University of Pécs
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PROPOSING A NEW MULTISTORY OFFICE BUILDING TYPE IN MODERATE CLIMATE AS A GENERIC PASSIVE STRATEGY

Ph.D. Thesis Booklet

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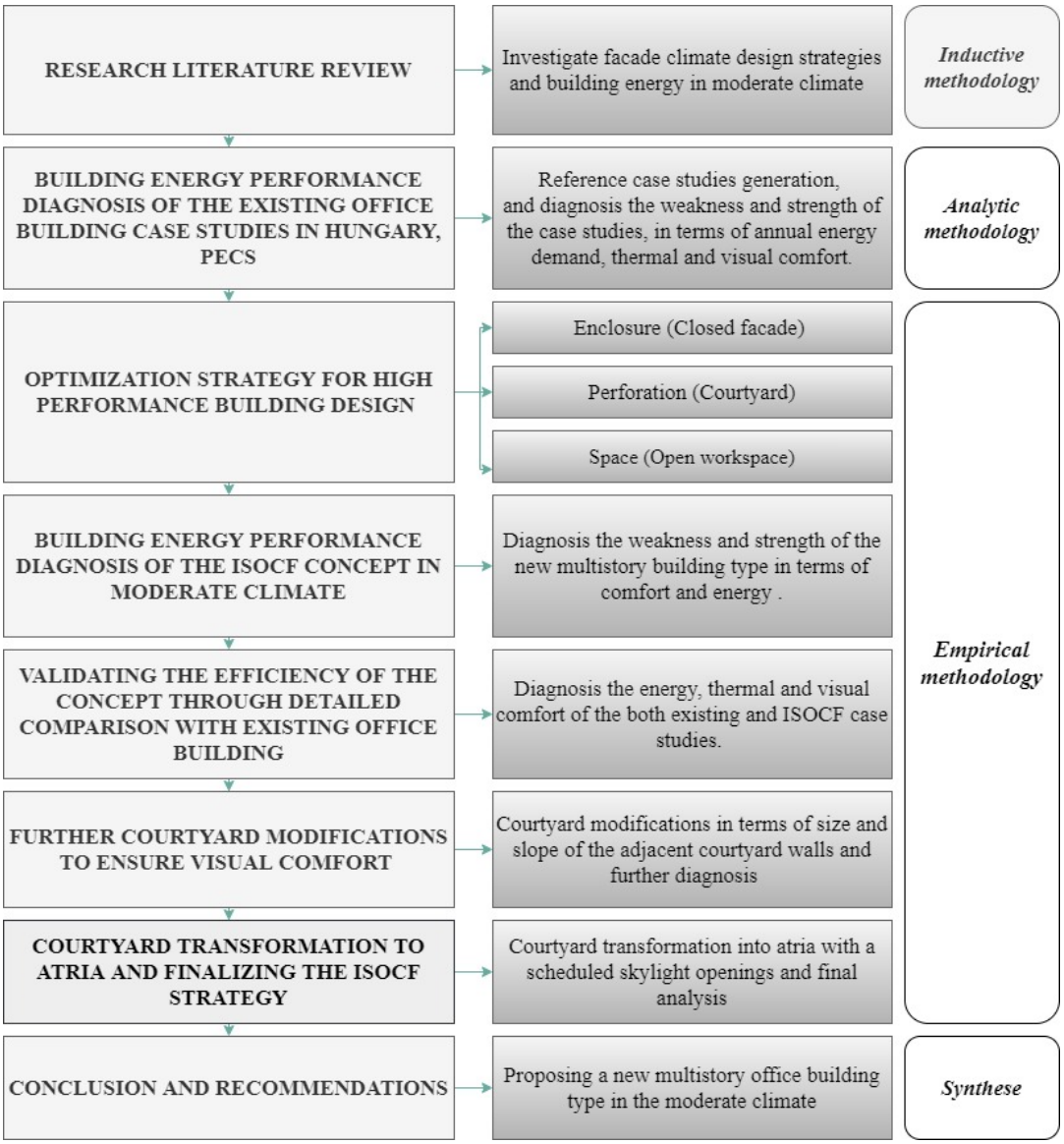
1. RESEARCH AIM AND OBJECTIVES

