A Typological Approach to Daylighting Analysis

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ABSTRACT: A typological approach to daylighting has been an unconscious feature of past daylighting research with the production of daylight performance diagrams and graphs in a manner similar to traditional typological exercises, such as Ruskin’s categorical analysis of architectural elements. The main objective of this paper is to highlight this latent connection between daylight design study and typological analysis and provide a validation method. The paper builds on recent work by Baker and Steemer and proposes that daylighting rules of thumb can be effectively studied by means of a typological approach. As a result, some of the inconsistencies in current daylighting rules found in architectural literature can be explained, promoting improved application in design.

Keywords: daylighting, typology, rule of thumb

INTRODUCTION

Daylighting analysis, with some justification, can be seen as an area which is highly technical and thus requiring individuals to have a good mastery of both physics and mathematics. A survey of approximately 200 architectural practices in New South Wales between 2000 and 2001 indicated that most architects rely upon simplified daylighting principles obtained from books, magazines and experience. Most of these practitioners avoided complex calculation and utilised empirical, common-sense knowledge in daylighting based on simple rules of thumb. The problem with this approach is that these principles can only be considered accurate within specific design boundaries. In other words, these rules are associated specifically to a combination of underlying type of space, dimensional limits and contextual conditions. However, they are assumed to be more generic (Nik Ibrahim 2002).

An alternate design guide approach is in the use of a typology of forms. Architects in the past, for example in late eighteenth century Australia, relied upon pattern books or design encyclopaedias to supplement their technical knowledge and allow them to create entire buildings. These sources provided typologies of precedents as design guides (Ostwald & Williams 2008) and have continued to provide assistance in architectural design, including daylighting. A number of daylighting researchers, e.g. Daniels (2003), have unconsciously used typological systems in their studies but others have used a more formal approach. Baker, Fanchiotti and Steemers (1993), for example, took this approach to provide a systematic guide to daylight design by devising their own typological system. Underlying any successful typological system in daylighting is a working set of physical rules and, consequently, typologies are a form of rules of thumb. This paper describes how these computational rules can be revealed by formal analysis of daylighting typologies.

1. TYPOLOGY AS AN ANALYSIS TOOL

Typology comes from the English word ‘type’ which in the Cambridge International Dictionary of English is defined as ‘a particular group of people or things which shares similar characteristics and forms a smaller division of a larger set’ (Procter et. al. 1995). ‘Type’ in this sense is associated with categorisation based on similarity of traits or characteristics. McHenry (1992) describes it in more detail as:

…a system of groupings, usually called types, the members of which are identified by postulating specified attributes that are mutually exclusive and collectively exhaustive - groupings set up to aid demonstration or inquiry by establishing a limited relationship among phenomena. A type may represent one kind of attribute or several and need include only those features that are significant for the problem at hand.” (P.89).

Wojtowicz and Fawcett used this definition to differentiate typology from classification by emphasising the former’s role as a system of grouping of types to aid demonstration, or investigation, by establishing a limited relationship among phenomena. Typology thus involves examination of particular aspects of objects in question while classification is seen as a method related to the problem of order (Wojtowicz & Fawcett 1986). A typological analysis which exemplifies this approach can be seen in Ruskin’s examination of column bases (Figure 1) in his book, The Stones of Venice (1907). The analysis involved proportional examination of the spurs on column bases and was demonstrated by drawing quadrants of the bases within equal size squares regardless of the bases actual dimension (Ruskin 1907). This typology, therefore, is a system of grouping to aid examination of a single variable aspect of the columns.
Teymur (1982) argues that typology is, further, the counterpart of classification. Whereas, classification produces classes of reductive and generalised objects, typologies group objects of similar properties according to a criterion that is specified in the problem defined by the inquirer. Typologies, therefore, are tools which allow analytical studies, including experimental and scientific ones, of specialised objects and serve as a comparative framework for recognising similarities between otherwise diverse variations (Teymur 1982).

