Automation and Processing Test Data with LabVIEW Software

Andrey Korgin 1, Valentine Ermakov 1, Laith Zeyd Kilani 1

1 Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

zeydkilanilz@mgsu.ru

Abstract. This paper presents the usage of LabVIEW software for automation of data acquisition and data post processing during structure testing. Using Labview could accelerate preparation of testing reports especially during performing repeatedly (obtaining statistics). The paper shows automations made during tests of oil tank models and aluminium bridge.

1. Introduction

Now days the static and dynamic testing of building structures and elements and samples are in demand. Tests are made to study the behaviour of construction materials, building construction joints, typical products in factories. Depending on the purpose of the test, standard testing machines, such as presses, torsional and tensile testing machines are used.

This kind of equipment is controlled by a computer and has specialized software. A machine record data of the force of compression / tension and controls the strain of the samples using extensometers. Test results are recorded and saved in a pre-formed template of a report.

For example, as a result of tensile testing, a stress strain curve is formed, the yield strength and ultimate stresses are determined (figure 1).

There are frequent cases of additional installation of strain gages, the data collecting of which can be performed separately from the testing machine [1,2].

Increasingly, tests (figure 2) of elements of building structures are carried out with loading along several axes that are not laying in one plane and recorded a large number of parameters (strains, displacements, rotation angles, temperature) [1,2,3].

To solve such problems, test benches are used, which can also record test protocols. At the same time, in the conditions of a large amount of data, the task is not only to collect data from the sensors, but also to produce a specific result, a graph, to make a comparative analysis with the database or the results of the testings made in the same conditions.

Software test machines allows you to perform simple mathematical operations, calculate functions, however, this is not enough.
Tests associated with the use of different types of sensors, as well as their large number, are difficult to process and interpret their results []. The amount of performed operations increases several times with the repeatability of tests, for example, collecting statistical data during static loading of the model. In connection with the growth of this type of test, the task of automatically generating reports with data comparison becomes particularly relevant.

2. Methodology

2.1. A software implementation

The LabView graphical programming system [4,5] allows not only to quickly obtain sensor readings, but also to perform additional processing.

Consider the LabView interface using the example of a program that receives the readings of two strain gauges and writes them to a file (figure. 3, 4). The program consists of several simple blocks and allows you to save data to a file with * .lvm extension, which is structured in rows and columns, stores data in ASCII text format and can be edited in Microsoft Excel.
The DAQ Assistant block is responsible for data acquisition setting and the “Write To Measurement File” block allows you to write the received data to a file. Each LabView block can have up to 20 additional settings.

LabView allows you to add measurement tools, adjust scales, calibration coefficients, and sensor data acquisition parameters. Measuring equipment can be connected according to different schemes and interfaces, such as RS232, USB, etc.

Data acquisition is possible, both when sensors are connected directly to a measuring station connected to a computer via USB, or remotely over a local network using the mobile Internet. What is especially convenient in the case of full-scale tests of large objects.

Depending on the test methodology and the desired result, additional signal processing is possible directly during the tests: averaging, noise smoothing, filtering implemented using various mathematical models.

The obtained measurements can be formed in a certain way in data arrays, for convenience of further processing. Part of the measurements can be rejected or saved to an additional table during the measurements when comparing them with the boundary conditions specified earlier.
Additional features can be achieved by using Microsoft Excel. In addition to the ability to customize the export of data in the desired form, LabView allows you to open the source file and add test data to it. For example, you can create a template for an Excel file in which the necessary calculations are made, graphs and charts are built, a report is generated ready for printing, etc. You only need to run the program in LabView and specify the path to this template, and then everything will run automatically.

In the case of a problem that is not solved using only LabView and Excel, then you can use Visual Basic programming. Visual Basic program code can be embedded anywhere in a LabView block diagram for processing measurement data, obtaining non-standard graphs, etc. in excel.

2.2. Aluminium bridge testing.
Specialists of NRU MGSU performed tests. Testing required complicated processing of a static and fatigue tests of the aluminium bridge [2] (figure 5). The purpose of the tests was the verification of analytical methods for calculation the number of cycles (fatigue life).

![Figure 5. Aluminium bridge model](image)

The bridge model was equipped with various measuring instruments:
- Two displacement sensors measuring centreline deflection;
- strain gages of 1-5 mm (a total of 240 gages).

Static tests of the bridge consisted of several cycles of loading with a total load of 270 kN, fatigue test ran with load of 200KN and a dead load with the frequency of a 0.5 Hz.

As a result, using the LabView statements of strains and displacements of the bridge elements were automatically obtained and a required graphics were plotted.

2.3. Testing models of oil tanks
Tests were performed by specialists of NRU MGSU and requiring complicated data processing of static and dynamic tests of the model of the RVSPA-50000 reservoir [3] (figure 6). The purpose of the tests was the verification of numerical simulation methods for the stress-strain state of the tanks, taking into account the non-linear behavior of structures filled with fluid, to seismic effects.

The test bench is mounted inside a rigid spatial frame and represents a movable platform on elastic horizontal supports with a model of a tank mounted on it and a pile pendulum. The scraper pendulum serves to create a horizontal dynamic impulse on the platform with pulses of varying intensity and length. The intensity values were set by the deflection angle and the mass of the pendulum of the copra, and the required length was achieved using various damping pads (soft rubber, dense rubber, wood, etc.)
The test bench and the tank model were equipped with various measuring instruments:
- displacement sensors on the four sides of the tank on three levels and one for monitoring the movements of the movable frame (13 pieces);
- strain gages and tensors sets of 5-10 mm (a total of 168 pieces);
- three and one-axes accelerometers on the walls of the tank and the movable frame of the test stand (5 pieces);
- load sensor installed between the pendulum head and the movable frame to monitor the force of the dynamic impact.