The predicted climatic changes will have significant implications for building planning in the future. The population explosion in comparatively young states will demand extensive construction projects, in which the standard European concepts will be insufficient to meet. The architecture of the future will need to be based on detailed climatic analysis, taking into account the impact of solar radiation, temperature, humidity, and wind on buildings. However, the studies show nonresidential building and agriculture are among the fastest-growing energy demand sectors and are projected to be 26% higher in 2030 than it was in 2005, compared to only 12% higher for residential buildings. Fully glazed facades have forced up the thermal loads in modern, contemporary office buildings, resulting in a considerable amount of cooling and heating demand. Moreover, occupancy time is increasing in office spaces, while the improvement of well-being and level of productivity is fundamentally based on the indoor comfort environment. To search for solutions for the 'literature analysis' shortcomings, a new "Introverted Climate Concept with Closed Facade" (ISOCF) for office buildings under a moderate climate is proposed. The main target of this research is to propose a strategy to enhance the necessary level of thermal and visual comfort while improving the level of energy efficiency in multistory office buildings. The study investigated under conventional office building boundary conditions and compared to existing sophisticated multistory office building, Szentágothai Research Centre office located in Pecs, Hungary. To fulfill this aim, the following objectives have set:

1. Comprehensive review literature on the building façade research and applications to investigate the optimization strategies has been done to improve the comfort and energy.
2. Review literature on the impact of courtyard and atria towards multistory buildings in vernacular architecture.
3. Review literature on the openwork space and flexible office design implemented in contemporary architecture.
4. Diagnose the energy and comfort performance of the current situation of the existing multistory office and research center in Hungary.
5. Proposing the new building type consisting of the closed façade, open workspace, and courtyard/atria and diagnose the various courtyard versions of the new building type.

6. Further development strategies in the case of ISOCF models to achieve the most optimum comfort and energy level.
7. Develop design guidelines for the closed façade architecture multistory office buildings in a moderate climate.
8. Determine recommendations considering the multistory office building design for helping architects to achieve the building design which performs highly in terms of comfort and energy consumption.

2. RESEARCH STRUCTURE OVERVIEW



3. CONCLUSIONS

Under the moderate climate, the new introverted open space with closed facade (ISOCF) strategy has been investigated to meet the necessary level of thermal and visual comfort while improving the level of energy demand. The study investigated under conventional office building boundary conditions and compared to existing sophisticated multistory office building, Szentágothai Research Centre office located in Pecs, Hungary. The following statements have been established:

3.2. Statements

1. Rethinking and redesign elementary architectural design factors can significantly improve today`s characteristic comfort and energy drawbacks in the office building sector. These design contents are under moderate climate are as follows:

- The proposed office building type becomes a completely closed façade surface to avoid winter heat losses and summer heat loads.
- The completely closed facade requires the perforation of the building body to be able to deliver missing daylight and passive ventilation provision in form of courtyards/atria. Since the passive ventilation possibility and natural lighting provision should be ensured through the courtyards, the internal space organization should provide accessibility for daylight and ventilation operation all over the interior space. This can be achieved by the open office spaces organization that ensures long term future functional flexibility.

2. A new architectural design concept is proposed, including an introverted space organization with a closed façade (ISOCF), an integrated courtyard, and an open interior workspace organization. In comparison to today's conventional multistory office building, the ISOCF represents a new multistory office building type that can deliver 80% less total annual energy demand (heating, cooling, and lighting). The main contributor is the heating energy consumption (a share of more than 80% of the total energy consumption), which is 140% lower in the ISOCF performance. The thermal comfort in the ISOCF office building performed a 20% higher number of occupancy hours with PMV-values, class B (II). The daylight performance reaches a 10% improvement in daylight factor ($DF_{1.7}$) under mixed sky conditions and 32% better daylight autonomy (DA_{300}) under global radiation circumstances.

