Wind tunnel test comparison of three facilities from Brazil, Argentina and Uruguay

Gilder Nader¹, Paulo José Saiz Jabardo², Antônio Luiz Pacífico³, Marcos Tadeu Pereira⁴, Valeria Durañona⁵, José Cataldo⁶, Federico Bacchi⁷, Juan Sebastian Delnero⁸, Jorge Colman⁹, Ulfilas Boldes¹⁰

¹PhD. Research, ²MSc. Research, ³PhD. Research, ⁴PhD. Research from Instituto de Pesquisas Tecnológicas do Estado de São Paulo – Brasil - cmf@ipt.br
⁵Assistant Professor, ⁶Professor from Universidad de la Republica de Uruguay Uruguay - jcataldo@fing.edu.uy
⁷Assistant Professor, ⁸Assistant Professor, ⁹Professor, ¹⁰Professor from Universidad Nacional de La Plata – Argentina - jcolman@ing.unlp.edu.ar

INTRODUCTION

Wind tunnel simulations of structures subjected to strong wind require the correct modeling of several parameters. Simple geometric scaling is not enough and dynamic simulation, which requires equal Reynolds (Re) numbers in both the prototype and model, is not usually possible due to scale problems: prototype Reynolds number is just too large. If the model has fixed separation points (surfaces) and the model Re is large enough, the flow is insensitive to Re.

Therefore, wind tunnel testing of wind load depends not only on model but also on facility characteristics and boundary layer simulation. Actually, simulation scale is a result of important scales on the simulated boundary layer.

In this study a building 40 m high with a square base 20 m wide at 45° angle of incidence on a type II terrain [1] (roughness length $z_0 = 0.1$ m) is simulated on three different atmospheric boundary layer wind tunnels, LACYFA (Argentina), IMFIA (Uruguay) and IPT (Brazil) which form the MERCOSUL wind tunnel network (RETUNEL) as part of an ongoing effort to determine important aspects of wind loads on structures.

EXPERIMENTAL SETUP

Each facility used its own method to simulate the appropriate boundary layer: IPT used the Counihan technique [2], IMFIA applied a technique similar to Cook [3] and LACYFA used a custom technique. The models scales used in each facility are: LACYFA 1:100, IMFIA 1:67 and IPT 1:57 corresponding to a maximum blockage ratio of 6% to each facility.

RESULTS

Velocity and turbulence intensity profiles obtained in all facility were similar.

Fig.1 presents the minimum pressure coefficient obtained in each facility and Tab. 1 presents the characteristic parameters of the boundary layer at the top of the models, where the turbulence intensity was around 7%.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prototype</th>
<th>LACYFA</th>
<th>IMFIA</th>
<th>IPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale factor</td>
<td>1</td>
<td>1/100</td>
<td>1/67</td>
<td>1/57</td>
</tr>
<tr>
<td>Roughness length – $z_0$ (mm)</td>
<td>100</td>
<td>1</td>
<td>1.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Integral length scale $L_u$ (m)</td>
<td>163-290</td>
<td>0.1</td>
<td>0.54</td>
<td>1.63</td>
</tr>
<tr>
<td>Small scales (mm)</td>
<td>20</td>
<td>30</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Non-dimensional spectrum peak</td>
<td>0.0245</td>
<td>0.0215</td>
<td>0.0252</td>
<td></td>
</tr>
</tbody>
</table>

Tab.1. Characteristic parameters
As shown in Cheng-Hsing and Meroney [4] there is a large correlation between winds with high lateral components and lower pressure on the roof right under the conical vortices. The energy of this lateral wind component, which is associated with the small scale turbulence content as shown in Tieleman and Akins [5]. Fig. 2 shows the relation between the small scale turbulence content and minimum pressure coefficient $C_{p,min}$. A clear tendency can be seen that relates pressure peak and small scale turbulence content using several published results and all ordered over it.

CONCLUSION

In the three wind tunnels similar flows were established at different scales. These flows presented to the prototype scale a roughness length ($z_0$) between 0.10 up to 0.13 m and the turbulence intensity was around 7%. In all cases the terrain was a rural type.

Additionally, it was possible to evidence that the minimum pressure coefficients obtained on the roofs of the models by the three involved laboratories fits well on one curve when the small scale turbulence parameter is used as the variable.

REFERENCES