A preliminary-design aid for daylight access to atrium or courtyard

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ABSTRACT: Light courts and atria in commercial and industrial buildings are frequently being designed with the intention of offering distant rest points for the worker’s eye. More and more buildings are knit into the little green spaces of an already compactly built city. How confined may a still effectively daylit atrium be planned? Designers decide on an atrium or patio in a very early phase of the design process. This paper will propose a design tool (PAR) leaving ample freedom for building and urban design. The Patio Aspect Ratio (PAR) is a minimum ratio of the horizontal ‘open sky area’ to the square of the building height surrounding the courtyard.

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INTRODUCTION

A major factor in the attractiveness of an atrium is the extent to which it is daylit, sunlit or in shade. People want to have the impression that an atrium is like a courtyard, outdoors. Therefore the level of illumination, more importantly the brightness of that ‘outdoors’, must exceed that of indoors in the daytime.

From an energetic point of view use of daylight in an atrium-adjoining space could potentially save energy of its artificial lighting. However, this will demand far larger ‘amounts’ of natural light admitted to the atrium than would be necessary for a pleasing brightness of that atrium. So as to the choice for the minimum brightness of an atrium or courtyard it is important to make a distinction between amenity and energy conservation.

COMPACT CITY

Light courts and atria in buildings are frequently being designed with a view to offering distant rest points for the human’s eye. More and more buildings are knit into the little green spaces of the already compactly built city. What size of ‘open sky’ will allow daylight still effectively entering an atrium or courtyard? A designer decides on an atrium or patio in a very early phase of his design. Such a choice should be supported by a design aid that adequately predicts a minimum admission and distribution of daylight throughout the atrium.

The brightness of an atrium depends on quite a few variables, such as the luminance distribution of the sky, the proportion of glazing and the reflectivity of internal surfaces and floor, and last but not least the shape and size of the atrium. Not until the last decade of the 20th century these topics have been investigated mainly with use of scale models under real or artificial skies. [1].

In the early phase of a design process the reflectance of the courtyard facade is usually not yet a question, and what’s more, its influence on the illuminance of the facade is often negligible [2]. So the intended design aid may focus on the direct illumination of the patio walls. Then the question of what luminance distribution of the sky should be taken. This decision will depend on the prevailing weather conditions (sunny, overcast) of the region (e.g. latitude) the design aid is meant for, and other things as accuracy, user-friendliness.

PATIO ASPECT RATIO

In a study for the daylight paragraph in the building and occupational health code in The Netherlands diagrams have been developed for the sky factor in patios and at recessed facades [3]. For the sake of simplicity, and since the CIE-overcast sky is a hardly occurring worst-case approximation [4], the luminance distribution of the sky vault has been taken isotropic.

Figure 1 will show the sky factor at a point of the wall in a corner of the patio as a function of the ‘Patio Aspect Ratio’ (PAR). The sky factor represents the illuminance at the reference plane relative to the illuminance due to an unobstructed, isotropic sky. The PAR has been defined as the ratio of the horizontal free-sky-area of the court to the square of its height. As shown in the diagram PAR is not an unambiguous variable. The sky factor in a point of the wall depends also on the length to width ratio of the court floor (better: open-sky-area).
DESIGN RULE FOR COURTYARD

From figure 1 a simple architectural method with regard to daylighting that will offer ample preliminary-design options for courtyard and atrium geometry can be deduced. Starting point is a just acceptable mean sky factor at the facades of the courtyard. Some evidence for the lower limit of the sky factor can be found in literature. That is, people will have a reasonable impression of a ‘daylit space’ as from a two percent sky factor. Therefore the lower limit for PAR in a courtyard has been rated at 0.44.

DESIGN RULE FOR ATRIUM

If the roof of an atrium is mainly transparent it could be considered as a courtyard with reduced access of daylight. Then figure 1 is still appropriate for determining the sky factor at the inner atrium facades. The obstruction of the daylight by the construction of the roof has been taken into account by a reduction factor of 0.7. The corresponding lower limit of the ‘atrium PAR’ is 0.64. In figure 2 this has been translated to an atrium design rule. A square atrium that is potentially pleasantly bright in daytime has no obstruction-height-to-spacing ratio of more than 1.25:1 (obstruction angle about 51°). The square ‘open sky area’ may be stretched to a length-width ratio of 4.1 (maximum obstruction angles in the direction of width and length about 68° and 32° respectively).

BRIGHTNESS

The design rules for open spaces between buildings that serve as points of rest for people’s eye, safeguard a minimum of natural illumination in those spaces. However it is not the illuminance to which the human eye adapts but the brightness of major parts of the courtyard’s facades. This brightness depends on illumination and reflectivity of surfaces. So the designer should include in his atrium or courtyard design sufficiently bright building parts that the building occupants can perceive and adapt to.

CONCLUSION

The Patio Aspect Ratio or the graphical equivalent is an easy to use design tool. For instance, a designer who considers making a vertiginous atrium in the middle of the redevelopment of an old building (42 x 32 x 48 m³) could at once conclude that a state-of-the-art full-height atrium would “fill” even more than the whole building. Many time-consuming scale-model studies and/or computer simulations will not be required any more in this early stage of the design process.

REFERENCES

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