Research Practicum

Simulating wind around the Flatiron building using RANS CFD simulations

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Abstract

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1 Introduction

The Flatiron building, as seen in figure 1, is the iconic Manhattan skyscraper shaped like a right triangle. Clasped between 5th Avenue and Broadway, with Madison Square Park just north-east of him, there is a lot of open space around this building. If the wind comes from the north, it will be forced through an "alley", creating a windtunnel effect around the Flatiron building. Legend has it that men would hang out out at the corner to watch the wind blowing women's dresses up so that they could see their ankles [2]. This is also shown on a postcard from the early 20th century (figure 2), showing a man being blown away by the wind and a woman's skirt being blown

up by the wind.

The main goal of this research is to see if it was actually the geometry of the building creating the updraft. This will be done by simulating the building and surrounding buildings in an in-house built CFD program made for CFD analysis for urban areas.

This report will first discuss the theory and numerical models of the CFD simulation, after which it describes the cases and their results, and furthermore these results will be discussed and a conclusion about the billowing of the skirts will be made.

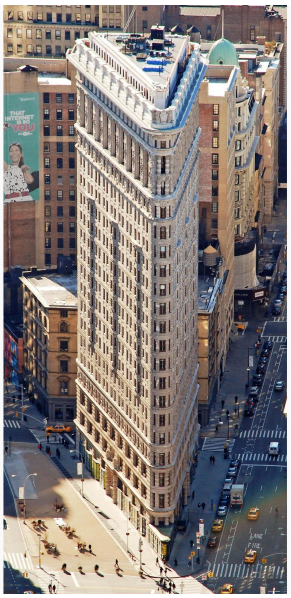

Figure 1: A picture of the famous Flatiron building

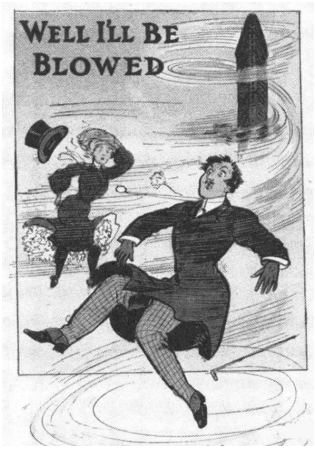

Figure 2: A postcard by an unknown artist displaying the unpredictable winds and billowing skirts around the Flatiron building [1].

2 Theory

2.1 Navier Stokes

2.2 Reynolds Averaged Navier Stokes

2.2.1 Turbulence

2.2.2 k-ϵ model

3 Case and Results

In this section the setup of the CFD analysis will be discussed. This includes the generation of the obstacles for the CFD analysis, a discussion on the Reynolds number associated with this geometry and the fluid properties used during the simulation.

3.1 Obstacle creation

To be as true to reality as possible (within the scope of the research practicum), not only the Flatiron building was simulated, but also 4 of the surrounding buildings, creating the "alley" of wind talked about in the introduction and [2]. The dimensions of the Flatiron building itself were found in Bradford and

Condit's book "Rise of the New York Skyscraper 1865-1913" [3], while the other dimensions were roughly estimated from Google Maps (see appendix 3.1 for a clarification of the method and a complete list of dimensions used).

The program used makes use of an "obstacle generator", in which you specify the start and end of the obstacle in the x, y and z direction, creating rectengular cuboids as obstacles. By combining multiple obstacles together, more complex shapes can be created. By discretizing a right angled triangle, the Flatiron building has been built up of X amount of 0.25 metre wide blocks of varying lenth and the heighth of the building.

3.2 Reynolds Number

3.3 Fluid properties

4 Results

5 Conclusion and Discussion

5.1 Grid convergence

5.2 Uncertainty

References

[1] Alice Sparberg Alexiou. *The Flatiron*. St. Martin's Griffin, 2010.

[2] Andrew S. Dolkart. *The Architecture and Development of New York City*. Columbia University, 2014.

[3] Carl W. Condit Sarah Bradford Landau. *Rise of the New York Skyscraper 1865-1913*. 1999.

A Dimensions of the obstacles

As discussed in section 3.1, the obstacles used in the CFD analysis were estimated using Google Maps. In figure 3 it is shown how these distances were estimated. From this figure and the measurement tool on the Google

Maps program, we found the following dimensions for the Flatiron building and surroundings. The numbers correspond with the building numbers in table **??**

Figure 3: A snapshot of the method used to estimate the dimensions using Google Maps. The red lines indicated the measured distances.