Facades Solar Screens Impact on Daylighting Performance in Buildings

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1 ABSTRACT

Cities in hot climates feature clear skies most of the year, guarantting the provision of daylight into the interior. With the use of large glazed façades, controlling the penetration of solar radiation that contributes to thermal discomfort with passive solutions is acheived through the use of shading devices.These devices decrease energy loads of mechanical cooling. The facade solar screens is one of the shading strategies used and reported to be succeful in such hot climatic regions, blocking solar radiation while allowing visual access to external views. Such a strategy of screening the opennings with perforated surfaces has cultural and historical significance in multiple urban environmnets, demonstrated by the use of the traditional mashrabeya which are the inspiration for contemporary screens design. However, throughout the last decade, a large body of research has been concerned with the negative impact of solar screens on daylighting performance in internal spaces, leading to an increase in energy loads of artifical lighting.

This paper aims to review the current research body concerned with the correlation between solar screens design parameters and daylighting performance. 21 articles fall under this paper's realm. They are reviewed according to multiple comparison points, including: aims, spatial configuration of the test spaces, types and design of the tested solar screens, design parameters tackled, daylighting simulation tools, daylighting metrics, and finally, findings including parameters impact, empirical process methodolgy, and coorelation with other enviromental aspects. Thispaper discusses how the curent reviewed research body informs the design process for an environmentally conscious design of optimized solar screens with respect to daylight availability thereby promoting the use of passive design strategies towards greener cities and urban environments.

Keywords: Parametric design, Passive design, Daylighting performance, Facade solar screens, Optimizing performance

2 INTRODUCTION

Since the inception of early modernist archtiecture, the use of large glazed facades has been an integral part of worldwide modernist and contempray arhcitecture. In regions with a hot climate, building facades are being designed to western standards with the aim to have a contemporary look by using specifically large glazed façades (Etman et al., 2013; M. ElBatran & Ismaeel, 2021; Mayhoub & Labib, 2015). With clear skies most of the year, the provision of daylight into the interior is guaranteed as a passive design strategy.

Shading devices are also being implemented to control the penetration of solar radiation which contributes to thermal discomfort and over-heating (Wagdy & Fathy, 2015). Yet, in the scientific discourse of the balance between diffused daylighting and solar radiation, several reviews have proven that the different shading devices may negatively affect daylight availability.(Eltaweel & SU, 2017; Kirimtat et al., 2016; Yu et al., 2020).

2.1 Problem

The previously mentioned reviews stated that the research concerned with the impact of shading devices on daylighting produces only recommendations for specific hypothetical design cases.These articles present no methodologies to study the correlation between daylighting performance and the parameters of shading devices. Such insightsand design frameworks may assist architects and designers in their decision making process about the impact of the variations in the values of a specific parameter on daylighting performance.

2.2 Scope

Among the different shading devices,the research focuses on facade solar screens, as it can block solar radiation and at the same time keep the users more in contact with external views (Kirimtat et al., 2016; Wagdy & Fathy, 2015). The same refrences agreed as well that solar facade screens provide successful shading, specifically in hot climatic regions, despite reportinga negative impact on daylight availability. Such features also have cultural and historical significance in hot climate regions through different traditional architectural vocabulary including the mashrabeya of Egypt, the moshabak of Iran, and the jali of India.

The research body concerned with the impact of facade solar screens on daylighting performance has been on the rise since the beginning of the last decade. This study reviews the literature concerned with this scope to assess if a methodology is developed to investigate the statistical correlation between different solar screens design paramaters and daylighting illuminance values in interal spaces.A brief introduction is conducted on daylight performance evaluation in architecture and research in order to understand how the impact of solar screens on daylighting is assessed. And then, the review of 21 selected papers is conducted and discussed to assess the presence of a methdodology that investigates the correlation between solar screens parameters and daylighting.

3 DAYLIGHT ASSESSMENT IN ARCHITECTURE

In order to understand the impact of façade solar screens on daylighting, it is necessary to understand how daylighting performance is evaluated in architectural design and research. The first mention of a daylight evaluation method was proposed by (Trotter, 1911): a fraction between the illuminance at a point inside and the illuminance outside under an unobstructed overcast sky excluding sunlight. This was known later as the daylight factor DF and expressed as a percentage, whereby the internal illuminace at a point is divided by the external illuminace and multiplied by 100 (Lewis, 2017; P. Tregenza & Mardaljevic, 2018). The same references stated that for its ease of use the DF is adopted to date in multiple design guidelines and building regulations. Yet, its reliability is questioned by multiple references. One critical argument is that the DF is idealistic as it regards only the overcast sky and excludes varying factors, such as different sky luminances and solar radiation interference. Thus, its simplicity compromises its reliabiltiy in realistic conditions (Lewis, 2017; Lou et al., 2019; Mardaljevic et al., 2000; P. Tregenza & Mardaljevic, 2018; P. R. Tregenza, 1980).

