

COVER STORY

METRO NEXT

Across 21 cities, 1,415 km of metro-rail projects worth ₹4.09 trillion have been approved. **CW** explores the construction opportunities for contracting companies and supporting industries.

QUICK BYTES

- About 600 km sanctioned metro lines under-construction; 1,000-1,500 km proposals under planning.
- Cost for elevated metro: ₹2.25-3 billion per km; underground metro: ₹5.50-5.75 billion per km.
- Scope of business expanding for lifts, escalators, elevators, tunnel ventilation systems and environment control systems.

Photo courtesy: Hindustan Construction Company

They say a true growth story is best reflected in numbers. Consider this: India's metro-rail story started at 8 km in 2002. Today, the country has achieved close to 600 km. And, going forward, roughly another 600 km of sanctioned metro lines are under construction with 1,000-1,500 km of metro-line proposals under planning.

Indeed, India's metro-rail network has grown rapidly to figure among the top 10 largest metro networks in the world.

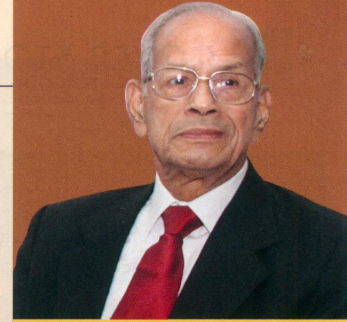
At present, Delhi Metro is the eighth largest metro train network in the world. Recently, the Delhi Government cleared the 103.93-km, six-corridor Delhi Metro Phase IV; once this is completed, Delhi Metro is expected to become the third largest metro network in the world. With a total length of about 453.58 km, it will overtake New York (380.2 km), Nanjing in China (378 km), Seoul (340.4 km), Moscow (381 km), Guangzhou (391.8 km) and London (402 km). Shanghai and Beijing are first and second, with a total length of 644 km and 599.44 km, respectively.

The revolution

Evidently, India is going through a metro revolution today. With 600 route km being used by over 5 million commuters today, over 15 cities in India are under various stages of adding an additional 1,500 route km in the near future.

That said, not all projects have been able to achieve timely completion within estimated costs. "The financial rate of return will be low (from +3 to negative) but the economic rate of return will be anything from 15-20 per cent," says **Dr E Sreedharan, Principal Adviser, Delhi Metro Rail Corporation (DMRC)**. "This means the metro is not an attractive area for an investor but it is a social need in which the government should invest."

For his part, **Mohammad Athar, Partner, PricewaterhouseCoopers**, says, "Like most major urban transit developments, the presence of a metro corridor has induced transformations in land use in connected areas. Commercial establishments and office areas place a high



Current challenges

Popularly known as India's Metro Man, Dr E Sreedharan, Principal Adviser, Delhi Metro Rail Corporation (DMRC), shares the main challenges faced by metro-rail projects in the present day:

- Although the metro is a rail-based transport mode that is technically more advanced and sophisticated, the Government of India (GoI) considers it as state subject, whereas railway is a central subject. GoI controls all technical parameters, safety certification and sanctioning powers but does not take the responsibility for losses and repayment of loans.
- The Central Government does not have a long-term vision or a sound and sustainable policy (the Metro Policy of August 2017 is short-sighted and restrictive) with regard to raising funds for metro construction, meeting operational losses or building up a managerial and technical framework to complete projects in time and within estimated costs.
- GoI considers private participation a must in all metro projects knowing fully well that all PPP metro projects in the country have failed so far.
- There is no effort on the part of GoI to reduce unit costs of metro projects through tax concessions or higher equity participation.

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TBMs, excavators, road headers, hydras, cranes, gantries, piling rigs, batching plants, transit mixers and boom placers, is being used in metro projects.

Construction Cost and Investment Returns

The cost of a metro project depends on the geographical location as well as many development constraints and requirements.

According to **Rahul Shah, COO-Urban Infrastructure, Tata Projects**, "The overall construction costs invested in materials, equipment and electrical components depend on various parameters." In fact, all these parameters are specified within tenders, which itself differ from one another.

Based on the data available in various DPR, **Mohammad Athar, Partner, PricewaterhouseCoopers**, says, "The cost of an elevated metro project is in the range of Rs 2.25-3 billion per km and underground metro is about Rs 5.50-5.75 billion per km."

For his part, **Nalin Gupta, Managing Director, J Kumar Infraprojects**, says the overall cost invested in construction materials, equipment and electrical components, etc, on an average,

is 50-60 per cent. Commenting on the per-km construction cost involved in underground metro, he shares, "It depends upon availability of specialised machinery and equipment (owned/hired/new) and experts to operate it. As for elevated metro, it depends upon availability of machinery and equipment and experienced men and the location of the site." He adds that the average investment return depends upon the availability of funds (capital plus interest for construction purpose).