3. In the ISOCF model development, different numbers and sizes of courtyards were tested to analyze the thermal and energy performance. Cases with 1, 2, and 4 courtyards were simulated in the experiments.

Under the same building dimension boundary conditions, by increasing the number of courtyards, their WWR is enlarging as well, lowering the PMV performance by 12%, while the total energy intensity becomes 35% larger. The heating demand performance here is the greatest ratio as well, representing more than 80% of the total energy demand, whereas heating is increased by 54%.

4. In the ISOCF building concept, 1 courtyard can maintain the appropriate level of $DF_{1.7}$ and DA_{300} distribution, by simultaneously lowering the energy consumption, when the dimensions of the courtyard geometry are properly sized. In the framework of the ISOCF experiments, the model with 1 courtyard has to be modified to ensure not only thermal comfort and energy improvements but also visual comfort, since the daylight qualities in that concept were suffering due to undersized courtyard and hence WWR. The courtyard layout was gradually increased to double size, while it was necessary to narrow the depth of the adjacent office zones by 50% and the external perimeters of the building at one side needed enlargement of 16%. It can be stated that 5-storey ISOCF office buildings under a moderate climate require a depth ratio of approx. 0,25 between the average depth of the office comfort zones and the mean courtyard/atrium depth to deliver the achieved improved level of comfort and energy performance results.

5. Under moderate climate circumstances, typical modern multistory office buildings possess significantly greater heating demand, compared to cooling. The open perforation of the building body (courtyard) increases transmission and thermal bridges based heat losses in winter. Therefore, the closing of the courtyard with a skylight creates significantly lower (110%) heating consumption, as well as an external multifunctional space for communicative functions (brainstorming, project office) in at least 60% of the year without space conditioning.

6. The particular investigation focused on a 5-story office building with a compact width to length ratio. The concluded insight and design rules are accordingly limited to buildings with a width to length ratio of around 1 and the mentioned building height. With an increasing number of levels, the daylight provision starts to decrease, while lower buildings with a decreasing number of levels show higher daylight qualities. Besides, a lower with to length ratio results in a less compact (e.g. elongated or splining) building shape that cannot integrate a sufficient sized courtyard.

7. This research was conducted under moderate climate conditions with its specific solar radiation and daylight path properties, therefore the conclusions are limited to this climate zone. Further research using various climate profiles can broaden the adaption of the developed building type under further climate locations.

8. The proposed ISOCF office concept represents a fundamental basis for the development of a comprehensive future ISOCF multistory office building typology and design guidelines.

