Automated Measuring Station for Road Structures Stamp Tests

Ivan Shuliak, Nadiya Pavlenko, Volodymyr Ilchenko, and Akif Gasimov

Abstract A research prototype of a measuring station was developed and created. It is a set of test equipment integrated into a single automated complex for the rapid determination of road structures and their layers deformation characteristics during stamp tests. This excludes the operator's manual work and increases tests productivity. At the same time, any truck or road vehicle may be used to create a load. A measuring unit with installed specific software is used for measurement results registration and processing.

Keywords Road construction · Elastic deflection · Static stamp tests · Automated measuring station · Modulus of elasticity

1 Introduction

One of the most objective road structures condition and their layers assessment methods is stamp tests, in which the load is transmitted through a rigid stamp, and the vertical deformation (full or elastic) is measured before or after the load is removed. The deformation modulus or the elastic modulus, which are the main indicators of the layer or road structure deformability is located at a certain full or elastic deflection.

At the operation stage, it is advisable to use stamp tests in layer-by-layer tests in order to determine the destruction causes of the road structure. The reason may

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be insufficient bearing capacity of the soil base or road surface structural layers, including pavement layers.

During the overhaul and roads reconstruction, it is also necessary to perform stamp tests to make reasoned project decisions.

However, in Ukraine these tests are rarely used in practice, as they require significant time and are associated with manual labor when creating a load. At the same time, the tools and devices development level for such tests lags significantly behind the level of similar devices developed abroad.

2 Defining the Problem

Static stamping tests consist in loading the stamp mounted on the road structure surface and measuring the surface coating vertical deformation depending on the applied load magnitude.

These tests give the most objective results in determining the road structures deformation characteristics, as the load scheme complies with the calculation scheme used by J. Businescu in solving the problem of stress–strain state of the half-space under the action of force applied to its surface and evenly distributed on the pressure stamp surface [1].

In most cases, a round rigid stamp and a hydraulic jack are used for stamp tests, and the stamp settling is measured by displacement indicators mounted on the deflectometer (Fig. 1 a, b) [2, 3].

The disadvantages of this measuring equipment are low tests performance due to the need to use the operator's manual labor when creating a load on the stamp with a manual hydraulic jack.

In addition, the considerable weight and bulkiness of the equipment create additional inconveniences while moving the equipment elements from one test site to another and during their installation.

Fig. 1 Measuring equipment for static stamp tests: **a** NTU stamp equipment; **b** SNPTs «ROSDORTECH» press-stamp PSH-050

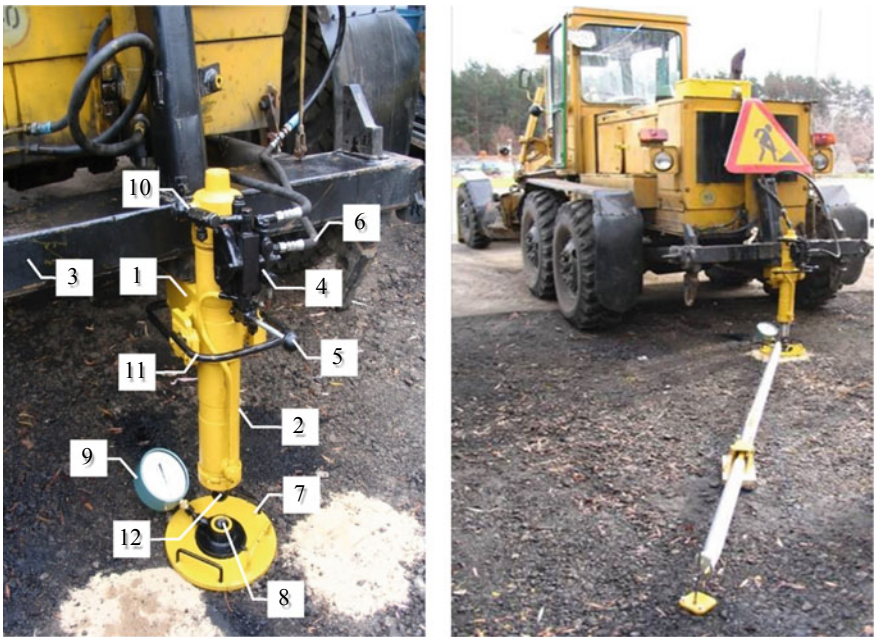

Fig. 2 NTU hinged equipment on a motor grader (photo Ivan Shuliak 2016): 1 – bracket; 2 – hydraulic cylinder; 3 – grubber frame; 4 – hydraulic distributor; 5 – control lever; 6 – hydraulic hoses; 7 – rigid stamp; 8 – base of the hydraulic load meter; 9 – manometer; 10 – throttle valve; 11 – mounting handles; 12 – rod tip of the hydraulic cylinder

