

A
BENCHMARK
ON THE
AERODYNAMICS
OF A
RECTANGULAR
5:1
CYLINDER



OVERVIEW
DOCUMENT





1. PREFACE

The aim of this Benchmark is to provide a contribution to the analysis of the turbulent, separated flow around a fixed rectangular cylinder with chord-to-depth ratio equal to 5. In spite of the simple geometry, it is believed that the problem is of interest not only for the purpose of fundamental research, but also to provide useful information on the aerodynamics of a wide range of bluff bodies of interest in Civil Engineering (e.g. long span bridges decks, high-rise buildings, and so on) and for other Engineering applications. Given the possible interest of Research Institutions and Industries operating in different fields of Engineering, using both computational and experimental tools, the benchmark addresses both the numerical and the experimental approach.

2. AIMS

The aims of the Benchmark are the following:

- (1) to deeply investigate one specific problem in the aerodynamics of bluff bodies, with contributions coming from as many researchers as possible worldwide;
- (2) to assess the consistency of wind tunnel measurements carried out in different facilities;
- (3) to assess the consistency of computational results obtained through different flow models and numerical approaches;
- (4) to compare experimental and computational results;
- (5) to assess the possibility of developing integrated procedures relying on both experimental and computational outcomes;
- (6) to develop Best Practices for experiments and computations.

In addition, the results provided by the participants will create a database to be made available to the Scientific and Technical communities for future reference.

3. ORGANISATION AND TIME FRAME

The Benchmark problem is promoted by the Organising Committee, with the support of the Italian National Association for Wind Engineering (ANIV), under the umbrella of the International Association for Wind Engineering (IAWE) and in cooperation with the European Research Community On Flow, Turbulence And Combustion (ERCOFTAC). The activities will be carried out under supervision of the International Advisory Board.



The activities will be scheduled with the following time frame:

- July 2008 The Benchmark is announced during the VI Colloquium on Bluff Body Aerodynamics and Applications (BBAA VI) in Milan (Italy).
- Fall 2008 The Benchmark is announced through publication in scientific journals.
- Summer 2009 A workshop and/or a thematic session will be organised within the 5th European and African Conference on Wind Engineering (EACWE) in Florence (Italy) to summarise the results obtained by the contributors during the first year of activity.
- Summer 2010 A workshop and/or a thematic session will be organised within the 5th International Symposium on Computational Wind Engineering (CWE) in Chapel Hill, North Carolina (USA) to summarise the results obtained by the contributors during the second year of activity.
- Summer 2011 A workshop and/or a thematic session will be organised within the 13th International Conference on Wind Engineering (ICWE) in Amsterdam (The Netherlands) for final discussion of the results obtained in the three years of activity and for closure of the Benchmark.

4. ORGANISING COMMITTEE

<i>Gianni BARTOLI</i>	University of Florence
<i>Luca BRUNO</i>	Politecnico di Torino
<i>Guido BURESTI</i>	University of Pisa
<i>Francesco RICCIARDELLI</i>	University of Reggio Calabria
<i>Maria Vittoria SALVETTI</i>	University of Pisa
<i>Alberto ZASSO</i>	Politecnico di Milano

5. INTERNATIONAL ADVISORY BOARD

<i>Peter BEARMAN</i>	Imperial College of London (UK)
<i>Lars DAVIDSON</i>	Chalmers University of Technology (SWE)
<i>Ahsan KAREEM</i>	University of Notre Dame (USA), <i>Iawe delegate</i>
<i>Masaru MATSUMOTO</i>	Kyoto University (JAP)
<i>Wolfgang RODI</i>	University of Karlsruhe (GER), <i>ERCofTAC delegate</i>
<i>Günter SCHEWE</i>	DLR Institute of Aeroelasticity (GER)



<i>Kenji SHIMADA</i>	Shimizu Corporation (JAP)
<i>Tetsuro TAMURA</i>	Tokyo Institute of Technology (JAP)
<i>Mark THOMPSON</i>	Monash University (AUS)

6. SPONSORS

Public and Private sponsors will be welcome. Funding made available will be used for the organization of Workshops and other dissemination activities.

The possibility of establishing a BARC Young Researchers Award will also be considered.

7. PROBLEM STATEMENT

The Benchmark addresses the high Reynolds number, external, unsteady flow around and past a stationary, sharp-edged rectangular cylinder, and the associated aerodynamic actions. The breadth (B) to depth (D) ratio is set equal to 5.

Participants are invited to submit their original contributions following the formats specified in the Annexes. These can include both results already available to the participants and results specifically obtained for the purpose of participation in the Benchmark. In addition, participants are invited to share with the Scientific and Technical communities the literature and the published results available to them.

