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DEVELOPMENT OF A PUSHING TOOL APPROXIMATING THE REAL TYRE MODEL

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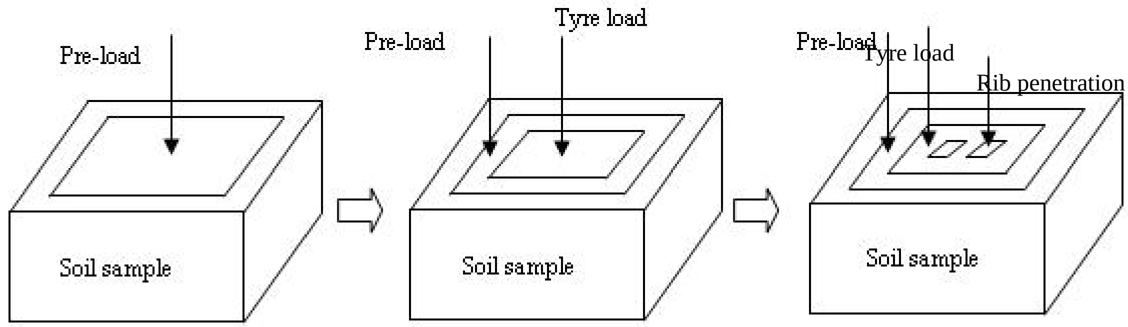
Conception of the 2006 year actions

Carrying on the activities displayed in 2005, the main task in 2006 was specification of conditions for measurements approximating the real tyre model and performing measurements as well.Model of the measuring process is shown in figures below.(Fig.1.)



Establishment of IN-SITU state — Stress state produced by tyre — Investigation of ribs influence

Fig. 1.

For determination of stress distributions generated in soil samples by different segments application of oriented pressure sensors mounted under the appropriate segments is necessary. In addition to the stress state determination measuring the deformation on the surface and inside of the sample is also resource of important information.A number of mechanical, hydraulic and software developments and modifications were needed for the realisation of this conception.Of course, the main element of this was planning and production of the hydraulic pushing tool approximating the tyre model and its installation. But for setting into operation the DANHAUSER machine some modifications of its control mechanism and mechanical modifications were needed as well.

Due to the big weight of the equipment application of a mechanical handling equipment became imperative as well.

Development of a pushing tool approximating the real tyre model

As one can see according to paragraph 2 the main point of the work in 2006 in addition to determination of the initial stress state of soil samples modelling the field conditions was examination of the influence of simplified tyre elements.The scheme of the pushing tool is shown in Fig. 2. From the point of view of the simplified tyre model it contains 3 main parts.

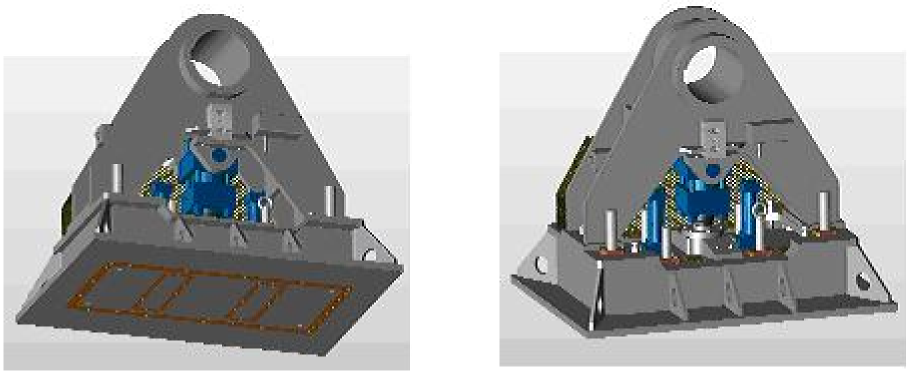


Fig.2.

The 3 main segments shown in the figure above are movable independently from each other and have functional properties as follows.

Controlling the plate generating the initial stress state of the soil sample – at the start together with the 2 other segments – assures development of the pressure specified for the soil surface (IN-SITU), but later, *during the loading process* – when the 2 other segments get out of their planes – *keeps the pressure on a constant level.*

The main point of this is to assure a constant state of the soil outside the tyre as the situation is in the reality as well.

