The Effect of Parapets on Roof Mounted Solar Collectors

Delight M. Sedzro, Timothy Anderson and Roy Nates
School of Engineering
Computer & Mathematical Sciences
Auckland University of Technology

INTRODUCTION

1. As the solar renewable technology industry expands, there is an increasing demand for **high energy yield.**

2. **Climatic conditions** amongst other factors, is significant in determining **energy yield.**

3. Solar irradiance, ambient temperature and equivalent sun hours, wind speed is considered to have a major effect on **performance**

LITERATURE

Perfomance

- Soltau et al., 1992*
- Molineaux et al ., 1994*
- Burch et al., 2003*
- Burch et al.,2005*
- Martinez et al., 2017

Achitectural Integration

- Probst *et al.,* 2007
- Kalogirou *et al.,* 2015
- Maurer *et al.,* 2017
- Martinez *et al.,* 2017

Weather / Climate

- Burch et al., 2004
- Ladas et al., 2017
- Oshiriki et al., 2017

Cost / Economic Assessment

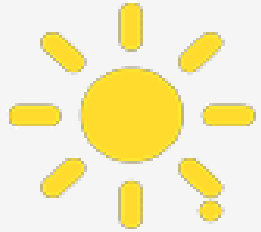
- Burch et al., 2005
- Hudson et al., 2012
- Brahim et al., 2017

Material

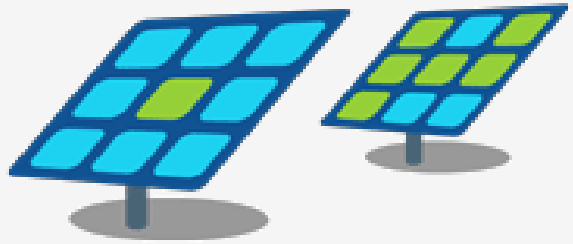
- Alghoud et al., 2005
- Koehl et al., 2014
- De La Rena et al., 2014
- Puvacz et al., 2016

BACKGROUND

1. Wind-induced heat losses are detrimental to the performance of **solar collectors** whiles the opposite is the case with **photovoltaic panels**

