INTERLABORATORY COMPARISON OF ACCREDITED LABORATORIES IN TERMS OF BENCHMARKING IN SLOVAKIA

Katarína Zgútová[1]

Summary: Benchmarking is not a standardized method and therefore, in practice we come across its various definitions. The following are 2 probably the most respected definitions. The first comes from the American Productivity and Quality Centre (APQC) [9] which currently represents the world leading benchmarking institution and provides benchmarking projects long-term [14]. According to the APQC benchmarking is the process of identifying, learning and adapting outstanding practices and processes from any organization, anywhere in the world, to help an organization improve its performance [1].

Key words: Benchmarking, Interlaboratory comparison, accredited laboratorie, On-line application, Quality indicators

1. INTRODUCTION – OUTLINE OF THE TERM BENCHMARKING

Benchmarking is a concept that is as old as the Olympics in ancient Greece. Ancient athletes recognized that it is possible to learn and continuously improve through comparisons with others: first to identify the "best" performance at sporting event, then evaluate the difference between their own performance and the "best" one, to carefully observe how the "best" performance was achieved and then calibrate the performance of others, to achieve it and go beyond. The bases of benchmarking are measurements. When athletes in ancient Greece calibrated performance of others, they used combination of measurements of their minds and measurements of referees [19].

Benchmarking is not a standardized method and therefore, in practice we come across its various definitions. The following are 2 probably the most respected definitions. The first comes from the American Productivity and Quality Centre (APQC) [9] which currently represents the world leading benchmarking institution and provides benchmarking projects long-term [14]. According to the APQC benchmarking is the process of identifying, learning and adapting outstanding practices and processes from any organization, anywhere in the world, to help an organization improve its performance [1].

According to the official dictionary of the American Society for Quality (ASQ) [10] benchmarking is a technique in which a company measures its performance against those of the world's best in class companies, determines how those companies achieved their level of performance and uses this information to improve its own performance[5].

The Slovak literature [22] states that benchmarking is a continuous and systematic process of comparison and measuring a product, processes and methods of an organization,

[1] Dr. Ing. Katarína Zgútová, University of Žilina, Faculty of Civil Engineering, Department of Technology and Management, Univerzitná 8215/1,Veľký Diel,010 26 Žilina, Tel. : +421 41 5135858, E-mail: zgutova@fstav.uniza.sk

against those that were recognized as suitable to measure in order to define the goals to improve organization's activities.

In connection with the reasons for benchmarking, literature written in English often states acronym 4C: Change, Compare, Challenge, Create.

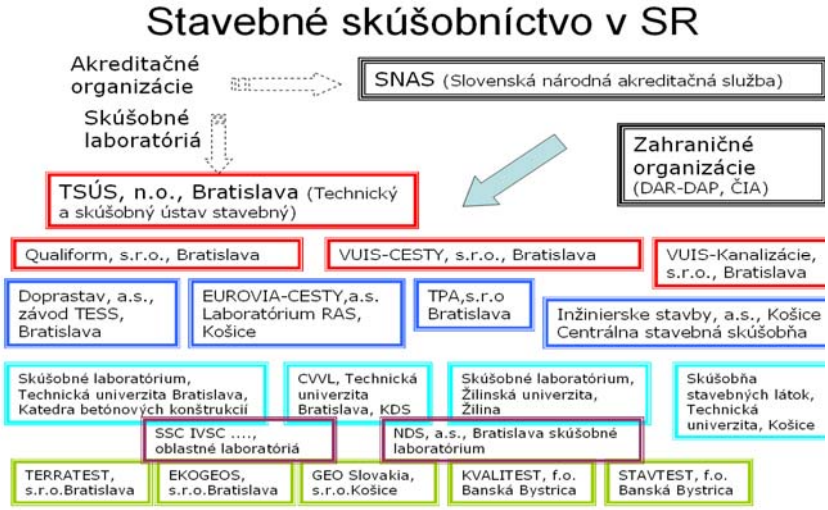
Under freer interpretation of 4Cs we can also speak of the reasons associated with:

- understanding the need to change the current state of affairs,
- with the internal need of organizations to compare with the best,
- with challenge towards our up to now processes and practices, and with creation and definition of challenging targets in our organization.