Subsequently we have 2 different loading opportunities and it is difficult to decide which one of these is closer to the reality.

The *first version is* when during keeping the pressure of the soil surface at a constant level *the ribs get out of their planes* at a prescribed length (rib height). After this *the footprint modelling plate* gets out of its plane to such an extent that the soil surface pressure generated by it reached a prescribed value, namely the practical soil compaction defined by the tyre surface. Naturally this value is higher than the pressure kept continuously at a constant level by the IN SITU plate.

The *second version* is when the ribs and the footprint plate displace in an opposite order. In this case the footprint plate's control mechanism has to assure a constant soil pressure value under the plate even during movements of the ribs.

Of course, controlling the IN SITU plate assures all the time a constant soil surface pressure.

All three segments are equipped with road sensors and force-measuring cells and so after finishing the measurements the appropriate force-displacement diagrams can be produced. The control mechanism, road sensors and force-measuring cells of DANHAUSER machine are designed for both, horizontal and circumferential movements of the system. This provides the opportunity to further develop the tests even for analyses of movements of a real tyre with slip. The hydraulic pushing tool models the real tyre with a considerable simplification, so later other designs closer to the reality could be required. For this sake the pushing tool is of modular character, the prism modelling the tyre footprint and the simplified rib segments are changeable.

Elaboration of a controlled procedure of measurements conducted by DANHAUSER machine

In 2005 the control mechanism of the DANHAUSER machine made possible to perform controlled measurements during determination of initial stress state of soil samples. This means during the measurement process the system controlled the pre-load value, but when the process became instable – especially in case of loose and wet soils – the control mechanism was not able to produce the specified pre-load value. In those cases non-conformity of the measurement was proved and it was repeated. But in view of high time and work requirements of the sample preparation this caused considerable wastes.

In consequence it was decided to further develop the control system of the measuring equipment so that it could perform a controlled measurement process.

Thanks to this the system is able to correct defects when it detects non-conformities during realisation of the measurement program.Because of the loading program's complexity this is of an especially great importance when applying a hydraulic pushing tool. One of the conditions necessary for elaborating a controlled measurement process was development of an electro-hydraulic air-pilot valve system what is shown in the figure below: (Fig.3.)

Fig.3.

Control of the valve system required creation of a computer program.

(Fig. 4. and Fig. 5.)

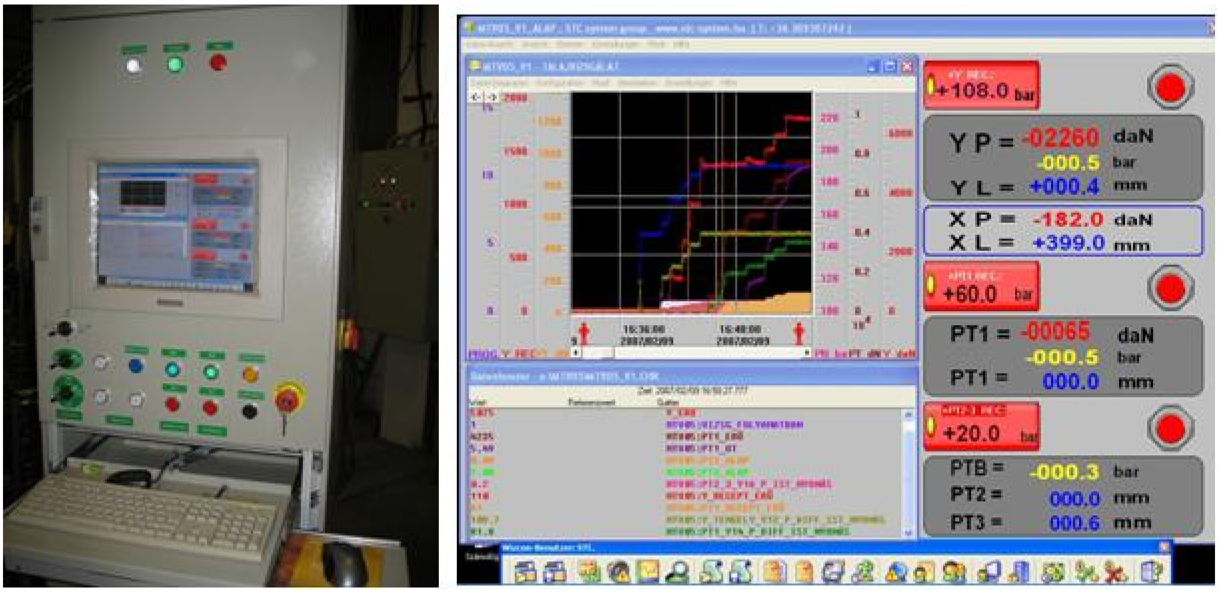


Fig. 4.

