



ENCARDIO RITE

ONE STOP MONITORING SOLUTIONS | HYDROLOGY | GEOTECHNICAL | STRUCTURAL | GEODECTIC

Over 50 years of excellence through ingenuity

CASE STUDY

MONITORING DURING LIFTING OF THE LINK BRIDGE AT ONE ZA'ABEEL ICD HQ PROJECT

PROJECT OVERVIEW

One Za'abeel Mixed-use is a landmark project currently under construction in Dubai, U.A.E. It is located between the Dubai World Trade Centre and Za'abeel Park. It comprises construction of two towers - Tower A with 305 m height and 69 levels (for residential apartments, offices, large retail area, high-end restaurants, and ultra-luxury hotel spaces) and Tower B with 240 m height and 59 levels (dedicated to residential apartments).

What makes the project iconic and a true engineering marvel is "The Linx" - a suspended bridge that will link two towers at a height of 105 m above the ground. It is approximately 230 m in length with a cantilever of 66 m projecting from tower A, spanning in the middle of the towers. The world's largest cantilever, The Linx, having a cross-section of 18 m² consists of four levels and will offer a choice of attractions, fine restaurants, lounges with a viewing deck, and a swimming pool on the roof.

The Main Contractor of the project, Alec, entrusted Encardio-rite to fulfill the monitoring scope during the complicated lifting and installation of The Linx weighing more than the Eiffel Tower!



The project includes a complex instrumentation & monitoring regime that comprises precise recording and near real-time transmission of horizontal & vertical deformations and geotechnical parameters during the construction process, to monitor and detect any unexpected behavior of the building well in time.

THE TASK

To monitor and send directly to the client the monitoring results in real-time, for towers A & B and the Link Bridge during the lifting and installation process.

THE LINK & ITS LIFTING IN NUMBERS

Length of the first section:	192 m
Weight of the first section:	9,000 t
Lifting distance of the first section:	77.5 m
Length of the second section:	34 m
Weight of the second section:	900 t
Lifting distance of the second section:	100 m
World Records:	Longest Cantilever

THE MONITORING EQUIPMENT

The project required a high degree of automation for the instrumentation & monitoring part because of the need of uploading the measurements virtually in real-time to the client's FTP server.

Unique I&M approaches were implemented by Encardio-rite in the project, both in terms of hardware and software, to achieve the best possible accuracy and telemetry speed.

Encardio-rite has deployed, four Leica TS16 fully automatic total stations with 1'' accuracy along with the Terramove Control Boxes that operated and transmitted the results of the total station's measurements after each cycle to the Terraweb database. These four completely automated 3D deformations monitoring systems are located on four pillars on both sides of the two towers. These are meant to measure the 3D optical targets that are located on the North & South sides of the two towers, and also the 3D targets located on the gantries of both the towers.

However, these four systems were not enough to cover the link bridge, as it would be lifted, as the position of the 3D optical targets installed on the bridge would change continuously as the lifting progresses.

For the monitoring of the Link Bridge, Encardio-rite used two semi-automated systems, that were located on the RTA bridge, throughout the lifting procedure.



Phase 2 Lifting in progress



Inside the Link Bridge



ATS with Terramove Control Box powered by solar panel



Each of these two semi-automated systems comprised a Leica TS16 1" accuracy total station and one tablet PC with Terraweb special software installed.

These two semi-automated systems were able to lift the telescope of the instruments, as per their operator's request, to locate the 3D targets installed on the Link Bridge being lifted. This ensured substantial time savings for the completion of the measurement cycles.

