

Technical University of Lodz, Faculty of Civil Engineering, Architecture and Environmental Engineering

## THE ABSTRACT OF THE DOCTORAL DISSERTATION

**The thesis title:** The Influence of Urban Forms and Adaptation Strategies on Microclimate and Human Thermal Comfort

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The implementation of adaptation strategies is considered as one of measures for adapting cities to changing climatic conditions. Making appropriate planning decisions, taking into account the specificity of a given area, requires having access to reliable data on the effectiveness of adaptation measures. It is necessary to determine the impact of planned projects on climatic conditions as well as on the thermal comfort of people living in urban spaces. However, the complexity of this issue requires knowledge of architecture and urban planning, construction, environmental engineering and climatology. As a result, it is possible to describe the complex processes occurring in urban areas.

The present dissertation is part of the current research on urban physics. The paper is divided into eleven chapters. The first part is the introduction. It justifies the necessity of undertaking research on the given issue. Research thesis has been defined, which assumes the existence of relation between the form of buildings and the effectiveness of introduced adaptation strategies. It also defines **the main objective of this study, i.e. the evaluation of (1) the influence of characteristic forms of urban development, (2) selected adaptation strategies on microclimatic conditions, as well as human thermal comfort**. The study delimits the geographical research area – the Metropolitan Area of Lodz, which is a key area for the city's identity and of interest to planners and municipal authorities. It defines the research methodology, which involves the use of available archival information sources, digital data resources, and computer-aided tools.

The second chapter describes the characteristic microclimatic conditions prevailing in cities, which are the result of spatial development, i.e. the compact nature of development structure, the large percentage of impermeable surfaces, and the reduction of environmental components. The description addresses potential adaptation strategies to counteract negative climate change that can be implemented in the inner city. It also discusses the research on human thermal comfort in the outdoor environment.

The third chapter presents the tool used, from the field of Computational Fluid Dynamics (CFD) to perform numerical simulations. Currently, the ENVI-met is one of the widely used applications for the assessment of complex climatic phenomena occurring in urban areas. It allows to create models that can be used for estimation of climatic conditions in public spaces. Finally, it is possible to determine the thermal comfort prevailing in the outdoor environment.

The fourth chapter is a description of the author's method of determining typical development structures in the Metropolitan Area of Lodz. The analyses were based on archival data resources (from the National Archive, the City Conservation Officer, and the Regional Conservation Officer) and information from digital databases of public institutions (Lodz Geodesy Centre). The information was processed using Geographic Information System tools. As a result, geometric models of typical development forms in the Metropolitan Area were created.

The fifth chapter covers the climatic conditions in the city of Lodz. The analyses were carried out for the basic parameters prevailing during a Typical Meteorological Year. Taking into account the fact that the information is obtained from the suburban zone – Lodz-Lublinek station, the author's approach has been proposed based on combining the conditions of the suburban and inner city zones. As a result, it was possible to calculate the air flow velocity in the city center. Data were used in numerical simulation processes.

The main part of this dissertation, related to numerical simulations, is the analysis of microclimatic conditions and thermal comfort. The sixth chapter discusses scenarios related to the influence of development forms of the Metropolitan Area on microclimatic conditions and external thermal comfort. The seventh chapter investigates the effectiveness of selected adaptation strategies, involving the introduction of green roofs, walls, tree rows, and water elements, in relation to the thermal conditions prevailing in the areas of typical forms of the Metropolitan Area of Lodz. An extensive discussion is also presented, including the research results, in relation to the effectiveness of adaptation strategies implemented in cities. The eighth

chapter presents the potential impact of green solutions on the thermal conditions inside buildings located in the Metropolitan Area of Lodz.

The ninth chapter presents a comparison of obtained results with the literature studies conducted. The description concerns both studies on the influence of development form on the external microclimate conditions and the effectiveness of adaptation strategies in relation to the internal thermal conditions. It is concluded with recommendation cards that refer to selected solutions that can potentially be implemented in the Metropolitan Area of Lodz.

The last part is a summary of conducted research. It confirms the research thesis that there is a relationship between the development structure and the effectiveness of adaptation strategies in cities. It presents conclusions of a general nature as well as discusses further directions of research.