Concerns about the DF led to the introduction of the Climate Based Daylight Modeling method into the development of computer software.The CBDM approach was introduced first hand by Mardaljevic et al., (2000); and Reinhart & Herkel (2000). In brief, CBDM considers long term assessment for daylighting performance in a space comprising the range of sky luminace conditions and solar radiation on an hourly basis for a full year. This process is conducted using daylight simulation software where different sky luminance values are modeled based on a weather data file for the site and processed by a calculation engine that produces output results. As the results comprise hourly illuminance values at a number of test points in a space for a full year, the CBDM relies on metrics developed to handle evaluating daylighting performance based on these results. These performance metrics assess the illuminance values at a point of specific minimum/maximum illuminance thresholds, based on research work concerning human comfort and daylighting functional requirements. The daylighting performance at that point is then assessed accordingly as being adequate or not regarding the percentage of hours throughout the year when it meets or falls short of the minimum/maximum illuminance thresholds. The commonly introduced metrics to date are: Daylight autonomy (DA) (Reinhart & Walkenhorst, 2001), Useful Daylight Illuminaces (UDI) (Nabil & Mardaljevic, 2006), Daylight Availability (DAv) (Reinhart & Wienold, 2010), Spatial Daylight Autonomy (sDA) (Heschong et al., 2012), and, Annual Sunlight Exposure (ASE) (Heschong et al., 2012).

4 FAÇADE SOLAR SCREENS AND DAYLIGHTING PERFORMANCE

This section tackles how the current research body investigates the impact of façade solar screen impact on daylighting, and whether a methodology to investigate a statistical correlation exists. First, the methodology of selecting papers is explained, and then a breakdown analysis is conducted for a number of aspects.

4.1 Paper selection

First, a search was done on several paper databases using a combination of the following keywords: solar screen, perforated facades, perforated panels, mashrabeya, jali, daylight availability, and daylight performance. The databases are: Science Direct, Taylor and Francis, Sage Journals, and Springer Link. There were no restrictions concerning the year of publication or the number of pages.

The search produced 386 papers, filtered to 14 relevant to this review’s scope: 11 from Science Direct, 3 from Taylor and Francis, and none from Sage journals nor Springer link (table 1). The 14 papers are published in 9 journals as follows in (figure 1). The second step of selection was done by adding papers cited in the previous 14 papers found reliable to this review's scope. Seven conference proccedings papers were found relevant as follows in (figure 2).

Database	Results	Filtered Results
Science Direct	**279**	**11**
		(Chi, 2022; Chi et al., 2018; Chi, Moreno, & Navarro, 2017; Khidmat et al., 2022; Lavin & Fiorito, 2017; M. ElBatran & Ismaeel, 2021; Sabry et al., 2014; A. Sherif et al., 2012; A. H. Sherif et al., 2012; Srisamranrungruang & Hiyama, 2020; Wagdy & Fathy, 2015)
Taylor and Francis	**73**	**3**
		(Chi et al., 2021; Chi, Moreno, Esquivias, et al., 2017; Vazquez et al., 2021)
Sage Journals	**34**	**0**
Springer Link	**0**	**0**
Total	**386**	**14**

Table 1: Details of the search done in articles databases.

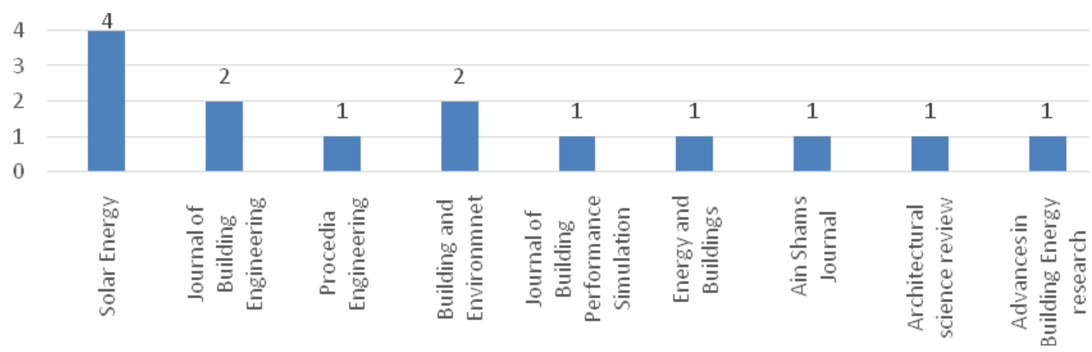

Fig. 1: Number of published papers per journal.