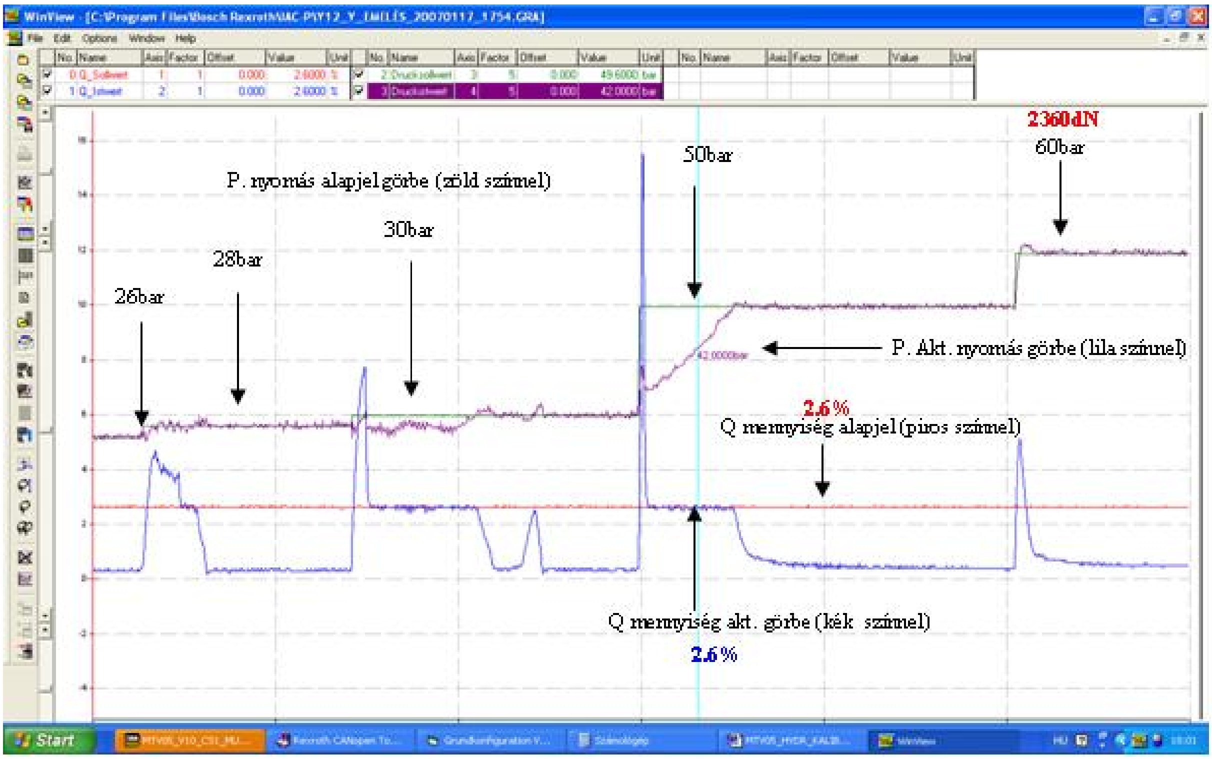


Fig. 5.

Measuring conditions

In the course of planning the test measures the following parameters were determined.

a. <u>Loading procedure</u>

Achieving the IN-SITU state:

The soil surface pressure is 1 bar, what is reached in 5 load stages with constant increment of 0,2 bars. Every load stage can be set in 15 seconds and afterwards there is a 15 second conditioning period at every given pressure value.

Establishing the simplified tyre footprint. The soil pressure under the tyre footprint modelling segment is a 1,8 bars increment relative to the IN-SITU state, that is altogether 2,8 bars. The load running up to the IN-SITU state + 1 bar value is continuous and is realized in 60 seconds, afterwards 15 second increment of 0,2 bars and conditioning cycles alternate with each other.

