A third party was engaged for testing construction materials such as RMC, rebar steel, concrete block, plaster materials, tiles, etc. The Abu Dhabi Municipality tested the structural materials and conducted rebar inspections, coordinates checks, alignment checks and pre-pour-level checks. While concreting, a specially assigned quality inspector monitored the RMC quality in terms of its temperature and slump to avoid in-situ water addition, proper compaction and consistent curing. It was covered with a 100 Micron PVC sheet and a jute mesh of 250 GSM for all vertical and horizontal structures with additional water ponding. The pre-pour checks were conducted by the Abu Dhabi Municipality for all horizontal structures and effective pre and post checks for all the architectural and finishing works. Training sessions were conducted at regular intervals and pep talks were given to workmen to follow quality parameters.

The NMC Specialty Hospital project has won the Quality Trophy for the year 2013-14 under Building International BU category.

Pioneering hospital infrastructure development

While L&T translates every idea into reality, the organisation takes pride in building health infrastructure for nations catering to the ever growing demands of the public. With more than 45 hospitals, 15,000 beds, 20 million sq.ft. of built-up area, L&T is spreading hope every day.

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Brightening the travel scene in the CITY of JOY
How Kolkata got its moniker of 'City of Joy' is a matter of debate. It could have been the cheerful attitude of the Anand Nagar slum residents or Dominique Lapierre's novel on the savior saint who walked the city spreading joy among the poorest of poor. Whatever is the origin, the moniker is very questionable these days if one were to travel on the highly congested roads of Kolkata. It is obvious that the roads are indeed a kill-joy. What with the persistent traffic jams that have become so vexing that frustrated authorities have even started looking up at the sky, not in prayer, but to introduce ropeway systems to take some crowd off the over-crowded roads!

To ease this traffic menace more practically, the Government of West Bengal announced a series of infrastructure projects aiming to bypass traffic through elevated corridors and dedicated highways cutting across dense zones of the city. L&T won the mandate to construct a cluster of projects including a flyover and four Rail Over Bridges (ROBs) which were all part of the larger infrastructure plan. This challenging task that Kolkata Metropolitan Development Authority (KMDA) entrusted to L&T to complete on schedule was complex enough to drive away several leading contractors. Scattered around the city within a radius of 70 km, these projects demanded construction methodologies that could overcome the inherent locational issues apart from technical complications. While all the structures had similar types of foundation and substructure, the type and design of the superstructure changed based on the span lengths, which at times, fell within railway zones.

The project was also marked by other associated structures such as minor bridges, retaining walls and approach roads. The foundations were usually 1 x 1.2 m bored cast-in-situ piles with the average depth varying from 23 to 42 meters. The substructure contained trapezoidal pile caps of suitable sizes, 1.2 to 1.5 m deep and the superstructure supported on single piers were 2 x 2.5 m on the 4-lane part and 2 x 1.5 m on the 2-lane part of the flyover. While the design and execution of these structures were straightforward, the complication lay in the perennial flow of traffic on the existing roads. Almost all locations lacked the luxury of working space. At the Park Circus junction, even storing material and positioning cranes were a challenge with hutments located just a few feet from the project command area.

**Park Circus ROB**

The Eastern Metropolitan bypass or simply, the EM bypass, is a byeway on the eastern side of Kolkata which users take to reach the airport or to the newly developed satellite town of Salt Lake or to any other southern suburb. Considered the longest in Kolkata at 4.5 km, the Parama – Park Circus flyover project connects the island of Parama in EM bypass to the Park Circus crossing bringing great relief to harried commuters. In the second phase of its construction, the new flyover will finally connect EM bypass to the AIC Bose flyover which was built by L&T about a decade ago. The total combined length of elevated construction will then be 8.14 km from Parama island at EM Bypass to Hastings is at the central part of the city. Located along the Parama flyover alignment at central Kolkata is the Park Circus seven-point crossing, a vital part of the entire infrastructure that acts as a connector to switch to various parts of the city. Being the most critical portion of the entire project, the mandate to build a 680 m 4-lane flyover with 23 spans of 27 meters each was given to L&T.

The central span that crosses the railway zone is 70 meters for which an aesthetically designed steel bow-string girder was planned while all the other spans were precast, pre-stressed concrete girders. Another landmark in the making, the Park Circus ROB is a steel spectacle that will soon typify the spirit and soul of Kolkata bringing more joy to its residents who can now breathe easy while commuting around its central parts. Commissioned using the push launch methodology, the 380 t Bow string girder, in the assembled condition, was placed on the adjacent deck slab, pushed to the exact location and side-shifted to accommodate the second girder before being finally assembled together in position. Even with mere 4 hour Railway-blocks per night, the team took only six days to commission the girder, an unparalleled engineering feat.

The ROB portion was a nightmare by all construction standards owing to the traffic, paucity of space, presence of the main railway line below, slums and markets. The existing road being the only approach area and the short window period during late nights being the only time allotted, team L&T lifted and placed 134 girders adopting an innovative method called ‘side-shifting’ where the girders were first lifted to position at the nearer end of the Pier caps and moved to the far end using rollers to make room for the placement and commissioning of the next girder.

**Major Quantities**

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<tr>
<td>Pre-stressing work</td>
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</tbody>
</table>

View of the bow-string girder from the deck slab
Kamalgazi Flyover

The EM bypass cuts across from the north of the city near the airport to the south at Kamalgazi junction. The government drew up a plan to extend this crucial road to Baruipur to further enhance its connectivity while at the same time avoiding junctions, apart from leaving the existing ponds and habitats undisturbed. A 4-lane flyover was therefore proposed by KMDA for a total distance of 1.2 km including approaches, featuring 34 spans of 26 meter each with the superstructure of precast prestressed concrete girders and RCC deck slabs. Speaking about the experience, the Project Manager recalls that the local residents of this region came forward to help and even those displaced by the project were cooperative and even willingly helped relocate a religious structure.
Chandannagar ROB

The Chandannagar ROB project left the team in total disbelief at the very beginning. In what came as a shock, the alignment that was originally finalized at the tendering stage had to be entirely changed due to the huge density of population, presence of agricultural lands and issues with the existing railway line. This change forced an increase in the length of the project by 200 m to include a 773 m flyover and an approach road of 3.18 km that will help connect the suburban township of Chandannagar to the Delhi road.

