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Customer Success Story

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AutoCAD Civil 3D has established India's first monorail project as a precedent for achieving a level of accuracy of up to 1 mm per meter and accomplishing 80% time optimization in deliverables.

Putting The Mumbai Monorail On Track

The Mumbai Monorail project is the first-of-its-kind in the country, built by an L&T-led consortium, using the AutoCAD Civil 3D software for optimized productivity, time, and resources.



A short test-run on January 26, 2010. The Indian flag is proudly waved as the country proudly adds itself to the developed nations of the world with its own Monorail. Image courtesy of Larsen & Toubro.

Project Summary

Having secured the Rs. 2,460 crore (USD 530 million) order from the Mumbai Metropolitan Region Development Authority (MMRDA), with the country's first monorail project. A consortium led by India's largest engineering and construction conglomerate, Larsen & Toubro (L&T) with Malaysian-based Scomi Engineering Bhd is currently in the process of implementing a pioneering development in the city of Mumbai.

Unlike conventional rail systems where the train runs on dual tracks, the monorail, operates on a single beam (also known as a guide beam) on an elevated corridor. It's considered amongst the world's most modern urban transport systems. In the urban context of India, especially Mumbai, where land resources are scarce, the monorail project duly assumes immense significance as it is seen as a viable option that requires the smallest footprint, it's eco-friendly, low on cost and free of noise pollution. The straddle type monorail system, equipped to carry two lakh (2,00,000) passengers per day, complies with the highest international standards of safety and reliability besides allowing high maneuverability by negotiating sharp curves and handling curves up to 6%. It's expected to decongest the highly crowded areas of Jacob Circle, Wadala and Chembur of Mumbai and will link its west and northeast corridors, the 19.54 km-long monorail project will have 18 stations in its route and will also connect the existing suburban railway system and the forthcoming Metro Rail in the city as part of a multimodal transport system.

L&T, an engineering technology and construction major, is among the largest and most reputed companies in India's private sector and a premier builder of infrastructure projects, with a track record of successful implementations of several large turnkey projects. As part of its new initiatives, L&T includes a dedicated Railway Business Unit to tap emerging opportunities in the rail sector. It already boasts design-and-build contracts from the Delhi Metro Rail Corporation. Scomi Engineering is one of the world's top three monorail manufacturers offering urban transportation solutions by providing the latest monorail electro-mechanical systems and rolling stock.

For the consortium, the scope of the project covers design works, development, construction, manufacturing, supply, installation, integrated testing and commissioning, and requires completion within a tight schedule. It is being implemented on a fast-track basis as the design facilitates execution with minimal demolition of structures. Given the strict confines, each of the project stakeholders heads a distinct responsibility. With Scomi Engineering involved as the design and technology partner, L&T has engaged three of its divisions – the Railway Business Unit, Engineering Construction & Contracts (ECC) and Integrated Engineering Services – Construction Engineering VBU (IES) – for the geometric detailing and construction of the monorail track. While L&T ECC prepares detailed construction drawings and documents besides executing construction work for this project, L&T IES produces 3D geometric

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models of the guide beams along the alignment to extract global, erection and casting coordinates for shop drawings.

The L&T-led consortium needed software that would help meet the challenge of building this first-of-its-kind Monorail project in the country, within stiff timelines and standards to also help bridge the multi-pronged simultaneous collaboration between the many teams and stakeholders. The consortium chose to adopt AutoCAD Civil 3D software, a comprehensive product for the design, drafting, and management of a wide range of civil engineering project types involving complicated geometry even in 3D spaces — including challenging transportation projects.

The Challenge

The Mumbai monorail project proved to be intricate at many levels beginning with its geometric design and its inability to find the appropriate technology to address it. In its initial phase, a partner additional to Scomi Engineering, designed the entire guide beam line profile, the beams and other details. It was imperative to transfer this complex geometry, correctly and accurately to the team at L&T ECC, which was entrusted with the actual construction. "The construction team needed these details not only to cast the beams but also to erect them in the required actual and ultimate line profile," says Mr. Swaraj Datta Gupta, Head IES – Construction Engineering, L&T Limited. "With L&T-Scomi having not received the geometric profile of the individual components of the entire line of guide beams from their design partner, IES Construction Engineering was entrusted to do the geometric work for all these guide beams. This was a big challenge," he added.