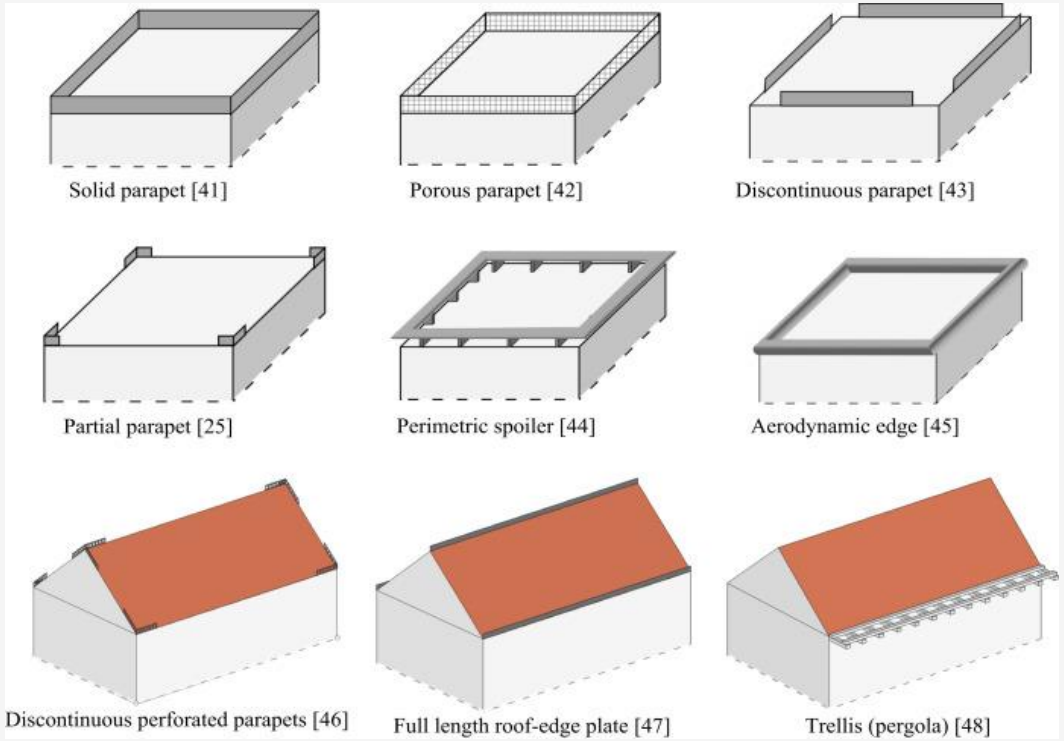


2. The efficiency of **photovoltaic panels** reduce as their temperature increase through e.g reduced wind velocity.



3. The efficiency of solar collectors