Envisaged to provide hassle-free access to road users from the Grand Trunk road to the Delhi road, this project, once commissioned will also allow heavy vehicles to cross over the railway line which presently they do after travelling 15 circuitous kilometers. Apart from land acquisition which was a major challenge that forced the municipality to purchase private and agricultural lands, procuring fresh railway clearances for the changed location has been laborious and time-consuming.
Residents of Bhatpara, a suburb of Kolkata, use an old ROB to reach the city. This ROB can no longer handle the burgeoning traffic resulting in heavy traffic jams. A new ROB adjacent to the existing one was planned and originally conceived with ten smaller spans. This plan was later changed in adherence to the new railway norms to accommodate two 54 m spans and another one of 14 m. This change altered the entire design converting it into an attractive Warren Truss bridge with a 153 m approach on one side and a 225 m approach on the other, totaling the project length to 420 m of 2 lane construction. The rehabilitation of 156 hutments to create the work front proved to be a thorny issue. With construction completed on all the sections, the project team now awaits Railway clearance on the Warren Truss structure which lies in an assembled condition, ready for launch at the approach area of the project.
Including four minor bridges and one flyover of 10 spans (233 m), the Rail Over Bridge at Kalyani is a 2-lane structure. The project involves one span over the railway zone apart from flying over a few large ponds which were left undisturbed to preserve the natural topography. The project that falls on the Barrackpore-Kalyani expressway faced a major speed breaker since the ROB portion had to be constructed only from the existing road bridge parallel to the new construction but team L&T pulled it off successfully.

Flying past the odds to connect the dots

Any flyover project that attempts to cut across heavily congested localities and other transportation infrastructure faces the challenges of constructing in the midst of heavy, flowing traffic on the existing carriageways and the presence of huts hemming in that gave no room for project activities. As was the case with the KMDA projects. Being scattered around the city, the resources for these projects had to be shared to optimize on cost and therefore needed frequent shifting. Since the roads were congested during daytime, the shifting was done only during the nights that demanded accurate planning on resource sharing and logistics.

Dealing with the Railway authorities was another area that required both experience and expertise. During the girder launches, even the top brass from the project and the Railways were at the site ensuring that the plan was executed to the tee. Much before the launch, the execution team ensured that the adjacent spans or approaches were readied for launch in all respects and temporary trestles were carefully positioned within the Railway zone with necessary approvals. While crossing these work zones, train speeds were also reduced to stipulated levels.

A few of the projects including Kamalgazi and Chandannagar were located at low-lying areas where waterlogging during monsoon was a huge dampener. Considerable time was lost due to this locational disadvantage which the team mitigated through various dewatering measures.

The unity of command

The project followed a hub-and-spoke management strategy with one central command office at Kamalgazi managing the other spoke locations. For all practical purposes, the in-charges of each of these projects were independently responsible and were duly bestowed with the authority to execute as per plan and deliver results. Speaking on the cluster of projects, the project manager recalls how both the admin and the industrial relations team were continuously on their toes as were the other support departments such as design, safety and quality due to the large spread of the project area. However, he credits the brilliant team for the successful execution of the project, an invaluable experience that will stand them in great stead to handle more challenging projects in future.
Raising corridors of POWER
For a power deficit country as India, the quest for ‘24x7 Power-for-All’ seems like an elusive dream as demand constantly outstrips supply and the inefficiencies in the transmission system add up to the energy crisis affecting day-to-day life. Thankfully, this scenario is beginning to change for the better as the government has initiated ground work to map the country’s electricity requirement and has launched the Integrated Power Development Scheme through which distribution networks will be strengthened and power infrastructure scaled up to realize the nation’s vision of ‘power to all’ by 2022. With the present power generation capacity in the country pegged at 295,000 MW, States are gearing up to upgrade their respective transmission infrastructure to boost power supply. Uttar Pradesh, one among the five major power consuming states in the country, is engaged in revamping its transmission system by constructing and modernizing a range of high voltage lines of which the Varanasi-Kanpur corridor is a strategic power link that interconnects the grid with Delhi and the Western UP regions.

Boosting 6000 MW more of power

Power Grid Corporation of India (PGCIL), the Central Transmission Utility (CTU) in the country, is engaged in the augmentation of this transmission line in two stretches across a span of 320 km which when commissioned will add 6000 MW of power to the state grid.

Linking the composite chords of power

L&T was entrusted the task to execute a major portion of this line in a short span of 25 months. The project involved tower erection and stringing of Double Circuit 765 kV and 400 kV lines between Varanasi-Kanpur and Sarnath and also a loop-in loop-out Double Circuit 400 kV line from Sasaram to Allahabad. With the project spread over a large area, the team’s task was cut out to secure the right of way across 281 km that encompassed 781 towers over a range of terrains. To get a first-hand understanding of their travails and milestones achieved at site, the editorial team visited some of the most challenging sections of this transmission line for some key insights on the making of this powerful network.

Towering high across the fields

It’s a scorching day at Varanasi with the temperature hovering close to 40 degrees as the editorial team moves along National Highway 1 towards the vantage points of the project. The first location comes up after a nearly 20 km drive and the towers are aligned in a zig-zag pattern over paddy fields. It takes almost an hour of maneuvering down narrow pathways to get up close and personal with the towers. “You never get a straight stretch for more than 10 km in this project as the alignment runs through some of the most thickly populated settlements. There is always an angle tower along the corner,” indicates the planning in-charge. Rising up to 90 m in height and weighing over 200 t, the tower base spans 64 sq.m. “These are the largest of the four types of towers that are installed in this project,” highlights the project head. L&T’s scope covered detailed survey, profiling, tower spotting/optimization, soil resistivity measurement, geo-technical investigation, check survey, foundation, tower erection and stringing works.

