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# Wind comfort assessment of a newly designed tower with a vertical green park

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**KEYWORDS:** wind-tunnel testing; CFD simulations; wind comfort; surrounding; vegetation.

## INTRODUCTION

An emerging type of architecture, aimed at multiplying the presence of forests and trees in cities through vertical green buildings, arose in the last decade. While green roofs are nowadays quite common, architectural design calling for more holistic green parts in buildings is still in its early days, promoting the benefits of plants incorporated into buildings as protection of habitats, heat island reduction and biophilic design. The needs of creating permeable and green spaces was further emphasized by the Covid-19 outbreak, which definitely arose questions about the efficiency of mechanical ventilations systems and the exigence of finding new energy saving strategies. However, whilst green spaces generally make buildings and cities more ecofriendly, it is insufficiently known to which extent the surrounding environment and the vegetation may positively or negatively influence the pedestrian-level wind comfort quality of buildings amidst historical and well-settled urban layouts. This was the scope of the present study for which wind-tunnel (WT) testing and 3D Reynolds-averaged Navier-Stokes (RANS) simulations were performed on two facing towers in Medellìn (Colombia), in order to (*i*) investigate the wind field and the pedestrian-level wind comfort around the towers; (*ii*) to compare the performance of WT and 3D RANS for wind comfort analysis; (*iii*) to evaluate the impact of the environment surrounding the two towers and (*iv*) the mitigation effects of vegetation on wind comfort.

## METHODOLOGY

WT tests were performed on a scaled model (1:250) of the two facing towers (i.e. South tower, ST; and North Tower, NT) in the closed-loop subsonic circuit of the University of Genoa, for 12 wind directions and 3 sets of measurement positions (i.e. *set 1,2,3*) (Fig. 1a). The approaching mean wind speed (*U*) and turbulence intensity (*I*) profiles were measured approximately 0.5 m upstream the model by a Cobra probe (Fig. 1b). Kanomax hot-wires with a sampling frequency of 10 Hz were used to measure the *U* around and inside the ST, at the three sets (1-3). The blockage ratio was kept below 5% for every direction analyzed. The same case study without (i.e. CFDs) and with (i.e. CFDd) surrounding environment was simulated by 3D steady RANS. Next, an implemented CFDd case including vegetation (i.e. CFDd-V) was simulated for three Leaf Area Density (LAD) values (Fig. 1c,d). For all CFD cases, a domain with dimensions 3.2 (L) *x* 3.2 (L) *x* 0.54 (H) km was constructed. In the CFDs case, only the two towers were explicitly reproduced and the surrounding was implicitly accounted in terms of aerodynamic roughness length ($z_0$). In the CFDd case, the surrounding was explicitly modeled within a radius of approximately 1 km and implicitly accounted by $z_0$ in the remaining part of the domain. The CFDs results were validated against WT results (Fig. 1e). Then, a first qualitative comparison between CFDs and CFDd was made in terms of wind speed ratio (*K*) (Fig. 2a). Finally, the wind comfort assessment was performed for all cases with the Dutch Wind Nuisance Standard NEN8100 (Fig. 2b).

