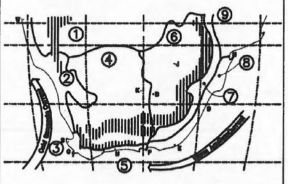
Enviro-friendly Methods in Small Building Design for South Africa

Alaric Napier B.Arch

CLIMATIC REGIONS



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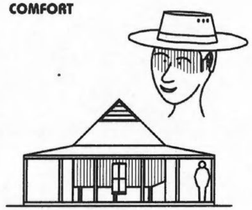

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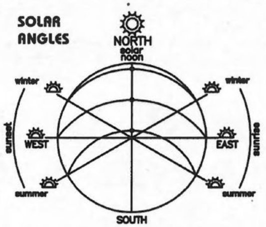

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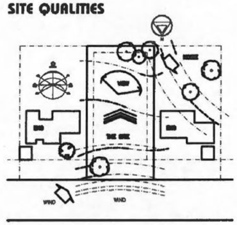

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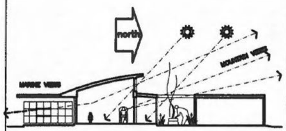

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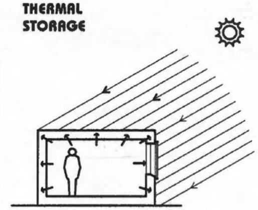

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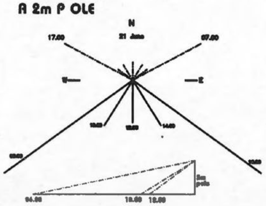

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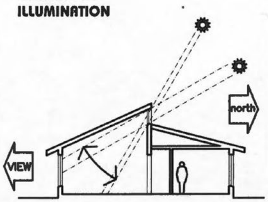

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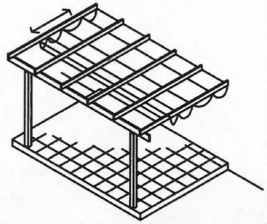

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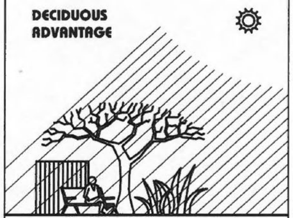

Enviro-friendly Methods in Small Building Design for South Africa

by

Alaric Napier   B.Arch

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Very sincere thanks is due to Ken Munro, previously of the Department of Architectural Technology, Durban University of Technology, for his interest, time and effort in writing the Foreword.

Gratitude is due to Autodesk Press for permission to use
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FOREWORD

By Ken Munro, Senior Lecturer, Durban University of Technology

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As a colleague of Alaric Napier's I have always been impressed by his passion for teaching and imparting knowledge. This he has always undertaken in a pragmatic fashion, simply talking, and making good sense around the practice of architecture. These qualities along with his many years of experience and interest in the field of environmental resource management have uniquely qualified him to write a book of this nature.

The book focuses on relevant and important issues around environment-friendly building design in living and working spaces within Southern Africa. It is primarily aimed at fulfilling an identified need amongst local students of architecture for information in this area, and to promote this very important field of study. It encompasses sections on personal comfort, climatic considerations in Southern Africa, the sensible and appropriate use of technical and design solutions and the search for an ecological and environmentally appropriate architecture.

A very good balance has been created within the book between an easy-to-read style and simple, clear line drawings. The book will both inform and delight the reader with its illustrations, practical examples from everyday life and its well documented technical solutions. It is a valuable resource for all within the built environment.

PREFACE

Published originally in hard copy in the year 2000 and written for students of architecture, this book has in the intervening years been used by both students and practitioners to understand and expand the practice of designing buildings to work with the climate rather than against it.

Now published electronically under a Creative Commons licence, the hope is that by making it available to a wider audience, the fundamental lessons and practices of passive and climate-conscious design will continue to spread. Although this electronic edition has been reformatted and edited slightly, most of the text has been left as originally written. Some place names and product names may have changed in the meantime.

This book is intended for quick reference. The contents, by chapter, lists details of each section, and a working index is included at the back. These facilitate quick access to information. The student is strongly advised to (a) work systematically through the "building blocks" or logic which relates to given themes; (b) to read the text as well as drawings - even if there is repetition; (c) to verify from experiment, from observation and investigation what is seen in print and (d) to look wider for further evidence or examples of what is presented, as the content is restricted to basic information. The reader should understand that the *combination* of application of principles brings the best result - as against applying a single solution.

Tasks are set at the end of each chapter to consolidate the previous chapter's content. They are, in many cases brief, and do not set out detail as one may do in an academic project. Tutors must naturally feel free to set alternative or variant tasks, and likewise, students who wish to prove the content to themselves (or otherwise!) may embark on their own observations or experiments. But again, the value of this form of learning is strongly recommended for reasons given in the text. Students should receive assistance in doing some of the tasks as they demand innovative enquiry and exploratory thinking.

It is sincerely hoped that architectural students will find the work enlightening and a useful tool. It will become a set of useful criteria from the very first days of study through to later years, and even beyond into the workplace.

INTRODUCTION

There is an urgent need for Architects and Building Designers to be more aware of their obligations to the community in conserving our valuable environment. If the world's community, up to now, had done nothing about controlling the conduct of uncaring and selfish individuals, we would have had a very poor world to live in. Many examples demonstrate where the process of deterioration of natural habitats has been reversed. These provide a realistic incentive to participate in doing the same now in architecture and its related fields. Industrial pollution destroyed life in large parts of, among many others, the Mediterranean and the River Thames, and by control, that life has been restored.

It is remarkable that at the turn of the millennium, in South Africa, it appears that the majority of buildings are conceived in the minds of their designers without serious thought to environmental issues. There are very large buildings professionally designed which absorb enormous quantities of heat, and their interiors have to be "reconditioned" to make them comfortable for occupation, and in some cases, possible to inhabit. The word "reconditioned" is deliberately used, because frequently, there are very comfortable conditions *outside* such buildings, but the interiors become overheated, then need cooling again. The same may be said for cold regions where heating has to be applied quite unnecessarily.

The widespread attitude which gave acceptance to these "solutions" emanated from an older generation who enjoyed the plenitude of the 1950's and 1960's; it came from those who occupied generous unspoilt open spaces, and others who enjoyed a good comfortable climate which needed little modification for internal use in shelters. There were yet others who had ready resources in wood or cheap coal for heating and food preparation. These attitudes have been passed on to succeeding generations, but at last it appears they are being changed through school education on the environment. Education is good, but needs now to be put into realistic and beneficial terms.

As an example, motor industries in Europe have reorganised themselves to ensure minimal damage to the environment. Materials are *chosen* which have minimal environmental effect in their production, and likewise, that they are recyclable. Those which have to be dumped are chosen - and are legally required - to have minimal harmful effect on the atmosphere, soil or on rivers. The building industry in South Africa comprises a large proportion of the national industrial component, and comparatively little has been done to address these issues.

There are many books illustrating specialised research and experimentation on various technologies such as underground accommodation, self-sustaining environments, futuristic techniques in building, and no doubt some of these concepts, given time, will materialise. What we wish to address in this work however, is what we can do here and now, with current, available technology, using conventional building techniques. We want to discover where we have been going wrong, and to make adjustments. We want to introduce easily applied new technology; and above all, simply to *apply* existing knowledge. Where a single individual makes the effort for improvement, little difference will be made to the whole. However, if we all make a practical effort, a worthwhile beneficial change will become evident.

A deliberate inclusion in this book, i.e. at "beginners" level, is very brief information on the principles of ecology and the environment with existing and potential dangers connected thereto. Many school leavers will have had comprehensive education in these fields. For such as have not had instruction, there is a need to acquire knowledge. Simply being aware creates an interest in, and an incentive to make a difference to our environment through better practices in building and architecture. It is worth taking intelligent notice of these principles as well as trying to find out in empirical terms what causes deterioration to our natural environment, and how to go about the prevention of further such trends.

This is done by noting how the building process is conducted, from conceptual stages in the architect's mind, through the drawing process, through construction, to completion of the building.

Since this work begins with the topic of clothing, it is worth drawing attention to a common societal and cultural trap! We see clothing paraded as fashion. We begin to think that *that* is the proper way to dress, and the temptation is there to enjoy the fun and sensation. The message is loud and clear that such clothing, in abundant cases is far from functional, and passes off the scene as quickly as it arrives. Let us also observe that architects, being attached to the art world, are subject to the same allurements, and we see too many followers of fashion at the expense of function. Sensationalism as seen in expensive glossy publications is seductive, and to go along with current universal trends and styles seems to be obligatory. We see similar weaknesses in other professions.

We therefore need to get into our minds the solid foundational concept, that only after the designer has fully and properly addressed the principles of function, can the problems of visual qualities be addressed. The one is not "inferior" to the other, neither are they mutually exclusive, but together they provide a unified wholesome solution which meets all aspects of human need and desire. After all, aesthetic values are also functional since they make the eye and mental process of appreciation satisfied. A good chair makes the body comfortable in a seated posture. However, a chair which is not comfortable will not be used, and its working qualities are therefore essential to its proper design. Its appearance only then, may be developed until a visually attractive solution is created.

A product designer or architect is, in broad terms like an artist working with a given medium. The artist works with pencil, paint, sculpture, or music. A strict discipline applies, and the talent of the creator is seen according to the limits natural to that medium. An architect has, as a medium a set of building materials, and the "sculpture" has to serve an occupational, and note, a *functional* purpose. With these and others as constraints, a work of art has to emerge. Side-stepping functionality places the designer's integrity in question.

Having written thus, it is necessary to point out that the design of buildings is a complex matter, and this work limits its focus to environmental issues. This is because energy conservation, the environment and pollution have become major concerns of our planet in recent decades. However, for beginners in architecture, design guidelines of a general kind are included, and accompanies the main thrust of this work. The book relates to small buildings, using the dwelling, its site and surroundings as the familiar example. The principles are commonly applicable in larger projects as well.

1 ● FUNDAMENTALS - THE ENVELOPE - CLOTHES, BUILDINGS

WHERE ARE WE GOING?

THE ECOLOGY It is assumed that students reaching this level of education know about the ecology and related environmental issues. For such as have not covered this topic at school, it is well worth finding an encyclopaedia in a library or elsewhere and reading up on the subject. It comes down to realising that our living planet would not be living, including ourselves as human beings, without the operating food chains, both in plant and animal life.

These chains exist in air, soil and water, and in many cases, where one link in the chain is destroyed, the other links suffer, and the whole system becomes endangered. Systems are fragile, and it is sobering to think that any *one* life line, be it the elephant, the squirrel or the agapanthus, exists because each has handed down life to the next time phase, whether it be a generation or a season, over uncountable numbers of years.

Mankind has existed along with the natural ecology for these ages, and comparatively recently has settled down from a nomadic life to farming, which was then aided with animal-driven (or water- or air-driven) machinery, which was then machine-driven. Each stage allowed agglomeration of populations, and the real damage came about noticeably after the industrial revolution. Through fumes, waste, accident and heat, the atmosphere, rivers and oceans and the earth have been polluted, all threatening ecological systems - in air, soil and water - as mentioned above.

Many species of plant and animal have been lost, and cannot be brought back to life again, except perhaps a very few, through latest genetic techniques. This calls for the urgent attention of all of humanity.

OUR LEGACY AND LIABILITY It follows then, that building and architectural professionals in South Africa have a growing environmental liability due the to past industrialisation of our planet. The building industry comprises a major segment of industry overall. This calls for thorough management in the fields of waste and pollution, and also to curb waste in energy, which draws on natural fossil deposits, which form the staple supply for that energy.

For decades the "doomsday" prophets have correctly pointed to habitual follies and hazards, and only comparatively recently have the governments, commercial, industrial and educational managers woken up and responded in specific terms. In the architectural profession however, very little has been taken up in realistic terms. There are many books on this topic on library shelves and in research institutions, but that knowledge needs to be transferred from ink-on-paper to visible action.

For example:

● Why do buildings continue to appear along our streets which really belong to the American Big Car gas guzzler-culture of the '60's, needing excessively large air-conditioning plants, fans, ventilators and heaters to keep them comfortable?

● To what extent do designers really think about making their buildings work efficiently in a given climate or micro-climate?

● Do we really know how our weather works: the times and angles of sun, the nature of wind, rain, and the thermal behaviour of materials and conventional forms of construction?

- How often do designers innovate, and experiment with models or make deliberate observations at existing buildings?
- Do our objectives in landscape development align with these principles, enhancing the passive performances of the buildings they accommodate? Do they help to cool the atmosphere or to warm it up?
- Why does only a small minority give thought to how materials are reused - or what happens after being thrown on the scrap heap after demolition?
- How many of us think about where such materials come from - where lengthy transport routes send harmful gases into the atmosphere?
- Do we consider how much energy has been invested in the materials and methods of building that we choose? Do we even look at alternatives to our magazine-fashion-inspired selections?
- Are we properly aware of construction habits on site, and is machinery operating efficiently, and is it being managed economically?
- Do architects and interior designers choose finishes which have minimal negative impact on our environment - i.e. reducing energy and harmful detergents needed for cleaning, longevity of finishes and ensuring that such materials and finishes make the most of ambient thermal qualities?

ENERGY The most elementary and effective method in beginning to make an environmental contribution through architecture is by saving energy. In the first few chapters we shall look firstly at typical problems in thermal wastage and then apply well known solutions. This will cover the building envelope - walls and roof, and then its included elements in openings whether for air or light, and their variations. Thereafter, how we manage outdoor living spaces, leading on to overall site development. From there we move to climatic design, climatic regional design, and to material choices, construction control and broad detail on choosing energy-consuming equipment for typical small buildings.

IDEAL COMFORT It is safe to say that most people would prefer to live and work out in the open - in cool but sunny conditions with trees above and green grass below, perhaps with a gentle breeze now and then - like the ideal flea market weather! Attractive as the idea may seem, we would soon become most uncomfortable. The weather never for a moment remains static, and at some time or other, we would have to take precautions against hot or cold, wet or wind, and so on. The elements of the weather have to be moderated for our continual comfort, and to enable us to undertake typical indoor activities such as drawing, writing, cooking or sleeping, controlled conditions are very necessary.

THE ENVELOPE A building envelope is not only a shelter, but becomes a sophisticated modulator by which the qualities of the external weather are processed into qualities which are suited to the interior.

Note an important point here: All buildings, whether small or large, use very similar principles to achieve interior comfort - simply because there are people in both types of building. So what you learn to apply in small buildings is just as applicable in the large. The techniques however usually become more complex for larger structures.

CLOTHING As a practical introduction, a good way to look at problems and solutions related to buildings is to observe how humans themselves make their bodies comfortable - by means of clothes. There are remarkable likenesses. Why? Clothes are designed for human bodily protection and comfort, inevitably related to environmental conditions of temperature, sun, wind, rain or other. Buildings are the same, for the sake of the humans that they shelter. Have a look at the accompanying drawings which make this point. You may wish to think of further examples that apply. As mentioned above, where an out-door existence may at first sight be attractive, so for a moderate climate, going about in a beach swimming outfit may, for more than other reasons, seem to be the most attractive. But then again, the weather does change, and one ends up with a number of sets of clothing for differing situations, seasons and weather conditions.

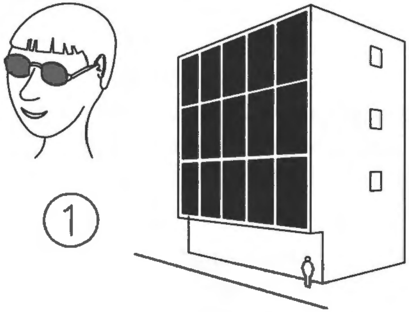
ILLUSTRATIONS

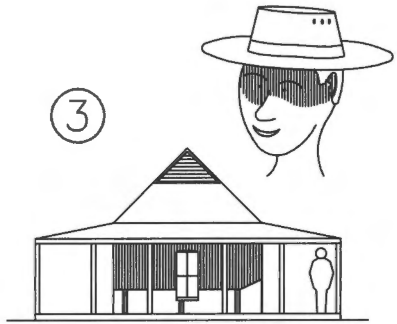
1 For sunny days, glare becomes uncomfortable to the eyes. We wear "shades" - or sun glasses to cut out some of the rays. You will see buildings with tinted glazing - for the same reason. Special glasses for building have been developed along complex scientific lines, and constitutes an advanced component of study at higher level.

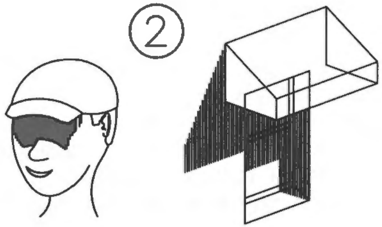
2 In our country, sun is prevalent, and to protect the face, a peak cap is worn. With deterioration in the protective ozone of the atmosphere, skin cancer has become a serious threat to our health. The peak cap is only a partial solution but is worn for energetic or sporting activities. It is also a fashionable necessity in some quarters. You will often see the same applied to windows where sun penetration is a nuisance, causing damage to furnishings, glare and over-heating to occupants. A window facing the sun needs protection.

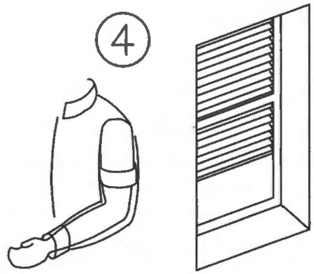
3 Taking this a step further, all-round shading is provided with a brimmed hat. Returning to sports, cricketers who spend time in the sun wear broad brimmed hats, again an essential against excessive tanning. Early Victorian houses had all-round roofs to verandas. The early settlers from Europe soon found that this was needed and added it as a "colonial" feature, the same applying to Australia and India. Note something else: the hat has vent holes in the crown - as does the Victorian

CLOTHES AND BUILDINGS
for human comfort: 1–4









counterpart - where roof ventilation was common. Otherwise heat can quickly build up in a sealed volume of air.

4 A shirt provides basic sun screening and if needed, a little warmth. However, one often sees the sleeves rolled up. This provides instantly controllable protection, to cool off or to warm up; to cover or to expose. In buildings we have curtains, shutters and blinds to windows to make the interior just right.

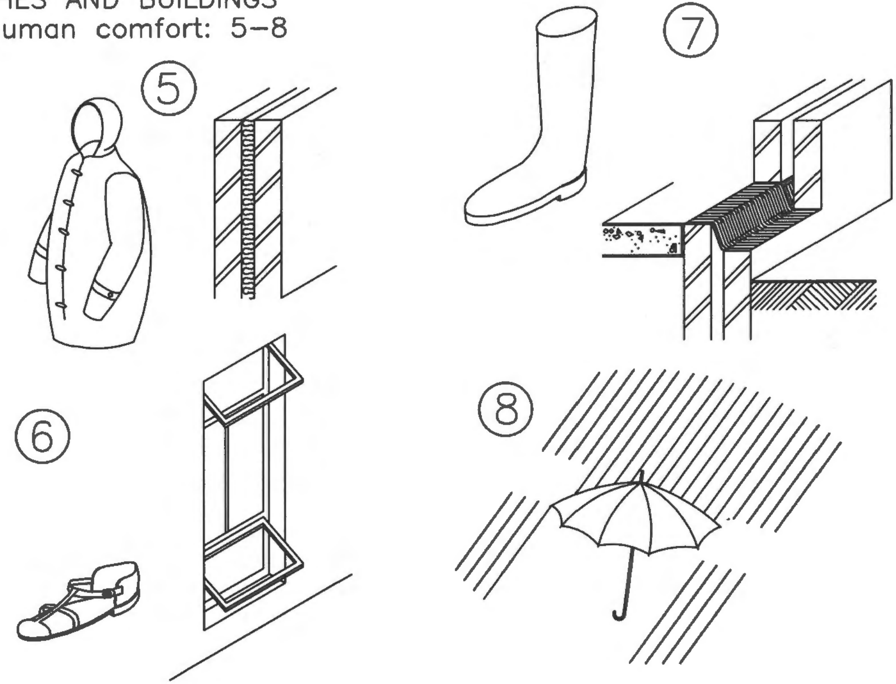
5 The anorak is needed in cold weather and is water-proofed too. It provides insulated thermal protection. Houses are insulated - often in both the walls and roof. The walls and roof of a house, as for the anorak, needless to say, are also water-proofed.

Trousers may be short or long. This illustrates that the full height of the body needs protection and comfort - a matter often overlooked in buildings.

6 Sandals illustrate the same principle - comfort from head to heel, and for warm climates, the sandal is light, and well ventilated. For hot climates, it is far better in buildings to provide low-level ventilation - in addition to normal and fanlight level. It makes a real difference to the interior.

7 Wellington boots are used against water penetration. One can walk about in quite deep water without being affected. A house must have its walls damp-proofed, and take special note that the floor level is always above surrounding ground level - so that the occupants are not engulfed by flood water. Always illustrate the elevation of a building with its ground floor level at least 150mm above the surrounding ground.

CLOTHES AND BUILDINGS
for human comfort: 5–8



8 After the bicycle wheel, the umbrella or parasol must rank as one of the great engineering inventions of the world. Imagine the versatility of such a scaled up device suitable for buildings. It is instantly put into action from something that looks like a walking stick, to an effective shelter - which can be angled, raised or lowered, to guard against rain, wind-driven rain, or sun. When all is well, it is immediately furled again into a very small volume. Engineers are developing tent-like shelters from strong fabrics and they are very effective, attractively light-weight and long lasting. As a relatively new innovation they are yet to be tested for longevity against cost, leave alone appearances which can quickly deteriorate in dusty atmospheres.

Having had a wide-angled glance at protective devices applied in clothes and buildings against unwanted weather elements, we shall take these one by one and see what effects each have in considerably more detail.

2 ● THE HUMAN BODY - PASSIVE PRINCIPLES

COMFORT STANDARDS

BODY TEMPERATURE CONTROL   The human body has an extraordinary ability to adjust to surrounding conditions. Within a very wide range of external temperatures, the body internally retains its constant temperature of 37° Celsius. It is a highly complex system, but the methods of adjustment with which we are familiar are: (a) in hot conditions, perspiring (or sweating), where moisture on the skin, through evaporation, takes heat from the body and gives it to the surrounding air; (b) in cold conditions, firstly by developing "goose pimples", drawing blood to the skin, causing its temperature to rise, and then (c), by shivering, where the energy required generates heat within the body. It is instinctive too, to become active by jumping about or from foot to foot, with the same result.

BODY HEAT LOSS   Under normally comfortable conditions, the body loses heat to its surroundings through (a) radiation; (b) through contact with the air, which by convection carries heat away, and perhaps, (c) by physical contact, in sitting on a concrete surface or leaning against a wall. We also (d), are losing heat through the evaporation of perspiration all the time, which includes breathing cool air in, warm air out. (The process is accelerated when we swim in a pool, where heat is transferred virtually entirely by contact with the surrounding water, say at 23°C, giving a 14°C differential, and with water having a high specific heat, (i.e. it needs comparatively a lot of heat to raise its temperature), it draws heat from the body very effectively.)

BODY HEAT GAIN Our bodies gain heat from surroundings in a number of ways: (a) when we are exposed to the sun's radiation; (b) when we are in warm air; (c) when we are active; (d) when we are well clothed; (e) when we are close to a radiating source such as a heater or a boiler. People working in factories are very aware of these latter situations. We mainly derive our heat from body metabolism, where food is digested and converted into energy. The human brain has mechanisms of response to messages whereby heating or cooling processes are triggered if the surrounding influences are too warm or too cool. The brain has some 100 billion nerve cells, so this particular task is probably not too complex compared with other functions for which it is required!

These inborn controls however have a limited range, and discomfort is soon experienced when the external conditions become too varied for the body to cope. Hence the human need for buildings, for clothing, for heaters and fans, and for the way such as cars or trains are designed. They are all for people, and in architecture it is a prime responsibility to not only put a roof and a set of walls about its occupants, but to ensure that those elements work to the best of their ability, in providing comfort, and most importantly, to do this in the most economic manner.

BUILDINGS AND AMBIENT CONDITIONS Buildings, like humans are affected by surrounding conditions brought about by the sun, air temperature, wind, and rain, but do not have a built-in response mechanism - unless installed by humans. Naturally, internal conditions must best be suited to humans, and so an enormous range of options are applicable, from designing the simple window, to fully automated weather response systems. Every single decision makes a difference - even the choice of a window position, its sill height, or its size and proportion. Even the colours and finishes chosen for surfaces within and around a building will have an effect upon temperatures.

Natural and artificial light will later be covered in similar terms - the aim being to use natural light to save energy on artificial.

