
DiD
WAREHOUSE
BASELINE
DOCUMENT

INTRODUCTION:

In the developing of a "target-setting baseline document" for DiD Warehouse, the Sustainable Building Assessment Tool (SBAT 2000: Jeremy Gibberd) was used as basis. The SBAT has been designed to assess the sustainability of buildings. This is done by determining the performance of the building in relation to a number of economic, social and environmental criteria. The tool also enables the building to be rated in terms of sustainability.

Much information was gathered to provide sufficient guidelines in terms of economical, environmental and social issues. This sets a target for the design-process of DiD Warehouse and the issues addressed here must be reflected in the building as far as possible. Some issues are more important than others, but an essential and interesting challenge would be to integrate the three main categories: social, environmental and economic.

The report gives guidelines in terms of size, percentages, angles, factors and properties, just to mention a few. Some of the information will be implemented when detail issues such as properties of lamps, glare indices, etc., are considered. The target-setting report must maximize the design alternatives and provide a solution for every problem that may occur during the design process. Many possibilities/values are compared with each other to ascertain what option will be the most obvious one to choose.

Well-known trade names are included in the report for elements such as glass walls, internal partitions, extractor fans etc. It is important to use local contractors and companies to support the local economy.

The success of the baseline document will be reflected in the reporting tool which will indicate after the completion of the design process, which targets that have been set, have been achieved, and to what degree.

Thus, the main purpose of the document is to set a target for DiD Warehouse – a target that will address all important issues related to economical, social and environmental aspects.

The document provides information on these three topics that is selected and proven to be the best option and consideration for the purpose, position and function of DiD Warehouse.

Target setting

1. **Lighting**
- allow maximum natural light to penetrate the building
- avoid glare at any cost
- block direct rays of sun
- use special sun control devices
- daylight – the coolest colour (coffee shops, sitting spaces etc.)
- white – intermediate (atriums)
- warm white – the warmest (restaurants)
- compacted fluorescent lights (CFL) – energy saving

2. **Ventilation**
- cross-ventilation
- atriums – create a stack-effect
- ventilation system (rock bin-system)
- flexibility, adaptability and choice – main features of ventilation-system
- night ventilation
- openable windows with louvers on north, west facades
- 4 extractor fans above atrium – remove hot air, dust and fumes
- (require no maintenance and can be closed during winter)
- corresponding minimum fresh air supply is 4,72 litre/s/person

3. **Noise**
- city center noise (highway) – 80dBA
- minimize the amount of windows on western façade
- cavity wall and insulation material – mineral wool
- 82dBA on highway 100m way from building – 68dBA at DiD warehouse
- 68dBA – noisy category
- bigger cavity – maximum results (better isolation capacity)
- 220 – 120 – 220 (101dBA)
- double glazing windows 6 – 100 – 4mm (39dBA)
- 6mm laminated glass (30dBA)

4. **Disabled**
- wc compartments for the disabled
- requirements for handrails and support
- ramps and access to and from the building
- ramps 1:12 fall or lift
- edges – between walls and floors – clearly distinguished
-

5. **Social spaces**
- design for easy informal/formal social interaction
- sitting spaces, coffee shops, restaurants, social gathering spaces
- available to community and neighbouring buildings
- easy accessible ablutions

6. **Security**
- highest possible level of security
- wardens on site and inside the building
- entrances and exits checked by electronic detection
- external doors and windows protected from illegal entry
- "camera-eyes" 24 hours activated
- 2,5m high fence around site
- vehicle control – booms and security guards on duty in parking area/basement
- manned guard point – adjacent to main entrance
- sufficient lighting must be provided

7. **Fire regulations**
- no smoking inside the building
- fire escape staircases according to SABS 0400
- sufficient outside space
- escape routes in case of fire will not exceed the maximum of 45m
- 6 exits for DiD warehouse
- SABS 0400: TT16.12

- 2 escape routes minim. not less than 800mm
- rise max. 200mm, tread minim. 250mm, 900mm high handrails
- fire-extinguishers provided on each level
- control facility (security room) – monitor on a 24 hour, 7 days a week basis
- smoke exhaust fans provided in atriums

8. Occupancy

- non-useable space – not more than 20% of total area
- occupied for and average equivalent of 30 hours per week
- DiD warehouse – 62 hours occupation per week

9. Vertical dimension

- minimum structural dimension of 3m
- 170 slab, 300 access floor, 3270 height (floor to ceiling) for DiD warehouse
- high floor to ceiling will ensure flexibility in future (long and short term)
- grills in access floors (ventilation)
- 600 x 600mm panels

10. Internal partitions

- knocked-out easily
- temporary partitions for exhibition purposes
- flexibility in terms of change
- glass partitions (shopfronts) and inside the building – views (Movitec)
- thick gypsum board (painted) in the atrium spaces
- non-load bearing so that you can remove partitions
- double glazing system – aluminium profile (sound proof)

11. Water

- rainwater from 80% of roof surface is harvested, stored and used
- 92,6m3 water per month harvest (1900 x 0,65 x 0,9)
- 9 000 litre tanks will be used (10 tanks)
- consumption indoors (248,6m3 per month)
- consumption outdoors (54m2 per month)
- total consumption more or less 300m3
- one third of the required amount of water will be used from tanks
- use efficient taps (below 0,03 – 17 litre p/s) and toilets (below 6 litre)

12. Landscape

- recycled concrete slabs
- clay tiles, concrete blocks
- restrict extent of paving – aiming for water to penetrate (soft landscape)
- grass concrete blocks – will absorb water
- deciduous trees (indigenous) – leaves in summer and sun in winter
- ekebergia capensis
- celtis africana

13. Recycling and reuse

- bins provided on site
- specify the use very clearly
- glass and organic bins
- adequate space are essential (share with neighbours)
- collection of waste to be specified
- contractors to be specified
- restaurants – biodigester in service yard (need ventilation)
- (shoot out of kitchen to organic containers)

