Passive design of buildings: A review of configuration features for natural ventilation and daylighting

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Abstract. Passive design involves the utilization of natural forces such as natural ventilation and daylighting without mechanical input of energy, and is a subset of environmentally sustainable design (ESD), which offers solutions for more environmentally friendly buildings. This review is based on the premise that ESD interventions have an inherent cost on building projects. The aim is to review existing research on applications of various building configurations for facilitating the economical application of passive design, in terms of natural ventilation and daylighting. A systematic review of existing research during the previous decade (2010 – 2020) was conducted. In our findings, we compare and categorise concepts within building configuration in terms of their applicability to natural ventilation and daylighting. Our review identified seven categories of building configuration i.e. building geometry, interior, context, envelope, fenestration, building plan and voids, with their associated parameters. It was discovered that building fenestration was the most frequently researched followed by building voids. The identified parameters point to the variety, diversity and trends of research in the field. The knowledge can be used in familiarising, assessing and evaluating various aspects of passive design of building configuration towards energy saving and ESD.

1. Introduction
During the 20th century, energy supply and demand witnessed a paradigm shift, precipitated by the energy crisis of the mid-1900s and a succession of United Nations (UN) initiatives in the late-1900s. Thus, world energy issues garnered even higher attention from the dawn of the new millennium. Building sector is known as a major consumer of energy and contributor of carbon emissions, both globally and locally. Energy efficiency is directly related to carbon emissions that cause global warming and climate change.

The negative impacts of urbanization has given rise to the field of environmentally sustainable design (ESD), that provide counterbalance and relief to the adverse effects caused. ESD offers many solutions for more environmentally friendly buildings, concentrating on passive design methods that utilize natural forces such as natural ventilation and daylighting. It needs to be pointed out that the relative weightage of ESD interventions should be considered, in terms of their potentials for economical application in a building project, to bring benefits over heuristic approaches of ESD interventions on building design. In this regard, building configuration has an important role in determining the actual efficacy of ESD interventions.
In particular, passive design methods such as natural ventilation and daylighting, are the more economical and fundamental types of ESD interventions that are related with building configuration. This paper addresses building configurations for passive design pertaining to natural ventilation and daylighting as the focus areas. The state of the art in current research on these focus areas are reviewed with an intention to identify and explore frequently researched variables in the field.

2. Literature Review

This section presents a broad, general introduction to the concepts and research focus of building features for natural ventilation and daylighting.

2.1 Building features

Firstly, factors affecting building energy performance from the internal and external environment, were categorised into three main groups, namely building characteristics, technologies and equipment as well as occupant behaviours [1]. The interaction of factors was stressed, while aspects of economy and cost-effectiveness was acknowledged to be challenging, especially if without contribution from occupant behaviors [1]. The group of factors known as building characteristics were commended for their importance for energy performance, and the major factors were identified as: building orientation; building shape; building insulation (materials and thickness), window to wall ratio (WWR) and window glazing [1]. Also, the role of the building envelope for thermal comfort and energy performance of high-rise buildings in the tropical climate was examined with reference to components of the roof, external wall, glazing and shading, as well as building orientation and formation [2].

2.2 Natural ventilation

Ventilation is an essential criteria for building habitation, for the removal of pollutants and moisture, as well as the convection of heat [3]. Ventilation occurs naturally as airflow in three known ways: wind driven due to pressure differences, buoyancy driven due to thermal differences, or simultaneously in combination [3]. These two principals have resulted in a range of methods for application in buildings, including: single-sided ventilation; cross ventilation; stack ventilation; vents and rotational ventilators; wind towers and wind catchers; as the primary or traditional types. Newer, solar energy assistive driven types are: solar chimneys; Trombe walls; double-skin facades (DSF); whereas there are larger-scale interventions such as atria [3]. Due to the dependence of natural ventilation on outdoor weather and indoor circumstances, mixed methods utilizing partial mechanical input such as fan-assisted systems were also introduced [3]. The viability of combined types of natural ventilation were discussed and the combination of both wind and buoyancy driven mechanisms was found to be prevalent [3]. Specific attention was given to components of the building façade, including openings, for the purpose of natural ventilation particularly in tropical climates [2]. The most effective features and techniques were identified from a range of heat avoidance, cross ventilation and stack ventilation strategies, in order to support perceived benefits of reduced operation costs, thermal comfort and air quality through natural ventilation [2]. Additionally, a more critical perspective was attempted through concepts such as: natural ventilation potential (NVP), thermal comfort; strategies in ventilating buildings; other passive driven strategies; saving energy; and hybridised systems; quality of indoor air; complementary materials for natural ventilation; as well as building use and operation control [4].

