The Silesian University of Technology



PRE-DESIGN STUDIES ON THE EXAMPLE OF MODERNIZATION PROJECT OF GEOTECHNICAL LABORATORIES

FNVIRONMENT

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Abstract

The paper is the second part of the description of an interdisciplinary research concerning the modernization of laboratories at the Faculty of Civil Engineering, The Silesian University of Technology. This paper was focused on the conditions concerning the specific nature of laboratory works involving geotechnics and the methodology of pre-design studies performed in stages. The recapitulation contained the conclusions and a presentation of design solutions based on the conducted research. This text constitutes a continuation of the paper: ERGONOMICS OF LABORATORY ROOMS – CASE STUDIES BASED ON THE GEOTECHNICAL LABORATORIES AT THE SILESIAN UNIVERSITY OF TECHNOLOGY.

Streszczenie

Artykuł stanowi drugą część opisu interdyscyplinarnego projektu badawczego związanego z modernizacją pomieszczeń laboratoryjnych na Wydziale Budownictwa Politechniki Śląskiej. Omówiono w nim przede wszystkim uwarunkowania dotyczące specyfiki pracy laboratoryjnej w zakresie dyscypliny, jaką jest geotechnika oraz metodykę przeprowadzonych etapowo badań przedprojektowych. Na końcu przedstawiono wyniki badań oraz zaprezentowano próbkę rozwiązań projektowych, powstałych na bazie tychże badań. Niniejszy tekst jest kontynuacją artykułu pt.: ERGONOMIA FUNKCJI LABORATO-RYJNYCH W UCZELNI. STUDIUM PRZYPADKU.

Keywords: Didactic laboratories; Laboratory process technology; Pre-design studies; Research and development laboratories; Users' needs.

1. INTRODUCTION

Within the framework of a faculty subject: "Interdisciplinary research in ergonomics" taught at the Faculty of Architecture, The Silesian University of Technology, for MSC. courses – supervised by the authors of this paper, a research project was conducted concerning the modernization of three laboratory facilities for soil analyses at the Department of Geotechnics and Roads at the Faculty of Civil Engineering, The Silesian University of Technology. The main objective of the faculty subject is to confront the theoretical knowledge of ergonomics in architecture with the practice of the functionality of buildings. It should enable students to carry out their own research conducted in accordance with the methodology designed by their supervisors. The research includes in situ evaluation of architectural solutions in selected buildings, with the participation of their users, concluded with the presentation of results and discussions during classes. The "interdisciplinary" nature of the research involved the cooperation between architects and research staff representing the fields of civil engineering and sociology.

2. OBJECTIVE AND SCOPE OF RESEARCH

The following objectives of the research were identified:

- Diagnosis of the existing state, i.e. advantages and drawbacks of usable space of the three rooms and their equipment;
- Investigation of users' needs (research and teaching staff and students) in view of the used space and its equipment;
- Dissemination of the knowledge on the design of laboratories among students of the Faculty of Architecture;
- Programming of functional criteria for the modernization of the space of the laboratories;
- Devising the documentation for the staff of the laboratories – enabling the application for funds for the modernization of the laboratory facilities.

3. THE STATE OF KNOWLEDGE

The bases for the elaborations of this paper were publications on the design of laboratory facilities [1, 2, 3, 4] discussed further in the paper ERGONOMICS OF LABORATORY FUNC-TIONS AT UNIVERSITIES. CASE STUDIES. The second group of publications describing the state of knowledge on quality evaluations in architecture with consideration of the Polish conditions, presented in numerous publications of the research stuff, including the authors of this paper, who are members of the research team focused on quality evaluation of built environment, coming from The Silesian University of Technology [5, 6, 7, 8, 9].

4. METHODS AND RESEARCH TECH-NIQUES

The methods applied were quality assessments, including POE (Post Occupancy Evaluation). This is the method of assessing the quality of an architectural object, building, or its parts in view of technical, behavioral, organizational and economic aspects in the time of the use of buildings or given spaces. The authors of the paper have several years experience in the application of POE, which was summed up in monographs, [10, 11]. POE is conducted on the orientation, research and diagnostics levels. In this case study, POE was conducted on the first two levels. The diagnostic level was not applied, as it requires comparative studies of other buildings and objects and should result in the detection of repeatable errors.