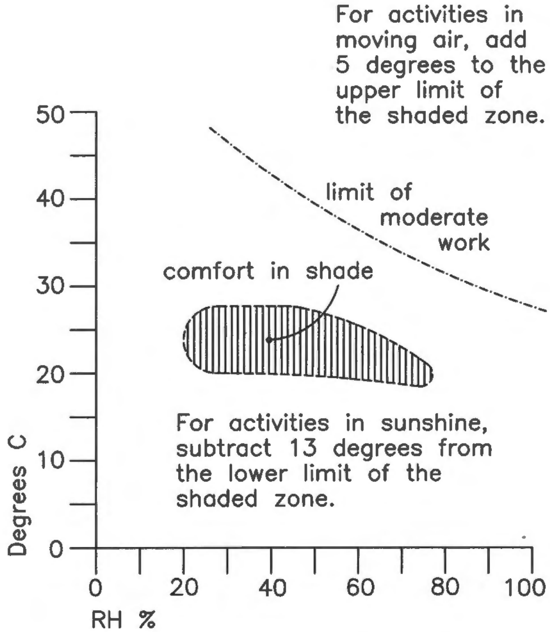
COMFORTABLE AMBIENT CONDITIONS A comfortable interior temperature for moderate activity is from 20°C to 26C°. For greater activity, a few degrees lower is acceptable. Note that younger people prefer slightly lower temperatures, men prefer lower temperatures and likewise, people accustomed to cold climates are comfortable in lower temperatures. When temperatures are in the range of 25 degrees and above, relative humidity has a significant effect on comfort, and readings of 65 to 70 and above begin to be uncomfortable. Note the simplified chart titled Comfort Zones, showing these effects. There are additional terms such as Discomfort Index, Humiture and Temperature Humidity Index, Effective Temperature, all of which give a figure which tells whether the human body is comfortable or not.

PASSIVE DESIGN A building which is comfortable to its occupants, but which does not require energy-using devices for heating or cooling, is classified as having good passive design. Obviously, the better the passive design, the less energy will be required. A well-insulated building will demand less heating in winter, (i.e. heaters), and less cooling in summer, (i.e. fans, air-conditioners) and will consume less energy. Typical SA temperature differentials are shown on the graph, but the flatter the lower line, the better.

Our over-ruling objective then as we look at this topic is to design buildings which will demand minimal energy. Every time energy is used - even to boil a kettle for coffee to warm up the cold inhabitants of a house, our diminishing coal resources are being unnecessarily used up and our atmosphere is unnecessarily polluted. It is worth stating here that the north eastern region of SA (Mpumalanga) shamefully has amongst the worst polluted atmospheres in the world, causing acid

COMFORT ZONES – TEMPERATURE AND RELATIVE HUMIDITY

(2.3.1)



rain and other health threats to large areas of population. This is because power stations are sited on the richer coal deposits to minimize transport costs.

WASTEFUL MANUFACTURING Take note furthermore that for every fan, heater or energy-using device that wears out, another has to be manufactured to replace it. The manufacturing process itself, demanding power and discharging waste products, is of major concern to environmentalists, and this needs to be reduced by halting wasteful habits of design and manners of living. The motor industry, amongst many others, is very active in answering to environmental demands - from the choice of materials for their vehicles to reduction in air drag. There is still a good deal to be done.

MAIN OBJECTIVES In very broad terms, in warm or hot climates and seasons, buildings need to be designed to remain cool. Conversely, in cold climates and seasons, buildings need to be designed to remain warm. In calm zones, natural ventilation is needed. Where cold winds cause cooling, living spaces need to be sheltered. Where humidity causes discomfort, natural air movement must be induced to relieve. And so on.

It is worth repeating that good design essentially incorporates good function, and with current bad practices and attitudes related to environmental issues, environmental design becomes an essential component of functionality. At this stage we are concerned with preventing wasteful energy use.

The next section gives attention to passive design in buildings, which in turn involves looking at the influences of external weather or climatic elements, and how to achieve the best objectives.

3 ● HEAT & BUILDING MATERIALS

THE ELEMENTS OF CLIMATE: PROBLEMS AND SOLUTIONS

The ensuing chapters, dealing with architectural passive design will look firstly at given climatic elements (sunshine or air movement, and so on), and then at specific architectural elements and how they are designed to respond, such as roofs, walls, and openings.

HEAT

The sun is the sole external source of heat for the earth. Earth's molten core does little comparatively to warm the surface. The radiant heat of the sun sets in motion other forms of transferred heat and it is worth taking a brief look at this topic, and for some, this will be a revision of school physics.

THREE FORMS OF HEAT TRANSFER   Firstly, heat is always transferred from a warmer body (or fluid) to a cooler until equilibrium is reached, i.e. heat is evenly distributed throughout. Heat is simply molecular excitation, and this movement is transmitted to the surrounding zone until all are "moving" at the same rate. (For such as have seen a radiometer (four-vaned rotating device in a glass bulb, and a little like an anemometer), the black faces receive radiant heat and on warming up, have the surface molecules put into movement, which drives that face away from the radiant source. The bulb has its air partially removed.)

There are three forms of heat transmission: radiation, conduction and convection.

RADIATION This heat we experience from the sun on the skin. Heat travels by electromagnetic waves at a speed just under 300 000 kilometres per second. When you see the sun set on the horizon, it has really already gone, because the light (and heat) takes some 8 minutes to reach us.

● Radiant heat always travels in straight lines. It may be easily screened by an opaque material, even in thin sheet form. (*Opaque* means that no light will pass through, and likewise impossible to see through, e.g. plywood or sheet metal. *Transparent* means allowing light to pass through with minimal interference, and able to be clearly seen through, e.g. clear glass or water. *Translucent* means allowing light to pass through but in broken or scattered form, e.g. obscure glass or opalescent glass.)
● Radiant heat may be reflected, or refracted (bent).
● Radiant heat will pass across a vacuum without interference.
● A radiant source, such as an open fire, gives its radiation out in all directions. Hence an electric radiant heater has a reflector to focus or direct the heat along a given path.
A body with a reflective surface will *absorb* far less heat than one with a dark, dull one. Note that for heat *emission*, the same applies: a reflective surface will *emit* far less heat than one with a dark, matt finish.

Evidence of this is seen in motor car radiators, which are dull and black and designed to lose or emit heat as efficiently as possible. The opposite is seen in a thermos flask with silvered finishes, which are designed to keep or contain heat. The thermos design likewise has a vacuum between its double wall to prevent conduction of heat, and loss by convection.

CONDUCTION Heat is transferred by conduction commonly in solid materials, (again by molecular excitation), and this is seen commonly in a stove plate, where the heating element below sends its heat through the steel to the cooking surface. Materials conduct heat to a greater or lesser degree, and copper for example will transfer heat much more effectively than timber. Heat travels from warm zones to cool, and otherwise takes no specific directional path, dispersing in all directions. Some materials hardly conduct heat at all, and are classified as insulators.

Thermal insulators comprise such as blankets, thick clothing, polystyrene, and insulation is applied in wall cavities to buildings.

CONVECTION Heat is transferred by convection through fluids, (liquids or gases). When fluids are heated, due to expansion (and thus reduced density), the warmer parts flow upwards, and the cooler, downwards. As molecules are dispersed, the flow causes an even distribution of heat. At other times separation into "layers" results, an example being when swimming in calm water, it is often cooler at deeper levels. The warm water remains at the top, having been heated by the sun. Similarly when inside a hall, in a gallery higher up, it is noticeably warmer. Air vents to allow the warm air to escape are applied to improve the comfort standard.

As we progress, we shall have to learn to continually think in terms of *all three* forms of heat transfer in buildings. If we omit any one or more we shall not be solving any problems properly at all.

THE SUN

The power of sunshine is easily apparent when:
One considers that a round magnifying glass only some 100mm in diameter may be used to burn a hole in a sheet of paper quite quickly;
A closed up motor car is parked in the sunshine and the interior quickly gets very warm;
We cross the beach barefoot by bounding along with large strides, until firm wet sand is reached, or a towel is hastily placed beneath the feet.

The Sun's energy output is 3.83 x 10^{26} joules/second.

At the surface of the earth, typical figures for mean solar radiation in kWh/m^2/year (kilowatt hours/square metre/year) ranges from, in the Sahara Desert 2500+ to, at Cape Town and the South Coast, 1500. In the Gauteng region the figure is 2000 to 2250. (For London it is 1000 and southern France 1500.)

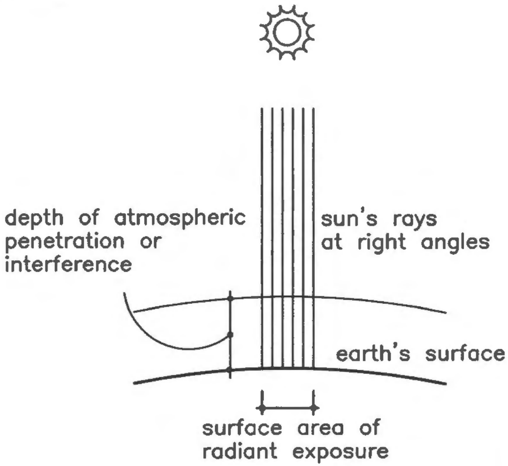
When the sun's radiation passes through the earth's atmosphere its strength is reduced. The content of the air in suspended dust, smoke or other matter (by pollution) and of course, cloud conditions, have varying weakening effects. When rays pass through at a low oblique angle, there is more air to pass through, causing a further drop in strength. Likewise, when rays meet the earth's surface at a low angle, they are spread proportionately over a wider area, and will have a lesser heating effect. See diagrams. Sun directly overhead will therefore deliver the strongest radiation.

This explains why in winter, with a low sun, surfaces do not warm up as in summer. A further reason

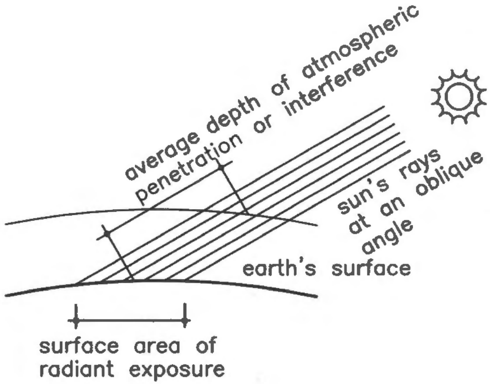
RADIANT SUNSHINE

THE EFFECTS OF ANGLE AND ATMOSPHERE

(3.4.1)



SOLAR RADIATION IS STRONGEST OVERHEAD



WEAKENING OF SOLAR RADIATION DUE TO
(A) WIDER SPREAD ON EARTH'S SURFACE &
(B) LONGER PATH THROUGH THE ATMOSPHERE

is the shortness of daylight, (or sunshine) which is dealt with in a later chapter.

It follows then that as we consider surfaces of buildings exposed to the sun, the degree of warming will depend partly upon their angle to the sun. Those normal to the sun's rays will warm more quickly and to a higher temperature. (*Normal* means at right angles in "all directions".)

SURFACE AND MATERIAL RESPONSES TO SUNSHINE

The absorption and retention of radiant heat from the sun is dependent on two characteristics of the material. The first is the nature and colour of the surface, and the second is the nature or composition of the material itself.

SURFACE A surface with say a white finish *reflects* all colours - that is why it is white. It correspondingly reflects the most heat. Conversely, a black surface *absorbs* all colours, and therefore absorbs the most heat. A glass mirror will reflect the most heat and consequently as a material, remains cool compared with say a sheet of dark brown particle board. A simple test will prove this just in touching by hand.

In other words, the *tone* of the surface of a material is an important factor in whether heat is required to be absorbed or not. Its gloss or matt finish will also reflect or absorb respectively.

NATURE OF HEAT RETENTION The second characteristic is the specific heat of the material. Some materials need more heat to raise their temperature than others. A given volume of water, with a specific heat of one, (needing one calorie to raise its temperature by one degree Celsius) takes a good deal more heat to raise it through a given temperature than does the same volume of granite. It needs about 5 times more heat. This means some materials, even if their surfaces are identical in tone, will take longer to warm up when exposed to the sun (or other heat sources). Likewise these materials with higher specific heat will lose their heat over a longer time as they cool. This is valuable when we need to store heat for buildings. Other factors also come into play such as conductivity, solidity and ratio of surface area to volume.

COMMON MATERIALS We need to familiarise ourselves with the nature of common building materials and whether they are good absorbers and reservoirs or not. For heat storage, this aspect, as we shall find out, is most important. From everyday observations we can begin to make judgements. We know for example that macadamised roads remain warm until well after sunset, whereas sand on the beach cools almost immediately. We could likewise observe that a thick face-brick wall, (say 220mm) having been exposed to the sun, will radiate stored heat well after dark, whereas metal roofing or cladding sheet cools immediately as the sun disappears.

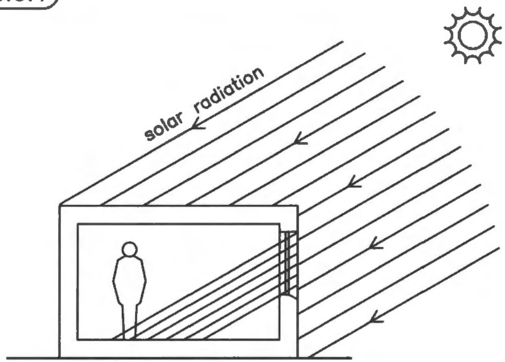
According to our needs, we may choose materials that will keep their surroundings warm after sunset, or on the contrary, use others if we want cooling to take place quickly.

APPLICATION -THE FLYWHEEL PRINCIPLE While the application of the above principles will be handled in greater detail later on, note here that:

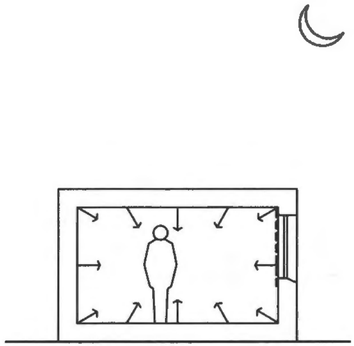
- If we want a building to remain warm after sunset, as in a cold but sunny winter region, we shall choose materials for walls, floor, and roof with heavier mass, with good heat storage capacity, and with suitable absorptive and emissive qualities.
- If we want a building to remain cool during the day, as in a warm summer, we shall choose the same as that above, on the reasoning that if the building mass is allowed to cool during the night, it will help to provide a cool environment during the day.

THE FLYWHEEL EFFECT
WINTER ADVANTAGE

(3.6.1)



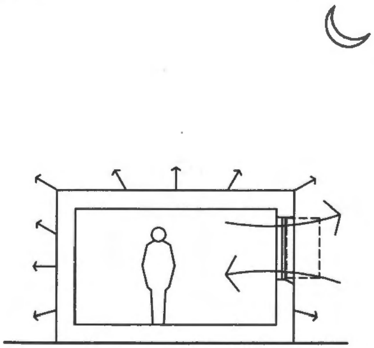
DAYTIME: structural mass absorbs heat from sun



NIGHT TIME: heat stored in structural mass is partially radiated to the interior. Curtain drawn conserves heat

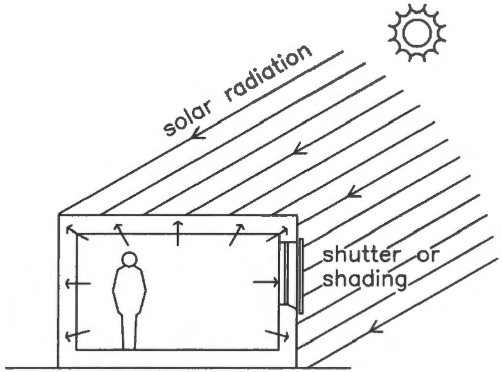
THE FLYWHEEL EFFECT
SUMMER ADVANTAGE

3.6.2



NIGHT TIME: heat stored in structural mass is radiated to space.

Open windows allow night air to cool interior mass.



DAY TIME: cool structural mass absorbs heat from the interior.

This is called the *flywheel* effect, because the wanted thermal quality is carried into the next cycle where needed. See diagrams. The mass gives a more evened out range of temperatures internally than externally. In different seasons we can begin to apply shading devices to control whether the sun heats the mass or not. This will be explained under the study on hourly, daily and seasonal sun angles.

EXPERIMENTS, INVESTIGATIONS, OBSERVATIONS AND RESEARCH

This being our first observational task, we shall prefix it with some guidelines on scientific method.

Our objective is to compare thermal behaviours of different common building materials and finishes. While we are not looking for precise results as in a laboratory, there is no excuse for carelessness where it can easily be avoided, thus ensuring the best results for our observations under limited conditions.

Students (and tutors) need to appreciate the immense value of practical observation, investigation, experimentation or research.

The practical hands-on approach is emphasised because we find it so easy to just read up on information, sitting in comfort, quietly taking it in. When we understand it, we believe that we have "got" it, and we are satisfied. The danger of course, is that after a day or two, we have forgotten the information, or are vague about it. The next is that we may not be sure that our source of information is correct. We may not even be understanding properly what we have read, and can easily misapply it.

The value of physical, personal experimentation is (a) that it is far more likely to remain embedded in the memory but also (b), that having made observations, we can record and quote our findings with authority, provided that the research is done in a reasonably scientific manner. Furthermore (c), doing such routines makes us familiar with the required techniques, and we are then more motivated to get on with further similar investigations.

For the experiments in this book you will need two *identical* bulb-type thermometers. These, like a pencil to an architect will be constantly useful, and for this study, will be essential. They are not too expensive, costing something between the price of a haircut and a shirt. (Quoting in Rands outdates very quickly.) Thermometers must have the rear part of their bulbs exposed so that they can be placed on, or very close to surfaces. Larger thermometers are easier to read and therefore provide more accurate results.

TASKS

OBJECTIVE To compare heat-absorbing and storage qualities of common building materials. To observe emission behaviours of the same.

1 Find two closely positioned walls of similar thickness, identical orientation, both having been fully exposed to the sun for the same time, and for at least two to three hours. One wall is to have a dark face-brick surface, and the other, either light face-brick or light painted plaster. Using two thermometers, compare their surface temperatures.

SCIENTIFIC METHOD As this is your first practical observation, a set of essential "scientific" guidelines are listed. These points must be adhered to and become habit for similar routines in the future. You may wish to add further refinements.

● The two thermometers must be accurately reconciled. If one reads 0.25°C *higher* than the other (under identical conditions) get a marker and boldly mark in on the front, "-0.25" and when taking readings, 0.25 degrees must be *subtracted* to reconcile with the other thermometer. For this reason, put your name on your instruments and do not exchange them with friends unless the procedure is carefully repeated. It is of course best to check before buying that readings are identical.

● Each thermometer must have its bulb the same distance from the surface in question. Another method is to put a small bead of Prestik (adhesive "putty") on the rear of the bulb, and ensure that this makes contact with the wall in question.

● Leave each thermometer, at the same time, on both walls. Secure them with masking tape or other. (Use two fixings for each, as these instruments break very easily.) Check when the moving alcohol or mercury becomes absolutely stationary.

● Cover the front of each bulb from direct sunlight with a small patch of aluminium foil. Do this before they are placed in position.

● Do not allow your own body heat nor any other (reflected) heat to interfere with the thermometers. Position them so that they are not individually affected by differing surroundings, e.g. the same distance above ground level.

● When taking temperature readings of a surface, make sure it is not just a small isolated patch in the required condition (e.g. of sun or shade). Use a clear consistent area at least 1000 x 1000.

● When you are ready to take readings, record them immediately one after the other. Add a column for the difference between the two readings. Recording is most important. Do not rely on memory. After recording, read the temperatures again. Checking is vital.

● On the record, include position, (and address) orientation of walls, time, date and if calm or windy. Record wall material, thickness, finish, or anything else, such as height above ground. When recording in graph or chart form, do not bog down in fancy drawing techniques, whether done by hand or using CAD. Do simple, neat, legible and meaningful work, and ensure that graphs are properly titled with correct information and have comprehensive annotations as listed in this and the previous paragraph. It is a common error to omit vital information making the whole task valueless to a reader - who may be giving you marks - or a job!

Graphs or charts should not be wasteful of space. Begin and finish figures for lowest and highest readings and not beyond. For example, graphs showing readings up to 60 degrees need not show calibrations to 100.

Add any other information which you feel is relevant.

● To be completely sure that your readings and the difference noted are reasonable, repeat the process in another position but close by.

● Do a mental check for strange results - which often occur - and discover why. A damp patch on a wall will give useless readings. An area which has been shaded by a parked vehicle a short while before will not give a reliable result.

● File information permanently for later reference. It be useful even beyond academic studies.

● Always have an intelligent look at what is happening - why are the results as they are? How can the findings be applied in real life? What would happen in hotter climates, or colder? An active, enquiring, analytical mind will be a better teacher than any tutor.

Having completed the above, repeat for the following tasks. These are not listed to make you think that you are a great academic, nor to provide material for a test or an examination, but as useful readings which will have their application both for further study and in real life situations after qualifying. They are set either for you to experiment with yourself, or for your tutor to set assignments, which may naturally be modified to suit a particular project in hand.

Continue with these readings:

2 Instead of the light toned wall of task 1, read the temperature of an identical wall that has been fully in shade, or faces away from the sun, around a corner.

3 Take comparative temperatures of red (or brown) brick paving, and of adjacent lawn, both exposed to clear sunshine.

4 Take temperatures as for the dark wall in task 1. Then for the same wall, take a reading in the shade of the eaves overhang (roof). (If no time, *feel* the difference!)

5 Take three or four pairs of temperature readings as for task 1 at half-hourly intervals after sunset on a west-facing wall(s). Plot a graph.

6 Take the temperature of a quarry tiled floor (on concrete) in a sun patch in an enclosed room (like a porch) in the afternoon. Continue after sunset as for 5. Do the same in an adjacent area but covered with a thick rug or blanket as the sun sets. (The thermometer must of course be *under* the covering.) The latter will retain its heat longer, and distribute heat to the room further into the night. Plot a graph.

7 Find a thin panel of walling such as fibre cement sheeting, exposed to sunshine, and take a

temperature reading on its away-from-sun surface. Try to find two examples, one painted dark and another adjacent, light. Compare temperatures. If this is a problem, place a panel of particle board (Hardboard) or fibre cement in the sun. (No smaller than 300 x 300). Do another adjacent, but chalk it over completely in white or paint it white. Take comparative readings on the inner face. You may be surprised at the result. Take readings after sunset. How does heat retention compare with the brick wall of 5 or the floor of 6?

4 ● SOLAR CONTROL - ROOFS, WALLS, WINDOWS

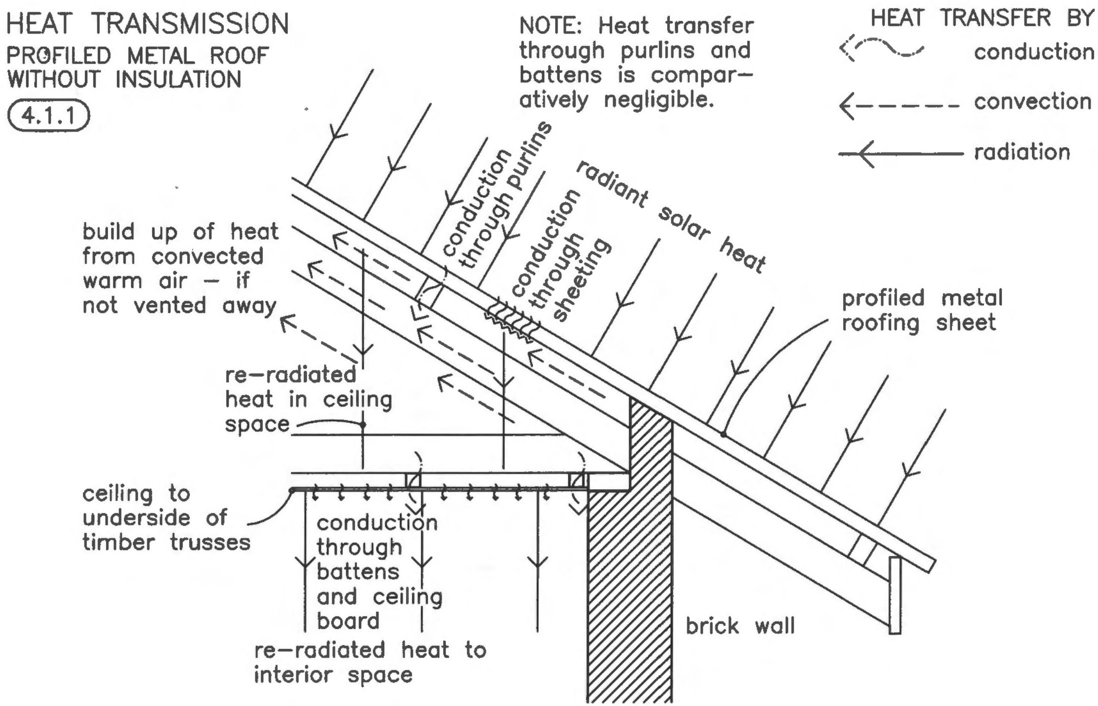
THERMAL TRANSMISSION IN COMMON WALLS AND ROOFS TO BUILDINGS

From the studies of the last section, we have basic knowledge and experience regarding the thermal behaviour of some of the most common mass building materials, namely solid brick walling, concrete paving and something on internal solid flooring. If you have explored further, all to the good.

To understand more fully the nature of heat transmission, in this section we shall look at a typical roof, brick walls, and then light-construction walls. These will help to train the mind in systematic thinking. Even well experienced people have some preconceived views on this subject and as a result make erroneous design decisions.

In all cases note the *internal* re-radiation that jumps across spaces, where it is easy to think that the air in those spaces either provides insulation, or if vented away, takes all heat transmission away. Likewise, where air is trapped and heated, it *moves* and accelerates heat transfer.