2.3 Daylighting

Daylighting of buildings in urbanised areas has been thoroughly analysed in terms of lighting conditions, lighting physics, visual comfort, illumination standards, simulation software, energy performance, and urban considerations [5]. The utilisation of parametric computational methods to enhance daylighting was explored, through design of elements including louvers, skylight, massing and shading, fenestration, windows, façade and photovoltaics [6]. The “thermal-daylighting balance” describes the rudimentary conflict between daylighting for visual comfort (without glare) and the associated heat gain [7]. The concept of daylight and thermal balancing was defined via aspects such as visual comfort, heat energy balance, views outside or visibility, and material properties [7]. These concepts were related to metrics for thermal and daylighting subcategories of comfort and energy, and the popular metrics include
daylight autonomy (DA), interior illuminance, lighting energy usage, heating/cooling energy usage and demand [7]. The approaches for evaluating and achieving the daylight and thermal balance involved research factors such as: building geometry; climatic locality; building openings; glazing technologies; shading design; and others [7].

2.4 Summary
Natural ventilation and daylighting are passive design methods that may be utilised through features integrated into buildings. The many possibilities presented raises concern over the economic feasibility of implementation. Critical perspectives on the risks, potentials and outcomes of natural ventilation and daylighting further increase the scope of considerations, and cause the economic reliability of such passive design methods to deserve attention. In fact, buildings are long term investments that cannot be easily changed once completed. Therefore, the effects of building features on natural ventilation and daylighting cannot be ignored or overlooked in view of passive design for building energy performance. Given the wide range of building features that influence either natural ventilation, daylighting, or both, it is important to distinguish features in terms of their economical application.

3. Methodology
This paper is developed based on secondary sources of past and existing research. As the aim of this review is to identify economical strategies for improving the performance of passive design, therefore parameters of the building itself is given attention over specialised technology related items. The review seeks to extract knowledge on “building characteristics” [1] that have an effect on natural ventilation or daylighting, or both – either directly or indirectly through building energy performance, referred to in this paper as the building configuration. The step-by-step systematic review process was adopted :-

Stage 1 - Research papers from the decade of 2010 – 2020 were retrieved from the ScienceDirect database, via search strings of “building AND (configuration OR shape OR geometry) AND (natural ventilation OR daylighting)” accessed from 3rd April to 14th May 2021. A total of 652 search results were retrieved, 649 from journal articles, with 3 from book chapters.

Stage 2 - The research papers were screened for inclusion and exclusion for this review, based on information in the titles and keywords. A total of 93 research papers were shortlisted after screening. As mentioned above, specialised technology related items were excluded, such as features for natural ventilation including double-skin façades (DSF), wind-catchers and wind-towers, solar chimneys, Trombe walls and Venturi roofs and phase change materials (PCM). Similarly, excluded features for daylighting were: light redirecting systems, light tracking (heliostats, diffuse sunlight), light transport (light tubes and pipes), dynamic and kinetic facades.

Stage 3 - Following that, the abstracts and articles were briefly evaluated for extraction of knowledge related to the variables of building configuration for natural ventilation and daylighting. One article was removed due to being different publication of the same study. Identified variables from the final selected 92 research papers were categorised within seven strategies as parameters that relate to various aspects of building configuration.

4. Results
The variables were grouped into seven categories of building configuration based on observed commonalities among the reviewed papers :-

- **Building geometry (B1)** - the spatial characteristics of a building in a mathematically abstracted way, usually taken in a broad scale and generalised perspective.
- **Building interior (B2)** - the internal spaces that are occupied and inhabited by people.
Building context (B3) - the external environment based on the property or site surroundings.

Building envelope (B4) - the external shell or fabric of the building, normally associated with surface elements such as walls, roof and floors but also includes integral features such as balconies.

Building fenestration (B5) - the openings and apertures of a building, forming the porous interface of a building between exterior and interior, primarily windows but also includes shading.

Building plan (B6) - the layout and arrangement of circulation and rooms that form the organising structure of the spaces of a building.

Building voids (B7) - the empty spaces within the enclosed boundary of a building’s footprint, usually associated with the absence of enclosing surfaces contiguous to the exterior.