Take the case of the Nagpur Metro project. According to **Sunil Mathur, Director (Rolling Stock & Systems), Maharashtra Metro Rail Corporation**, about 10 per cent of the total project cost comprises electrical installation. "The per-kilometre construction cost for the traction distribution system (TRD) of the elevated metro line comes to around Rs 100 million (per route km)," he shares.

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premium on better connectivity and have thus benefitted from the presence of the metro. Metro-rail systems are also increasingly viewed as a more environment-friendly mode of transport and have led to improvement in air quality."

In India, metro-rail has emerged as a preferential transport alternative in Tier-I cities faced with growing population, high traffic and increased pollution, according to **Ashwini Bhide, Managing Director, Mumbai Metro Rail Corporation**. "With the remarkable success of Delhi Metro, many states including Karnataka, Rajasthan, Tamil Nadu and Kerala have rapidly implemented metro-rail projects," she says.

And **Anuj Dayal, Executive Director, Corporate Communications, Delhi Metro Rail Corporation**, points out, "Metro-rail is non-polluting and carries a large number of people without restricting or occupying road space. Therefore, it is a potent answer to the congested roads of our urban centres."

Demand for support industries

With metro-rail systems growing, the scope of business and opportunities for various components like lifts, escalators, elevators, tunnel ventilation systems (TVS) and environment control systems (ECS) is also expanding.

Bhide shares the example of Mumbai's Metro Line 3 project, which comprises 33.5 km. "This line will have 26 underground



"Mumbai Metro Line 3 has 162 lifts and 381 escalators of different lengths."

- **Ashwini Bhide**, Managing Director, Mumbai Metro Rail Corporation

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City-wise distribution of approved metro projects

Project	Length (km)	Approved cost (₹billion)
Delhi*	411	1,100.25
Noida	29	55.03
Gurugram	11	36.35
Mumbai	197	820.78
Navi Mumbai	11	30.64
Kolkata	135	213.90
Bengaluru	114	402.50
Hyderabad	72	141.32
Chennai	54	183.70
Pune	54	175.44
Nagpur	38	86.80
Ahmedabad	36	107.73
Indore	32	75.01
Patna	31	133.66
Bhopal	28	69.41
Kochi	26	51.82
Lucknow	23	69.28
Jaipur	12	31.49
Surat*	40	120.20
Agra*	29	83.80
Kanpur*	32	110.76

Source: ICRA Research; Ministry of Housing & Urban Affairs (MoHUA)

*Delhi Metro Phase 4, Agra, Kanpur, and Surat Metro were approved recently (Feb/March-2019)

stations, attracting a great opportunity for the providers of TVS and ECS," she says. "This project has a total of 162 lifts and 381 escalators of different lengths. So, automatically, there is a huge demand for such component providers and support industries. A lot of equipment, including tunnel boring machines (TBMs), excavators, road headers, hydras, cranes, gantries, piling rigs, batching plants, transit mixers and boom placers, are being used."

Drawing attention to the large project development opportunities for contracting and component players across various metro



The most modern driverless metro coaches result in maximum utilisation of the available network.

packages (civil, signal and telecom, station infrastructure, etc), **Keshav Mishra, Director, PricewaterhouseCoopers**, says, "Metro stations, whether elevated, at grade or underground, are equipped with lift, travellers and escalators, and other BMS-controlled systems. Accordingly, the opportunity for manufacturers and suppliers during project execution and for operation and maintenance of installed systems exist."

"The increase in the number of kilometres in the metro network will necessitate more stations," says **Nalin Gupta, Managing Director, J Kumar Infraprojects**. "More stations will require more ticket counters and ticket vending

machines. And the need for security and safety will require more CCTVs and related accessories."

Arbind Kumar Rai, Deputy Project Director, CEC-ITD Cem-TPL JV, says, "In Mumbai, the ground is mostly rocky. Therefore, for Metro Line 3 underground works, the top-down method of station construction using D-walls was ruled out and the bottom-up method with secant piles was preferred. For the same reason, we constructed circular shafts for TBM lowering. We have also used concrete walers in place of steel to support excavation and our stations are also concrete-decked." After studying the geology of the area, the company opted for EPB TBM's from Herrenknecht, one



"Metro corridors have induced transformations in land use in connected areas."

- **Mohammad Athar**, Partner, PricewaterhouseCoopers



"Metro stations are equipped with lifts and escalators, and BMS systems."

- **Keshav Mishra**, Director, PricewaterhouseCoopers

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"AFD is currently working with Maha-Metro on the Nagpur and Pune metros."