14. Materials

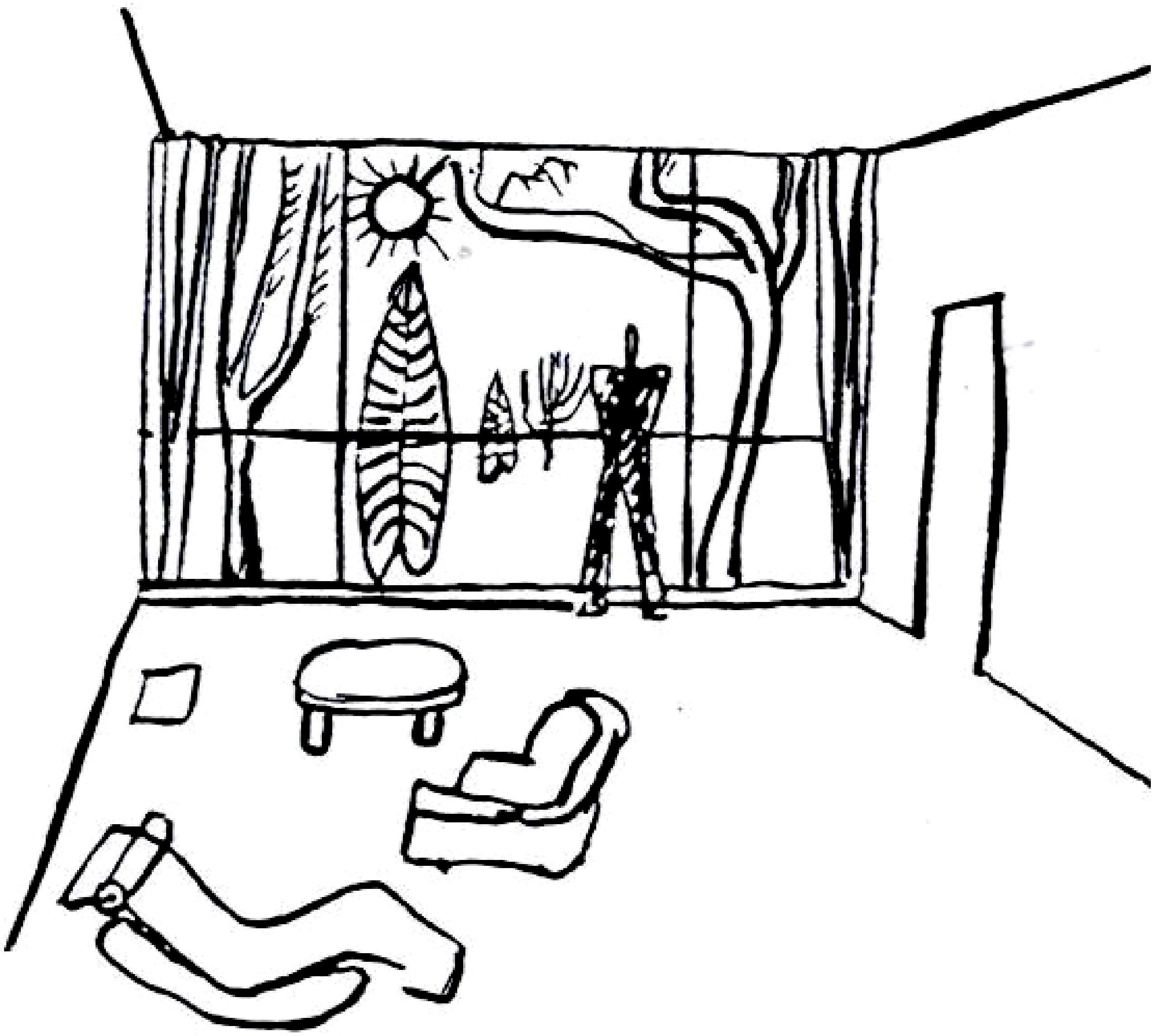
- materials with low embodied energy
- steel 20 GJ/TON
- brick 2,5 GJ/TON
- concrete 1,7 GJ/TON
- aluminium (by hydro electricity) 75 GJ/TON
- plasterwork (clay coloured pigmented plaster) – Coprox
- tiles – natural clay tiles (very low embodied energy)
- natural stone cladding – entrances
- louvers – enamel double coated steel (lower embodied energy than aluminium)

RECENT EXPERIENCE IN ENERGY-EFFICIENT DESIGN

With technological advances in the 1950s and 1960s when compact heating and air-conditioning equipment was developed, a high degree of comfort in buildings was achievable even in adverse climates. But as a result, the wisdom of designing with climate was too often ignored. If in a hot climate, one would use more air conditioning. If a cold climate, one would just call for an oversized heating system. The design of the building itself could be the same, it seemed, whether placed in the arid desert or the snow-bound mountain. With the energy emergencies and shortages of the 1970's, the liabilities and hidden costs of our over reliance upon high energy use to create comfort in buildings became apparent, thus making climatic design and energy efficiency important once again.

[Watson, Labs, 1983:3]

[Gibberd, 2000:SBAT]



LeCorbusier – 20th century

1.1 OCCUPANT COMFORT:

The quality of environments in and around buildings has been shown to have a direct impact on health, happiness and productivity of people. Healthier, happier, more effective people contribute to sustainability by being more efficient and therefore reducing resource consumption and waste. However, the quality of this environment needs to be achieved with minimal cost to the environment. [Gibberd, 2000:SBAT]

1.1.1 LIGHTING AND SOLAR QUALITIES:

Definition: Light is an electromagnetic energy radiation within the spectrum between ultraviolet and infrared radiations. Light causes a sensation perceived by the eye which is interpreted by the brain as vision. (The eye sees best in natural sunlight). [Holm, 1996:6]

One must be bathed in light on entering the building. The sun's presence will be most pronounced in the atrium spaces, where skylights and louvers will harness the sun. Innovations in the use of natural light and playful presentations of it will be a main feature of and consideration in the building. Sunlight will almost bounce around the interior.