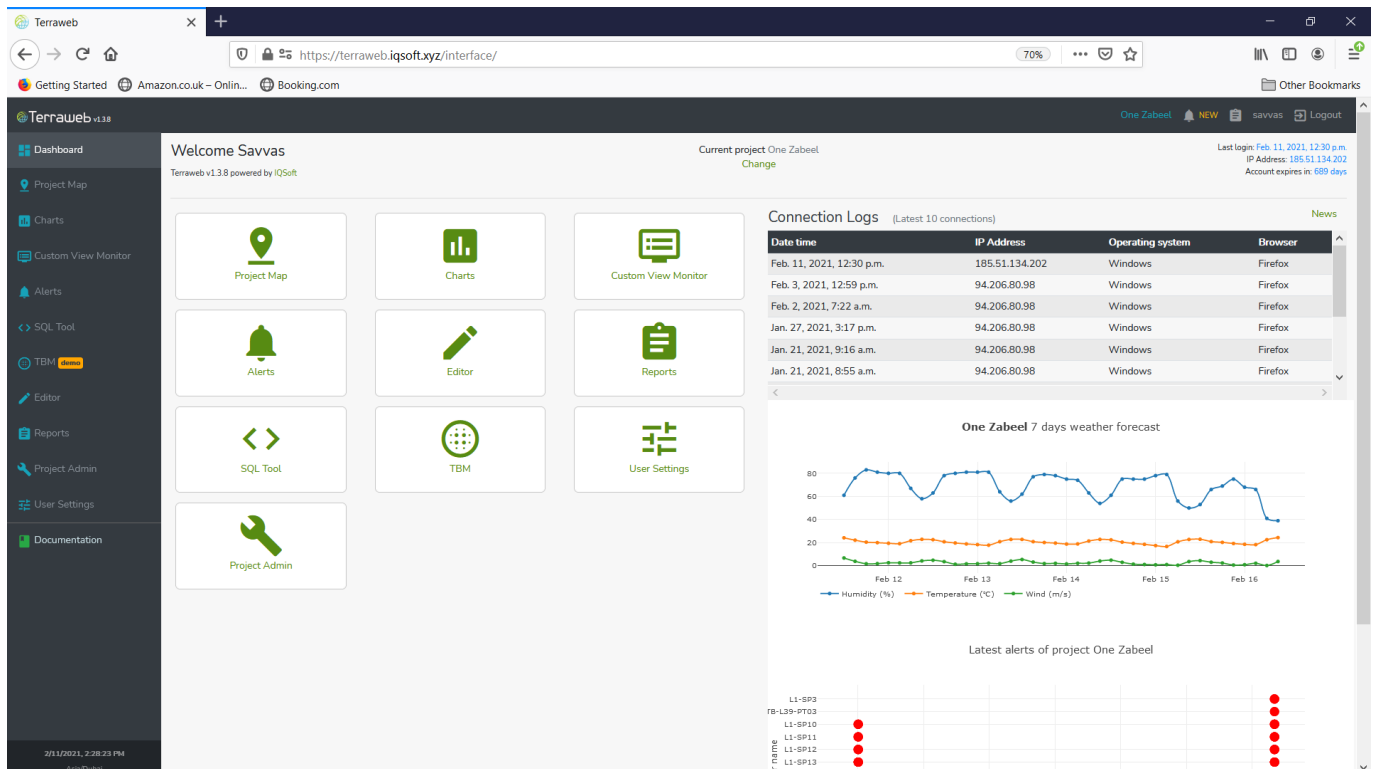
At the end of each measurement cycle, the two tablets connected to the internet automatically sent an e-mail to the Terraweb database with the updated results.

Encardio-rite developed a software for the project that transformed the received and processed data from the Terraweb database and send it directly into the client's FTP server in the requested format.

Within just 2 minutes of each reading cycle, the processed data was available in Terraweb's database as well as that of the client.



Semi-automatic ATS with tablet



Terraweb on-line data monitoring system



TerraWeb interface showing a list of surveying points and measurements. The interface includes a sidebar with navigation options like Dashboard, Project Map, Charts, Custom View Monitor, Alerts, SQL Tool, TBM, Editor, Reports, Project Admin, User Settings, and Documentation. The main area displays a table of surveying points with columns for State, ID, Point ID, Point Name, Active status, Date & Time, X, Y, Z, XTH, DCL, DH, Zero ID, Zero Date & Time, DX, DY, DZ, DXTH, DCL, and DOH. The table contains 24 rows of data, each representing a surveying point with its coordinates and associated measurements.

Data processed by TerraWeb DMS

Excel file produced automatically in requested by client format, ready to be uploaded in their database