- **Rajnish Ahuja**, Project Manager (Transport), French Development Agency (AFD)

New Delhi-based French Development Agency (AFD) has financed four metro projects in India: Kochi, Bengaluru, Nagpur and Pune. **Rajnish Ahuja**, Project Manager (Transport), AFD, shares more...

Success of metro-rail in India

Metro-rail projects are coming up rapidly. As more people move to cities, pressure on existing public transport systems – mainly public buses – increases, and the efficiency and quality of the service drops.

In Tier-I and Tier-II cities, this public transport is especially relevant. AFD, the French development bank, has supported the metro in Kochi and Bengaluru, and is currently working with Maha-Metro on the Nagpur and Pune metros as well.

Metros in India have improved connectivity, increased accessibility for people living further from city centres, and reduced travel time. Recent drives to introduce technological innovations and

promote integration with other modes of transport under the new Metro Rail Policy have further improved the quality of services proposed. With this and the growing demand for metro-rail, it is safe to say metro-rail projects in India have been quite successful.

How can the sector benefit?

The success rate of PPPs in this sector is yet to be ascertained. Without a clear idea of what their potential return on investment (RoI) could be, fewer private companies are currently willing to engage in PPPs. The sector could also benefit from the development of more innovative financing patterns, including bringing in private partners on the operations phase. Finally, owing to the scale of these projects, it is absolutely vital that land and environment and social issues related to a project are assessed ahead of time. The importance of having a diligently prepared resettlement action plan cannot be overstated.



Importance of metro-rail in India

India is conscious of its carbon emissions and air-quality challenges. The metro is one of the ways to reduce traffic congestion in cities. Also, as more people switch to the metro as the preferred mode of public transport, petrol and diesel consumption will also reduce. Ultimately, the metros aim to be a model mode of transport contributing to a low-carbon, climate-friendly future.

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of the safest equipment in such an urban environment.

Meanwhile, **Sunil Mathur**, Director (Rolling Stock & Systems), Maharashtra Metro Rail Corporation, says, Although most metro coaches run on electric mode, energy-efficient technologies like solar panels on-site/off-site installations, regenerative braking in rolling stock and regular energy monitoring in stations make the metro system

more eco-friendly. Apart from operations, last-mile connectivity through feeder buses or non-motorised transport also provides a reliable transport solution. And integration of metro stations with shopping malls and restaurants increases FSI." He sees a bright future for foreign companies to manufacture in the country as part of Make in India.

"Implementation of a metro

system includes installation of innumerable equipment along the stations, trackside, and off-site areas," Mathur continues. "There is a huge demand for telecom, machinery, air-conditioning systems, intelligent CCTV cameras, sensors and detection systems, which make the metro even smarter." According to him, major equipment used in the construction of metro projects are customised as per the requirement of individual

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"JICA will support metro projects through ODA loans and technical cooperation."

- **Katsuo Matsumoto**, Chief Representative, JICA India

To assist India in building its metro network, JICA has extended a cumulative loan amount of Japanese ¥1.3 trillion (about Rs 870 billion) for six cities: Delhi, Bengaluru, Chennai, Kolkata, Mumbai and Ahmedabad. **Katsuo Matsumoto**, Chief Representative, JICA India, shares more...

Current success of metro-rail projects in India

India has successfully expanded its overall transportation network to ensure better connectivity within cities. The country's robust metro-rail network has added to the economic development within these cities by providing easy, smooth and environment-friendly commuting. Metros have not only been successful in coping with the increasing demand for urban transport but in increased speed of vehicles and reduced road accidents. JICA-supported ongoing metro projects envisage building an efficient urban transportation system to cater to the growing population. The success of metro projects in India can be seen from the fact that besides carrying billion of passengers, they have considerably reduced vehicular pollution and provided commuters with an alternate means of travel that is faster and reliable. The metro has supported women who travel alone by strengthening security and ensuring safety even at odd hours and at remote places – 31 per cent of all Delhi Metro passengers are women, of which

82 per cent travel alone in the metro. Indeed, the metro networks in Delhi, Bengaluru, Kolkata, Chennai, Mumbai and Ahmedabad have been carefully designed keeping in mind the specific needs of the cities, including inclusive growth and development. JICA wishes to continue to support metro projects through ODA loans and technical cooperation in India.

Projects supported

JICA has been supporting projects in Delhi, Bengaluru, Chennai, Kolkata, Mumbai and Ahmedabad. In 2018, JICA signed an official development assistance (ODA) loan of Rs 16 billion for the third tranche of Kolkata Metro between Howrah Maidan to Salt Lake Sector V, including an underwater section, which is first-of-its-kind in India. A Rs 33-billion loan for Delhi Metro Phase 3 and Rs 43 billion for the first tranche of Chennai Metro Phase 2 were also signed for building a metro-rail system.

