NARODOWE CENTRUM NAUKI

„Wind effects on building fires in a multiparametric risk assessment with numerical modeling”

Individual project of ITB financed by the National Science Centre in Cracow, Poland within grant **OPUS-19** based on the agreement No. **UMO-2020/37/B/ST8/03839**.

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Goals of the project:

The primary goal of the project is to determine the effects of wind on building fires through an unbiased multiparametric qualitative and quantitative fire-risk assessment, with numerical modelling. To reach this goal, we will use the Design of Experiment methods to choose representative wind and fire development scenarios based on historical wind measurements data and event/fault tree scenario modelling for fires. These will be accompanied by computer modelling of occupant evacuation process, to determine number of people at risk.

For the scenarios identified in the first step we will perform transient Computational Fluid Dynamics (CFD) calculations with the use of ANSYS Fluent. The CFD calculations will include transient development of fires, and wind action on a building located in a suburban landscape. CFD model will be validated with use of wind tunnel experiments on a scaled down model of the urban habitat. The results of the CFD simulations will be, among others: fields of temperature, mass smoke density and toxic pollutant concentrations. The results will be used to calculate the time available for evacuation and Fractional Effective Doses (FED), which will further be used to draft an FN-Curve of the wind effect on fires.

A significant challenge in the project lies in the determination of scenarios. For wind, we will relate to historical measurements over a period of time, in a predefined geographical location. This statistical data will give us information about hourly mean wind velocity and direction distribution, which will be further changed into a 3D transient wind profile with the use of post-processing software. The fire scenarios will be determined by the bow-tie methodology, providing us not only with the basic descriptors of the fire (Heat Release Rate, soot yield, area) but also with their frequency of occurrence. This will allow us to measure the risk of fires, and not just its consequences.

The risk-based approach will allow us to determine, what wind velocity may be considered as important for the safety of buildings. It may also help in the design of future large scale fire-experiments. The project should also finish with a complete risk-oriented framework for wind and fire coupled modelling.

Research program overview:

1. Determination of representative wind and fire scenarios: wind scenarios will be based on the statistical data from meteorological stations (external data) based on which we will determine the CDF of wind velocity and direction, as well as, frequency of occurrence of particular values. The generation of transient wind boundary conditions for CFD analyses will be performed with WindSym and WindNinja models, next will be transferred into UDF's that can be imported into ANSYS Fluent simulations.
2. Preparation, validation and sensitivity analyses of numerical models: the detailed 3D model of a sub-urban area will be created. The mesh size, turbulence model and numerical schemes will be chosen following in depth sensitivity studies. Subsequently, a physical model of the same area will be built in scale (1:100 or 1:250) and tested in a wind tunnel. Pressure and velocity distributions from wind tunnel experiment will be used to validate the assumptions for CFD.
3. Coupled wind and fire numerical analyses: once the CFD model is validated, over 300 numerical simulations will be performed for coupled wind and fire scenarios. The simulations will be performed in batches (related to occupancy) to streamline post-processing and qualitative analysis of the results.
4. Occupant, property and environmental risk assessment: the aim to perform meaningful result analysis from the beginning, with new results providing incremental improvements in risk assessment. This strategy will allow us to perform WP 3 and WP 4 in parallel, as we will not need to wait for all analyses to complete to calculate the risk. The output will be presented in the form of FN-Curves, and CDF's of output variables.