Letting out the simplified rib segment

Simplified rib elements penetrate into the soil sample modelling 50 mm rib height. Achieving this state requires 60 seconds. Positioning pressure sensors and the remembering plastic bar. During the test 20 pressure sensors and the remembering plastic are placed at the depth of 200 mm in the prepared soil sample. The scheme of their localization is shown in Fig. 6. and photos of this installation in fig. 7. The remembering plastic bar is warmed up 3 minutes before beginning the loading procedure, and it is cut off after finishing the procedure.

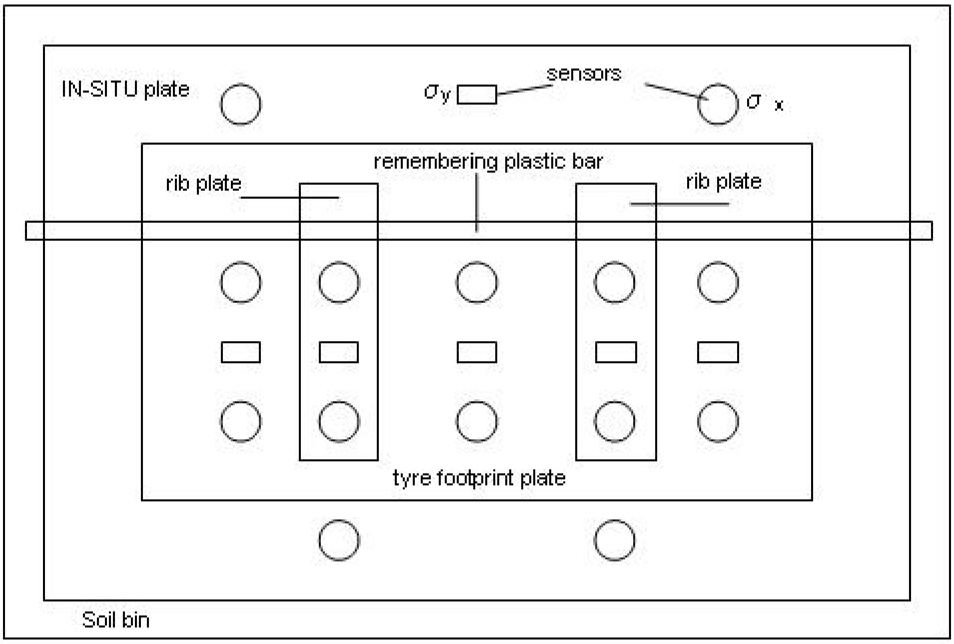


Fig. 6.