During the test specifically on the road, there is a risk that the operator gets under the wheels of road construction equipment or moving transport.

NTU has developed a hinged equipment for a motor grader (Fig. 2), designed to create a calculated load during stamp tests of road surface layers and soil bases, which is devoid of many these shortcomings [4, 5].

But at the same time it requires a connection to the motor grader hydraulic system, i.e. it is focused on the use of road machinery certain types.

The aim of this study is to improve the method of road structures static stamp tests in the roads diagnosis by increasing its productivity, accuracy, informativeness and safety.

3 Research Results

The road structures and their layers stamp tests measuring station has been developed in the National Transport University to achieve the goal [6–13].

A station is a complicated measuring instrument, which is a set of test equipment combined into a single automated complex for the rapid determination of the road structures and their layers deformation characteristics during stamp tests.

The station includes: pump station; pump station control panel; stamp with hydraulic cylinder and pressure sensor; lever-holding mechanism; lever-holding mechanism control unit; deflectometer; measuring unit.

A general view of the measuring station mounted on the basic car "GAZelle" is shown in Fig. 3.

The measuring station also performs:

- an ambient temperature determination;
- a determination of the surface temperature of the structural layer under test;
- determination of measurements place current geographical coordinates;
- geospatial binding of the obtained results.

Technical characteristics of the station are given in Table 1.

A force created by the oil pressure in a hydraulic cylinder connected to a pump station, an autonomous controlled source of oil pressure, is applied to the pavement

Fig. 3 General form of the measuring station mounted on the basic car "GAZelle" (photo Ivan Shuliak 2016) 1 – pumping station; 2 – hydraulic pump; 3 – engine; 4 – a stamp with the hydraulic cylinder; 5 – lever-holding mechanism; 6 – deflectometer; 7 – basic car; 8 – loading means; 9 – mounting bracket; 10 – grip of the lever-holding mechanism

Table 1 Technical characteristics of the measuring station for road structures and their layers stamp tests

Parameter	Value
Weight, kg	80 ± 0,5
Overall dimensions:	
- height, mm	500
- width, mm	400
- length, mm	1600
Stamp diameter, mm	300
Absolute load measurement error, %	5
Maximum load on stamp, kN	100
Displacement measurement error, mm	0,0025
Operating temperature, °C	From + 5 to + 40
Maximum relative humidity, %	95
Required power supplies:	
- alternating current (power plant), V/kW	220/1,0
- direct current, V/A	12/0,5
Storage temperature, °C (PC is stored at a temperature of +10 to +35 °C)	From –10 to + 60
Service personnel, pers	2

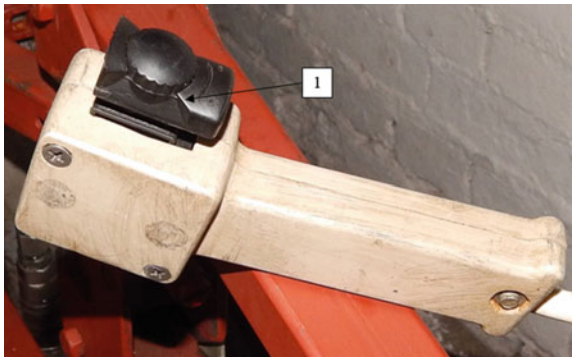

Fig. 4 A pump station remote control (photo Ivan Shuliak 2016) (1 – force creation button on stamp)

through a rigid stamp. Force measurement is carried out by registering the fluid pressure in the power hydraulic system using a pressure sensor. This sensor is connected to the hydraulic system in close proximity to the hydraulic cylinder, thus ensuring high accuracy and stability of measurements.