The northern glass façade of the building will be protected from the sun's rays by means of computer controlled louvers, while the western and eastern facades will be fitted with angled fabric sails and fixed louvers. West façade louvers will allow natural light into the building.

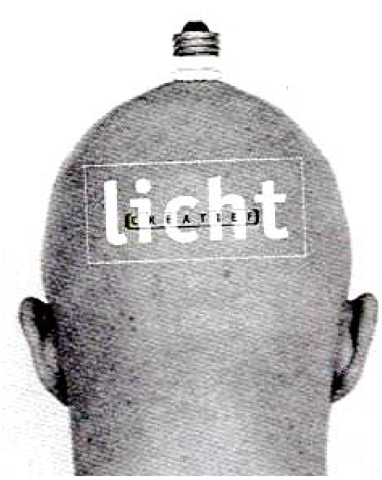
Light will filter into the atrium spaces through at the north, south and east ends, and gaps between the roof and northern walls will allow the sun to play across interior surfaces.

By passing through different layers and types of materials, (opaque, transparent or semi-reflective, double-glazed, simple metal screens punctured with holes, and spaces alternating between light and shadow) light will be transformed in numerous ways. The use of different materials and textures will be reflected throughout the façade and interior of the building. Energy-efficient fluorescent strips provide good artificial lighting for in the interior. Natural light will enter the building in different ways and not only through the atrium spaces.

The challenge concerning natural lighting will be to design a building that will invite natural light and fill spaces with daylight, but at the same time, withstand the hot summer climate. Despite north and south walls that will be nearly 100% glazed, and roofs filled with skylights, systems should be provided that will bring the building within a lighting budget half that of other buildings.

The most important purpose of the atrium, however, is to bring daylight down to all levels, using a daylight system at its top. Skylights will house computer-controlled mirrors that will track the angle of the sun; their tilt angles will then adjust to reflect light in a vertical direction.

The two main glass entrances will form a transparent and friendly focal point that will offer natural light and aid circulation and orientation. An equatorial window with an area equal to 19,2% of the floor area is effective for the entire period when overheating occurs. Openings for solar gain should be orientated towards the winter sun and screened in summer when solar control is necessary, to prevent overheating. [Holm, 1996:66]



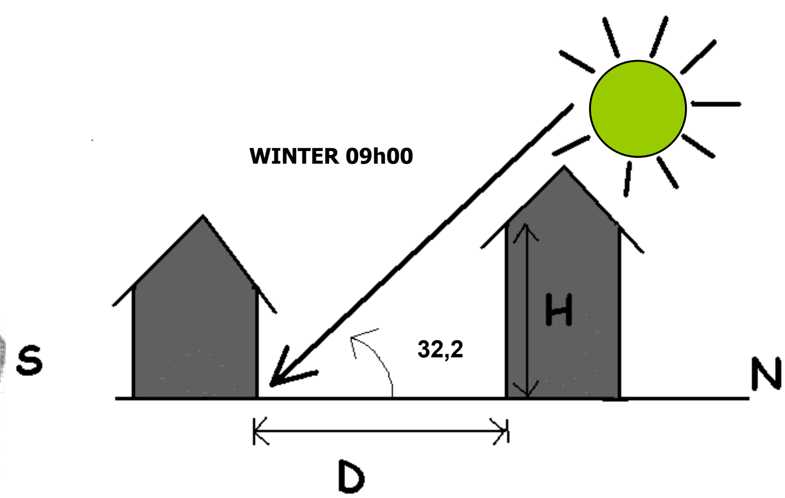


Fig. 22 - Solar access for building spacing in JHB. D = 1,5H.

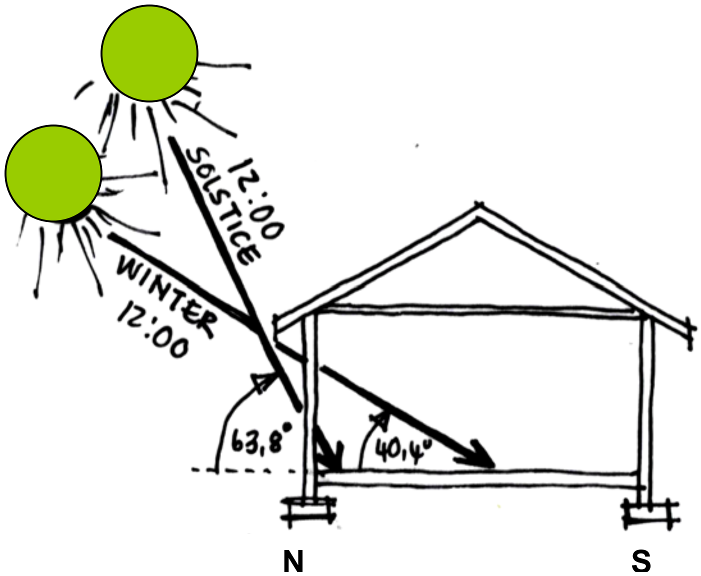


Fig. 23 - Roof overhang, window height and positioning for Johannesburg.

