SRG

Airflow Simulation and Analysis of a Campus Courtyard

Research for the design of U.C. Davis International Complex, Phase I

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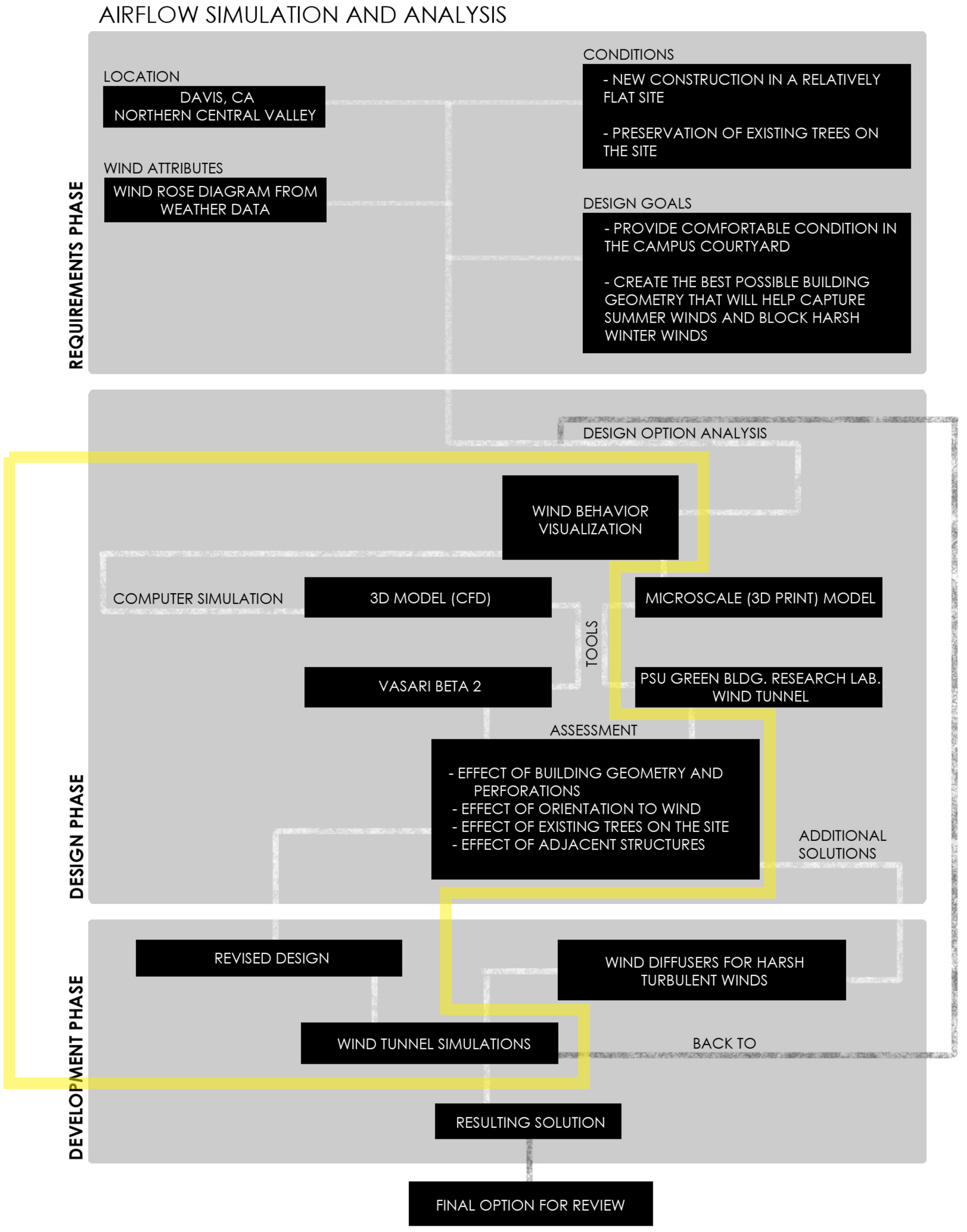
1. Introduction