Complexity of Geometric Design

Contrary to roads and highways that are single entities with a top surface and can be seen only from the top two points, an individual track or guide beam profile is radically different. It needs to consider both top and bottom profiles for its geometric design, a complexity that was compounded further by the lower part of the beam not being circularly curved but parabolic in nature.

Mr. Arun Varadhrajan - Project Leader Engineer explains, "Our project was to get the total line layout from L&T-Scomi and the design partner, which would in turn give us the pier locations and the individual guide beam profiles along the line. Only then could we deliver both, the casting as well as erection coordinates for each and every guide beam along with its local coordinates".

Imagine a 3D line, which may be curved or have a super elevation or be straight, that also has a bottom profile where the soffit has a bit of a vertical curve apart from the profile curves. "This needed to be brought down to its coordinates on the ground level for effective casting!" In both cases, all four coordinates across the cross section on all four corners, starting every 500 mm from the pier location, were needed.

Lack of Appropriate/Customizable Software

The lack of appropriate software created a huge gap. "This project is the first-of-its-kind in India, and our research indicated there was no solution that was exclusively designed for the monorail," says Mr Datta Gupta. "All existing software was mainly for roads and highways, and since a monorail project profile is very different we were looking for software that could be

customized for this project." Other geometric software were not flexible enough to address the complexity of the geometry of the track profile, varying cross-section from rectangular to skewed and reverse to maintain track super-elevation, further complexity added with parabolic soffit of the guide beams.

Generation of Geometric Profiles from Paper Output

One of the biggest challenges emerged from the need to reuse information from drawings. "In many cases we did not have the actual profile from the designer. We had to make do with data from drawings in hard copy or PDF format, or from tabular data, from which we needed to recreate the profile," says Mr. Arun Varadharajan.

The Solution

AutoCAD Civil 3D software, the building information modeling (BIM) solution for civil engineering, helps teams deliver higher-quality transportation, land development, and environmental projects faster. Its model-based approach helps keep project information coordinated while delivering higher-quality documentation and visualization. AutoCAD Civil 3D helps users gain the competitive advantage of BIM to deliver more innovative project solutions. Its key new features include scalability and performance improvements, as well as an optimized 64-bit version of Civil 3D tools to better manage the creation and editing of corridors, and enhanced super-elevation functionality that provides a dynamic link to the alignment and flexible editing options.

Customized to tackle Unique Challenges

"We had explored several software solutions in our hunt for the right answer, and when Autodesk

I do not know whether we could have done it without AutoCAD Civil 3D. There is no match to its capabilities. The only other alternative was that we would have to do it manually using basic data analytics tools, and that would have certainly been laborious, time consuming and, needless to say, cost ineffective.

- Mr. Datta Gupta, Head IES – Construction Engineering, L&T Limited.



One of the first monorail beams for a new system: a beautiful sight for monorailists. The flat sided beam is being attached to special trailers for transportation to the monorail alignment. Image courtesy of Larsen & Toubro.

Against the need for a whole new training cycle for the team, it required only incremental learning to their existing understanding of current tools.

showcased us the complex capabilities of AutoCAD Civil 3D, during a meeting in Chennai, we felt it was exactly what we needed for our project,” says Mr. Datta Gupta. “It gave us so much flexibility that we can do almost anything in geometric design, and could easily create and profit from the digital design data, and better communicate across extended project teams. Furthermore, it could also be easily fine tuned to make it specifically usable for this particular project.” Constant engagement between the teams at L&T and Autodesk thus generated a fully customized software solution that helped the L&T team use 3D technologies to visualize, simulate and analyze the real-world performance of their designs early in the design process. Arun Varadharajan reinforces, “A big thank you to the Autodesk team for helping build a customized special assembly profile exclusively for the monorail alone. This had been a large vacuum and once this need was fulfilled successfully – all the other gaps were automatically taken care of as a result.”