2. CIVIL ENGINEERING TESTING IN THE SLOVAK REPUBLIC

One of the society instruments to regulate the market diversity of civil engineering testing and unification of professional level within civil engineering testing is a process of accrediting the testing laboratories, which have to meet the system and technical requirements of the norm STN EN ISO / IEC 17025 [24] what creates a platform for comparison of their competence and conditions for assuring quality of measurements. The current construction environment is characterized by:

- high public demand for quality works,
- high pace of construction, new entrants in the field of linear works construction,
- budget tensions,
- decline in skilled workers in relation to requirements,
- the introduction of new technologies and modern methods of testing the building materials and construction elements, therefore, under the scope of complex introduction of active benchmarking - the transmission and implementation of good practice in a closed circle in the civil engineering, the interlaboratory comparisons are one of its components. In order to secure this mission, model of civil engineering testing was created Fig. 1.



Source: Author

Fig.1 - Schematic representation of the Civil Engineering testing in the Slovak Republic

3. BENCHMARKING CLASSIFICATION

Based on the subject of benchmarking survey, following benchmarking classification was determined [20]:

- competitive, where the subject of interest is a particular product or performance of direct competitors on the market,
- functional, where several or only one function of certain organizations is compared
- generic, where the centre of attention is the comparison and measuring the specific organization's process. This is brought against any appropriate organization which provides similar process, although it may well not be a direct competitor.

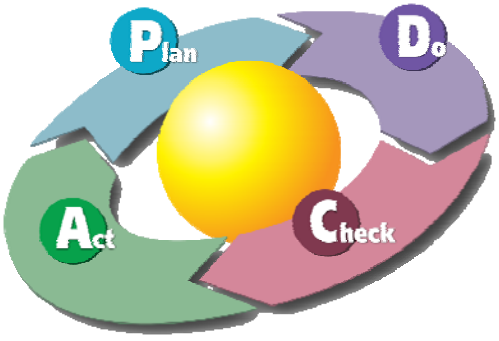
Depending on where a benchmarking is undertaken, it is almost always divided as

- Internal, implemented within one organization between organization's units which provide same or similar processes and functions,
- External, where the partner for comparison and measurement is a different organization.

4. THE PRACTICAL IMPORTANCE OF BENCHMARKING

Benchmarking in general:

- helps to better understand requirements of customers and other stakeholders
- allows managers to obtain information that would otherwise have been the result of an incidental findings, or would remain unknown - also helps to dispose of sometimes excessive optimism
- is the way towards the discovery of objective indicators for measuring own performance and productivity in order to accurately identify own strengths and weaknesses,
- is one of the most effective process to gather suggestions for improvement.



Source: [8]

Fig. 2 - Benchmarking four-step PDCA cycle

Benchmarking is the continuous and systematic process of comparison and measuring a product, processes and methods of own organization against those that were recognized as suitable to measure in order to define the goals to improve organization's own activities.

Benchmarking is not strictly closed process or a method with clearly defined rules and procedures. The number of stages or steps is very diverse and varies in different companies

and organizations from 4 (representing the PDCA cycle - Fig.2) up to 20 steps. The starting cycle for application of benchmarking onto accredited laboratories is a four step benchmarking cycle, with customer involvement according to Fig.3.

For all professionals in the field of quality management, the important information is that a draft of new ISO 9004 considers benchmarking, as the article 8.3.5.recommends that organizations use benchmarking methods with clearly defined rules and procedures [14]. ***It may therefore be expected to supplement the ISO 17 025, which is today fully compatible with the standards of the 9000 class, that benchmarking will become a component of accredited laboratories, thus it will not be only a comparison in the area of test results, which are subject of interlaboratory comparisons, but also in the system section which is also supported in the ISO/IEC 17025: 1999 point 5.9.***

Source: Author

Fig. 3 - Customer involvement in benchmarking process

The laboratory shall have quality control systems to monitor the validity of the tests and calibrations undertaken. The data collected have to be recorded in such way as to identifytrends and, where feasible, to use statistical methods to assess the results. This monitoring has to be planned and controlled, and may include but not be limited to the following:

...b) participation at interlaboratory comparisons or the competence testing projects;...“

Therefore, ***benchmarking tool is proposed - web portal which is to be an open system for different types of quality indicators***, because output of any process of benchmarking is to identify areas of self improvement. As already mentioned, benchmarking without the implementation of improvement projects is a worthless and unnecessary waste of energy and resources, only implementation of projects of improvement ***gives benchmarking a meaning.***

5. BENCHMARKING IN TESTINGLABORATORIES

For customer oriented benchmarking in testing laboratories, there are three basic prerequisites [6]:

1. ***Leadership.*** Customer oriented benchmarking, in most cases requires a complete reorientation of laboratories from thinking of maintenance resources, production and activities to the thinking of providing a product and service, which are important for the

customer and at the same time to thinking of efficiency and performance related to products and services. Reorientation requires strong support from the management. Without the leadership, to bring a change through a customer-oriented benchmarking will not be successful.