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Initial Position (Coordinates)																
Live Position (Coordinates)																
Sl No	Location	Monitoring Point ID	X	Y	Z	Date and Time Recorded	X	Y	Z	Station	Offset	Date and Time Recorded	X	Y	Z	Station
52	Tower B	TL-26-SPB1	495896.0564	2791254.8024	110.1687	8/15/20 9:55 AM	495896.4102	2791255.0507	110.1577	226.79353	39.19412	24/08/2020 21:55:00	495896.4101	2791255.0601	110.1600	226.79889
53	Tower B	TL-26-SPB4	495927.0407	2791233.8632	109.3783	8/14/20 1:00 PM	495927.0427	2791233.8650	109.3803	189.55009	39.54482	15/08/2020 11:00:47	495927.0427	2791233.8650	109.3803	189.5501
54	Tower B	TL-26-SPB5	495913.0200	2791213.7027	109.3035	8/15/20 9:52 AM	495912.9883	2791213.7247	109.2914	189.42181	14.98613	24/08/2020 21:59:00	495912.9826	2791213.7077	109.2921	189.41645
55	Tower B	TL-26-SPB8	495882.4219	2791235.5701	109.2760	8/14/20 1:00 PM	495882.4100	2791235.5985	109.2769	227.01763	15.22882	24/08/2020 21:56:00	495882.4030	2791235.5850	109.2732	227.01527
56	Tower B	TL-29-SPB1	495897.4511	2791254.6871	127.4026	8/15/20 9:52 AM	495897.4491	2791254.6861	127.4031	225.73424	39.49486	24/08/2020 21:57:00	495897.4324	2791254.6773	127.4024	225.742835
57	Tower B	TL-29-SPB4	495926.3101	2791235.1946	127.5644	8/15/20 9:52 AM	495926.3074	2791235.1931	127.5645	190.91653	40.20595	24/08/2020 21:57:00	495926.2870	2791235.1774	127.5572	190.92421
58	Tower B	TL-SP72	495910.3895	2791212.7654	127.8327	8/15/20 9:52 AM	495910.3721	2791212.7952	127.8343	191.02323	12.7179	24/08/2020 21:59:00	495910.3592	2791212.7660	127.8237	191.02101
59	Tower B	TL-SP74	495882.2499	2791232.5502	127.4024	8/14/20 1:00 PM	495882.2089	2791232.5654	127.3927	225.4327	12.6339	24/08/2020 21:59:00	495882.2076	2791232.5441	127.3887	225.421695
60	Tower B	TL-SP71	495910.6791	2791212.1061	134.2455	8/14/20 1:00 PM	495910.6737	2791212.1414	134.2482	190.39974	12.35743	24/08/2020 21:56:00	495910.6639	2791212.1180	134.2391	190.394505
61	Tower B	TL-SP66	495881.3897	2791233.4873	134.7774	8/14/20 1:00 PM	495881.3791	2791233.5143	134.7787	226.65784	12.93087	24/08/2020 21:56:00	495881.3678	2791233.4977	134.7692	226.65773
62	Tower B	TL-SP70	495910.6933	2791212.5542	148.8565	8/14/20 1:00 PM	495910.6868	2791212.5917	148.8583	190.64906	12.73348	24/08/2020 21:56:00	495910.6726	2791212.5655	148.8468	190.64534
63	Tower B	TL-SP65	495881.4826	2791233.5813	149.2422	8/14/20 1:00 PM	495881.4722	2791233.6073	149.2436	226.63539	13.06054	24/08/2020 21:56:00	495881.4633	2791233.5764	149.2287	226.625045
64	Gantry B	TL-SP73	495905.6072	2791205.0281	131.6605	8/14/20 1:00 PM	495905.6035	2791205.0608	131.6629	190.46048	3.64941	24/08/2020 21:56:00	495905.5883	2791205.0395	131.6478	190.460475
65	Gantry B	TL-SP74	495902.0377	2791199.9371	130.8071	8/14/20 1:00 PM	495902.0341	2791199.9723	130.8097	190.44287	-2.56656	24/08/2020 21:56:00	495902.0228	2791199.9528	130.7826	190.441015
66	Gantry B	TL-SP68	495876.6900	2791226.5240	132.5490	8/14/20 1:00 PM	495876.6802	2791226.5527	132.5504	226.48381	4.53416	24/08/2020 21:56:00	495876.6685	2791226.5280	132.5340	226.47898
67	Gantry B	TL-SP69	495871.8785	2791219.6626	132.3230	8/14/20 1:00 PM	495871.8712	2791219.6885	132.3250	226.45566	-3.84679	24/08/2020 21:56:00	495871.8593	2791219.6642	132.2975	226.451085
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70	Tower B	TL-135-SPB1	495897.6475	2791255.2338	148.8506	8/15/20 9:52 AM	495897.6456	2791255.2330	148.8517	225.88906	40.05509	24/08/2020 21:57:00	495897.6246	2791255.2077	148.8503	225.891635
71	Tower B	TL-135-SPB4	495927.1034	2791234.5497	147.6892	8/15/20 9:52 AM	495926.9819	2791234.5787	148.5343	189.89611	39.92974	24/08/2020 21:57:00	495926.9560	2791234.5382	148.5303	189.90214
72	Link Bridge	TL-SP1	495753.8563	2791296.9499	28.8200	8/14/20 1:00 PM	495755.2621	2791296.0204	28.7909	365.74118	-8.70991	24/08/2020 22:16:00	495755.2277	2791295.9379	28.8965	365.722
73	Link Bridge	TL-SP2	495774.6804	2791282.534	28.914525	7/20/20 12:00 AM	495774.682	2791282.535	28.914	342.09914	-8.53156	24/08/2020 21:00:00	495776.0909	2791281.476	28.9048	340.3375
74	Link Bridge	TL-SP3	495783.3930	2791275.6228	28.5935	8/14/20 1:00 PM	495783.3689	2791275.6175	28.5783	331.61401	-8.4971	24/08/2020 22:16:00	495783.3329	2791276.4409	28.8113	331.599
75	Link Bridge	TL-SP4	495802.8705	2791261.9184	28.6597	8/14/20 1:00 PM	495802.9014	2791261.9141	28.6403	307.15311	-9.11048	24/08/2020 22:16:00	495802.8726	2791261.8368	28.7891	307.1321
76	Link Bridge	TL-SP5	495822.1557	2791248.5901	28.6076	8/14/20 1:00 PM	495822.1577	2791248.5920	28.6096	283.73872	-8.89327	15/08/2020 11:00:47	495822.1577	2791248.5920	28.6096	283.7387
77	Link Bridge	TL-SP6	495846.9872	2791230.5091	29.9152	8/14/20 1:00 PM	495846.9891	2791230.5319	29.8956	253.0744	-9.33302	24/08/2020 22:16:00	495846.9572	2791230.4698	29.9076	253.0277
78	Link Bridge	TL-SP7	495869.5911	2791214.6242	29.8053	8/14/20 1:00 PM	495866.4977	2791216.7613	29.8169	291.5804	-9.33722	24/08/2020 22:16:00	495866.4532	2791216.7134	29.8072	291.1652
79	Link Bridge	TL-SP8	495898.2368	2791194.5960	29.9856	8/14/20 1:00 PM	495899.3601	2791193.6991	29.9413	189.01103	-9.23369	24/08/2020 22:25:00	495899.2984	2791193.6826	29.9156	189.0349
80	Link Bridge	TL-SP9	495764.3128	2791230.9414	28.8447	8/14/20 1:00 PM	495764.3955	2791230.8947	28.7937	366.85472	8.70976	24/08/2020 22:16:00	495764.3625	2791230.8204	28.8211	366.8387
81	Link Bridge	TL-SP10	495785.2277	2791297.117	29.82305	8/14/20 1:00 PM	495785.2341	2791297.115	29.82285	341.88343	9.46501	24/08/2020 22:16:00	495785.2034	2791297.049	29.8734	341.8706
82	Link Bridge	TL-SP11	495793.5074	2791290.4469	28.7314	8/14/20 1:00 PM	495793.4849	2791290.5535	28.6892	331.35927	8.86121	24/08/2020 22:16:00	495793.4464	2791290.4852	28.7528	331.3511
83	Link Bridge	TL-SP12	495813.3073	2791276.6527	28.6875	8/14/20 1:00 PM	495813.3286	2791276.6591	28.6828	307.13458	8.9489	24/08/2020 22:16:00	495813.2920	2791276.5877	28.7503	307.1234
84	Link Bridge	TL-SP13	495832.3167	2791262.3624	30.0443	8/14/20 1:00 PM	495832.3138	2791262.3031	30.0438	382.13438	0.6061	24/08/2020 22:16:00	495832.3068	2791262.3370	30.1374	382.1658