Challenges foreseen

Metro projects form the mobility backbone of the transport system in urban areas and the need to expand them becomes a crucial concern. Many engineering challenges in the underground and elevated stations, including safety protocols, land acquisition and rehabilitation and resettlement (R&R), become bottlenecks in project execution.



The financial requirement poses another challenge, which needs to be tackled through careful assessment of feasibility and readiness to involve private-sector participation. We believe India has been successful in mitigating these bottlenecks so far, ensuring quality infrastructure for its people. Looking further, there is probably much more room to forge a good framework where sustainability of metros could be enhanced through conversion of their spill-over economic effects into measures for new revenue generation. There is also a need to secure easy access of passengers to metro stations.

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“Integration of metro stations with shopping malls and restaurants increases FSI.”

- **Sunil Mathur**, Director (Rolling Stock & Systems), Maharashtra Metro Rail Corporation

metro systems, like road-cum-rail vehicles, man-lifting cranes for installation of overhead conductors, truck-mounted cranes or hydras for installation of lifts, escalators and heavy ventilation equipment like chillers and air-handling units (AHUs).

Key offerings

As is evident, supporting industries are also set to cater to the growing demand for metro projects.

For instance, BEML has supplied metro coaches to Delhi Metro, Bangalore Metro, Jaipur Metro and Kolkata Metro (East-West project). In fact, over 50 per cent of metro coaches being operated by DMRC are manufactured by BEML. Currently, the company is executing contracts for the supply of metro train sets to Bangalore Metro and Kolkata Metro and driverless metro coaches to Mumbai Metro's Line 2 and 7 projects. Further, the company is bidding for the supply of metro coaches to Phase 2 of Pune Metro and Bangalore Metro. "Metro coaches save on electric energy owing to regenerative



“The increase in the number of kilometres will necessitate more stations.”

- **Nalin Gupta**, Managing Director, J Kumar Infraprojects

J Kumar Infraprojects

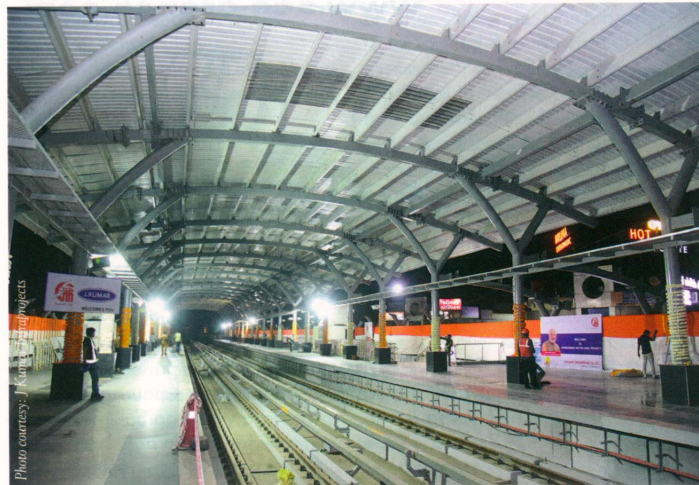
braking, have lower carbon emissions and are environment-friendly," says Deepak Kumar Hota, Chairman & Managing Director, BEML. "The most modern driverless metro coaches result in maximum utilisation of the available network and are a safe mode of transportation."

Otis India recently won an order for Bengaluru Metro for elevators, where units will be provided from its Bengaluru factory. The company also has 542 units at Hyderabad Metro, the largest order in the history of the elevator and escalator industry. It also recently commissioned 232 units for operation at Delhi Metro.

Status of operational/under implementation Metro-Rail Projects in India

City	Length (km)	Approved cost (₹billion)	Status
Delhi/NCR	379	905.8	Major part is operational
Mumbai	208	851.42	Partly operational
Kolkata	135	213.9	Operational
Bengaluru	114	402.5	Phase 1 operational
Hyderabad	72	141.32	Partly operational
Chennai	54	183.7	Partly operational
Pune	54	175.44	Under implementation
Surat	40	120.2	Recently approved
Nagpur	38	86.8	Under implementation
Ahmedabad	36	107.73	Under implementation
Indore	32	75.01	Recently approved
Kanpur	32	110.76	Recently approved
Patna	31	133.66	Recently approved
Agra	29	83.8	Recently approved
Bhopal	28	69.41	Recently approved
Kochi	26	51.82	Partly operational
Lucknow	23	69.28	Partly operational
Jaipur	12	31.49	Partly operational
Gurugram	11	36.35	Operational
Total	1,354	3,850.39	

Source: ICRA research, MoUD, Metro websites



More stations will require more ticket counters and ticket vending machines.