Another part of the leadership is to bind the organization to the benchmarking. Time, effort, labour resources and attention to the required details of the laboratory shall not be underestimated. It is necessary to use the same performance measurements as the benchmarking partners; however, it is very likely that the data are not the same at the beginning. Data shall be collected in accordance with a specific plan. It is necessary to document practices of all levels of laboratories and share them with benchmarking partners if they have different structure of levels in an organization. It is necessary to make a commitment that the implementation of obtained new ideas is to take place and improvements are implemented to achieve goals. It should also be borne in mind that performance measurements and new practices will bring re-allocation of resources within a laboratory.

2. ***Culture.*** Culture (ethics code) must support the idea of continuous quality improvement. Customer oriented benchmarking requires culture which is not satisfied with the current status and considers it unchangeable. Prior to starting the benchmarking, it is necessary that organisation makes changes for continuous improvement and comparison with others is seen as improvement to providing the product or service to the customers. This culture should be based on the leadership which constantly monitors and studies the success. This approach quickly reveals a failure, can reward the honest improvement and genuine efforts to improve.
3. ***Common indicators.*** Participants in customer orientated benchmarking must agree with measurements to be used. It is much easier to agree measurements for benchmarking inside the laboratory than outside.

6. BENCHMARKING INDICATORS AND THEIR UNITS

Benchmarking indicator indicates to what extent, the laboratory achieves the performance of competition

$$U_b = \frac{P_v}{P_{vk}} \cdot 100 \qquad (1)$$

where: U_b – Benchmarking indicator [%]

P_v – characteristic parameter of performance of own organisation

P_{vk} – identical parameter of performance of the competition

Increasing value of this indicator and its permanent getting closer towards 100% is obviously a positive trend [2].

This part is one of the key outcomes of submitted habilitation work and suggests a ***catalogue of measurable indicators suitable for benchmarking of accredited laboratories - orientated on to the customer*** – purchaser together with units. These indicators are those that

are directly or indirectly relevant to the customer, however, there are many other measurements that are already recognized or are still to be identified.

The measurements are divided according to elements - items based on the requirements for accreditation and then by attributes, where are associated measurements and their units and the note. The catalogue should include ***items*** such as the following:

1. Sampling
2. Validation of methods
3. Data control
4. ***Assurance of quality tests results*** - this is the only indicator that is measured within the scope of interlaboratory comparisons
5. Complaints
6. Personnel
7. Manipulation with testing items and other.

Indicators of selected items are identified by:

- professional assessment
- brainstorming
- by studying professional literature
- cooperation with personnel of accredited laboratories

It is an open system, where items are associated with attributes, methods of measuring, units as for example:

Table 1 - Quality indicators example

Attribute	**Measuring**	**Units**	**Note**
Homogeneity of the sample	Standard deviation	Quadrate of evaluated parameter	Procedure, which is carried out by the laboratory and its instruments
Discordant sample	Average number of non-homogeneous samples	Number	Procedure, which is carried out by the laboratory and its instruments

Source: Author

Benchmarking costs:

- Costs of meetings – include the costs of overheads. This includes travel, accommodation, per diem allowance and other costs,
- Costs of time - benchmarking team participants invest their time to review the problems, to find suitable and willing partners, into the mutual visits, into the implementation and not least the study. These factors are withdrawing participants from their everyday work tasks what creates the need for auxiliary workers,
- Costs of benchmarking database - an organization that wishes to introduce the benchmarking into the daily process must create and maintain a database of their benchmarking results and the best results of organizations which participated in the comparison.

7. CONCLESION - WEB PORTAL AS A BASIC BENCHMARKING TOOL

Web portal for benchmarking emerged as a result of practical requirements to make execution of interlaboratory measurements more efficient. System for benchmarking of accredited laboratories is designed and intended to serve for comparison. The nature of its applicability is far broader. It can also be used for comparison of other sectors of construction and operators of construction works.