The detailed parameters under the seven types of building configuration categories are presented in Table 1. The most frequently found parameters (by order of frequency) were related to: building fenestration (B5) with 47 articles and building voids (B7) with 31 articles, while the rest of the parameters belonged in building geometry (B1) with 4 articles, building interior (B2) with 17 articles, building context (B3) with 13 articles, building envelope (B4) with 11 articles and building plan (B6) with 12 articles. (Figure 1)

| Strategy       | Parameters                                      | Source          |
|----------------|-------------------------------------------------|-----------------|
| Building geometry (B1) | Flexibility: Perimeter area / Total floor area (NV, DL) | [8]             |
| Building depth and width (NV, DL) |                                          | [59], [55]      |
| Height profile (NV, DL) |                                          | [59], [77]      |
| Building interior (B2) | Room geometry (NV, DL) | [30], [37], [42], [61], [62] , [66], [73], [83], [89] |
| Space type division (DL) |                                         | [8]             |
| Unit size (NV) |                                            | [92], [9]       |
| Unit height and orientation (NV) |                                         | [92], [9], [11] |
| Partitions layout and surface reflectance (DL) |                                         | [12], [86]     |
| Indoor floor planning (NV, DL) |                                         | [33]            |
| Room sizes (NV) |                                            | [78]            |
| Building context (B3) | Building orientation (NV, DL) | [15], [2], [62], [63], [78], [82] |
| Solid sky angle (SSA) (DL) |                                         | [8]             |
| Building orientation and spacing (NV) |                                         | [13], [33], [38] |
| Façade self-shading (DL) |                                         | [63]            |
| Night ventilation (NV) |                                         | [90]            |
| Category                  | Description                                                                 | References     |
|--------------------------|------------------------------------------------------------------------------|----------------|
| Sky view angle           | Terracing, setbacks (DL)                                                     | [30]           |
| Urban aspect ratio       | (UAR) (NV)                                                                   | [55]           |
| Building envelope        | Thermal mass (NV)                                                            | [19], [69]     |
|                          | Balconies on façade (NV)                                                    | [14], [80], [84]|
|                          | Balcony with wing wall (NV)                                                  | [87]           |
|                          | Wind deflection (NV)                                                         | [38]           |
|                          | Roof profile (NV)                                                           | [35], [40]     |
|                          | Wall profile (DL)                                                           | [64], [74]     |
| Building fenestration    | Window to wall ratio (WWR) (DL)                                              | [8], [10], [29], [45], [49], [57], [61], [62], [63], [67], [75], [76], [79], [85] |
|                          | Window to wall ratio (WWR) (NV)                                              | [2], [55]      |
|                          | Window to floor ratio (WFR) (NV, DL)                                         | [8]            |
|                          | Window size (NV, DL)                                                        | [59], [42], [50], [38] |
|                          | Window position (NV)                                                        | [50], [38]     |
|                          | Window orientation (DL)                                                     | [30], [42], [57], [61], [79], [82] |
|                          | Window geometry (DL)                                                        | [45], [49], [66] |
|                          | Window opening type (NV)                                                    | [68]           |
|                          | Window opening area (WOA) (NV)                                               | [55]           |
|                          | Openings shape and position (NV)                                             | [36]           |
|                          | Openings configuration (NV)                                                  | [15]           |
|                          | Asymmetric openings (NV)                                                    | [35]           |
|                          | Skylights (DL)                                                              | [59], [12], [30], [70] |
|                          | Clerestory windows (DL)                                                      | [30]           |
|                          | Light shelf (DL)                                                            | [28], [57], [60], [82] |
|                          | Shading devices (DL)                                                        | [10], [12], [22], [28], [63], [67], [76], [81], [85] |
|                          | Cross ventilation (NV)                                                       | [19], [35], [36], [46], [48], [52], [54], [73], [77] |
|                          | Single-sided ventilation (NV)                                                | [11], [54], [68], [84], [87], [91] |
|                          | Displacement ventilation (NV)                                                | [37], [47]     |
|                          | Stack ventilation: vertical shaft (NV)                                       | [52]           |
| Building plan            | Linear wings (NV)                                                           | [92], [9]      |
|                          | Rectilinear with irregular corners (NV, DL)                                  | [10]           |
|                          | Circular radial (NV)                                                        | [11]           |
| Central clustered (NV) | [13], [15], [53] |
|------------------------|------------------|
| Linear clustered (NV)  | [15], [53]       |
| Tall oval: height-width ratio (HWR) and height-thickness ratio (HTR) (NV) | [58] |
| Corridors: single-sided, double-sided (NV, DL) | [62], [78] |
| Distributed volumes (NV) | [38] |
| Building typologies (DL) | [83] |
| **Building voids** (B7) | **Atrium / building circular cross-section (NV)** | [16] |
| Atrium wall vertical angle (NV) | [16] |
| Atrium enclosure type (DL) | [17] |
| Atrium roof (NV, DL) | [16], [17], [27] |
| Atrium with clerestory windows (DL) | [43] |
| Atria proportions (DL) | [17] |
| Atrium well Index (DL) | [17], [21], [24] |
| Atrium well geometry (NV, DL) | [25], [27], [32] |
| Atrium well façade ratio (DL) | [25] |
| Atrium internal balconies (DL) | [21], [25] |
| Atrium surface reflectance (DL) | [24], [25], [71] |
| Atrium building (NV, DL) | [85], [88] |
| Atrium with night ventilation/purging (NV) | [26] |
| Atrium with buoyancy-driven ventilation (NV) | [31], [32] |
| Courtyard openings (DL) | [20], [72] |
| Courtyard morphology (DL) | [88] |
| Courtyard proportions (NV, DL) | [19], [48], [71], [72] |
| Courtyard building (NV, DL) | [10], [20], [34], [85], [77] |
| Light-well with horizontal voids (NV) | [39] |
| Light-well size, height and orientation (NV, DL) | [12], [18], [56], [65] |
| Light-well roof aperture (DL) | [12], [18] |
| Light-well wall vertical angle (DL) | [18], [56] |
| Air wells (NV) | [23], [2], [51] |
| Double-height space (NV) | [41] |
| Vertical and horizontal “wind-paths” (NV) | [13] |
| Sky view factor (NV) | [19] |
5. Discussion