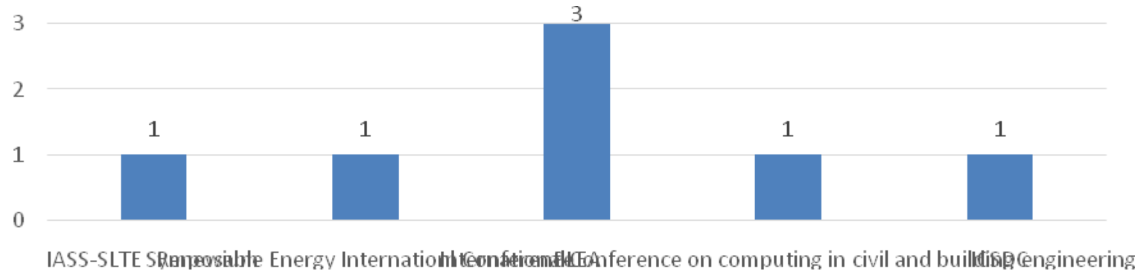

Fig. 2: Number of published papers per conference.

By reviewing the total selected 21 artilces, it is found that the first papers were published in 2010 by A. Sherif et al. (2010) in a conference proceeding. Since then until December 2022 a minimum of one paper was published each year except for years 2013, 2016, and 2019. Whereas 2017 marks the highest number of published papers proceeded by 2012, 2021, and finally 2022 (figure 3).

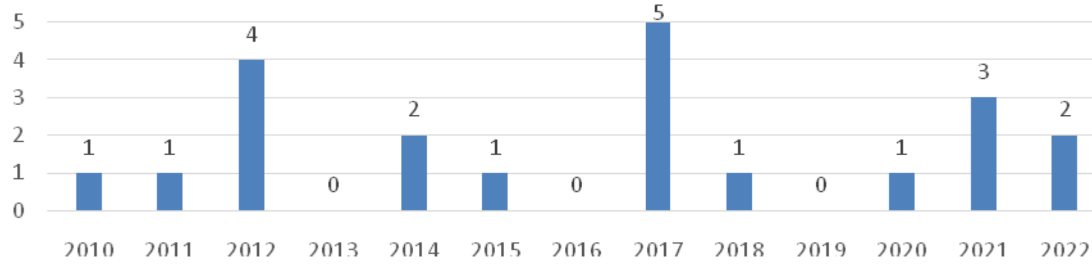

Fig. 3: Number of published papers per year.

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The papers are investigating the impact of façade solar screens on either daylighting performance only, or combined with other environmnetal performance aspects, including: cooling loads, heating loads, artificial lighting loads, shading coefficient, solar radiation energy and finally natural ventilation. Daylighting is evaluated only in 12 papers, and combined dfferently with other environmental aspects as follows in (figure 4). The most combined environmental aspect with daylighting is the cooling load, followed by both heating and artificial lighting loads. Solar radiation was considered two times and only once for both natural ventilation and shading coefficient (figure 5).

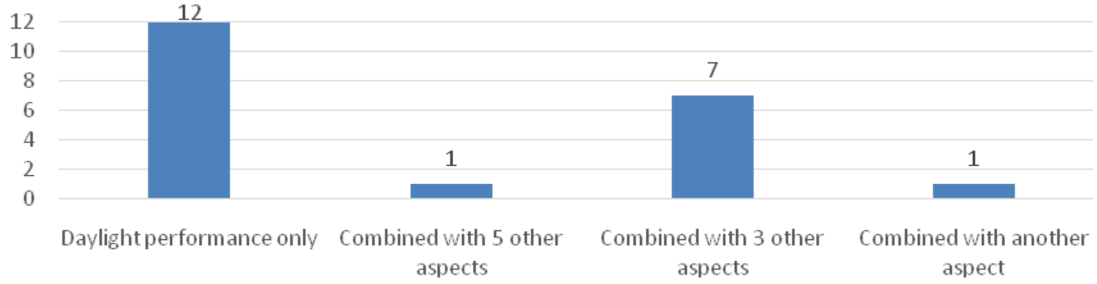

Fig. 4: number of papers testing other aspects performance with daylighting.

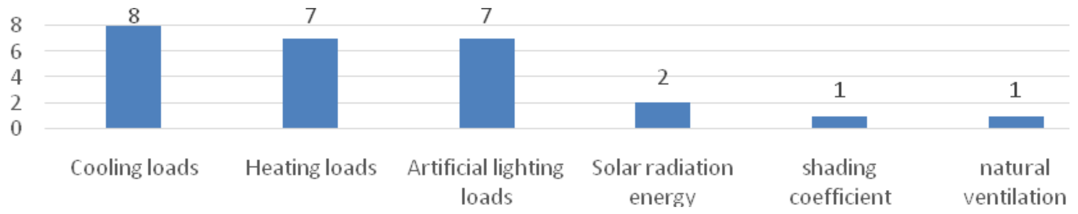

Fig. 5: Number of times specific aspects were tested with daylighting.

4.2 Review methodology

After selecting the papers, an analytical review was conducted. The selected methodology was related to the process in the reviewed papers of conducting their investigations about the impact of solar screens on daylighting performance. First, each paper proposes a space where the test is done, then, a solar screen type is selected along with variations in its paramters to generate test cases , finally a computer simulation is conducted and findings are deducted from the results. According to this process, the review methodology is conducted as follows (Figure 6):

(a) Review the test spaces: site, function, and physical configurations.

