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Vertical Surface Lighting Techniques
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This issue of Implications is intended to provide the reader with an overview of the conceptual development of lighting techniques for illuminating vertical architectural surfaces, objects mounted on vertical surfaces, and accent lighting on persons within an architectural space. Specifically, this material addresses wall wash, accent lighting, and the lighting of speakers at podiums or lecterns in spaces. A quick, graphic technique for predicting scallops on walls is also described, since down lighting and accent lighting can result in “scallops” of light on vertical surfaces. This overview is not intended to address specific space types, but rather general techniques usable for interior and, to a degree, exterior spaces.

This article also provides an overview that should influence design decision making relative to appropriateness and use of these strategies. See primary sources identified at the end of this article and review earlier issues of Implications for more detailed information about lighting design. The length of this article does not allow an in-depth review of all requirements, guidelines, performance issues, or subjective or emotive response by users of interior spaces.

Consider recommendations contained in this article as starting points for the techniques that are described. Any technique explored in conceptual or schematic design should be examined in more detail during the design development and construction document phases of a project. For example, actual client needs, photometry of the luminaire utilized (fixture, lamp type and beam spread, light distribution and control components), ceiling heights, mounting distances and angles, surface reflectance, energy performance, LEED requirements, local code requirements, illuminance and exitance/luminance requirements, and other attributes significantly impact the final performance of a design technique and, most importantly, the design success that results. Review the lighting design guide in the Illuminating Engineering Society of North America (IESNA) Lighting Handbook for a process for lighting design and discussion of design issues (Rea, 2000).

Light Sources

Vertical surface lighting can be accomplished with incandescent, halogen, fluorescent, HID, LED, and daylight sources. Choice of specific type of artificial
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or daylight source should be based upon lighting effects desired, code and energy requirements, other requirements (see above), and related to additional needs of the client and project. As an example, fluorescent sources may be acceptable for a wall wash technique but seldom are appropriate for accent lighting on artwork. Performance and white light characteristics of LED sources are improving rapidly and are now more readily considered by lighting designers. Daylight strategies must be supplemented by artificial sources for night time lighting requirements depending on the hours of operation or use of the space. Because of the recent regulating of various incandescent sources through the Energy Independence and Security Act (EISA) of 2007, most lighting professionals expect to see continued emergence of new, more efficient, and environment-friendly light sources and recommendations by lamp manufacturers on replacement sources (http://www.aboutlightingcontrols.org/education/papers/2008_refectorlamps.shtml). Accent lighting with lower wattage halogen and with low voltage sources are still viable.

**Luminaire Types**

Lighting for vertical surfaces typically requires luminaires specifically identified as appropriate for wall wash, accent lighting, or focal lighting. Designers should review manufacturer descriptions of luminaires to verify that they are designed specifically for vertical surface illumination. Luminaires may be recessed, surface or track mounted, and generally should be adjustable in rotation—in other words, aimable. Equipment should accept filters or other optional acceptable accessories for light diffusion, glare control, and cutoff if required for the project. Excellent overviews of luminaire types are available in Gordon (2003) and Karlen and Benya (2004).

**Luminaire Photometry**

Photometry is the measurement of light and is a required component of any performance analysis of a lighting design. During design, the designer should determine the luminous intensity of light sources that may be used in the project. Since humans perceive brightness and brightness changes within the field of view in spaces, understanding the luminous intensity of a source is important as this intensity, represented through a distribution curve, “gives a picture of the total light pattern produced by a source” (Gordon, 2003, p. 123). The most common forms of reports are polar and rectilinear. A rectilinear form is used when the distribution changes rapidly over a small angular area—very narrow beam spread lamps, for example. Figures 1 through 3 illustrate three different luminaire polar graphs. Figures 1 and 2 illustrate the same wattage low voltage lamps with differing distribution patterns while Figure 3 represents a fluorescent wall wash source.

**Illuminance Levels**

The IESNA recommends illuminance values for differing tasks and space types (Rea, 2000). The tables provided within the *IESNA Handbook* should be

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Figure 1: 40 Degree MR16 Low Voltage  
Figure 2: 10 Degree MR16 Low Voltage  
Figure 3: 32W Fluorescent Wall Washer
used to establish requirements for performance. The design process chapter, noted above, can be partially summarized in the following steps:

- Go to design guide to find location or task under consideration.
- Learn about the design criteria that are very important, important, and somewhat important for the location or task.
- Review design issues to understand every design criterion.
- Review IESNA Handbook chapters specific to space or task type for other issues.
- Review illuminance selection for recommended illuminance categories.
- Select the appropriate category (A-G).
- Document the design process.

Illuminance criteria may be based on horizontal or vertical surfaces, depending on task or location type. This paper focuses on vertical surfaces; therefore, vertical illuminance (fc) should be the determining metric. It is important to recognize our human perception of brightness, thus exitance/luminance of vertical surfaces is also important. As noted by Gordon, surface reflectance “properties are fundamental to the lighting design” as “these surfaces affect both the efficiency of the initial light distribution and our perception of surface brightness” (2003, p. 133).