Routing the corridor

Tower locations were finalized after a detailed land survey and feasibility study within a span of 4 months after which the project was broken into significant stretches to plan execution. “As the volume of construction and quantum of tower works involved were comparatively higher than in normal transmission line projects, we divided the entire line into 20 km stretches and plotted the zones as problematic or easy-to-handle locations,” informs the execution engineer that enabled the team to be better prepared when starting stretches.

Managing the right of way

Acquiring the right of way through the corridor was tough and while the scope of providing compensation to the individual or commercial landowners was with the client, the execution team had to bear the brunt of direct interfaces with the ‘informed’ locals because as the Project Head points out,
Partnering
A POWERFUL VISION

Sharing insights on the gains for the power sector on the commissioning of this line, Mr. U.R. Singh, Deputy General Manager, PGCIL says, “A transmission line of such span and capacity is being done for the first time by PGCIL and that we have completed this stretch in a record time speaks volumes of the efforts put in by L&T. Acquiring the right of way throughout the line was one of the toughest tasks but we have managed to sort out all the problems with in-depth planning and have worked together to achieve this milestone that would greatly benefit both the industry and people of Uttar Pradesh.”

“The villagers were already well versed with the pattern of compensation since there were commissioned transmission lines running along the new alignment and confronted the team with a host of issues.” By roping in the local administration and police officials, the team took charge of the most volatile locations and commenced the tower works in a phased manner. “In one of the areas we had close to 100 policemen for three days to facilitate safe working,” recalls the safety in-charge. The administration team interacted closely with the field crew and in cases where concurrence from land owners was required it was followed up diligently. The project team members camped at the adjacent habitats when the work was in progress and gradually made the locals understand the benefits of this transmission system.

Innovating on the work plan

A few stretches where the tower erection work is in its final stages of execution give a glimpse into the intricacies of the task. “A single tower comprises more than 4000 components and needs to be put together with precision,” smiles the tower in-charge. Tagging the vast range of joints and cross bars is like unravelling a jig saw puzzle! The planning head then elaborates, “The project team brainstormed on the way forward and for the first time in transmission line projects, a Bill of Material (BOM) with panel-wise structural drawings of the towers, was prepared at site taking the help of EDRC to evolve a tagging system for the components. With the client’s

Stringing work in progress
approval, the BOM was passed on to L&T’s tower manufacturing factories at Pithampur and Puducherry. To make the process further fool-proof, a team was deputed to oversee the production and despatch of the lots in a phased manner. Through this scheme, the erection of lighter and heavier towers was done simultaneously across a single stretch.”

A SOP for stores management

To facilitate timely issue of materials, three store yards were established at strategic junctions. “An existing SOP for stores was revised to cater to requirements of the project and materials were stacked in line with the panel codes. ITI fitters well versed with the tower erection works were deputed to segregate the tower elements,” shares one of the stores personnel at Bhadohi. During peak execution, the stores team handled and despatched on a daily basis around 60 t to 80 t of tower materials across locations.

Charting a secure way forward

One of the key factors that contributed to the success of the project was the minimization of tower material wastages and achieving maximum productivity across locations. The tack welding team which usually comes in when erection works are halfway through was deputed along with the tower erection team to speed up base welding works so that the towers were firmly grounded as early as possible and secured from pilferage as the alignment passed through unsafe areas.
Scaling heights

The tagged tower bundles were manually erected by a team of 30-35 skilled workmen using gin-poles, derricks and pulleys and the tenure for each tower erection extended from a week to a fortnight depending on its height. Most of the work was carried out when the terrain was barren during the non-agricultural period which hastened mobilization of resources. During peak activity, 1300 workmen along with 30 subcontractors were engaged across locations and achieved a monthly productivity of 2500 t.

The stringing of the line commenced only after completion of the entire 20 km stretch with tower back stays, conductor pullers and tensioners through a team of specialized workmen under strict supervision with the entire area cordoned off from the public after duly communicating through loudspeakers.

Critical cross-overs

As we approach a railway crossing, we see a passenger train slowing down at a nearby station. The stringing in-charge nods at the train, “Because there is only a single line linking Varanasi with the adjacent villages, this sector is always busy. In fact, this is the first time in a transmission project line that crossings were executed during the initial stage. We innovated on the task by optimizing the use of tools and tackles such as the double sheave pulley arrangement which saved on time, cost and facilitated the transmission wire sagging and insulator erection works. For the railway crossings, an hour’s shutdown was allocated during which a team of more than 100 people worked on a war footing to ensure that line and conductors were pulled over in a safe manner. Major road crossings were executed by blocking the traffic for a limited period of time and scaffoldings were arranged for smaller cross-overs. The presence of adjacent power lines posed a serious threat during the stringing works across 10 locations which were mitigated by enforcing temporary shutdowns with the help of the client and other power suppliers.”

Tower dynamics

It’s hard to gauge the height of these towers as all of them look imposing when seen from ground level. Throwing light on the dynamics, the tower in-charge at site indicates, “The three voltage lines comprised 441, 305 and 35 towers rising to a maximum height of 94 m and 80 m in the 765 and 400 voltage levels while the tallest tower in the loop in loop out line stood at 76 m. The weight of the towers varied in proportion to their height and ranged between 207 t to 61 t. Close to 1 lakh cu.m of concrete was used for the civil works and 50000 t of steel was used for the tower erection works.”