Based on the results, there were 37 parameters related to natural ventilation (NV), 25 parameters related to daylighting (DL), and also 16 parameters related to both (NV, DL), as shown in Figure 2. The discussion below provides some explanation on the characteristics of the building configuration categories and their relevance to passive design in terms of natural ventilation and daylighting. The comprehensive range of possibilities are reviewed in order to form an outline of the research domain, in view of the review objective of seeking economical approaches to passive design.

![Figure 1: Frequency of parameters in each category based on articles](image1)

![Figure 2: Parameters for natural ventilation, and daylighting and both in each category](image2)
5.1 Building geometry (B1)
Building geometry (B1) involves the building’s perimeter area, building depth and width, and height profile. Perimeter area is defined as a particular interior zone adjacent to the building façade, and thus able to interface with the exterior environment for on-site renewable resources, such as daylight and airflow [8]. This metric was used to indicate the flexibility of a given floor area for alternatives to active electrical usage and consumption [8]. It indirectly shows the proportion of floor area that is not at the perimeter, i.e. Located deeper inside the building, which entails a higher degree of servicing and conditioning [8]. Next, aspect ratio or (building width / depth), was found to have a noticeable effect for daylighting and overall energy use under different climatic conditions, with larger aspect ratio preferred for hotter climates, and vice versa [59]. Similarly, building aspect ratio was among the variables for assessing thermal and visual comfort in buildings with natural ventilation [55]. The height profile, based on the highest point in the building at the roof ridge, had a small negative effect for daylighting, and a larger negative effect for overall energy use, particularly in a colder climate [59]. However, the height profile as defined by relative height of rooms, was found to be suitable for inducing buoyancy-driven stack ventilation [77].