The research techniques included:

- Local vision (in-situ research),
- Non-participation observations,
- Testing of traces of users' functionality and behaviour in laboratory spaces,
- Free interview, directed but without a questionnaire (during focus meetings),
- Surveying, conducted on thirty people which was not representative, for example: it was circumstantial – as only one student group was subjected to the surveys that took place in a given day during laboratory classes.

5. THE COURSE OF THE RESEARCH PROJECT:

The project was divided into the following stages:

Stage I - preparatory, included:

- Organizational classes, introduction, presentation of the objective and schedule, division of students into three groups, each of which took charge of one of the three laboratories to assess and find out the solution to the diagnosed spatial problem,
- Introductory lecture on: "Presentation of the programming of laboratories for the Bio-Medical Engineering", expanding student knowledge and based on students own research (author: Dorota Winnicka-Jasłowska, DSc PhD Eng. Arch.),
- Analysis of Occupational and Safety Standards for working in laboratories,
- Acquisition of documentation (projections of the concerned facilities).



Figure 1-3.

Design and colour lines of the laboratories at the New Technologies Centre, The Silesian University of Technology, Gliwice (photos by Joanna Tymkiewicz)

<u>Stage II – POE on the orientation level- included:</u>

- The first visit at the laboratories at the Faculty of Civil Engineering, including the general recognition, initial measurements, familiarising with documentation (projections), occupational health and safety procedures concerning the laboratory, preparation of photographic documentation of the existing condition, initial talks with users, observations,
- Preparation of the research plan, scenario and detailed questions for focus meetings with different groups of laboratory users,
- Preparation and correction of survey questions, devising a pattern survey form for students- laboratory users.

<u>Stage III – evaluation on the research level- including:</u>

- The first focus meeting: interview with the users research staff in consideration of the following issues:
 - Type of laboratory tests and their characteristics,
 - Laboratory process technologies,
 - Types of actions performed by the staff and students during laboratory work,
 - Main and supporting activity,
 - Main and supporting equipment (stationary and mobile),
 - Users' organizational and behavioral needs,

- Continuation of ergonomic measurements (detailed measurements),
- Identification of users' students' needs on the bases of non-participative observations and the conducted survey,
- Analysis and recapitulation of the results, discussion and conclusions,
- Elaboration of the report from the research.

Stage IV - are inspirations

During this stage students were acquainted with novel solutions used in laboratories. To achieve this, a visit was organized to the laboratories at the New Technologies Centre, The Silesian University of Technology, combined with a round tour in the presence of the building administrator and interviews with two research workers who use the laboratory facilities at the Centre. In the course of the visit the students had the opportunities to see modern equipment, safe manner of conduction of installations and modern design of the facilities, amenities, materials and colour lines. During the interviews they learned the opinions of the laboratory users concerning the applied solutions, which, although had seemed appropriate in the planning stage, do not always meet the needs of users in the functional phase.

<u>Stage V – programming of the functional and spatial</u> <u>guidelines for laboratory facilities</u>

This stage involved the synthesis of the collected information, i.e.:

- The conclusions from the focus meetings, from the interview, in situ analyses and ergonomic measurements;
- The conclusions from the visit to the laboratory facilities at the New Technologies Centre (design, modernity);
- The conclusions from case studies of modern Polish and foreign laboratories.

The students became acquainted with laboratory process technologies (technology lines, sequence of the use of the equipment during routine tests, characteristics of the equipment and apparatuses, support functions, etc.), learned about the users' needs and about modern laboratory design. The synthesis led to the preparation of designs for modernization of laboratories and initial modernization concepts.

<u>Stage VI – Correction of the assumptions, prepara-</u> tion of final documentation and Project completion

At the second focus meeting with the users of the laboratories at the Faculty of Civil Engineering, the assumed initial design solutions were assessed and discussed. The corrections concerned improvements of the assumed solutions in terms of work places ergonomics, arrangement of installations and of the equipment, as well as conditions of the internal environment – ventilation, natural and artificial lighting. In the next stage, the concept of the laboratory facilities was designed – initial projections and visualization of the arrangement of the accepted solutions. The entire works were given attractive graphic design. The final presentation of the modernization proposal was made in front of the staff (future users of the laboratory facilities).