Mandatory Parameters for Standardisation and Indigenisation

The Centre has issued mandatory parameters for electrical components used in metro-rail systems, like lifts, escalators, tunnel ventilation and environmental control system.

According to **Nalin Gupta, Managing Director, J Kumar Infraprojects**, this will result in a boom in ancillary industries. "The notification makes it mandatory to use 50 per cent local content in compliance to public procurement, straightaway promoting Make in India," he says.

"Any mandatory technical parameters are meant to help standardisation and indigenisation," says **Dr E Sreedharan, Principal Adviser, Delhi Metro Rail Corporation (DMRC)**, viewing this as a correct step forward. However, he adds a note of caution: "Our zest for Make in India should not lead to dilution of specifications, which will jeopardise the safety and reliability of the system."

Meanwhile, **Keshav Mishra, Director, PricewaterhouseCoopers**, says, "This initiative will help reduce

the cost incurred for procurement (primarily design and validation), inventory management and spare availability and enable interchangeability and reliability." He adds that the capabilities of ancillary industries will also improve as the requirement for standard products, components or LRU will be higher. OEMs will undertake improvements in design and focus on cost-optimisation to comply with standard procedure and safety requirements to secure compatibility and interface consistency. This will also facilitate a competitive environment and removal of trade barriers, lower the capital cost of lifts and escalators, and open the opportunity for leasing services for OEMs. However, he points to a major challenge with standardisation: "It could limit innovation to develop or introduce a new product range owing to thin margins, limited improvement of product or service quality, and limited number of manufacturers and service providers in the market for

supply and maintenance of system, equipment and components."

As **Sunil Mathur, Director (Rolling Stock & Systems), Maharashtra Metro Rail Corporation**, informs us, "The Ministry of Housing & Urban Affairs, in consultation with Mumbai Metro, has issued standardisation parameters for all electrical equipment in metro systems for easy availability of spares and special tools during operation and maintenance." He says standardisation of lift mechanisms, like room-less elevators, VVVF motor use, safety switches and emergency mechanisms, has made lifts even safer, while standardisation of tunnel ventilation fans has made installation and maintenance easier. And the rating of chillers, fans and AHUs has an added advantage as these have a wide variety of specifications in the market.

"However, the guidelines on some equipment should be relaxed as these would be customised according to the particular city and metro project," adds Mathur. "For instance, tubular

"Metros have also turned to Otis's flagship product, the Gen2 elevator," says **Sebi Joseph, President, Otis India**. "Gen2 is designed to increase the elevator's efficiency, safety and reliability with key components that include a coated steel belt, as well as the ReGen

drive, permanent magnet machine and PULSE monitoring system."

To help effectively manage all the elevators at a metro or railway station, Otis offers the Web-based EMS Panorama system that enables building staff to monitor, control and report on a full range of operation-critical functions for an elevator and escalator from any computer with an Internet connection. Elevators and escalators installed at metros and railways are designed and adapted for use in public spaces considering heavy peaks and other traffic patterns throughout the day.

Robbins TBMs have been successfully used in projects in

Delhi Metro and Jaipur Metro, as well as a water transfer tunnel of 8.3 km in Mumbai, establishing an Indian tunnelling record of 870 m in a month – the entire tunnelling was completed in 18 months. Recently, two Robbins 6.65-m crossover TBMs have been deployed



"Metro coaches save on electric energy owing to regenerative braking."

- Deepak Kumar Hota, Chairman & Managing Director, BEML



"Gen2 is designed to increase the elevator's efficiency, safety and reliability."

- Sebi Joseph, President, Otis India

portals are used in the Nagpur and Pune metro projects for an aesthetic look; some standardisations of the electrical panel and switchgear equipment are new and would be designed again."

For her part, **Ashwini Bhide, Managing Director, Mumbai Metro Rail Corporation**, says, "In Metro Line 3, we are using machines keeping the mandatory parameters in mind. With this standardisation of specifications or requirements of equipment (lifts, escalators), there will be uniformity in general specifications of procurement stage. This leads to competitive prices, ease in operation and maintenance, shorter design finalisation and quicker deliveries of materials. It will generate more indigenisation and OEMs will be assured of markets for their products developed and manufactured in India."

As for elevators, **Otis' Bengaluru** factory is equipped to manufacture for this sector. "The elevators for Bengaluru Metro will come from the

Otis India facility," says **Sebi Joseph, President, Otis India**. "Our global technology transfer programmes have helped build the Make In India narrative. Such programmes help ensure that the Indian customer is offered the best tried-and-tested technology from across the world and give them the value they appreciate."