Ensuring a safe return

The successful completion of this project with more than 3 million safe-man hours is one more benchmark in the annals of L&T’s myriad achievements in transmission line projects. And with the nation focusing on the augmentation of the power infrastructure through a slew of long distance, high voltage energy systems, L&T is well poised to take forward the challenge of building a robust power infrastructure for the country.
Optimizing process systems for effective WATER MANAGEMENT
Among the water supply and regulatory boards across India, the Delhi Jal Board (DJB) holds a special place as it has pioneered the efficient distribution of water to meet the growing demands of the Capital’s burgeoning population. Through systematic planning and implementation of new technology, the Board has been revamping its infrastructure capabilities to manage water supply which becomes critical especially during summer. L&T has been ably partnering DJB for over a decade in its quest for providing quality drinking water by executing a slew of vital projects among which the 110 MGD Bhagirathi Water Treatment Plant is a landmark as it involved refurbishing a 32 year old treatment plant suitable to run for several more years.

Redefining the purification process

L&T was entrusted the critical task of managing a first-of-its-kind project in the annals of DJB with the added onus of a year’s Defect Liability Period and O&M for 10 years. The scope of work involved complete rehabilitation of the existing 100 MGD WTP replacing the old machineries, construction of a new chemical house building, bifurcation unit, renovation of the existing administrative building, filter houses, pump houses along with automation of the main plant, a 10 MGD WTP, 6 MGD reactor thickener recycle plant of the main plant, a 10 MGD WTP, 6 MGD reactor thickener recycle plant and the alternate source of pump house at Sangam. With a range of civil, mechanical and electrical works across critical junctures to be undertaken, it was up to the team to ensure that the different facets of the project. ‘Every presentation gives a primary insight into the criticalities while the project head suggests that a tour of the plant would unravel the engineering and construction process.’

Interconnecting the inlet main

The main source of raw water to the plant flows from the upper Ganga canal across 25.3 km through a 2800 mm diameter RCC gravity main to the intake at Muradnagar while there is also an alternative source of water which is tapped from river Yamuna through the adjacent Sangam pump house. While looking into the flow of water in the inlet main, the civil in-charge indicates, ‘Water flows throughout the year except for a brief period in November when UP Jal Nigam shutdowns for maintenance.’ The planning head adds, ‘Actually, this was the last leg of the project that we took up synchronizing with the shutdown. Cutting and removing a segment of the inlet main weighing close to 64 t was a precision task as we had to do it without affecting the existing inlet main for which the team deployed the diamond rope cutting method. And in about 20 days the interconnection was done with the new bifurcation chamber.’

Making every drop count

In operation since 1983 and being the oldest water treatment plant around, the system was stretched, productivity was low and cost of Operations and Maintenance (O&M) high. Findings of a survey initiated by DJB to find means of improving the plant’s performance suggested the rehabilitation and automation of the plant, outsourcing O&M to reduce cost of production of potable water, save on electricity and enhance equipment life to make the plant suitable to run for several more years.

Hostile environment as DJB had shifted close to 300 of its operators for which there was an agitation. We had to face their wrath and quickly mobilize a team to handle the O&M which was the first task at this project.’ A walk through the portals of Bhagirathi WTP is a delightful experience as the serene 65-acre campus is soothing, away from the sweltering heat of Delhi. It looks more like a park with neatly laid roads, rows of trees and vast stretches of lawns. Inside the plush corridors of the administrative office building, the planning in-charge takes us through the different facets of the project. ‘Every structure in this campus was built in a phased manner and the project is all about innovative re-engineering. When we began in December 2011, it was a
sluice gates before and after the bar screens and 4 motorized delivery valves to supply water to eight clarifiers of 100 MGD and one 10 MGD WTP. Overflow control measure is implemented with bypass access during power outages or any emergencies. When the main inlet is shutdown, alternative supply from the Sangam pump house is drawn to supply water.

Making over of the chemical house

As we move into the new chemical house building which is a ground plus one storey structure, there is tanker positioned just outside with hose pipes. The operator seeing the core team mentions, "Poly Aluminum Chloride (PAC) is being discharged into the storage unit." The safety in-charge provides protection masks and says, "Demolition of the old chemical house was a sensitive task as huge piles of alum was moved manually by skilled workmen in a short period of time with utmost safety. Presently, around 1000 t of alum and PAC are stored with provisions for saturation and dozing." As we seek further insights, the process engineer clarifies, "PAC and alum are mixed into the raw water to act as flocculants to purify the water while the chlorination system involves pre and post chlorination across three points in the WTP." During the construction of the new facility, the chlorine tonner capacity was enhanced from 4 to 16 cylinders and upon the insistence of the core team; one of the ducts is opened. "Chlorination piping layout was customized at site and facilitates conversion of chlorine gas to vacuum which is added to water for purification."

The transit phase was the most crucial one affirms the automation engineer, "We had to prepare standby units in the new facility and gradually attain full capacity and only then demolish the old building. While the civil scope was vast, the electrical and mechanical portions had to be deftly handled."

Reinforcing the treatment process

One of the most joyful sights at the WTP are the 10 clarifiers, brimful with water and its steel arm rotating slowly during the treatment process. Drawing close to one of the units, we can identify the difference between raw and treated water which was getting collected in the outer rim. L&T’s scope involved providing corrosion protection lining to the clarifloculators, replacement of V-notch and associated civil works along with installation of new scraper and flocculation mechanisms and electrically operated on/off timer based sludge line valve replacement. The section in-charge explains, "Dismantling the existing bridge which weighed around 12 t and de-slugging was done in a phased manner as shutdown was permitted for only one clarifier and it had to be synchronized along with the revamp works across the respective filter beds that were interconnected with the clarifloculator."