6. RESULTS OF RESEARCH PROCESS

Recapitulation of focus meetings

Focus meetings with users were important elements of the research and design process. As mentioned above, the first meeting was organized to identify the users' needs concerning laboratory space. The second meeting was held for an initial correction of the assumed solutions. The students participating in the project had the opportunity of confronting the proposed solutions concerning the arrangements of the interior space of the laboratories with the users' opinions (the research staff). The discussion and negotiations included:

- Attempts at breaking through the users habits and at convincing them to new solutions (for example: arrangement of desks and equipment); as far as student work stands were concerned – a useful argument were negative students' opinions on the deficiencies of laboratory spacer – given in the surveys discussed in the next part of this paper;
- The compromise between ergonomics and insufficient laboratory space, especially in consideration of a large number of student classes;
- Realistic possibilities of new installations and technological floor;
- Aesthetic solutions (including the color line of furniture).

Recapitulation of the surveys

As already mentioned above, the surveys were conducted on the group of 30 students - participants of classes held in one of the laboratory facilities. Most of the students assessed this room as neglected, used up, a remnant of the old "Social Realism" epoch, but still, serving its function - "obsolete and ugly but still functional". As far as the size of the room was concerned the majority claimed that it was big enough, although "some places were crowded, at the apparatuses or work stands", "insufficient work places, cramped, and the arrangement of the furniture makes moving around especially difficult". As far as the ergonomics of work places was concerned, the students mentioned: "low and uncomfortable desks, inconvenient cases under the working boards, no hangers for jackets". The indicated advantages were: "soft and cozy chairs", "high work boards", "good natural lighting system", easy access to samples and tools".

The majority of the surveyed students expressed no reservations as to the set up/ arrangement of the equipment , however, the following suggestions were expressed:

- The weight should be placed next to the dryers,
- The access to the dryers is cramped (the same concerns the sink),
- The equipment for macroscopic tests should be placed under the window, to secure better natural lighting.

The surveys also contained some suggestions about the quality and age of the equipment. The storage of the equipment did not evoke many reservations, yet, there were opinions that there was a clear insufficiency of space, or that the space was not properly managed, or that "all things are left behind on the surface".

As far as wiring system was concerned, no major reservations were made, however, sanitary fittings were considered a serious problem. The majority of the surveyed users complained about insufficient accesses water intakes and poor quality of water.

Natural lighting is a big asset of the discussed room, and many users appreciated this aspect; however, there were singular suggestions about installing sun protection systems. Several users mentioned that natural light is available behind the working staff, which hinders their work efficiency. Artificial light is rarely used. But, there were reservations as to its color and adjustment to the type of work. There were also remarks about poor ventilation system, odors and noise emitting equipment.

In the course of the research the surveyor also performed a non-participative observation which confirmed the cramped condition of the room and the collision of the functions that focused on critical points (for example: at the apparatuses).

The surveyed students were also asked to propose changes - in the form of slogans (they could be real but courageous, or even unreal to implement). In the response there were proposals about "lifting" the existing condition, "painting the walls", "putting tiles on the floor", "replacement of the furniture for new, higher quality equivalents", "enlarging the number of cases for the equipment and describing them in detail", "organizing hangers for coats ", "increasing the number of weights". Among more creative proposals the following should be mentioned: "moving the projector to the central part of the room", "getting rid of the desks - so that taking notes should take place at the work stands", "providing a social and sanitary room", and "a kitchen nook with an electric kettle".

The conclusions from the surveys could be summed up in the following way:

The size of the room is enough to hold twenty students, in bigger groups it is too cramped (sometimes it happens that there are twenty five and even thirty students). The space at and around the apparatuses and equipment and work stands is too crowded. The arrangement of the furniture and other fittings is not optimal, for example: the work stands are not adjusted to modern needs and functions. The access to water is a serious problem. Other inconveniencies involve poor efficiency of the ventilation system, odors and the noise emitted by the equipment. The natural light is sufficient, but the artificial lighting system does not meet the users' expectations, however, it is rarely used. The equipment and furnishings of the room are obsolete, prone to break down and they are just insufficient.

