

A. ABSTRACT

This thesis includes the results of the candidate's research activity after the defence of the Ph.D. thesis in 2010, entitled "Theoretical and Experimental Contributions to the Rehabilitation and Modernization of Water Supply Systems in Urban Localities".

The Ph.D. thesis has addressed a major research theme for the field of fundamental Engineering Sciences, specialization: Civil Engineering. Starting with the global, historical, cultural and technical significance of the water resource, in the Ph.D. thesis, besides explaining the essential specialty concepts, we provide an overview of the norms and standards in force at national and international level. Also, with special consideration to the technical reports based on practical experience, inventions and innovations applied worldwide, we provide a presentation of technical possibilities and computational relations in the areas of: water catchment, water storage, water treatment, and water distribution. The materials used in the manufacture of pipelines fitted in the water distribution systems, the failures in the pipeline networks found through imaging diagnostics, as well as the pipeline rehabilitation and modernization technologies - classic and modern methods, such as the rehabilitation technologies of the pipelines without excavation -, are also presented. In the end of the thesis, we present a case study in order to highlight the concept of rehabilitation and modernization of water supply systems. The main results of the thesis were presented at several national or international conferences and were disseminated by publishing articles in journals indexed in international databases.

The post-doctoral activity focused on the following main research directions:

1. Rehabilitation of water supply systems in urban localities.
2. Use of alternative hybrid energies in stationary applications.
3. Sustainable development in the field of construction.

As a first step, in order to continue the work carried out in the doctoral studies, the research activity focused on scientifically solving the issues of rehabilitation or modernization of the water distribution systems using the multi-criteria analysis methods for grounding decision-making.

In general, the multi-criteria analysis should be organized as follows: objectives must be expressed in measurable variables; once the "vector of objectives" is built, a technique must be found to aggregate information and make a choice; definition of evaluation criteria; impact analysis; estimation of the effects of the investment expressed in the selected criteria; identification of the typology of the subjects involved in the investment and collection of the respective preferences (weight) given to the different criteria; aggregation of the scores of different criteria based on their relevant preferences - each score can be aggregated by giving a numerical appraisal to the investment, comparable to other similar investments.

In the context of the foregoing, case studies have been carried out on the water distribution network of the City of Cluj-Napoca, Romania, regarding the choice of the optimal moment of rehabilitation of water pipelines; the analysis of setting priorities for the rehabilitation of water distribution networks and the choice of the optimal technology of rehabilitation of pipelines in the water distribution systems.

As a result of the case studies, it was found that the water supply system of the City of Cluj-Napoca is inhomogeneous both from the point of view of the materials used and their age. When initiating the rehabilitation program, it will be necessary to take into account the increase in the number of faults in the system and the regression coefficients to be determined depending on the length of the sections to be rehabilitated. An excess of water loss has been found, which leads to high production costs and, implicitly, to the economic inefficiency of the company. Better tracking of losses and implementation of programs for the priority rehabilitation of high loss sectors, in the asbestos pipeline area, is recommended. Multi-criteria analyses have been successfully applied for the choice of pipelines to be rehabilitated and subsequently for the establishment of the rehabilitation technology. The study has shown that the first measure to be adopted by the company is the rehabilitation of asbestos pipelines. According to this study, it can be done with the Slipline method, by introducing a polyethylene pipe into the old pipe, without having to be removed or destroyed.

Also, within the framework of the research activity, the link between the failures in the water supply system and the road traffic in Cluj-Napoca, Romania, was analysed. The calculations in the case study were made using the 2011 Autodesk Robot Structural Analysis Professional software. In the case study, the following types of pipes were analysed: made of steel, grey cast iron, ductile cast iron and high density polyethylene (HDPE). On the basis of the results obtained from the analytical calculation, it was found that heavy road traffic affects primarily the pipes with a small nominal diameter, i.e. pipes with a nominal diameter of up to 300 mm. The results of the research are useful on the one hand in the phase of design of the water distribution networks, so that depending on the type of material in the pipes, the minimum fitting depth can be indicated, so as to avoid pipeline failure due to road traffic. Further, similar studies could also be carried out with regard to the negative influence of road traffic on sewer networks, gas networks and thermal networks.

Interest has been shown and significant research has been carried out in the field of energy efficiency of buildings by studying the possibilities of using alternative hybrid energies in stationary applications.

In the first stage, a study was conducted on the selection of technical solutions for the thermal and energy modernization/rehabilitation of existing buildings in order to increase their energy performance. In fact, the study aims to fill the existing gaps in the laws on energy audit of buildings regarding the selection of optimal measures for the rehabilitation of existing buildings as well as on feasibility studies of energy audit projects, using the TOPSIS multi-criteria analysis method.

The success of implementing energy efficiency in the field of stationary applications depends directly on the solutions to capitalize on the alternative energies through the various energy generation systems that will be adopted for the energetic support of these buildings.

A first direction in the field of alternative energies addressed for analysis and research deals with particular and specific aspects of electrolytic hydrogen production by using energy systems that use solar irradiance as the primary source of energy. The aim of the study is to identify and develop a scientific model for the documented choice of sustainable and efficient hydrogen production using concentrated solar radiation. The paper is addressed to energy engineers, researchers, solar system developers and alternative fuel manufacturers. At the same time, the paper aims to present to the specialists in the energy field the potential of

energy poly-generation systems by converting concentrated solar radiation and to establish new research directions in this field, as well as in the adjacent fields.

The main specific concern in the field of hybrid power generation systems for energy-efficient buildings is synthesized in the habilitation thesis by synthetically presenting the results of a comprehensive study on alternative energy solutions (sun, wind, hydrogen) for powering a passive house located in Cluj-Napoca, Romania. Five scenarios for different combinations of hybrid energy have been optimized and analysed in the studies. Hybrid systems have been designed and virtually simulated in operation, and the main conclusions are: the best energetic and environmental performances are achieved through hydrogen and fuel cell technology, and the use of hydrogen energy is more efficient and less costly than the seasonal storage of primary renewable energy by batteries.

Another study concerns the design and development of an energy system based on renewable energy sources for a sustainable agricultural greenhouse. The case study that has been addressed shows how to develop a sustainable agricultural greenhouse concept to implement an integrated energy system based exclusively on renewable sources such as solar energy, hydrogen energy, and biomass, possibly applicable in the future.

The studies, the analyses and the results of the researches, as well as the problems, the technical limitations encountered allow identifying and establishing future directions of research in the field of the themes approached:

- continuing research directions in the field of water supply sustainability;
- conducting research activities for obtaining new products, new technologies for water treatment with absorbent material obtained from zeolite material;
- expanding research on the implementation of hybrid power generation solutions for the energetic support of standard residential consumers, but also for energy-efficient commercial and industrial applications;
- carrying out a study outlining socio-economic perception, viability and public acceptance by Romania on the use of hydrogen as an energy alternative and the regional transition to hydrogen-based sustainable and green energy generation systems;
- developing a database to create the necessary premises for the elaboration of procedures, norms and standards regarding the design, execution and safe operation of alternative energy systems, having as field the stationary applications, as well as the elements regarding the production, storage, transmission and distribution - the infrastructure needed to develop an economy based on alternative energies.