LINEAR LIGHTING IN ARCHITECTURAL INTERIOR AND EXTERIOR DESIGN: CURRENT TREND OR A FUTURE?

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Abstract. Contemporary LED technology in lighting industry allows today for almost endless design opportunities in architecture. Since 2000 the LED strip lighting became available on the lighting equipment market and slowly became affordable as the typical light source (bulbs) or linear light source (neon bulbs). Today it is implemented everywhere around the globe in exterior and interior design. Technological solutions are even more portable / easy-fixed and take less space and so linear lighting is not extraordinary or exceptional anymore. Although the linear lighting became very common since ca 10 years it have been used in interior or exterior design before but had some limits due to the technological reasons or have been implemented in another way. Design Lighting typology for interior and exterior design has been presented in the article along with several case studies that have been implemented. Limits and obstacles, advantages and disadvantages of the linear lighting have been discussed. Conclusions might be helpful for architects, interior designers, artists and light industry specialists. The author is a practicing architect with over ten years of experience in architectural and interior design with many implemented projects.

1. Introduction

This paper shows results of the research on linear lighting in architecture and interior design. The research on contemporary literature showed that there are very few publications that focus on lighting design and linear lighting design aesthetics. As Skarlatou states, unfortunately, lighting design does not have the historical background of architecture to try and originate theoretical material, since it starts having a serious presence from the 1920s and onwards with the archaic period being at the end of the 19th century [1].

With the know-how of contemporary technology, the term architectural lighting seems to be one that expresses the mainstream subject of research. Zielinska-Dabkowska and Dugar Amardeep define architectural lighting as a field within architecture, interior design and electrical engineering that is concerned with the design of lighting systems – daylight, electriclight, or both – to serve human needs[2].

Linear lighting is not a phenomenon: it has been used in architecture since ages. We can presume that narrow windows in Roman architecture and later on the narrow vertical gothic windows. Chartres cathedral from theXIIIth century is a classic example. Also, Le Corbusier's Ronchamp chapel from the
XXth century can be presumed as an experiment with light. This case study shows that linear lighting can be achieved in interior design also by daylight. A long horizontal line can be observed inside the Le Corbusier's chapel as it visually 'cuts off' the ceiling and makes it looks like rising in the air. In Ronchamp, light is contained and used controllably, in creating a deep mystical experience: an atmosphere of shadows and midst’s highlighted by a poetical and metaphorical contained use of light [3]. All examples above and much more have been designed and realized with no concept for electric lighting. Gyourkovich argues that depending on detailed function, the daylight in cultural facilities can be more or less useful. Actually, it can be successfully replaced by current technologies with the artificial light [4].

The best-known and acknowledged theoretical input of Richard Kelly is the classification of three types of light impact: a) the focal glow, b) the ambient luminance, and c) play of brilliants [1]. The author argues that contemporary common light sources allow for more than the Kelly’s classification. Typical light sources for linear lighting are: longitudinal luminaries - longitudinal light fittings, LED strip lighting or other systems that allow shaping the light source as a line. The other systems can be LED modules as light source with a cover of any type. All mentioned above types of light impact have been illustrated in Figure 1. The first neon light source with its characteristic longitudinal shape has been invented in 1910 by George Claude, and we can assume that its idea has been vital until the end of the XX century. The real revolution in lighting has been brought by LED lights which have been more common in use since the XXI century. The LED power (luminescent) and durability are the main reasons for its success. et al state that LED lights advantages are photometric properties consisting in the emission of light only in the lower half-space cause that almost the entire stream emitted by the LED lamp becomes a useful stream the additional advantage is exceptional durability reaching even 50-60 thousand hours and energy efficiency [5]. Also, its small scale shows great potential for making LED modules and LED stripes. The small source of light (LED diodes of high power) mounted close one to each other on specific band became a universal, affordable and very effective light source used with other various light fittings.

Coles and House argue that it is the designer can create the most eloquent space, crafted in exquisite detail using the finest materials in the most gorgeous colors, but, without light, he or she has wasted time, effort and money. Light and the effects of light are key to the enjoyment and functional success of spaces [6].

2. The contemporary linear lighting in architectural exterior design
As the classic examples of exterior and also interior design concept that bases on lighting are two museums: The Jewish Museum in Berlin – Daniel Libeskind 1998, the POLIN Museum of the History of Polish Jews by Lahdelma&Mahlamäki + Kuryłowicz& Associates, Warsaw 2013. Petelenz argues
that In the case of these types of works, much of the emotion is elicited by expressive light and shade effects, which support the dramatic tension that accompanies Daniel Libeskind’s entire oeuvre[7]. In both case studies linear lighting performs as a tool that strengthen sand makes the space narrative, and also helps in orientation. The facade of Jewish Museum in Berlin attracts attention with long diagonal gaps that provide natural daylight. Linear lighting is also used as wayfinding help in interiors with the use of architectural lighting. Architectural lighting opportunities for the exterior are getting more and more efficient nowadays. Also, the affordability of LED stripes enables to bring a linear design to facades and an urban landscape that is very often connected with buildings’ exterior aesthetics. The author discusses several case studies which were designed and implemented in a professional architectural carrier. Personal experience in design and implementation allows for real objective conclusions.