DMRC will specify indigenised equipment such as fans, chillers, etc, for its upcoming Phase 4 work. **B Ravindranath, Senior General Manager-Infrastructure Projects, Voltas**, says, "It will help lower the overall project cost and reduce dependence on foreign suppliers for such equipment and spares." Voltas is currently executing tunnel ventilation projects for six underground stations in Kolkata Metro and E&M works for two underground stations and six elevated stations in Chennai Metro. The company is also executing depot building E&M works in Chennai Metro for the Phase 1A extension.

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"Construction of three corridors has been approved for Delhi Metro Phase 4."

- **Anuj Dayal**, Executive Director, Corporate Communications, Delhi Metro Rail Corporation

in Mumbai Metro Package 1, performing over 250 m per machine per month. And Mumbai Metro Package 3 has two Robbins 6.65-m slurry TBMs running in its starting stages. Commenting on the Bangalore Metro, **Kapil Bhati, Managing Director, Robbins India**, says, "We have completed back-to-back operations on per-metre basis, including all manpower and procurement of materials for the complete drives from Chickpet to Majestic Drive in the difficult geology of Bangalore Metro Phase 1."

For Nagpur Metro, Siemens provided the modular and future-proven Trainguard MT automatic train control system. The East-West Corridor will have 19 stations and the North-South Corridor 17 stations, linking the airport with the Automotive Square at the north of the city. The communications-based train control (CBTC) solution can enable headways of 90 seconds or less with precise train detection achieved through a digitalised track database, enabling an increase in the frequency of trains. "The metro will play a pivotal role in enhancing quality of life and economic growth of the city and region," avers **Tilak Raj Seth, Executive Vice President, Siemens and CEO, Mobility Division**. "Mobility is an area of expertise for us and Siemens will continue to partner with the government to help improve connectivity and public infrastructure."



Photo courtesy: Delhi Metro Rail Corporation

Metro-rail is non-polluting and carries a large number of people without restricting or occupying road space.

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Achieving Landmarks with Technology

Afcons Infrastructure has been on the metro construction landscape since it was first introduced in India, with Kolkata Metro commencing operations in 1984. Subsequently, for Delhi Metro, the Shapoorji Pallonji Group company secured an elevated metro package in 2000 and completed the 4.5-km construction in 2003. Since then, it has completed over 42 km of elevated metro construction, underground station construction and aero-city alignment in the national capital.

At present, Afcons is building metro-rail infrastructure in Kolkata, Ahmedabad, Nagpur and Chennai. "We have constructed over 100 km of metro-rail, and more than 30 elevated and underground stations in five Indian cities," says **R Anantakumar, Executive Vice President, and BU Head, Urban Infrastructure, Afcons**, as he shares the company's key achievements in the segment...

Success of metro-rail projects in India

In India, Metro Rail Transit System (MRTS) projects are being undertaken across 13 cities, with the plan to introduce MRTS in 50 cities. Afcons built India's first underwater metro tunnels for Kolkata Metro below Hooghly River in just 67 days, and is also constructing the country's deepest metro station at Howrah. We are among the first Indian infrastructure companies to have constructed an underground metro station without a foreign JV at Barakhamba in New Delhi. Recently, we also completed the construction of one of Asia's biggest metro stations, Chennai Central.

Processes or mandates for quality

An ISO 9001:2015 certified company for quality of work, Afcons is also OHSMS ISO 45001:2018 certified. We follow an approved Standard Quality Assurance plan for every project as well as specific Quality Assurance plans, which form part of our contract. Also, construction materials, including cement, reinforcement and structural steel, is sourced directly from primary manufacturers. We ensure further quality checks in laboratories at sites as well as by third parties. Every lot of construction material is sampled at prefixed intervals and tested before use. This streamlines the entire process and provides the best output.

Technology innovations

- We have used the under-slung method of segmental construction to facilitate lighter launching system capable of negotiating sharp curves. This was further improvised to negotiate portals without dismantling by temporarily raising the launching of spans and thereafter lowering them.
- We have implemented top-down methodology for underground station construction to reduce the temporary structuring requirement.
- For certain projects, we have used temporary staging to facilitate the launching of truss walk over the station location without complete dismantling.
- The extensive use of steam curing to hasten concrete curing in winters has proved effective for us. Besides, we extensively use prefabricated steel spans, concrete girders

erected by cranes, sacrificial formworks and additives like silica fumes and GGBS to improve overall construction quality.

