Evaluation of the building form in relation to the energy demand and environmental impact of residential buildings – Summary of a master's thesis

- ***Marianna Ciepiela, Shivani Mutatkar***

The study focuses on investigating a co-relation between the building's form, its energy demand and environmental impact, in relation to different residential typologies. Moreover, a possibility of using the form factor to predict the building's performance is explored.

In the face of rapidly progressing climatic changes, it has become crucial to focus our efforts on reducing the impact that we, as humans, have on the quality of life on earth and the planet's gradual degradation. Among a myriad of factors negatively impacting the environment, the green-house gasses emissions resulting from the energy production and other industrial processes are considered leading issues. As it is estimated that the building industry is responsible for about 40% of the global emissions of green-house gasses and about 35% of the global energy demand, it is considered a priority to undertake steps needed to decrease those numbers.

It is perceived, based on literature, that by assessing the building's form, the energy demand and environmental impact of a building can be accounted for already in the early design stage. However, with sparce research regarding the relationship between the three forementioned features, no clear conclusion could be made regarding the influence of the form on the energy demand and the environmental impact of a building simultaneously. The objective of this paper was to address that research gap.

The *Shoebox Study* was developed for the climatic conditions of Malmö, Sweden, where a basic unit, shaped like a shoebox, was multiplied and assembled in different shapes. Performance of the "shoebox" buildings was then assessed in terms of energy demand and global warming potential (GWP). The *Shoebox Study* findings allowed to determine a correlation between the building's form, defined by a form factor and a heat-loss form factor, it's energy demand and environmental impact. It was, however, observed that varying inputs in the analysis, dependent on the building character and corresponding values in the building standards, influence the results, making it more difficult to establish a clear relationship. However, the trend representing the best-performing and worst-performing building was proportional to the value of form factor and heat-loss form factor in all instances.

Based on the *Shoebox Study* findings and a defined form of a building used in a real-life project, the prediction of energy demand and GWP was carried out. Having simulated and compared the actual energy demand and environmental performance of the considered building, it was determined that, based on the value of the form factor, and the outcomes from the *Shoebox Study*, a relatively accurate prediction of the results could be made.

When comparing the results expressed per m^2 of the heated floor area with the results expressed per m^2 of the liveable floor area, excluding any common spaces in the buildings, it could be observed that in the second representation of the results, the energy demand as well as GWP were much higher for the buildings where the heated floor area was not equal to the liveable floor area. It was noted that the form-factor and heat-loss form factor where no longer proportional to the building's performance when the liveable space was considered.

Ultimately it was concluded that, when considering the results per heated floor area and accounting for any changes to the design or varying standards requirements, the form of the building can be assessed to account for the energy demand and environmental impact in the early design stage. Architects and engineers can use the form factor as a tool in the assessment.