ROUND ROBIN Exercise 3 *(VERSION 1, 2015)*

Collating wind data for the basic shapes of tensioned surface structures

This is Round Robin Exercise 3, launched by the TensiNet Working Group Specifications and WG5 of the COST Action TU1303 Novel Structural skins and aims at collating wind tunnel and CFD (Computational Fluid Dynamics) data for the basic shapes of tensioned surface structures. The wind loading on basic membrane shapes will be assessed and the outcomes will be related to the structural analysis of a membrane structure.
(available at: *http://www.tensinet.com/files/General_information/NEW_CALL_ROUND_ROBIN_III-1.pdf*)

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Round Robin Exercise 1, launched by the TensiNet Working Group Materials & Analysis, was a comparative study of analysis methods and results for a set of well-defined membrane structures. The results were published in 'Engineering Structures'. (Full paper at *http://eprint.ncl.ac.uk/pub_details2.aspx?pub_id=184881*.)

Round Robin Exercise 2, just launched by the TensiNet Working Group Materials & Analysis and WG4 of the COST Action TU1303 Novel Structural skins, follows a similar format. A comparative exercise will be carried out by practitioners and Universities worldwide on the interpretation of biaxial and shear test data, i.e. the assessment of the stiffness of architectural fabrics and how these properties are represented in the analysis of a structure. [1]
(available at *http://www.tensinet.com/files/General_information/NEW_CALL_ROUND_ROBIN_II_-1.pdf*)

1 What is a "round robin"?

A **"round robin"** exercise Refers to an activity (e.g. measurement of properties, structural analysis, or physical experiment) performed independently by different groups, institutions, or companies. Each participant will provide an independent solution to a particular problem. Once the exercise is complete the solutions are reviewed and analysed. The collective outcomes are then used to produce a number of key conclusions and recommendations. [1]

2 The purpose of the round robin exercises

Firstly, and most importantly, it should be noted that the round robin exercise is *not a competition*. The exercise aims to determine the current state of activity in a particular field and to assist in the development of that field. [1]

Membrane structures are typically applied in outdoor applications as sheltering or facade element. Therefore, they are subject to the natural elements and must be designed to resist these external loads. Especially in the field of wind analysis accurate wind load determination on these pre-tensioned lightweight structures has to be investigated, as stipulated in the European Design Guide for Tensile Surface Structures [2]. The need for accurate wind-load Standards on these structures has also been stressed in several international publications [3], stating the lack of the current Standards (ASCE) in governing the wind-resisting strength for these structures and the need for an industry-wide set of Standards.

In general, conventional Codes on wind design give upper bound values for the majority of structures (conventional building typologies), but the level of uncertainties increases as the building configuration deviates from the codified Norms. The structural analysis of membrane structures can only benefit from improved and more accurate wind load estimations and analysis methods. Currently, wind loading on tensioned surface structures is often based on rough approximations referring to flat or spherical shapes of EN 1991-1-4, while the special nature of the textile covers are not taken into account (EN 1991-1-4 and EN 13782, which refers to EN 1991-1-4 for wind loading, is insufficient for tensile surface structures, dynamics actions, flexible deformations etc.). Extrapolation from the Standard may be acceptable for static structures, but for flexible membrane structures, with a non-uniform curvature, additional wind investigation has

to be performed. Appropriate wind pressure data is essential to provide confidence in the analysis and design process, and to ensure the development of the Eurocode that will facilitate the safe and efficient design of membrane structures.

Within this perspective, **Round Robin Exercise 3 is launched to collate existing wind tunnel test and CFD results for simple fabric structures. It is the general purpose of the Round Robin exercise to explore the available existing (but fragmented) pressure coefficient distributions for different basic doubly curved forms and to create a reference for further systematic and complementary test campaigns.**

3 Principles

The Round Robin exercise is proposed as a non-commercial activity. It is intended to serve the purpose of advancing scientific knowledge and engineering practice in the analysis and design of membrane structures. Participation in the Round Robin exercise is further based on the following principles [1]:

- Involvement in the round robin exercise is voluntary,
- Completion of the round robin tasks is undertaken without fee and liability,
- The completed tasks will not be used outside the remit of the round robin exercise and will not be made available in a format that could be used for design purposes by a third party,
- The round robin outputs will be reported anonymous and the participants will be acknowledged in all dissemination (journal papers, reports etc.), while the ownership of the data will remain with the participants.