(b) Review the tested solar screens: types, parameters, and generated cases.

(c) Review the Simulation process: tools and performance metrics.

(d) Discuss the findings.

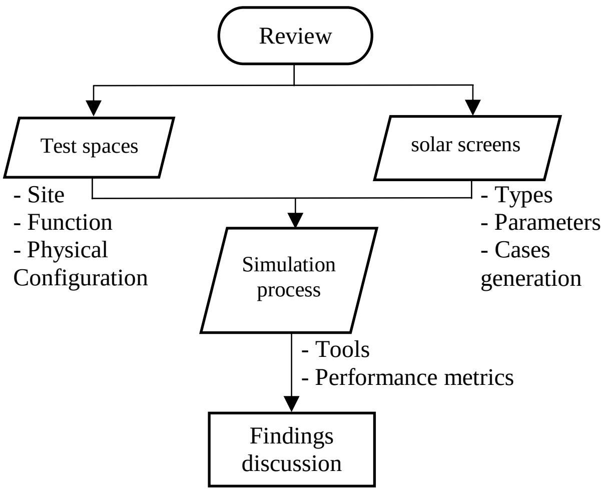

Fig. 6: Review methodology.

4.3 Test spaces

Each paper considered a space where the impact of the solar screenon daylight availability is evaluated. This section outlines these test spaces concerning site, function, and physical configurations.

4.3.1 Site

The methodologies of multiple papers reported that authors considered sites with clear and sunny skies most of the year, as shading screens were likely to be used. Egypt was the most common site with its cities Cairo, Al-Sadat and Alkharga Oasis, followed by Spain, mainly Seville. Saudi Arabia was next with its cities Jeddah and Riyadh, followed by Japan with Tokyo and Kitakyushu, and finally, there were single considerations in Australia (Sydney), Iran (Tehran), Paraguay (Asuncion), and USA (Phoenix) (figure 7).

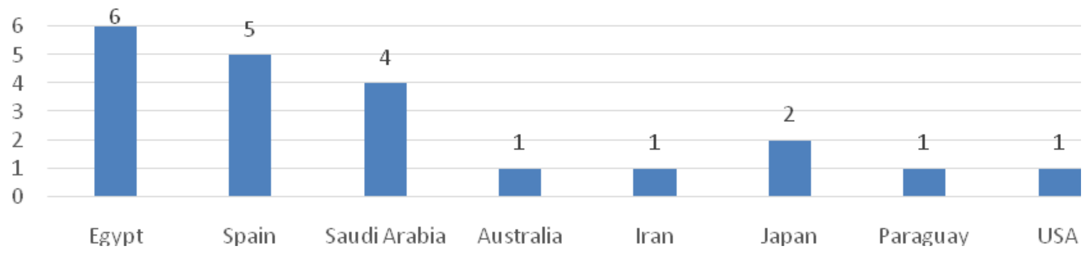

Fig. 7: Number of papers per chosen site.

4.3.2 Function

All test spaces are hypothetical, except one paper in which M. ElBatran & Ismaeel (2021) modelled the space after an office building in an administrative campus of the Smart Village campus in Cairo, Egypt. Three papers assigned no function to the test spaces and considered them as a test room. Administrative functions where adopted most in 9 papers, whereas 7 papers adopted residential functions, and finally educational functions were adopted in 2 papers (figure 8).

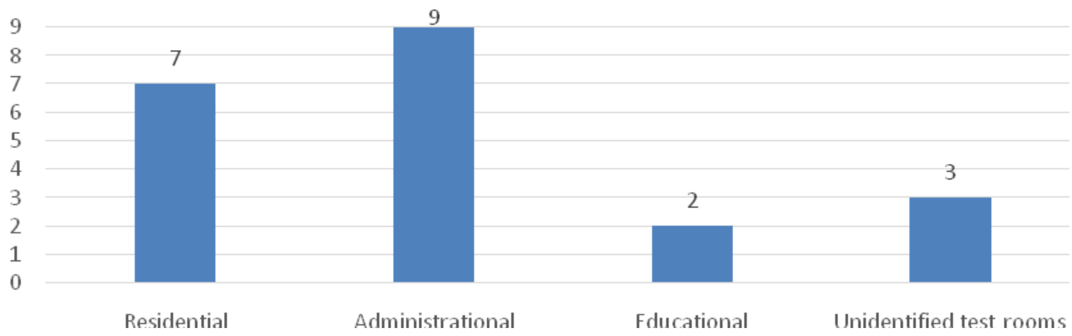

Fig. 8: Number of times a type of function was chosen the papers.

4.3.3 Physical configuration

The dimensions of the test spaces in all the papers were constant, as only one scenario was considered in each. The length of the spaces varied from a minimum of 3 meters to a maximum of 12 meters, and the widths varied from a minimum of 3.6 meters to a maximum of 12 meters, while the heights varied from a minimum of 2.6 meters to a maximum of 5.00 meters. Yet, only one space had a considerable difference in its physical configuration compared to the other 20 papers, namely the previously mentioned space modelled after an office building in Cairo, which had 42 meters length and 37.5 meters width. Apart from this space, the floor areas of the test spaces varied between a minimum of 10.8 m2 and a maximum of 144 m2.