- Our engineers have designed a customised staging system to erect spans without launching truss to be used at difficult locations.
- Another example of innovation in Chennai was the use of plunge column construction by Wirth Rig, also known as Reverse Circulation Drilling (RCD), to penetrate higher grade rock for pile construction. In Chennai, we have also successfully retrieved a TBM from a bentonite flooded shaft.
- We used the overcut method for D-wall construction using a trench cutter and an innovative blade saw cutting method for cross-passage sump excavation.
- To negotiate loose soil strata, we have implemented tam grouting from surface for ground improvement. This has helped stabilise loose pockets over rock during mixed-face tunnelling.
- For Nagpur Metro, our in-house team has designed a double-decker launching girder that can negotiate a radius up to 200 m.
- Our engineers have also designed a 'Softeye' using styrofoam to ensure that TBMs can cut smoothly through D-walls. Also, special stripping stop-ends, imported from Germany, have been used for the first time in India for the Kolkata Metro.



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“We have completed back-to-back operations on per-metre basis in Bengaluru Metro Phase 1.”

- **Kapil Bhati**, Managing Director, Robbins India

Meanwhile, Voltas has successfully completed and handed over eight underground stations of DMRC and its execution work for the TVS package for six underground stations of Kolkata Metro is in progress. The company has executed works for 19 underground stations of Chennai Metro (station air-conditioning for all 19 stations and electrical and mechanical (E&M) works for seven out of these 19 stations), eight underground stations in Delhi Metro (station air-conditioning and tunnel ventilation works) and E&M works for six elevated stations in Kolkata Metro. “We are now in a position to offer ECS, TVS and E&M packages, which are the major services packages, for upcoming metro projects,” says **B Ravindranath**, Senior General Manager-Infrastructure Projects, Voltas. “It gives us a competitive advantage in the sense that only Voltas, and a few others, have credentials to qualify for such tenders on their own.”



“For Mumbai Metro Line 3 underground works, bottom-up method with secant piles was preferred.”

- **Arbind Kumar Rai**, Deputy Project Director, CEC-ITD Cem-TPL JV

Investment and execution challenges

Metro projects are capital-intensive in nature, with a long construction period and traffic build-up requiring several years.

“All these issues make debt-servicing a challenge,” says Athar.

“Accordingly, metro development corporations have been exploring long-term concessional financing. Multilateral development banks like JICA, ADB and KFW have played an active role in financing several projects across Indian cities. Hence, most projects in India

How effective has the Metro Rail Policy been?

Approved in 2017, the Metro Rail Policy not only makes PPP mandatory but directs states to adopt innovative mechanisms such as value capture financing tools and enable low-cost debt capital by issuing corporate bonds.

While he views the policy as progressive, **Dr E Sreedharan**, Principal Adviser, Delhi Metro Rail Corporation (DMRC), points out, “It fails to meet the challenges involved in introducing metros in our cities with a population over 2 million. There will be 35 of them within the next 10 years, for which we have to build metros at the rate of 200 km every year as against the present speed of 25 km per year.” He says the policy does not recognise that metro, being a highly sophisticated rail industry, has to be a central subject, not a state subject. It ring-fences the financial involvement of the Government of India and puts major problems such as raising loans, their payback, sharing of losses, etc, as part of the state’s goals; further, reducing cost and compressing implementation periods are not addressed. “In the transport sector, whether by road, air or water, basic infrastructure facilities are funded by the government and operators are required to fund only the vehicles and their operation and maintenance costs,” he adds. “But in a rail-based transport system, the operator has to fund the entire cost of infrastructure and the cost of vehicles, operation and maintenance.”

The PPP model aims to lessen the burden on the Central Government in funding metro projects. “This is not the first time the PPP model has been tried in India,” says **Nalin Gupta**, Managing Director, J Kumar Infraprojects. “The new policy of the Union Cabinet seeks to enable private investments in metro operations to deal with the financial state of the country.” As metros are capital-intensive, it makes it tough for private players to get their return on investment (RoI) – it can only be generated by increasing fares, which comes with its own share of issues.

For his part, **Mohammad Athar**, Partner, PricewaterhouseCoopers, lists key highlights of the policy:

- It provides for rigorous assessment of new metro proposals and proposes independent third-party assessment by agencies.
- Taking a note of the substantial social, economic and environmental gains of metro projects, the policy stipulates a shift from the current acceptance criteria for metro projects by MoUD ‘Financial Internal Rate of Return of 8 per cent’ to ‘Economic Internal Rate of Return of 14 per cent’, which is in line with global practices.
- The new policy empowers states to make rules and regulations to enable viability drivers; for example, setting up a permanent Fare Fixation Authority for timely revision of fares.

TO SHARE



COVER STORY



“Heavy traffic flow means short-time windows, making timely completion difficult.”

- Rahul Shah, COO-Urban Infrastructure, Tata Projects

have been implemented under EPC mode and with limited private-sector participation.”

For his part, Mishra shares areas for reducing delivery or implementation challenges in metro-rail projects: “Dedicated land or RoW for construction of projects; reduction of delay in clearance of site for construction; creating space to handle equipment and materials; research on indigenisation of metro technology and products; and enabling transport and traffic management policies to enable multi-modal integration.”