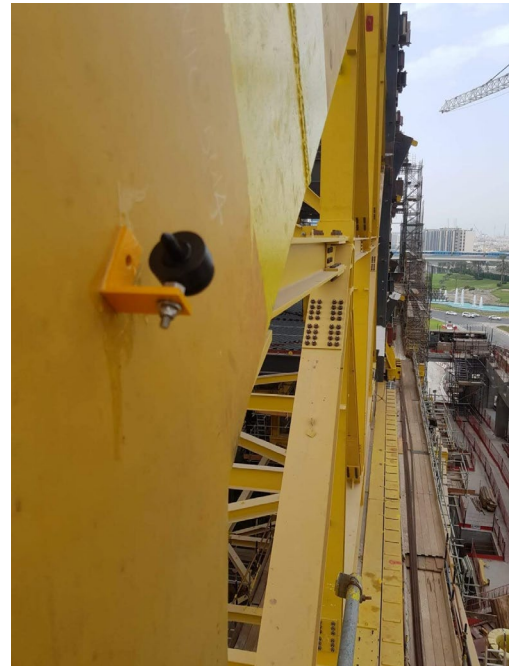
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Excel file produced automatically in requested by client format, ready to be uploaded in their database

THE INSTALLATIONS

From early July 2020, Encardio-rite's team started the installation of the prism targets on the two towers and the Link Bridge. Fifty-four (54) numbers 3D prism targets were installed in Tower A including 20 numbers in its gantry. Forty-eight (48) numbers 3D prism targets were installed in Tower B including 10 numbers in its gantry. In Link Bridge 44 number 3D prism targets were installed for phase 1 and an additional 12 numbers for the lifting during phase 2.

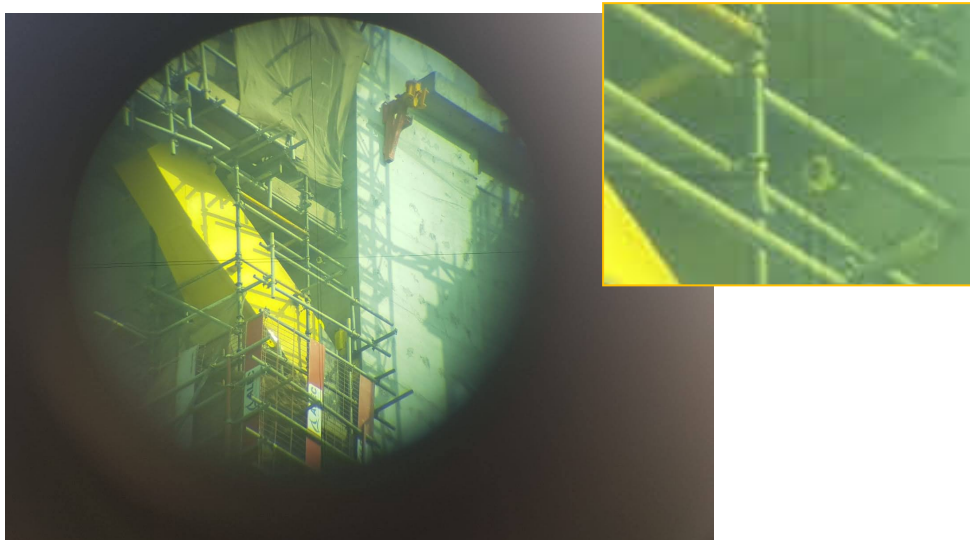
It was a challenging task, however, it was accomplished safely, strictly following Alec's and Encardio-rites' safety protocols, and in time, thanks to the installation team's extensive experience.