Regarding the openings placement, 19 papers had a single façade opening, whereas 1 article had openings in adjacent facades and another had openings on all 4 facades. Concerning the opening design, 14 papers had singular continious openings, 6 papers had fully glazed facades, and finally one paper had patched windows along the façade. Each paper considered only one scenario, and no variations were adopted in the physical configurations. Yet, three articles (Chi et al., 2021; Oghazian, 2017; Wagdy & Fathy, 2015) conducted variations in the window to wall ratio WWR in their tests.

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4.4 Solar screens

Each paper tested the impact of a solar screen on daylighting and other environmental aspects. This section reviews the types of solar screens chosen, the tested parameters, and the case generation process.

4.4.1 Types of solar screens

18 papers identified their solar screens as a perforated panel, sometimes as a specific design application, whereas for other cases the methodology was adopting a simple perforated plane to simplify the test and the modelling process. Three papers specified other façade solar screen types as follows: a screen of horizontal louvers (Wagdy & Fathy, 2015), a masonry brick wall (Vazquez et al., 2021), and an expanded metal mesh (Khidmat et al., 2022).

4.4.2 Tested parameters

A total number of 19 design parameters were tested in the 21 papers. Divided between the three types of tested solar screens, 8 parameters are related to the perforated panels, 4 parameters related to the screen of horizontal louvers, 5 related to the expanded metal mesh, and finally 2 related to the masonry brick wall.A description for each parameter is available in (table 2). Parameters are sorted by giving a code and a numbering for each indicating which type of screen it is related to:PP for perforated panels, HL for horizontal louvers., BW for masonry brick wall, and MM for expanded metal mesh.

Type/number of times tested		**Code**	**Parameter / number of times tested**		**description**
Perforated panel (PP)	18	PP01	Perforation percentage	11	Percentage of the panel's permeable surface area.
		PP02	Openings aspect ratio	5	Proportional relation between horizontal and vertical dimension of the openings/perforations.
		PP03	Screen axial rotation	4	Rotation angle of the whole panel.
		PP04	Screen depth	3	Identifies the panel's thickness.
		PP05	Matrix dimensions	6	Perforation distribution in horizontal and vertical directions.
		PP06	Geometry of openings	5	Indicates the geometrical shape of the openings/perforations.
		PP07	Non-uniform perforation	1	Targets the non-uniform distribution of the openings
		PP08	Gap screen and glazing	2	Distance between the glazing's plane and the perforated panel
Horizontal louvers (HL)	1	HL01	Louvers count	1	Identifies the number of louvers used to form the screen.
		HL02	Louvers tilt angle	1	Rotation angle of the louvers around its horizontal axis.
		HL03	Louvers depth	1	Louvers' depth in its horizontal plane.
		HL04	Louvers reflectivity	1	The finishing's reflectivity of the louvers.
Masonry brick wall (BW)	1	BW01	Bricks rotation angle	1	The rotation angle of each brick around its x,y and z axis.
		BW02	Bricks building pattern	1	The arrangement of bricks used to form the screen.
Expanded metal mesh (MM)	1	MM01	Diamond height	1	The dimensions of the diamond module.
		MM02	Diamond length	1	
		MM03	Diamond depth	1	
		MM04	Diamond angle	1	The tilt angle of the modules around its horizontal axis.
		MM05	Connecting bond length	1	length of bonds connecting the diamond modules

Table 2: coding, and description of tested parameters.

The parameters related to the horizonal louvers, masonry brick wall, and expanded metal mesh were tested each only once, as their types of screens were tested only once in the 21 papers. The perforation percentage PP01 was the highest tested parameter -11 times, followed by 6 times for the matrix dimensions PP05, 5 times for each of PP06 and PP02, 4 times for PP03, 3 times for PP04, 2 times for PP08, and finally once for PP07.The number of parameters tested in one study varies from one paper to another, 6 papers kept its testing limited to only one parameter, whereas the highest number of 7 paper tested on 2 parameters, 5 papers on 3 parameters, 2 papers on 2 parameters, and one article on 6 parameters (figure9).

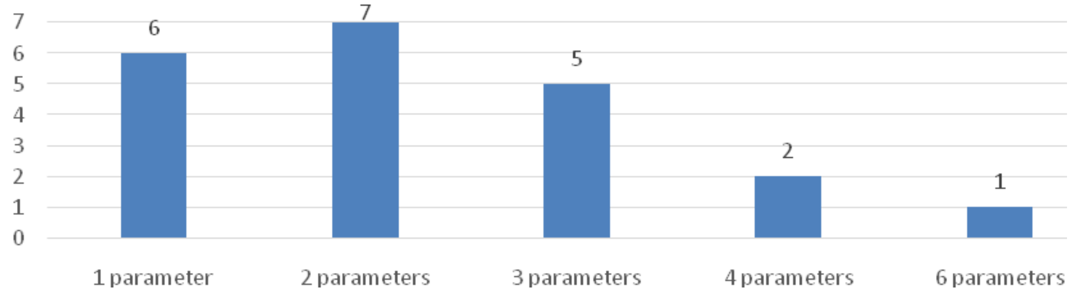

Fig. 9: Number of times several combined parameters have been tested together.