increase due to reduced wind velocity as their temperature increase.

RESEARCH GAP



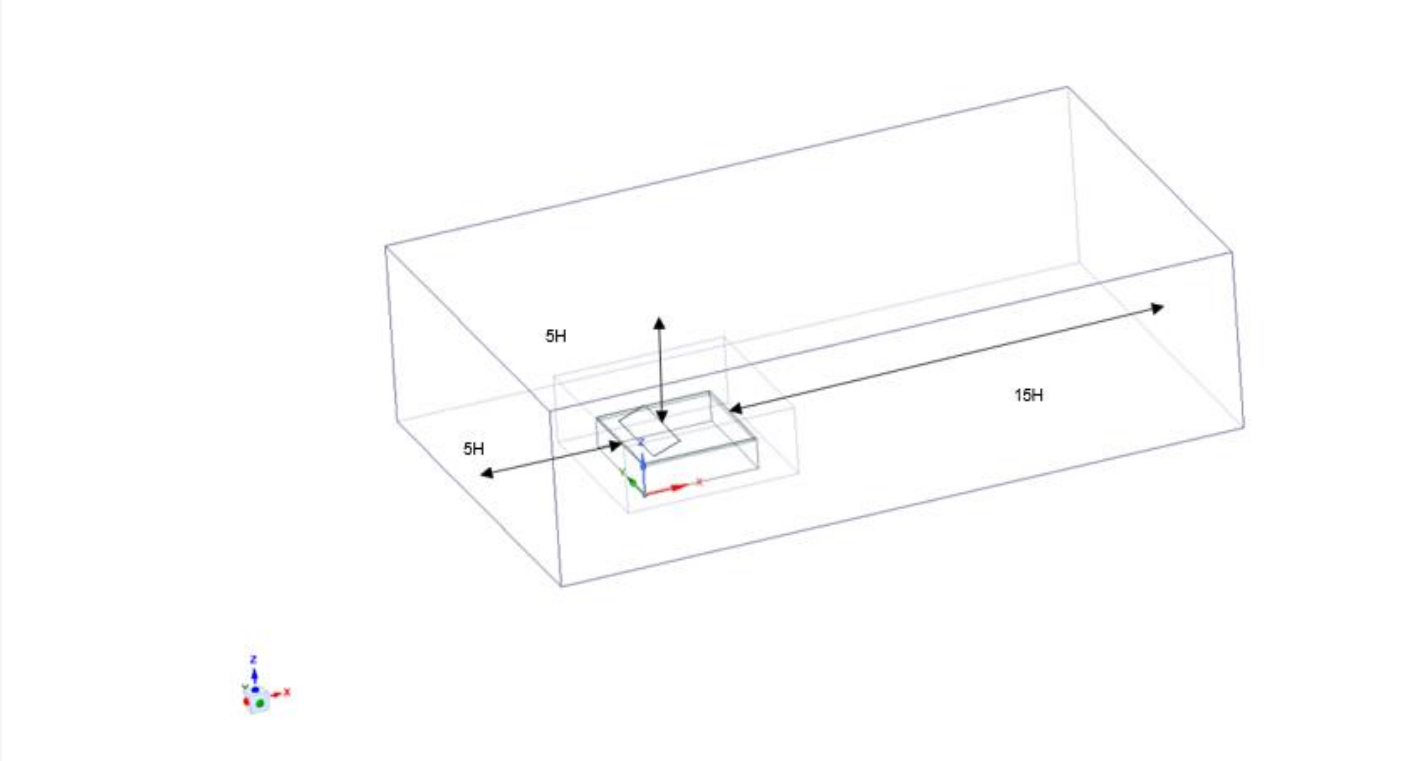
1. Most solar technologies are often mounted on **roof surfaces**.