“DMRC has almost completed construction of the third phase

of expansion,” shares Dayal. “In 2018-19, over 140 km of new lines have been opened. We have also received approval for the construction of three corridors under the proposed Delhi Metro Phase 4.” He points out to land acquisition as the main challenge while executing mammoth infrastructure projects within city limits.

Mumbai Metro Line 3 has successfully completed six tunnel breakthroughs till now. Out of 52 km of tunnelling for the entire project, about 22 km has been completed. Overall, approximately 35 per cent work of the entire project has been completed. The total value of the project is 231.34 billion, of which 57 per cent is funded by JICA and the rest by the Centre and state governments. “This project faced multiple challenges in the beginning related to land and rehabilitation, shifting of utilities, coordination with multiple agencies for various approvals, social and environmental issues and issues related to public perception,” reveals Bhide, while

Metro-rail projects in DPR/ approval stage

City	Estimated cost (₹billion)
Delhi Metro Phase 4 and Extension	644.63
Uttar Pradesh (Varanasi, Meerut, Agra, Kanpur)	631.32
Guwahati	180.20
Andhra Pradesh (Visakhapatnam, Vijayawada)	165.59
Chandigarh	139.09
Mumbai – Line 2A, Line 7	118.02
Kerala (Thiruvananthapuram, Calicut, Kochi)	89.68
Others	24

Source: ICRA Research, MoUD, Metro websites

asserting that there have been no challenges as far as funding is concerned. “However, this entire project is technically challenging. So, there are some interface and design-related challenges that are being dealt with judiciously.”

Nagpur Metro has a total of 38 stations, and is divided into North-South and East-West



Energy-efficient technologies such as solar panels on-site/off-site installations make metro systems more eco-friendly.

COVER STORY



The cost of a metro project depends on the geographical location as well as many development constraints and requirements.

corridors. To date, it has 141 elevators and 213 escalators. As Mathur shares, the project had several challenges across various sections. For example, the foundation work needed utmost care while executing by the side of the existing Ram Jhula RoB foundation in such a manner that it did not disturb the soil strata adjoining the existing foundation. Further, the metro alignment near Sitabuldi interchange goes over railway lines, which necessitated the construction of a bridge over this section. One major challenge of Phase 1 was also the viaduct going from the airport to Sitabuldi metro

station. This stretch included the 15-year-old Chhatrapati Flyover, which needed to be demolished with public support. However, all these were overcome with iconic construction engineering techniques and solutions (*for details on the solutions adopted, log on to www.ConstructionWorld.in*).

As a major contributor to the metro-rail network in India, J Kumar Infraprojects is currently working on a total of nine projects across the Mumbai, Pune and Ahmedabad regions. "We work from foundation to superstructure, ie, up-to-deck slab in case of elevated metro-rail and construction of tunnel in case of

underground works," says Gupta.

Commenting on Mumbai Metro Line 3, Rai says, "The corridor is planned fully underground either on the edge of the existing road or along the median of the road." With 41 per cent of work completed, he adds that major execution-related challenges included old buildings with no record of foundations, lack of space, the shifting of utilities, and logistics for excavation and concrete.

Tata Projects recently completed Lucknow's 3.68-km Phase 1A (underground) metro extension and Delhi's 9.63-km Dilshad Garden-Ghaziabad New Bus Adda elevated metro extension. The company's team is currently working on Mumbai Metro Line 4, which involves two packages of elevated viaduct of 12.5 km connecting 14 stations. In addition, it is working on Mumbai Metro Line 3, which is a package involving underground twin tunnels of 6 km and three stations. In recent months, the company has also bagged tunnelling projects for the underground section of Pune Metro – this includes Package 1 of 2.5 km and Package 2 of 2.5 km.

"The execution of metro-rail projects in bustling urban areas requires specialised expertise and experience as additional precautions need to be taken to ensure minimal inconvenience to nearby residents and local businesses," says Rahul Shah, COO-Urban Infrastructure, Tata Projects. "In addition, heavy traffic flow means short-time windows, thereby making completion within stipulated timelines difficult."

That said, clearly, the metro revolution is on – and how!



"Metro will play a pivotal role in enhancing economic growth of the city."

- **Tilak Raj Seth**, Executive Vice President, and CEO, Mobility Division, Siemens



"We can now offer ECS, TVS and E&M packages for upcoming projects."

- **B Ravindranath**, Senior General Manager-Infrastructure Projects, Voltas

- **SHRIYAL SETHUMADHAVAN** | CW

To share your views on the Metro-Rail segment in India, write in at feedback@ConstructionWorld.in