4.4.3 Cases generation

Each paper generated a number of cases through creating systematic variations in the parameter(s) (table 3). The range varies greatly between the maximum and the minimum number of case 3176 and 5 respectively.

	Reference	screen Design	Studied parameters	Cases
1	(A. Sherif et al., 2010)	Perforated panel	PP01	9
2	(A. Sherif et al., 2011)	Perforated panel	PP02	6
3	(A. Sherif et al., 2012)	Perforated panel	PP01	9
4	(Sabry, Sherif, & Rakha, 2012)	Perforated panel	PP03	10
5	(A. H. Sherif et al., 2012)	Perforated panel	PP02, PP03	12
6	(Sabry, Sherif, Gadelhak, et al., 2012)	Perforated panel	PP02, PP03	8
7	(Sabry et al., 2014)	Perforated panel	PP02, PP03	12
8	(Emami et al., 2014)	Perforated panel	PP01, PP04	5
9	(Wagdy & Fathy, 2015)	Horizontal Louvers	HL01, HL02, HL03, HL04	1600
10	(Lavin & Fiorito, 2017)	Perforated panel	PP01, PP05	10
11	(Chi, Moreno, & Navarro, 2017)	Perforated panel	PP01, PP05, PP06	16
12	(Chi, Moreno, Esquivias, et al., 2017)	Perforated panel	PP01, PP05, PP06	16
13	(Oghazian, 2017)	Perforated panel	PP06, PP07	22
14	(Kotbi & Ampatzi, 2017)	Perforated panel	PP02	36
15	(Chi et al., 2018)	Perforated panel	PP01, PP05, PP06	64
16	(Srisamranrungruang & Hiyama, 2020)	Perforated panel	PP01	5
17	(M. ElBatran & Ismaeel, 2021)	Perforated panel	PP01, PP04, PP08	36
18	(Vazquez et al., 2021)	Masonry brick wall.	BW01, BW02	12
19	(Chi et al., 2021)	Perforated panel	PP01, PP05` PP06	64
20	(Chi, 2022)	Perforated panel	PP01, PP05, PP08, PP04	72
21	(Khidmat et al., 2022)	Expanded Metal mesh	MM01,02,03, 04, 05	3176

Table 3: Summary of solar screen's types, parameters, and cases generated.

Moreover, 8 articles proposed other approaches to generate cases as part of their studies aims as follows. (Wagdy & Fathy, 2015) used a parametric exhaustive research method that enabled them to explore all possible scenarios that can be formed by different parameters values. 1600 cases were generated from this

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method, and to handle the computational load of simulations they proposed a "parallel computational algorithm" that uses all PC cores to run multiple simulations at the same time. (Chi, 2022; Chi et al., 2018, 2021; Chi, Moreno, & Navarro, 2017) used the "orthogonal arrays", a statistical method to find optimized solutions. It allows to test with the least number of experiments/simulations multiple variables; thus, the computational load is reduced while giving an insight into the impact of the variation in each parameter. Finally, (Khidmat et al., 2022; Lavin & Fiorito, 2017; Vazquez et al., 2021) used a genetic algorithm method. It is a process that mimics the natural process of selection where the fittest prevails. It requires defining genes (variables with values) and a fitness value. In the study case the fitness value is a daylighting performance metric, and the genes are the studied screen parameters.

4.5 Simulation process

Daylighting simulation tools are being used in all the 21 papers to test the impact of solar screens on daylighting. This section reviews the used tools, and the adopted daylighting metrics (table 4).