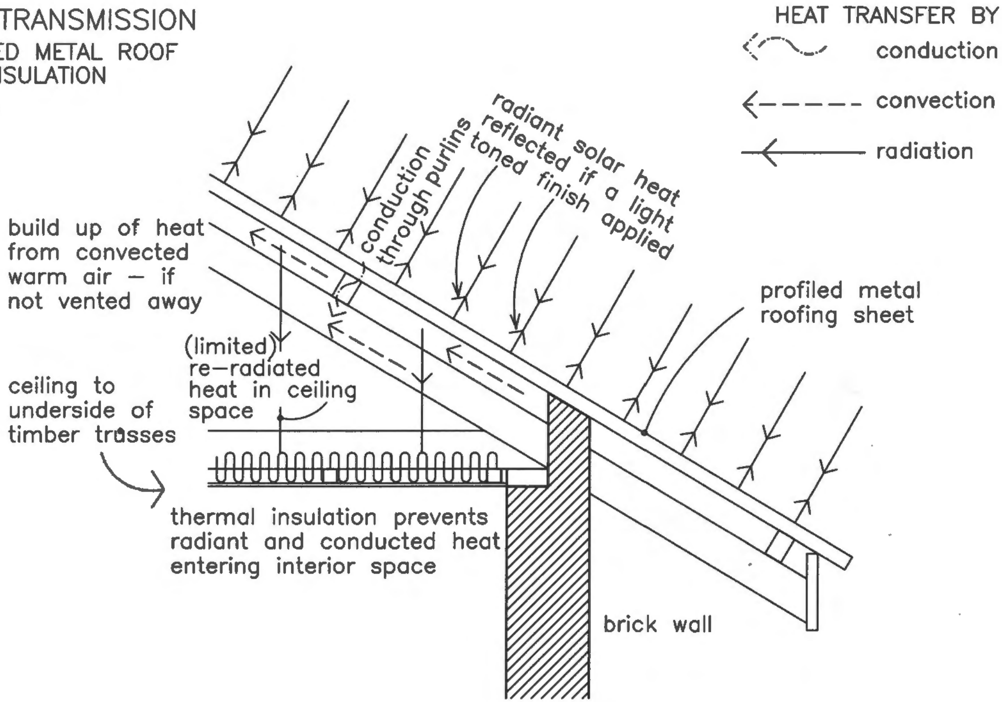
In the rest of the diagrams, note how each form of transmission is included, and remember to apply


HEAT TRANSMISSION
PROFILED METAL ROOF
WITHOUT INSULATION
4.1.1
NOTE: Heat transfer through purlins and battens is comparatively negligible.
HEAT TRANSFER BY
conduction
convection
radiation
conduction through purlins
conduction through sheeting
radiant solar heat
build up of heat from convected warm air — if not vented away
profiled metal roofing sheet
re-radiated heat in ceiling space
ceiling to underside of timber trusses
conduction through battens and ceiling board
re-radiated heat to interior space
brick wall

HEAT TRANSMISSION

PROFILED METAL ROOF WITH INSULATION

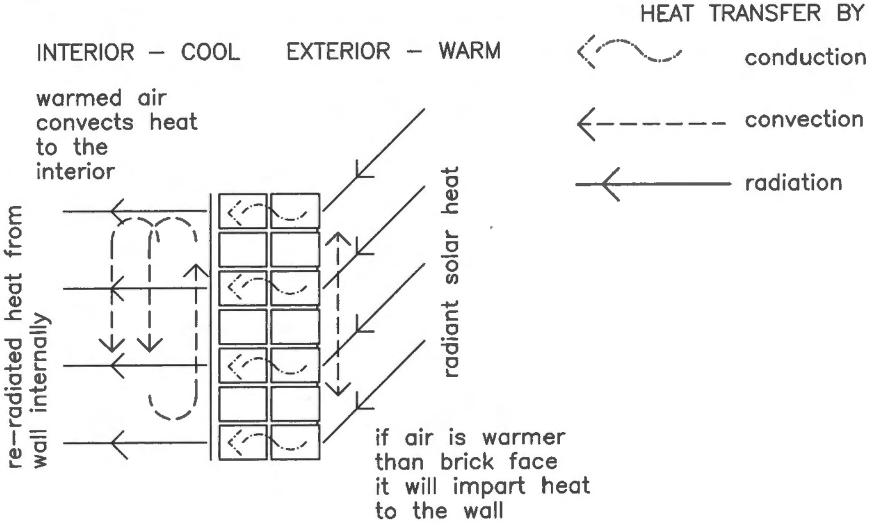
(4.1.2)



SOLID BRICK WALL
plastered internally
dark face brick externally

HEAT TRANSMISSION TYPICAL
ON A WARM TO HOT DAY

(4.1.3)

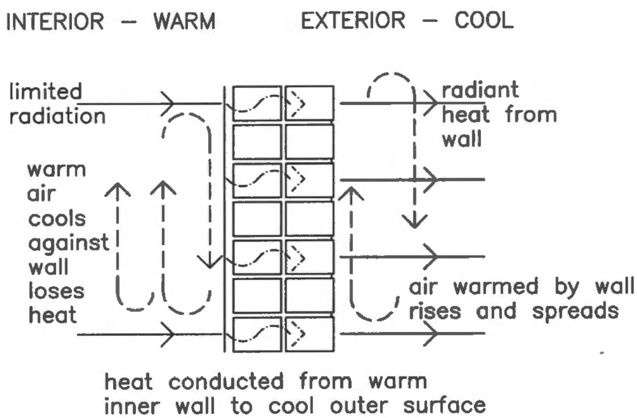


SOLID BRICK WALL

plastered internally
dark face brick externally

HEAT TRANSMISSION TYPICAL
AT NIGHT

(4.1.4)



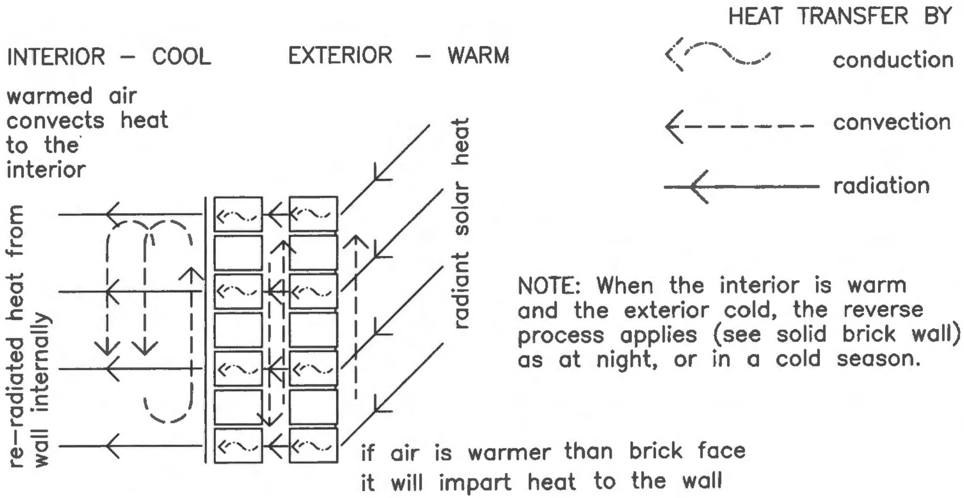
CAVITY BRICK WALL

plastered internally
dark face brick externally

HEAT TRANSMISSION TYPICAL ON A WARM TO HOT DAY

4.1.5

Similar to solid wall except heat is radiated and convected across cavity



NOTE: When the interior is warm and the exterior cold, the reverse process applies (see solid brick wall) as at night, or in a cold season.

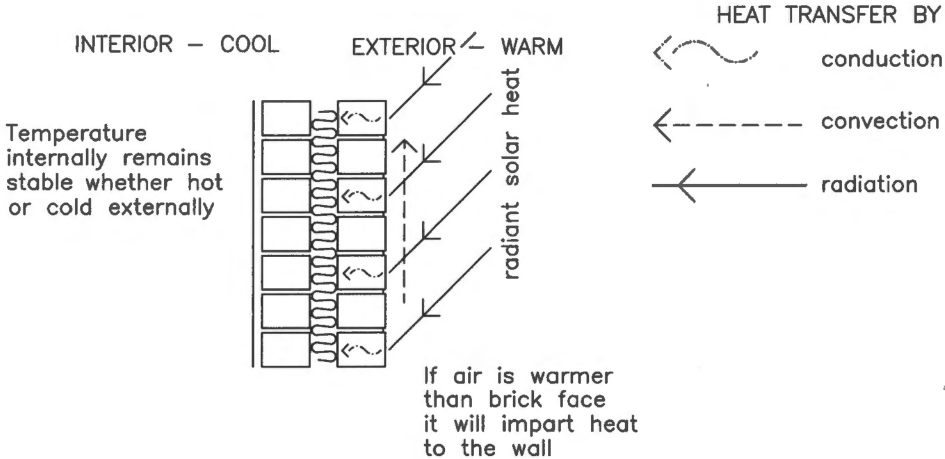
CAVITY BRICK WALL

plastered internally
dark face brick externally

HEAT TRANSMISSION TYPICAL
ON A WARM TO HOT DAY

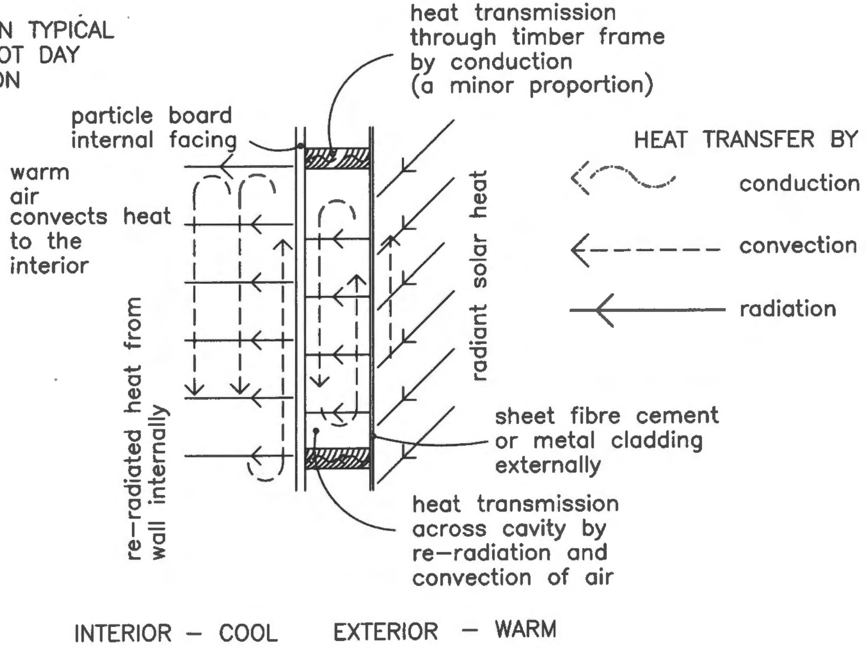
(4.1.6)

Insulation placed in the cavity of the previous example effectively reduces thermal transmission. Both radiation and convection taking heat across the cavity are stopped. The insulative material is a poor conductor and again prevents transmission by conduction.



EXTERNAL WALL:
FRAMED CONSTRUCTION
VERTICAL SECTION
HEAT TRANSMISSION TYPICAL ON A WARM TO HOT DAY WITHOUT INSULATION

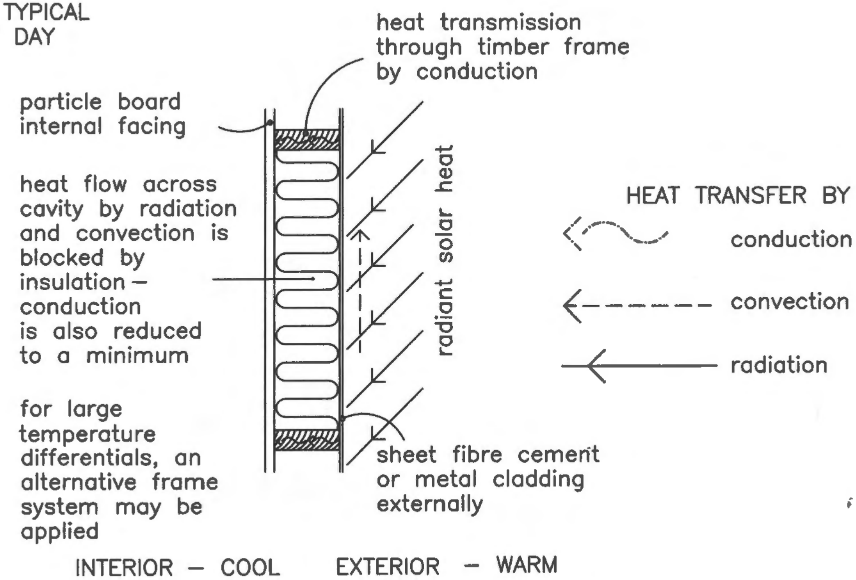
(4.1.7)



EXTERNAL WALL:
FRAMED CONSTRUCTION
VERTICAL SECTION

HEAT TRANSMISSION TYPICAL ON A WARM TO HOT DAY WITH INSULATION

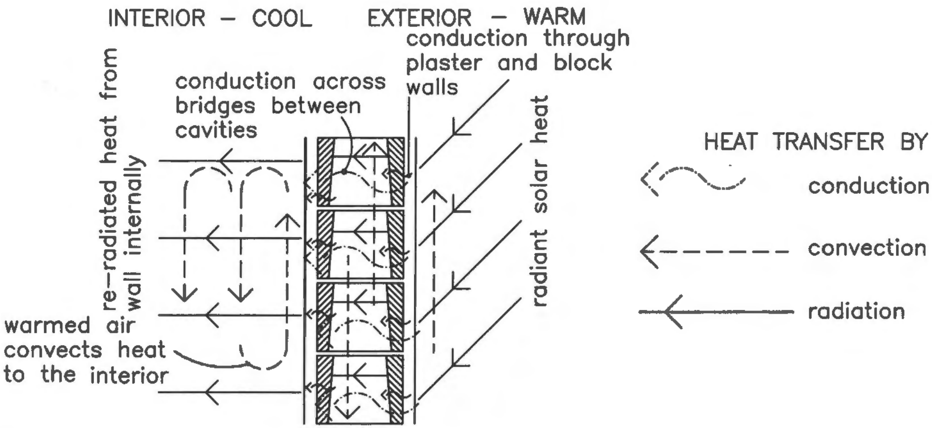
(4.1.8)



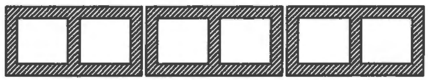
HOLLOW BLOCK WALL
plastered internally
and externally

HEAT TRANSMISSION TYPICAL
ON A WARM TO HOT DAY
(4.1.9)

Similar to cavity brick wall except that solid bridges are at frequent intervals between cavities, thus conducting considerable heat, as indicated



PLAN OF HOLLOW BLOCK WALL: NOTE FREQUENT HEAT BRIDGES



all of these in your thinking when solving thermal problems connected with buildings. There is for example, a common and incorrect perception that hollow construction walls (say in timber and sheet cladding) are good heat resistors, whereas they are not. A thin outer sheet cladding heats quickly and then re-radiates from the inner side. The movement of cavity air then creates an effective bridge across the gap. Insulation is the solution to these problems, as annotated on the diagrams.

THERMAL TRANSMISSION FOR WINDOWS

Window designs, in their most common form will include the following:
- Small in size (i.e. relative to the surrounding wall area). It may be square, tall, or long and shallow, like a horizontal band.
- As above, which may be positioned at a low or high level; on plan, it may be at the centre of a room wall, or to one side or in a corner. A room may naturally have more than one window being a combination of any of the above.
- A large area of glass, to the extent of being called a "window wall", where glass extends from floor to ceiling (or door head) and from wall to wall.
- An intermediate size, to which we are most accustomed in South Africa, as seen in living rooms. Often the area of glass in these examples is some 20% to 50% of the wall area in which they are accommodated.

NOTE that in this section solar radiation is the prime topic
Design of openings as related to air movement and other issues is dealt with later.
Before getting directly to the design of windows, we need to understand a little on how glass behaves when exposed to radiant sun, and we shall begin with well known examples.

GREENHOUSE PRINCIPLES

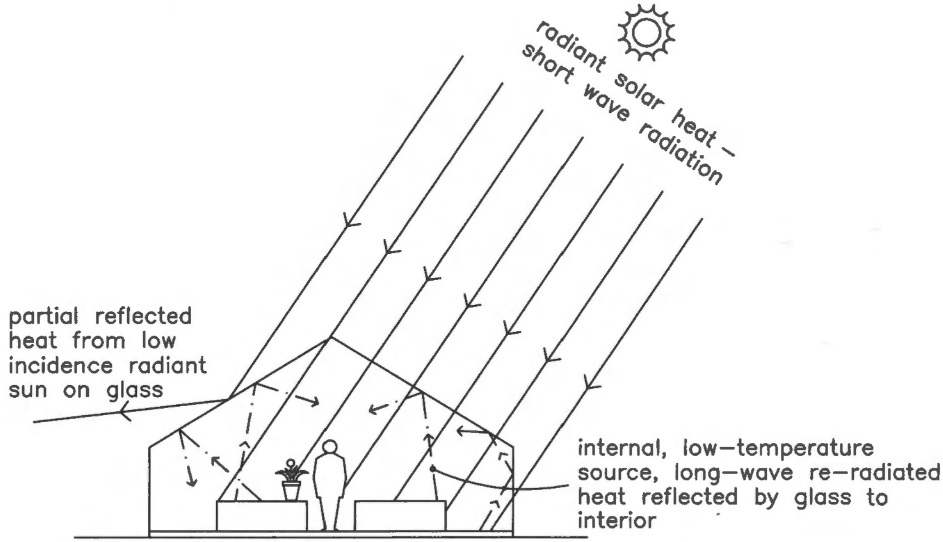
We know simply by feeling that the heat of the sun will pass through clear window glass. As a result, we know that the interior of a glazed and enclosed veranda will get very warm, and often too hot. A similar situation applies in a block of flats, where the access corridors may face west, are glazed and closed off, and become uncomfortably warm. Try to find an example where you can take temperature readings just to see how warm it gets. We also know that a closed up motor car parked in the sun will get extremely hot. The steering wheel may even be too hot to handle.

All these conditions result from what is called the "Greenhouse Effect", where for hundreds of years, especially in cooler climates, plants have been grown in glass shelters or green houses, where the heat has been intentionally trapped. Have a look at the diagram explaining this phenomenon, and make sure you understand it because it is a most important principle that is applied in buildings universally. The sun's radiation comprises mostly *short wave radiation* because it is a high-temperature source, and short wave radiation passes through transparent glass with little reduction in strength. However, note that heat which is *re-radiated* from heated objects internally has only *long wave radiation,* which does *not* pass through glass at all, but is reflected back to the interior, and heat builds up very quickly.

Whilst on this phenomenon, you will also know that sometimes the sun reflects from clear glass and can almost blind us if we look at it. When the sun's radiant heat (or light) strikes a flat glass surface at a very oblique (or flat) angle, because the glass is far more dense than air, it reflects nearly all the light, and we see the glass as a mirror. Note this on the diagram as well.

GREENHOUSE PRINCIPLES

4.3.1



SECTION: GREEN HOUSE PRINCIPLE

WINDOW DESIGN - INTRODUCTORY

The illustrations of a small window with related alternatives to sill, head, position of glass (in the wall thickness) and so on indicate the large number of variables that the designer can play with. A suitable solution may be derived for a particular application in hand, whether it be sub-tropical or semi-desert, and likewise its relation to the type of internal accommodation to which it belongs.

The basic outcome related to a normal small window in a thick wall is that not much solar radiation penetrates, no matter which direction the sun comes from, provided that it is fairly high in the sky - or put another way, has a good angle of altitude. The radiation which does penetrate may be used to gain or lose heat internally depending upon where the glass is positioned in the thickness of the wall - on the outer face, the inner, or somewhere between as a compromise.

To avoid lengthy explanations here in the text, notes on the drawings clarify what happens, and these should be studied systematically.

From here we shall move onto larger windows - again all related to radiant sun and ambient thermal conditions. Much later on we shall look at the design of openings as related to air movement, precipitation and other matters.

SUN ANGLES

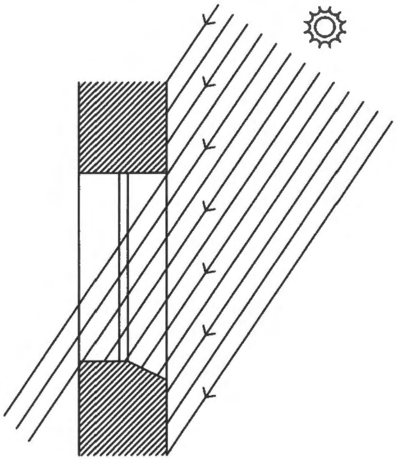
Before dealing with problems and solutions related to larger glazed openings, (as well as other elements), it will be necessary to study the illustrations on sun angles, or sun paths. Under more

WINDOW DESIGN — INTRODUCTORY 1

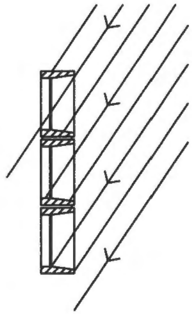
(4.4.1)

Note that the thickness of the wall reduces entry of radiant heat and light

Sun at a lower angle will allow more radiation to pass through and at a higher angle, less



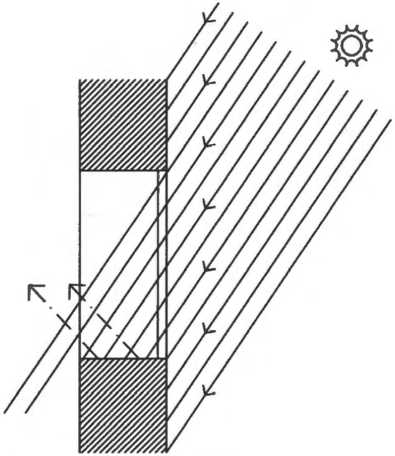
WINDOW DESIGN



This is why a window with a precast frame e.g. Winblok is successful as a sun screen, especially when arranged in groups

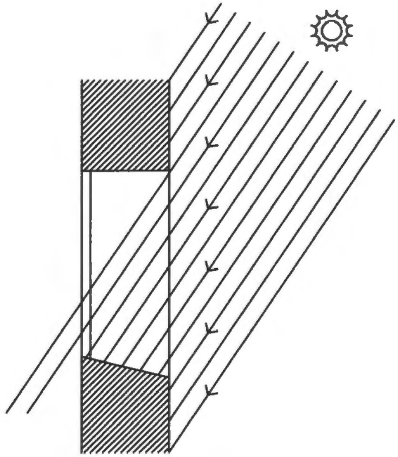
WINDOW DESIGN – INTRODUCTORY 2

(4.4.2)



A large area of internal sill behind glass will absorb more heat internally

WINDOW ON EXTERNAL FACE OF WALL



A large area of external sill will dissipate heat externally keeping the interior cooler

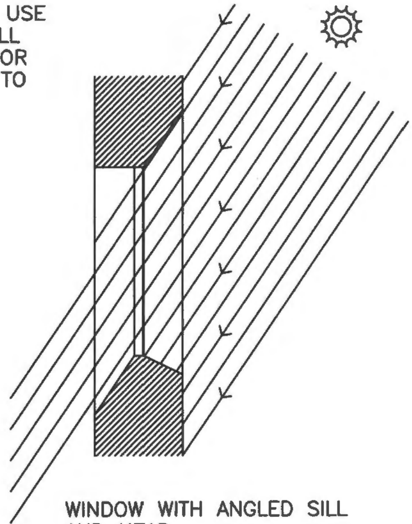
WINDOW ON INTERNAL FACE OF WALL

WINDOW DESIGN — INTRODUCTORY 3

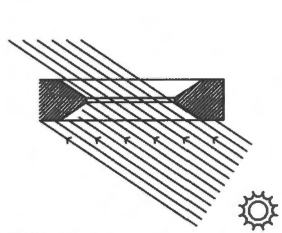
(4.4.3)

NOTE THAT THE DESIGNER CAN USE VARIATIONS OF THE ABOVE SMALL WINDOW TO ALLOW A GREATER OR LESSER AMOUNT OF RADIATION TO PASS THROUGH

sky light, without direct sun, will also illuminate the interior far more effectively



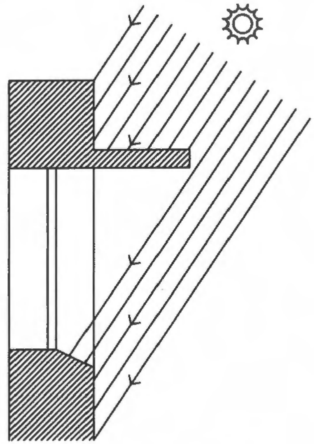
WINDOW WITH ANGLED SILL AND HEAD



NOTE that on plan, a window with oblique reveals will likewise allow more radiant heat and light to pass through; the view from inside is also widened

WINDOW DESIGN –
INTRODUCTORY 4

(4.4.4)



A small projection at window head level will shade the interior from radiant heat

WINDOW WITH A
SMALL CANOPY

advanced studies, you will be able to read, quite accurately, sun angles from published solar charts. For the present level of work, the table of sun angles will suffice. However, the basic diagram showing places, times, seasons, sun angles, all as related to the cardinal directions of the compass is extremely important, and the basic diagram showing positions of sunrise, sunset, noon angles and times should be committed to memory for life - at least for your own locality - because it is used often, and is essential to the design of all buildings which house people.

