caused by subjective factors such as oversimplified modeling for simulation, non-uniform calculation methods, casual input parameters and boundary conditions, etc. Moreover, it's expected that the issuance of green building identification and this industry can be further regulated. In this paper, starting from questionnaire survey and case study, standardized simulation process is discussed in detail.

QUESTIONNAIRE SURVEY

Review of Previous Surveys

A number of surveys have been carried out in the past that presented the results of the use of building simulation tools. In a survey administered in 2004, C.F. Reinhart pointed out that most users now believe that simulation tools can yield accurate results and that simulation errors result from incorrect input, instead of the Aizlewood and Littlefair's 1994 survey results which showed that trust in the reliability of tools was an issue. This understanding might prompt users to put more emphasis on quality assurance procedures than in the past.

Methodology

This survey is accomplished by a web-based questionnaire on the current use of daylight and outdoor wind simulations in building design. The form of questionnaire is mainly based on the survey conducted by C.F. Reinhart but focused more on details of participants' operation when using simulation tools. The questionnaire was administered from May 14th to July 3rd 2014. And 82 individuals completed this survey.

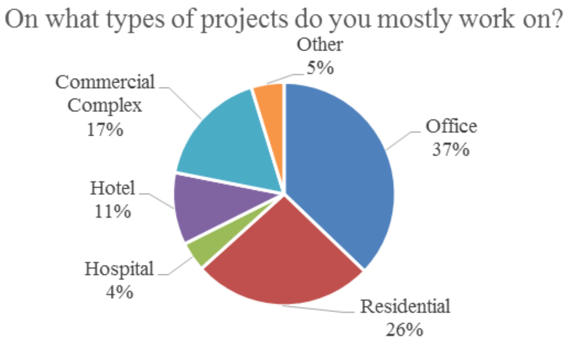
Survey results (Part of Daylighting Survey Result)

- **Participants' background**

Table 1. *Profession of participants*

Architect	15	18.3%
Building Technology	8	9.8%
HVAC engineer	29	35.4%
Green building Consultant	14	17.1%
Researcher	12	14.6%
Other	4	4.9%

Figure 1. *Project types*



- **Criteria used to assess the overall quality of a daylighting design**

When asked what criteria they used to assess the overall quality and performance of a daylighting design, 70% of 82 participants choose uniformity/variation of daylight, followed by minimum/maximum levels for daylight factor (63%), avoidance of glare (59%), illuminances on selected work planes (49%), the assessment of solar heat gain (44%), daylight autonomy levels (40%), the presence of lighting controls (21%), and aesthetics (6%). When further asked detailed output indicators used in simulation, responses are as follows.

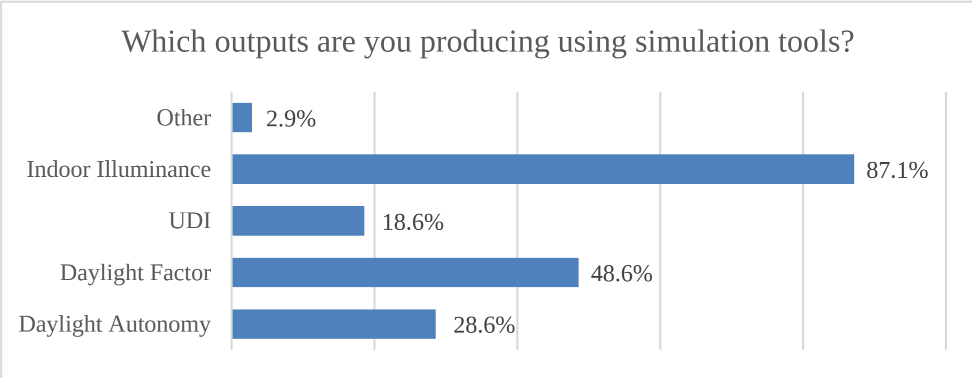


Figure 2. *Responses given by survey participants about what performance indicators they used to assess the overall quality of daylighting*

The above data shows that the participants have a large concern in the uniformity of daylighting environment, glare, DF as well as illuminance levels.