4 Overview

In a first stage, research institutes, universities, specialized laboratories and engineering offices are asked to provide the available experimental data for basic forms in a uniform way to allow comparing and interpolating the information. Further, where crucial data is missing new experimental campaigns should be launched in a second stage, where engineers and research institutes experienced in performing wind tunnel tests are invited to perform standardized wind tunnel tests and/or CFD calculations on the basic membrane forms. The standardized results could be used for a prospective Eurocode section on wind loading for tensile surface and shell structures.

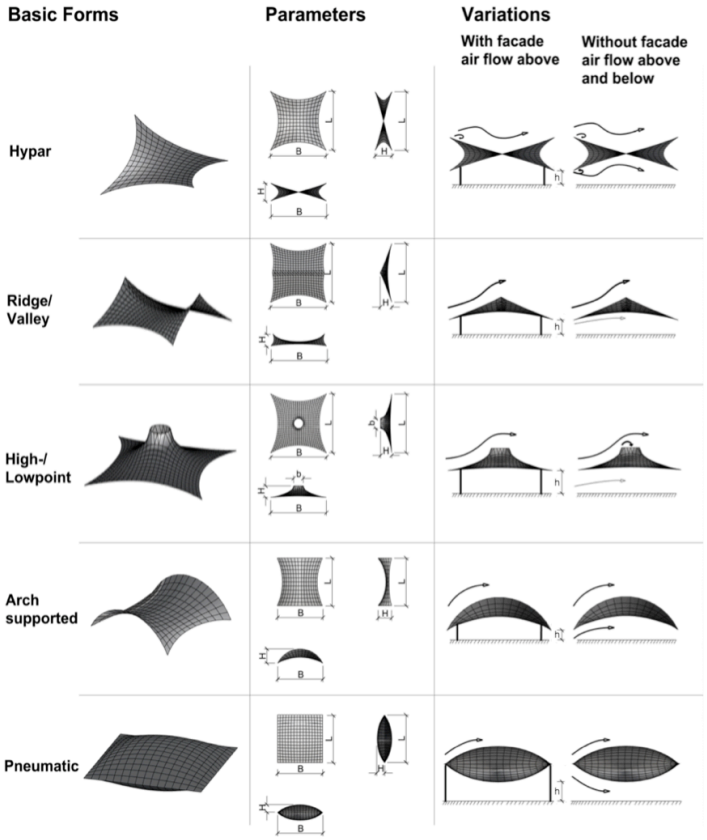

Figure 1: Overview of basic shapes, established by Alex Michalski

5 Reporting of results

When collating the wind tunnel test and CFD data on basic shapes a general description of the performed tests should be made available in a uniform way. A standardised results data form is specified to be able to present, compare and interpolate the results. (See Annex A for implementations and Annex B for input form)

5.1 Description test-setup (wind tunnel and/or CFD)

- **Wind tunnel test**
  - specifications wind tunnel (type, dimensions, plans)
  - measuring device (software)
  - boundary layer profile

- **Computational Fluid Dynamics**
  - CFD software
  - Boundary layer profile

5.2 description model

- plan and elevations
- shape parameters (H, B, b, L, s and t)
- building configuration (open/partly open/closed)
- measuring points (locations and dimensions) / Meshing
- material and finishing
- photos

5.3 Result data form (Extensive and/or simplified)

- test case (wind speed, angle of attack, building configuration, shape parameter, boundary layer profile)
- pressure coefficients (open configuration: $c_{p,up}$, $c_{p,low}$, $c_{p,net}$ / closed configuration: c_{pe})
- post processing (sampling length and frequency, mean/peak values, standard deviation RMS value)

6 Timeline

January 2015	**Round Robin 3 is launched.** **Research institutes, universities, specialized laboratories and engineering offices are invited to volunteer to provide available experimental or analytical data for wind analysis of basic membrane shapes.** Participants are asked to register their interest in the exercise by emailing Eng.-Arch. Jimmy Colliers at jimmy.colliers@vub.ac.be.
June 2015	Full details of Round Robin 3 are circulated to participants.
September 2015	Deadline for return of results by emailing to jimmy.colliers@vub.ac.be.
Oct 2015 – Jan 2016	Analysis and dissemination of results.

7 Bibliographical references

[1] Bridgens, B., 2015. Round Robin Exercise 2: Interpretation of Biaxial and Shear Testing. TensiNews 16–17.

[2] Forster, B., Mollaert, M., Tensinet, 2004. European Design Guide for Tensile Surface Structures. VUB, Brussels.

[3] Gorlin, W.B., 2009. Wind Loads for Temporary Structures: Making the Case for Industrywide Standards 35–36.