Starting points for portal emergence

The basic starting point for designing the system was that the system is to be flexible and useful for comparing all types of laboratories at all levels, with a perspective of use not only within the Slovak area, but also in Europe. Or as the case may be, it will serve only one such organisation, for example National Motorway Company - at the motorway construction, as a tool for selecting an accredited laboratory.

Due to the reasons listed, it is possible to expect a large range of different types of indicators, parameters and divided into different forms. Therefore, the starting point for creating the system was a creation of forms by an administrator, according to the need with varied number of columns and rows where relevant unit can be assigned to them. The basic system is designed in a way that during the registration, the representatives of laboratories have to enter basic information about the laboratory and subsequently parameters they measured and the basic characteristics of the testing environment. These characteristics can be edited by the administrator.

Benchmarking participants, after permission to register, have to fill in individual forms created by the administrator.

Participation of laboratories in benchmarking provides objective evidence about the reliability of the results [26] they produce, allows to identify sources of potential errors and subsequently to improve the quality of work of testing laboratory. Motivation of individual entities is the need to compare the results of their own work with other laboratories (partners but also competitors).

Participation of laboratories at the competence testing and comparative measurements is an important part of ***showing compliance with the accreditation requirements*** already at the phase of assessing the laboratories. It is one of the basic criteria to fulfil the accreditation requirements of accredited laboratories [24]. That's why it is very important that laboratories, in their own interest, participate at such competence tests and comparative measurements.

Company Calibrium, Ltd., in conjunction with the Faculty of Civil Engineering of Žilina University, organizes the national competence tests and comparative measurements in the field of construction, in accordance with the valid Methodical guidelines for accreditation and the Slovak National Accreditation Service, coordinates national system of competence testing and comparative measurements aiming to:

- allow, within limits, the individual laboratories to prove compliance with the follow-up and measuring instruments via participation in the competence testing and comparative measurements,

- serve as an effective tool of the Slovak National Accreditation Service for ensuring the comparability of results of testing and calibration activities of laboratories.

On-line application of benchmarking

The basic assumptions the application should meet are:

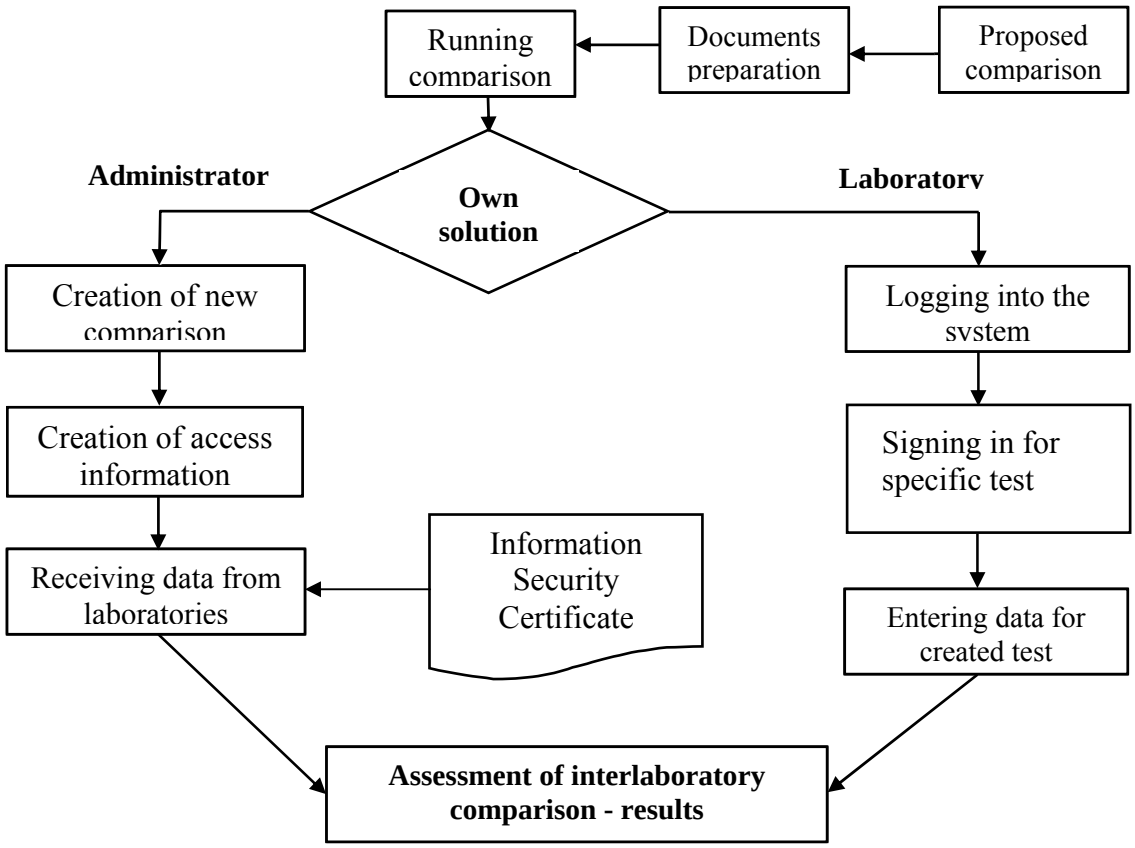
- multi platform, namely the independence of the system used by the testing laboratory or other organization,
- accessibility not only via LAN, but also over the Internet (accessible 24 hours a day).