The following variables affect human comfort: [Holm, 1996:64]

- Temperature – the comfort range is defined from 16 – 23 grade Celsius with the optimum temperature being 21 to 22 for seated persons exposed to air movement of 1m/s.
- Humidity - the desirable relative humidity range lies between 30 – 65%. Johannesburg's average monthly relative humidity level is 56,05%. The humidity level is moderate and not considered problematic. Humidity levels are low in the winter,
- Air movement
- Radiation – for ex. a person seated at a window may sit in the sun and will hotter than colleagues in the shade.
- Type of clothing worn – encourage clothing to be comfortable for eg. no ties in winter and big jackets in winter (save 20% of energy bills)
- Acclimatisation
- Age
- Body type
- State of health
- Metabolic rate

[Holm, 1996:5]

Thermal efficient buildings provide the desired comfort zone and promote productivity, health and mental/physical energy.

- Allow maximum natural light to penetrate the building.
- Establish type of lighting after deciding which activities are going to take place.
- The light source will influence the overall effect.
- Compact Fluorescent Lights (CFL) – (tiny tubes folded into a compact shape).
  - energy saving
  - operate at lower temperatures
  - last a long time
  - can be used indoors/out
- Avoid glare.
- Contrast of light and shade are a special effect.
- Revealing textures.
- Large glass areas will provide:
  - healthy psychological reaction associated with the sense of openness and freedom.

- Control penetration
- Block the direct rays of the sun before they can pass through glazed areas.
- Use special sun control devices (fixed or movable).

Entrance/atrium:

- Fully illuminated by the natural light that pours flashes of colour and the combination of textures present come out as one moves into the building.
- The large glass wall will link the elements, textured materials, light and textured walls.
- The light, air and breathing space of the building must overwhelm you when entering.
- Form a transparent and friendly focal point by using glass that offers natural light and aids circulation and orientation.

Design the building to make optimal use of day lighting:

- Orientation, space organization and geometry of spaces to be lit.
- Location, form and dimensions of openings.
- Location and surface properties of internal partitions which reflect daylight.
- Location and form of devices controlling light quantities and solar control.
- Light and thermal characteristics of glazing materials.

[Holm, 1996:6]

Glazing in windows, doors and skylights is the source of the greatest heat loss in winter and at night and the greatest solar heat gain. Glazed areas need to be designed to eliminate solar radiation in summer and capture it in winter to ensure superior thermal performance of a building. Direct and diffuse solar radiation is transmitted through glass. Shading of windows only stops direct sun- rays. Heat gain is possible during daylight whereas heat is loss at night. [Holm, 1996:12]

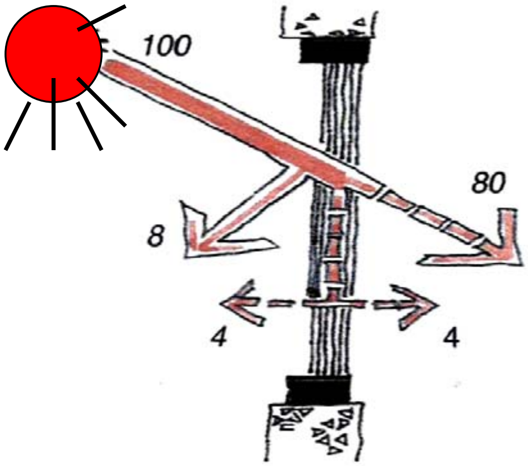


Fig. 24 – **Transmission of heat through clear glass.** 4mm clear float glass with 0,02% Fe2O3 admits 84% of solar energy.

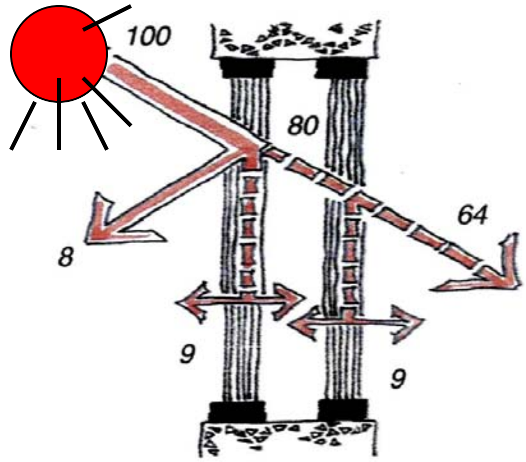


Fig. 25 – **Transmission of heat through double glazing.** Double glazing is not a strategy to stop penetration of sunlight.

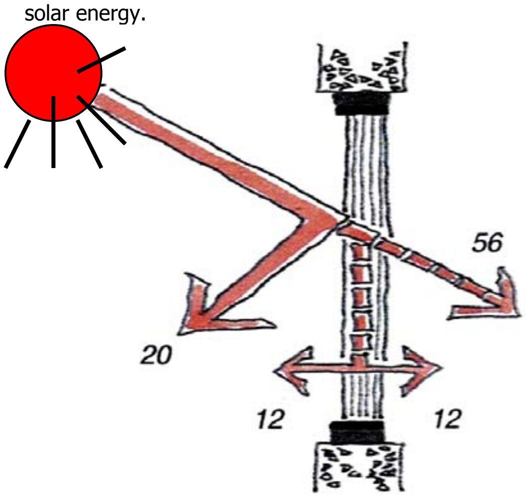


Fig. 26 – **Transmission of heat through reflective glass.** Note the increased temperature of the glass panes.

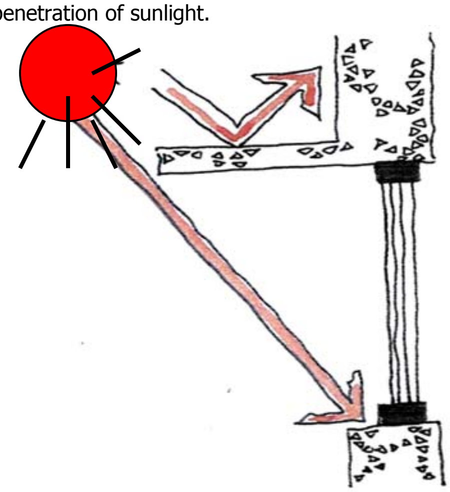


Fig. 27 – **Design of external solar control devices according to vertical sun angles.** Watch sight lines.