Natural Ventilation has the attractive qualities that it is free and unlimited. The task is how to utilize it in such a way that it properly transports its capacity in making a well-conditioned environment. Preliminary design of a campus is tested and studied, in an attempt to find out if the geometry of the building provides suitable amount of air through its courtyard. The courtyard is the most important space requirement of the project. The main focus of the preliminary design analysis is to create a comfortable condition within the courtyard, since it will open up onto the different wind flow patterns. The motivation for this experiment came from the idea of applying computer modeling techniques to passive cooling design and to increasingly understand the varying characteristics of wind. The approach for this research is fairly empirical. The method uses Computational Fluid Dynamics (CFD) as a tool that makes the investigation faster and easy to perform the calculations required to simulate the wind behavior.

2. Methodology

Indication of the research process is important in providing understanding of the work procedures and may well increase awareness to the participants. A workflow diagram is better way of communicating the logic of a method to all concerned. With the help of this workflow diagram, problems possibly will be investigated in more effective way. It acts as a guide during analysis and through the development phase.

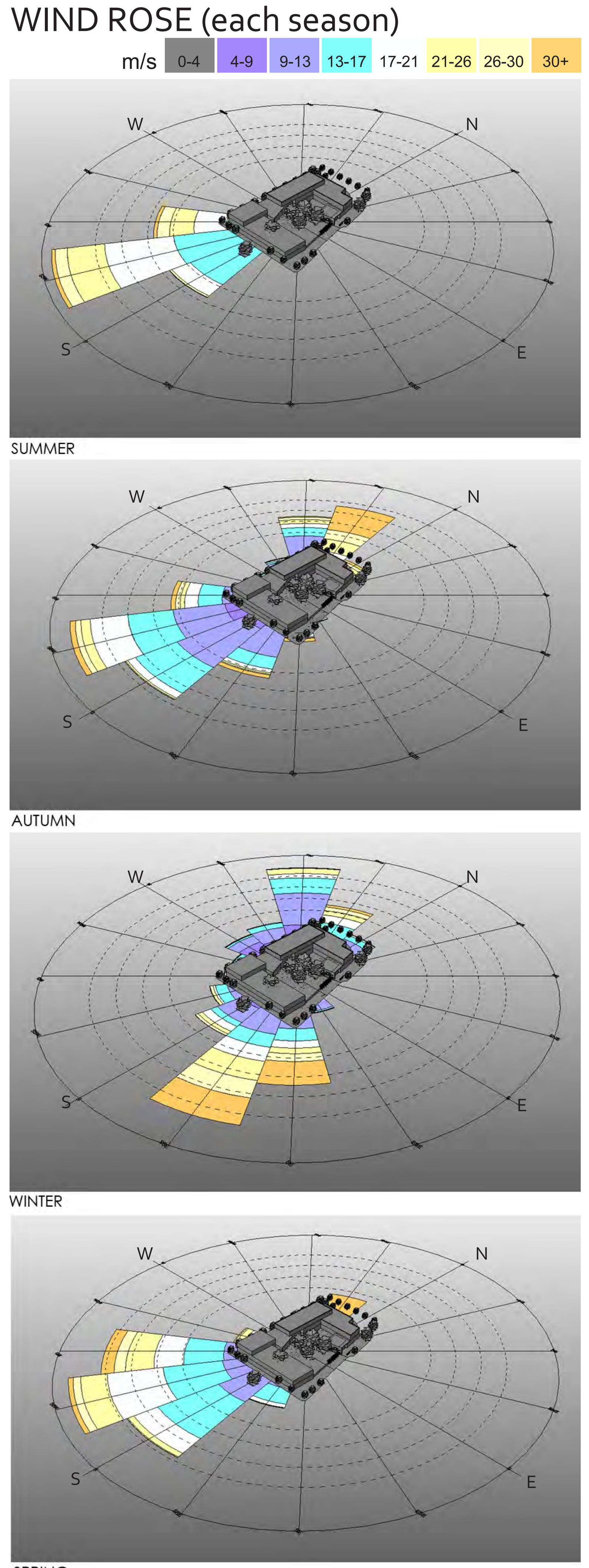


WORKFLOW

MODELING — SketchUp 8

WIND TESTING — Autodesk Vasari Beta 2

WIND ROSE (each season)