5.2 Building interior (B2)
Building interior (B2) parameters include room geometry parameters as the leading concepts. Room geometry as defined by room depth for a given height is well-established and relied on for its inversely proportional relationship to side-lit daylighting [30], [61], [62]. Furthermore, height and depth of rooms were found to contribute beneficially to single-sided and cross ventilation [73]. A variety of room width-to-depth ratios were also tested for daylighting and thermal performance [42]. However, no noticeable differences between square and rectangular room geometries were present in a basic comparison [66]. Free-form room geometries was explored in relation to their effect on influencing indoor airflows [37]. Many attributes of room geometry were evaluated for daylighting, including room depth and width, floor area, glazing area and glazing to floor and to wall ratios [83]. The vertical inclination angles of walls were found to have a substantial influence on daylighting and thermal performance [89]. Additionally, different room sizes were investigated for the effect on natural ventilation of spaces [78]. Moreover, it was found that the distribution of units in a high-rise residential building, affects the natural ventilation performance of individual units based on their height positions, orientations and sizes [92], [9], [11]. The space type division was parameterized for daylighting as the division of office space into modules differentiated by varied sizes, their horizontal positions in floor plan (corner, middle, etc.) and vertical locations in each storey [8]. The interactions between indoor space planning with improved daylighting performance and natural ventilation were studied in a paper [33]. Finally, the interior partitions layout and surface reflectances, were shown to affect daylighting performance of spaces [12], [86].

5.3 Building context (B3)
Building orientation and spacing were the major parameters compared to the rest. In general, the site orientation of buildings with respect to the N-S-E-W directions etc, and the distance between buildings sharing the same site had effects for natural ventilation [13], [15], [33], [38], [2] as well as for daylighting [62], [82]. For example, the building orientation was varied according to the prevailing wind direction in a study [78]. Also, building orientation was an important factor for shading devices on facades, taking into account daylighting [63]. Façade self-shading, through the use of vertically inclined façade walls, was a factor that was examined for solar control in buildings with daylighting taken into consideration [63]. The solid sky angle (SSA) is calculated from the building height, and shape, height of surrounding buildings, as well as their separated distance and topography [8]. This metric describes the building environment and the sky hemisphere visible from a vertical window, for daylighting application [8]. Also, night ventilation was assessed as a strategy for natural ventilation [90]. An urban aspect ratio (UAR) was applied as a function of building height and the street separation distance to opposite buildings in addition to varying building dimensions, for the purpose of assessing natural ventilation based on thermal and visual comfort [55]. The sky view angle represents the angle subtended
by the window and the closest edge of adjacent buildings, determines the relative area of sky visible from a window, and may be improved for daylighting with property setbacks and terraced facades [30].

5.4 Building envelope (B4)

Parameters for building envelope (B4) were balconies on façade, wing wall, wall profile, roof profile, wind deflection, and thermal mass. Four critical features of balconies that affect natural ventilation performance are: availability, location of unit level, depth and orientation of balconies [80]. Balcony geometry was investigated [84] and the airflow effects were compared with buildings without balconies [14]. The addition of wing walls to balconies was studied to improve single-sided ventilation of medium-rise residential units [87]. The use of deflecting devices was mentioned for improving the distribution of airflow at positions lacking ventilation [38]. Wall profile as defined by offsets, or undulations in the building envelope were investigated for their obstruction to daylighting, as exacerbated by balconies [64]. Also, aesthetic façade designs with undulating wall profiles were optimised for daylighting [74]. The roof inclination angle of an isolated space was shown to affect the wind-driven cross ventilation performance of vertically asymmetric wall openings [35]. A variety of roof geometries, such as straight, convex, concave and hybrid types were tested for a building with cross ventilation, using a saw-tooth shaped roof on the leeward side [40]. A paper indicated that the use of thermal mass had a pronounced cooling effect, that could complement the lack of cross ventilation in deep plan, courtyard buildings [19]. Another study showed that thermal mass moderated the internal temperature fluctuations in both summer and winter conditions, and that this could enhance thermal comfort in the latter climatic condition [69].