7. PROJECT FOR THE MODERNIZA-TION OF THE LABORATORIES

On the grounds of the pre-design studies, which entailed, first and foremost, the evaluation of the existing condition of the laboratories and programming new solutions, derived from the assessment of the functional needs, the project of modernization and modification of the three rooms was prepared. Room one (118L) - is a research and development laboratory, where research staff and diploma students perform advanced soil strength and deformation tests [12, 13]. Furthermore, tests on the determination of basic physical properties of soils are run. The pre-design analyses indicated the randomness of the arrangements, which were not in accordance with the process line, so important for experiments on the mechanics of soils. In most of the cases, such condition was caused by the need of cramping large-size apparatuses in insufficient space. The laboratory is also equipped with randomly assembled furniture, the standard of which is really divergent from modern, comfortable and health- promoting ergonomic solutions. The new design solutions considered the ordering of the laboratory process line and supplementing it with easily-operated work stands equipped with computers.

An important element of the project are ergonomic furniture solutions, adjusted to the organizational needs of this room and to its functions.

The other two room are laboratory and teaching classes, where performed activities involve students. Room 2 (119L) is mainly devoted to the designation of the physical properties of soil, including their types and conditions, for the first degree students. Its equipment consists of tables for seminar classes and an experimental board on which tests and analyses are conducted during the classes. In the proposed new solutions the following stages of the classes were: from the theoretical introduction to experiments with the use of samples. Thus, universal boards were designed, as they may be used for both stages of the work with students., i.e. at the same work stands stu-

dents may take notes about the instructions, and, in the next stage, perform practical tests. Sinks were proposed to be installed to prepare and clean the stage. The accessory functions were located along the walls, constituting an appropriate process line.

Room 3 (120L) is mainly used for designating the mechanical properties of soils by the MSc. students [14], which requires special and large-size apparatuses. This results in very poor furniture state, which, in the modernization project was supplemented by new, profoundly analysed arrangement solutions. The biggest asset of the concept is a big board – like an island – used by all student group for tests and practical exercises.

It should also be noticed that rooms (119L and 120L) are connected not only in terms of the process line (there is a passage between them) but also in terms of the subjects that students learn depending on their equipment. The introduction to practical classes usually takes place in 119L.

In all of the three cases the rooms were profoundly analysed and designed, as well as furniture arrangements and ergonomics, good lighting conditions and ventilation of the work stands. Each part of the design consists of projections, cross sections and development of the walls, as well as realistic 3D visualizations.

This paper presents selected drawings and photographs from the project for the modernization of classroom 120L. It is worth mentioning, that described studies have been presented at the ergonomic conference in Karpacz (Poland) in September 2016. Delivered speech will be published as a chapter of monograph in the future (Winnicka-Jasłowska D.: "The application of ergonomics in the project of modernization of laboratories for research and teaching on the example of case study", XLIV National Ergonomic Conference OKE'2016 including 14th International Ergonomics Conference "Man – Science – Environment" MSE '2016).

8. FINAL CONCLUSIONS

The users are experts in the functionality of their space of work. The role of an architect is to recognize their needs, the functionality and to propose the best design solutions, however, dependent on efficient work and activity of man in space, providing ergonomic and health promoting working conditions. The grounds for good pre-design solutions in the case of laboratories are the pre-design studies. Their methodology - the cycle of the successive stages makes it possible to comprehend the essence of the activities and the needs involved in the use of such type of space. The bases of such research and analyses is the knowledge of the research and development technologies, teaching needs, and users' expectations. This paper presented the stages of the pre-design studies, which, according to its authors, should always be conducted to achieve a good design or project. In the discussed case, the project concerns the modernization of the existing state. The project was based on in-depth analysis based on the knowledge of the users' needs.





Figure 4-14. Classroom 120L – existing state; team work of students: K. Caban, M. Kampka, M. Rajczykowska, A. Szema, B. Radwan



Figure 15-16.

Classroom 120L – the project for the modernization; team work of students: K. Caban, M. Kampka, M. Rajczykowska, A. Szema, B. Radwan











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