Leica TS30 Measures Lifting Cranes

by Jozef Predan

Portable extension boom cranes made of high strength steel are used for raising cargo on to and off of ships and trucks, e.g. loading equipment or food onto large cruise ships. Customers demand ever-increasing lifting capacity, while at the same time wanting the cranes to remain lightweight, versatile, mobile, and as small as possible when folded. Together with his students, Professor Jozef Predan from the Faculty of Mechanical Engineering at the University of Maribor, Slovenia, carried out a series of tests for the crane manufacturer Palfinger Systems using a Leica TS30 total station.

To ensure a lifting crane meets industry standards and to guarantee a smooth and safe operation, crane producers such as Palfinger Systems check each crane before delivery to the customer. Tests include checking the supporting frame structure, the hydraulic drives, as well as the control system. One of these tests covers a load capacity test at nominal and increased load. Most important is that the crane can take the load without being destroyed or permanently deformed. The second most important thing is the static and dynamic response of the crane in terms of load versus deflection of the crane cantilever. Modern cranes are slim, as they are made of very high strength steel, and consequently allow large deflections. Therefore it is very important to know the deflected shape of a crane and its dynamic response.

The Faculty of Mechanical Engineering was approached by engineers from the Palfinger Systems assembly plant in Maribor. Together, we wanted to find new possibilities to accurately measure cranes. We decided to use a Leica TS30 high precision total station to carry out the measurements. There were two reasons for this decision: Firstly, the total station is able to carry out very accurate measurements

Palfinger Lifting Crane in use on a ship.

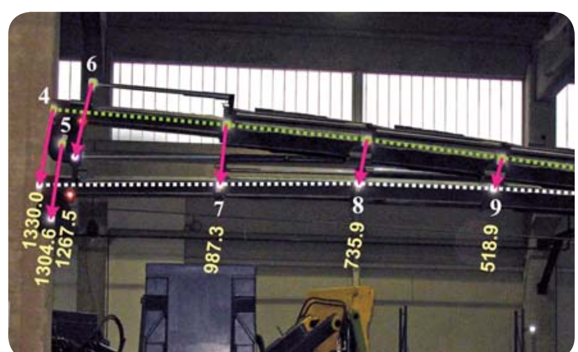
to a lot of points in a relatively short time. The second argument for the Leica TS30 was that it could take measurements to moving points to also get the dynamics of the crane mounted on the ships, where ship movement plays an important part. So, by following the target, we wanted to measure dynamic responses of the crane or the structure. In the latter case, the total station was fixed on the pier, but the target was moving on the crane's cantilever or on a point of interest on the ship or the crane. From the measurement data it was possible to calculate the movement and corresponding velocity and acceleration vectors.

We performed two different kinds of measurements – static and dynamic. For the static measurements we attached sixteen targets to the crane's cantilever and an additional three as reference points on the workshops walls. To define the unloaded (reference) shape of the cantilever, each target was measured 20 times in both faces. After defining the first set of all measurement points, the 19 repetitions were done automatically by the Leica TS30. All together these 20 measurement-sets only took approximately 18 minutes, a very short time compared to the usual manual measuring. Using the target recognition functionality of the Leica TS30, the set of points was also defined in very short time.

After this, the crane was loaded with 2,000 kg (4,400 lbs) weight and was lowered. The first procedure for measuring the reference configuration was repeated again for the deformed crane. The displacement vector for each point was calculated from the coordinate differences of the target positions. These vectors showed the displacement and rotation of the cantilever and for each boom of the crane.

The second series of measurements was designed to determine the dynamic response of the crane by tracking a moving target mounted on its outer end being rapidly raised and lowered. This was made possible by the ability of the Leica TS30 to track ten measurements per second. The system behavior was computed from the collected target position data over time. The two important mechanical system parameters were determined by fitting the measurement data with under-damped oscillation function, angular frequency, and damping ratio. Additionally, the dynamic load of the crane was executed as a time function of acceleration.

As a result of our series of tests, we could not only provide Palfinger systems with valuable measurement data, but also learned that the Leica TS30 is an accurate enough total station for mechanical engineering, and has some advantages beside its user friendly interface. It is appropriate for the static measurements of the deflection of a large number of marked points because it measures automatically in both faces after the first target definition. The measurements were carried out quickly and accurately, and it was not necessary to minimize the number of measurement points, as the automatic measurement was so fast we got a lot of useful data in a relatively short time. Its ability to follow and measure the position of the target on the crane cantilever during movement was very useful for the dynamic tests. The collected data of the target's path carried information on the crane's cantilever maximal amplitude and it also provided us with acceleration data, which can be directly scaled to additional dynamic loads.



The movements of the crane's arm were measured with a Leica TS30.

Measurements such as those we carried out for Palfinger Systems provide us with a lot of additional information on mechanical systems and we can use them for the optimization of structures, system cybernetics, for proof of statics calculations, and other analyses. So we hope we will be able to carry out future projects in connection with Palfinger Systems and other manufacturers. We will certainly use the Leica TS30 in the future; such as we currently are for a hydro powerplant at Đerdap in Serbia. ■

About the author:
Jozef Predan is a professor at the Faculty of Engineering at University of Maribor, Slovenia.