The pump station is managed by the operator remotely, using a remote control (Fig. 4), by pressing the function button which creates a force on the stamp, and adjusts the load speed as well.

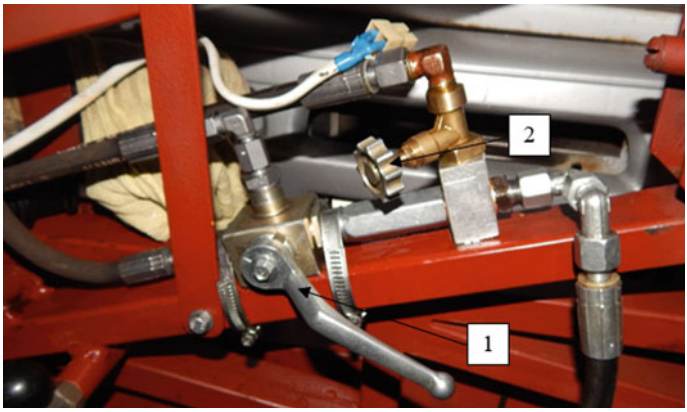

Fig. 5 Control unit VUM (photo Ivan Shuliak 2016) (1 – tree-way crane; 2 – oil drane tap)

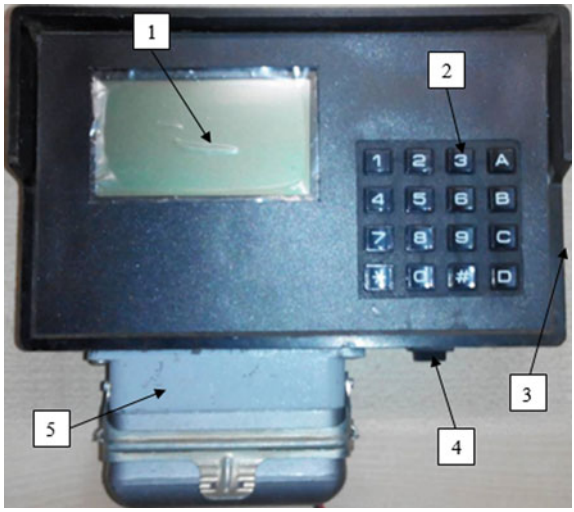

Fig. 6 Measuring unit (photo Ivan Shuliak 2016) 1 – graphic display; 2 – keyboard; 3 – connector for an external data carrier; 4 – power switch; 5 – system connector

Meanwhile, to create a load, it it possible to use any truck or road vehicle that could provide a load on the stamp of at least 7.5 Tf. Thus, dependence on a certain type of road machinery is excluded.

The equipment is mounted on a vehicle. Transportation of equipment elements from one test site to another and installation of a stamp in the test point is carried out by means of the lever-holding mechanism. The presence in the latter of three lever links with a lifting cylinder allows the operator to move and install at the measuring point a heavy set of hydraulic cylinder with a stamp without much effort.

The control of the lever-holding mechanism and work of the lifting hydraulic cylinder is carried out by means of the VUM control unit of (Fig. 5). It consists of the three-way crane and the oil drane tap for effort removal on a stamp.

The measuring unit (Fig. 6) is used for registration and processing of measurements results. A special software is installed, and its operation algorithm is resulted in Figs. 7, 8 and 9.