SOLAR ALTITUDE AND AZIMUTH Note that the sun's position is always given by means of two angles - as illustrated. If we stand facing exactly north, say at 10.00, in the month of September, we will cast a shadow somewhere behind. It will be (a) at an angle around towards south west (i.e. on the opposite side from the sun), and likewise, (b) the shadow will have a given length, which relates to the height of the sun. So to tell someone where the sun is, we need to give a *horizontal* angle away from the north point, east or west, which is call the *azimuth*, and secondly, the *vertical* angle measured from the horizon, as we face the direction of the sun, which is called the *altitude*. Such a reading, depending upon where we may be located, and which season pertains, would be "Azimuth - 60 degrees east of north; altitude 30 degrees".

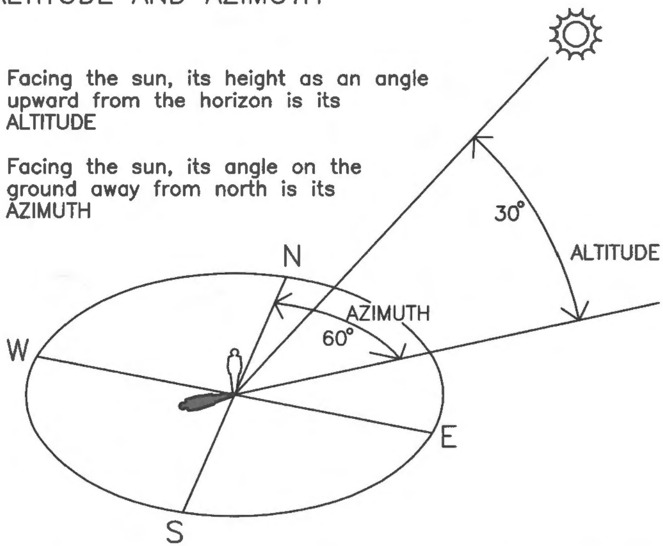
Readings are always given for a time and a date. To make matters more complicated, (but easy to understand), we refer to solar time and to clock time - or Greenwich Mean Time. The world's time zones all relate to longitude or meridian 0, which historically was resolved as the world's "base" or bench mark reference, and was accepted as passing through Greenwich, London, which had an astronomical observatory. Hence all countries could then relate accurately to each other. You may read all about this in any encyclopaedia under "time" and it is most interesting. Your tutor should demonstrate times and seasons to you on a globe of the world if not covered in geography at school.

SOLAR ALTITUDE AND AZIMUTH

(4.5.1)

Facing the sun, its height as an angle upward from the horizon is its ALTITUDE

Facing the sun, its angle on the ground away from north is its AZIMUTH



In the above example, the sun's position would be described as having and altitude of 30 degrees and an azimuth of 60 degrees east of north

The position of the shadow of the figure depends upon both of these angles

South African time is based upon longitude or meridian 30 degrees east of Greenwich. We are two hours "earlier" than Greenwich - in other words, our clocks are two hours in advance of theirs. When it is 12.00 in Greenwich, it is 14.00 in South Africa. However, in summer, Britain moves its clocks an hour "forward" making a *one* hour difference from South Africa. They do this to use daylight to better advantage, saving a lot of energy. In South Africa, all places on meridian 30 degrees east, will have solar and clock time synchronous. When it is 12.00 noon, the sun is directly overhead. (Durban for example is on 31 degrees east, making a 4 minute difference, which for general purposes may be ignored.) There are other minor deviations which will be dealt with in advanced studies. However, for places say west of 30 degrees, at noon, (because the earth rotates from west to east) the sun will not yet have reached its solar noon overhead position. Cape Town has to wait some 52 minutes for this to happen. Solar noon therefore takes place at 12.52 clock time. Those who have visited both cities know also that the sun rises much earlier in Durban than in Cape Town, and likewise, Cape Town enjoys longer light in the evenings, especially in summer with an extended twilight. During World War II, South Africa had "daylight saving" again to save energy, and the sun set in Cape Town close to 21.00 in December.

"*Solar time"* on the tables is the imaginary time as derived from the sun. For example, when the sun is exactly at its zenith (highest point), the solar time is 12.00. At the equinoxes, when the sun rises, it is 06.00 solar time, and when it sets, 18.00 solar time. NOTE therefore that *clock time* for Cape Town will be *later*, as shown on the tables. So again, at 12.00 *solar time* in Cape Town, clock time will have *passed* noon, and the difference is *added* - i.e. is later.

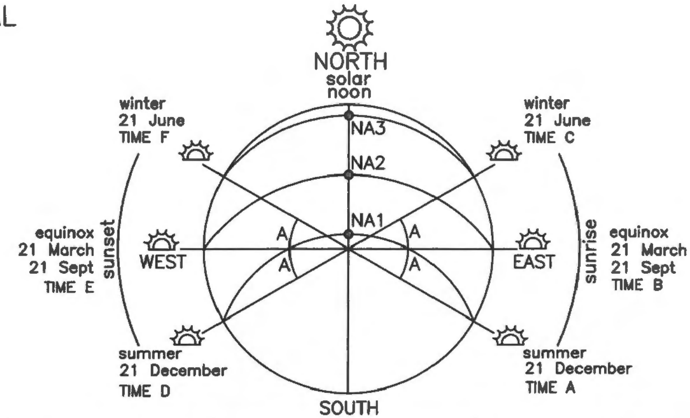
To compensate for these time differentials, for *solar* times shown on the table of sun angles, "corrections" are made for clock time by *adding* 4 minutes for every meridian degree *west* of 30 degrees east, and by *subtracting* 4 minutes for every degree *east* of 30 degrees east. (Another way

CARDINAL SOLAR SEASONAL TIMES AND ANGLES

SOLAR & CLOCK TIMES
See explanation in text

(4.6.1)

To read diagram, imagine you are standing at the centre of the circle. All angles are read from this position, with north straight ahead, east 90 degrees right, and west, 90 degrees left, and so on for the other sun positions.



PLACE LATITUDE & LONGITUDE	SUNRISE solar time & clock time TIME A	TIME B	TIME C	SUNSET solar time & clock time TIME D	TIME E	TIME F	ANGLE A	NA1 Noon altitudes of sun summer	NA2 equinox	NA3 winter
DURBAN 30S 31E	05.00 04.56	06.00 05.56	07.00 06.56	19.00 18.56	18.00 17.56	17.00 16.56	28°	83°	60°	36°
CAPE TOWN 34S 18.5E	04.45 05.30	06.00 06.45	07.15 08.00	19.15 20.00	18.00 18.45	16.45 17.30	29°	80°	56°	32°
PORT ELIZABETH 34S 25.5E	04.45 05.05	06.00 06.20	07.15 07.35	19.15 19.35	18.00 18.20	16.45 17.05	29°	80°	56°	32°
JO'BURG & PRETORIA 26S 28E	05.10 05.28	06.00 06.18	06.50 07.08	18.50 19.08	18.00 18.18	17.10 17.28	27°	88°	64°	40°

NOTE: ANGLES AND TIMES ARE APPROXIMATE

of expressing these figures is to allow 15 degrees for every hour. Remember that there are 24 hours per day (1440 minutes) and 360 degrees around the world's circumference - so for every degree, divide 1440 by 360. Which = 4.). Looking at the diagram CARDINAL SOLAR SEASONAL TIMES AND ANGLES - solar times are given in the table, and below, clock times. The solar times are shown because they are derived in this form from solar charts, *then* the clock times calculated as described above. As long as you memorise (for your particular location) the solar times and angles, the rest follows easily if you know the longitude of the location in which you are interested, or in which you live. These are given in the tables as well.

Other points of importance are (a) the rising and setting positions in all four seasons (the equinoxes are the same), with their times and (b) the noon (or zenith) angles - probably the most important for general purposes of solar design in buildings.

TABLES OF SUN ANGLES The tables which follow are derived from solar charts produced by CSIR in South Africa. All such charts indicate sun positions at given times *without* addition or subtraction for clock times. The charts relate only to positions on lines of latitude, not longitude. Therefore, for places on lines of longitude which are east or west of the solar time meridian, clock time is added or subtracted respectively - as explained earlier. For these reasons, *solar* times are given in italics, and then for given centres, clock times are in normal text.
These tables provide just a few salient angles as a basis for undertaking shadow-projection exercises, and for understanding basic sun positions.

DURBAN Latitude 30° South

Durban longitude 31° E (subtract 1° or 4 minutes from solar times)

Solar times		*06.00*	*08.00*	*10.00*	*12.00*	*14.00*	*16.00*	*18.00*
Clock times		05.56	07.56	09.56	11.56	13.56	15.56	17.56
Azimuth	21/12	111E	98.5E	83E	0	83W	98.5W	111W
Altitude	21/12	12	36	62	83	62	36	12
Azimuth	21/3 & 9	90E	75E	49E	0	49W	75W	90W
Altitude	21/3 & 9	0	25	49	60	49	25	0
Azimuth	21/6	-	54E	32E	0	32W	54W	-
Altitude	21/6	-	11	30	36	30	11	-

CAPE TOWN & PORT ELIZABETH Latitude 34° South

C Town longitude 18.5°E (add 11.5° or 46 minutes to solar times)

P Elizabeth longitude 26.5°E (add 3.5° or 14 minutes to solar time)

Solar times		*06.00*	*08.00*	*10.00*	*12.00*	*14.00*	*16.00*	*18.00*
Clock times C Town		06.46	08.46	10.46	12.46	12.46	16.46	18.46
Clock times P Eliz'th		06.14	08.14	10.14	12.14	14.14	16.14	18.14
Azimuth	21/12	110E	105E	76E	0	76W	105W	110W
Altitude	21/12	12	37	62	80	62	37	12
Azimuth	21/3 & 9	90E	72E	46E	0	46W	72W	90W
Altitude	21/3 & 9	0	25	46	55	46	25	0
Azimuth	21/6	-	54E	30E	0	30W	54W	-
Altitude	21/6	-	9	26	32	26	9	-

JOHANNESBURG & PRETORIA Latitude (nearest) 26° South

Both cities taken as longitude 25.5°E (Add 4.5° or 18 minutes to solar time)

Solar times		*06.00*	*08.00*	*10.00*	*12.00*	*14.00*	*16.00*	*18.00*
Clock times C Town		06.18	08.18	10.18	12.18	14.18	16.18	18.18
Azimuth	21/12	112E	101E	91E	0	91W	101W	112W
Altitude	21/12	10	35	63	88	63	35	10
Azimuth	21/3 & 9	90E	76E	53E	0	53W	76W	90W
Altitude	21/3 & 9	0	26	51	65	51	26	0
Azimuth	21/6	-	55E	34E	0	34W	55W	-
Altitude	21/6	-	14	32	40	32	14	-

SOLAR ANGLE PROTRACTOR To afford easier and thorough understanding of sun angles and shadow patterns, you may build your own shadow projection instrument - see illustration "Shadow Angle Protractor" - with its instructions on how to build and how to use it. It is worth the effort and you will find it useful throughout your studies *and* beyond, where in architectural offices, models are often made. They may be photographed with the sun in its correct position for given times, dates and seasons, illustrating to a client how the design caters for their needs of comfort and efficiency.

Another useful application is to experiment with large scale models of roof overhangs, rooms with windows or other, simply with a folded cut-out from plain thin cardboard or thick paper. Each model *must* have a north point clearly indicated to get realistic results.

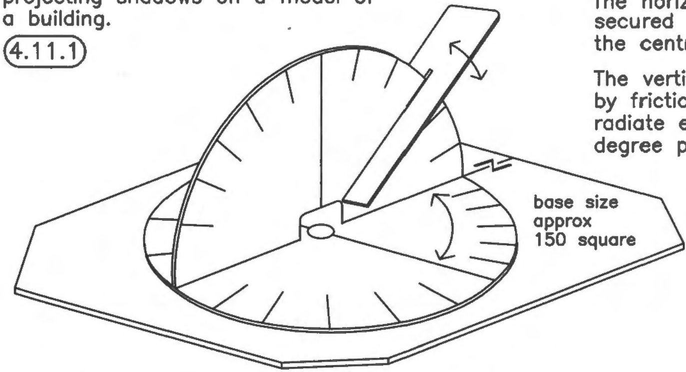
SOLAR PROTECTION With the above knowledge of basic sun angles, whether one is seeking to shade from sun or to expose to sun for warmth, the following building elements may be properly designed: windows, doors, roof overhangs, stoep roofing, placing of patios, window shades, placing of trees and swimming pools, garden summer houses and juxtaposition of buildings, e.g. large structures shading smaller neighbouring buildings. And there are many more examples.

For each of these, unless systematic consideration is given to detail, the building owner either pays a good deal more for energy to compensate, or the occupants are less comfortable than they need be, both diminishing the value of the property. The time, thought, and even perhaps extra initial expense given at the design stage is very little to pay for a building which stands for perhaps 100 years, or in which particular occupants may reside for decades. Over this time, where extra energy is given to heating or cooling, leave alone the deterioration of materials exposed to sunlight, the environment is threatened with unnecessary degradation.

SOLAR ANGLE PROTRACTOR

may be used for (a) measuring the azimuth and altitude of the sun; (b) projecting shadows on a model of a building.

(4.11.1)



TO USE THE PROTRACTOR on an architectural model: Place it on a horizontal surface next to a model with the north point in the same direction as that of the model. For a given time and date, you will have a given azimuth and altitude. Set the protractor to these angles. In a darkened room, take a light and place it well away from the model, and move it about until both the blade and the vertical protractor are in line, casting minimal shadows. You will see the shadows on the model.*

TO MAKE THE SOLAR PROTRACTOR photocopy a normal protractor, cut out and stick to cardboard. Assemble as shown.

The horizontal 360 degree protractor is secured to the base with a metal pivot in the centre, allowing it to rotate.

The vertical angle "blade" stays in position by friction and when adjusted must ALWAYS radiate extactly from the centre of the 180 degree protractor.

TO USE THE PROTRACTOR to measure the angles of the sun: Place it on a horizontal surface in the sun. The "N" – north point – must face true north. Turn the horizontal protractor until the vertical protractor is in line with the sun; (i.e. it will cast minimal shadow).

Move the blade on the vertical protractor until it also is in line with the sun; (i.e. it will cast minimal shadow). Remember it must be on a radiating line.

Read the angles of azimuth and altitude. Record the time and date.

* This procedure may be done in the sun, but the model WITH the protractor are moved about to achieve the same result.

PROJECTING A SHADOW The illustration with this heading shows how to do a simple shadow projection of a canopy on a wall for Durban. At your level of study you may not yet have done shadow projections, which are quite complex, so you could resort to using the protractor (with a model) or using the drawings as described under the next heading as a guide. They are at this stage merely provided as an introduction to how the sun moves, and what the designer must do to achieve best results for the building in hand.

SEASONAL SHADOW LINES The drawings with this heading show shadow lines on a wall for a small canopy at 08.00, 10.00, 12.00, 14.00 and 16.00 for the main seasons only. You can measure the proportions involved to transfer to your own project. For example, if the canopy projects 4mm (full size) on the illustration, and your own example projects 8mm, then understandably the shadow will fall twice the distance down the wall from the canopy edge. For dates and times other than those shown, you may take an intelligent guess on the basis of interpolation (or extrapolation), but your studio instructor should be called in to check your work.

WINTER WARMING, SUMMER SHADING Of particular importance is the difference in shadow depths on the wall for December and June. This difference of angles, almost more than anything else, is used to gain *or* shade from heat during various seasons, as shown in the illustration with the above heading. When designing the external wall and roof to a building, a number of important factors come into play. The eaves projection is variable. Its height is important - e.g. if it is too high it will not provide effective shade. The sill level must relate to the eaves projection, its height and to sun angles. A low sill will allow a good deal of sunlight into the interior. When the function of the room is known, as well as the geographical location of the building, all elements can be positioned to get the greatest benefit.

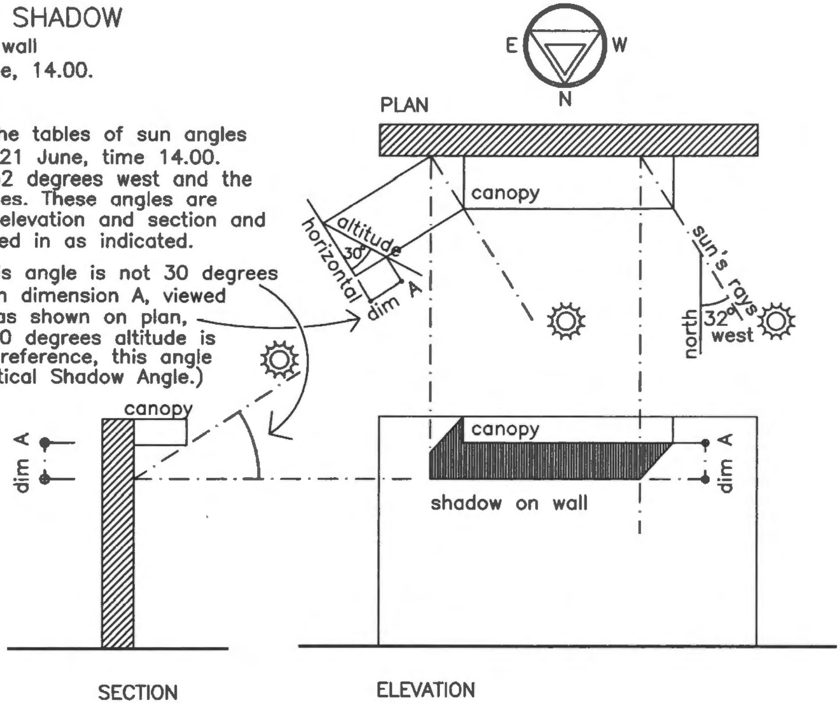
PROJECTING A SHADOW

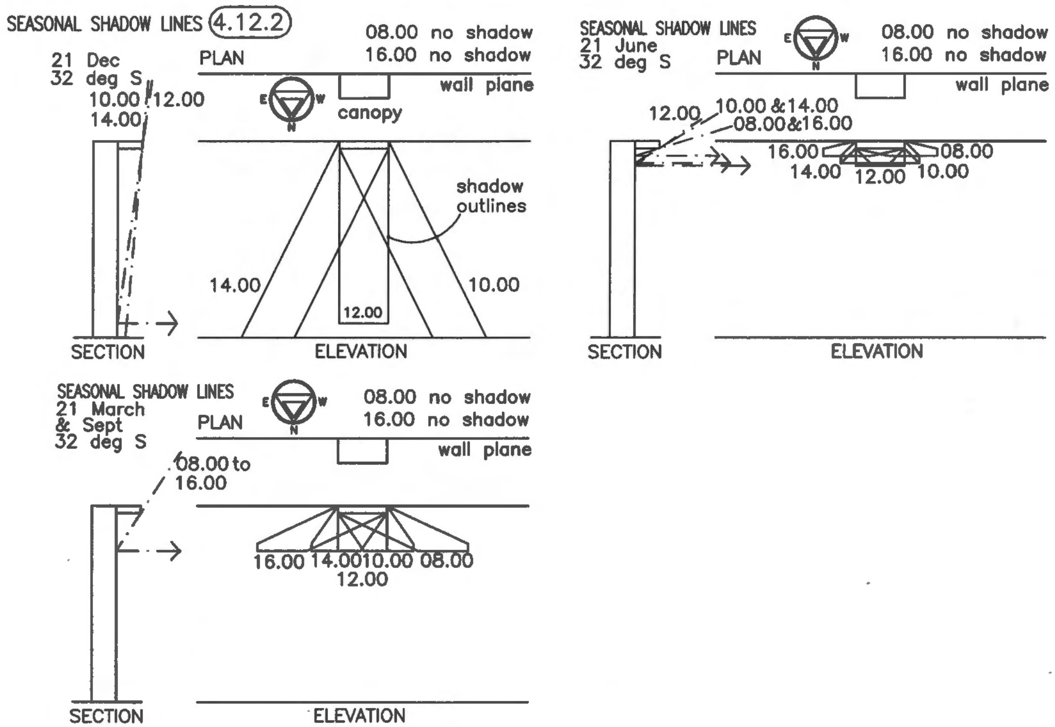
of a canopy on a wall
for Durban, 21 June, 14.00.

(4.12.1)

METHOD From the tables of sun angles look up Durban, 21 June, time 14.00. The azimuth is 32 degrees west and the altitude 30 degrees. These angles are plotted on plan, elevation and section and the shadow shaded in as indicated.

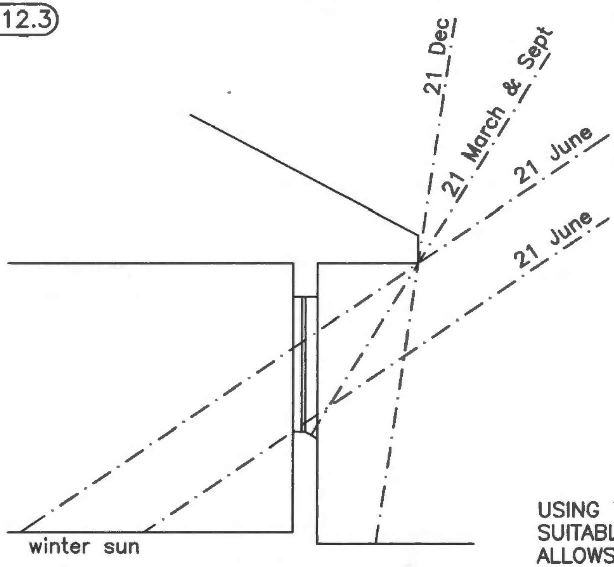
NOTE: This angle is not 30 degrees but is taken from dimension A, viewed from the "side" as shown on plan, where the true 30 degrees altitude is seen. (For future reference, this angle is called the Vertical Shadow Angle.)




SEASONAL SHADOW LINES 4.12.2
21 Dec
32 deg S
10.00 12.00
14.00
PLAN
08.00 no shadow
16.00 no shadow
wall plane
canopy
E W N
shadow outlines
14.00
12.00
10.00
SECTION
ELEVATION
SEASONAL SHADOW LINES
21 June
32 deg S
PLAN
08.00 no shadow
16.00 no shadow
wall plane
12.00
10.00 &14.00
08.00&16.00
16.00
08.00
14.00
12.00
10.00
SECTION
ELEVATION
SEASONAL SHADOW LINES
21 March
& Sept
32 deg S
PLAN
08.00 no shadow
16.00 no shadow
wall plane
08.00 to
16.00
16.00 14.00 10.00 08.00
12.00
SECTION
ELEVATION

WINTER WARMING, SUMMER SHADING

(4.12.3)



SECTION: EXTERNAL WALL & WINDOW
TO DWELLING • WALL FACES DUE NORTH

1 All angles of sun are at solar noon.
2 Assumed latitude is 32 south. Deviations from these angles for such as Cape Town or Pretoria are not significant except for special detailed situations.
3 NOTE how for June, sun penetration is maximum, and for December, the whole wall is shaded.
4 NOTE that from various rising and setting positions of sun for different seasons, in June, at say 09.00, the wall and window are exposed to sun while in December, they are shaded. For the equinoxes, (March and September), the vertical shadow angle remains constant. In these last cases, provided the roof continues past both sides of the window, it is shaded all day from the sun.

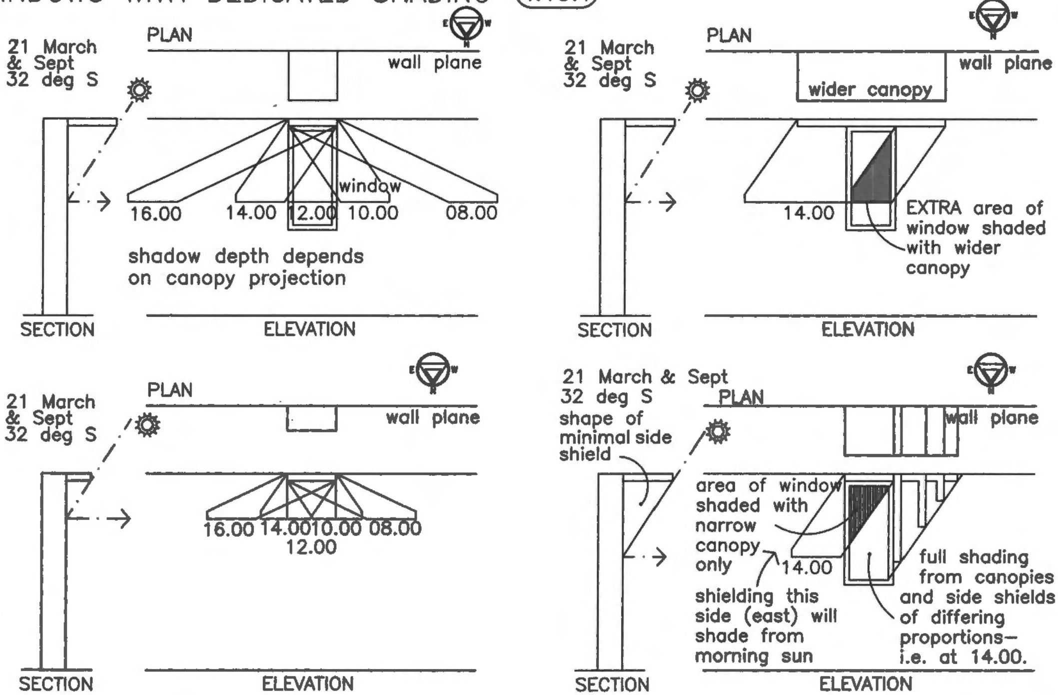
USING THESE ANGLES, THE DESIGNER WITH A SUITABLE ROOF OVERHANG AND HEIGHT OF SILL, ALLOWS THE SUN TO WARM THE INTERIOR AND THE EXTERNAL WALL IN WINTER, AND TO SHADE THEM IN SUMMER.