Typological decomposition abstracts particular features from a set of, say, building types which could be generalised and compared in a standardised way (Schneekloth & Franck 1994). Such a comparative scheme was adopted by Durand in his 1801 Recueil et Parallèle des édifices de tout genre anciens et modernes (Compendium and Parallel of Ancient and Modern Buildings) (Steadman 1979) in which the plans of different historical buildings were drawn to the same scale and arranged like natural history specimens. The book, comprised of ninety two plates, could be used to compare particular buildings with the same functional program by their plans, elevations and cross sections (Heylighen & Verstijnen 2003). In this way, only particular aspects of the variations were examined at a time.

2. INFORMAL TYPOLOGICAL SYSTEMS IN DAYLIGHTING RESEARCH

A similar method of typological analysis has been frequently applied unconsciously in daylighting research. For example, comparisons of daylight distributions and levels inside rooms with different openings of identical size are common (Fig. 2). The typological comparison of different apertures in terms of daylighting performance is made possible by keeping constant window and floor area across all other variables.

Such an approach has also been used by Diepens, Bakker, and Zonneveldt (2000) at the TNO-TUE Centre for Building Research to study the daylighting performance of different aperture designs using Radiance software (Fig. 3). Typological frames are implied by the restriction of the room to a typical office space configuration of 3.6 m width,
5.4 m depth and 2.7 m height, 10% window area to floor area ratio and 'standard' surface reflectances of 0.7 for walls, 0.8 for ceiling and 0.2 for floor (Diepens, Bakker & Zonneveldt 2000). Another example of this typological approach in daylighting (Fig. 4) are the simulations conducted by Hastings and Junghans, again using Radiance, for a reference room, 3 m width, 5 m depth and 2.5 m height with a 20% window to floor area with different window configurations (Hastings & Wall 2007).

There are other instances, beyond the examples shown, which demonstrate the application of typological systems in daylighting. In most cases the researchers do not claim any consideration of typology in their work, perhaps being unaware of its existence.
3. A TYPOLOGICAL APPROACH TO THE STUDY OF DAYLIGHT

Baker, Fanchiotti and Steemers (1993) developed a ‘morphological box’ for the decomposition of daylit buildings, in a similar manner as Durand, which recognizes the interdependence of various elements contributing to daylighting performance which occur at room, building and site levels (Fig. 5). The typological classification, therefore, acknowledges correlations between elements at different levels and shares a similarity with Cuvier’s classification (1798) in its awareness of the complete functional system (Baker et. al.1993).

Following this study and the basic canons of architectural typology, three typological approaches can be considered for daylighting studies:

i) Decomposition into basic schemes and elements
Decomposition is a canonical approach to architectural typology such as proposed by Durand and many others after him (Steadman 1979). Factors influencing daylighting performance can be broken down into individual units such as room depth, floor area, ceiling height, window head height, surface reflectance, etc. These units are studied separately in individual typological series given a specific range of variables. In the simulation experiments carried out by Nik Ibrahim (2002, 2009), two levels of typological series were addressed. The first, an internal typological series, involves individual room parameters such as window size, window head height, floor area, ceiling height, and interior surface reflectance, whilst the second, an external typological series, is concerned with exterior influences such as external obstructions, ground plane reflectance, sky conditions and latitude angles.

ii) Morphological progressions and transformations
Steadman (1981), borrowing from Goethe, proposed that a morphology is “a general science of possible forms”. Each typological series consists of variables which represent gradual progressions, or transformations, from an initial state or basic schema. The transformations involve dimensional and characteristic changes (such as increasing floor depth, ceiling height, surface reflectance, etc.) as well as contextual changes (such as latitude variations, etc.). The transformations within each typological series are not simply differentiations but involves some constant property, or what Steadman terms as ‘topological similitude’, which connects all variables together.

iii) Specific aspect or specialised comparison
A typological system has been highlighted above as different from mere classification and is a method of grouping to aid investigation by establishing a limited relationship among phenomena (Wojtowicz and Fawcett 1986) as used by Ruskin (1907) in his analysis of architectural elements. Therefore, in order to engage in a typological analysis, only one aspect of a set of variables is examined and compared. When a specified parameter is studied, others are kept as constants. In other words, typological frames are implied in standard scientific practice.
4. ESTABLISHING PARAMETERS FOR DAYLIGHTING TYPOLOGIES

Daylighting typologies can be organised into two series at either interior or exterior levels. Each typological series contains a parametric framework of variables with a the core taken as the ‘room’, rather than the ‘building’, as it is the main object of internal daylighting analysis. Taking the definition from Baker, Fanchiotti and Steemers (1993), a room consists of a set of planes forming the floor, walls with apertures and ceiling. The planes composing a room become ‘parameters’ of the typological series at the interior level and the various possibilities for floor, walls, windows, doors and junctions are the room’s ‘variants’. The external level involves contextual parameters concerned with the location of the room within the site. These typological levels are shown in Fig. 6 and Fig. 7 with only basic daylighting parameters to avoid unnecessary complexity in this discussion.