Since glass is transparent, solar radiation is transmitted through it. Glass also reflects and absorbs radiation which it reradiates to both inside and outside. Glazed areas create a greenhouse effect by allowing direct radiation (short wave) to be transmitted through it, but not to return. The direct radiation converts to heat when it strikes objects and is reradiated as heat (long wave radiation), this heat is captured. [Holm, Viljoen, 1996:12]

External shading, generally in the form of overhangs, fins or external louvers, is the most effective means of reducing radiant heat gains through glass. This is because solar heat is prevented from reaching the glass and entering the building. [Holm, Viljoen, 1996:12]

The benefits of external shading are maximized if these few guidelines are observed:

- east and west facades should be as small as possible
- the use of glass on east and west facades should be minimized

- glass heights should be kept to a reasonable minimum to enable maximum protection from overhangs; and
- building layout and orientation should be arranged such that the major facades are north or south facing.

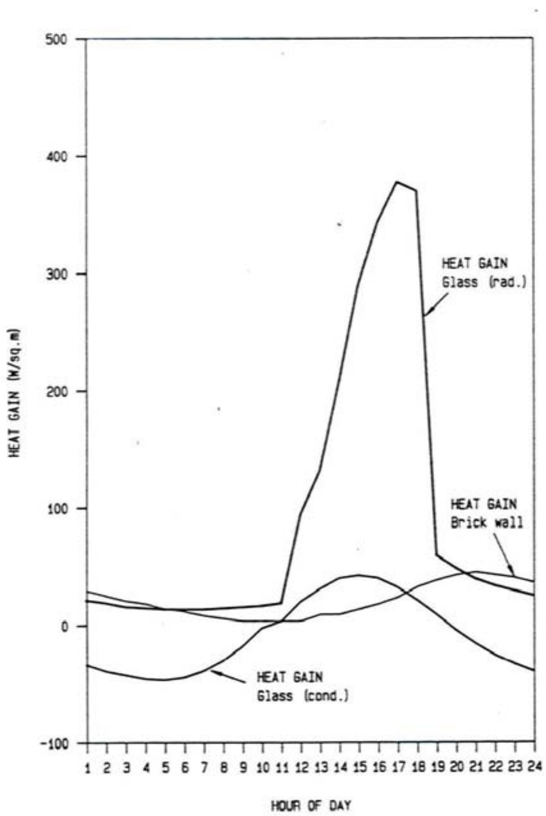
[Holm, Viljoen, 1996:12-13]

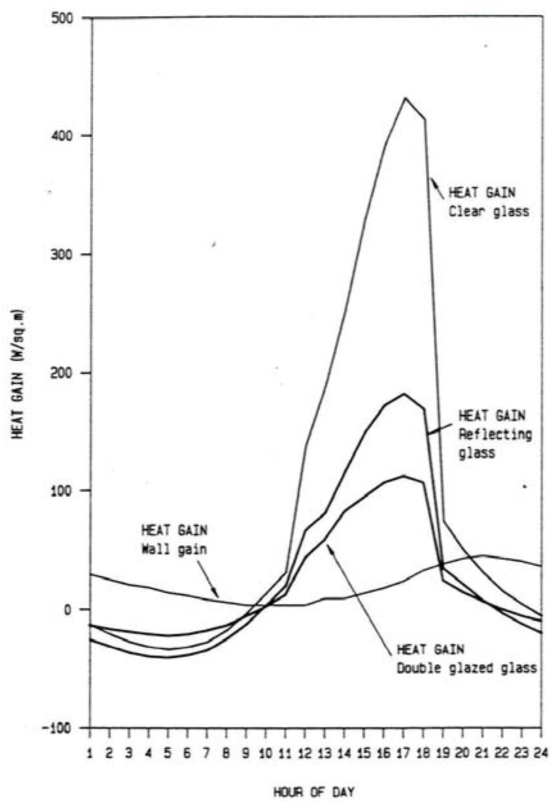
The parameters pertaining to the incorporation of overhangs or fins in façade design which might be considered important architecturally are identified as follows:

- minimum overhang or fin length;
- corresponding vertical or horizontal shadow angle.

CONCLUSION:

Large glass areas mean large heat gains or losses to or from any building. Solar controlling glass, while effective in reducing direct and diffuse radiant heat gains, allows large conductive heat gains in summer and large conductive heat losses in winter. Double glazing systems are effective in substantially reducing both radiant and conductive heat gains, but they are expensive. External shading is a simple and effective means of reducing solar heat gains and can be a cost effective means of controlling heat gains if it is handled appropriately. Façade design is the crux of energy efficient building design. [Raats, 2002:38]





A rough guide, for continuous lighting during exhibition (museum) hours do not exceed:

- 50 lux on sensitive items (textiles etc.)
- 150 – 250 lux on most other classes of items.

Exhibition lighting is crucial to the success of the exhibition spaces. Visitors expect to be able to see exhibits clearly and study them in detail, the atmosphere of the exhibition to feel "right", to enjoy their visit, and to feel that they are seeing the "real thing". Staff have equally high expectations – that the lighting dosage for exhibits will be within safe limits, maintenance and running costs will be kept to a minimum, and that equipment and controls will be adaptable/flexible, reliable and easy to use.

Ascertain whether natural light is required to feature in the design of exhibit areas and determine a basic lighting strategy:

- Full natural lighting of exhibits, supplemented by artificial light below specified level of illumination.
- Background natural lighting of space and exhibits, plus highlighting of exhibits with artificial light.

- Ambient natural light, plus artificial lighting of exhibits.
- Top-lit or side-lit spaces.
- Artificial lighting – diffuse, directional or combination – of space and exhibits.
- Electronic mechanical or manual controls of natural and artificial lighting, independently or interactively.