Furthermore, take particular note of the fact that the wall itself is also in sun or in shade. A dark face brick wall in sun all day will absorb a considerable amount of heat, which will re-radiate at night, both to the interior and the exterior. It is therefore an important design factor in shading such a wall in summer, and exposing it in winter - provided the winter is cold enough. In some of our coastal sub-tropical areas, even winter warming of this nature can be overdone.

The principles above clearly are ideally achieved where the wall in question faces due north, and are on or near the lines of latitude indicated. Where other sun-facing orientations apply, e.g. north east, north west, due east or west, the Table of Sun Angles as well as the illustration on Cardinal Solar Seasonal Times and Angles should be used, and the appropriate geometry applied. At the earlier stages of study, precise deductions may be difficult and projects should be kept simple. Later however, solar charts will be used to indicate exactly where the sun is at any time and on any date allowing shadows to be accurately projected. Remember however - much can be achieved by experimenting with models and your solar protractor.

WINDOWS WITH DEDICATED SHADING This applies where a roof overhang, as in a single storey building, does *not* provide solar protection to windows or walls. In many situations, and too often, shading is not provided at the design stage of the building. The most common cases are the lower storey of a double-storey house, and the gable end of a single or double storey house. After only a few years of occupation the owner has to face the expense either of fitting heavy curtaining or installing sunshades, and then will often choose the least costly, ending up with a poorly designed, inferior result. In multi-unit and high-rise residential blocks there are countless cases where windows to exterior walls are fully exposed to the sun and have no canopy or overhang to counter the fierce heat of the sun. Such accommodation is very uncomfortable, and the cost of replacing furnishings is

WINDOWS WITH DEDICATED SHADING (4.13.1)



almost an immediate factor, and for the investor, rental rates are affected.

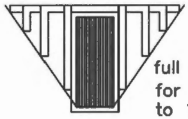
VARIATIONS IN CANOPY DESIGN AND WINDOW SIZE Illustrated are stages of logic showing how dedicated window shades may be designed. (It is wise here to revise on an earlier section, Window Design - Introductory, with relevant drawings.) The object is to show how differing designs of canopy may be tailored to given openings. The angle of sun is taken at the equinoxes (as it is "average") and the method of deducing the shadow patterns is simply to take those of a previous drawing and extend them proportionately as needed. The illustrations are adequately annotated to understand the methods.

EAST AND WEST FACING WINDOWS The illustrations show firstly that eastern and western orientations cannot be simply be shaded by an overhead canopy because the sun angles are very low. An effective solution is by using horizontal or vertical louvres, which in turn may be of many differing types. These in their least costly or simplest form, are fixed, and larger in size. More efficient are the adjustable (rotatable) louvres, where they may be opened for times when there is no solar interference, and closed when there is. Finally, the most complex are the adjustable type which may be moved out of the way on sliding tracks or on hinges. Variations on the above include the fabric type which have a shorter life span, but are very flexible and less costly at the initial stage. Note from the illustrations such considerations as view out, re-radiated heat, light reduction, noise and others.

East and west orientations are difficult to shade from the sun without losing the outward view, and without reducing natural lighting from outside. Compromises have to be accepted, and in the illustrations, the simplest solutions are shown, then the more costly controllable type. The problems with these orientations are (a) that sun exposure applies only for less than half a day, but (b) that

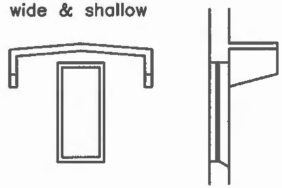
VARIATIONS IN CANOPY DESIGN (4.14.1)

FROM A BASIC ANALYSIS OF SHAPES which give shading as required, any number of variations may be derived

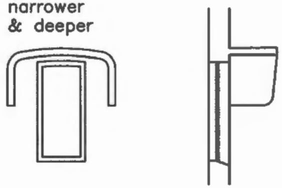


full shading for 10.00 to 14.00 at equinoxes

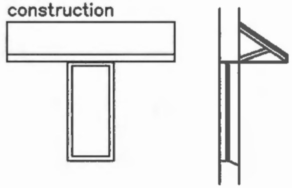
wide & shallow



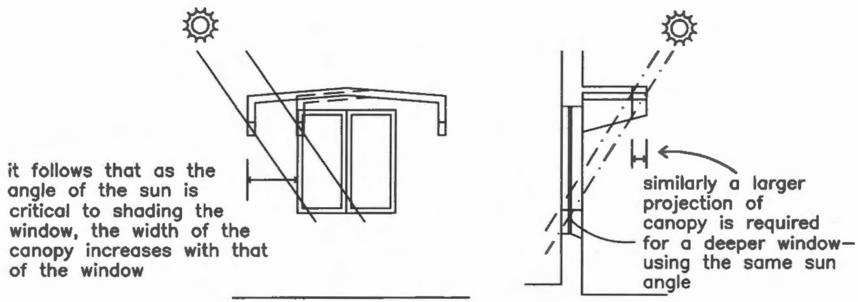
narrower & deeper



conventional construction



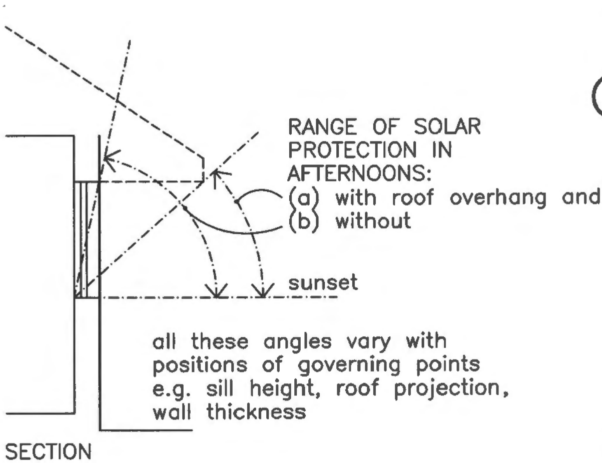
VARIATIONS IN WINDOW SIZE (4.14.2)

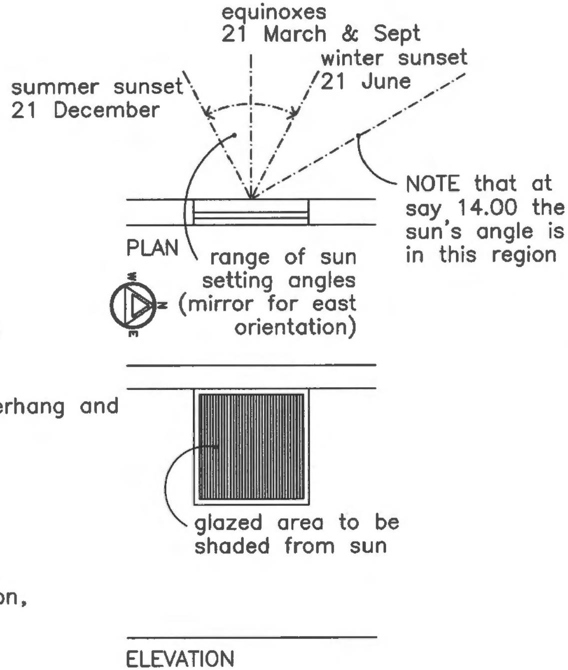


EAST & WEST FACING WINDOWS

ANGLES OF SUN WHICH HAVE TO BE CONTROLLED

(4.14.3)

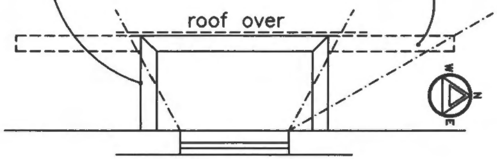




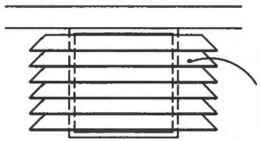
HORIZONTAL FIXED LOUVRES FOR EAST & WEST FACING WINDOWS

(4.14.4)

on plan, (a) sides to louvres must be closed in with louvres or opaque sheet material or (b) louvres extended laterally to control oblique angles of sun



PLAN



shown are smaller louvres with louvred returns to sides

NOTE that these louvres may be easily produced in adjustable form. The side panels would remain fixed.

ELEVATION

NOTE the following in the design of the louvres below:

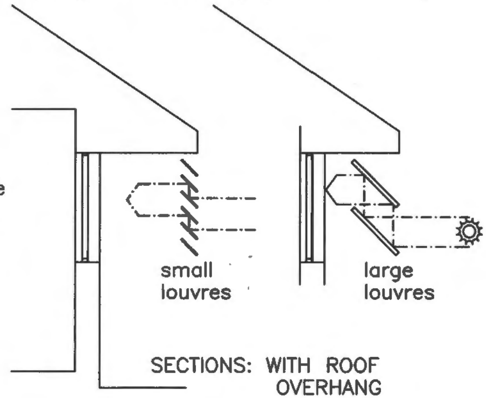
1 they should be light–toned to reflect maximum light

2 they should be reasonably distant from the window to prevent warmed air from entering

3 size of louvres are variable; the smaller are normally more attractive

4 the design shown excludes 100% radiant sun; lower exclusion may be acceptable

5 other obstructions such as existing buildings or trees may provide shading



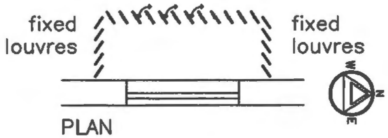
SECTIONS: WITH ROOF OVERHANG

VERTICAL ADJUSTABLE LOUVRES FOR EAST & WEST FACING WINDOWS

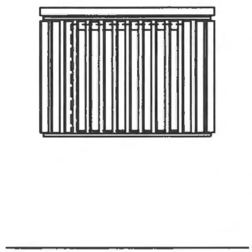
(4.14.5)

NOTE Sides to adjustable louvres are shown with fixed louvres, allowing free air movement. Opaque sheet material may be used as an alternative but becomes unsightly unless carefully designed.
The adjustable louvres are ideally controlled from the interior, but a lever reached through the window is a good compromise.

adjustable louvres may be rotated to any angle or closed

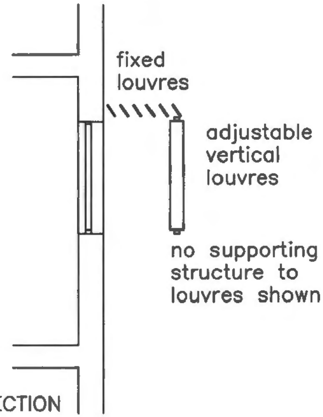


PLAN



NOTE that vertical louvres may be made as fixed, but are not effective against varying angles of low sun at different seasons. For fixed louvres, the horizontal are the most efficient for east or west orientations.

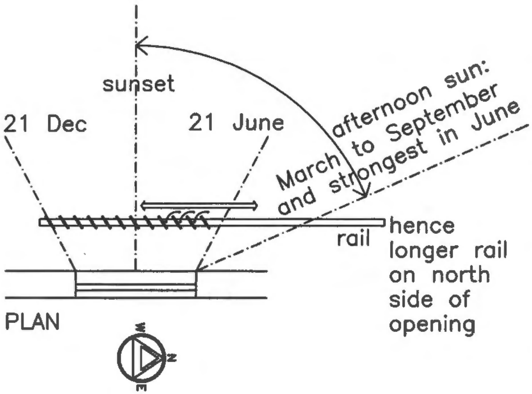
ELEVATION



SECTION

VERTICAL ADJUSTABLE AND SLIDING LOUVRES FOR EAST AND WEST FACING WINDOWS

(4.14.6)



NOTE These louvres are individually adjustable (rotatable) as well as moveable as a panel along a track. (They are not however collapsible as for interior vertical blinds.)
This arrangement is practical for both vertical and horizontal louvres that face east or west.
For the times of day that solar radiation is not a problem, the louvres may be moved to one side to allow a clear view from the interior.
Side shading is not necessary with this arrangement.
The facade of the building will consequently have an arbitrary arrangement of louvre panels and this needs attention in the overall treatment architecturally.
The complexity of internal control for both rotational and positional adjustment of louvres needs careful aesthetic and mechanical detailing. External controls are not a problem.

exposure is to very low angles, and radiation is very strong. A further complication is that the low sun moves its setting and rising position by close to 60 degrees from north to south, (of east or west), making vertical louvres less efficient. (However, these variations may be used to good effect by other shading devices, as will be seen further on.) The western aspect is the worse of the two because by the afternoon, everything has already warmed up (in summer anyway) and the western sun heats the environment still more. The east is not without problems because on the eastern seaboard of South Africa, the sun rises in summer at or soon after 05.00, and even by 09.00, in the early hours of the working day, there has already been four hours of solar radiant heating. Interiors having windows with this orientation become unbearably warm if not properly protected.

It may be argued that the simplest form of shading is to position an opaque or translucent panel directly outside the window to cut off solar radiation. However, an opaque shade will reduce light drastically, and if spaced further away, will allow scattered and reflected light to enter - but still of very reduced value. Alternatively, if a translucent panel is placed outside the window, it will allow a good deal of filtered light to pass through and will partly reduce heat. Both these types, to shade 100%, will cut out the view from inside almost completely and are therefore seldom seen.

RETRACTABLE FABRIC SHADES As a good compromise, on the market are retractable fabric blinds or shades, which come in many forms, and can be very effective. However, too many householders (and others) do not make a proper analysis of sun angles, and the shades are not properly chosen for shape nor installed in appropriate positions. They are useful in that they are flexible and may be folded away or opened out partly or fully as required. They have a limited life, but are less costly than fixed metal louvres, and do not keep as tidy in appearance. Many shapes are available, and choices need to be made with consideration to the nature of the building where they are to be installed. The illustrations give an indication of basic shapes.

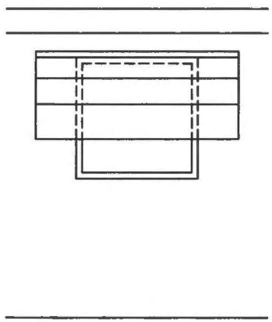
RETRACTABLE FABRIC SUN SHADES FOR EAST AND WEST ORIENTATIONS

(4.15.1)

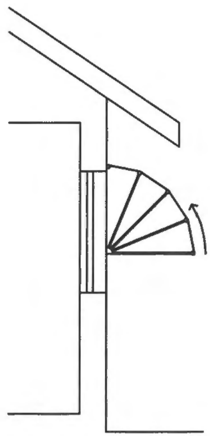
Section A: The framed domestic type shade is retractable or fixed and works like a pram hood. There is a variety available and costs are comparatively reasonable.

Section B: The cantilevered shade also for domestic use is supported on metal arms at both ends. These have "elbows" and fold upward neatly, the whole mechanism being operated with gears and a crank. They have a long reach and are effective for a number of applications.

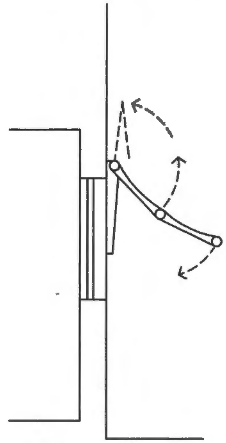
PLAN



ELEVATION of Section A



SECTION A



SECTION B

INEFFICIENCY OF INTERNAL BLINDS It should also be mentioned here that *internal* blinds of any kind have the potential danger of being good heat absorbers. The sun penetrates the glass of the window and strikes the blind, which absorbs the radiant heat. If dark in tone, it re-radiates to the interior very effectively, re-radiates back to the glass, which in turn reflects it internally (on the greenhouse principle). Air both sides of the blind heats up quickly and by convective movement, circulates to the interior. For lighter tones, the effect is reduced, but still applies, and it is important to note that to cut down heat, sun shades should always be used *externally*. More will be covered later on regarding types of internal blinds and their effects.

OBSERVATIONS

It is strongly recommended that students systematically observe window shades and shadow shapes on actual buildings and assess their efficiency. This type of study is also enhanced by observing the angle of the sun as related to the sun-protection device (use your solar protractor for this), and to note the season and the time of day.

TASKS

1 OBJECTIVE To observe shadow patterns and sun angles on existing buildings.
A fuller study - and a helpful project for your tutor to set up - would be to look at a particular building and to record (sketch or camera) at given times of day, the shadow patterns that apply. It would be

necessary here to know exactly where the north point is, and to record the sun angles - azimuth and altitude, by means of the solar protractor. Choose a building preferably that has its facades facing close to the cardinal points (N S E and W), that has projecting canopies, balconies, stairs and roof.

Photograph all four sides at 2-hourly intervals at the key dates of 21 December, March, June and September. All photographs should be titled with dates and times. You will have a very useful and educational set of pictures.

Remember particularly that the sun is our major source of heat and that it needs to be well controlled for comfort and to prevent damage to finishes and furnishings - leave alone the vital issues of energy, rentals and overall public investment.

2 OBJECTIVE To observe the cooling effects of shading a sun-exposed window.

Undertake one of the following:

1 Find a room which has an external retractable shading device to its window, which in turn must face the sun. Keep windows and doors closed during the observations which follow. Watch the weather forecast and aim for a few days of clear sunshine. Using the dry season of your region will help. On the first day, leave the sunshade in position and take temperature readings at 2 hourly intervals in the shade *outside* and simultaneous readings *inside* the room. Three pairs of readings during solar exposure should be adequate. On the following day, which needs to be sunny, (if not take the first one available), fold the shade away to allow sun to enter the room. Take readings as before at the same times. Compare the *differences* between the two sets of readings. Record and plot methodically. (Remember scientific methods - especially not to take readings with thermometer bulbs directly in the sun. Try for calm weather too.)

2 Find a room with a window but without sun shading and take readings as in 1, but after building your own sun shade. Preferably use good shade cloth draped over or stitched onto or stapled to wood dowelling, (broom stick?) which in turn is hung from the eaves projection above. Use weights (bricks) on cord to hold blind down against breezes. Make sure the blind is effectively positioned to give good shade. Some shade fabrics need to be doubled to be properly effective.

5 ● THERMAL CONTROL - AIR MOVEMENT - WINDOWS, DOORS

OPENINGS IN WALLS

The subject of window and door openings, as controlling devices for air movement, would readily take up a large book. The average householder or office person does not begin to realise the significance of this topic, and we are all rather blameworthy for assuming what we see around us to be acceptable or good solutions to given problems. As a specialist, the architect or architectural technologist needs to look at detailed aspects of the elements that effect the workings of these "controlled openings" and make informed design decisions to take maximum advantage. Where overall design criteria are required, appropriate publications should be consulted - where such matters as security, privacy, servicing and other functions are dealt with.

Our aim is to look at commonly used window and door types, and to choose or formulate designs related to such as air movement and air temperatures, which ensure the minimal usage of energy, whether for air supply, for cooling, or for warming.

In broad principle, buildings in very cold climates have smaller openings in their external walls and roofs. Those nearer the equator have larger openings for obvious reasons, bringing problems at the other end of the temperature scale - i.e. over-heating. IT IS WORTH EMPHASISING AGAIN THAT TOO OFTEN IN SOUTH AFRICA, EXAMPLES OF BUILDINGS ARE TAKEN FROM NORTHERN HEMISPHERE PUBLICATIONS AND PERIODICALS, WHICH ARE PROFESSIONALLY AND VISUALLY CONVINCING BUT ARE OFTEN DESIGNED TO *GAIN* HEAT, WHICH IS THE *OPPOSITE* FROM WHAT WE WANT TO DO IN VERY MUCH MILDER LATITUDES WITH WARMER OCEAN CURRENTS, WINDS AND CLIMATES.

In this chapter we shall look at typical window designs and what they have to offer and how best to use them - to save energy - and then briefly, with doors.

COMMON WINDOW DESIGNS

Most of the information is covered by notes on the drawings which have been specifically simplified.

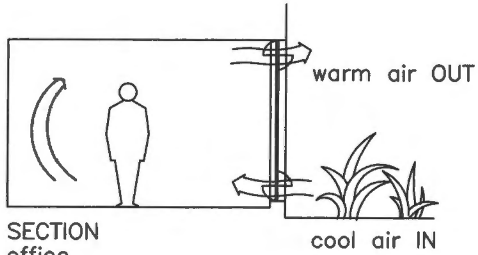
WARM AIR RISES - COOL AIR FALLS   An understanding of the fundamental behaviour of air is worth revising. In calm conditions warm air rises and cool air falls. This movement is enhanced firstly if the temperature differential between warm and cool is greater and secondly, if there is greater height in the space in which the air moves. For interior spaces, for example, this means that in a kitchen, the warm air over the stove moves up more quickly, creating a distinct column of upward movement. However, where a floor in a room is warmed by sunlight, the movement is slower and of course less noticeable. Then, for each case, where a low ceiling level applies, the warm air accumulates from the top down, like a vessel turned upside down, and the lower levels of air are soon warmed up. This effect is significantly overcome either by having higher ceilings, (e.g. mono-pitch, sloping), or by allowing the warm air to escape upward.

It follows that to provide cooler lower levels of air within living spaces, higher ceilings would provide good relief, but this is a costly solution.

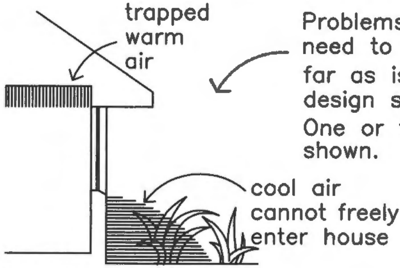
WINDOW VENTILATION (5.2.1)

THE STACK PRINCIPLE

Under calm conditions, warmed air within a space moves upward to the ceiling, leaving the cooler air below. Air is warmed by humans, by lighting, by office machinery or cooking equipment and most often by radiant sunshine passing through a window.
Ideally a window as illustrated provides natural stack ventilation in allowing the upper warmed air to escape and cooler air to enter at low level. Outlets at ceiling level are feasible for offices, but seldom are floor-level sills practical. In houses a beam at ceiling level, required to support the roof, disallows the escape of all warm air.

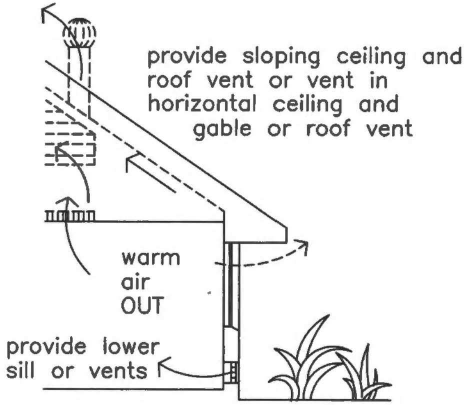


SECTION
office



SECTION
house

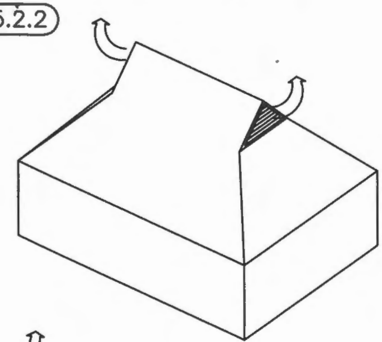
Problems such as these need to be addressed as far as is feasible at the design stage.
One or two solutions are shown.

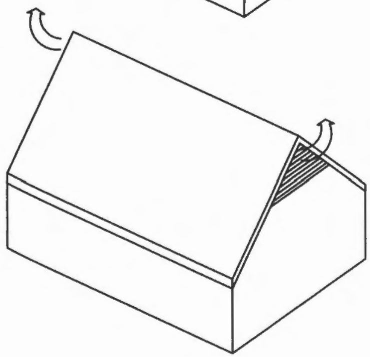


SECTION
house

ROOF SPACE VENTILATION

(5.2.2)



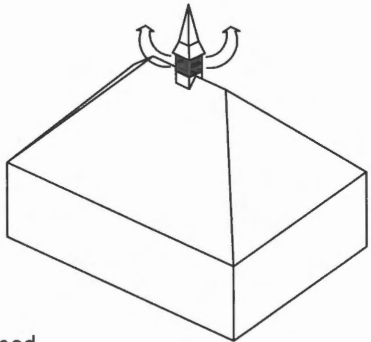


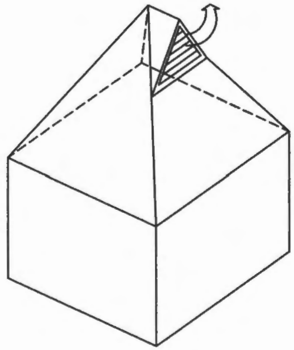
The stack principle is utilised to vent out warm or hot air from roof spaces. The design must allow ample free–air space between louvres for a satisfactory flow.