**Behavioral Response to Lighting Effects**

Behavioral response to lighting effects has been studied and explored extensively. For example, subjective impressions were the focus of studies by John Flynn (1973), Steffy (2002, 2008), Gordon (2003), and Russell (2008). All discuss issues that directly or indirectly resulted from Flynn’s early work and that of others. The intensity and uniformity of light in a space create “impressions” of visual clarity, spaciousness, preference, relaxation, and privacy (Steffy, 2002). Designers should review these materials to gain a more comprehensive understanding of modes of lighting and how they contribute to subjective impressions.

**Lighting Layers**

Many lighting designers advocate a concept of lighting layers as part of the design process. For example, Karlen and Benya (2004) describe layering principles based on achieving “composition and aesthetics in lighting design” (p. 56). In many cases, the lighting of vertical surfaces is a part of the focal layer where the “primary purpose is to illuminate features and displays...” (p.56). Russell (2008) also discusses the layering concept and indicates that lighting to accent objects is done to create “visual interest and logic” thus achieving visual clarity (p. 33). Illuminating vertical surfaces in spaces is one of several lighting layers which contributes to visual clarity and spaciousness in the overall lighting design.

**Analysis Tools**

Designers have four options for defining and ultimately fine-tuning a lighting design concept. The first option is to utilize “rules of thumb,” which this article addresses. Secondly, designers can use manufacturers’ “quick estimate charts” as a means of estimating illuminance based on typical spacing criteria for a concept. Caution is necessary using quick estimate charts when the spatial characteristics (room size and finish) or lamp selection varies from the manufacturer’s basis for the actual charts. A third option is on-line calculation programs provided by lighting manufacturers and others. Use of rules of thumb, quick estimate charts, and on-line programs provide the designer with a place to begin exploring a concept rather than a final performance estimate!

Lighting calculation programs are most appropriate for final design analysis (calculations, lamp selection, precise aiming angles, rendering of results). Programs that this author typically uses are AGI 32 (www.agi32.com) and Visual Professional (http://www.visual-3d.com/Software/Professional/Default.aspx). Radiance (http://radsite.lbl.gov/radiance/) is an excellent public domain option with a steep learning curve.
Lighting Techniques

A wall wash technique is used to highlight or emphasize architectural materials on vertical surfaces or to draw attention to a wall or large area. There are two types of coverage for this technique: shadowless and grazing.

**Shadowless** coverage creates an even wash of light over the vertical surface using one of the following:

- Perfect wall wash: even coverage across the entire wall area.
- Graded wall wash: graduated coverage from top to bottom of a wall (brighter to darker).
- Random wall wash: random spread of brightness across the wall area.

**Rule of thumb guidelines for shadowless coverage include:**

- Luminaires are typically mounted 3’-4’ from the wall depending on luminaire type, photometry, and ceiling height. Do not mount luminaires closer than 2.5’ from wall, hot spots can result.
- Use a 1:1 spacing ratio for incandescent, halogen, and low voltage sources (see Figure 4). For example, place units 3’ from wall; 3’ on center (O.C.) spacing between luminaires. Fluorescent wall wash luminaires require a different spacing ratio—3:3.33 is often an acceptable starting point for spacing during concept development.
- Luminance will generally decrease toward the bottom 1/3 of a wall.

- Do not wash shiny surfaces—reflected glare will create vision problems.
- Glare can be a problem depending on viewing angles to luminaires.
- Shadowless coverage will obscure irregularities in the wall surface.
- Do not use wall washers down the center line of a corridor.
- Generally avoid use of a single wall wash luminaire unless a narrow wall width is being illuminated. A better solution may be an accent luminaire.

Figures 5-7 illustrate three different random wall wash concepts using differing fixtures and lamps, spacing, and total wattage.

Each of these images represents beginning concepts, not final solutions. Each exploration requires further refinement to become an acceptable solution for illuminating a 16’ wide wall with an 8’ high ceiling.
The actual reflectance values and architectural materials would also affect the final solution. In all AGI 32 examples within this paper, surfaces are represented as diffuse materials with ceiling reflectance of 90%, target wall 90%, and floor 40%. Figure 5 illustrates a 50MR16 low voltage source, Figure 6 a 50R20 incandescent lamp, and Figure 7 an 18 watt fluorescent source. The low voltage and incandescent equipment is spaced using a 1:1 spacing ratio while the fluorescent concept is based on a 3:3.33 ratio.

**Grazing coverage** is used to highlight desirable textures, materials, and architectural character. The following rules of thumb apply:

- Mount fixtures 1’ from wall and 1’ O.C. using a 1:1 spacing ratio as a minimum; this rule of thumb will vary depending on lamp/fixture combination.
- Do not use grazing coverage for gypsum board wall construction since designers generally do not want to emphasize surface irregularities.
- Do not attempt to accent art work with a grazing technique. Simply stated, art work generally will not be highlighted effectively.
- This technique is not energy-efficient unless fluorescent wall slot or linear luminaires are used. Wall slot provides continuous wash horizontally but not vertically as the top 1/3 of the wall will have the highest luminance and the lower 1/3 will have the least luminance.