![Diagram of 1st Level Typologies](source)

**Figure 6: First level typologies**

![Diagram of 2nd Level Typologies](source)

**Figure 7: Second level typologies**

5. EXPLORING RULES OF THUMB WITH DAYLIGHTING TYPOLOGIES

Rules of thumb have been regarded by some authors as a form of knowledge which is devoid of any theoretical reasoning and is therefore unreliable (Stevens 1988). By adapting a typological approach to analysing rules of thumb in daylighting, this misconception can be dispelled. By means of the typological system, daylighting rule of thumbs can be scientifically framed, examined and their limitations tested. This potential has been explored extensively in previous work from an unconscious use of typology related to internal variables (Nik Ibrahim 2002) to a formal typological approach with variations in external obstructions (Nik Ibrahim et. al. 2008) and latitude angles (Nik Ibrahim et. al. 2009). In the latter studies, two broad typologies were analysed and new daylighting rule of thumbs for the respective typologies were generated. Each typological group consisted of only one or two variables simulated by means of a lighting software AGI-32. Typical outcomes, shown in Fig. 8, demonstrate several internal and external typological series assigned to resulting daylighting rule of thumbs. What is also of interest is the implied ‘meta-rule’ of thumbs (DF$_{avg}$ ≈ 0.35 A$_g$/A$_f$ and DF$_{avg}$ ≈ 0.35 A$_g$/A$_f$ $\theta$) that can be inferred across the series shown which could be formulated with associated confidence intervals given the size of the sample used. Future work will extend across typological series to embrace such ‘collective’ or ‘generic’ daylighting rules of thumb.

In addition, daylighting simulations performed on these room and environmental series have made possible the identification of daylighting rule of thumbs’ parametric limitations based upon typologies (Nik Ibrahim 2009).
INTERNAL / ROOM LEVEL TYPOLOGICAL SERIES:

\[
\text{DF}_{avg} = 30 \left( \frac{A_g}{A_f} \right) \%
\]

\[
\text{DF}_{avg} = 25 \left( \frac{A_g}{A_f} \right) \%
\]

\[
\text{DF}_{avg} = 35 \left( \frac{A_g}{A_f} \right) \%
\]

\[
\text{DF}_{avg} = 28 \left( \frac{A_g}{A_f} \right) \%
\]

EXTERNAL LEVEL TYPOLOGICAL SERIES:

\[
\text{DF}_{avg} = 0.4 \left( \frac{A_g}{A_f} \right) \theta\%
\]

\[
\text{DF}_{avg} = 0.3 \left( \frac{A_g}{A_f} \right) \theta\%
\]

\[
\text{DF}_{avg} = 0.4 \left( \frac{A_g}{A_f} \right) \theta\%
\]

\[
\text{DF}_{avg} = 0.35 \left( \frac{A_g}{A_f} \right) \theta\%
\]

DF$_{avg}$ - average Daylight Factor, $A_g$ - area of window glazing, $A_f$ - area of floor, $\theta$ - angle of obstruction (in degrees)

Source: (Nik Ibrahim 2009)

Figure 8: Typological series and their respective rules of thumb

CONCLUSION

This paper expounds the idea that typological systems have often been used unconsciously in daylighting research. This insight provides an opportunity of relating daylighting studies to the architectural method of typological series. Two broad daylighting typologies, internal and external, have been defined and their constituent elements and associated parameters outlined. This concept of typology has also become the basis for the hypothesis that daylighting rules of thumb are applicable within certain typological frameworks or boundaries. Several typological series are used as examples to define daylighting rules of thumb based upon associated parameters. Thus, by means of a traditional approach to architectural typology, daylighting research and its application can find its place within mainstream architectural culture.
REFERENCES