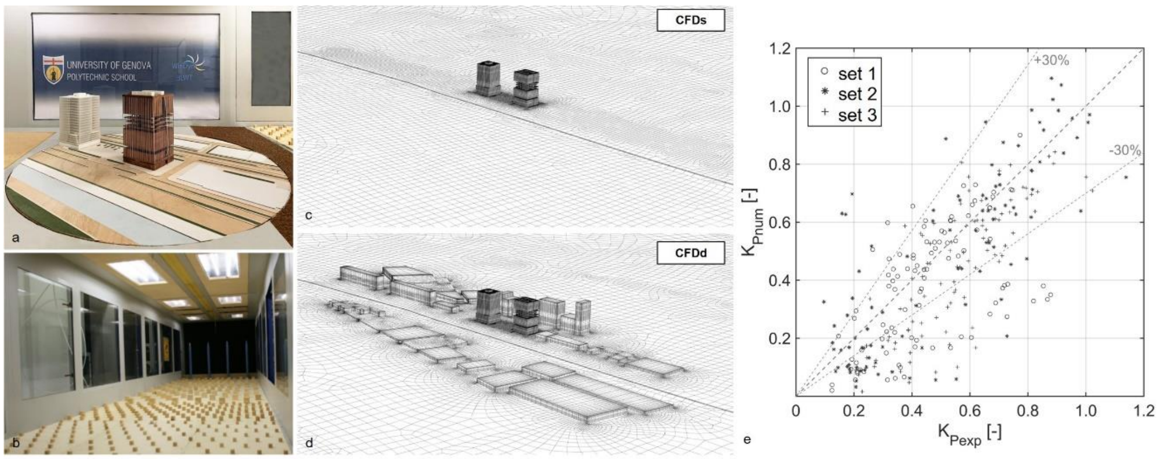


**Fig. 1** (*a*,*b*) Photos of the WT model (scale 1:250); (*c*,*d*) computational grids of CFDs and CFDd; (*e*) comparison of WT and CFD in terms of wind speed ratio at sets 1-3.

## CONCLUSIONS AND REMARKS

Overall, the follow conclusions are drawn:

- The surrounding had a significant impact on wind comfort assessment.
- The CFDd case showed a better wind comfort quality class than WT and CFDs.
- The CFDs and WT case showed a satisfactory agreement and the similar comfort quality class.
- The vegetation provided a remarkable improvement of comfort quality class for *set 1* and *2*, but not for *set 3*.

More detailed results about the wind comfort assessment will be provided in the full-paper version.

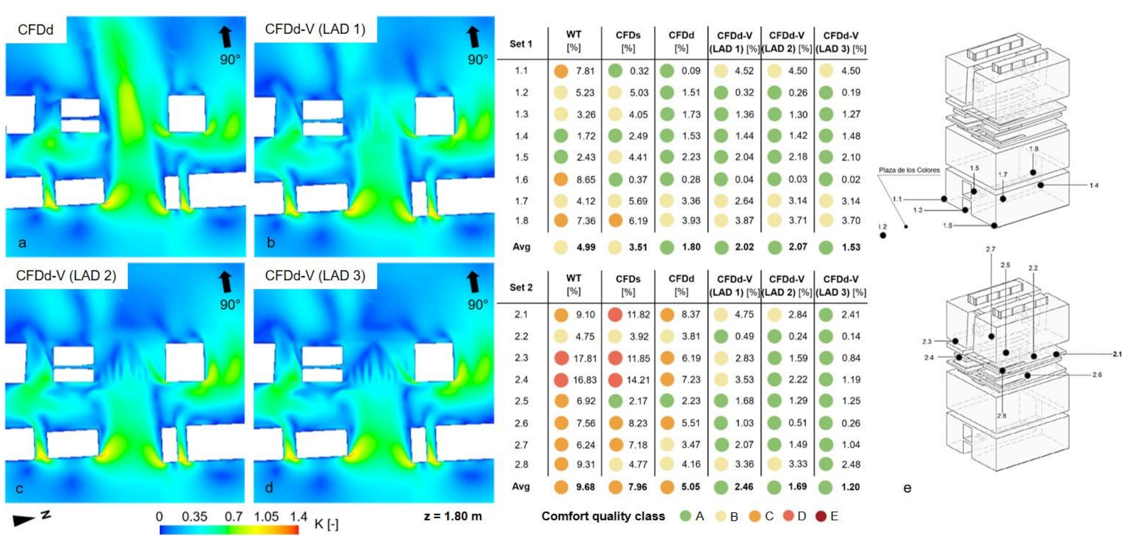


**Fig. 2** (*a-d*) Contours of *K* for the CFDd and CFDd-V cases; (*e*) wind comfort assessment for all cases (WT and CFD) and two sets (i.e. *set 1* and *2*) of measuring positions.