Indoor Lighting Design

Ir. Dr. Sam C. M. Hui
Faculty of Science and Technology
E-mail: cmhui@vtc.edu.hk
Contents

• Overview
• Basic Principles
• Design Process
• Design Factors & Issues
• Emergency Lighting
Overview

- Video: What is lighting design? (4:13)
  - http://www.youtube.com/watch?v=hqT4alUaHfQ
  - Award winning Architectural Lighting Designer, Annette Hladio, discusses her views on lighting design.

- Galleries of lighting design portfolio by Annette Hladio:
Overview

• Lighting design can have many different objectives
  • Determined by the client and the designer
  • The most common objective is to allow the users of a space to carry out their work quickly and accurately, without discomfort

• Design constraints
  • Such as financial and environmental concerns
  • Architectural integration, installation & maintenance issues
Considerations for lighting design

- Architectural integration
- Visual function
- Visual amenity
- Energy efficiency
- Costs (capital and operating)
- Installation maintenance

(Source: The SLL Lighting Handbook)
Overview

- A holistic strategy for lighting should consider:
  - Legal requirements
  - Visual function
  - Visual amenity
  - Architectural integration
  - Energy efficiency and sustainability
  - Maintenance
  - Costs
  - Photopic or mesopic vision
  - Light trespass and sky glow (light pollution)
Overview

• Defining the lighting design project:
  • Lighting for a new space?
  • Need to correct existing lighting problems?
  • Change in the use of the space?
  • Desire to save energy and stretch the budget

• Opening assessment:
  • Meet with owner, occupants, architect, etc.
  • Identify legal constraints
  • Identify uses of space
  • Identify physical challenges, opportunities
Overview

- Examples of **indoor lighting design:**
  - Emergency lighting
  - Office lighting
  - Industrial lighting
  - Lighting for educational purposes
  - Retail lighting
  - Lighting for museums and art galleries
  - Lighting for hospitals
  - Lighting for homes and hotels

(* For details, please refer to the *SLL Lighting Handbook.*)
Overview

• Basic design decisions
  • Use of daylight (what role would daylight plays)
    • To provide a view out
    • To provide enough light to work by
    • To save energy
    • To provide lighting for particular tasks requiring very good colour rendering
    • To enhance the appearance of the space by providing meaningful variation in the lighting
  • Choice of electric lighting system
    • Such as general, localised and local lighting systems
Overview

• Basic design decisions (cont’d)
  • Integration
    • Within the space, architecture, interior design
    • With other services (e.g. fire, HVAC)
    • With daylight
    • With the surroundings
Overview

• “Lighting designer”
  • Determine how things will look and feel in a space
  • Understand and interpret the clients intent
  • Devise a suitable lighting concept & translate it into a plan (creative vision)

• “Illuminating/Lighting engineer”
  • Usually works from someone else’s conceptual plan
  • Provides the “how to” or solves the problems….optical, visual or mechanical….of making the concept work

(* See also http://en.wikipedia.org/wiki/Architectural_lighting_design)
Basic Principles

• Three main functions of lighting:
  • Ensure the safety of people
  • Facilitate the performance of visual tasks
  • Aid the creation of an appropriate visual environment (appearance & character)
Basic Principles

- Lighting of interior as a whole is affected by:
  - General brightness
  - Patterns of light, shade, colour
  - Degree of glare
  - Modelling of people, objects and features

- Illuminance needed for the task depends on:
  - Visual difficulty & complexity of the task
  - Average standard of eyesight
  - Level of visual performance required
Basic Principles

- Lighting design criteria*
  - Luminous environment & luminance distribution
  - Illuminance and uniformity
  - Lighting directional effects
  - Colour aspects, variability of light
  - Glare, flicker and stroboscopic effects
  - Lighting of work stations with display screen equipment (DSE)
  - Maintenance factor
  - Energy efficiency requirements

(* For details, please refer to the SLL Code for Lighting, Chapter 2.)
Basic Principles