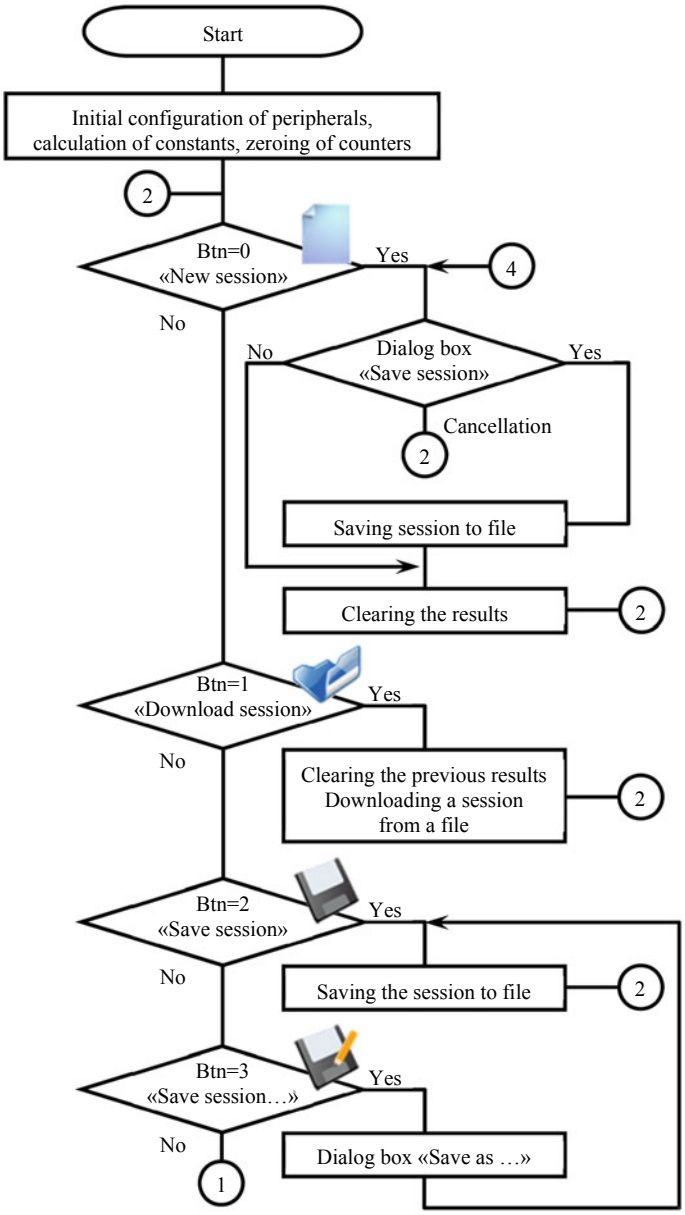

Fig. 7 Operation algorithm of automated control system of measuring processes at the station

