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The new WTG- Guideline M3: recommendations for numerical simulation of wind flows around structures

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SUMMARY

The German-speaking Association for Wind Engineering (Windtechnologische Gesellschaft WTG e. V.) published its new WTG-Guideline M3 on Numerical Simulations of Wind Flows in 2025. The guideline covers key aspects such as wind effects around structures, classification of numerical methods, quality assurance procedures, numerical implementation, and documentation requirements. The guideline contains assistance and recommendations to support engineers, consultants, and researchers performing and evaluating numerical flow simulations in wind engineering (Computational Wind Engineering - CWE).

Keywords: *Guideline, CFD, CWE, Wind Simulation*

1. INTRODUCTION AND PURPOSE

Due to the increasing presence and availability of commercial and open-source CFD simulation tools, engineers, consultants, and researchers are increasingly confronted with simulation results or requests for wind flow simulations around buildings and structures. Even though Computational Fluid Dynamics (CFD) is already being used successfully in numerous other areas of application, its applicability and, in particular, its limitations in the field of Wind Engineering must be clear and understood.

The Eurocode EN 1991-1-4-2010 already contains an opening clause which states: "(1) In addition to this standard, wind tunnel tests and proven and/or recognized numerical methods may be used to determine loads and system responses if the structure and natural wind are modeled accurately." The updates in prEN1991-1-4:2024 specify information and recommendations for numerical methods in Annex K in more detail. It explicitly states that CFD simulations in wind engineering must be carried out by experts. An expert is defined in Annex K as a person who has adequate knowledge in the field of CFD simulations and in the field of wind engineering. Annex K makes it clear that the ability to use CFD simulation software alone is not sufficient.

Therefore, it is up to the user to verify the adequacy and accuracy of the respective methods for the specific application. In the case of wind tunnel testing, the boundary layer wind tunnels are typically only operated by experts at highly specialized facilities or universities. There are already many years of experience, and guidelines and quality requirements have also been developed in the past, e.g. WTG-Merkblatt Nr WTG 001/ 1996. In contrast, when using CFD simulations, this "natural" quality assurance is not applicable due to the general availability of CFD software. For this reason, it is particularly important in CFD simulations in wind engineering (Computational

Wind Engineering – CWE) to ensure that the software is used correctly and that the results are interpreted correctly by experts.

In 2025, the German-speaking Association for Wind Engineering (WTG) published the "WTG-Guideline M3: Numerical Simulations of Wind Flows" in both German and English. This guideline is intended to support engineers and architects who commission or use numerical wind simulations, such as the method CFD. It also provides consultants and users with a common basis for modeling, evaluation, and quality assurance in atmospheric boundary layer simulations. However, it does not replace an understanding of the fundamentals of fluid mechanics, wind engineering and the professional responsibility of the engineer.

The guideline outlines key principles for performing numerical aerodynamic simulations in structural engineering and describes the current state of the art for practical application. The software used must be verified by the developer to ensure correct implementation of the equations, and it must be validated by the user for the specific application. Users must confirm that the appropriate models and equations have been selected. Validation should rely on experiments or full-scale measurements, or, with sufficient experience, on comparable previously completed cases.

2. STRUCTURE OF THE WTG – GUIDELINE M3

The Guideline is structured in the following main chapters:

In *Chapter 2. Wind and Wind Effects* around structures are described. Various areas of application in wind engineering are addressed, as well as the definition of loads for structural design and stability followed by the definition of characteristic values.