Installation of the prism targets on the Link Bridge



Checking the installed 3D prism targets in the gantries



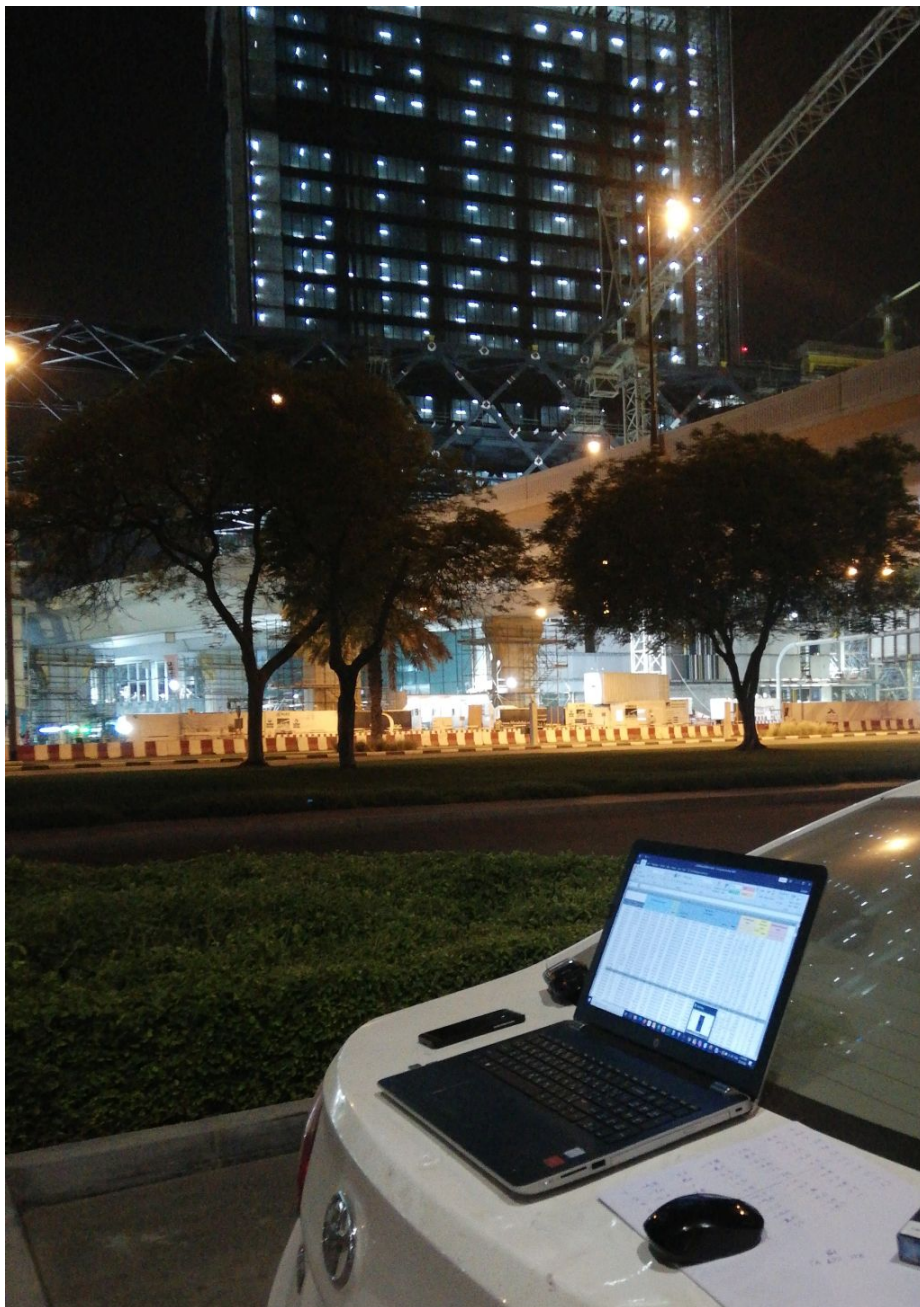
View of 3D target from Leica TS16 ATS

THE MONITORING

Before the lifting started, from August 15, 2020 onwards, all the ATs were programmed to measure the building's targets every one hour. A baseline reading was created and the readings collected during the exercise were uploaded to the client's FTP server automatically.

Once the lifting started, Encardio-rite had access to the operations remotely and the readings were collected using both automatic and semi-automatic machines as per the client's requirements. It was ensured by our site team that readings were uploaded to the databases after each monitoring cycle happening on a 24x 7 basis, seamlessly. Relentless remote support by the teams located in UAE, India, and Greece went a long way towards achieving it.

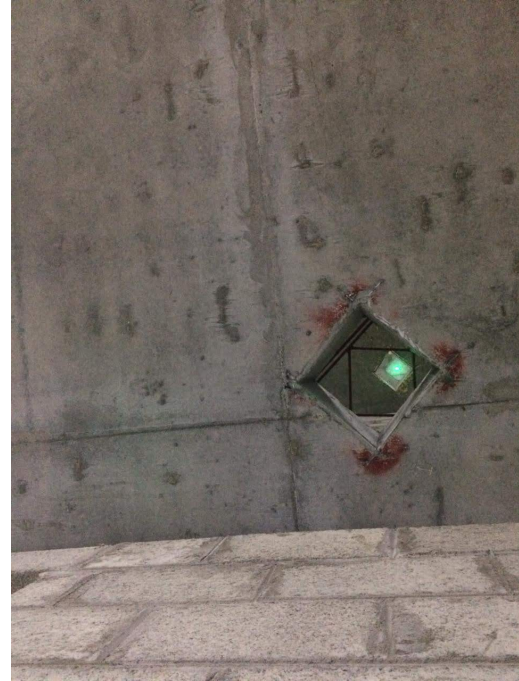
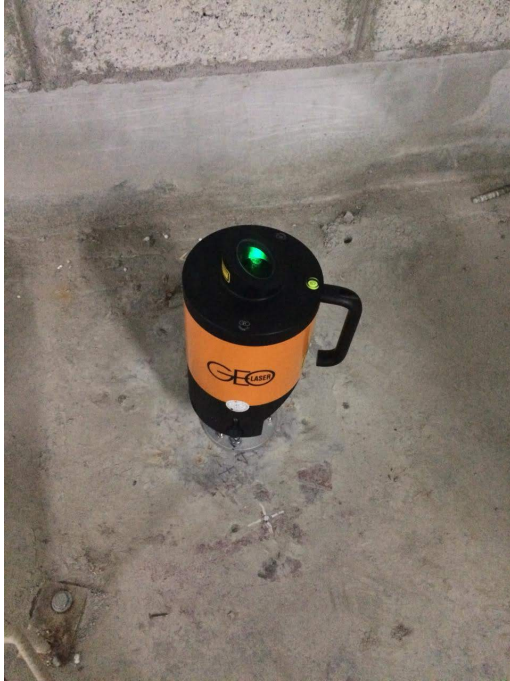
The trigger values (AAA values) for deformation provided by the client were incorporated in the graphical data presentation for a quick and easy assessment of the structure's behavior.