	Reference	Daylight simulation engine - Interface	Daylighting performance metric
1	(A. Sherif et al., 2010)	Radiance	Point in time illuminances
2	(A. Sherif et al., 2011)	Radiance - DIVA for Rhino	Point in time illuminances
3	(A. Sherif et al., 2012)	Radiance - DIVA for Rhino	Point in time illuminances
4	(Sabry, Sherif, & Rakha, 2012)	Radiance	Point in time illuminances
5	(A. H. Sherif et al., 2012)	Radiance - DIVA for Rhino	DAv, DGP
6	(Sabry, Sherif, Gadelhak, et al., 2012)	Radiance - DIVA for Rhino	DAv, DGP
7	(Sabry et al., 2014)	Radiance/Daysim - DIVA for Rhino	DA
8	(Emami et al., 2014)	Radiance/Daysim - DIVA for Rhino	DA DF
9	(Wagdy & Fathy, 2015)	Radiance/Daysim - DIVA for Rhino	sDA, DAv, ASE, DGP
10	(Lavin & Fiorito, 2017)	Radiance/Daysim - Ladybug and honeybee for Grasshopper/Rhino	UDI, DF
11	(Chi, Moreno, & Navarro, 2017)	Radiance/Daysim - DIVA for Grasshopper/Rhino	DAv, UDI
12	(Chi, Moreno, Esquivias, et al., 2017)	Radiance/Daysim	DA, DAv, UDI
13	(Oghazian, 2017)	Radiance	sDA,DGP
14	(Kotbi & Ampatzi, 2017)	Radiance/Daysim - DIVA for Grasshopper/Rhino	DAv
15	(Chi et al., 2018)	Radiance/Daysim - Honeybee and ladybug for Grasshopper	DAv
16	(Srisamranrungruang & Hiyama, 2020)	Radiance – DIVA for Grasshopper	DAv, UDI
17	(M. ElBatran & Ismaeel, 2021)	Radiance/Daysim - DIVA for Rhino	sDA, ASE
18	(Vazquez et al., 2021)	Radiance - DIVA for Grasshopper	sDA, ASE
19	(Chi et al., 2021)	Radiance - DIVA for Grasshopper	DAv
20	(Chi, 2022)	Radiance, Daysim / DIVA for Rhino	DAv
21	(Khidmat et al., 2022)	Radiance, Ladybug and honeybee for Grasshopper	UDI, sDA, ASE

Table 4: Summary of daylight simulation: tools and metrics.

4.5.1 Metrics

Each paper uses one or multiple performance metric(s). The DF is used in only 2 papers coupled with another CBDM metric. The DA. and rough points in time illuminance values were used to explore the impact in 4 papers. The authors of these papers decided their own minimum and maximum thresholds during the methodology phase, thus none of these articles used any CBDM metric. Finally, 17 papers used different CBDM metrics, either one or multiple per paper. The DAv was the most used metric followed by the sDA (figure 10).

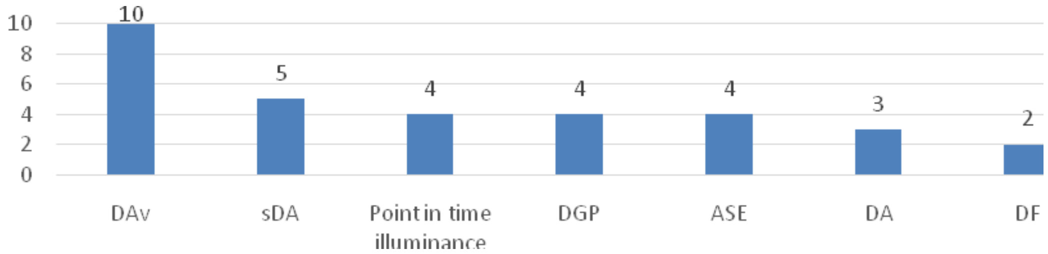

Fig. 10: Number of times a daylighting metric was used in the articles.

4.5.2 Tools

The Radiance simulation engine (and its method Daysim) is the only engine used in all of the 21 papers. The most used plugin/interface is DIVA for Rhino/Grasshopper to control Radiance in 14 articles. Honeybee and Ladybug for Grasshopper are used in 4 articles, and 3 articles did not identify the used interface (figure 11).

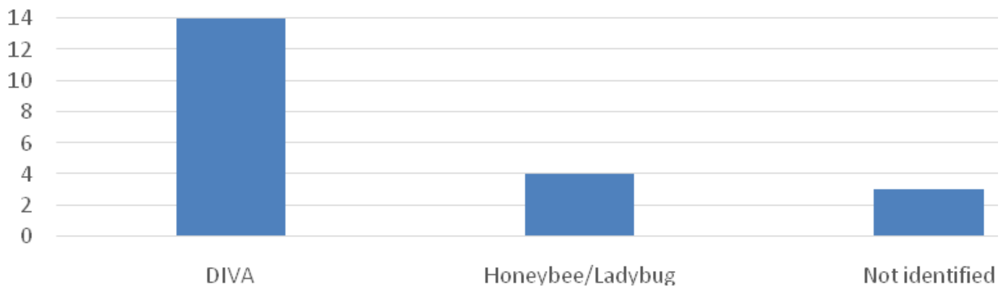

Fig. 11: Number of times an interface was used in the simulation process.

5 FINDINGS DISCUSSION

This section aims to discuss how the previously mentioned points of analysis impacted the findings of the papers, and whether they are relevant or not to the question of this study: whethere there is an investigation of the statistical correlation between daylighting performance and screens paramters. When the investigation of the daylighting performance was combined with other environmental performance aspects the aim shifted towards discovering optimized solution for screen design in specific cases. Such an approach led to the lack of in-depth insights concerning the targeted correlation, as the process was driven by a tradeoff between the different parameter values towards best case scenario for the overall environmental performance targeted. This approach to the optimization process was adopted in 9 papers.