2. A **cost-effective** options to enhance efficiency would be to attempt to **regulate** the effect of wind.

3. **Parapets,** a common architectural element on roofs can **mitigate wind loads** by influencing wind velocity at varying heights and configurations.

4. **Lower perimetric** parapets ($h/(H+h) \leq 0.09$) and for **higher perimetric** parapets ($h/(H+h) \geq 0.23$)

METHODOLOGY

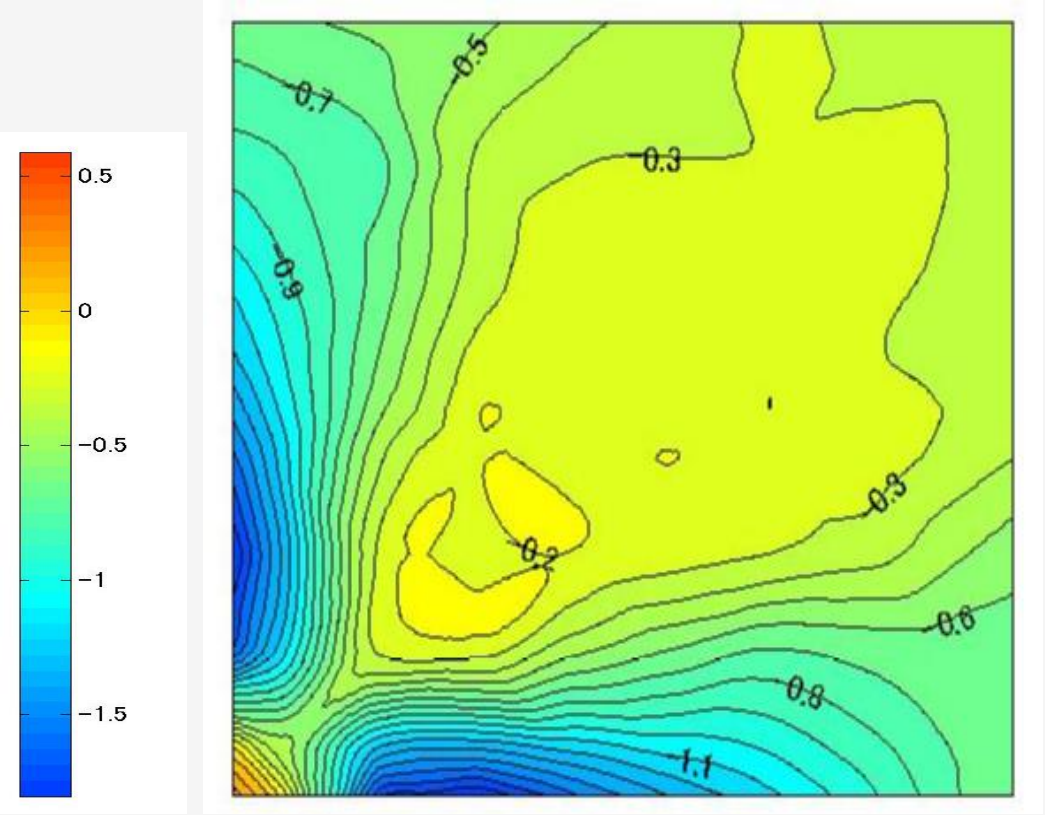


1. ANSYS CFD v. 2019 R2, Validated with Tokyo Polytechnic University (TPU) Wind database.

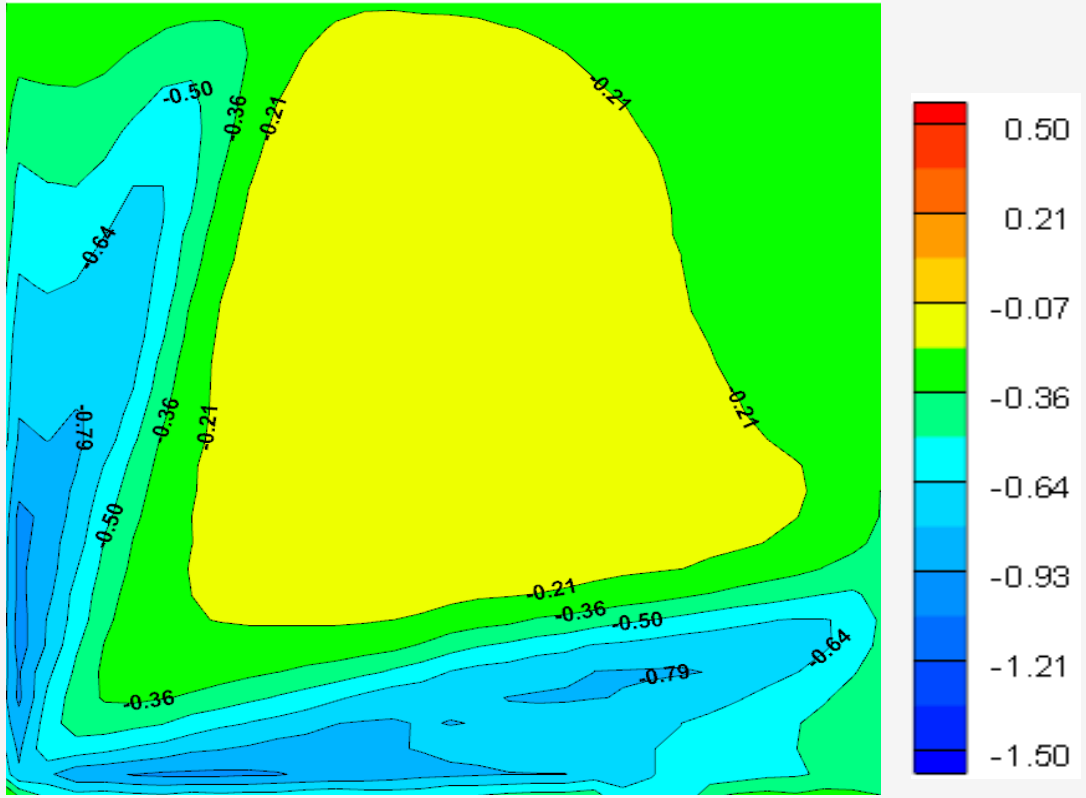
2. Collector inclination angles between 20^0 to 40^0. Wind incidence 0^0 .