5.5 Building fenestration (B5)

The most frequent parameter in this category is window to wall ratio (WWR), that is the ratio of glazing area to wall area of the building’s façade, or part thereof. The effect of window to wall ratio on energy use and savings in terms of lighting and thermal performance is well-documented. Varied WWR specific to a particular building orientation were shown to influence daylighting and energy use [8], [10], [29], [45], [49], [61], [62], [63], [67], [76], [79]. The importance of sunshading to reduce solar heat gain was considered [76], as well as the inclusion of courtyards [10], [76]. Also, this was balanced with consideration of natural cross-ventilation performance in one paper [55]. Furthermore, a paper also examined window to floor ratio (WFR), measured by the glazed area and floor area, as well as the façade area in relation to floor area, that showed a compounded effect due to compactness on energy use for a given WWR [8]. Moreover, a paper noted the contribution of WWR to effective cross-ventilation in buildings [2]. Parametric variations of façade patterns were varied while maintaining the same WWR, to study the effect on daylighting performance [75]. The next most frequent parameters were window-related variables, cross-ventilation and shading devices. Parameters related to windows were examined for their effect on daylighting and thermal performance, such as their size, geometry, and orientation [59], [30], [42], [45], [49], [61], [66], [79]. Additionally, window performance for natural ventilation was also considered separately from daylighting [38], [50] or as part of the holistic system as based on the window opening area (WOA) [55]. A variety of window opening types were tested for buoyancy-driven, single-sided ventilation performance [59], [68]. The visual comfort in terms of avoiding glare from daylighting was also highlighted [57]. Cross ventilation is a common technique whereby windows or openings are placed on opposing sides of an enclosed space, and this was studied extensively [35], [36], [46], [52], [54], [77]. Cross ventilation was also considered for buildings with courtyards [19], [48], and for its role in buildings with a solar chimney [73]. Shading devices such as static exterior projections and overhangs [10], [22], [28], [67], [76]. awnings, internal blinds, roller screens [12], complex geometries [63], and louvered slats [81]. The use of shading devices was also studied for daylighting and thermal performance of courtyard and atrium buildings [85]. Single-sided ventilation involves the use of windows or openings on the wall of only one side of an enclosed space, and was studied for its influence on thermal comfort in buildings [11], [54]. Single-sided ventilation driven by thermal buoyancy was investigated for a variety of window opening types [59], [68]. Also, the separation between two apertures in single-sided ventilation coupled with the angle of incoming wind affected the ventilation rate relative to wind velocity and aperture size [91]. Additionally, single-sided ventilation
performance were examined in conjunction with building envelope features, such as balcony geometry [84] and balcony with wing walls [87]. Door openings were included for analysis of natural ventilation in high-rise residential units [15], while wall openings were included for analysis of inter-connected spaces [36]. Displacement ventilation, referring to airflow from lower to higher elevations in an enclosed space, was explored using low windward and high leeward openings [37], and in conjunction with various specialised technologies [47]. Stack ventilation using vertical shaft was included in a study on natural ventilation performance of office buildings [52]. A detailed examination of vertically asymmetrical openings was done in conjunction with inclined roof profile for cross ventilation [35]. Skylights have been shown to be effective for daylighting especially in deeper floor plans, provided with adequate sizing and arrangement [59], [30] or may be combined with light-wells or internal floor voids for multi-storey buildings [12], [70]. Similarly, clerestory windows which are above eye-level glazed areas on walls, are able to improve daylighting performance [30]. The light shelf is an extended projection at openings used to improve daylight distribution into an enclosed space, and was compared with other daylighting systems such as: sun breaker, external louvers and internal blinds or in combination thereof [82]. A building with light shelves was appraised for daylight performance and visual comfort [57]. Furthermore, a light shelf was designed with louvered slats was explored to reduce the cooling load [28], or attached with photovoltaic solar modules to explore power generation [60].

5.6 Building plan (B6)
The parameters in this category are based on the various types of spatial organisations. Buildings with linear wings of corridors projecting radially from a centre were examined for their potential to achieve energy savings through natural ventilation, albeit with careful avoidance of solar heat gains [92], [9]. Rectilinear building plans with projecting corners of varying complexity, and also internal courtyards were simulated for daylighting, natural ventilation and solar control for optimal energy efficiency [10]. A circular radial plan layout for a high-rise residential building, whereby each unit was facing each of eight directions, was analysed for thermal performance through single-sided ventilation, with variegated results [11]. A central clustered plan layout is arranged in a square grid around a centre, and was involved in the investigation of natural ventilation for high-rise residential buildings [13], as well as a variant with concave corners resulting in a cruciform shape [15]. A linear clustered plan layout, spread out along a directional axis, was utilised for investigation on natural ventilation [15]. The central clustered type was compared to the linear clustered type, with the latter essentially having better performance for natural ventilation [53]. A range of generalised building typologies assessed for daylighting, were described as A to Z patterns, included plan layouts that were bent into U, L or O shapes to form outdoor yards and courts [83]. Smaller, distributed building volumes were recommended to enable airflow between each building for natural ventilation [38]. In an investigation on high-rise buildings with oval shaped floor plans, height-thickness ratio (HTR) and height-width ratio (HWR) were examined for wind pressure effects on building surfaces [58]. Finally, plan layouts with single-sided and double-sided corridors were examined for daylighting and thermal performance [62], and also for wind-driven ventilation [78].