Due to the reasons listed, as the most suitable solution for the issue of customer driven benchmarking appears to be the use of the platform Client - Server, which allows complete separation of the application section from the user section, where the user enters the data and results into the user interface on his computer and these are being evaluated, processed by a program located on the server.

The connection between the user - client and server must be encrypted by SSL protocol, in order to prevent leakage of information that testing laboratory or other organization is not willing to disclose. By this, operating body guarantees the inviolability of the information provided by testing laboratory for comparison. Implicitly, the table of results with information from testing laboratories will identify the laboratory only as a number, which will be changed regularly and different for each testing laboratory.

Application environment

Due to the diversity of operating systems, software facilities on user computers we have applied the environment of web pages for communication of testing laboratories with the server. This ensures trouble free access into the application for all users - testing laboratories. For programming the applications, we have used the programming language PHP in conjunction with the MySQL database which is located on a separate rented server manufactured by Compaq DL380 with configuration 2x Pentium III processor 866MHz, 2048 MB ECC SDRAM memory, 4x HDD 18.2 GB connected in RAID 5 for full data consistency and protection from potential damage to some discs, 2x power supply and 2x network card for redundancy of Internet connectivity and power supply, contributing to the reduction of server unavailability. Server hardware is located in an air-conditioned server room, under 24 hour surveillance by security service, camera system, a system for ensuring constant connection of servers.



Source: Author

Fig. 4 - Scheme of on-line comparison process

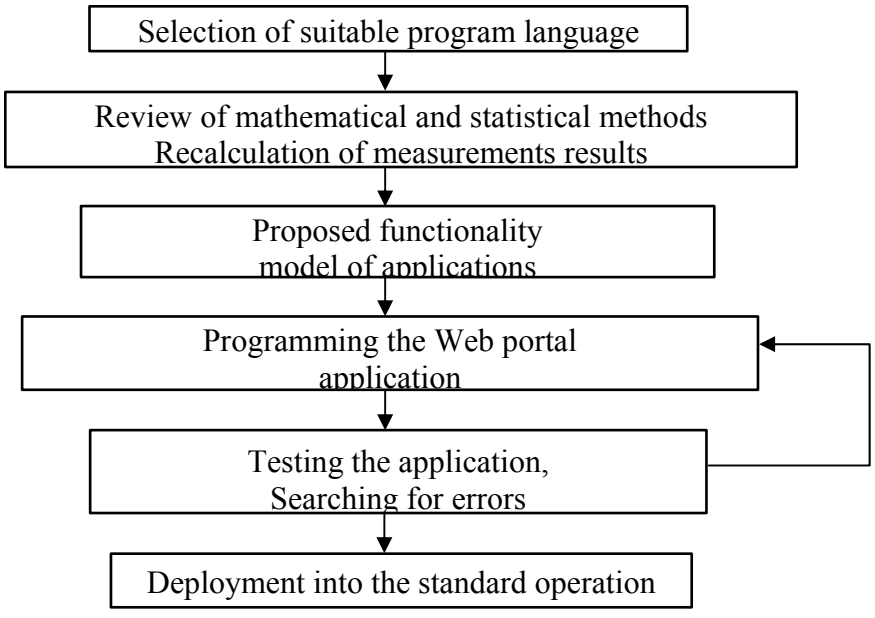


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Fig. 5 - Scheme of work on creation of web portal application

Web portal user interface

After studying mathematical methods for statistical comparisons of interlaboratory tests, we started programming the application itself. The body of the application is divided into the following sections for clarity.