The other 12 papers, concerned only with daylighting performance had more in-depth findings concerning the correlation between daylighting and design parameters. 11 papers targeted the perforated panels while only one paper targeted the screen of horizontal louvers. Five of these papers tested the impact of one parameter, and another five tested the impact of 2 parameters, only one article tested 3 parameters, and one article tested the impact of 4 parameters. The impact of the parameters on daylighting performance was addresed as follows:

(a) First, findings exploring the minimum and maximum parameter(s) value to achieve adequate daylighting. For example, A. Sherif et al., (2010) stated a minimum value of perforation percentage that can produce adequate daylighting. A. Sherif et al. (2012)stated that to achieve adequate daylighting in the depth of the test space higher values of perforation percentage is required, recommending the use of non-uniform values to achieve it. In another study, Oghazian, (2017)stated that different geometries of perforations with the same area affect daylighting performance differently. Such findings do not observe the presence of a statistical correlation between the parameter’s values and daylighting. Moreover, the results are bonded to a specific physical configuration of a test space. Sabry, Sherif, Gadelhak, et al., (2012) and A. H. Sherif et al.

(2012)agreed on this,mentioning that other spatial configurations of test spaces may affect the concluded results.

(b) Regardless of the previously mentioned concern, Sabry, Sherif, & Rakha, (2012) is the onlypaper that observed the statistical correlation,they found an increasing linear relationship between average illuminance values and axial rotation angles. They suggested that such a correlation could be used by architects as a guide to choose suitable axial rotation angles knowing their impact on daylighting availability.

(c) The orientation and solar radiation impact was addressed in a number of findings. A. Sherif et al. (2012)observed that the impact of screens in the north with the absence of solar radiationis more effective. Similar findings were stated by Oghazian, (2017) who claimed that non-uniform perforation could deal with the efficiency/deficiency of other screen parameters when daylighting values are influenced by solar radiation. Sabry, Sherif, Gadelhak, et al. (2012) and A. H. Sherif et al. (2012) found that the aspect ratio of openings can improve daylighting while taking into consideration that it may cause over-lighting due to solar radiation for southern and eastern orientations.

(d) The previously mentioned findings prove that adopting solar radiation into the simulation process affects the insight of how the diffused daylight is impacted by tested parameters. Emami et al. (2014)agreed and stated that it is important to consider the DF in such a process as an indication of the percentage of diffused daylight blocked by the solar screen rather than CBDM metrics that considers solar radiation.

(e) Such insights put the finding of Kotbi&Ampatzi (2017)in question, who suggested a table for architects to use which indicates how several perforation aspect ratio values impact daylighting performance according to the DAv thresholds. Such a table is only valid when using the CBDM metric and when it is related to a specific spatial configuration.

(f) Several other findings relate to both studies which had the highest number of tested parameters (M. ElBatran& Ismaeel, 2021; Wagdy & Fathy, 2015). These papers addressed the impact of the trade-off between the different values of parameters on daylighting performance. Whereas the higher number of cases may give statistically a better insight for a correlation, the high number of addressed parameters makes the singular impact of each parameter unclear to observe.

6 CONCLUSION

This review of papers aims to observe how the impact of façade solar screen design parameters on daylighting is interpreted in research, and assessing if there is a methodolgy to fnd a statistical correlation between parameters of solar screens and daylighting levels. The topic relevance has been proven throughout the last decade, as an average of one to two papers per year are being published on it in journals or conferences proceedings. The tests in the 21 studies have been conducted on sites in different hot zones with hot climate, which proves awareness of the research community and their interest in the scope of this study.

Although there was only one study that observed and described the correlation between the variation in design parameters and daylighting levels, there is no reliable attempt towards devising a methodology to investigate the statistical correlation between a specific solar screen design parameter and daylighting levels. This failure could be related to the following:

(a) Using metrics that adopt the interferance of solar radiation which impacts the results of diffused daylight.

(b) Introducing no variations in the spatial configuration of test spaces, which renders the results relatingto only one specific spatial configuration.

(c) The combination of a large number of parameters in one study and the testing on other environmnetal aspects which leads to shifting the paper’s aim into creating trade-offs and investigating a number of best-case scenarios.

However, the reviewed papers provide insight about what could be recommended to propose such a methodology in further research work, for example: adopting point in time illuminace values rather than CBDM metrics to exclude the interferance of solar radiation and have a clear judgmnet about the direct impact of solar screens on diffused daylight. Also, considering only one paramater with its variations per study, whereas introducing multiple cases in the test space’s spatial configurations and compare their results to each other, thus any coorelation suggested would not be related to one specific spatial configuration case.

Finally, the reported ease of its modelling and manipulation made the perforated panel the most tested type of solar screen, together with its parameters. This conclusion may denote a lack in covering the reported growing number of screen types and morphologies. This leads to the need of reviewing a pool of international examples to create a catalogue to categorize screen morphologies into families and types with their respective design parameters.

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