The quality of light is very important: level, dynamics, colour rendering and absolute colour, direct and indirect glare, and shadows must all be considered and controlled. Great care must be taken in devising natural lighting systems, in choosing luminaries and lenses, and in deciding their position. Methods of eliminating UV light include:

- Absorbent paints for light wells (indirect natural lighting).
- Absorbent film applied to the interior of the glazing.
- Plastic film sandwiched in the glazing and on glazed display case tops.
- Glazing with 6mm VE Perspex of equivalent rigid filter.
- Plastic sleeve on fluorescent tubes.
- Glass filter on tungsten – halogen lamps.
- Use of non-UV-radiating lamps and fittings – stand bulbs and spots, fibre-optics, etc.

Surface heating effects on exhibits and the raising of air temperature inside display cases/exhibit areas caused by lighting must also be avoided. Method of reducing infra-red radiation and air heating include:

- Use of cool sources – fluorescent lamps, fibre-optics.
- Use of reflectors on tungsten-halogen lamps.
- Removal of heat-generating gear (transformers, fibre-optic lamp box, etc.) from danger areas.
- Extraction of lamp-heated air via luminaries.

By establishing of lighting requirements, consider:

- What visual tasks must be provided for.
- The shape of each space in relation to sizes and positions of windows, light wells, etc.
- Lighting levels required for general and task/exhibit illumination.
- Natural lighting – orientation, and shape and sizes of glazed areas to avoid glare, uneven light, direct sunlight in exhibit, storage and sensitive work areas, reflections, and unwanted solar gain and heat loss.
- Artificial lighting – appropriate system, e.g. general (luminous ceiling, indirect, direct diffused), localized, task or combination; intensity, quality of light (glare, excessive contrasts, colour), efficiency, length of life, initial and on-going costs.
- Type of lamps and luminaries; also location and arrangement.
- Elimination of ultraviolet light in all exhibit, storage and sensitive work areas.
- Flexibility, e.g. individually controlled task lighting versus general lighting; alternatively, track with movable fittings of modular luminaries in suspended ceiling.
- Veiling reflections (bright reflections in the task area) – particular care must be taken with visual display unit screens; lighting for these will require special consideration (an indirect lighting system).
- Emergency lighting requirements – generator or batteries; automatic change-over device; separate circuit to light strategic routes and exits.
- Access to luminaries for maintenance and cleaning.
- Controls and switching patterns – control from central point, time control, etc.; also individual switches for rows of light in storage areas; special switch for groups of lights for cleaners or other users.

[Matthews, 1991:80-81]

Natural day lighting-design should include:

- window size
- room depth
- internal colours
- orientation
- solar control

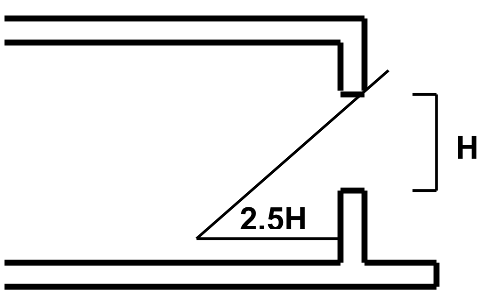


Fig. 30 – Rule of thumb.

For all normal environments, adequate light should fall not merely on the horizontal working plane, but also on walls and ceiling; or the room will look gloomy. Light-coloured room surfaces make it very much easier to achieve good light distribution than dark-coloured surfaces.

Rule of thumb:
[Tutt, Adler, 1998:412]

Light-coloured room surfaces (including the floor); side windows, rooflights and electric light fittings of high B2 number (downward light distribution tends to be dispersed) will aid the achievement of good scalar illumination in most ordinary rooms.

Overhead light fittings are less likely to cause glare to occupants than more distant fittings; glare is therefore more likely in long rooms. There should be a dominant direction of lighting inside the building (windows/rooflights/electrical fittings etc.) rather than completely diffused light. A generally well-liked angle of lighting is downward and from the side, at an angle of 15 – 45 degrees to the horizontal plane.
[Tutt, Adler, 1998:416-417]

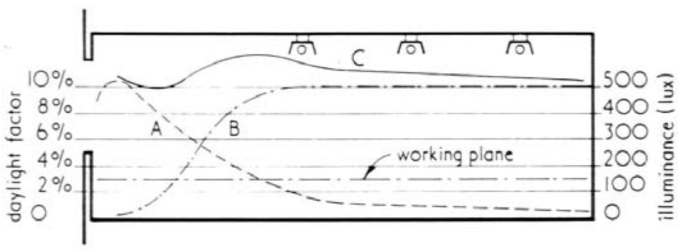


Fig. 31 – The PSALI principle. Daylight near the window, and artificial light deeper in the room, combine during daylight hours.

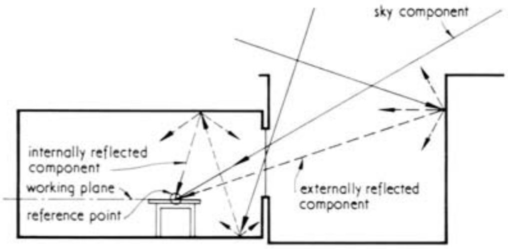


Fig. 32 – Daylight reaches indoor working plane in three ways: 'daylight factor' calculation takes account of all three.