- **Selection of daylight simulation tools**

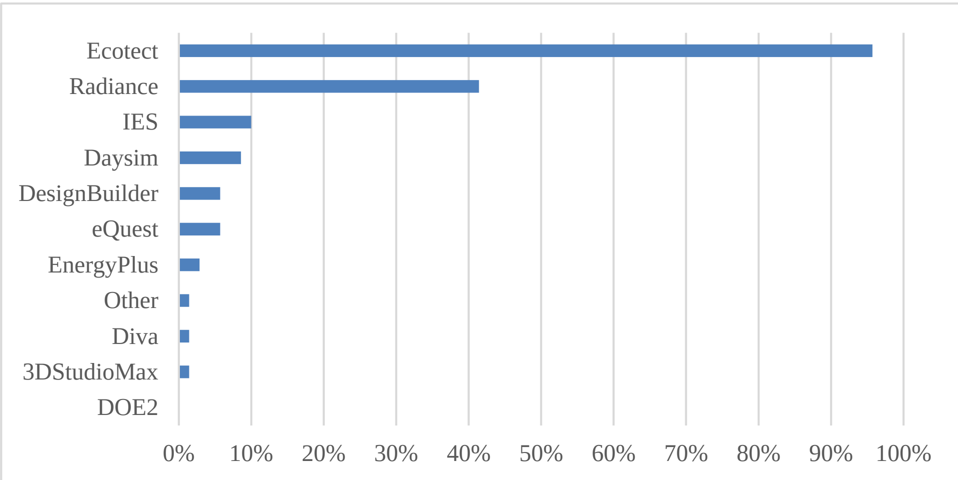


Figure 3. *Responses given by survey participants about selection of daylight software*

- **Detailed simulation process**

Table 2. *Responses given by survey participants about detailed modelling steps*

	√	×
Whether model all significant neighboring obstructions such as adjacent buildings and trees	66%	34%
Whether model ground plane	40%	60%
Whether model wall thickness in model	16%	84%

44% of the participants calculate outside illuminance referring to *Standard for daylighting design of buildings*. 37% calculate outside illuminance by software based on longitude and latitude input. 13% use default setting. And the rest 4% think they do not need to set outside illuminance.

As for the setting of analysis grid, 61% follows the rule that the size of each grid is no more than 1m and the number of grids in each direction is more than 10. Another 21% follow rules of larger grid size and less amount of grids.

DOMESTIC CASE STUDY

Take 130 domestic cases in Beijing, Shanghai, Jiangsu, etc. which have attained green building identification (China-3star) as research targets, the current condition of the use of simulation software is analyzed, especially for daylighting simulation and outdoor wind simulation. Among the 130 cases, there are 49 residential buildings and 81 public buildings including office buildings and commercial complex, etc. The detail information and building types statistics are listed in *Table 3.*

Table 3. *Basic information of target domestic cases*

	3-star	2-star	1-star	Unknown	Sum
Sum	84	21	24	1	130
Residential	34	8	6	1	49
Office	45	5	3	-	53
Commercial Complex	2	4	14	-	20

Daylighting

In the analysis of indoor daylighting environment, projects that integrate daylighting simulation accounts for 41% in residential projects and 73% in public building projects. Detailed problems are mainly discussed from the aspects of reference standards, climate data source, simulation tools, model set-up, parameter setting, grid generating, calculation accuracy and output indicators, etc.