The planning head adds, "The team innovated on the process of installing the new bridge that weighed close to 15 t by fabricating and erecting a special tower/derrick and rope arrangement with a lifting capacity of 5 t that facilitated secure movement of the bridge components and resulted in huge savings on cost and time. Another edge added to this new system was the provision of controlling the operation in remote mode."
Re-engineering the filtration system

Two filter houses with 40 rapid sand filter beds located on the western and eastern part of the WTP forms the heart of the purification system and L&T was entrusted with the task of revamping a major portion of the works covering replacement of manually operated valves, filter media, under drain system with new motorized operated inlet, outlet and backwash inlet and outlet valves with a range of monitoring devices. “The crux was in timing the works with the clariloculator revamp as each bed was interconnected to the respective units,” indicates the civil in-charge. “Strengthening the roof was one of the first tasks and the way forward was innovatively planned as the work was done across the filtration zone.” Stretching a bit over the railings of one of the beds, he briefs, “Being a conventional filtration process, it was necessary to evolve a system whereby quality of the process was not affected.

After a lot of brainstorming, a suspended staging platform that could move on rails across the beds was developed at site and positioned at a height of 3.5 m. Further, to cover any other pitfalls, the whole work area was covered with tarpaulin sheets and the entire roofing works was completed in 4 months.” Another innovation was the installation of a special rubber bush for the jointing arrangement for the filter under the drain system for which the team won a PRASE award!

The mechanical scope had to do a lot with precision as the replacement of equipment fittings needed to be executed without damaging the existing puddle flange arrangements. To facilitate working in a stringent space, the team fabricated and installed two manually operated special gantry cranes for dismantling, shifting and erecting the new valves and other equipment during the limited shutdown period,” shares the mechanical engineer. As we move across the filter beds, our photographer focuses for a close-up image of the water movement and says, “This doesn’t look all that clear.” The automation engineer responds, “It is the mid-stage of filtration and the final output can be seen at the outlet valve in the equipment section below.’’ On course, he highlights that the facility is fully automated and equipped with a range of analytics to assess water quality and is secured with CCTV cameras. Opening one of the filter control boxes which encases the outlet valve, he shows the final output of water which is crystal clear and points to the monitoring equipment nearby that indicates the turbidity level that is well below the norms. The micro PLC based feature of the filter bed feature ensures monitoring the healthiness of the beds and updates the central control room.
Managing challenges below ground

It’s hard to believe that we are standing above the largest facility in the WTP, a 60x60 m lawn under which are the 5 reservoirs that stores water coming from the filter houses and supplying to the clear water sump. There are only four openings to access this vast chamber indicates the project manager, “One of the foremost things we did was to install the axial flow exhaust fan to remove the chlorine fumes. Getting into the reservoir needed a lot of guts as there was no access to light and the staircase was damaged. Renovating the pathway opened up the channel and we got to know that silt close to 1 m in depth was deposited across the chamber. Plus, there was the dampness and carbonization effect to contend with.”

The safety in-charge quips, “The area was cramped with a meager height of 3.6 m.”

A team of skilled divers first closed the gates of the respective reservoirs with dummy plates. This was not at all easy highlights the section in-charge, “The water was freezing at around 10 degrees as the work was taken up during the peak winter season and the divers found it extremely difficult to stay underwater for long periods bearing the load of the special tools and tackles to close the sluice gates over a week’s time.”

The art of desilting and revamping

Once the gates were closed, each tank was drained by isolating it from the filter channel and clear water sump in a phased manner to facilitate the desilting work that was carried out by a team of 230 workmen with special purpose negative suction head pump sets. The floor was wiped manually as the presence of 1024 pillars prevented the use of any kind of support machinery. On the safety front, arrangements were made for lighting and a customized blower system was introduced to reduce the moisture level and the whole process was closely monitored by the core team. Clearing the ground opened a way to assess the structure which needed reinforcement on the wall and roof areas. The civil team quickly applied sand and water

Landscaping view over the clear water reservoirs

Vertical turbine pumps at the Sangam pump house
jet blasting to remove the dust particles and reinforced the surface with repair mortar.

Breathing life into the heart of the system

Inside the clear water pump house, the sound of the motors working in tandem is deafening. The operator guides us to the basement where a row of centrifugal pumps are grounded in close proximity. “The pumping capacities range from 13.9 to a maximum of 14.3 MGD with pumps numbering 1 to 9 located in the eastern side of the pump house and 10 to 17 on the western side.” The dismantling and installation of the 17 pumps was achieved across five phases without affecting the pumping capacity remarks the section in-charge. The critical task was accomplished in a confined set-up wherein the old pump was dismantled in stages without damaging the companion flanges and the new pumps were precisely fitted into the existing puddle flange structures. The electrical engineer adds, “As there was water seepage from the running pumps, we had to ensure insulation and secure the work spot from electrical hazards.” The mechanical scope also included laying of a vital new main header of 1200 mm diameter across 150 m parallel to the existing CI header along with 17 branch pipes of 700 mm. For this crucial linking, the team laid the main header initially and fixed the branch pipes as the header was charged after taking the first shutdown. The existing branch pipes and main header were isolated by applying special purpose mechanical joints and blind flanges. The electrical scope included replacement of existing HT and LT transformers and a range of panels, starters, bus ducts and cables.

Wealth out of waste

A 6 MGD reactor thickener recycle plant recycles the sludge that is generated from the clarifiers and recycled water is pumped back into the bifurcation chamber while dried out sludge is carefully disposed off as per DJB guidelines.

A state-of-the-art control centre

The administrative building houses the core teams of DJB and L&T. An exclusive SCADA station in the central control room is connected through optical fibre cable ring and monitors the entire operations of the plant while access to the Sangam pump house is ensured through a point-to-point RF VPN system. Water from the 4 rising mains reaches out to 21 underground reservoirs in the eastern part of Delhi which is also monitored from the central control room and the updates are shared with the distribution centres across DJB.

Forging bonds of trust

Having done the hard work it was time for team L&T to extend support to DJB for the operations and maintenance of this plant over the next decade. A robust team of engineers drive the system forward and look back with pride of having achieved a particularly difficult task which is talked about with awe in the water sector across the country.
Empowering the land of HAPPINESS and POSSIBILITIES
The Kingdom of Bhutan is in wonderful harmony with its cultural heritage and thrust on economic growth. While the rest of the world pegs material development and GDP as indicators of growth, Bhutan advocates a loftier approach of measuring progress with ‘Gross National Happiness’ (GNH), testimony to which is the feeling of happiness that soars to welcome one as the plane glides into a valley to touch down at the breathtakingly beautiful and narrow airstrip at Paro, a few kilometers from the capital Thimpu – the seat of the Royal Kingdom.