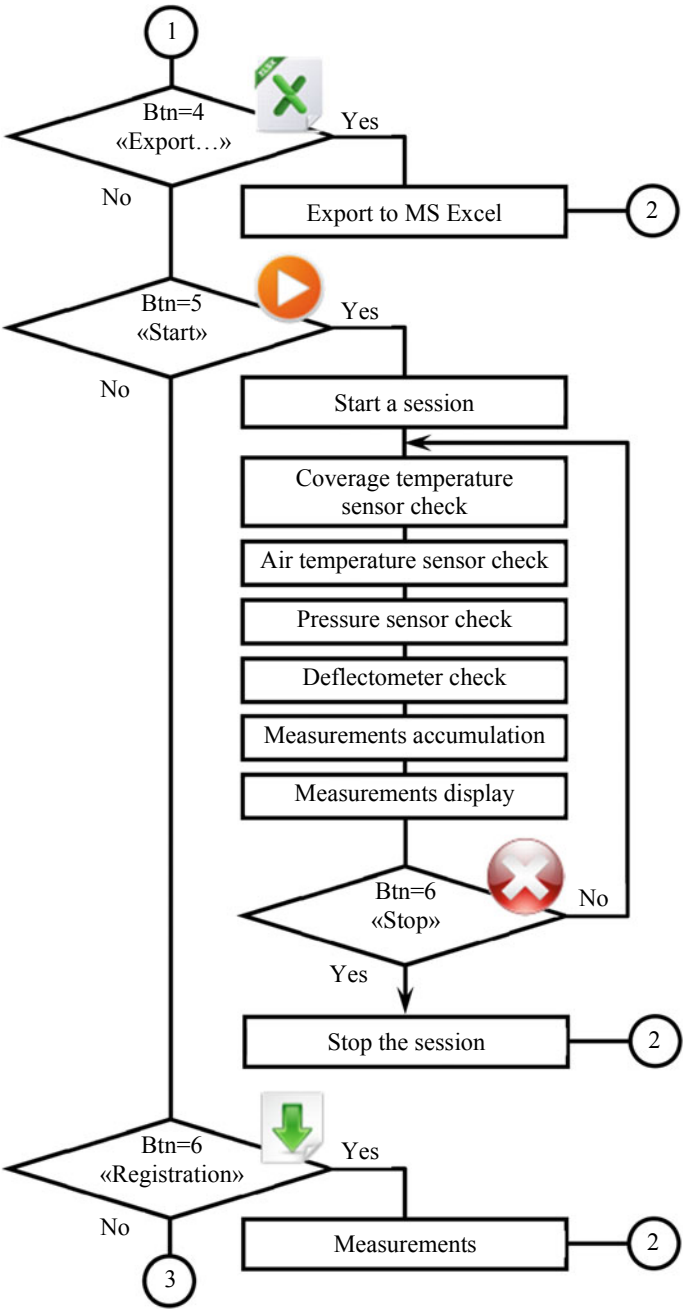

Fig. 8 Operation algorithm of automated control system of measuring processes at the station (continuation)

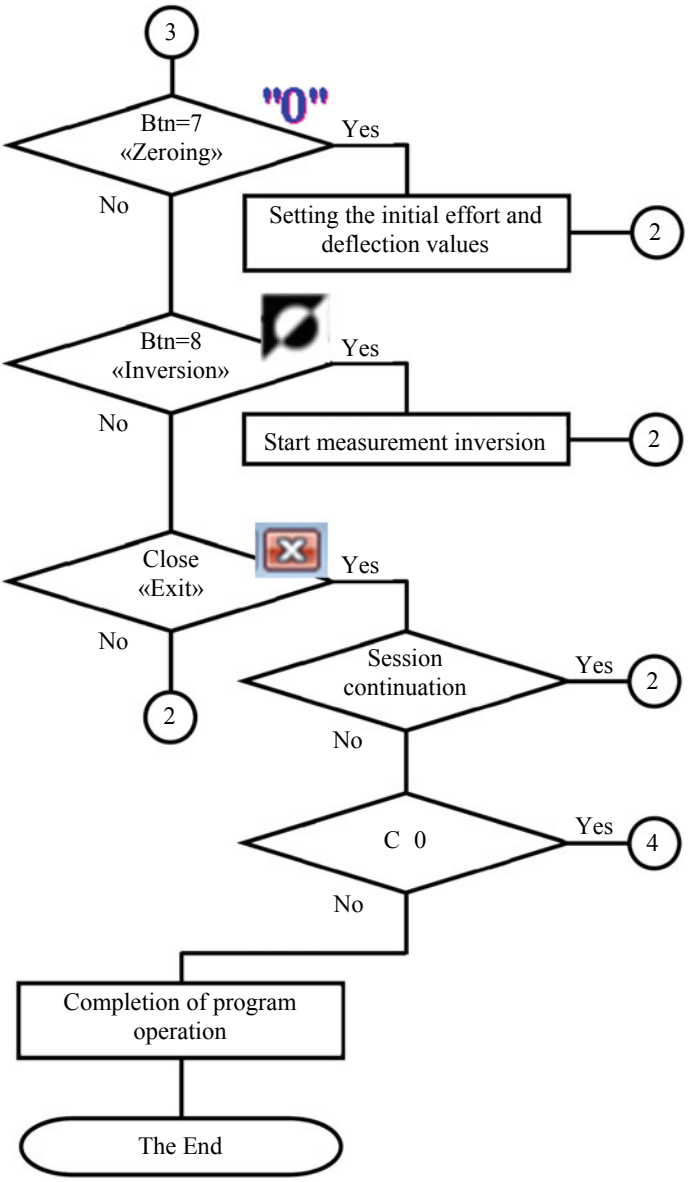

Fig. 9 Operation algorithm of automated control system of measuring processes at the station (the end)

One of the main measuring unit features is the ability to display the measurement results in text and graphical form on the display, with subsequent storage and export of these results to an external non-volatile data carrier.

The deflectometer is a metal telescopic reference beam on three supports, the rear of which has a vertically movable base and the other two on wheels. This allows the operator to quickly and easily configure it for measurements.

4 Conclusions

The static stamp tests method has been improved due to the development of an automated measuring station, which combines test equipment into a single complex mounted on a basic car and eliminates the need for operator manual operation, provides multiple loads, and increases test performance by 5 times.

The research results are protected by a patent for the utility model in Ukraine [7], and an improved method of road structures testing when diagnosing roads is reflected in the state standard DSTU B V.2.3 42:2016 [2].

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