- Reference standards:
  Mainly refer to *Green Building Evaluation Standards (CGBES), Standard for daylighting design of buildings* of China. One of cases refers to LEED.
- Climate data source
  There're 2 different approaches to obtain outside illuminance data based on the survey results: calculate by software based on longitude and latitude input, refer to *Standard for daylighting design of buildings.*
  However, in this case, there're two main problems existed in the target cases.
  1) Use critical illuminance of exterior daylight directly without being multiplied by daylight climate coefficient in the calculation of outside illuminance.
  2) Use design illuminance of exterior daylight by mistake instead of using critical illuminance of exterior daylight, which will cause the illuminance calculation result 3 times as the correct value.
- Output indicator
  Unlike the response in questionnaire results, 100% of the projects use Daylight Factor. No reports have mentioned detailed simulation of glare or uniformity.
- Simulation tools

57% of cases use Ecotect split flux method, and 37% of cases use Radiance backward raytracing simulation engine. These two simulation tools accounts for most of the selections.

- Modelling and parameter setting

  In the aspect of modelling, some important steps, which are more likely to have non-standard operations or have no specific requirement, are summarized referring to the Appendix of Design Standard of Green Buildings of Beijing (DSGB) and former experience. Then, each of the project reports are examined one by one to check these steps mentioned above which have large influence on the simulation results yet often neglected. *Table 4* shows the statistical results.

Table 4. *Conditions of target projects concerning important steps of modelling*

	√	×	-(not mentioned)
Whether build complete multi-story model	67%	31%	3%
Whether model all significant neighboring obstructions such as adjacent buildings and trees	15%	85%	0%
Whether model ground plane	4%	96%	0%
Whether model wall thickness in model	10%	86%	4%
Whether model interior partitions	89%	8%	4%
Whether specify material optical parameters	57%	43%	
Whether specify work plane height	50%	50%	

Projects related to the typical problems mentioned above are shown in *Figure 4~5.*

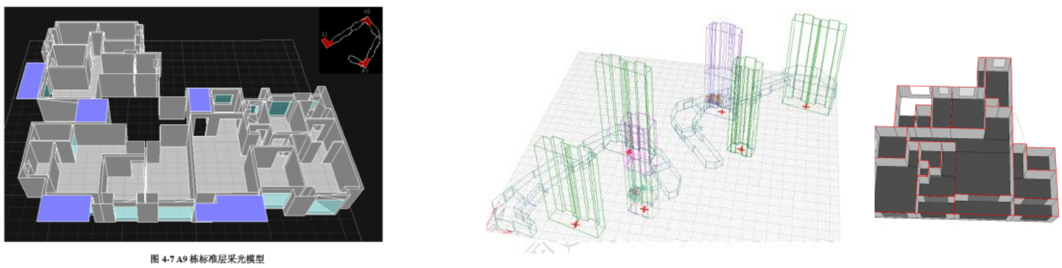


Figure 4. *Only build typical floor VS build complete residential community model*

Figure 5. *project which fails to model all significant neighboring obstructions*

43% of the projects haven’t specify relevant material parameters in reports and part of the project only specify the setting of glass transmittance. Although the rest 57%

of the projects give specifications of material parameter settings, the data source are various and often very casual and informal.

- Grid setting

  Only 17% of the projects give specific description of grid setting and only 4% of the projects meet the requirement of grid setting given by the Appendix of Design Standard of Green Buildings of Beijing.

Outdoor wind

In the analysis of outdoor wind environment, projects that integrate wind simulation accounts for 80% in residential projects and 65% in public building projects.

Detailed problems are mainly discussed from the aspects of reference standards, climate data source, simulation tools, parameter setting, computational domain setting, grid generating, and output indicators, etc.