Bhutan, a country nestled amidst the craggy Himalayan mountains, is marked by several swift, mighty and perennial rivers offering excellent opportunities for economic development in the form of generating Clean hydroelectric power. For this otherwise tranquil nation that fiercely guards its immaculate environment. Apart from agriculture and tourism, the two major sectors of the economy, the world’s youngest democracy has recently trained its eye on hydroelectric power for the necessary impetus to forge ahead.

On the course of its fast flowing glacier-fed rivers, Bhutan seeks to construct hydro power projects making the power sector the biggest contributor to the Bhutanese exchequer. With a vision to harness 20,000 MW by the year 2020, Bhutan is expected to be left with a capacity of 30,000 MW to spare. Following the successful implementation of Chukha, Tala, Basochu and Kurichu, the Punatsangchhu I (1200 MW), Punatsangchhu II (1020 MW) and the Mangdechhu (720 MW) are the recent and ambitious endeavours towards realizing this vision.

Punatsangchhu I is the first Project of the 10,000 MW initiative taken up jointly by the Royal Government of Bhutan (RGoB) and the Government of India (GoI) in May 2008. A milestone in the Indo-Bhutan relations, the Punatsangchhu I-Hydroelectric Project, is presently the largest hydropower project undertaken in Bhutan and is an environment-friendly, run-of-the-river scheme located on the left bank of River Punatsangchhu in the Wangdurchodrang Drongkhang of Western Bhutan.

Utilising a 357 m fall in the 11 km river course, the project will cost Rs. 9375 Crores and is being funded by the GoI through a 40% grant and a 60% loan to the client, Punatsangchhu Hydro Power Authority (PHPA), an autonomous body set up for the implementation of the project. WAPCOS Ltd., (Ministry of Water Resources, GoI) are the engineering design consultants with premier organizations such as the Central Electricity Authority, Central Water Commission, Central Water & Power Research Station, Central Soil & Materials Research Station, Geological Survey of India and Survey of India lending their invaluable expertise for the project through WAPCOS.

**Water to wire - Punatsangchhu I**

1. **Concrete Dam** – 130 m high and 249 m long at the top
2. **Two Diversion Tunnels** – each of 11 m diameter 1427 m and 1296 m long respectively
3. **Four Desilting Chambers** – each of 330 m length x 18 m width x 24 m depth
4. **Headrace Tunnel** – 10 m diameter, 8.9 km long
5. **Surge Shaft** – 24.5 m diameter, 128.5 m height
6. **Two Pressure Shafts** – 6 m diameter, 431 m long each & 6 penstocks of 3.32 m diameter
7. **Underground Power Station** – 236.5 m x 22.9 m x 53 m size to house 6 turbo generators of 200 MW capacity each
8. **Tailrace Tunnel** – 10 m diameter, 1.3 km long
9. **Underground Transformer Cavern** – 216 m x 14.7 m x 26.5 m to accommodate 20 single phase generator transformers each of 13.8KV/400KV & 82MVA capacity.
10. **Evacuation - Two 400kV Double Circuit transmission lines for 86 km**
Diverting with determination

In a hydro power project, the construction of diversion tunnels and coffer dams are perhaps the first and foremost tasks to excavate and later construct the dam and other downstream infrastructure. Initially planned for a river flow of 1930 cumecs, the coffer dam was originally a rock fill dam which was later converted to a 27 m high Colcrete dam following the flow analyses of the river during a flood which recorded 2500 cumecs. The coffer dam also includes cut-off walls made of plastic concrete using sophisticated trench cutting machines to prevent seepage due to the deep rock profile in the dam foundation. For the first time in Bhutan and, perhaps even in India, a 1.2 m wide, 93 m deep, positive concrete cut-off wall was constructed for a hydro power project.

Horseshoe-shaped, the pair of diversion tunnels were constructed using drill and blast method. Despite rapid mobilization of resources and going full steam ahead, the change in the design and execution of both the coffer dam and the rock fill dam delayed progress by over a year.

Harnessing quantum power

Being an environment friendly, run-of-the-river scheme, the dam structure has been planned to divert the copious flow of River Punatsangchhu into the head race tunnels towards the power house for power generation. For this purpose, four 6 m dia horseshoe-shaped power intake tunnels have been constructed that run for a total length of 1485 m to channelize the flow of the river towards the power house after passing through four gigantic desilting chambers.

Flushing out the silt

Himalayan rivers are famous not only for their might but also for the copious quantity of silt they carry along. All hydel projects spend heavily to remove this silt because they can potentially damage the turbines resulting in high wear and tear over a period of time. The large metallic trash racks at the mouth of the intake tunnels are designed to filter out large floating debris such as trees and animal carcasses. To filter out silt and smaller debris, the water is channelized through mammoth sized structures known as desilting chambers. In what can come as a surprise, these chambers are designed to sediment silt as small as 0.2 mm allowing only silt free water into the head race tunnel.

At Punnatsangchhu, for want of land, almost all structures are underground, as are the desilting chambers. Buried deep under the belly of the Himalayan Fold Mountains are four stunningly massive desilting chambers that are truly manmade underground marvels. The far end of the chamber features a
large wall that scales to almost the entire height of the structure, allowing just a few meters of head room to let debris-free water flow out. At the bottom of the chambers are small vents through which the silt trickles out into a dedicated D-shaped silt flushing tunnel that runs for 1629 m (diameter varies from 3.5 m to 5 m) before opening out into the original course of the river.