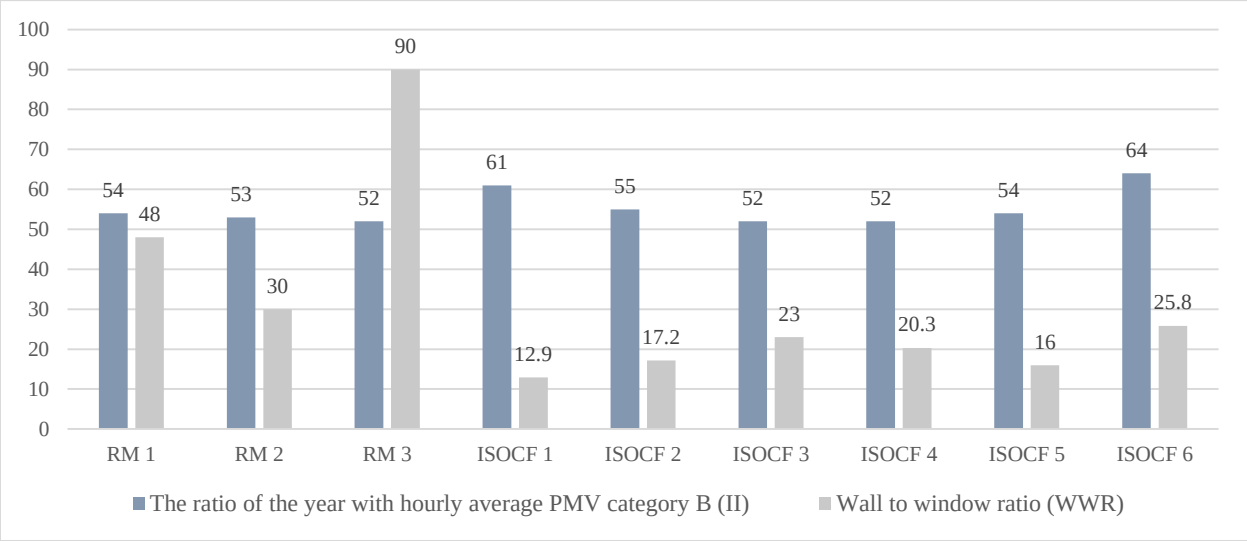


Figure - The ratio of the year with hourly average PMV category B (II), Wall to window ratio (WWR) in the ISOCF models in all zones of the buildings [%]