2.1. Linear lighting as a virtual separation

An example of the implementation of the Diament hotel in Zabrze presents the lighting of the eaves erected over the link between two lumps of hotel buildings. The object itself is an example of reconstruction and extension of existing buildings, which in their original function (working-class hotels) did not present any exceptional aesthetic values (a simple rectangular non-distinctive form). All of the newly designed buildings have a consistent yet distinctive (from existing ones) character as a result of their architectural design: large windows, decorative overhang covered with a laminate board, and linear lighting of the exterior [8]. The linear lighting source was a lighting LED stripe mounted in a U-profile at the corner of the front glazing and large overhang [see Figure 2]. The led line length of approximately 20 meters was simple, but very powerful. That caused some problems since the reflection on the glass facade was on some occasions too strong and was disturbing the interior design.

Figure 2. Example of the exterior linear lighting: highlighted overhang over the main entrance
Hotel Diament Zabrze, Poland; photo: Tomasz Bradecki
2.2. Refracted linear lighting

An example of a single-family house in Gliwice illustrates the creative use of linear lighting on facades. The solid of this one-story building is relatively simple, so an element was sought that would decorate the facade. LED lighting strip was led in aluminum troughs in such a way that the light strip passes to different sides of the facade and breaks down. The composition of light elements on the facade is simple asymmetrical, underlines the decorative grating which overhangs on the front above and also breaks down (see Figure 3). The width of the front elevation is about 24m, while the length of the led strip is about 28m. The effect of the division of the building's body on the lower part extended forward and upper was obtained. The linear lighting partly illuminates the grating.

![Figure 3. Example of exterior refracted linear lighting used for highlighting: refracted shape, Poland; photo: Tomasz Bradecki](image)

3. The contemporary linear lighting in architectural interior design

Interior lighting design becomes a profession for experts today since new technologies offer more and more opportunities and the interior designer must follow. Contemporary solutions for linear lighting in the interior design seem to be unlimited today. One of the well-recognized interior design experiments with linear led lighting is Dominion Office Building by Zaha Hadid Architects, Moscow, Russia. As Baldwin Eric states in this case study, the continuous strips of light provides a soft glow that works its way up the atrium [9]. This unique staircase design is an example that shows the potential of the linear lighting in interiors.

3.1. Free form linear lighting

An example of living room lighting in a single-family house in Pyskowice is very unusual. In this case, the owners of this relatively small house (the total area of the open space of approximately 50 sq m) wanted to achieve the effect of unique and unique space. The small scale of the open space and its spatial diversity - the shape of L with bends did not give opportunities for the typical and effective use of straight lines of light. Instead, it was proposed to make fanciful curved patterns on the ceiling, which will not refer to the shape of a single family home plan. The curves design assumed a fanciful, but not very diverse composition: it was assumed that none of the curves would start and end in the corners (see Figure 4). The curves of the light belts were obtained thanks to the use of LED strips laid
in recesses of a specially made ceiling. The distribution of light sources in the resulting gaps is the result of on-site tests. Initially, 7 W LED strips were to be placed on a horizontal plane on each side of the slit. The effect, however, did not live up to expectations because the symmetrical illumination of the gap meant that its contour was lost. After a few experiments with the power of the lighting itself and its arrangement, a solution was chosen in which a strip with LEDs of 14 W per linear meter was placed only on the inside of the slit, on its vertical plane, 5 cm above the ceiling level, so that it would not be visible from below [10]. The material of the ceiling is GK boards and gypsum stucco. The rounded elements of the ceiling had to be performed by professional workmen. During the implementation of another technical solution that would allow this type of forms were not available to the investor.

![Image](image_url)

**Figure 4.** Example of interior linear curved lighting: individual free shape, Poland; photo: Tomasz Bradecki

### 3.2. Linear highlighting

An example of the interior design of hotel rooms at the Diamond Hotel demonstrates how to creatively use linear lighting to illuminate the graphics on the wall, in this case, the implementation of a nice place in an old building in the center of Katowice. The design intention was to maintain the interior design in a style that partly refers to the history of the building. Decorative frames were designed on the walls that imitate the frame of the picture. Many of the existing structural walls of the hotel were uneven, which is why the designed artificial paintings were withdrawn in relation to the newly designed walls made at a distance from plasterboard panels (Figure 5).
Another typical example of linear illumination is presented in Figure 6. The image shows a local reduction of the ceiling with an RGB controlled color LED stripe. This project effects in a distinctive exposition of the ceiling which performs as a decoration: the ceiling were designed as a colored (brown) reflective stretch ceiling. The user has control and can set a desired color of the LED light. This allows for setting the mood of the interior depending on the mood of the hotel guest.