RULE OF THUMB:
Risk of glare is increased with:

- Long rooms
- Low ceilings in large rooms
- Dark decorations
- Lack of diffusers or louvers on light sources
- Electric light fittings with high B2 values. [Tutt, Adler, 1998:418]

Large rooflights can cause great problems of solar heat gain summer and of heat loss in winter. In proposed buildings, sides facing due south, or in any direction east or west of south, should have all points 2m above ground level accessible to sunlight for 3 hours on March 1. Sunlight is only counted if the sun is 10 degrees or more above the horizon, but sunlight at a bearing of less than 22,5 degrees to the side of the building is not excluded. [Tutt, Adler, 1998:421]

AREA OF GLAZING REQUIRED TO GIVE A CERTAIN MINIMUM DAYLIGHT FACTOR:

Estimated by the following formula:
P = 10 x D
P = area of glazing as % of floor area
D = minimum daylight factor

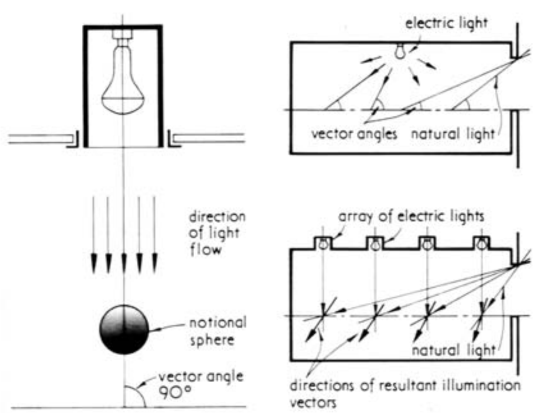


Fig. 33 – Direction of illumination vector under a downlighter will be virtually vertical; most people will find this unpleasant. A single overhead light fitting, in the middle of the room, gives good modeling (provided it emits light sideways as well as downwards). Daylight through side window also gives a satisfactory vector angle of about 45 degrees; and the combination of overhead electric lights plus side windows gives excellent modeling qualities to light.

Sufficient escape lighting should also be provided:

- to indicate escape routes in the building
- to allow safe movement towards the exits
- to illuminate fire alarm call points and firefighting equipment.

All exits and escape routes in places of public assembly must be clearly identified by signs reading "EXIT" (see BS 5266 and BS 2560). In a darkened auditorium, an illuminance of 0,02 lux is accepted, provided another 0,18 lux is added from a non-maintained system when the mains fail, to bring the illuminance up to 0,2 lux.

Fluorescent tubes consist of a glass tube filled with mercury vapour at low pressure, through which an electric arc is struck. Maximum efficacy produces the "high-efficacy" class of fluorescent lamps, giving 50 to 80 lumens of light output per watt of electricity, but providing less than ideal colour rendering. Good colour produces the "de luxe" class of fluorescent lamps, giving only 30 – 55 lumens per watt.

[Tutt, Adler, 1998:430]

The three kinds of "high-efficacy" tubes can be used to create different atmospheres: [Tutt, Adler, 1998:430]

- Daylight (the coolest colour) – reading rooms
- White (intermediate) – combined, atriums
- Warm white (the warmest) – restaurants

Situation	**Standard service illuminance (lux)**		**are index**	**appearance of lamps**	**letters of suitable lamps (See table 2)**	**es**
Corridors, passageways	100 scalar	1,2m above floor	22	Intermediate or warm	CDEFHIJLMQ	Solar illuminance not less than 120 lux if there is no daylight
Lifts (passenger)	150	Floor	-	Ditto	CDEFHIJ	
Stairs	150	Treads	-	Ditto	CDEFHIJLMQ	Limit glare
External covered	30	Ground	-	Ditto	CHIKLMNPQ	Illuminance should be compatible with adjacent lit areas
Entrances and exits	30	Ground	-	Intermediate or warm	CHIKLMNPQ	
Restaurants	200	Tables	22	Ditto	DEFHIJQ	Arrange switching to allow variation of all illuminance
Stores and stock rooms	150	Vertical plane	-	Intermediate or warm	CHIKLQ	
Car park - underground	30	Floor	22	Intermediate or warm	CHILMN	Vertical obstructions should be lit to a higher illuminance than floor
Libraries – reading rooms	300	Desks	19	Intermediate or warm	CDEFHIKL	Low noise level required
Offices - general	500	Desks	19	Ditto	CDEFHIKL	Minimise desktop reflections by suitable luminaire location
Conference rooms - office	750	Tables	16	Ditto	DEFJQ	Consider variation of illuminance to suit different functions
Computer rooms	500	Working plane	19	Intermediate or warm	DEFHIKL	Avoid specular reflections in consoles
Shops	500	Display – vertical and horizontal	19	Cool, intermediate or warm	ADEFGHIKLPQ	Local or localized lighting needed to emphasise displays

Fig. 34 – Recommended illuminances, limiting glare indexes, and lamp colours for specific situations.

Glass is one of the most versatile materials in extensive use throughout the building industry. Perhaps the most visible glass developments have been featured on security, and the importance of solar and acoustic control. Tremendous advances have been made in glass technology to meet the requirements needed to overcome the specific difficulties that these aspects provide.

Laminated glass can be designed to withstand bullets and bomb blasts by using multiple laminates of glass and thicker interlayers. Glass has long surpassed other materials in the role of solar control.

The thermal zoning of the building is a very important energy conservation strategy to take into account. The utilization of solar gain to heat areas in winter (when placing offices etc. relative to the path of the winter sun), will minimize the need for active heating. Thus, the offices and meeting rooms should take first preference.

The storeroom, toilets, equipment room, delivery lifts and passages will be placed on the west side of the building. Spaces like these will serve as buffer zones between hot summer afternoon sun, and the occupied zones. During winter, these zones will act as buffers for outward heat conduction.

The optimum orientation will be the façade that receives a combination of the most radiation during winter and the least during summer. The building is orientated so that openings are predominantly facing north and south. Openings in the west walls are minimized. The optimum orientation for solar windows and solar collectors is north.

The direct component of solar radiation is best controlled by the use of external shading devices. The general principle of the design of the shading devices will be to intercept the solar radiation before it enters the building during summer periods. In winter, the devices must allow the winter sun into the building.