On-site data uploading during the lifting process

THE LASER PLUMMET

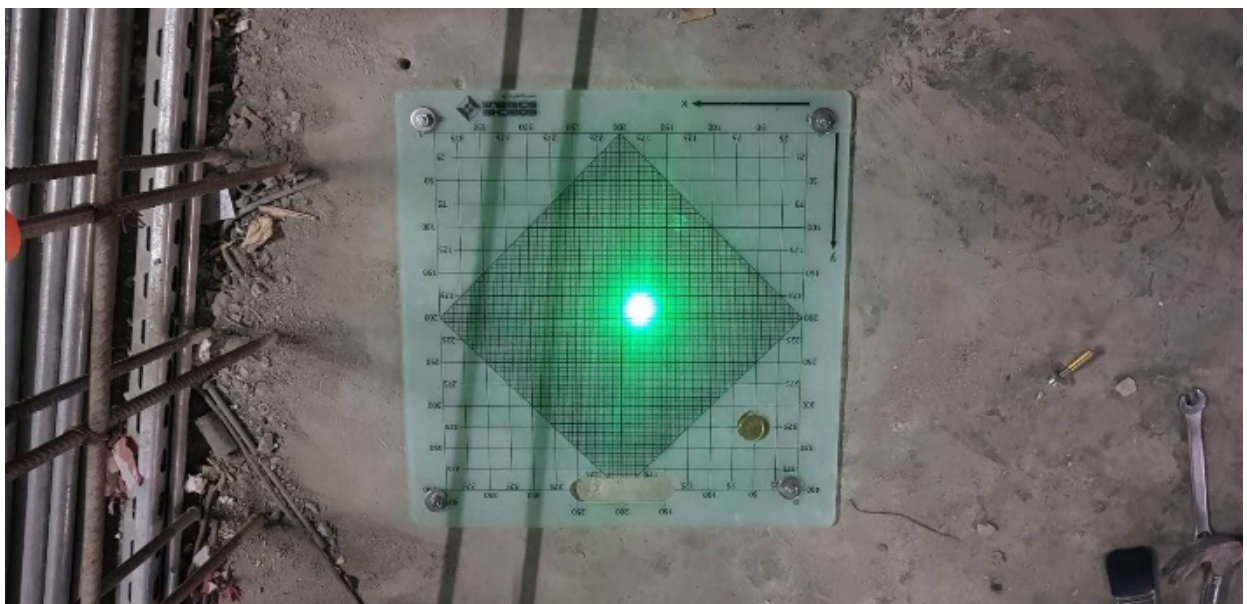
In parallel to the 3D deformation monitoring by automatic and semi-automatic machines, monitoring of the horizontal movements is being carried out on each of the towers using a laser plummet. A plummet is placed in each of the tower's lowest basement and measurements are being taken using its beam up to the highest accessible slab.



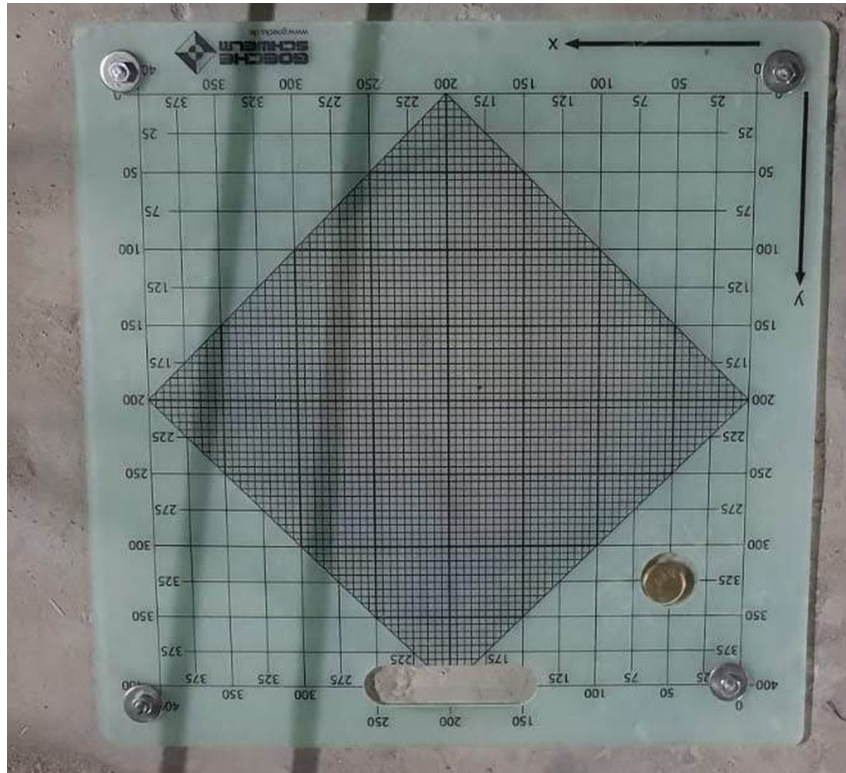
Laser Plummet on the tower's basement and the projection of the laser beam on the highest floor