5.7 Building voids (B7)
Parameters in this category are commonly related to atria, courtyards, and lightwells. The buoyancy-driven ventilation in atria was investigated for thermal performance in buildings [31], [32]. In contrast, the airflow of wind-induced natural ventilation in a building with a patio, or central courtyard was studied in detail [34]. Night purge ventilation was studied for an atrium to investigate the displacement ventilation of heated air into the cool, still night environment [26]. Various effects of atrium characteristics were examined, such as the vertical angle of atrium walls on natural ventilation and thermal performance [16], and also using the case of a circular atrium cross section with glazed roof instead of opaque roof [16], as well as using rectilinear cross section with various atrium roof types [27]. Comparatively, daylight performance was examined for various types of atrium enclosures, atrium apertures such as skylight and monitors, and well index as defined by geometric proportions of the atrium [17]. Clerestory windows were explored for their effects on daylighting based on the atrium geometry [43]. Similarly, well index was tested for daylighting performance with consideration of
internal balconies or corridors in the atrium [21], and the consideration of light reflecting surfaces on the atrium internal walls [24], [71]. Also, light reflectance of internal balcony walls were examined for daylighting, with consideration of well geometry as defined by aspect ratios of the atrium plan and section, compared with atrium façade conditions without balconies and with adjoining room partitions [25]. Additionally, well geometry of atriums affected the natural ventilation and thermal performance of atria through the atrium size, height, width and depth [27], [32]. Finally, atrium buildings were examined for the benefits of atria in terms of combined daylighting and overall thermal performance from natural ventilation [88], as well as compared with courtyard buildings [85].

Courtyard buildings with windows facing inside were compared with conventional buildings [20], or inserted into irregularly shaped buildings [10] to examine daylighting and energy performance. Also, courtyards were combined with solar chimneys for natural ventilation and thermal performance [77]. The effect of courtyard proportions were examined for natural ventilation and thermal performance, with consideration of the courtyard height to width ratio [48] and geometrical relationships to adjoining spaces [19]. Comparatively, daylighting and energy performance was investigated with consideration of the courtyard aspect ratio, as well as the ratio of openings in the courtyard [72]. The contribution of courtyard for daylighting was affected by surface reflectance of internal walls [71]. Three types of courtyard morphology was examined for daylighting and thermal performance, including dual, triad and quadrangle enclosures [88]. The sky view factor (SVF), estimated using equisolid-angle projection lens, was found to be a major determinant of air temperatures in courtyards for natural ventilation [19]. The use of light-wells as floor openings to enable the transmission and distribution of daylight was coupled with skylights [12] or variations thereof [18]. The geometrical characteristics of light-wells were examined for daylighting and energy performance in terms of size only [12], or in combination with height, orientation and wall vertical angle [18], [56]. The size, height and orientation of light-wells are also important for the stack effect application of natural ventilation, in addition to daylighting [65]. The application of horizontal voids connected to light-wells was explored for buoyancy-driven natural ventilation, based on exterior wind directions [39]. Horizontal “wind paths” were explored for a high-rise residential building to enable the passage of airflow for natural ventilation [13]. Air-wells are vertically continuous voids used for buoyancy-driven natural ventilation, such as carrying airflow from individual units in a residential high-rise building [51], and was associated with the operation of vertical airflow channels such as wind towers or wind catchers [23], [2]. Similarly, double-height spaces were explored for buoyancy-driven natural ventilation through the stack effect of warmer air rising and displacement ventilation with incoming cool air [41].

6. Conclusion
This paper focused primarily on critical and strategic decisions concerning architectural and building design, and less on specialised technologies and ongoing innovations at the element-scale. The fact is that buildings are relatively permanent structures and difficult to modify once constructed. While the proliferation of options affords many possibilities, we must not overlook the more fundamental issues of building configuration and their role in providing economical, passive design towards realising the goals of energy efficiency and sustainable development. This review has outlined the range of parameters related to building configuration for passive design. It is acknowledged that the parameters identified were based on the terms and concepts from existing research, which could involve various levels of complexity, considerations and combination of factors. However, the identified parameters point to the variety, diversity and trends of research in the field. Our results should not be taken to indicate the importance of one over others but such knowledge can be used in familiarising, assessing and evaluating various aspects of passive design of building configuration towards energy saving and ESD.
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