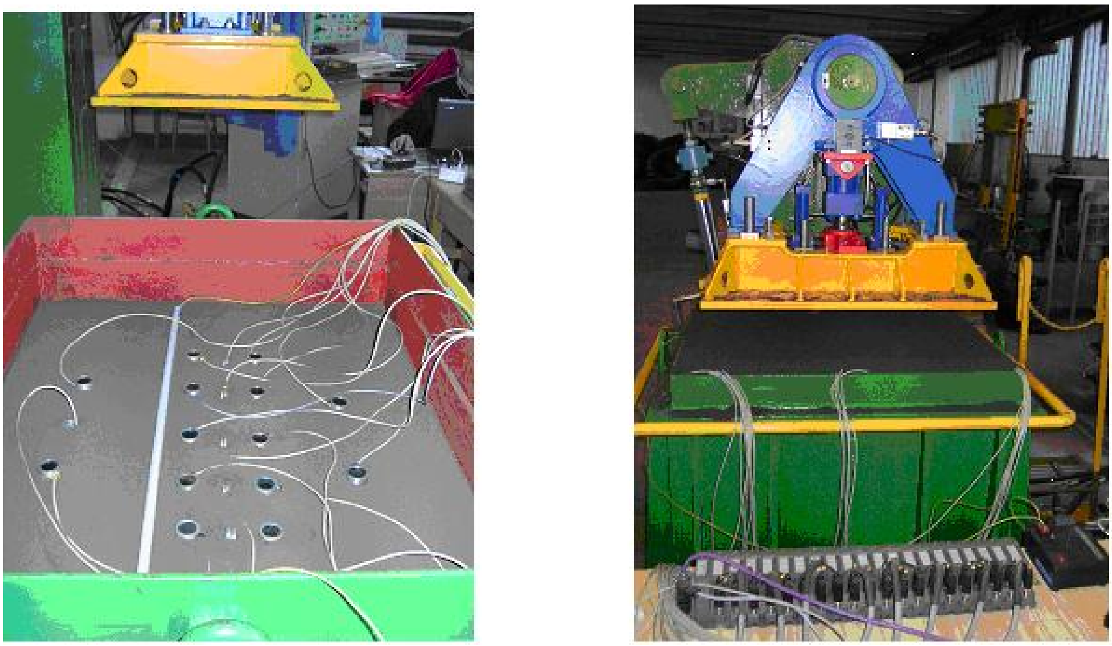


Fig. 7.

Description and evaluation of the measurement

a. <u>Pressure distribution measurements</u>

The measurement was undisturbed until reaching the IN-SITU state, but in the second phase when establishing the simplified tyre footprint response of sensors was different from the usual. Due to observation of this problem in the third phase the simplified rib elements were let out just 2 mm instead of the originally planned 50 mm, so that we could test their proper control.

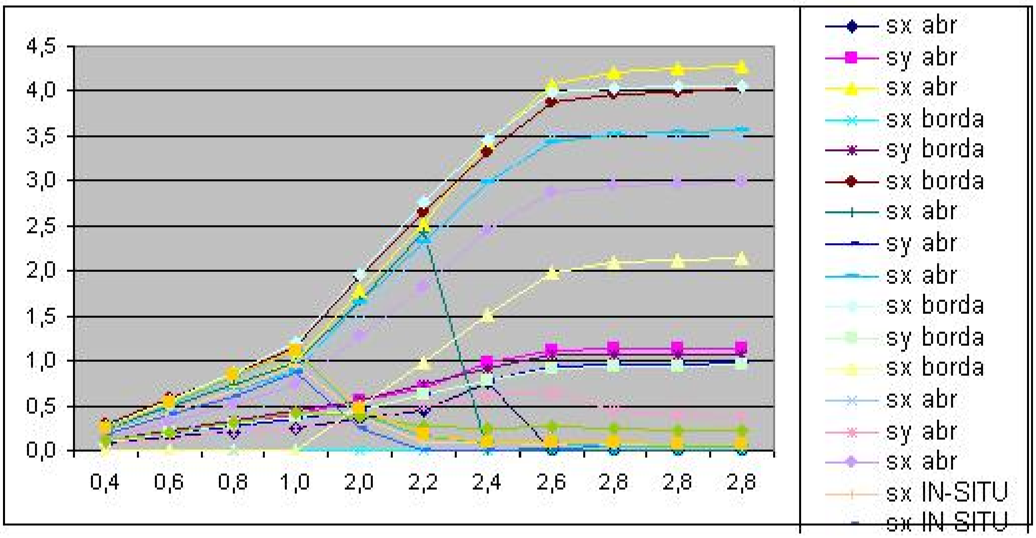


Fig. 8.

This part of the process functioned normally but for the sake of preserving the sensors the test was stopped. The values measured by sensors during loading procedure are shown in Fig. 8.

The most remarkable thing in this figure is that after reaching the IN-SITU state the pressure in sensors under the IN-SITU plate suddenly fall.

A logical reasoning for this can be that during the loading procedure the control mechanism of the IN-SITU plate can not keep continuously the soil surface pressure at a constant 1 bar value, and sensors indicate this.

In this second loading phase 3 sensors experienced pressure loss and in case of 2 from them the pressure suddenly took zero value.

Summarizing the report one can state the following findings:

- It should be decided where to apply for the measurements wire type, and where wireless sensors.
- In any case, oil should be replaced by silicone rubber as sensors transmitting medium.
- Algorithm of the loading control software should be reviewed.
- Application of the remembering plastic bar was proved suitable for measuring the deformation of the soil sample’s internal points.
- Due to their easy handling during future measurements it would be practical to mount plastic bars in different levels of the soil samples.
- The measuring process in the local “nyírség” sandy soil should be stabilized by taking the necessary measures.

After that measurements should be extended over other soil types and humidity grades as well.