The opening in the slabs of both the towers enables the transfer of the known coordinates of the bases of the laser plummet, to all constructed levels and use them as reference points.

Also, by recording the position of the laser beam in the installed grid plates, graphs of the movement of the slabs with time were produced. This exercise was done for every opening of both the towers, daily after the lifting procedure and X and Y movement graphs of the movements with time were produced in the local coordinates system.



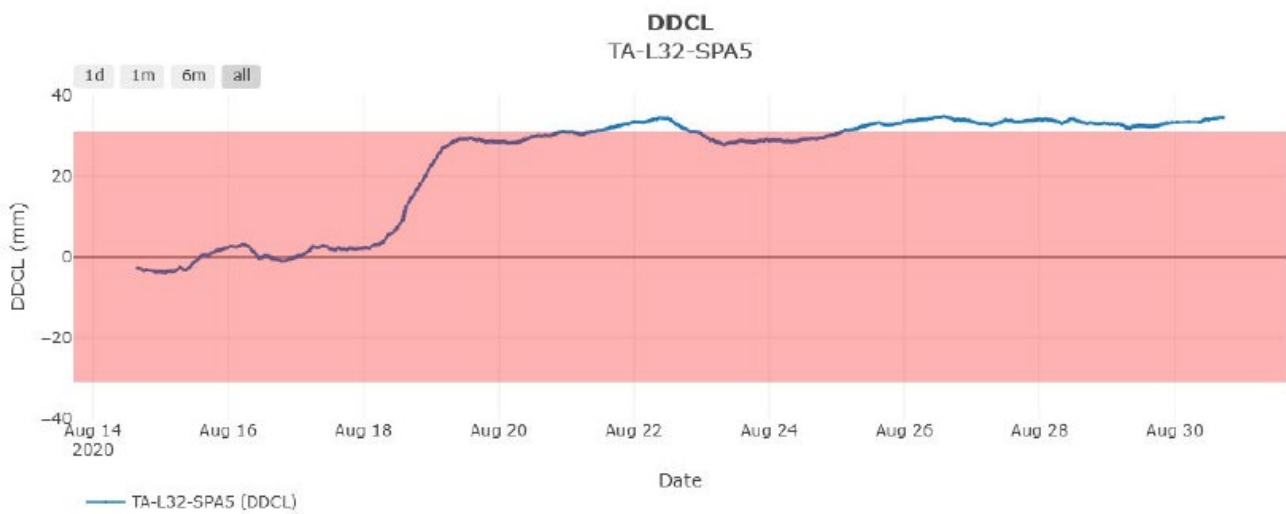
Laser plummet beam visible on the installed grid plate



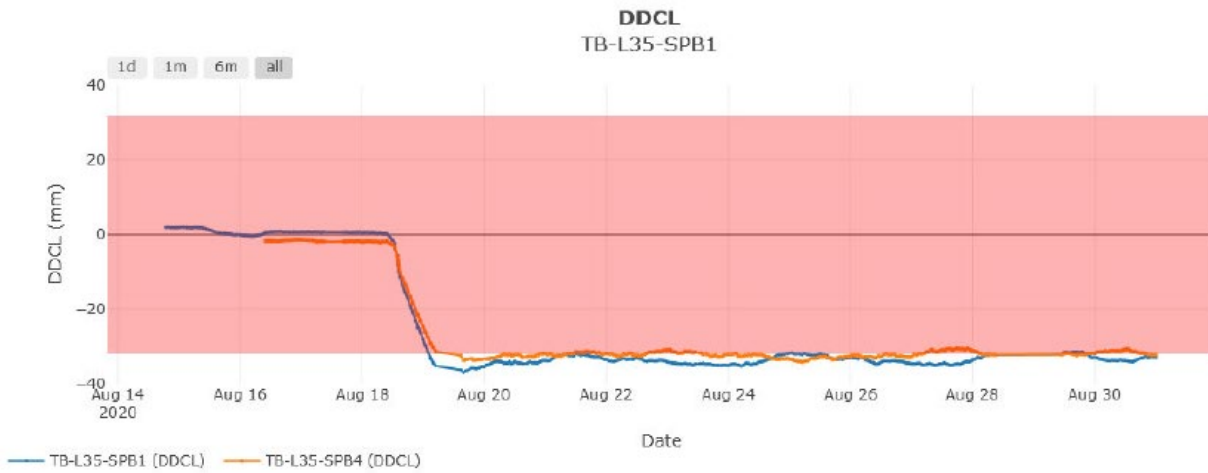
Mark of the laser beam on the grid plate (can be measured with ± 2.5 mm accuracy)