3. No parapet, 0.4m parapet (lower parapet) and 1.2m parapet (higher parapet)

Model Validation

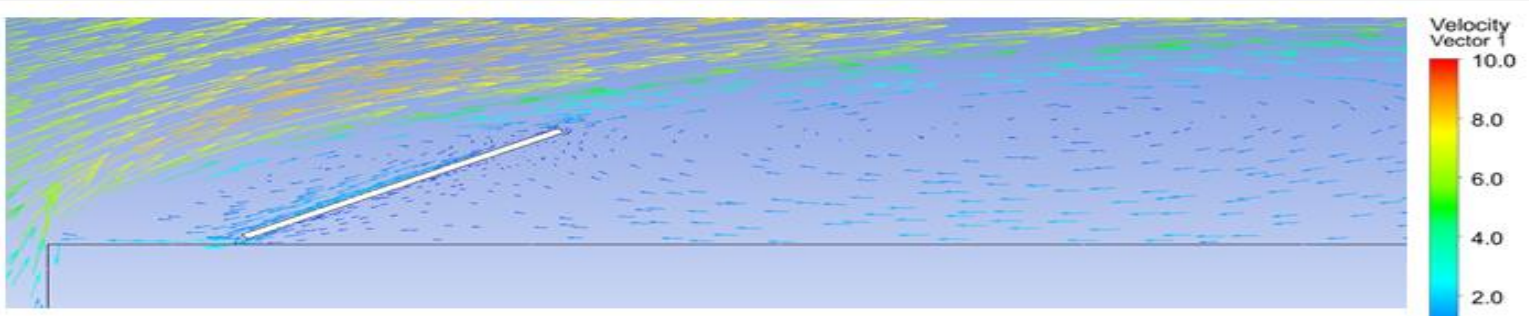


TPU Experiments

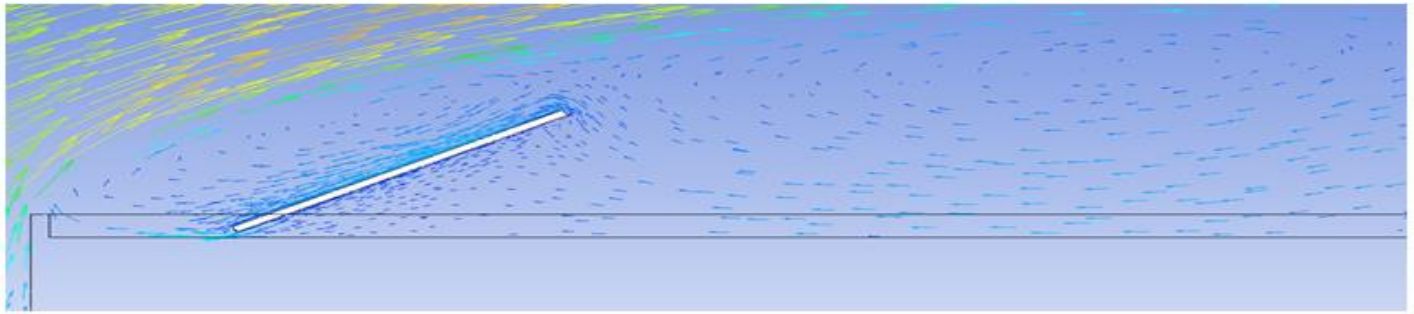


CFD Results

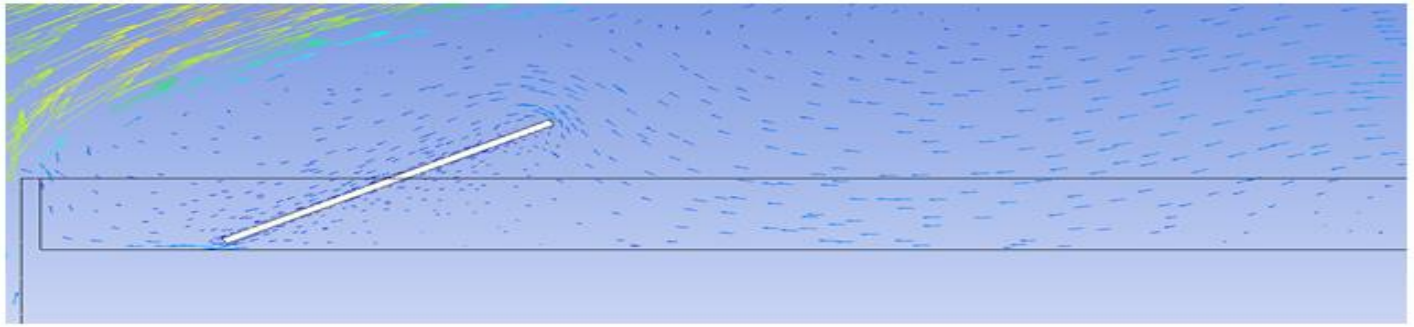
Wind incidence and Parapet Height



a) no parapet



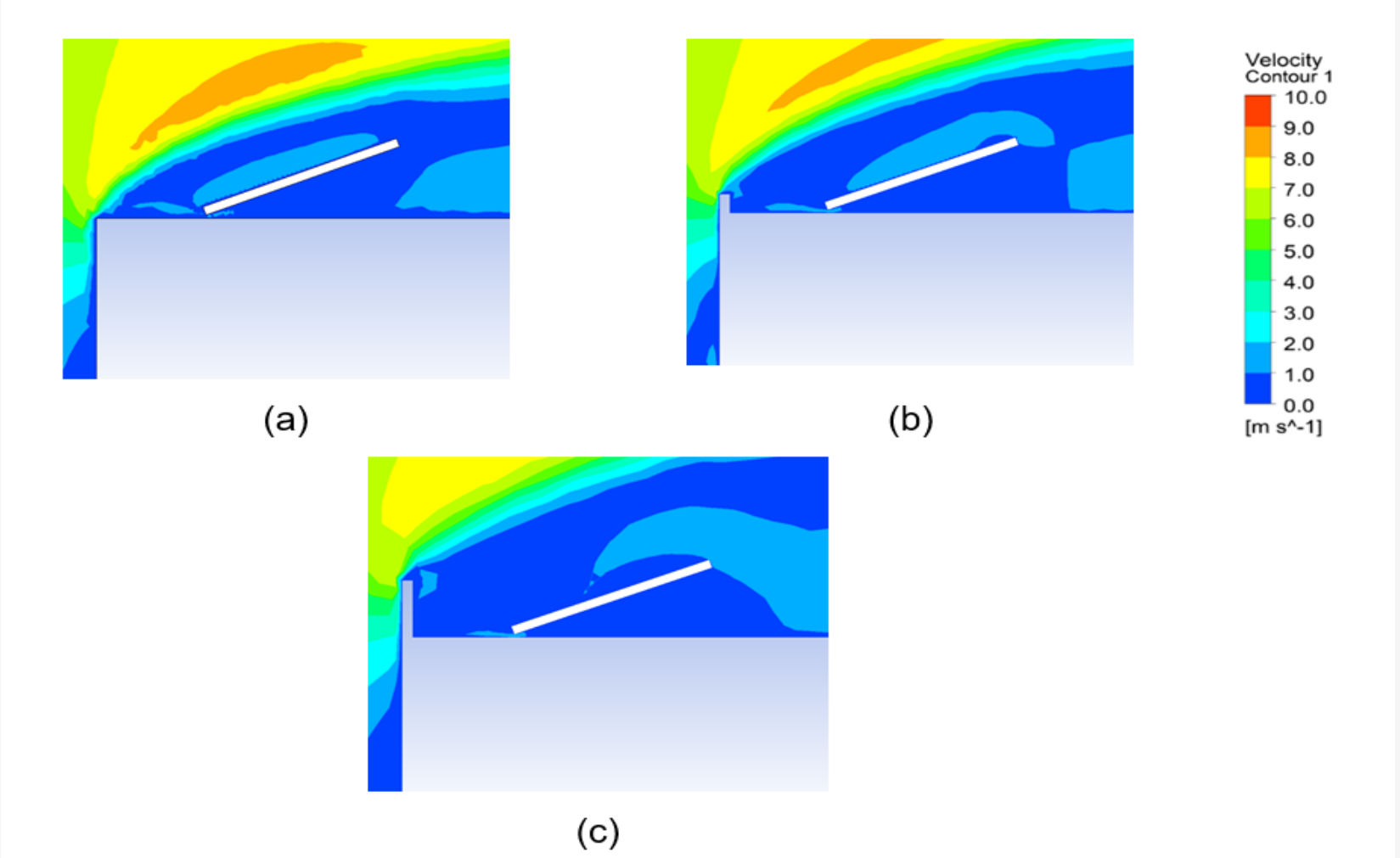
b) 0.4 m parapet



c) 1.2 m parapet

RESULTS AND DISCUSSION

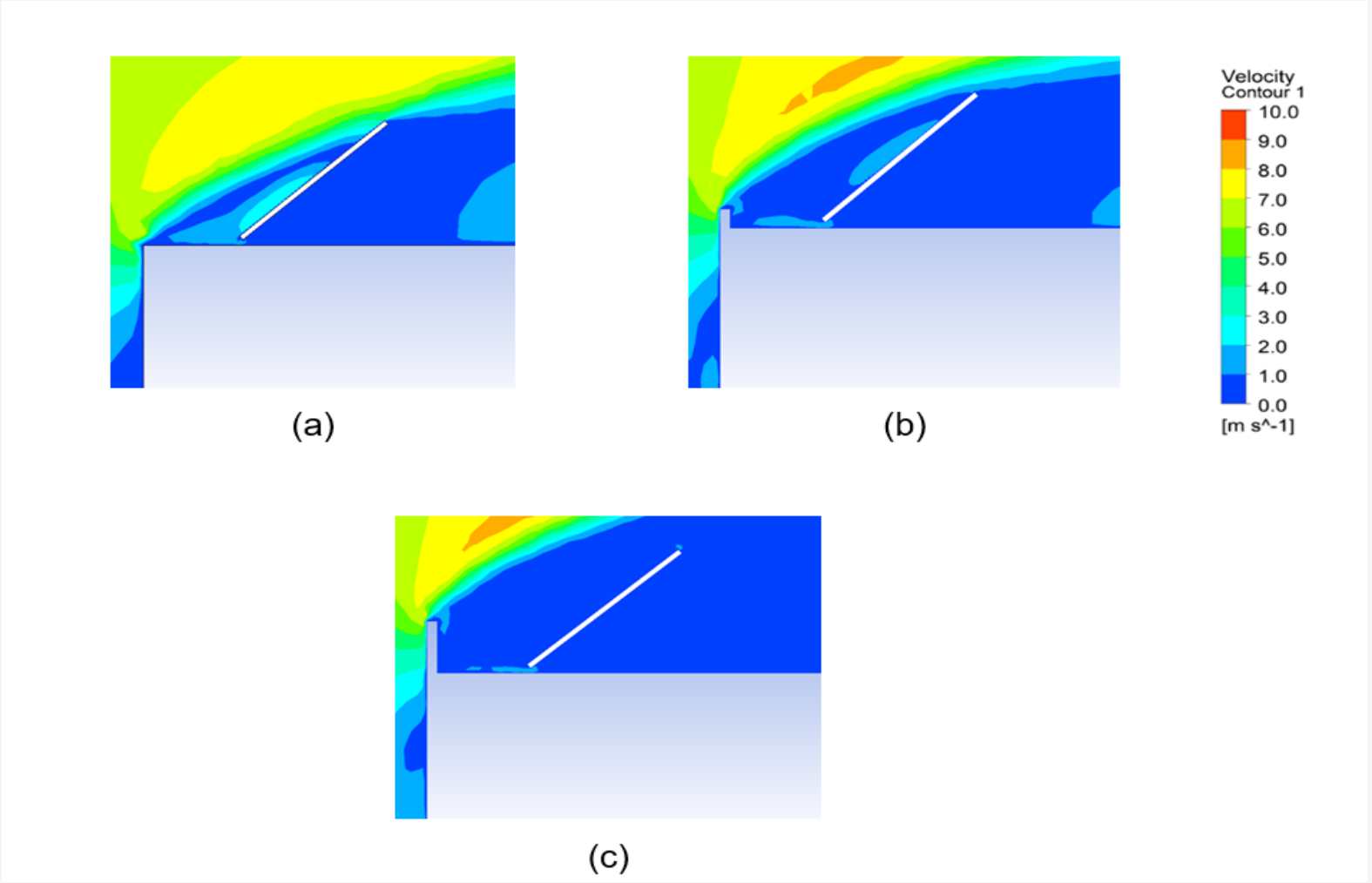
Effect of Collector Inclination Angle and Parapet Height



Flow over a collector at 20^0 inclination for a) no parapet b) 0.4m parapet and c) 1.2m parapet

RESULTS AND DISCUSSION

Effect of Collector Inclination Angle and Parapet Height



Flow over a collector at 40^0 inclination for a) no parapet b) 0.4m parapet and c) 1.2m parapet

CONCLUSION

1. **Wind velocity** near the surface of a roof mounted collector, can affect thermal performance . This is **reduced** with an increase in **parapet height.**

2. The generation of **lower pressures** on the roof corner is of concern as this affect the **structural support systems** of the collectors.

3. It would be interesting to understand; how the **parapet** affects the **performance** of the collectors for different parapet **heights** and at varying **wind incidence angles .**

4. The **gap** between the **roof surface** and **leading edge** of the collectors is pivotal in reducing the **stagnation** over the collector surface.