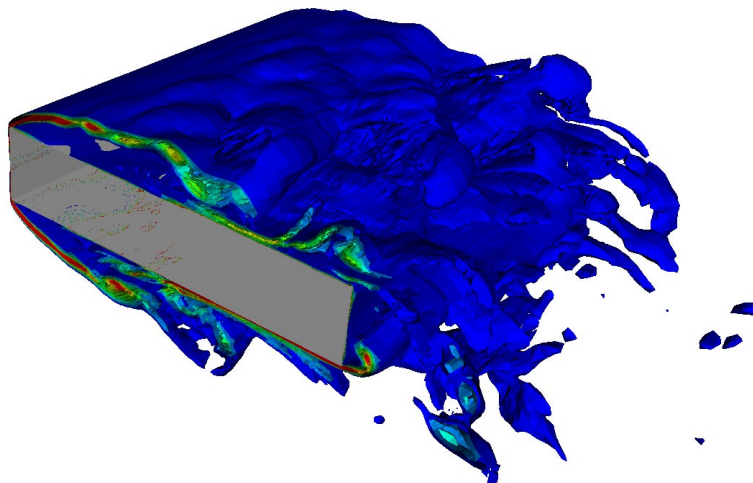


Figure 1 - Orienting image

8. REQUIREMENTS FOR THE MAIN SETUP

The following common requirements are set for both wind tunnel tests and numerical simulations:

- (1) *Reynolds number*



The depth-based Reynolds number $Re = UD/\nu$ has to be in the range of 2×10^4 to 6×10^4 .

(2) *Incidence*

The oncoming flow has to be set parallel to the base of the rectangle; such angle of attack is termed $\alpha = 0$.

(3) *Intensity of turbulence*

The maximum intensity of the longitudinal component of turbulence is set to $I_u = 0.01$.

(4) *Spanwise length of the cylinder*

The minimum spanwise length of the cylinder for wind tunnel tests and 3D numerical simulations is set to $L/D = 3$.

(5) *Sharpness of the section*

The maximum radius of curvature of the edges of the cylinder is set to $R/D = 0.05$

(6) *Sampling frequency*

The minimum sampling frequency is set to $f_s D/U = 8$, f_s being the shedding frequency.

The following additional requirements are specified for wind tunnel tests:

(7) *Blockage*

The maximum wind tunnel blockage is set to 5%.

(8) *Flow uniformity*

All the points of measurement have to be outside the boundary layers developed at the tunnel floor, roof and side walls. Uniformity of the flow at the locations where measurements are taken must be checked in the bare tunnel and appropriately documented.

9. SENSITIVITY ANALYSES

In addition to the main setup described in section 8, sensitivity studies are strongly encouraged. The follow additional values of the parameters in section 8 are suggested for both wind tunnel tests and numerical simulations:

- Angles of incidence $\alpha = 1^\circ, 3^\circ, 6^\circ$
- Reynolds number $Re = 1 \times 10^3, 1 \times 10^4, 1 \times 10^5, 1 \times 10^6$
- Turbulence intensity $I_u = 0.02, 0.05, 0.10$

10. OUTPUT FOR WIND TUNNEL TESTS AND COMPUTATIONAL SIMULATIONS

For participation in the Benchmark, information concerning the setup and a minimum set of output data must be provided by the participants, through upload on the Benchmark web page



<http://www.aniv-iawe.org/barc>. These data will be available to all participants for download. This is to allow researchers to compare the results obtained by other researchers.

All the problem quantities must be scaled with respect to the following reference dimensions:

- section depth D ;
- fluid density ρ ;
- undisturbed flow field velocity U_∞ ;

Both setup information and output data are classified as “required” (i.e. data that participants are requested to provide) and “encouraged” (i.e. additional data that participants are encouraged to provide). Finally, any further data can be provided by the participant, as “additional”.

Setup information and output data requested for wind tunnel tests and numerical simulations are set in separate sheets (see Annex 1 - *Requests for Computational Simulations* and Annex 2: *Requests for Wind Tunnel Tests*).

All data must be provided following the format described in the Annexes, and must be collected in the given tabular.

11 Literature

Reference information can be shared among participants, upgrading the non-exhaustive bibliographic database provided in the file *reference.doc* (formatted text) and *reference.bib* (BibTex database). Published material not restricted by copyright can also be shared among the participants through upload on the Benchmark web page <http://www.aniv-iawe.org/barc>.

12. CONTACTS

All information concerning the Benchmark and registration procedures will be made available at the web page <http://www.aniv-iawe.org/barc>.

Any questions or comments can be sent to the following email address: barc@aniv-iawe.org.