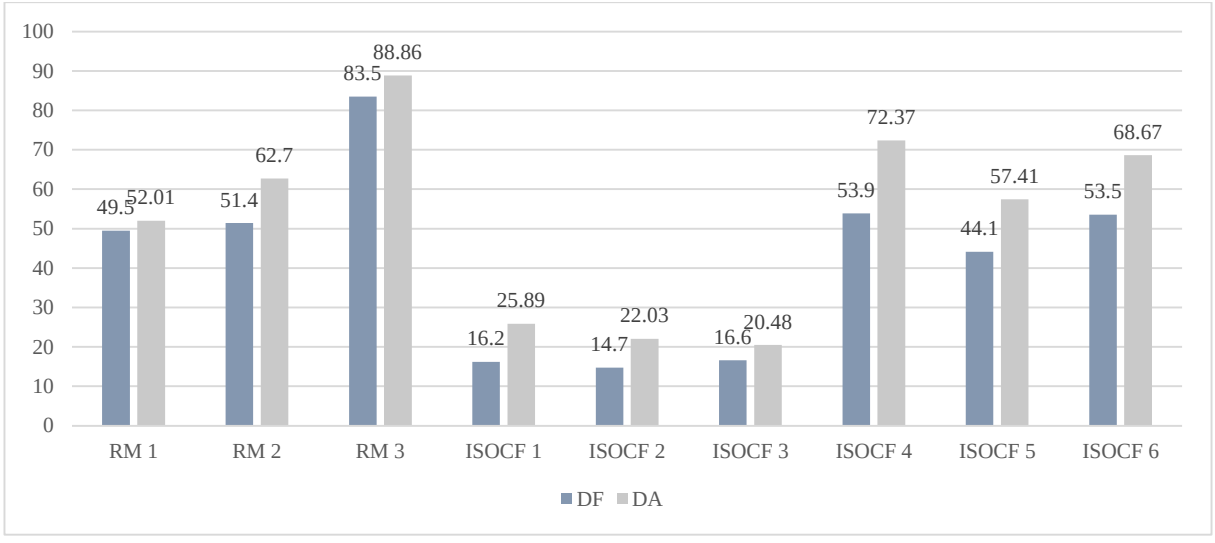


Figure - Daylight factor above 1.7 and Daylight autonomy above 300 Lux % Models

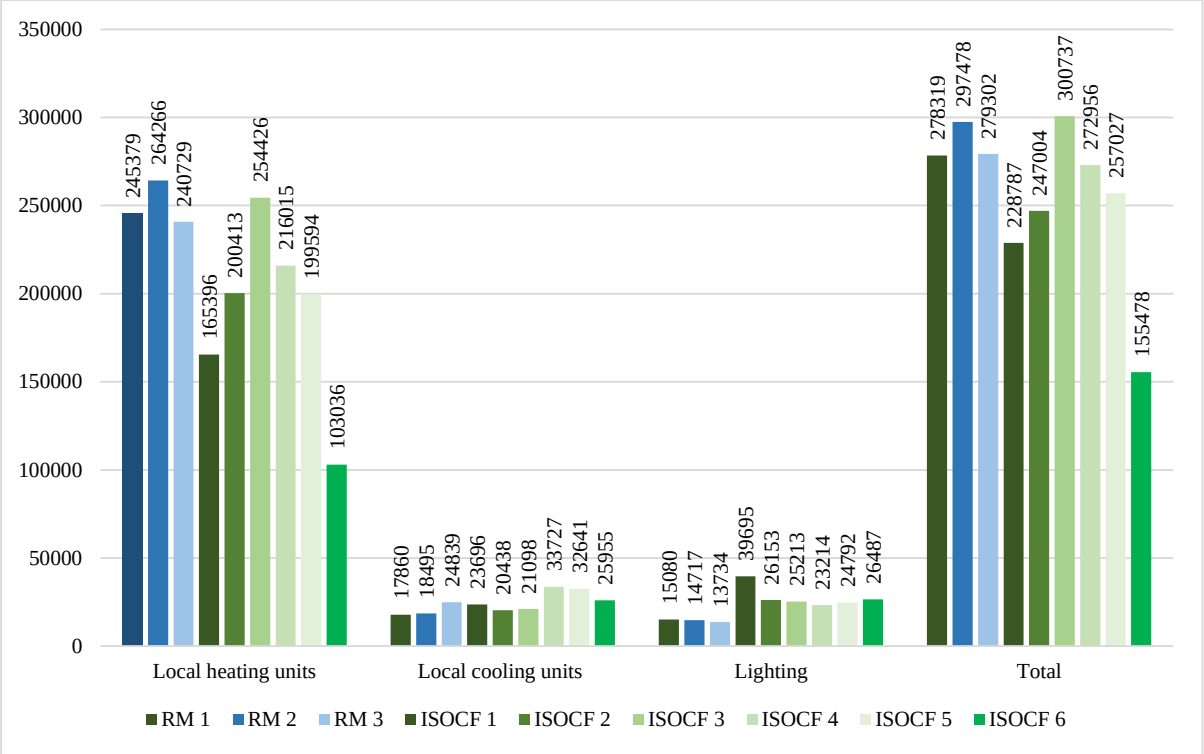


Figure - Final energy demand performance [kWh/m2a] in the RM and ISOCF scenario

4. Contributions

Scientific contribution

- The prior literature in the multistory façade optimization strategy lacked a comprehensive new building type, using radical and elementary passive architectural strategies as a completely closed building envelope according to the reorganization of the interior spaces. This research contributes to the multistory office and workspaces in literature with the innovation and knowledge about the proposed new office building type.
- The following research provides a direction for further investigations on multistory office building typology and energy design guidelines.

Social contribution

- The new building type provides a friendly work atmosphere and due to its open workspace, it increases the positive interactions between co-workers and colleagues, resulting in more efficient group work.
- The new multistory office building type has improved the indoor thermal comfort and energy performance for the working spaces.

Architectural contribution

- With the integration of an atrium, a kind of multifunctional `transition-space` with communicative functions (brainstorming, project office) is created, performing acceptable thermal comfort in at least 60% of the year without space conditioning.
- Using the open workspaces, various required temporary functions can be utilized and the new building type is convertible to any other suitable temporary and permanent functions.

4.1. Future directions

- In the future, further investigations about daylight performance will help to improve the visual comfort level of the new multistory building type.
- It will be useful to analyze the atrium aerodynamic conditions using computational fluid dynamics (CFD) software. This will complete the new building type to increase hygienic comfort (indoor air quality, IAQ) together with lower energy consumption.
- Since the building envelope is free of external windows, it is suggested to use the envelope surface and to investigate the effect of the implementation of PV-technology on the façade surface to improve energy efficiency.
- An energy-positive yearly balance is aimed to be reached by implementing further investigations including HVAC-systems, environmental sources utilizing systems, etc.
- Future studies in terms of interior architectural and temporary visual and acoustical separations in the floor plan will provide more efficient space optimization.

5. Scope and limitations

This study is focused on the analysis of the new proposed multistory office building type to improve comfort and building energy efficiency. While the study is carried out in a Hungarian location with according climate profiles, the concluded statements are not only limited to this region but the application could be generalized to all further moderate climate with analogue meteorological characteristics.