Automatic Optical Measurement of Concrete Steel

It began with one of the usual sort of customer inquiries and has now been filed as a patent. On behalf of the Industrial Research Institute (IRI), in Beirut, Lebanon researchers at Fraunhofer IPK developed an automatic optical measuring device for inspecting the quality of concrete steel. The Lebanese teaching and research institute conducts scientific tests and analyses in compliance with national and international standards for customers across the world, and one of its remits is to test concrete steel. Even though concrete steel – also known as rebar – is mainly used in the construction industry for strengthening reinforced concrete buildings, it is also used in commerce and by metal bending companies. The problem is that as the production processes and types of concrete steel vary considerably from manufacturer to manufacturer, this makes inspection of rod or ring-shaped concrete steel and mats much more difficult as they differ widely in terms of construction, diameter and rebar (reinforcing bar) characteristics.

To assess both the mechanical resilience and tensile strength of ribbed steel in concrete, you need not only to conduct load testing but also to measure the geometry – the diameter and parameters of the rebar – of the concrete steel and validate its conformity to the relevant standards. Such tasks are usually performed by certified measurement labs like the IRI which pass judgment on the suitability of such steel for particular building projects.

Measurement of the geometry of concrete steel is usually a manual operation involving length and angle measuring devices. The given measurements are put in a table and compared with the nominal diameter of the test specimen’s reference values and their tolerance. The result of the comparison is entered in an inspection protocol as the test result with the remark “in conformity” or “not in conformity.” As they involve manual inspection, measurements are relatively time-consuming and the accuracy of the measurements varies from inspector to inspector. And in borderline cases this can lead to doubts being raised about the objectivity of the inspector, and the conduct of the inspection and thus about the validity of the final result itself.

Automated and Objective

Against this background, researchers at Fraunhofer IPK have developed a novel automatic optical measuring device which in future will enable touchless – and thus objective – measurement of the geometry of concrete steel. In researching the current status of technology for inspection procedures and the inspection means used for concrete steel, the Fraunhofer scientists did indeed come across literature dealing with the mechanical resilience of concrete steel and ways of validating it. And there are also standard sheets which specify authorized forms and dimensions, and search devices which can estimate or calculate the position and depth of the rebars in concrete. Yet up to present there has been no measuring device capable of automatically surveying all the relevant geometrical dimensions in this steel.

The desktop device developed by Fraunhofer IPK is suitable for use in measuring labs and is composed of both electromechanical and optical and electronic components. Examination samples consist of sawn-off pieces some 200 mm in length which are mounted on an electrically driven chuck, rotated on their axis and illuminated so that their silhouettes can be recorded by a digital camera and their surfaces can be scanned using light-section techniques and a line laser. After rotation of at least 360° degrees on their symmetrical axis all the relevant geometrical features of the specimen like rebar diameter, height, length, angle, width, spacing and flanks can be precisely recorded and evaluated.

The core element of the measuring system’s optical unit is a digital CCD camera. This is equipped with a telecentric lens with integrated redlight, reflector foil to generate back-light, an optical filter mounted in the camera’s light path to cut out ambient light and a line optic laser that spreads the laser beam in a fan-shape and projects a thin vertical strip of light on the specimen. The camera and lens are securely connected on a C-mount and can be adjusted to focus on the specimen by two retaining plates mounted at an angle on the assembly plate. The laser is connected to the assembly plate with a retaining plate so that the symmetrical axis of the specimen lies on the laser light level which forms a 30° degree angle with the objective’s optical axis (triangulation angle).

The advantages they offer are crystal clear – easy to operate, quick and objective. Both the actual inspection procedure and compilation of the inspection report are fully automatic and thus guarantee results whose finality cannot be doubted. On top of this, the results can be directly archived in a computer. The measuring system can also be used to evaluate the geometry of all kinds of prismatic and cylindrical bodies no matter what kind of material they may be made of. 

The evaluation unit is the final element in the set-up. This is mounted underneath the assembly plate of the optical unit and consists of a computer board, a hard disk, a DC/DC power supply and two interface cards for control of the actuator and light source.

A Patented Solution

The measuring system developed by Fraunhofer IPK has already successfully completed its field trials and three of the devices have been used by Industrial Research Institute in Beirut since 2009. The advantages they offer are crystal clear – easy to operate, quick and objective. Both the actual inspection procedure and compilation of the inspection report are fully automatic and thus guarantee results whose finality cannot be doubted. On top of this, the results can be directly archived in a computer. The measuring system can also be used to evaluate the geometry of all kinds of prismatic and cylindrical bodies no matter what kind of material they may be made of.