Static tests of the tank consisted of several cycles of filling and draining a constant temperature fluid for a set of statistics. The values of displacements of the walls of the reservoir and its deformation were recorded.

As a result, using the LabView statements of strains and displacements of the walls of the tank were automatically obtained and a required graphics were plotted.

The greatest difficulties came in processing the data of dynamic tests of the reservoir. The tests were carried out at various parameters of the form, intensity, and extent of impact. For each new combination, a series of tests was conducted at a certain level of liquid (at least 10 times to achieve statistical indicators of repeatability of results). Thus, with one type of damper, the angle of the copra and its mass at 5 loading levels (empty tank, 0.25 height, 0.5 height, 0.75 height, full tank), 50 tests are required.

During the dynamic tests, all indications of installed sensors with a frequency of 1000 Hz were recorded.

The duration of one test was approximately 5-6 seconds, that is, the measuring equipment recorded 5-6 thousand measurements for each of the 168 strain gauges, not counting displacement sensors, accelerometers, load sensor.

This amount of data array not only take time to record but also complicated and require additional processing. So, developed. Therefore, the program developed in the laboratory by the laboratory specialists in the LabView environment with the use of Visual Basic commands in Excel carried out automatic additional processing (figure 7).

3. Results and discussions
3.1. Results of testing bridge.
At static test the program was collecting data with a step of 22.5 kN and plot a graphic for every stain gage and displacement sensor as it shown at figure 8 and figure 9.
At a fatigue test, the program has to make measures every 20,000 cycles and eventually plot a strain-number of cycles graphic.

3.2. Results of oil tank models.
In the file with testing data the program defined the maximum strain value and determined the corresponding time instant. Corresponding strains of the remaining sensors (cross sections and rings) were entered into a separate array. After a set of 10 tests using a different program in LabView, averaged test results were averaged.

As a result of averaging the test results at different liquid levels in the tank and analysing them, it was determined that the maximum deformations occur at the site closest to the point of application of the impact-impulse effect (Figure 10).

The development of the program in LabView was carried out in parallel with the preparation of the model for testing and took 3 weeks. Recording a single test file with additional automatic processing took 7 minutes, which did not affect the total test time, since at that time there was a damping of fluid oscillations in the model. Graphical and digital materials obtained automatically are of much greater value and exclude the human factor. The memory capacity of a computer that occupies one protocol after processing has become 42 MB.
4. Conclusion

The combined use of LabView, Excel and Visual Basic allows to:

- Supplement standard sample testing with real-time data processing. For example, the imposition of several controlled parameters of the sample on one graph to determine the relationships between them when the load changes.
- Create unique, in terms of content and presentation of results, test reports of structures and their elements, depending on the goals and tasks to be solved. For example, the formation of tables of deformations of vertical sections and ring strain gauges, and further automatic plotting in Excel when testing tanks (an example of a graph is shown in figure 7).
save test results in a convenient format for further work. For example, the deflections of the coating beams obtained during the tests may be recorded in a *.txt file. This file, in turn, can be used to adjust the computational model in the ANSYS software package.

The combined use of LabView, Excel and Visual Basic has been successfully applied in static and dynamic tests (dynamic impact tests) of the RVSPA-50000 and RVS 5000 reservoir models, as well as in the static tests of the aluminium alloy pedestrian bridge [3].

References

[1] Andrey Korgin, Vladimir Romanets, Valentine Ermakov, Laith Zeid Kilani, Experimental and analytical study of an aluminium alloy bridge made of 1915T, MATEC Web of Conferences 251(3). pp. 1-8. 2018

[2] Andrey Valentinovich Korgin, Yury Ivanovich Kudishin, Valentin Alekseevich Ermakov, Mikhail Valerevich Emelianov, Leis Zeydovich Zeid Kilani, Modeling of Seismic Impacts on the Oil Tanks, IJAER volume 11. pp. 1680-1686. 2016.

[3] Dmitriy Kapustin, Rostislav Krasnovsky, Leis Zeid Kiliani, Stress strain behavior (SSB) of Steel Fiber Concrete, SP-326-63, vol 326. pp. 63.1-63.10, 2018.

[4] I. Gankevich, V. Gaiduchok, V. Korkhov, A. degtyarev, A. Bogdanov Middleware for big data processing: test results, Physics of Particles and Nuclei Letters, 14 pp 1001-1007, 2017

[5] Siti Amely Jumaat, Ammar Syahmi Bin Mohd Anuar, Mohd Noor Abdullah, Nur Hanis Radzi, Rohaiza Hamdan, Suriana Salimin, Muhammad Nafis bin Isma, Monitoring of PV Performance Using LabVIEW, Indonesian Journal of Electrical Engineering and Computer Science vol.12, No.2, pp 461-467. 2018

[6] R. Bitter, T. Mohiuddin, M.Nawrocki, LabVIEW: Advanced programming techniques, 2000.

[7] Yuka Yomamota, Combining LabVIEW with OpenCV, 2018

[8] Muhammad Chhattal, Hina Madiha, Veer Bhan, Shoaib Shaikh, industrial automation & control trough plc and labview 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), Pp 1-5, 2019

[9] Korgin A V, Emel'yanov M V, Ermakov V A, Zeid Kilani L Z, Krasochkin A G and Romanets V A 2013 [Using LabVIEW software to collect and process measurement data as part of development of systems of monitoring of bearing structures. Proceedings of Moscow State University of Civil Engineering 9 pp 135–142, 2013.