- Simulation tools

  42% of the project use Phoenics, followed by Fluent (27%), Star-CD/Star-CCM+ (2%), ANSYS ICEM CDF/ANSYS CFX (1%), Airpak (1%), and the rest 27% not mentioned in reports.
- Output indicators

Table 5. *Selection of Output indicators*

	Percentage of projects using this output indicator
Wind velocity at the height of human activity	99%
Wind speed amplification	40%
Wind pressure at the height of human activity	65%
Wind pressure of building surface	43%
Local vortex or corner	22%
Average heat island index of typical summer day	1%

- Parameters and computational domain setting

Table 6. *Conditions of target projects in parameters and computational domain setting*

	Percentage of projects following this step
Set as gradient wind	86.8%
Specify ground condition and gradient wind index	71.1%
Describe computational domain setting	22.4%
Describe analysis grid setting	23.7%

In the analysis of outdoor wind environment, due the different principles in mesh generating in different simulation tools, it’s more difficult to have a uniform standard. Besides, as for the setting of computational domain, there is also no specific requirement in the current standard. However, the credibility of the simulation results of wind field is largely related to the setting of computational domain. The current survey results show that most simulation reports have no description of computational domain setting, while the few reports which have such description follow very different rules in the computational domain setting and some even have very obvious mistakes.

Table 7. *Typical descriptions of computational domain setting*

Description of computational domain setting	Number of project
Have illustration for computational domain setting, yet the setting is obviously problematic.	11
Take the target building as center, the distance in the inlet direction and both left and right is more than 3H. The distance in outlet direction is more than 8H. The distance above the building to the boundary is more than 3H. (H equals the height of the highest building in the target building group)	2
The area of building coverage is less than 3% of the area of the whole computational domain. Take the target building as center, the area within a radius of 5H is the horizontal computational domain. The distance above the building to the boundary is more than 3H.	3
The distance in the inlet and outlet direction is both over 8H. The wind block index (the ratio of the area of building to the area of computational domain in the windward side) is no more than 5%.	1
The setting of computational domain mainly follows the rule of not affecting airflow near the boundary of building group. The distance from building to each boundary should be more than 300m and the height of computational domain is more than 3H.	4

DISCUSSION

From the questionnaire survey and case study, common problems have been found out in building performance simulation.

1) Non-uniform calculation method and theoretical model

   The current simulation all lacks standard of how to simply model reasonably, consideration of model components inside and outside, consideration of surrounding. For instance, in the daylighting simulation, 60% participants in survey noticed the importance of building surrounding scenes, while in the real reports, it turned out that only 15% of the projects built surroundings. Also, details such as whether build ground plane and wall thickness all have not be unified effectively while these details will cause big difference in calculation results. In a study case of a single-floor model with south independent window, with the presence of ground, indoor daylighting is enhanced due to the reflection of ground. Especially for the interior zone, average of DA increases by 6% compared with no ground.

2) Setting of Analysis Grid

The analysis grid is required in most of the current simulation software such as CFD simulation, natural lighting simulation and noise level simulation. Currently, there are no standards and guidelines about the size, number and location of the grid setting which have a significant impact on the final calculated results.

One obvious example is that in the CFD simulation, where too much grid will affect the calculation time while too little grid will reduce the calculation accuracy. In a study case of a residential community, different grid sizes lead to a 14.8% difference in the calculation result of average wind speed around building.

3) Boundary Conditions

Setting of boundaries conditions is essential in every performance simulation, such as in outdoor wind simulation, the inlet wind velocity and direction, whether gradient wind is considered, etc. However, these boundary conditions inputs are all in chaos. For example, in the daylighting simulation, there are different approach toward the value of outside illuminance which has a large difference.

4) Calculation Accuracy

The judgment of the calculation results in the CFD simulation for wind environment is largely depending on the experience of export. And the simulation accuracy of daylighting and the simulation step of the energy simulation is not specified. Similarly, take daylighting simulation with Daysim as example, in a study case of a single-floor model with south independent window, DA average using 5 times of reflection is 22.5% larger than DA average using 2 times of reflection.

5) Parameter Setting

Currently, the specification of the parameter setting in building energy simulation is relatively comprehensive compared to other simulation. But there are still some important parameters which are not specified, such as infiltration rate of the building envelope, natural ventilation, and the control of artificial lighting. And there are less specifications for the other types of simulation. For example, the transmittance and cleanliness of the glass is not specified in the daylighting simulation, as well as the reflectance of the wall, roof and floor in the room.

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