An insect–proof gauze is essential and is placed behind the louvres.

These designs are the most common, but many variations apply according to the abilities of the designer.

Warning: Free–air areas are very deceptive with louvres, and it is better to err in providing a larger set of louvres.





Therefore, as illustrated, if windows are taken to ceiling height with openings at that level, the warm air is allowed to escape, and a simultaneous supply of cool air at lower or floor level needs to be provided. Windows are often designed (for office or industrial use) to allow such movement and we refer to this as the Stack Effect. (This comes from the chimney stack where hot fumes from a fire escape upward.)

If warm air is not allowed to escape, an internal space soon becomes uncomfortable, and likewise carbon dioxide from occupants accumulates causing stuffiness and eventually, suffocation.

The illustrations show a typical office cross section with air movement (under calm external conditions), and then a domestic section where warm air is trapped because of conventional construction. (Sophisticated office solutions are covered in the advanced sections of these studies.)

Another way of thinking of the above principles and effects is to imagine an empty container which has perforations at the bottom, immersed in water, and seeing it filling up - i.e. from the bottom. It is just the same where a room with warm air inside is surrounded with cold air outside. The cool air is denser, and like the water, tries to flow into the room with warm air, of lower density. And it actually happens - at low level openings. It is the same in reverse where in hot times of the day, if cool air is inside and warm outside, the cool will try to escape, as if it is water, having a greater density. For all these cases, the designer has to provide controllable openings which will make the air do the right thing to provide internal comfort.

STACK VENTILATION The stack principle applies far more widely than is generally thought. A taller building with stair wells which provide vertical shafts will provide a "flue" for either warm air to rise or cool to fall, creating exaggerated temperatures at the extremities.

In a double storey house, the upper floor is usually warmer than the lower for this very reason. (Other reasons apply as well which we shall see later.)

In conclusion, the stack effect is most noticeable and effective when general weather conditions are calm.

AIR MOVEMENT EXTERNALLY We shall now look at principles which need attention where there is air movement outdoors, creating breezy or windy conditions.

AIR IS HEAVY Air has mass and therefore has momentum when in motion. A cubic metre of air has a mass of just over one kilogram. If we take a kilogram of stone and thrust it say along the surface of level ice, it will slide along on its own for a considerable distance. If we took a cubic metre of air, and in a vacuum did the same thing with it, it would behave in just about the same way. Again, think of buildings as if they were immersed in flowing water. There would be enormous pressures to contend with. Because air is invisible and relatively much lighter than water, we tend to think it does not exist in terms of its forces. Anyone who has had to handle even a small sailing dinghy knows how much energy is required to keep the sail, and boat, in an upright position. A small boy with a large kite has a real challenge keeping it under control in a good breeze. Notice that when a travelling bus brakes fairly quickly to a standstill, provided windows are open, the air continues to move forward for some seconds, by momentum, creating a noticeable draught internally at the front of the bus.

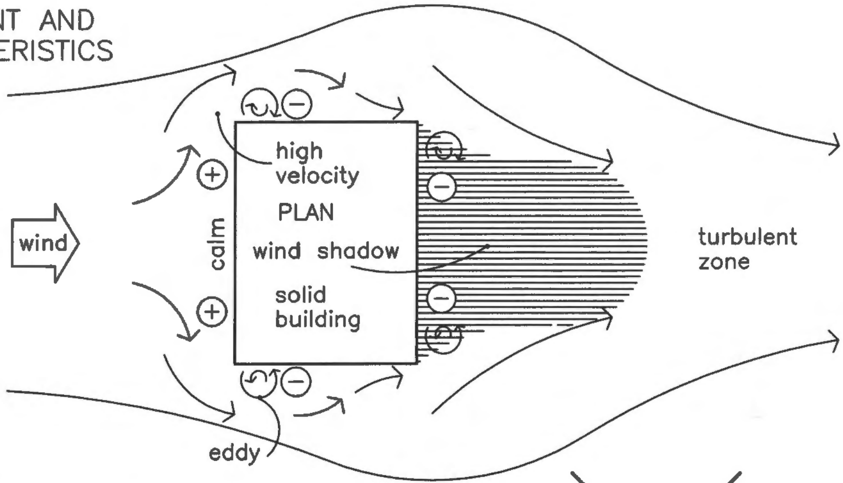
PRESSURE ZONES Because of the mass of air, in windy conditions it builds up tremendous forces or pressures against obstacles, and for solid masses like buildings the results are extremely important.

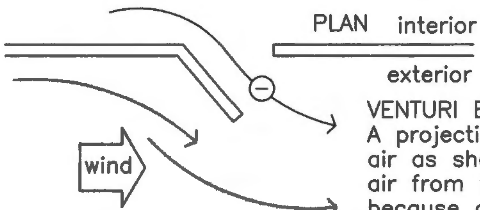
AIR MOVEMENT AND ITS CHARACTERISTICS

5.4.1

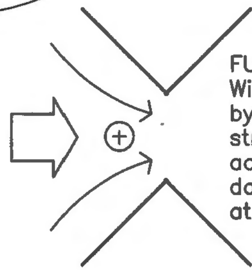
⊕ = higher pressure

⊖ = lower pressure





VENTURI EFFECT
A projection deflecting air as shown will draw air from the interior because of the lower pressure zone



FUNNEL EFFECT
Wind dammed by two solid structures will accelerate dangerously at the gap

Openings that provide an escape for the air from these pressure zones experience highly accelerated velocities. Similarly openings between building masses which dam up air have the same result. There are also resultant eddies, turbulent zones and wind "shadows" - or sheltered areas. Students should take specific note of these forces and their effects in buildings to which they have access.

EFFECTS OF OBSTRUCTIONS As illustrated, when moving air comes up against a solid structure, because of momentum, a number of things happen, namely, (a) positive and negative pressure zones develop; (b) eddies occur at the corners; (c) wind speed, or velocity is increased at the escape zones, e.g. at the corners; (d) areas of calm apply, sometimes in unexpected places.

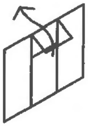
Understanding the governing principles allows one to deduce air patterns for most regular shapes. Curved overall shapes and corners allow smoother flows, reducing eddies and turbulence in leeward zones. As we are concerned mainly with the behaviour of openings, and not primarily with all effects of air movement, only the simplest and basic conditions are covered at this level.

Also illustrated are the funnelling effect between buildings, which is fairly prevalent in built up areas, and then the venturi effect, where air moving past an angled obstruction, by momentum "throws" itself outward, creating a negative or lesser pressure zone on the leeward side, where an opening allows air to be drawn out - provided naturally it is able to enter somewhere else.

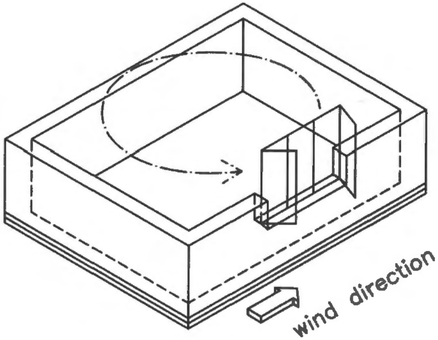
By judicious placing of openings then, it is possible to utilise high or low pressure zones to channel or direct air where required. Further attention to such as which way windows open, and how they open, hinged or pivoted, whether top-hung or side-hung, whether they are at high or low level all allow fine tuning to the needs of ventilation, temperature control and personal comfort.

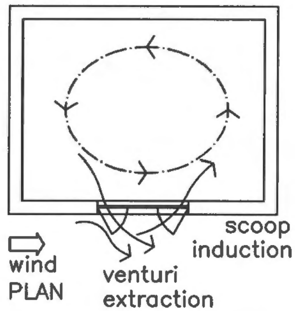
WINDOW TYPES AND VENTILATION NEEDS

(5.5.1)

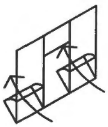


A fanlight allows smaller volumes of air to move in or out. It is commonly used to provide air for ventilation in colder temperatures or very windy conditions.

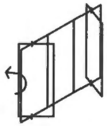




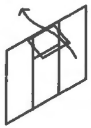
Interior air movement is determined by the design of window openings.



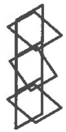
A bottom–hung inward opening "hopper" gives ventilation at lower levels, specially suited to offices or schools deflecting air over occupants in a seated position.



Pivot–hung windows primarily allow cleaning from inside, but also provide ventilation against the reveal of the window.



Fanlights hung thus thrust the air up to a slightly higher level.



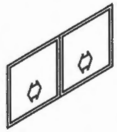
The vertical window with sets of sliding, pivoted opening case–ments works well for ventilation, as it is ad–justable at three levels controlling the entry and exit of air at high, middle and low levels. Defleciton of air as for a side–hung window however is not possible.

WINDOW TYPES CONTINUED

5.5.2

Adjustable glass louvres provide ventilation at various levels and at every louvre, giving a wider spread of air vertically than the pivoted sets previously illustrated. Louvres are controlled in banks of 3 or 4 blades as shown. Louvres, even when open are secure, and burglar proofing is not needed to the same degree as other window types. They can be finely adjusted for air.

The sliding sash window allows larger areas of glass to open. It provides for easy stack ventilation, and it is able to be opened from the bottom — pleasant for seated occupants, and from the top — good for protection from strong winds. However, without centre–height opening possible, it has its limitations.



The horizontal sliding sash window allows very large panes of glass to open. Ventilation is not efficient, because for a small opening the full height of the leading edge frame has to be opened, often causing droning in stronger winds. It is popular because a large unobstructed opening is provided.

An up–market window which was developed for colder climates and more affluent buyers, has hinges on three sides which come into operation as desired by the use of levers and catches. It is most efficient because of its versatility.

Trickle ventilators are used in climates with very cold winters and comprise a small slot in the top frame of the opening sash. It may be closed or opened by degrees by sliding or rotating a perforated metal cover, allowing small amounts of air to enter.

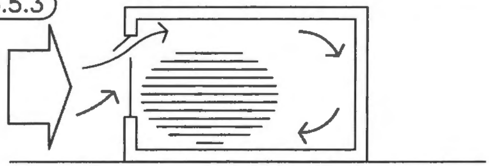
For orientations into stormy weather, two sets of louvres provide an excellent stop to blown rain, even in gale winds.

There must be a gap between the sill and the bottom of the outer frame to allow water to escape.

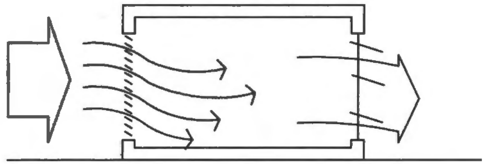
AIR MOVEMENTS IN CROSS SECTION

(5.5.3)

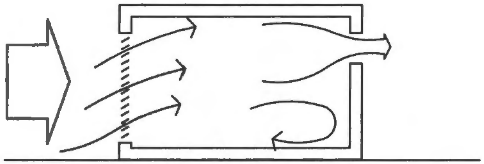
Using window types previously illustrated, the following patterns of air movement may be achieved.



Low level calm (shaded); limited ventilation

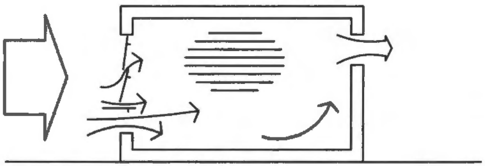


Full height cross flow; good cooling

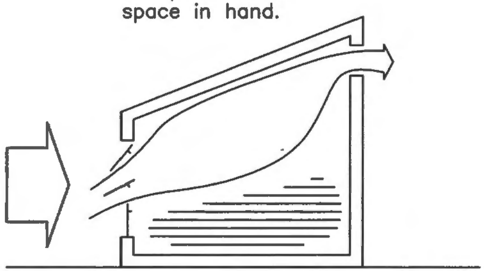


Full height, upward inflow; limited cross ventilation

NOTE that the designer chooses the window configuration that best suits the needs of the occupants of the space in hand.



Good low level air supply and cooling



Low level calm; good for school room or office

THERMAL TRANSMISSION AT WINDOWS

See illustration with this title.

So far we have made a study of heat transfer by (a) solar radiation through windows, and then (b), the flow of air through openings in windows, as well as conventional (stack) movement. Both these have an effect upon the temperature of the interior, and can be controlled to provide improved comfort conditions for the occupants, whether they be householders, school children or office workers.

HEAT LOSS BY CONDUCTION There is yet a further important form of heat transmission through windows and that is by conduction - allied to a lesser degree, with convection.

Winter temperatures in many parts of South Africa at night are often near to, or below freezing. Between the outside air at this temperature and the inside - that is, living space - is often only 3 or 4mm of glass. In recent years most glass used is thicker, and up to 6mm for domestic use. The thicker dimension counts for little when after a few hours of very cold external temperatures, the glass cools down, conducts its temperature to the inner face, where the air in contact cools down, flows downwards, warm air taking its place. And the cycle continues through the night. Little is done to stem this cycle except for curtains which are often very open at the bottom end where the cool air escapes, and as we have seen before, begins to fill the room from the floor up. Seats and beds are at this low level, and occupants soon feel the drop in temperature and then turn on heat sources. Blankets are added, the heaters turned up, and by dawn, the problem of getting to work on time is serious. At least there is relief on a sunny winter's day, by say 10.30. The problem commences its cycle once again at sunset, and goes on through the cold season, year after year.

In colder northern climates where temperatures are still lower and continue low throughout the day, buildings have been appropriately insulated and heating systems properly developed. However, in South Africa, because of the warm daytime relief, bridging the night is often courageously faced, for which, remarkably, a number of people are quite proud. The next deception or error, is that where householders apply heating devices, whether they be hot water bottles or electric blankets, air warmers, radiant heaters, fires or gas heaters - even central heating systems, it is assumed that the problem is solved. This is treating the symptom and not dealing with the cause. The windows still leak cold air, the walls are uninsulated, the doors have large gaps to their edges. Where proper climatic design applies, the need for all these heating mechanisms largely falls away - not completely, but certainly costs are reduced - not only in purchasing high performance appliances but especially in their running. Replacement cycles are also more frequent.

LOWER COSTS, ENERGY WASTE The truth is that it is preferable to have properly designed comfortable living spaces, and naturally, lower heating bills, and most important, lower fuel consumption. In an inefficient system the extra cost in energy alone, when added up at the end of the season is significant. Besides space heating, think of extra bath water; hotter meals & drinks; hot water bottles, electric blankets. Heating one single "inefficient" room for one winter's night would at present rates cost *conservatively:*
1kw x 7hrs x R25/100 = R1.75 For 1 month = R52.50 For 4 months = R210.00 For 4 rooms = R840.00! (In summer, a typical 3-bedroom home electricity account monthly is from R200 to R300.) Think of the saving per season - which could be spent on some needed item of furniture, food, sporting equipment, clothes - or anything else.

As we take most of our local building technology from Europe, (predominantly British) so it is with the thermal protection of windows. While, from the above reasoning, it is possible to survive using existing out-dated and inefficient building practices, in the interests of both cost and conserving energy and the environment, it more than pays to take steps to design buildings which are properly thermally efficient.

SOLUTIONS

CURTAINS From the illustrations, beginning with the least costly, insulated and air resistant curtains provide the best solution. They need either to have U-shaped pelmets to all four sides, or be able to be fastened at sides and bottom to walls and sill. Velcro or studs provide some suggestions. This traps the cold air at the window, and the interior remains warm.

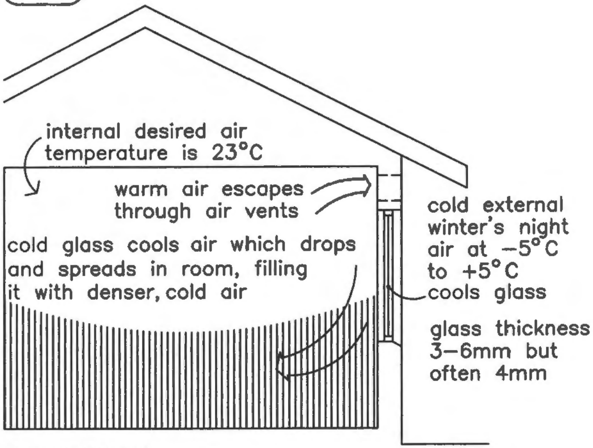
At the same time, air bricks or other vents, while desirable in summer, should be able to be blocked off to prevent warm, less dense air from escaping. They are usually placed at high level, making the problem more serious. In any event, care needs to be taken to ensure that there is a sufficient air supply to prevent suffocation, especially in rooms housing a number of people. Even a moderate loss in oxygen supply will reduce the output of workers, both physically and mentally.

SECONDARY GLAZING Secondary framing or glazing is commonly used in Europe in existing buildings where, especially with thicker walls, there is space to install a new, efficient window and frame. Care must be taken to allow easy opening and closing, as well as cleaning.

DOUBLE GLAZING Double glazing is a practical solution for new smaller buildings where instead of the frame rebating housing a single sheet of glass, extra rebating and beading secures an extra sheet of glass.

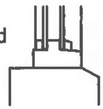
THERMAL TRANSMISSION AT WINDOWS

(5.8.1)

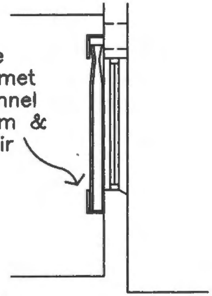


THE PROBLEM

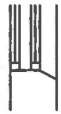
3 For a new building, the use of double glazing is the most appropriate, and frames are designed to take an extra sheet of glass, with an air gap between the two layers.



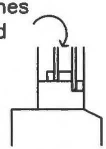
THE SOLUTIONS



1 Thick insulative curtains with pelmet at top and "channel pelmet" at bottom & sides, blocking air movement.



2 For an existing building, secondary windows may be added, provided that openings can still be operated, and cleaning done. In timber frames beading can be added and further panes of glass installed, creating an air gap that helps reduce thermal loss.



4 Insulative glass, used in large commercial buildings, comprises window panes of double glass, with a small space between, filled with argon gas, a good insulator.

Here there is at least some reduction in heat transfer, as an interim layer of air has to change in temperature before changing that of the interior. The air between the glass sheets, by convection transfers heat, and if it were possible to fill this gap with an insulative gas (such as argon) it would be a better solution. The sealing of edges creates a problem when looking at the long life of a building.

INSULATIVE GLASS For large commercial buildings, there is a wide range of glasses which have been developed, and perform on highly sophisticated lines. The most common solution in this field is to use insulative glass, comprising two layers of glass with a thin inter-space of argon gas, some 4mm clear. The gas transfers minimal heat and the system is most effective. To include all other systems would be too advanced for this level of study.

As a warning, the use of reflective or tinted glasses for smaller buildings is both expensive and not as effective as at first thought. Mirror glasses reflect the sun's heat onto the ground or somewhere where it is not wanted, creating further heat, and tinted glass itself warms up significantly and transfers a good proportion of the heat to the interior by re-radiation and convection. A visit to any larger building with this glass will clarify the point. It is worth at this stage, making the observation by feeling the internal face of the glass while it is in sun.

WINDOW SIZING Finally, where a hot climate creates problems, window sizes need to be carefully designed to provide optimum conditions. Incorporating a large window where it is not really needed leads to long term costs in cold-season heating and warm season cooling. As a reminder, positioning of windows both horizontally and vertically are important. Likewise, as we shall see in later sections, the entire design of the building must evolve along preventative lines, whether for keeping heat out or in. And so for all the other elements of the weather.

DOORS

Since we are dealing with the environment as related to these topics, we are concerned with external doors only. Internal doors however do have to do with cross-ventilation and perhaps lighting, and these will be referred to much later on. External doors may or may not have an important role in designing for the comfort of the interior depending upon how many there are in relation to the area of the building they serve. Some building owners want external doors to nearly every room, while others, being highly security-conscious, only want the minimum possible.

The range of door types is almost unending, and for smaller buildings the common types will be commented on and then illustrated where necessary. Being the external type, we shall include the following: single panel opaque, single panel half- or fully-glazed, stable pattern, fanlights and sidelights, sliding aluminium framed and glazed.

See relevant illustrations covering the information below.

SINGLE FULL OPAQUE DOOR - HINGED The word "opaque" is used simply because there are doors in materials other than timber, and what is mostly in mind here is the timber door, whether fielded, battened or flush panel, but of an external quality. Firstly, timber is in itself a reasonably good insulator and simply by feeling the inside of such a door standing in the sun will reveal that it provides a better heat barrier than transparent glass. Also worth observing is that if the door is painted, a light glossy finish will be much cooler than a natural wood finish. Likewise, a flush panel door (not often chosen for exterior use) will be a better insulator than a battened, because of its semi-hollow construction.

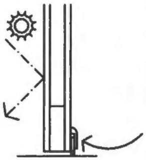
Solid flush panel doors are also used, and again are better than the battened type, being some 45mm thick as against only 16mm (or less) for the battened type.

As far as solar radiation is concerned, most external doors are sheltered and radiation is not a problem. However, where doors are exposed to direct sun, a certain amount of heat will be transferred to the interior, and consideration must be given to the duration of exposure and to the angles of sun. In winter, with low angles, this could be an advantage, and for summer, it would be wise to provide a shading cover, a recessed entrance or porch and roof. For cold temperatures, a light-toned glossy finish to both interior and exterior surfaces of an exposed door will keep heat in. A common weakness in such conditions is the quality of fitting of the door leaf in its frame, and large gaps especially at the bottom edge (at the floor) will allow serious loss of heat. Windy conditions exacerbate this weakness enormously. Draught excluders need to be incorporated in the door design from the beginning as well as careful detailing and supervision of the building process. The ultimate (and costly) precaution is to provide a lobby entrance, which has two doors with a lobby between. This provides a very good shelter for the delayed process of removing raincoats, folding and shaking off umbrellas. This design is very common in regions of prolonged, freezing conditions, which we seldom have in South Africa. We do however have strong winds, and in this case the two-door lobby provides an excellent solution.

SINGLE PANEL HALF- AND FULL-GLAZED These are illustrated, and glazing may be clear or obscure, both allowing radiant heat to pass through, the latter moderately scattering the rays and therefore heat. The position of these external doors as related to sun angles must be treated in principle as windows, except that shading devices for east or west orientations must not interfere with the passage of pedestrians. If shading is necessary, it must be easily swung away, like a door, to allow a way through.

DOORS

(5.11.1)

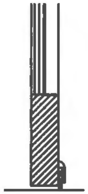


SECTION
semi-solid
construction

a timber door 45mm thick provides a reasonable resistance to heat transfer

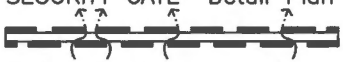
light, glossy surfaces both sides will reduce heat transfer

a draught-excluder will prevent cold air entering



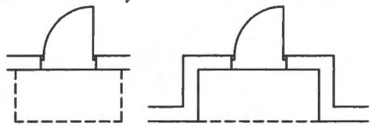
SECTION
framed &
battened

SECURITY GATE Detail Plan



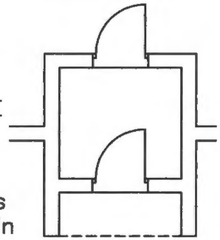
vertical battens spaced apart allow air movement provide privacy, security

ENTRANCE / EXIT DOORS: WEATHER PROTECTION



1 roof overhang

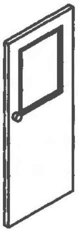
2 recess



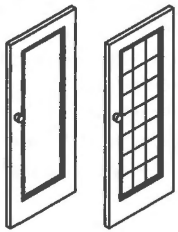
3 weather lobby

Each arrangement provides protection against sun, rain and 3, strong winds

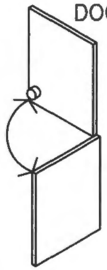
HALF AND FULL GLAZED DOORS



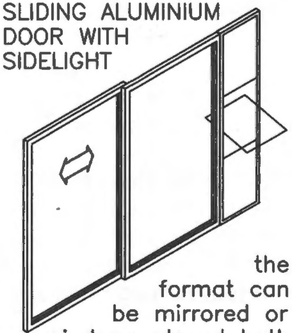
Glazed doors provide extra light, as well as the ability of seeing who is at the door; these doors are also more decorative



STABLE PATTERN DOOR



SLIDING ALUMINIUM DOOR WITH SIDELIGHT



the format can be mirrored or windows placed both ends

Remember that glass in a door may be very necessary for natural lighting. Again, as for most entrance doors, it is normal to provide a recess, a porch, or side screening with a small roof.

There is often a small delay before entering a building whether to find keys and unlock the door, or to put down a parcel or baggage, or to furl an umbrella. A visitor has to wait while the door bell is answered. Overhead shelter is needed against rain or strong sun. In some regions a side screen from the wind is desirable.

Half glazed doors provide a good area of light, and from the interior, a waiting visitor can be identified. For clear glass, if privacy is needed, internal lace curtaining can be applied, or other equivalent, such as a pull-down blind or a Venetian blind.

