Spring 5-23-2018

Designing Model Experiments Around Harriet Tubman Middle School

Ryan Crist
Portland State University

Sarah Smith
Portland State University

Greg Sakradse
Portland State University

Ryan Scott
Portland State University

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Ryan Crist[1], Sarah Smith[1], Greg Sakradse[1], Ryan Scott[1], Elliott Gall[1], Linda George[2], Raúl Bayoán Cal[1]

Portland State University

[1] Department of Mechanical and Materials Engineering, [2] Environmental Science and Management

Abstract

Air quality is of concern in densely populated areas and especially near sources of inefficiently exhausted fossil fuel such as near the highway. Harriet Tubman middle school in North Portland, Oregon is situated alongside highway 5. Model experiments are designed and proposed to observe the instantaneous flow fields reflect modifications. LIDAR data was used to model the school and surrounding topography three-dimensionally in order to construct a model school and surrounding area from laser cut cardboard with a surface smoothed with papier mâché. This model will be placed in the Portland State University wind tunnel; transport of mean and fluctuating quantities may be measured by way of particle image velocimetry (PIV). The data obtained from PIV can be used for reconstruction of flow passage with respect to the region of interest.

Motivation

Harriet Tubman middle school in north Portland has faced several closures in the past due to air quality concerns. The sensors placed on site to monitor air quality indicate the particle size of pollutants is typical of exhaust from fossil fuels. This suggests the highway traffic has considerable effect on the quality of air near the school. A highway expansion might be forthcoming and understanding flow transport due to these modifications will provide insight into flow around Tubman.

Location

Figure 1: Satellite image of Harriet Tubman Middle School location

Wind Direction

The wind data used for determining the directions and magnitudes of interest were collected at the DEQ at 5824 SE Lafayette St., Portland, OR from 2015-Present. Both seasonal and annual data was considered to determine prevailing wind patterns.

Pollution particulate sensors placed at Tubman middle school, when combined with the wind data indicate the most significant directions of interest to the experiment are south, south-southwest and north-northwest.

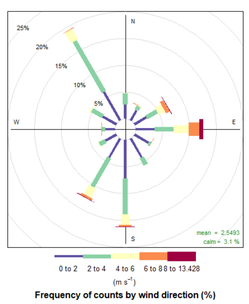
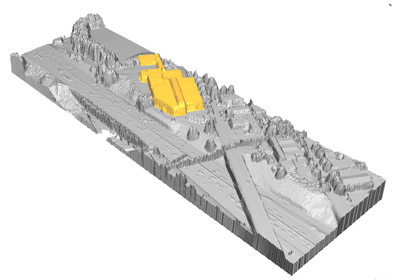


Figure 2: Wind Data (2015-2018) showing counts of magnitude per direction.

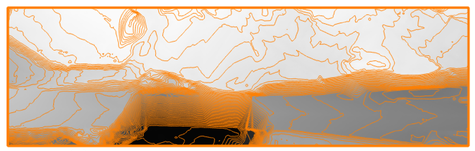
LIDAR Imaging and Three-Dimensional Modeling

LIDAR data was acquired from 2014 Oregon Department of Geology and Mineral Industries LIDAR survey shows distance as it relates to greyscale (NOAA, 2018).

(a) LIDAR image showing elevation map of Tubman Middle School and surrounding area.



(b) 3D model developed using GIS SOFTWARE from LIDAR data.



(c) Contour lines developed for laser cutting topography.

Figure 3: The LIDAR data, (a), contains 3 dimensions of measurement accurate to 3 feet allowing analysis via GIS SOFTWARE to create a 3D model.(b) Elevation slices were defined from the 3D model to create 0.5 m elevation gains per slice for laser cutting 4 mm cardboard sheets.(c)

Manufacturing

- A scale of 1:120 was determined to allow for significant surrounding structures and topography to be included in the model with highest possible resolution to achieve a model that fits the Portland State University wind tunnel.
- LIDAR data and GIS used to create three dimensional model for laser cutting elevation slices of the area to reproduce the scaled topography and surrounding structures.
- Laser cutting of cardboard to create the slices developed from 3D models with each 4 mm layer of cardboard representing 0.5 m of elevation.
- School and nearby building dimensions developed from LIDAR and modeled in CAD with elements projected onto flat sheet for construction and attached to topography slices.
- The surface of the cardboard model is covered in papier mâché to smooth the surface of the elevation jumps produced by the layering method used.

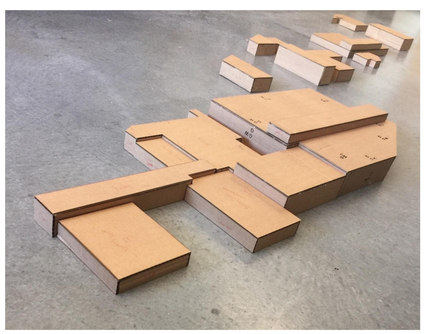


Figure 4: School and surrounding structures constructed from laser cut cardboard.

Sample Experiments

The model will be placed within the 1.2 x 0.8 x 5.0 m wind tunnel at Portland State University. Data collection will be taken via stereo Particle Image Velocimetry (PIV). PIV creates a planar laser sheet to capture instantaneous flow fields by cameras located outside of the tunnel. The data from PIV may then be analyzed to reconstruct the flow passage from the directions of interest for the four expansion configurations being considered.

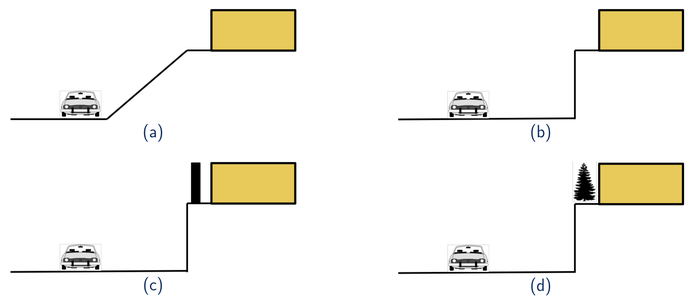


Figure 5: Four models of (a) current topography, (b) expansion, (c) expansion with extended wall and (d) expansion with trees

Future Work

The model is currently under construction and will be finished June 2018. Once completed the model will placed into the wind tunnel for PIV data collection. Analysis will provide a means of reconstructing flow passage for the model and will be considered in final construction design considerations for the highway expansion.

References

[1] NOAA.
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Acknowledgements

The authors acknowledge the support of the Semiconductor Research Corporation (SRC) Education Alliance (award 2009-UR-2032G) and of the Maseeh College of Engineering and Computer Science (MCECS) through the Undergraduate Research and Mentoring Program (URMP)

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