- ***Logging*** into the application, we have resolved by an allocation of a unique code, which will be allocated to the particular laboratory by a generator program, in order to avoid possible human error. Application user will authenticate himself by the username and the assigned code. On the server we have created a secure connection via HTTPS (encryption by generated, or Certification Authority verified, authoritative certificate). In terms of application users, the highest level of security shall be ensured.

Fig.6 - Logging into the application

For authentication of users we have incorporated into the application a system for recording the access into the application.

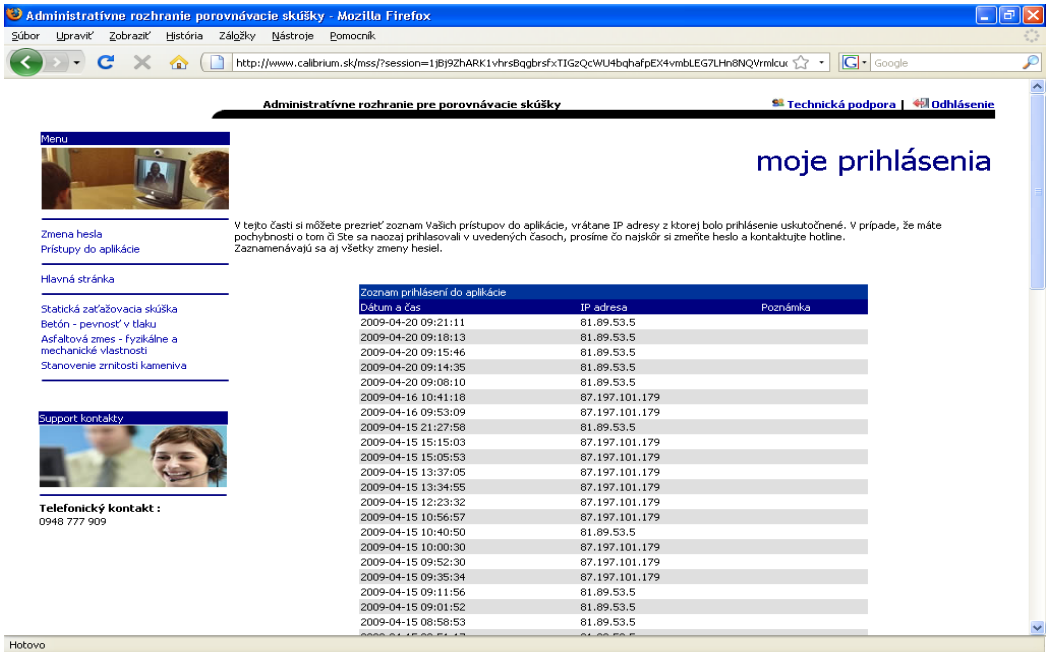

Fig. 7 - Recording access into the application

At the same time the database stores IP address from which the application was accessed, password changes and other important data facilitating the detection of potential misuse of access data. Each figure recorded in the database is Time Stamped, thus the time is precisely defined and can not be changed not even by the administrator.

Password change - following successful login, the user has the option to change the password. The minimum number of characters for the password, we selected six characters.