Full glazing has the same merits as half glazing, but allows a greater amount of light to enter, and the designer has to be more careful to provide proper shading for sun-facing orientations. A full-glazed door can be very attractive, whether glazed in one large pane or in a number of small ones. Probably most owners choose this pattern of door for its appearance.

Note that outward opening fully glazed timber doors provide a generous opening as a link with the outdoor area, and can provide a good substitute to the sliding aluminium door at a much lower cost.

STABLE PATTERN DOORS These are made to match any form of construction and finish of standard doors, and they are split horizontally in half, allowing the upper half to open while the lower half remains closed and bolted. These doors have specific functions in allowing half or full height ventilation. The upper half may be left open for ventilation or light while the lower locked half prevents the passage of small children or pets. They also provide partial security where the occupant can converse with a visitor with the lower half closed. If the door is to be swung as a single leaf, the two halves are simply bolted together. They are very appropriate for use as a kitchen external door.

FANLIGHTS AND SIDELIGHTS Entrance doors are often manufactured with fanlights and / or sidelights, and these simply need to be treated as for windows. Opening casements to sidelights provide useful through ventilation to circulation spaces within, and again, for security purposes, are good for the occupant to check a visitor who has rung the door bell.

SLIDING ALUMINIUM FRAMED & GLAZED DOORS These are used to achieve very large areas of glass for large living rooms, board rooms and semi-public spaces. A range of standard sizes is available. They come in two panels, the one remaining fixed and the other sliding. Of paramount importance here is that while these doors in their open positions provide ventilation, the degree of control is very limited in that even for a small opening, it gives a full-height vertical slot, which causes droning in wind - the very time that a small opening is wanted. As an optional extra, these doors are supplied together with windows (see illustration) at the side, as a vertical rectangle of three panes, or as a horizontal band above the door. These provide needed and controllable ventilation. The designer is also free to specify such as louvres or other as suitable.

Whenever these doors are specified by the designer, remember that by themselves, they are *not* efficient ventilators. However, there are patent makes that are framed in timber and while they slide on rollers on a lower track, they also have an overhead mechanism which allows, without sliding the opening sections at all, to open inwards, "bottom hung". The opening angle is very small but allows a smaller controlled amount of air to enter over the top of the door and around its sides. It is understandably more expensive than the above basic type.

SECURITY GRILLES Since security is a very widespread need, note that for external doors, steel grilles (or gates) are common. Since we are looking specifically at environmental issues, such grilles need not only be thought of in terms of physical protection against forced entry, but as prevention against opportunists making swift visits to thieve unnoticed, (under pretence, if caught, of selling goods - or other). The point is that with grilles locked, doors may be left open for generous ventilation, often needed in South Africa. This is especially welcome on warm humid evenings.

These grilles however do not provide privacy, nor protection against threat by a firearm bearer, and a suggested option is illustrated, with wide timber "battens", overlapping and with slots between to allow air through. Such a device would provide protection against forced entry as well. A more common alternative is the fixed, panel of angled louvres, all made in timber, but giving less resistance to forced entry. These designs have limited air flow compared with the steel grille.

TASKS

1 OBJECTIVE To observe temperature separation within living or working spaces. Within such areas as bedrooms, kitchens, offices and laboratories, we understand that warm air rises to the ceiling while cool air remains at floor level. But what is the actual difference in terms of degrees Celsius?

1.1 Take your two thermometers and secure one at just above floor level (say 100mm, on a book) and the other, at the same time, just below ceiling level, hanging on tape, and allow both to settle down, and *record* the difference. Try this in several different rooms as well as an office if available. Make sure the lights are not in close proximity if switched on.

Likewise avoid sun patches. Take readings at various times of day, but especially in the afternoon of a sunny day. 1.2 Similarly, if you have a double-storey residence, take readings on both floor levels, say at desk height. *Record* the difference. 1.3 If you have access to space under a sloping roof (above the ceiling), then take a reading on a sunny day in the latter part of the day, say at 15.00. Compare this with readings in the living areas. With your recordings, write down the date, the location and any other pertinent information.

2 OBJECTIVE To observe air movement patterns around and within buildings by means of simple models. In this section you have been given a very brief introduction to air movements, where such as pressure zones and wind shadows develop inside and outside buildings.

2.1 With the aid of a household fan, (or preferably two, identical), together with cardboard cartons (or built up models from card), make a box shape, say 400 square by 300 high, with rectangular openings cut, so that they can be opened or closed, with side folds, as hinges for a window. The box, with "windows" in set positions is placed in front of a fan, (which must not oscillate), at a reasonable distance, say a metre away, and by attaching streamers at the openings and around various parts of the box, the behaviour of the air movement can be observed. (A streamer is a long, very thin, strip of light paper.) In addition, a streamer can be attached to the end of a metre-long, thin, hand-held dowel, enabling it to be placed anywhere around the model without your own body interfering with the air patterns. The box or fan can be moved or rotated, to obtain various results. Likewise the openings may be varied in size, or alternative box shapes, even cylindrical, used. A candle used in wind shadow areas provides an instant indicator of conditions. *Record* your findings, which must include a sketch of the box, openings, screens or other features.

2.2 The following experiment is not recommended unless you have means for clearing up afterwards! Use a smaller box, cut openings as desired, and bury it all in polystyrene pellets. (A pellet is a small 3mm ball.) These are available at art shops or similar and are not expensive. Place the fan nearby, again one metre away, turn on to slow, then medium and if necessary, high speed, and observe carefully the pathways of the pellets, and eventually the pattern of where they remain undisturbed. Taking a video would help. To save work clearing up, the whole experiment should be placed on a large plastic sheet, and then gathered up for perhaps another experiment.

3 OBJECTIVE To observe the effects of thermal transmission at windows.

For this observation, you will need one unoccupied room, preferably with thick curtains. You will need to do the observation over two cold winter nights, each with clear sky, and the temperatures fairly similar.

On the first night, leave the curtains open and the windows closed. The inside door or other openings must closed and no heating devices left on. Take air temperatures inside the room, at say 300 above floor level, and outside the window, (but not at ground level) at the same times, after sunset at 2 hourly intervals until about 23.00. Do the same just before or at sunrise the following morning.

On the second night, do exactly the same, except that the curtains must be closed just before sunset, with their lower hems pushed onto the inner sill, with books weighing them down, creating an air seal. For the sides, seal them as effectively as possible, for example by putting a long timber dowel (broom stick) or square, vertically against, with bottom end resting on sill or floor, and held against the wall with the back of a chair, a ladder or any suitable object. Again the windows must be shut.

Write down all temperatures and compare the differences. While the two nights' outside temperatures respectively will seldom be the same, the two sets of *differences* between inside and out are important to compare. If the curtains are adequately thick, you will see the actual difference in degrees, which is worth putting down for reference for your own education and future reference. (As an alternative, if the curtains are too thin, buy or borrow a roll of aluminium kitchen foil and sticky-tape it onto the inside of the glass, (before sunset) ensuring (a) that it covers the whole area and is well secured at all edges, and (b) that the glossy side faces into the room. This may not be successful in humid climates or in over-warmed interiors. Condensation will neutralise the effect of the glossy inward surface, and heat will escape.) Furthermore, you just *may* have available two identical rooms adjacent in which these comparative sets of temperatures may be taken on one night, one with curtains shut and the other with them open. But all aspects of the rooms must be the same: size of window, orientation, floor finishes - and anything that can affect the internal temperatures. You can still manage this with two thermometers, as readings spaced 10 minutes apart inside will not make a serious difference. Three thermometers will naturally be better.

4 OBJECTIVE To control air movement within buildings by means of adjusting window openings.

The following experiment should be undertaken on a day when there is a fairly steady breeze blowing. A stronger wind will also suffice.

Observe the direction of the wind. Take note of the windows in the residence where you live and how they open. (If you live in a small room, join with a friend who has a larger residence to do the experiment.)

Take note of the effects of opening one side-hung casement at a time, at varying angles, and test the air movement internally - with a streamer or a candle. Try with more than one casement, if available. Then make an attempt to direct the air movement from room to room, first making it travel in one direction, then the other. An example of the usefulness of this is where kitchen cooking odours drift into living areas. If this can be reversed, you are winning. In many buildings this result is quite achievable.

Observe the wind obstacles externally such as neighbouring houses - especially double storey, and track wind directions there too, and how they affect pressure zones around the windows where air enters or exits. Record all your findings.

6 ● OUTDOOR LIVING - SHADING

OUTDOOR LIVING SPACES

AN IDEAL CLIMATE FOR OUTDOOR LIVING In South Africa, renowned for its generous sunshine, mild temperatures and low rainfall, outdoor living is enjoyed and practised as much as any other country in the world. This places an importance upon outdoor living space which demands the careful attention of the designer. Again, in many situations, the ubiquitous patio is added as an afterthought when the plan of the house itself has been satisfactorily worked out at the drawing board, with less than satisfactory results. From a general planning point of view, if the patio is used for eating, it needs to be placed proximate to the kitchen. If used for social entertainment, it also needs to be close to related facilities within the house, such as the main entrance, the toilet, music sources and, for between-meal snacks, near the kitchen. It therefore becomes part of the house plan, and by comparison with internal spaces, the cost per square metre of floor area is much lower for understandable reasons, and it is conceivably affordable to have more than one patio for reasons that will become clear as this topic is covered.

HEALTH AND ENERGY How does this have to do with the environment? Firstly, it is normally healthier to be outdoors not only for the air that is breathed (away from the "sick building syndrome"), but for the holistic experience in enjoying a closeness with nature. Further, if indoor conditions are too warm, or even too cool, moving outdoors will save turning on a fan, air-conditioner or heater, saving energy. As we have seen previously, take note that exterior spaces connecting to the interior have a significant effect upon temperatures as well as quality of air, (whether in scented flowers or refuse odours in the kitchen yard!) A warm to hot paved patio in the sun in winter will have a noticeable effect upon the temperature of the air passing over it and entering the interior. The opposite happens in summer, where a cool shaded patio with planting cools an adjacent internal living space. Again energy is saved.

TYPES OF OUTDOOR LIVING SPACE

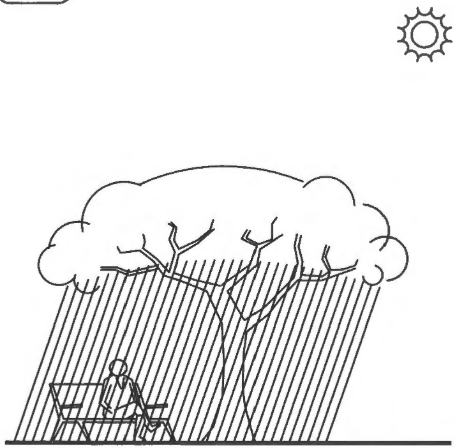
Note that illustrations are diagrammatic and only show elementary principles. The shape or proportion of patio, with finishes, planting, is entirely in the hands of the designer, and many exciting variations are possible.

THE TREE Little can match the pleasure of sitting and reading or chatting under a large tree in a garden. If a shady tree is available to the planning of a house or small office, it should be used without hesitation, provided that there are no inherent drawbacks - or dangers - such as falling fruit. The best type of tree sheds it leaves in winter (large leaves are easy to collect), to let the sun through. Ideally, a firm grassed surface is good under foot, but often grass will not grow under trees, and paving may be necessary, or the planting of a grass suited to shade. This arrangement provides the most economical and most enjoyable form of outdoor living space. There are weaknesses however, which become apparent as the following solutions are covered. Trees are not always available and structures have to be designed to simulate such conditions and to improve on them.

OUTDOOR LIVING SPACE

THE TREE

6.2.1



A grassed or paved area under a tree provides a pleasant outdoor living space. IN SUMMER leaves provide shade.

IN WINTER a deciduous tree allows a good proportion of sunlight to penetrate. Bushes or a built screen may be needed for wind shelter.

THE GAZEBO (Pronounced gezee-bo; emphasis on the zee) Also named as a Summer House, this simulates the tree in that a roof structure is placed somewhere in the garden, and may be open all round or partly screened for wind, and is strategically placed to give a good view, catch the breeze or be sheltered from strong winds. Seating is provided and surrounding garden designed to give the most pleasant result. These are not commonly seen except in larger properties, and are comparatively more expensive than most of those that follow.

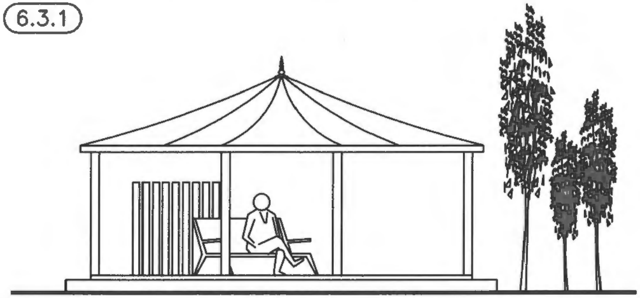
THE ELEMENTARY PATIO ("Patio" is pronounced patty-o; emphasis on the pat.) Normally this comprises a paved outdoor area contiguous with the main building and linked to a "semi-public" living space such as a lounge or dining room. It exists for outdoor living, whether for eating meals or lounging socially. The patio has a timber (sometimes concrete) framework designed to carry a horizontal overhead shading creeper, again, which is deciduous, shedding its leaves in winter for sun, but giving shade in summer. The timber members overhead form a Pergola (pronounced pergela, emphasis on the per). The plant may be trained to give side shade as well, or the structure so designed to do the same.

The patio is placed, as illustrated, for *winter use* to gain heat, and sheltered from wind, but exposed to the sun, especially in the afternoons, and may be in a recess provided by the external walls of the main building. Shelter from the wind can be provided by planting or by suitably designing the structure. The paving should receive plentiful sun and have a dark finish, allowing heat to be re-radiated, to warm the air, and thus to transfer indoors.

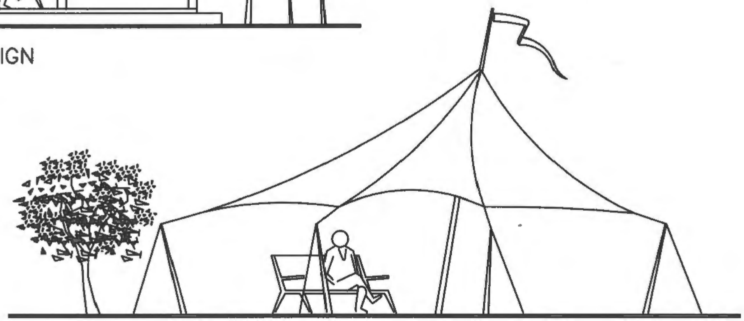
For *summer use* the opposite applies, and the area is given maximum shade, exposed to breezes, and the paved areas should not receive sun, as heat builds up and becomes unpleasant, and is transferred indoors.

THE GAZEBO OR SUMMER HOUSE

(6.3.1)



TRADITIONAL DESIGN

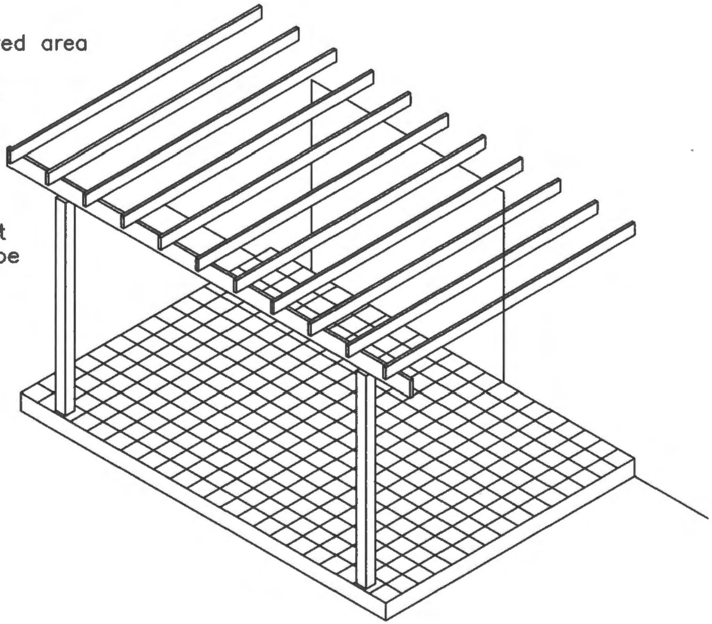


CONTEMPORARY DESIGN

THE ELEMENTARY PATIO

(6.3.2)

This usually comprises a paved area at a door to a living area. This provides ease of access as well as a pleasant view out from such as a living room or dining room.
The paved seating area is covered by a timber pergola which supports a shady plant preferably of a deciduous type to shed its leaves in winter, allowing sun to penetrate in cooler weather.

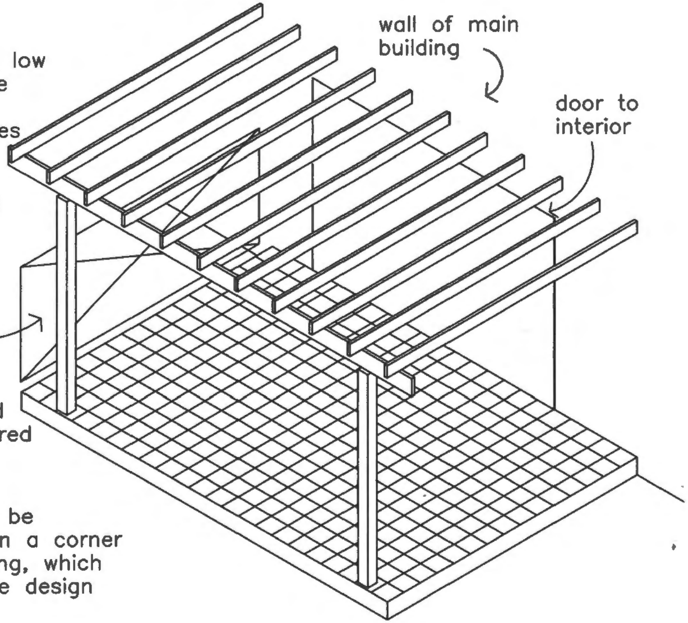


ADDITIONAL FEATURES TO THE ELEMENTARY PATIO

SIDE SCREENING (6.3.3)

A wind shield or a shade from low sun may be placed to one side and may comprise vertical or horizontal timber slats or louvres closely or widely spaced, the latter less costly and suitable for supporting a creeper, again of a deciduous nature.

Such screens may provide a desirable barrier for privacy but on the other hand, may interfere with a good view.



This raises the dedirability for such features to be adjustable and able to be swung or rolled out of the way when not required and is covered further on.

NOTE that such screening may be achieved by placing the patio in a corner or a recess of the main building, which calls for careful planning at the design stage.

The patio may even be an internal courtyard type, with the main building surrounding it.

Logically, it would be ideal to have two patios, one positioned and designed to gain maximum benefit in summer, and the other in winter. As intimated earlier, because of the lesser cost in construction, (as well as the ability for self-building) it is highly advisable to provide two patios if financially possible. If not, one patio, designed as far as possible to meet the needs of both seasons (and the others between) should be provided. This may be done successfully if carefully thought about, and more effectively still by the use of mechanical controls, as described below. The above are illustrated simply in principle and should be studied.

MECHANICAL DEVICES   As developments from the above, patios may be constructed to provide close to ideal outdoor living conditions simply by using mechanical devices designed to control the weather elements, whether sun, wind, or rain. Control may involve either protection or exposure, whichever is needed for comfort for a given season or for particular weather conditions. Naturally in hot conditions, the sun is to be shaded and air movement enhanced. If rain is a problem, in a warm humid climate, outdoor living may still be a choice, in which case, a water-proof roof is needed.

Available are many forms of adjustable mechanisms - as illustrated - suitable for both side and overhead applications, and (a), may be closed to provide shade from the sun, or opened for exposure in cooler conditions; (b) may be closed to shelter from the wind or opened to allow it to flow; (c) may be closed (overhead) to shield against normal falling rain, or blown rain (from the side)..

These mechanisms comprise in principle the following, and the student or designer must look up appropriate trade literature to find the product that suits their needs best. There is naturally a far wider range of products than those shown.

1 OVERHEAD SHADING

1.1 Retractable nylon (or other) fabric sheet provides full shade over whatever area is needed, and extends, or retracts and folds, and is suspended on runners which are in guides secured to overhead pergola members. These provide good shade, and for sun, may be retracted giving almost full exposure to sun.

1.2 Adjustable metal louvres which when closed, give full shade as well as good rain protection. Whether water would penetrate in heavy rain with wind is open to question - not many people would want to be out in such weather. When open, a good deal of sunshine penetrates but not as much as the previous example, since the louvres, in the vertical open position, are fairly closely spaced. They are long-lasting and are able to be adjusted exactly to the needed proportion of sun and shade.

2 SIDE SHADING AND WIND PROTECTION

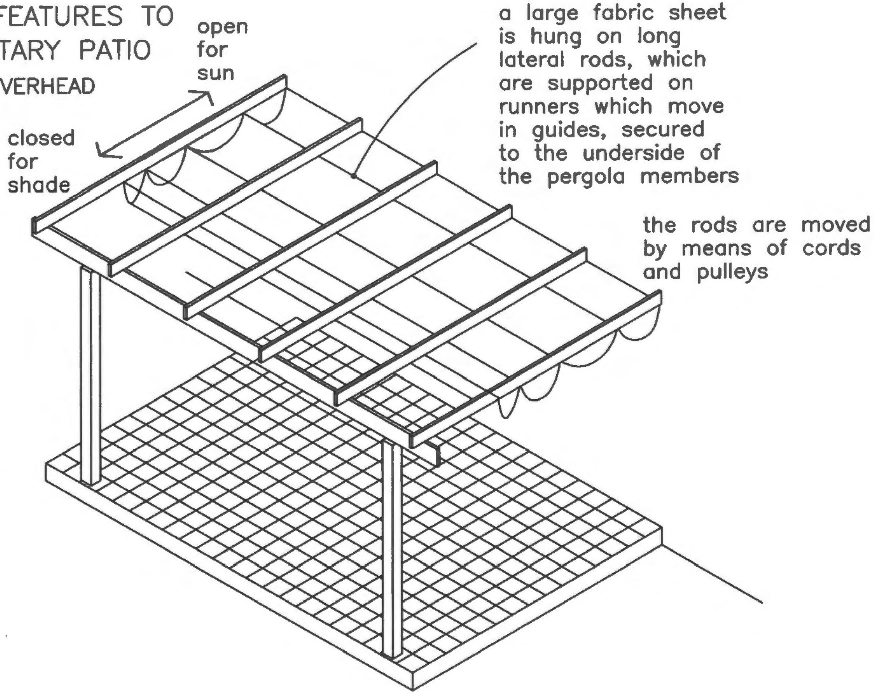
2.1 Where low afternoon sun needs to be shaded, screening with permanent timber or metal louvres or slats, as a vertical panel provides a solution. These will also give moderate shelter to strong wind, and will allow the needed air flow from a breeze in warm weather. The degree of shelter from sun or wind depends on the spacing and size of the louvres.

2.2 As for 2.1 but louvres are adjustable and therefore enable more or less wind or sun to penetrate. NOTE that the louvres may be in glass which will allow a view where needed - and often desirable in a garden setting. Where sites exist in perennially windy regions, framed sheet glass panes, though expensive, is appropriate as a wind barrier.

ADDITIONAL FEATURES TO THE ELEMENTARY PATIO

RETRACTABLE OVERHEAD FABRIC SHADE

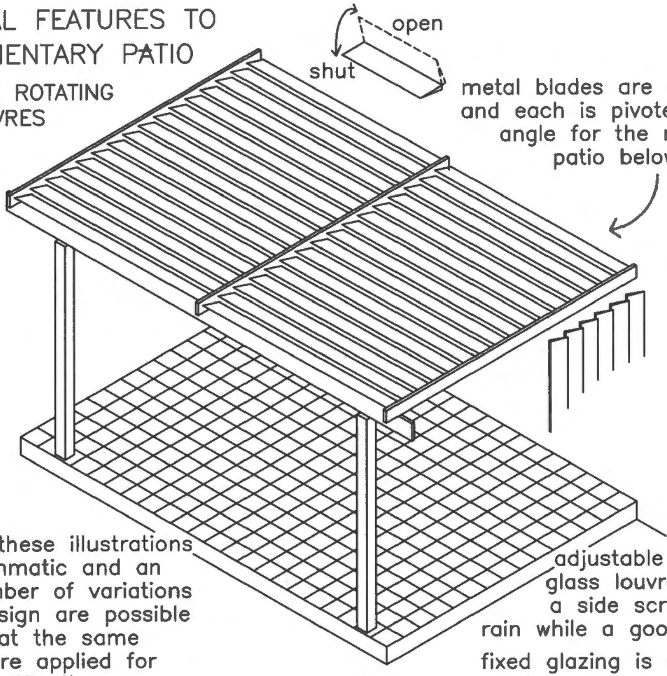
(6.5.1)



ADDITIONAL FEATURES TO THE ELEMENTARY PATIO

ADJUSTABLE ROTATING METAL LOUVRES

(6.5.2)



metal blades are controlled in groups and each is pivoted to provide an angle for the required shade to the patio below

side louvres of the same design are adjustable to create shade or otherwise

these are useful to deflect or reduce wind as well

NOTE that these illustrations are diagrammatic and an infinite number of variations in patio design are possible provided that the same principles are applied for weather modification.