Excavating for the large desilting chambers was indeed a Himalayan task owing to the unexpected combinations of hard rock and soft rock. Apart from the usual grouting and the rock bolting, special techniques were used to avoid settlement of the excavated portion. Another innovation that greatly reduced cost and time was that instead of the planned 4 m bench, the team operated on a 7.3 m high bench to speed up execution, drawing accolades from the client. The project team integrated several additional requests from the client such as including steps and handrails inside the chamber apart from an access shaft to the roof portion for maintenance.

The concrete quality and finish of the desilting chamber is truly something to write home about. For a buried structure of such immensity, there is neither any trace of seepage nor joints that are easily visible. The finish equals to that of a city commercial building. This aspect of finish and quality of the entire underground structure has drawn the attention of the global engineering fraternity that has been making a beeline to witness this engineering marvel which will get inundated and inaccessible once operational.

From the desilting chamber, the water flows out through circular connecting tunnels of varying diameters (6 to 10 m) which merge two at a time to finally converge as the larger and circular profiled head race tunnel which will snake through the hills for 8.9 kilometers before ending at the powerhouse.
Creating access through adits

Being underground, all the structures need several adits for access. A 359 m long, 6.5 m diameter access tunnel from the adit through the desilting chamber to the top of the dam has been constructed to facilitate traffic to the gate operation chamber. In the process of executing this work, an industry benchmark of 255 m tunnel progress was set in a month, which is the highest achieved in Bhutan and in the Himalayas as well. In all, eight adits of various sizes have been constructed as enabling and permanent structures.

Burrowing deep down

In its own inimitable style, L&T quickly mobilized resources to take up the massive excavation task of the dam pit and reach the toe portion to enable foundation works. A whopping 64 lakh cu.m of earth had to be excavated for which a large fleet of 10 excavators, 45 dumpers, a couple of dozers, ten ROC with compressors and two drill jumbos were deployed. Racked by decades of excavation experience in complex geological conditions, the team fired on all cylinders setting a benchmark of 2 lakh cu.m per month which could well be a global benchmark. With an ambitious target of digging down to 80 m using the open pit excavation method, execution was progressing fast when a natural disaster struck!

The mountain starts to move!

In what could be described as a most unfortunate and unexpected occurrence, the right bank of the dam axis underwent a shear zone failure. The rocks and soil mass were moving along three axes at the same time giving rise to fears that the entire hill might slide downwards towards the dam pit. The team swung into action, along with the client, and acting on expert geological opinion from across the globe, started restoration works by which time the land mass had settled by about 5 m. The team drove 325 mm diameter micro piles into the hill at an angular depth of 120 m, apart from 95 m deep, 100 t cable anchors to ‘stitch’ the rocks together in place. Sophisticated instruments were installed to monitor and measure the hill movements which have now reduced to a bare minimum. As a final resort to permanently safeguard the right bank, the team envisages carrying out 2 m dia RCC piling work which will be driven to varying depths of 65 to 85 m. Once completed, this will yet again be another first-of-its-kind engineering feat for large diameter concrete piles driven to such depths.
A dam good reservoir in the making

Located in a deep valley flanked by steep hills, the view from the highway into the dam pit which is over a hundred meters below is vertiginous. Originally located about a kilometer and half downstream, the present location of the dam has been chosen in view of increasing the overall capacity by 200 MW. While the left bank of the dam pit features a steep and rocky hill face, the right bank slopes down gradually with hill cuts that allow for the arterial national highway to pass through apart from the few infrastructure that has been developed to enable construction.

The excavation work at the dam pit has presently been stalled awaiting the stabilization of the right bank. Once constructed following the excavation, the Concrete Gravity Dam will create a gross storage of 8.38 million cubic meters of water with a design head of 343 m for power generation. Standing 130 m high and 249 m long, the dam will house 13 blocks with seven central spillway sluices with an auxiliary bay for flushing the floating debris. The sluices have been designed to pass a flood discharge of 11500 cumecs along with glacial lake outburst flood discharge of 4300 cumecs.

L&T will also be installing critical hydro mechanical structures such as flood gates apart from constructing the associated civil structures including grouting galleries and vertical shafts. Originally planned with conventional concrete, the design was changed to include Roller Compacted Concrete (RCC) to make up for the initial delay in the project period. Being speed concrete that can be placed rapidly, leveled and compacted in quick succession needing virtually no curing time, the project management felt that placing over 17 lakh cu.m of RCC could crash the project period significantly. However RCC being a continual process needed a quicker and innovative method of placement. The team therefore came up with the idea of deploying conveyor delivery system to place 80,000 cu.m/month to achieve the schedule.

The team also planned two 28 t capacity cable cranes for concreting the spillway and piers for which a bench was cut on both sides of the banks to house the crane mechanism. The access to the left bank bench was so steep that the team had to lay a track and use wagons to shift material to the location. Later on, owing to the shear zone issue, the project team had to quickly dismantle this painstakingly installed infrastructure to ensure safety of not just the project team but of the users of the national highway that runs right below the path of the cable car.
Aggregating the resources

Once commenced, RCC will have to be poured continuously to avoid cold joints on the dam structure making ‘just-in-time’ sourcing a pressing issue and the project team will have to think out of the box about bringing material from India. They envisage that for the 10 lakh cu.m of concrete, 21 lakh tonnes of aggregates will be needed apart from the huge cement and flyash requirement. While aggregates up to 50% capacity can be stockpiled before concreting, the same cannot be done for cement and flyash due to quality issues and inherent material properties. Relying on flyash bowers across the long and arduous ghat sections is not a reliable option hence the project team is working on designing a right mix of cement and flyash that can be transported in bags from a cement plant in Siliguri, India.

Destruction for construction

Located 50 kilometers from the dam site, the 57 acre quarry location is a steep cliff of excellent quality stone but presently lacks good access for shifting the boulders. Flanked by two other private operational quarries, the access to this vertical strip of land needs to be cut in zigs which the team is right now busy with. Once quarried, the boulders have to be transported down the steep terrain using dumpers to the crusher plant. About 1500 tons are quarried per day (TPD) and productivity is expected to touch 5500 tpd during peak periods.