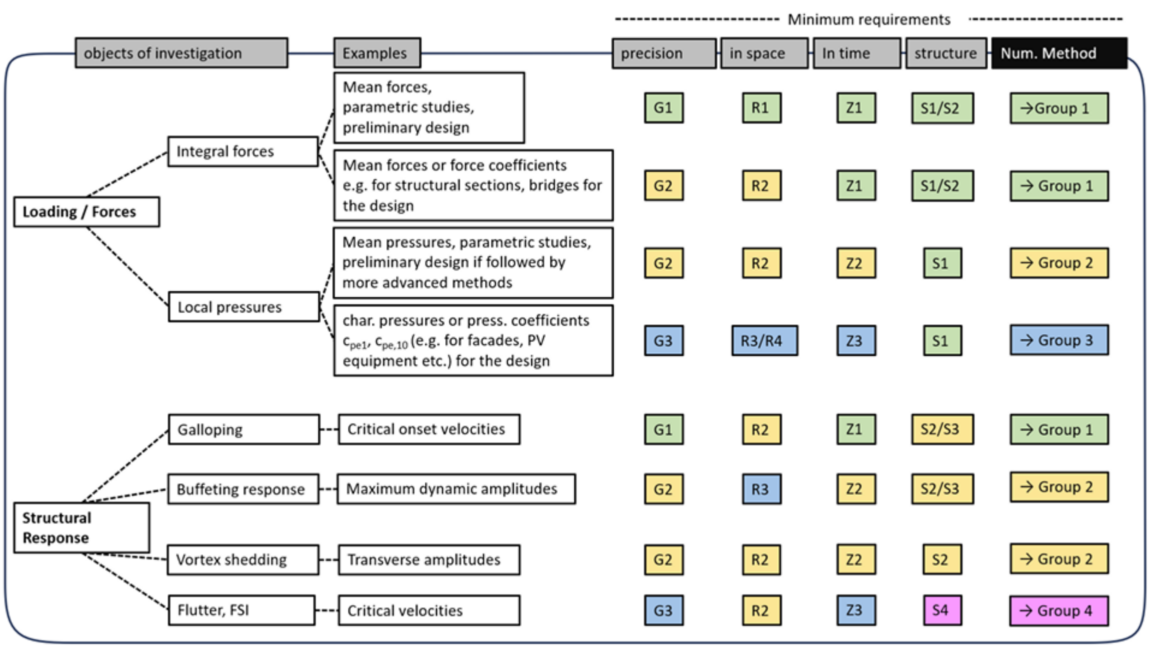

Figure 1: Typical minimum requirements for the numerical methods and assignment to objects of investigation and exemplary questions taken from WTG-Guideline M3, (2025)

After discussing the requirements for numerical simulations in terms of accuracy, spatial and temporal resolution, and structural analysis, classifications for numerical methods are introduced according to the target investigations. Figure 1 provides this classification of the individual problems and lists the typical minimum requirements for the necessary numerical computation methods.

Chapter 5. Quality Assurance deals in detail with basic definitions relating to uncertainties, validation and verification, and user responsibility. The selection of a model must be based on the objective to represent the essential target variables with sufficient accuracy. A list of questions is provided as a recommendation for action, enabling users to check the most important aspects regarding modeling, grid quality, numerical parameters, and the plausibility of the results. Various aspects are addressed for the validation of simulation results with measurement data from real measurements or wind tunnel measurements, and a possible procedure is also explained. A separate subchapter is devoted to the topic of requirements for reference data, such as documentation and scope.

In *Chapter 6. Numerical Implementation*, practical tips on the CFD simulation process and options for user control are provided. In addition to various methods of spatial discretization, grid types and their properties and quality requirements are presented. Furthermore approaches for modeling boundary conditions, such as inflow conditions and wall interaction, are summarized. The requirements for temporal discretization and recommendations for convergence control are also discussed.

Chapter 7. Documentation: To support the quality assurance and enable third parties to verify or evaluate the results of a simulation, comprehensive information about the program and the input data is required. This section also addresses issues relating to the evaluation of wind fields, pressures, and quasi-static coefficients, as well as forces. Additional information for dynamic studies is given, and characteristic values are determined according to the same rules that are also applied in wind tunnel applications. However, information is also provided on quasi-static methods that are still applicable in some areas of wind engineering.

Finally, Appendices A and B provide more detailed information on the turbulent atmospheric boundary layer and examples of validation data.

3. CONCLUSIONS

The new WTG-Guideline M3 represents a step toward standardizing the use of numerical simulations in practical wind engineering. It highlights key CWE challenges, stressing expert responsibility, correct model choice, and thorough verification and validation. As with wind tunnel tests, which are conducted within defined quality assurance frameworks led by experts, numerical simulations in practice also require explicit quality assurance to ensure both the reliability and accurate interpretation of the results. This guideline provides guidance without replacing the fundamental knowledge and professional judgment required of engineers. By establishing recommendations for modeling, validation, numerical implementation and documentation, the guideline aims to create a basis for quality assurance in CWE applications and is free of charge online available (www.wtg-dach.org).

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