Achieving Geometric Parameters with a High Level of Accuracy

“I don’t think we would have been able to execute the monorail project without AutoCAD Civil 3D,” says Mr. Datta Gupta. The software helped the project team take into account components of variation for individual beams, which are each 850 mm wide and 2000 mm in depth. Each of these components has been put together to create a curvilinear space in the air, viewed after construction as aesthetic curved rails running above the ground. “Between designing

a curvilinear path to measuring it in space in order to make the actual construction happen – there is a vital link between design, engineering and construction. We have achieved this very successfully and today 4 kms of our construction is over – and it would not have been possible without AutoCAD Civil 3D,” he adds. The software helped the team achieve the requisite level of accuracy - up to 1 mm per meter, setting a definite precedent for all future monorail projects in the country.

Optimization of Time and Resources

Autodesk software shapes itself as a common design platform that allows teams to collaborate and share project data effectively. Given that different divisions of L&T were already using Autodesk software such as AutoCAD as a basis for 2D design, detailing and documentation; the deployment of AutoCAD Civil 3D for the monorail project created an optimum advantage because it allowed a solution within the Autodesk environment. Against the need for a whole new training cycle for the team, it required only an incremental learning to their existing understanding of current tools. The design-centric approach of Autodesk differentiates it from most software solutions in the market that use a document-centric approach. While the initial time taken to build the standards and processes is a little high, when it comes to reusability of the same data, the user stands to gain considerable advantage. Mr. Datta Gupta states, “In the long run, it gives more beneficial returns and one can cut down on the real production time, enhancing overall productivity and efficiency.” With some initial

time investment the team created seven to eight templates for various kinds of beams for such as straight, curvilinear and horizontal beam etc. These became the standard or basic drawings, to which only coordinates needed to be supplied for every individual beam. “In sum – the familiarity of Autodesk software delivered about 80% time optimization, and we were able to drive an additional 20% internal optimization by managing the process efficiently,” he added.

Easily Make Changes & Minimize Errors

Considering that this was a fast track project with simultaneous collaboration between multiple stakeholders and several iterations involved during the design-to-execution stages, the advantage of AutoCAD Civil 3D software’s dynamic model-based design and its scalable, attainable and reusable technology became a pivotal link between the survey, design and, drafting and execution teams. This approach allows the process of design, visualization and simulation to be developed at its convenience, wherein any change automatically factors into the other parameters. Since it evolves as a digital prototype and accommodates changes digitally, the margin for error in a time-bound project can be minimized.

Interconnectivity between Design and Drafting

One of the challenges of the project was the replication of design from paper output into reality and AutoCAD Civil 3D was the only tool that facilitated the translation of hard copy into actual coordinates. “Although creating profiles was not in



The first beam being lifted into place. Image courtesy of Larsen & Toubro.

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our scope of work, we needed to create designs on our own, in the interest of maintaining the tempo of the project. In some cases we did not receive the actual profile from the principle designer but by using AutoCAD Civil 3D we could generate these just from the end points, tangent points or transition points,” explains Mr. Datta Gupta. “Now, we believe we are equipped to handle this additional element, and incorporate such backward integration within our scope of work for subsequent projects. This strengthens our capabilities and positions us as an end-to-end executor of complex monorail projects anywhere in the world.”

The Result

Using AutoCAD Civil 3D, the Mumbai monorail project has literally and figuratively fast tracked

its success story. “I do not know whether we could have done it without AutoCAD Civil 3D. There is no match to its capabilities. The only other alternative was that we would have to do it manually using basic data analytics tools, and that would have certainly been laborious, time consuming and, needless to say, cost ineffective,” says Mr. Datta Gupta.

AutoCAD Civil 3D has established India’s first monorail project as a precedent for achieving a level of accuracy of up to 1 mm per meter and accomplishing 80% time optimization in deliverables. Today the team is able to deliver one beam of 25m length within 30 minutes, including the quality checks and everything. “The per kilometer efficiency is mind-bogglingly high!”,

says Mr. Datta Gupta. “Autodesk has allowed us to redefine design processes, spurring innovation, achieving competitive advantage and enhancing overall productivity, and profitability. The magnitude of Autodesk’s value addition to L&T is immeasurable.”

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In a matter of days, with little disruption to the surrounding area, twelve pieces of track were put into place. Temporary bracing holds the track perfectly in position while gaps are filled with concrete. Even during the construction phase it’s evident that Mumbai Monorail has a good chance of being one of the best looking monorail systems in the world. Image courtesy of Larsen & Toubro.