3. CFD Wind Analysis Results

According to the airflow simulations, the test results pointed out that on model A (with less openings) during the summer months, with wind approaching from South of Southwest at initial velocity of 18.8 m/s, bigger portions of the courtyard is not receiving any wind at all compared to model B (with more openings) which only shows a smaller area of stagnant air. One of the chief benefits of CFD wind analysis is that it immediately indicates where the problem areas occur in the preliminary designs.

In the winter wind analysis, it appears that the L-shaped form and height of the building is acting effectively on the existing wind that is mostly coming from the Northwest at a speed of 11.3 m/s. Whether the building has lesser or more openings, the overall geometry successfully blocks most of the harsh winter winds from entering through the courtyard space.

The desired wind speed specified in the wind acceleration key that is displayed in each analysis image, is within the range of 0.3m/s to 10.8 m/s stated by the Modern Beaufort Wind Scale. This scale created by Sir Francis Beaufort, is a numerical relationship to wind speed based on an observation of the effects of the wind. It is, until now is being used to estimate wind speed conditions.

MODERN BEAUFORT WIND SCALE

Force	Anemometer reading mph	kmh	m/s	knts	Description	
0	0-1	<1	<0.3	0-1	Calm; smoke rises vertically.	Calm
1	1-3	1-5	0.3-1.5	1-3	Direction of wind shown by smoke drift, but not by wind vane.	Light air
2	4-7	6-11	1.5-3.3	4-6	Wind felt on face; leaves rustle; ordinary vanes moved.	Light Breeze
3	8-12	12-19	3.3-5.5	7-10	Leaves and small twigs in constant motion; wind extends light flag.	Gentle Breeze
4	13-18	20-28	5.5-8.0	11-16	Raises dust and loose paper; small branches are moved.	Moderate Breeze
5	19-24	29-38	8.0-10.8	17-21	Small trees in leaf begin to sway; crested wavelets form on inland waters.	Fresh Breeze
6	25-31	39-49	10.8-13.9	22-27	Large branches in motion; whistling heard in telegraph.	Strong Breeze
7	32-38	50-61	13.9-17.2	28-33	Whole trees in motion; inconvenience felt when walking.	Near Gale
8	39-46	62-74	17.2-20.7	34-40	Breaks twigs off trees; generally impedes progress.	Gale
9	47-54	75-88	20.7-24.5	41-47	Slight structural damage occurs (chimney-pots and slates removed).	Severe Gale
10	55-63	89-102	24.5-28.4	48-55	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	Storm
11	64-72	103-117	28.4-32.6	56-63	Very rarely experienced; accompanied by wide-spread damage.	Violent Storm
12	73-83	≥118	≥32.6	64-71		Hurricane

DESIRED WINDSPEED

4. Conclusion

It is important to note that this research covers one phase of many more analysis towards the main end goal of making the most out of natural ventilation. As previously specified, the CFD simulations concentrated merely on wind patterns. The use of CFD as a tool to quickly test, re-design and retest has allowed an early decision-making and significant modifications and revisions, than of making a physical small-scale model each time to test and analyze. The simulations immediately highlight problems that occur from the interaction of the wind and the building geometry. Early on in the CFD wind analysis, it was clear that some areas in the courtyard space are not reaching the comfortable thermal level. Also, it was showed that the building geometry plays a great impact on the movement and acceleration of the wind velocity.

> "The simulations immediately highlight the problems that occur from the interaction of the wind and the building geometry."

As the simulations give immediate results, the design alteration process has been easily applied to make the best building form that could manipulate the performance of the wind. And since this process could give encouraging data faster, it could easily be instigated in architectural design practices that aim for sustainability and reduction of a building's energy demand. In this investigation, it has been clear that the application of CFD modeling in the early design stage allows concepts and forms to be speedily evaluated and optimized.

AIRFLOW SIMULATIONS (using XY axis 2D grid)