- Effect of lighting
  - On architecture (defines space & shows form)
  - On interior design (reveals texture & colour)
- Psychological effects of an environment are as important as the physiological
  - Good quality light to “see by” and to “feel by”
- Three main aspects to consider:
  - General lighting
  - Localised lighting
  - Local (task) lighting
General lighting

[Source: CIBSE Lighting Code]
Localised lighting

[Source: CIBSE Lighting Code]
Local (task) lighting

[Source: CIBSE Lighting Code]
Basic Principles

- Methods for creating the total (visual) environment:
  - 1. Ambient lighting
  - 2. Accent lighting
  - 3. Task lighting
  - 4. Perimeter lighting
Basic Principles

- **Ambient lighting**
  - Provides general, overall illumination
  - Defines the space, and makes it a comfortable visual environment
  - Two approaches:
    - Direct lighting (brightens objects and surfaces)
    - Indirect lighting (can give the feeling of spaciousness)

- **Accent lighting**
  - Focuses on selected objects and surfaces, providing drama and excitement
    - Such as key light, fill light and silhouetting, sparkle & glitter
Basic Principles

- **Task lighting**
  - Illuminates areas where work is performed, such as concentrated light from above

- **Perimeter lighting**
  - By lighting vertical surfaces to emphasize the architecture of the space and provide the necessary surround brightness

- Two common approaches:
  - **Wall Washing**: appropriate for smooth surfaces; provide a uniform wash of light from floor to ceiling
  - **Grazing**: for non-uniform surfaces; emphasize the features of rough surfaces, e.g. wood-grain finishes, stone, brick and other textured surfaces
Design Process

• Video: Lighting Design Process (4:12)
  • http://www.youtube.com/watch?v=hpyq6uktBwM

• Typical building design process (7 steps):
  • Programming
  • Schematic design
  • Design development
  • Construction documents
  • Bidding (tendering)
  • Construction
  • Post-occupancy evaluation (POE)
1. Objectives

Determine the objectives of the design in terms of safety, task and appearance requirements. Priorities should be allocated and constraints identified.

2. Specification

Express the design objectives as a set of compatible design criteria, and acknowledge those objectives which cannot be quantified.

3. General Planning

Consider the relationship between natural and electric lighting. Resolve the type of lighting system which will achieve the desired objectives.

4. Detailed Planning

Plan the final scheme (or alternative schemes) using accurate data to ensure the most economical and effective final design.

5. Verification

After completion, examine the installation in order to assess its success in terms of the design objectives and its acceptability to the client/users.

Lighting design and planning

[Source: CIBSE Lighting Code]
Design Process

• Basic approach to lighting design
  • Determine lighting design criteria
    • Quantity of illumination (lighting level, lux)
    • Quality of illumination (e.g. overall appearance, colour)
    • Codes and regulations (e.g. building, electrical, energy)
  • Record architectural conditions & constraints, e.g.
    • Window location & size, ceiling height, finish materials
  • Determine visual functions & tasks to be served
  • Select lighting system to be used
Design Process

- Basic approach to lighting design (cont’d)
  - Select luminaire and lamp types
    - To produce the desired light & fit the client’s needs
  - Determine number & location of luminaires
    - Through calculations & assessment
  - Place switching & other control devices
    - User convenience & energy management
  - Aesthetic & other intangibles
    - Aesthetic & psychological factors
Design Process

- The process of designing with light focuses on:
  - What to light
  - How to light it
  - What to light it with
Design Process

Questions to ask at the planning stage:
- What activities will the space be used for?
- What tasks are to be accomplished in the space?
- What are the object(s) you most want to see?
- Which architectural features are to be emphasized?
- Where is the seating area?
- What is the desired mood (ambience). Does it need to be varied?
- What style must the lighting coordinate with?
Design Process