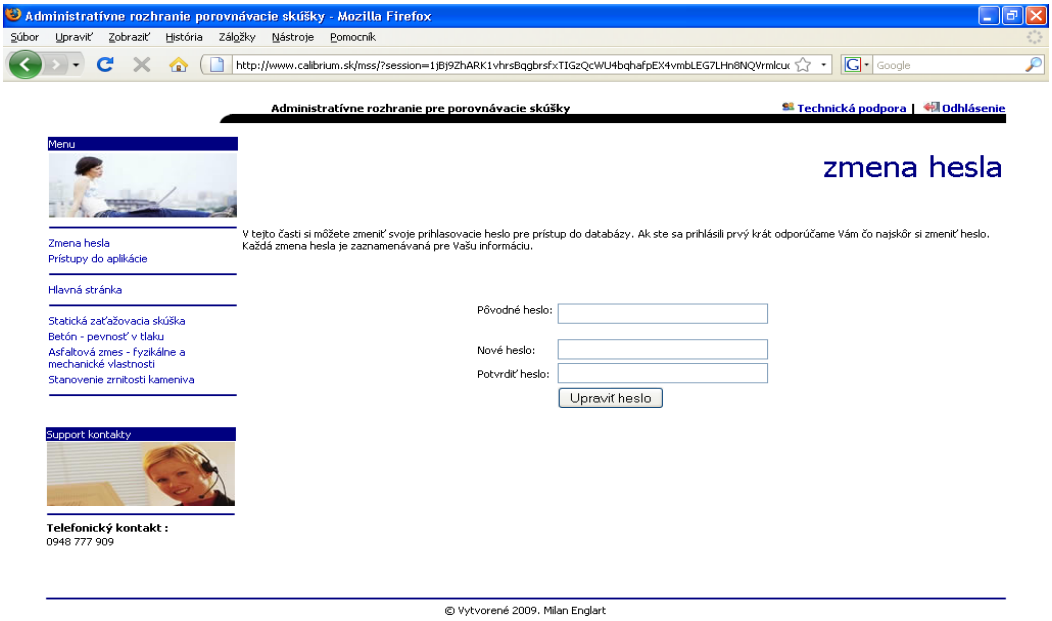

Fig. 8 - Option to change the application access password

[1] ***Data entry*** - we have chosen a system where an application user selects, in the left menu, the test for which he wishes to enter the data, for example for the static load test. Following the click on the given item it is programmed that the form is to appear to the user, into which he enters the values that he measured. In the future we see more benefits in automatic control of data entered, in order to prevent the users, because of their inattention, to enter the data which are diametrically opposed.

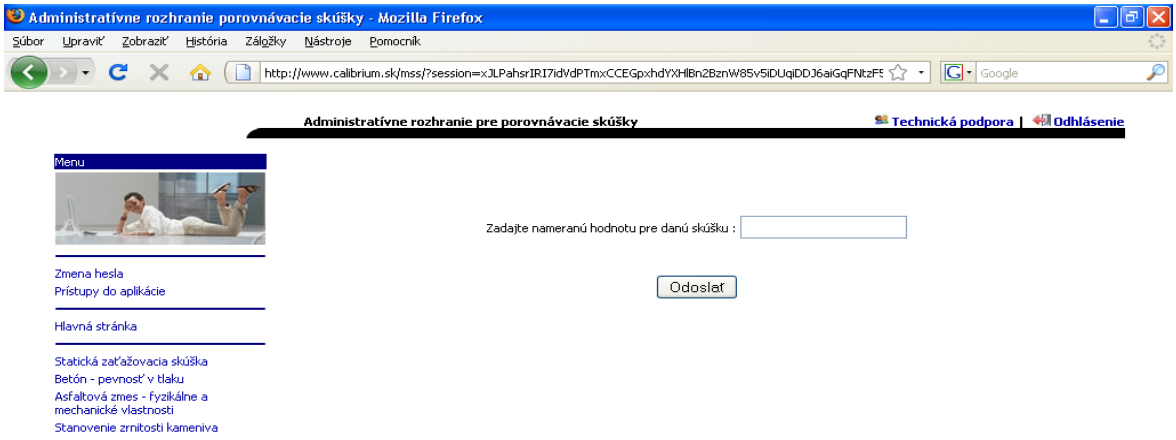

Fig.9. Method of data entry into the application

- ***Displaying the results*** - if the user enters his values for particular measurement and other participants of the interlaboratory comparison have also entered their values, the evaluation will be displayed. To protect the user data, each user views the results table

reshuffled. So even if 2 users agree that they will provide the results table to each other, it will not be identical, the arrangement of laboratories will be different.

- ***Trial testing*** - we have created a group for testing the web application. Each participant was assigned a unique code for the laboratory test. The user logged into the application under his name and password and entered the value measured, specifically for Concrete - compressive strength. Unfortunately, some participants were not familiar enough with the system and entered incorrect values, and therefore it was necessary to send them the information about re-entering the results into applications. This delay meant that the outcome of interlaboratory comparison have not been evaluated in such a time span as we would expected. However, over here we see the possibility of adjustments in the future.
- ***System Adjustments*** - during the simulation of the interlaboratory comparison minor errors have appeared and are currently being remedied, this mainly concerns:
  - control of input data entry
  - to allow continuous monitoring of the results of comparison
  - possibility to export the results to PDF, CSV or other.

8. ACKNOWLEDGEMENTS

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