5. It would also be worthwhile to get an understanding of the nexus between the **gap, parapet height,** collector local **surface velocity.**

REFERENCES

1. Mans, C., Kopp, G. A., & Surry, D. (2005). Wind effects of parapets on low buildings: Part 3. Parapet loads. *Journal of Wind Engineering and Industrial Aerodynamics*. https://doi.org/10.1016/j.jweia.2005.08.007
2. Mathew, D., Rani, C., Kumar, M. R., Wang, Y., Binns, R., & Busawon, K. (2018). Wind-driven optimization technique for estimation of solar photovoltaic parameters. *IEEE Journal of Photovoltaics*. https://doi.org/10.1109/JPHOTOV.2017.2769000
3. Molineaux, B., Lachal, B., & Guisan, O. (1994). Thermal analysis of five unglazed solar collector systems for the heating of outdoor swimming pools. *Solar Energy*. https://doi.org/10.1016/S0038-092X(94)90600-9
4. Schwingshackl, C., Petitta, M., Wagner, J. E., Belluardo, G., Moser, D., Castelli, M., … Tetzlaff, A. (2013). Wind effect on PV module temperature: Analysis of different techniques for an accurate estimation. *Energy Procedia*. https://doi.org/10.1016/j.egypro.2013.08.010
5. Soltau, H. (1992). Testing the thermal performance of uncovered solar collectors. *Solar Energy*. https://doi.org/10.1016/0038-092X(92)90005-U
6. Stathopoulos, T., Marathe, R., & Wu, H. (1999). Mean wind pressures on flat roof corners affected by parapets: Field and wind tunnel studies. *Engineering Structures*. https://doi.org/10.1016/S0141-0296(98)00011-X
7. Surry, D., & Lin, J. X. (1995). The effect of surroundings and roof corner geometric modifications on roof pressures on low-rise buildings. *Journal of Wind Engineering and Industrial Aerodynamics*. https://doi.org/10.1016/0167-6105(95)00016-K
8. Tamura, Y. (2012). *Aerodynamic database for low-rise buildings*. Retrieved from http://www.wind.arch.t-kougei.ac.jp/system/contents/code/tpu
9. Baskaran, A., & Stathopoulos, T. (1988). Roof corner wind loads and parapet configurations. *Journal of Wind Engineering and Industrial Aerodynamics*. https://doi.org/10.1016/0167-6105(88)90147-X\
10. Blocken, B., Defraeye, T., Derome, D., & Carmeliet, J. (2009). High-resolution CFD simulations for forced convective heat transfer coefficients at the facade of a low-rise building. *Building and Environment*. https://doi.org/10.1016/j.buildenv.2009.04.004
11. Blocken, Bert, Stathopoulos, T., Carmeliet, J., & Hensen, J. L. M. (2011). Application of computational fluid dynamics in building performance simulation for the outdoor environment: An overview. *Journal of Building Performance Simulation*. https://doi.org/10.1080/19401493.2010.513740
12. Browne, M. T. L., Gibbons, M. P. M., Gamble, S., & Galsworthy, J. (2013). Wind loading on tilted roof-top solar arrays: The parapet effect. *Journal of Wind Engineering and Industrial Aerodynamics*. https://doi.org/10.1016/j.jweia.2013.08.013
13. Franke, J., Hellsten, A., Schlünzen, H., & Carissimo, B. (2007). Best practice guideline for the CFD simulation of flows in the urban environment. In *COST action*.
14. Kopp, G. A., Mans, C., & Surry, D. (2005a). Wind effects of parapets on low buildings: Part 2. Structural loads. *Journal of Wind Engineering and Industrial Aerodynamics*. https://doi.org/10.1016/j.jweia.2005.08.005
15. Kopp, G. A., Mans, C., & Surry, D. (2005b). Wind effects of parapets on low buildings: Part 4. Mitigation of corner loads with alternative geometries. *Journal of Wind Engineering and Industrial Aerodynamics*. https://doi.org/10.1016/j.jweia.2005.08.004
16. Kramer, C., Gerhardt, H. J., & Scherer, S. (1979). Wind pressure on block-type buildings. *Journal of Wind Engineering and Industrial Aerodynamics*, *4*(3–4), 229–242. https://doi.org/10.1016/0167-6105(79)90003-5