NORTH-FACING WINDOWS:

- horizontal overhangs extending beyond the window width will be sufficient or vertical fins should be employed

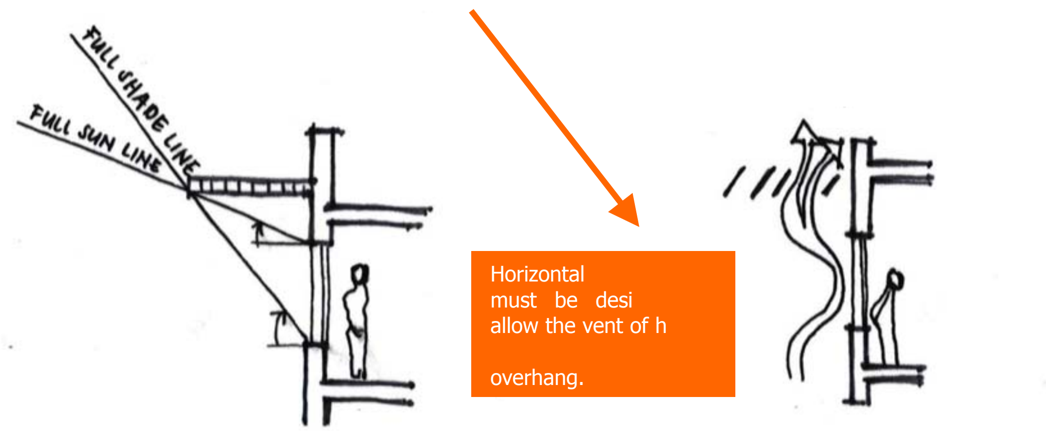


Fig. 35 – Horizontal overhangs and louvers – northern façade.

It is proposed that the lighting for the offices be ceiling mounted low brightness luminaries and allowance for indirect lighting systems in the more social areas. For parking bays a level of 80 lux will be sufficient, elevator lobbies 200 lux and entrances 100 lux. The lighting of the entrances/exits will provide a transition zone to avoid sudden changes in illuminance between inside and outside the building and basement.

Luminaires will be open tube twin fluorescent of 1200 and 1500mm length. For general areas, the luminaries will be evenly spaced, ceiling mounted on a grid pattern. Sensors that control room lighting according to occupancy should be provided.

Lighting will be controlled from a distribution board on each floor, with the facility to switch off all the lights on the floor. A central control panel in the security control room will allow the various floor lighting to be switched off in zones. Entrance/exit lighting will stay on continuously for security reasons. Dimming of incandescent lighting in meeting/conference rooms and restaurants will be allowed.

Productivity is adversely affected by discomfort. It has been established that work efficiency can drop up to 40% with an increase in dry bulb temperature from 28 - 34 degrees Celsius. However, optimum performance conditions do not coincide with those for optimum comfort. Cooler than optimum promotes mental activity and warmer, physical activity. Optimum conditions promote sleep and relaxation.

Light provides visual comfort or causes discomfort. Glare and high contrast in lighting levels promote discomfort and cause a blinding effect. This can be alleviated by more even distribution of light (use of diffused light).

Light is an electromagnetic energy radiation within the spectrum between ultraviolet and infrared radiations. Light causes a sensation perceived by the eye which is interpreted by the brain as vision. The eye sees best in natural sunlight.

Critical measurements related to dimension of openings are the area (e.g. 20% of the floor area), the height of the opening and the position of the opening in the wall. Roof overhang plays an important role in window positioning.

- location and surface properties of internal partitions which reflect daylight –
    - dark interior surfaces absorb light and do not reflect it deeper into the spaces
    - reflective roof surfaces adjacent to roof monitors will aid light distribution
- location and form of devices controlling light quantities and solar control –
    - solar control devices are designed according to sun angles and usually allow winter sun to penetrate the building, but screen summer sun to prevent overheating
    - solar control devices reduces the amount of natural daylight entering the building
    - they may absorb light depending on the materials used
    - solar control devices can be designed to reflect light into the building, for example, light shelves
- light and thermal characteristics of glazing materials
    - different glazing types exhibit different light transmission and thermal characteristics
    - clear glass transmits about 80% of light while some heat resistant glass transmits 50% and reflects approximately 40%
    - glass that transmits much daylight also admits much heat, so solar gain is high
    - reflective glass reduces heat gain and day lighting levels [Holm, 1996:6-7]

MINIMUM STANDARDS:
The National Building Regulations (SABS 0400) specifies minimum requirements for the areas of openings that provide natural day lighting.

The minimum area of openings should be 10% of the floor area of a room served by the opening or 0,2m2 whichever is the larger. The regulation also gives minimum standards for distances between openings and outdoor obstructions.

DESIGN FOR SUPERIOR/SATISFACTORY DAY LIGHTING:
One of the greatest problems with natural day lighting is the prevention of glare. Glare can be prevented by devices which diffuse light. This can be achieved in the following manners:

- light shelves allow reflected light to enter, but reduce the area where daylight can enter
- reflective indoor colours reflect light into darker interiors
- skylights, roof monitors and atriums allow light to enter from above; this can be exploited where rooms are deep or where they don not border on a façade; in atriums the glare may need to be controlled by shading because direct light reflected off walls of atrium may cause glare
- reflective blinds or solar control devices (shading) reduce glare
- glare is also avoided by creating an artificial sky; this simulates overcast sky conditions, i.e. diffused light; it can be created by using direct daylight or artificial lighting
- mirrored walls give multiple reflections which create the illusion of an infinite horizon

[Holm, 1996:7]

"The sun, usually man's friend, becomes his implacable enemy in certain latitudes at the height of the summer. Therefore some device enabling the sun to have its full effect in winter and checking it in the dog-days of summer was indispensable." Le Corbusier in the 20th century

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