- What to light
  - Setting priorities
    - Give the space a focus
    - Consider the space as a whole
  - Analyse the space
- How best to light it
  - Using ambient, accent, and task lighting
- How much light
  - Depends on these factors: age, speed, accuracy, and the reflectance of the task
  - Also consider architectural and energy/environment
Design Process

- Where to place the light
  - To avoid glare and veiling reflections
  - To emphasize or minimise surface texture
- What to light with
  - The lamp, the luminaire, and the controls
  - Choosing the lamp
    - Light distribution
    - Electric energy consumed
    - Colour rendering and color appearance
    - Maintenance costs
Design Process

- Obtaining the desired distribution
  - Depends on the lamp and luminaire, and purpose
  - The required light distribution may range from broad and widely diffused to narrow and focused

- Choosing the luminaire
  - Intended light distribution, function or purpose
  - Appearance or style
  - Mounting: recessed, surface, pendant, wall
  - Type of building construction: new, existing, insulated
  - Product quality: detailing, finish, durability
  - Operating cost: energy, relamping, cleaning
  - Initial cost
Design Process

• Choose the lighting controls when you want to:
  • Change the lighting scene to suit the activity
  • Set a mood
  • Create an atmosphere
  • Extend incandescent lamp life
  • Control the lights from several locations
  • Save energy by turning off the lights automatically when no one is present
Design Process

- Typical lighting control strategies:
  - User controlled lighting
  - Scheduling
  - Daylight harvesting
  - Task tuning
  - Adaptive compensation
  - Lumen maintenance
  - Occupancy sensing
Design Process

- Lighting control equipment:
  - Switches
  - Occupancy sensing
  - Scheduling (timeclocks)
  - Daylight dimming
  - Tuning
  - Preset dimming
  - Building management

Remember: switch off unnecessary lights!
Design Factors & Issues

- Factors affecting visual performance:
  - Inadequate illuminance
  - Too great or too low a contrast
  - Disability and discomfort glare
  - Veiling reflection
  - Flicker from fluorescent lamps
  - Psychological factor (occupant’s satisfaction with the environment)
Design Factors & Issues

• Important to consider:
  • **Situation** – is it a working, viewing, circulation or a living space?
  • **Function** – what will people do in the space?
  • **Quantity and Quality of Light** – what's needed to perform the tasks?
  • **Architecture and Décor** – consider the aesthetic of the space
  • “**Atmosphere**” – what is the mood or ambience of the space?
Design Factors & Issues

- Lighting quality and criteria
  - Lighting level (lux or luminance e.g. road lighting)
  - Luminance distribution
    - Better distribution of brightness within the field of view
  - Freedom from disturbing glare
  - Spatial distribution of light
    - General lighting, directional lighting, backlighting and uplighting, diffuse lighting
  - Light colour and colour rendering
    - Colour temperature and colour rendering index
Design Factors & Issues

• Typical lighting design issues
  • Planes of brightness (high brightness creates cheerful atmosphere)
  • Glitter and sparkle (stimulating points)
  • Light and shadow (create focal points)
  • Modelling (reveal dimensionality)
Design Factors & Issues

• Directional effects (form, dimension & texture)
  • Direction and distribution of light within a space
    • Influence perception of the space
    • Relates partly to desirable illumination levels and partly to architectural style and visual emphasis
    • Good light design - an appreciation of the nature and qualities of the surfaces
  • Modelling – ability of light to reveal solid form
    • Fail to do that will result as bland and monotonous
  • Emphasis – e.g. surface texture & characteristics
Examples of directional effects in lighting design
Design Factors & Issues

- Choice of appropriate colour of light source
  - Determined by the function of the room
  - Involve psychological aspects & practical factors
- Appearance of coloured surfaces
  - Controlled by spectral power of source
  - Power balance and presence or absence of certain wavelengths affect colour rendering
Design Factors & Issues

• **Glare** 眩目光
  - Occurs when objects, seen directly or by reflection, are too bright c.f. the general background
  - **Disability glare** - impairs ability to see detail w/o necessarily causing visual discomfort
    - Shift in adaptation level
  - **Discomfort glare** - causes visual discomfort w/o necessarily impairing vision
    - Depends on occupant’s activity, angle of view, size and brightness of source, average luminance of background

