RMCE: Homework 1 : Extracting information from a paper:

S. M. Avila, M.V.G. de Morais, M. Barcelos, M.A.M Shzu and R. de C. Silva, "Vibration control of the set tower and wind turbine under the wind influence", Proceedings of COBEM 2009, Gramado, Brasil, Nov 2009.

Instructions:

Imagine that your research topic is "Optimum design of pendulum tuned mass dampers for applications to high-rise buildings subjected to wind-induced vibrations".

Read the paper assigned to you and do your best to answer the following questions :

1) **Identify the structure of the paper and extract the type of information that is detailed**

What is the structure of the paper? What kind of information is presented? Do the authors use models and if so which types? What are the main hypotheses? Do the authors perform experiments to check their models?

*Structure:

- Abstract
- Introduction
- Modal analysis (=model of the structure)
- Wind model (=model of the excitation forces)
- Pendulum Absorber (=solution against vibrations)
- Numerical Example (=verify the efficiency numerically)
- Conclusion

*Information:

1. Introduction: wind power is clean energy. Wind turbines undergo high levels of vibrations which need to be controlled. One possibility is TMD, or PTMD, the later is easier to design and implement.

2. Modal analysis: the wind turbine is modeled as a cantilever Euler-Bernoulli beam (simplified model) with a rigid mass on the top (rotor) and only the first mode of vibration is considered. An equivalent mass and stiffness are derived using Rayleigh's method (Paz 1997), and an equivalent force is derived base on the wind velocity profile

3. Wind model: The wind model is a combination of the Van Der Hoven spectrum and von Karman spectrum. For Van Der Hoven, the time domain velocities are formed using an inverse Fourier transform with random phases, for Von Karman, it is based on a filtered white noise input. While the first one is classical, the second one is not so much. Reference can be found in Morais 2009

4. Pendulum Absorber: The model of the absorber is coupled to a 1dof mass-spring system. The optimum parameters (length and damping) are computed for a white noise input, based on Zuluaga 2007. Note that is is not clear what is the objective function for the optimization.

5. Numerical example: Realistic values are considered for the tower and the wind spectra, and a simulation is run with and without the PTMD. A first simulation is run with a white noise input instead of a realistic wind spectrum. Optimal values of Zuluaga lead to a reduction of vibration (75% peak-to-peak). Applied to the real wind spectrum, worse results are obtained, so a parametric study is conducted, and shows that the best results are achieved with the smallest value of the mass ratio.

Note that these results are not very convincing and a bit contradictory. Increasing mu should lead to better results. Authors have not been very critical about their results, and one should have some doubts. It is difficult to believe that non optimal TMD would lead to an increase of vibration levels, so this should be better investigated and explained

6. Conclusion: the author conclude that Zuluaga formula is not adapted for realistic wind excitations. They advocate for the use of semi-active devices instead as they claim that TMDs are sensitive to different frequency spectrum than white noise. This might be true, but clearly requires more investigations. The arguments are not convincing.

2) Extract the information that is meaningful for your research project

Does the state-of-the-art refer to papers which might be of interest for a further reading? Can the methods presented in the paper be used in your project?

The models (structure and wind) are usable for the research topic. Reducing the model to a 1dof system with equivalent mass and stiffness is meaningful, and the generation of the wind velocities is also adequate. The formulae for the structural model are however limited to a cantilever beam with tip mass, so a generalization is needed if the structure is different (i.e. computing k and m based on a finite element model). Von Karman is not so classical, so further reading to check hypothesis might be needed.

The formula of Zuluaga could be a good start for optimal design of the PTMD under random excitation, there is not other formula proposed in the work. Further investigation is needed on that point.

3) What more do you need to solve your problem?

What type of additional methods would you need? How could you find additional references?

A more general method is needed to compute equivalent mass and stiffness of the main structure, and perhaps the level of damping in the structure should be taken into account.

Are there any other wind models that could be used or is it the commonly accepted method?

When applying Zualaga's method, it would be interesting to first validate the results on the same example as the one treated by Zualaga, to make sure everything is implemented correctly.

Further reading is needed on optimal tuning under wind excitation, when white noise input hypothesis is not valid.

The usefull references seem to be:

Morais 2009 to better understand wind turbulence due to von Karman

Zualaga 2007 and 2008 on optimal tuning of PTMD would be a nice reading, but it seems to be in Spanish only. May be the equations are self-explanatory. Are there other references on optimal tuning of PTMDs and in which excitation conditions ? (Gerges 2005, Orlando 2005, Avila 2006, although the last two are also in Spanish).

Fischer 2007 might be interesting to understand design issues of PTMDs which are not treated here. Soong 1997 as well. This is if a real application is foreseen in the research project.

➔ Actions to take :

- Collect references in this paper and read them/extract information
- Look for further references on optimal tuning of PTMDs, in particular under random non gaussian excitation (white noise)

(Completed in 1h by Arnaud Deraemaeker)