**Lighting objects** on a vertical surface (2D) or adjacent to a vertical surface (3D) should be approached through the following steps or guidelines:

- Design to spotlight rather than provide even coverage.
- The aiming angle should be adjustable from nadir (center line) and generally is in the range of 30-35 degrees depending on ceiling height, size of object, and resulting mounting distance from the vertical surface. Figure 8 illustrates this aiming angle guideline. Figure 9 shows luminaire mounting distances from the wall, based on ceiling height and an assumed adult eye level height of 5’-3”.
- Luminares should have adequate baffling to shield the light source from view and reduce glare.
- Medium to large objects may require more than one light source. When two sources are required, considering a 1:1 spacing ratio along with aiming both luminaires at, or near, the center of the object.
- Field focus and aiming is required for illuminating any object or surface with accent lighting techniques using adjustable luminaires.

Three figures (10-12) illustrate variations on accent lighting for a single 2D art object mounted on the wall. Each option uses a different beam spread 50MR16 low voltage adjustable accent
luminaire (15, 25, and 40 degrees). In application, a lower wattage lamp, dimming, and further assessment of choice of lamp beam spread may be desirable.

Lighting speakers or actors on a stage requires the use of multiple light sources correctly placed. To eliminate shadows on the human face or body and to minimize stray light that might strike scenic elements, place the light source at 45 degrees above the acting area and at 45 degrees from center axis to audience. Figures 13 and 14 illustrate this approach.

• Use two light sources at a 45 degree angles on either side of the center axis to illuminate the actor (or speaker).
• Use a warm colored filter or gel on one luminaire and a cool filter or gel on the other luminaire. Warm is normally associated with the front of the speaker and cool with the shadow side of the speaker. This approach has evolved through theatrical lighting and, in a simplified form, is an excellent approach in architectural spaces.
• Top lighting may also be used to create dramatic effect. However, this approach should not be used alone for lighting the human face; it in fact results in production of shadows below the eyes. Top lighting is best combined with single light sources from each side using the 45 degree angle approach.
• When 45 degree angles cannot be used, “jewel...
"lighting" should be considered. Mount one source directly above and in front of the speaker or actor. The speaker is then cartooned through strong side and back lighting to place a radiant glow on hair, shoulders, and sides.

Predicting scallop patterns on walls is useful to avoid unwanted “spill” of light on art objects, wall surfaces, cornices, soffits, corners, and other attributes of the interior of a space. When illuminating 2D art work in groups, it is usually necessary to understand when the scallop of light strikes adjacent surfaces. This sketch technique has been well documented in the literature (Egan & Olgyay, 2002) and can be used for predicting scallops from down lighting or, with slight modification, for accent lighting.

Use the following steps to estimate where a scallop will fall:

- Mark spot on the elevation where beam angle intersects the wall (upper ray) (Figure 15).
- Draw a light ray on the elevation from O.C. of the luminaire at the maximum beam angle (Figure 16).
- Draw a line parallel to the top beam line of the luminaire’s distribution pattern. The top of the scallop is at “A” (Figure 17).
- Draw a line in between the beam lines and connect it with curve to the “A” spot. This sketch represents an approximation of the scallop from a single luminaire (Figure 18).
- The final perception of the actual edges of a scallop is modified by inter-reflected light and actual sharpness of beam edge.
• Repeat the above steps for additional luminaires along the wall to create a conceptual sketch of the scallop pattern.
• Optionally, a computer run using AGI 32 or similar lighting analysis programs can generate a rendered 3D or elevation image that accurately predicts scallop locations using the actual photometry of the accent or downlight luminaire.

Figures 19-21 illustrate initial scalloping concepts produced through AGI 32 software. Figure 19 represents a low voltage idea using a 50MR16 lamp with a 40 degree beam spread while Figure 20 shows a 50W halogen source using a square downlight. Finally, Figure 21 indicates a scallop effect using an 18W fluorescent downlight. The aiming angle used in all three examples is normal to the luminaire (i.e., straight down). Spacing from the wall and between luminaires varies with each example.

Summary
Conceptual ideas for lighting vertical surfaces as a focal layer in architectural spaces have been presented. Many other options and ideas exist and are possible. The reader should consider this article and the noted references for gaining more knowledge about vertical surface lighting techniques. Space does not allow a more detailed explanation, refinement of conceptual ideas, or complete lighting solutions placed in context of the design and use of spaces. Explanation of all key aspects of a lighting design process that the author, or referenced authors use in actual practice has not been possible. The reader is encouraged to use this article as a starting point for additional exploration of the art and science of lighting design.

References
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interior designer and lighting designer. La Jolla, CA: Conceptnine.

Additional Resources
—www.aboutlightingcontrols.org
—www.agi32.com
—www.cooperlighting.com
—www.gelighting.com/na
—www.iesna.org
—www.lightolier.com
—www.lithonia.com
—www.sylvania.com
—www.nam.lighting.philips.com/us
—http://radsite.lbl.gov/radiance
—www.visual-3d.com

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