Screened to suit

The 2 x 200 ton per hour (tph) crusher plant is a sight to behold. With ease and elan, the sophisticated machinery breaks the huge boulders, crushing it into 40, 20, 10 mm and crusher sand to touch a peak productivity of 1.5 lakh ton per month. Appearing to sit on the valley like a giant tarantula, the multitude of conveyors keep delivering aggregates to the desired size. About 48 lakh tons of aggregates are required for the dam structure alone and to ensure continuous supply, the crusher unit has a captive stock yard of 6 lakh ton capacity. Utilizing the period before the stabilization of the right bank, the quarry team is inching towards stocking 50% of the aggregates near the dam site, the proof of which is the array of dumper trucks that one can see shuttling along the highway between these two facilities.

- 9.6 km of tunnel excavation
- 74 lakh cum of open excavation
- 5.5 lac cum Desilting Chamber excavation
- 80 m deep dam pit excavation below river bed (in progress)
- Massive excavation (12 m dia) for diversion tunnels
- ≤ 2.0 lac cum/month dam excavation continuously in a sustainable manner
Apart from the deep spirituality that typifies the Bhutanese way of life, it is impossible to miss the portrait of the royal family in every home and all public spaces. The reverence of the people for the royal family is pleasantly surprising as they recognize them for introducing GNH. Introduced by His Majesty the Fourth King of Bhutan, Jigme Singye Wangchuck, in the 1970s, the concept implies that sustainable development should take a holistic approach towards notions of progress and give equal importance to non-economic aspects of wellbeing. The concept of GNH has often been explained by its four pillars: good governance, sustainable socio-economic development, cultural preservation, and environmental conservation.
L&T’s power play in the second quarter

The Power Transmission & Distribution IC witnessed strong order inflows from both the international and domestic markets during the second quarter of the fiscal. A strategic breakthrough was made in the ASEAN market with a key order from Tenaga Nasional Berhad (TNB) for the design, manufacture, supply, installation, testing and commissioning of a 500 kV double circuit transmission line in Malaysia. This is one of the three packages of the 500 kV overhead double circuit transmission line for TNB from Yong-Peng to Lenggeng in Peninsular Malaysia which will be critical for evacuating power from the power plants in the Johor state.

Another significant mandate was won from Qatar General Electricity & Water Corporation ‘KAHRAMA’ for its ongoing Qatar Electricity Transmission Network Expansion Plan-Phase XII. The EPC order encompasses construction and strengthening of substation packages and the extension of a 132 kV substation apart from construction of four new 66 kV substations.

L&T Oman LLC, a subsidiary of L&T in Oman has bagged two major orders from Oman Electricity Transmission Company SAOG (OETC) for the engineering, procurement and construction of a 132 kV Grid Station at SAADA and 220 kV / 132 kV / 33 kV Grid Station at Madinat Sultan Qaboos (MSQ). An EPC order was received from Dubai Electricity & Water Authority (DEWA) for the construction of a 132/11 kV substation at Dubai.

On the domestic front, PT&D IC bagged orders from Tamil Nadu Transmission Corporation (TANTRANSCO) for the engineering, procurement and construction of a 400 kV double circuit (Quad) transmission line linking Kamuthi and Karaikudi and a turnkey project from the Transmission Corporation of Telangana Limited for the supply, erection, testing and commissioning of a 400 kV quad moose double circuit transmission line across Adilabad and Karimnagar districts.

Business in the Water Supply & Distribution business vertical flowed with the winning of a slew of projects. The Business won a major water supply order from Telangana Drinking Water Supply Project for the construction of a water treatment plant, 2835 km of pipeline network, twenty-five major water storage reservoirs and other associated works to meet the water needs of the Adilabad district. In the same state, L&T secured another water supply order from the Rural Water Supply & Sanitation Department for the construction of three water treatment plants, 1700 km of pipeline network, fifteen major water storage reservoirs and other associated works at Khammam district.

986 villages, seven urban towns in the Nagaur district and 111 villages and two towns of the Bikaner district in Rajasthan will receive potable water thanks to a project bagged from Public Health Engineering Department, Ajmer, under the Rajasthan Rural Water Supply and Fluorosis Mitigation Project. The scope includes a 5310 ML raw water reservoir, a 250 ML water treatment plant, raw and clear water pumping stations, mild steel and ductile iron pipelines, electro-mechanical, instrumentation and other allied works including operation and maintenance.

Rajasthan Urban Infrastructure Development Project (RUIDP) awarded another mandate for the construction of a treatment plant, waste water network and allied works in addition to works for the reduction of non-revenue water.

Transportation Infrastructure IC has won repeat orders from Delhi Metro Rail Corporation Limited for the supply, installation, testing and commissioning of ballast-less track of standard gauge on the elevated and underground sections of Mundka to Bahadurgarh and Dwarka to Najafgarh along with tracks in the depots of the Delhi MRTS Project Phase-III.
Mr. A.M. Naik, Group Executive Chairman, has been honoured with the GIANTS International Award 2015 for his pioneering contribution to the cause of Business and Industry. In a glittering ceremony in Mumbai, Mr. Naik was felicitated by Mr. Manohar Parrikar, Union Minister for Defence on September 16, 2015. AMN spoke about the critical role of the infrastructure sector in the Indian Economy and how Larsen & Toubro has been at the forefront of driving India's growth story and its commitment to nation building. "This recognition reflects the significance of this sector in national growth. I believe infrastructure underpins the economy and sound infrastructure is the springboard for the growth of all other sectors like transportation, process industry, agriculture, education, agriculture, health, consumer goods etc.”

Giants International is an India-based International Service Organization and provides its members an ideological base and organisational platform to enable citizens to play their role in improving socio-economic conditions for communities and position India as a premier nation in the evolving new world order.