(Vide: What is glare? (2:13) [http://www.youtube.com/watch?v=PwHXut8lw4M]())
Disability glare from bright sky in front of a VDT makes the screen difficult to read

Discomfort glare from bright luminaires
Design Factors & Issues

- Reduce glare from artificial light sources
  - Limit the luminance of sources in eye’s direction
    - Replace a bright source with few weak sources
    - Restrict light distribution to ↓ sideways light to the eye
  - Screen the sources from view
    - Introduce downstand screens
    - Use screening within the fitting (e.g. louvres)
    - Enclose source in light diffusing panel/fitting
    - Conceal fittings from view (e.g. by beams)
Design Factors & Issues

- Reduce glare from artificial light sources (Cont’d)
  - Re-position the work station to avoid glare
  - Raise background luminance
    - Use fittings with more upward flux (brighten ceiling)
    - Specify higher reflectance floor
    - Use light-coloured finishes
Design Factors & Issues

- Reflected glare & veiling reflection
  - Bright patches on glossy surfaces from reflection
    - *Reflected glare* - produce visual discomfort
    - *Veiling reflection* - reduce contrast and visibility
  - May be minimised by:
    - Ensure no part of the task is at or near the mirror angle with respect to the eye & bright source
    - Increase light falling sideways onto the visual task
    - Use luminaires w/ large surface area & low luminance
    - Use paper, machines, materials etc. with matt surfaces
Glare control for video display unit (VDU)

[Source: CIBSE Lighting Code]
Emergency Lighting

- Main purpose (when normal lighting fails)
  - Guide people quickly & safely from the building
  - Enable specific tasks to be completed
  - Avoid panic
  - Restore confidence
- Design shall follow the relevant regulations (e.g. fire services) & standards/codes (e.g. BS5266)
- Also, exit signs & signage lights

Specific forms of emergency lighting and design drawings

Emergency Lighting

- Emergency escape lighting
- Standby lighting

Escape route lighting

Open area (anti-panic area) lighting

High risk task area lighting

(Source: ICEL 1006: Emergency Lighting Design Guide http://www.icel.co.uk)
Emergency Lighting

- Three typical types:
  - Emergency lighting (when normal lighting fails)
  - Escape lighting (assure means of escape)
    - Escape route, open area (anti-panic), high risk task area
  - Standby lighting
- Design requirements:
  - Illumination level = 1 lux; uniformity 40 : 1
  - Must be in operation ≤ 5 sec, last for 1 or 2 hours
  - Correct positioning & power supply
  - Battery backed up & automatic switch on
Emergency lighting & signage on escape route

[Source: Thorn Lighting, UK]
Emergency Lighting

- Two types:
  - **Maintained luminaires**
    - Permanently illuminated, and remain illuminated when power fails, such as for emergency exit lighting
    - In some cases they may be switched off deliberately, but are usually required to be active when a building is occupied, or when the public are admitted, such as for a theatre
  - **Sustained or non-maintained luminaires**
    - May be switched on and off normally
    - If the power fails, they turn on automatically
Example of an escape route lighting design

Figure 20: Transverse spacing between emergency luminaires, within a 2 m wide corridor

(Source: http://www.emergi-lite.co.uk/)
Further Reading

• Lighting Training Courses (Online) by Philips Lighting University:
  • Introduction to Lighting Application
  • Office Lighting: Knowhow [Design Lights Consortium] [PDF]
  • Small Retail Lighting: Knowhow [Design Lights Consortium] [PDF]
  • Task Lighting Design (EMSD)
References

  - Chapter 6: Lighting design
  - Chapter 8: Emergency lighting
  - Chapter 9: Office lighting
  - Chapter 11: Lighting for educational premises
  - Chapter 12: Retail lighting

  - Chapter 2: Indoor workplaces