Figure 6. Example of interior linear lighting used for highlighting of the lowered ceiling, hotel Diament Zabrze, Poland; photo: Tomasz Bradecki
3.3. Linear aesthetics and orientation
The interior remodeling project at the Gliwice plastic factory was aimed at the spatial extraction of the most important pedestrian routes connecting the office part with the production part. An additional element of the interior is the glazed meeting room located in the middle of the office part - where the entire process of monitoring and monitoring of the current production takes place. To emphasize the different function, linear lighting in the floor was proposed: on the one hand for visual separation of the office part and on the other hand for glazing (see Figure 7). Such a procedure facilitates orientation, especially in the evening hours, when there is no daylight, and there is no need to illuminate the entire office space with fewer employees.

Figure 7. Example of interior linear lighting used for wayfinding: individual free shape, Poland; photo: Barbara Uherek-Bradecka

4. Results and discussions
The presented cases demonstrate how differently and creatively linear lighting can be used. Several ways of proprietary applications have been presented and their typology has been proposed. The division into architectural exterior and interior applications seems to be obvious. However, the proposal to divide the types of applications into illumination, highlighting and orientation lighting is original and probably unfinished. The approach showed above mainly concerns the aesthetic impressions of the backlight typology associated with the form.

Linear lighting in architecture should be treated as additional lighting, performing aesthetic functions. It cannot be treated as a source of light that provides the proper intensity (luminescence) of light. This is due to the concept of linearity, and thus the concentration of light along a given section, thus the constant intensity of light on a given length. The linearity effect is achieved by a small width of the source. It should be said that the linear lighting cannot perform as uniform lighting. The exceptions are contemporary linear light sources used in public buildings, which remain without light due to their functions (concert halls, cinemas, theaters). Certainly a statement from Coles and House is
true: the designer's choice will be determined by the effect that needs to be achieved to meet aesthetic or practical goals, by the cost of the fitting and its power consumption and maintenance, and by the extent to which the light fitting itself contributes to the appearance of the space [6].

5. Conclusions
The main conclusions of the study show the great importance and growing possibilities of use of the linear lighting. The technical possibilities of the use change very quickly and become more available. Accessibility can be understood both by supporting the price category (the costs of linear light sources are decreasing), as well as through the category of ease of execution and implementation itself. Linear lighting systems are becoming more and more common and easy to adapt to lighting up the rooms.

In the title and at the beginning of the article, the thesis that the linear lighting is a fashion or a modern and future solution was accepted. According to the author, this dissertation, including the mentioned examples and references to the literature, definitely confirm the thesis. Line lighting is an increasing share of possible sources of light. This is evidenced not only by architectural realizations, but also by more and more frequent applications visible in everyday objects, such as household appliances or in the automotive segment (e.g. in car headlights, car illumination, etc.). The main contribution to the success of this type of lighting promotion is LED technology, and perhaps a different one, which will give other possibilities. It is therefore hopeful to observe the use of new linear lighting in the architecture.

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References
[1] A. Skarlatou, “Architectural lighting design and aesthetics: in quest of theories and manifestoes in artificial lighting projects”[Online]2015 [Accessed 26. 03. 2019] Available at: <https://www.academia.edu/1662254/Architectural_lighting_design_and_aesthetics_in_ques t_of_theories_and_manifestoes_in_artificial_lighting_projects>.
[2] K. M. Zielinska-Dabkowska and A. M.Dugar, “Meaningful Defragmentation - Engaging design research strategies in the education and practice of architectural lighting”. Professional Lighting Design no. 103, p. 46-51, 2016.
[3] S. F. Dias and M.J. Durão, “Architecture and Art: La Ronchamp’s symbiosis as a ‘total work of art’”, November 2015 Conference: LC2015 - Le Corbusier, 50 years later Z. A. Latif, I. Zamri, and H. Omar, “Determination of tree species using Worldview-2 data,” 2012 IEEE 8th Int. Colloq. Signal Process. Its Appl., pp. 383–387, 2012.
[4] M. Gyourkovich, “Role of Light in architecture upon the example of iconic cultural facilities”. Selected examples. January Housing Environment ŚrodowiskoMieszkaniowe, nr 18, pp. 95-105,2017.
[5] J. Gondek, S. Kordowiak and T. Habdank-Wojewódzki, “Energooszczędne moduły do zasilania LED-owych liniowych źródeł światła”, Electrical Engineering no 73, p.219-225, 2013.
[6] J. Coles and N. House, “The Fundamentals of Interior Architecture”, AVA Publishing SA, 2007.
[7] M. Petelenz, “Light and its Antinomies as a Narrative Tool in Architecture Housing environment”, nr 18, pp. 58-66, 2017.

[8] T. Bradecki and B. Uherek-Bradecka “Renovation And Modernization Of Hotel Buildings - Case Studies In Silesia”. Civil and Environmental Engineering Reportsissn2080-5187CEER; 19 (4): 005-012, 2015.

[9] E. Baldwin, “On Track: 5 Stunning Projects Built with Linear Lighting”[Online] 2018 [Accessed 25. 04. 2019] Available at: <https://architizer.com/blog/inspiration/collections/linear-lighting>

[10] B. Uherek-Bradecka, Living Room magazine, “Rozświetlić salon inaczej”[Online] 2015 [Accessed 26. 03. 2019] Available at: <https://livingroom24.pl/artykul/design/rozswietlic-salon-inaczej>.