GRAPHICAL DATA PRESENTATION

Two types of graphs were presented to the client. Firstly, graphs showing the displacement of the towers relative to the direction of the Link Bridge which were produced automatically using the data uploaded to the database, as shown below:

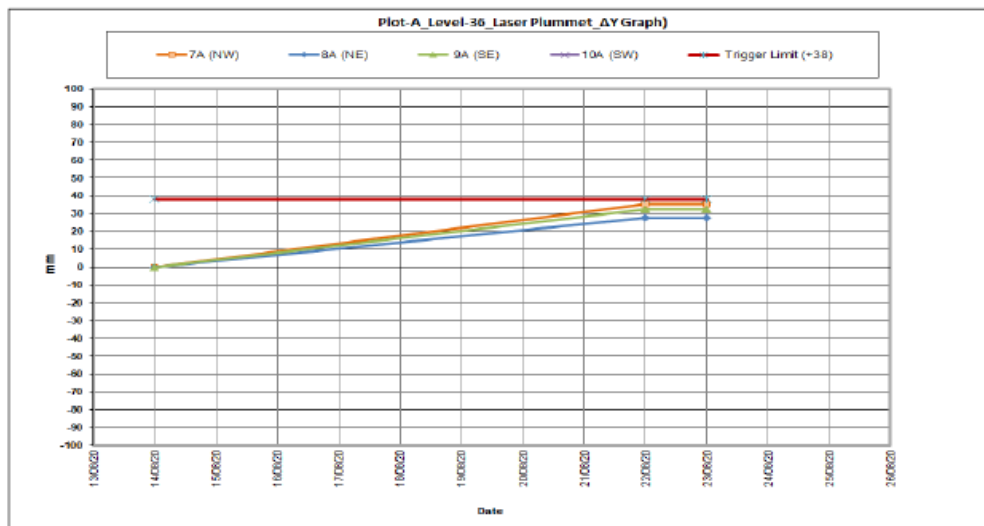


Graph of the movement of the Tower A perpendicular to Link Bridge at Level 32

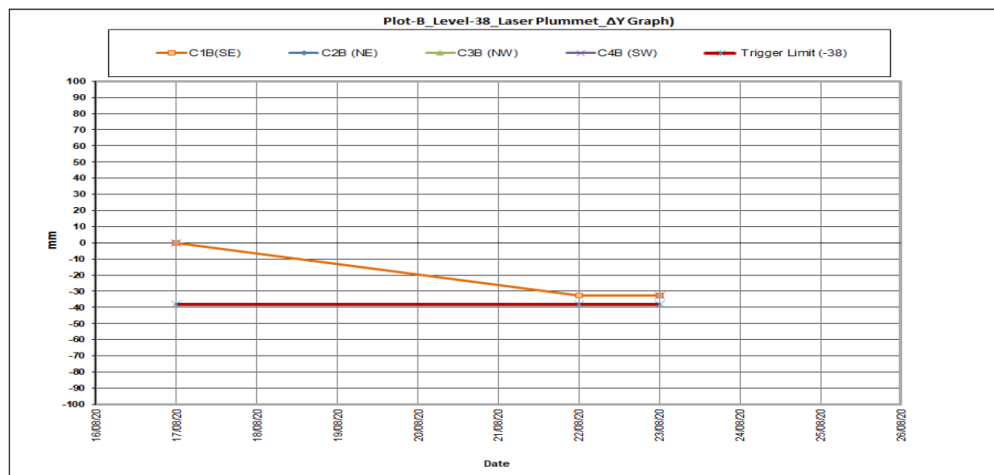


Graph of the movement of the Tower B perpendicular to Link Bridge at Level 35

Secondly, graphs were produced using the values recorded from the laser plummet grid plates, as shown below:



Graph of Y value in Level 36 in Tower A



Graph of Y value in Level 38 in Tower B



The difference in the displacement data collected using the total stations and the laser plummet grid plates was found to be less than 1.5 mm.

The Link Bridge was lifted 77.580 meters in the first phase, as shown in the change in elevation (DZ) graph of one of the 3D targets installed on the link bridge, The graph produced using the Terramove 3D software is easily accessible and one can determine the lift progress over a day, a week, between any two definite dates and overall (as shown in the below graph) just with a few mouse clicks.



Graph of change of elevation of the Link Bridge during the full lifting procedure

CONCLUSIONS

Encardio-rite's world-class instruments and expertise in the field helped to monitor a complicated lifting operation with the required accuracy, meeting all the deadlines, to the satisfaction of all stakeholders. Monitoring data was made available seamlessly almost in real-time, with meaningful information, with warnings and alerts. This was possible with a combination of rugged sensors, advanced data collection, transmission, web-based data monitoring service and last but not the least an experienced and dedicated team.

The monitoring results helped in reducing risks, protecting existing assets, and giving confidence to the lifting process. The role of instrumentation and monitoring in the project was not only limited to design optimization and construction control but also to ensure the safety and stability of work at the construction site and of the infrastructure within the zone of influence.