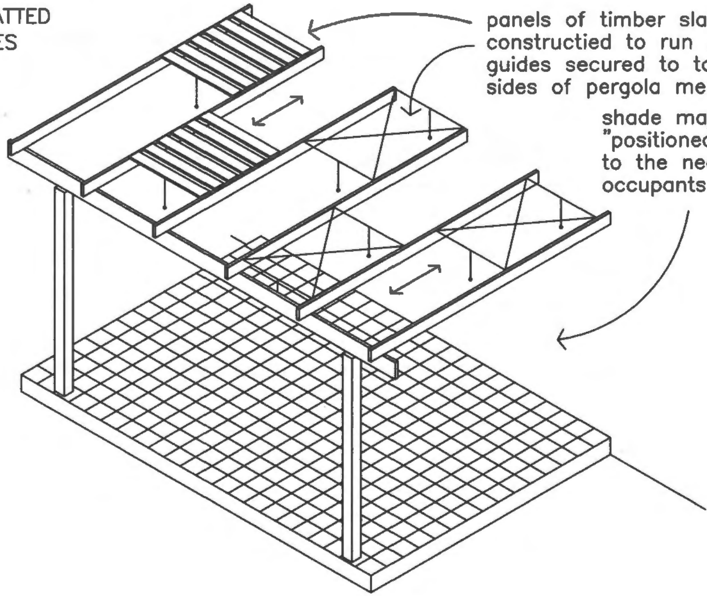
adjustable vertical or horizontal glass louvres are appropriate as a side screen against wind or rain while a good view is still visible

fixed glazing is also commonly used

ADDITIONAL FEATURES TO THE ELEMENTARY PATIO

OVERHEAD SLATTED SLIDING SHADES

(6.5.3)



In the process of designing side screening, one must be aware that other factors come into play, such as privacy from neighbours - or even from the next room of the house, as well as conserving good views, not only distant, but near by, within the garden. It is often not possible to satisfy all requirements in the design process, but this must be striven for at the drawing stage - where changes and alternatives may be easily experimented with, as against trying to make changes. The mind of the designer is by far the most effective tool to produce the required result. The more it is exercised, the more it will be enabled to solve difficult problems.

INNOVATION   Finally, devices for shading, wind screening and even rain protection may be contrived and detailed by the designer. These may comprise simple fabric-on-frame structures, panels of slats or louvres, or complex adjustable louvres, able to be rolled or swung away.

SUN ANGLES AND VERTICAL SHADES

In an earlier section, the topic of sun angles was primarily analysed for the sake of overhead, horizontal shielding, such as canopies, roof overhangs, and then in addition, louvres and windows in the vertical plane. Here our brief analysis will cover shadow patterns generated by vertical objects such as trees, walls or side screens, and falling onto horizontal surfaces,.

REAL LIFE OBSERVATIONS   It is again an extremely beneficial exercise to observe in real situations what happens for given sun angles at various times of day, as well as different seasons. The latter is of tremendous importance to gain the optimum benefit from seasonal sun rising and setting positions. It is worth using the solar protractor because judging the altitude of the sun for example by eye, can be seriously erroneous.

Observations are best kept to readily available buildings which have suitable trees, screens or walls and it is imperative to know just where the north point is, and hence due east and west. This is best established by noting shadow angles at exactly solar noon, and not chronological noon, and then referring to your tables. To use a magnetic compass is inviting error, unless a good compass is available and you know exactly for your area, the deviation of magnetic north from true north.

Once we have looked at this subject, we shall see how to design outdoor areas relative to their surroundings, which comprise the main building, adjacent buildings, trees or other relevant elements.

SHADOWS FROM VERTICAL OBJECTS Look at the illustration on Shadows Cast from Vertical Objects onto Horizontal Surfaces, and those following.

The illustrations are self-explanatory regarding the principles of casting a shadow, first for a vertical pole, then say, a wall, which is equivalent to a row of poles. One must know the height of the pole, the azimuth and altitude of the sun. By simple geometry of the triangle, one can plot the length of the shadow. Then, using the angle of azimuth, the *direction* of the shadow is drawn, and the length transferred from the section, as shown.

SHADOWS AT DIFFERENT SEASONS Then look at the diagrams for Shadows for a 2m Pole at Various Seasons and Times, together with the succeeding illustrations which show Shadow Lengths for the same pole. The sections indicate shadow *lengths* at various times and seasons. Note, as we have seen before, how low the sun is in winter at mid-day, and the length of shadow cast. The opposite applies for summer where the mid-day shadow is very short - or putting it another way, the sun is high overhead.

On the plans, note for summer, how the shadows for up until about 09.00 (for Durban), are on the northern side of the east-west line. In June it is the opposite, with shadows clearly on the southern side. The Equinoctial seasons have all shadows on the southern side, since the sun rises and sets due east and west respectively.

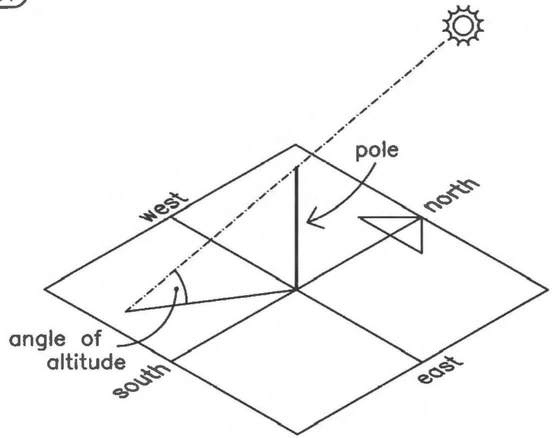
PROJECT YOUR OWN SHADOWS You may use the above information and principles for your own purposes. The original drawings were done to scale, but could be published otherwise. However, the *dimensions* on section for the length of shadow relate to a 2m high pole. Should you wish to use these dimensions and angles to cast your own shadows, first use a calculator to establish the *proportion* of pole length to shadow length. Then, if you have a pole, (or building feature) which is double the height, simply double the chosen length of shadow for the given time and date required. An example follows.

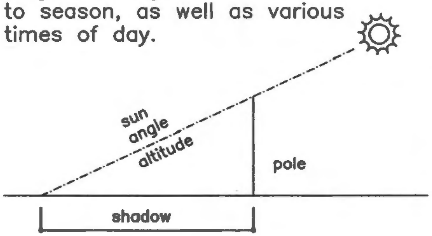
EXAMPLE You wish to project the shadow of a point on the gable-end of a ridge of a roof. You know from drawings that it is 3750 high. (The surrounding ground is assumed to be level.) The location is Durban, and the time, 14.00 on 21 March. (1) From the relevant sectional diagram, one can see that the shadow for a 2m pole is 1.739m long: i.e. the shadow is 0.8695 of the length of the pole. (2) For your shadow length, take 0.8695 of 3750, which is 3261. (3) On your drawing of a house plan, pin-point the end of the ridge in hand, and mark it. Then draw the *angle* from the sun/shadow plans illustrated for 14.00 on 21 March and *note carefully,* on *your* house plan, that the angle is from the north-south line, and *not* from the wall directions of the house plan. This is a very easy mistake to make. (4) Now measure from the ridge point, the distance 3261, and that is the shadow of the point required. Now for the shape of the roof verge on the ground, follow the same procedure for the extreme ends of the roof of the gable, and join the ridge shadow point with the two others. And so for the rest of the structure.

SHADOWS CAST FROM VERTICAL OBJECTS ONTO HORIZONTAL SURFACES (6.8.1)

For such as hedges or walls, it is easiest to think of a vertical pole and what happens to its shadow for given sun angles. Then for a wall, one may think of it as a row of poles, or as a pole at each end of the wall, connected by a straight line at the top.

Once the method of casting these shadows is mastered, it is very important to see how the shadow angles and lengths change from season to season, as well as various times of day.



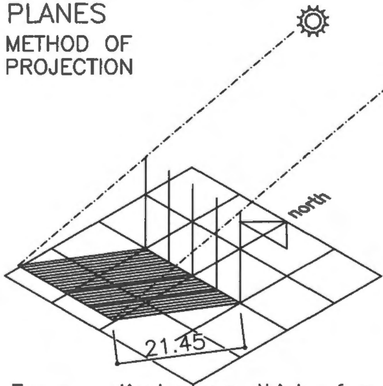


The length of shadow depends upon the angle of altitude of the sun, and the height of the pole.

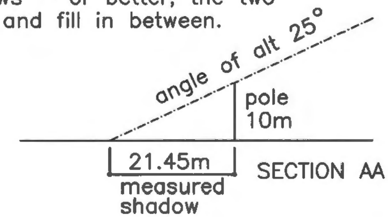
Geometrically then, for the draughtsperson it is easy to draw the pole to scale, and the sun angle, and to measure the length of shadow, and plot it on plan, or wherever needed.

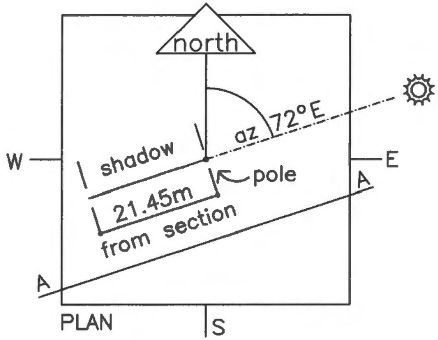
SHADOWS FROM VERTICAL PLANES (6.8.2)

METHOD OF PROJECTION



For a vertical plane, think of a row of poles, and cast their shadows – or better, the two ends, and fill in between.





HOW TO PLOT A SHADOW from a straight vertical pole onto a horizontal surface or plane at its base. Assume the location to be Port Elizabeth.

The pole is 10m high and the north point as shown. The sun shines at 08.00 solar time on 21 March. Plot its shadow.

Method: Look up angles of altitude and azimuth from the table of sun angles.
On plan, plot the angle of the shadow, and on section, as left, draw the pole, and plot the length of shadow. Transfer this dimension onto the plan for the length of the shadow.

SHADOWS FOR A 2M POLE AT VARIOUS SEASONS AND TIMES

(6.8.3)

OBJECTIVE: To observe the nature of shadows cast from a vertical object onto a horizontal plane at various times and at VARIOUS SEASONS.

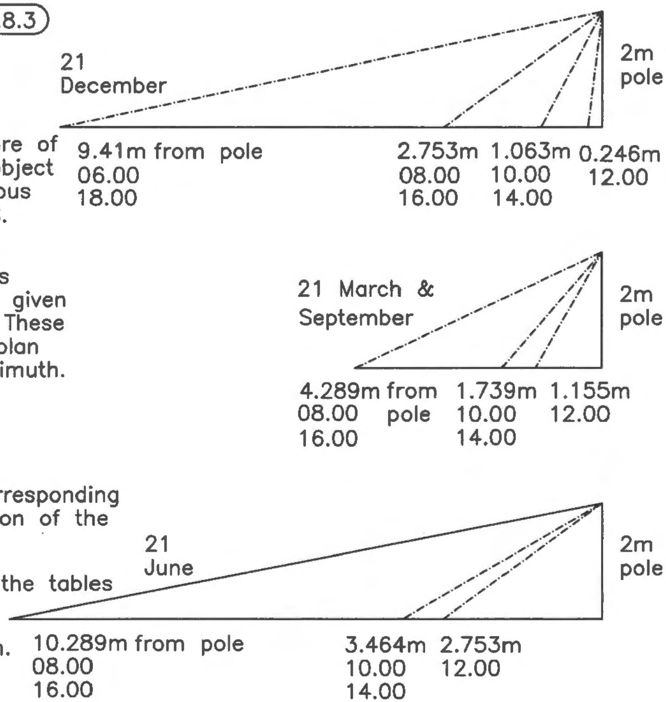
Dotted lines indicate angles of altitude of the sun at the times shown. Lengths of shadows are given in metres for a 2m high pole. These lengths are transferred to the plan views, which show angles of azimuth.

The location is taken to be Durban, being almost on 30° east, and on latitude 30° south.

It is recommended that the corresponding angles be plotted for the location of the region under study.

All sun angles are taken from the tables of sun angles.

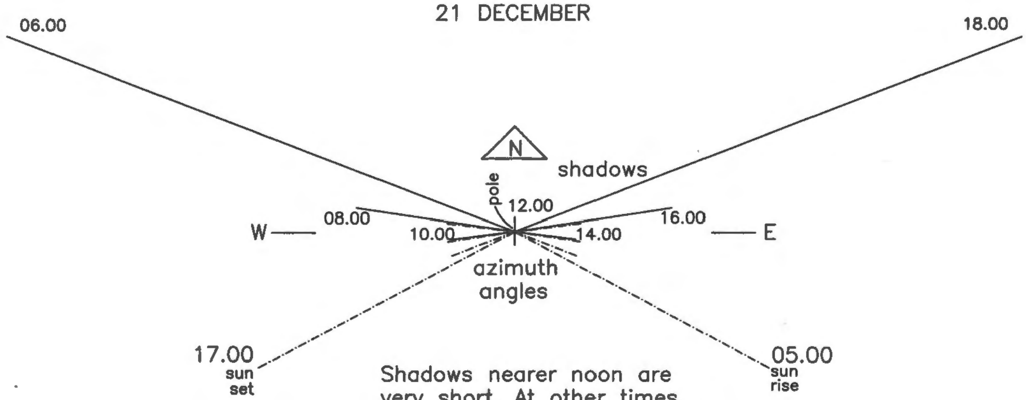
Diagrams are in vertical section.



SHADOW LENGTHS
OF A 2M POLE
at various times
on 21 December
(6.8.4)

Diagram is in plan, and shadow lengths are taken from cross section.

Angles of azimuth are taken from the table of sun angles.



Shadows nearer noon are very short. At other times, are on the northern side of the E–W line.
Duration of day: 14 hours.

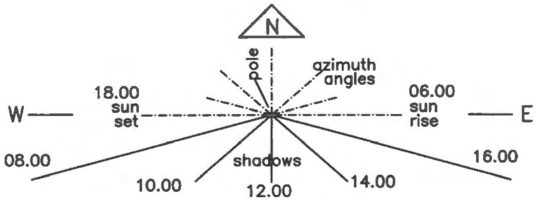
SHADOW LENGTHS OF A 2M POLE
at various times
on 21 March and
21 September

(6.8.5)

Diagram is in plan, and shadow lengths are taken from cross section.

Angles of azimuth are taken from the table of sun angles.

21 March & September



Shadows nearer noon are moderate in length. They are on the southern side of the E–W line.

Duration of day: 12 hours.

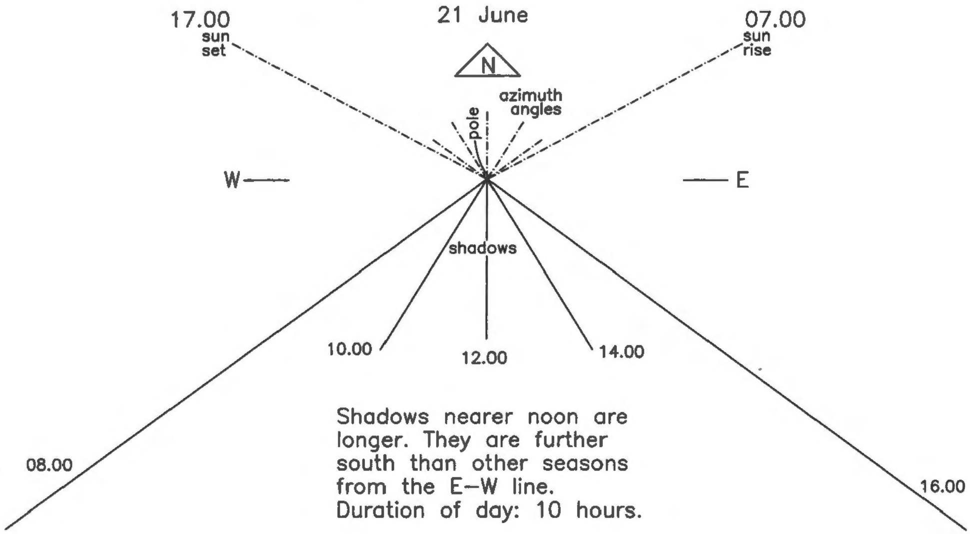
SHADOW LENGTHS OF A 2M POLE

at various times
on 21 June

(6.8.6)

Diagram is in plan, and shadow lengths are taken from cross section.

Angles of azimuth are taken from the table of sun angles.



Shadows nearer noon are longer. They are further south than other seasons from the E–W line.
Duration of day: 10 hours.

TASKS

1 OBJECTIVE To prove, with a little fun, that shadow projection is accurate.

Make this as a simple 3D model of size about 300 sq x 150 high. Design your own shape, but it should have a flat, thin base; it could be a box, with a flat top projecting a little on all sides, with a short mast (dowel) placed in the middle of the roof. Mark on a north point. From tables for a given place, time and date, (i.e. a day or two ahead of the day of making) and cast estimated shadows in pencil outline on the model, both on the base and elsewhere as applicable. Place the model in the sun on a horizontal surface at the time and date as above, make its north point face exactly the same way as real north, and check if real shadows coincide with pencil outlines. If there is a small amount of inaccuracy do not worry, as other variations than those covered do occur. Accuracy should be within about 15 minutes each way of the goal time.

2 OBJECTIVE To compare the effects of various patio protection devices.
Find two or three patios which have the same sun-facing orientation (e.g. in cluster housing) but differing forms of solar protection - which the owners may have added. Compare the performances of each by taking temperatures of surfaces, and air, for each at important times of day or the year. Also record elements such as roll down blinds, louvres, or nearby trees. This is for your own information and will be very useful later in life in an office.

3 OBJECTIVE To observe and confirm times and angles of sun given in solar tables.
Using naked-eye observations, note sun-rising and sun-setting positions and times on the 21st of December, March, June and September. Take all precautions to ensure as accurate readings as possible. Plot the angles on a plan drawing. On the same dates, read the angle of the sun from the horizontal plane at noon (the altitude) and plot as a sectional drawing.

7 ● ENVIRONMENTAL SITE DESIGN

OUTDOOR SPACES BETTER THAN INDOOR

Outdoor living space, as we have seen, very often provides more comfortable and enjoyable living conditions than those found indoors. It follows that in cold weather, outdoor space needs to be positioned to take advantage of radiant sun, and similarly sheltered from cold winds. The opposites apply in hot weather, where outdoor space needs to be sheltered from the sun, and exposed to the breezes. These conditions, if thought of in their extremes, make it easy to arrive at good design solutions. However, it is the interim seasons and weather combinations that make decisions more difficult. Here it is important that provision should be made for areas in which one can place a seat, a table, be able to read a book or undertake any activity, such as writing, painting, preparatory work for cooking, or doing small repair work. As the day changes, it may be better to move to a more or less sheltered spot from sun or wind. It is with these principles in mind that the illustrations are generated and annotated.

It is worth being reminded of an important principle here, and that is, the simpler the solution in basic planning, as against using correctional devices, the less costly the project. A negative example is to place a patio on the warm westerly side of the main building and then to spend money on corrective shading against sun, and on wind scoops to catch the breeze - all of which are much more costly.

There are certain situations where for example, a view is the first priority, and positioning the patio ends up needing protection. Corrective compromises are unavoidable, and careful thought must be given to choosing the best of the alternatives. The designer must think through all seasons, times, weather conditions, uses, and then test (on paper) all the options available.

BUILDING SHAPES ON PLAN Look at the illustration titled Building Shapes (On Plan), and note that of all the common shapes of outline, say of a house, those with "rebates" or recesses offer the best opportunities for accommodating good patio designs. Depending upon the direction of the north point and prevailing winds, differing shapes may work more, or perhaps less successfully. They may be mirrored, or the proportions changed to obtain a better solution. Much will depend upon what happens inside the building, because patios are inextricably related to the functions of the interior.

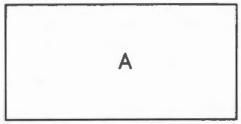
It is imperative then that the outline shape of the main building be borne in mind *while designing the overall building*. This will open the way for planning more functional patios.

The diagrams that follow provide some simple solutions, again in principle, with comments upon what performances may be expected. Note that such functions will vary tremendously with a change in direction of the north point (or reorientation of the building). Note that prevailing winds are also shown - which will vary from region to region. They are indicated simply to show that they do have an effect on the design of patios. Later, when dealing with the planning of houses and small buildings, various orientations and conditions as they affect design will be covered.

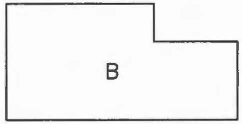
BUILDING SHAPES
(ON PLAN)

7.2.1

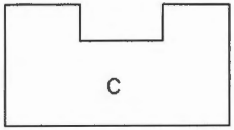
The outline shape of a building will determine the first stages of thinking in regard to placing outdoor living space.
For consideration are:
- exposure to or shelter from radiant sun;
- exposure to air movement:
- shelter from cold wind;
- direction of view, distant and near;
- relation to indoor living space.



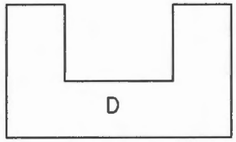
A difficult shape to position a good patio



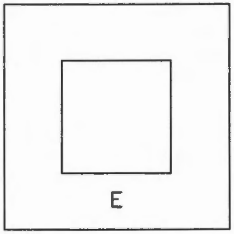
A corner "rebate" affords wind shelter



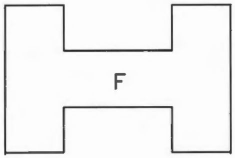
A recess shelters from 3 sides, catches sun well

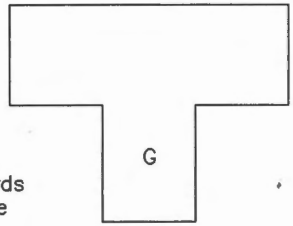


A U– or L–shape can be used to good effect



An internal courtyard is well shaded, but no wind is afforded for cooling

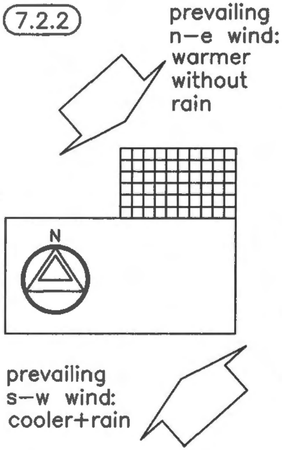




The H– or T–shape affords placing on more than one side, and offers excellent opportunities

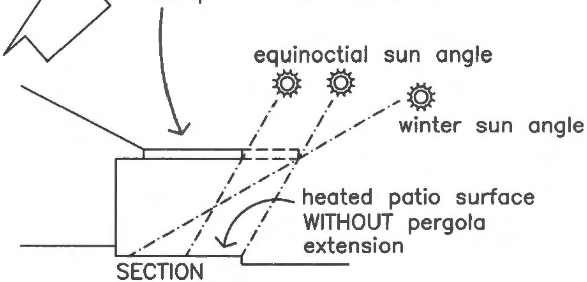
SHAPE A

(7.2.2)

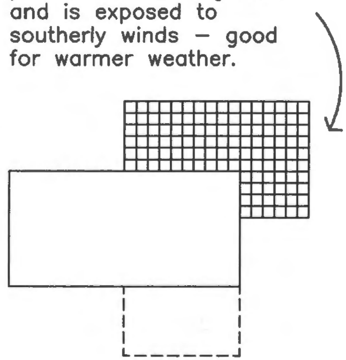


With a covering pergola, this patio will be pleasantly warm in winter and reasonably cool in summer. There is little shelter from wind.

For seasons when the sun is low, and temperatures warm, the pergola needs to extend to provide shade to the paved patio. Otherwise the heated surface warms the air which then may flow into the interior, and the patio itself overheats.



An additional area is well placed for morning sun, and is exposed to southerly winds – good for warmer weather.



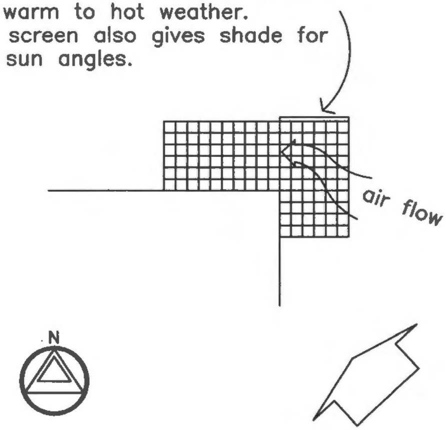
A further patio on the south side will be pleasantly cool for summer.

SHAPE A

FURTHER VARIATIONS

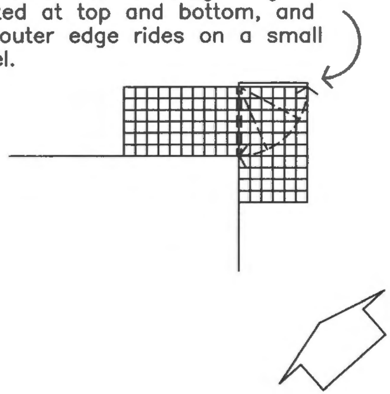
(7.2.3)

A screen, as shown would act as a wind deflector, making the main area more comfortable for warm to hot weather.
The screen also gives shade for low sun angles.

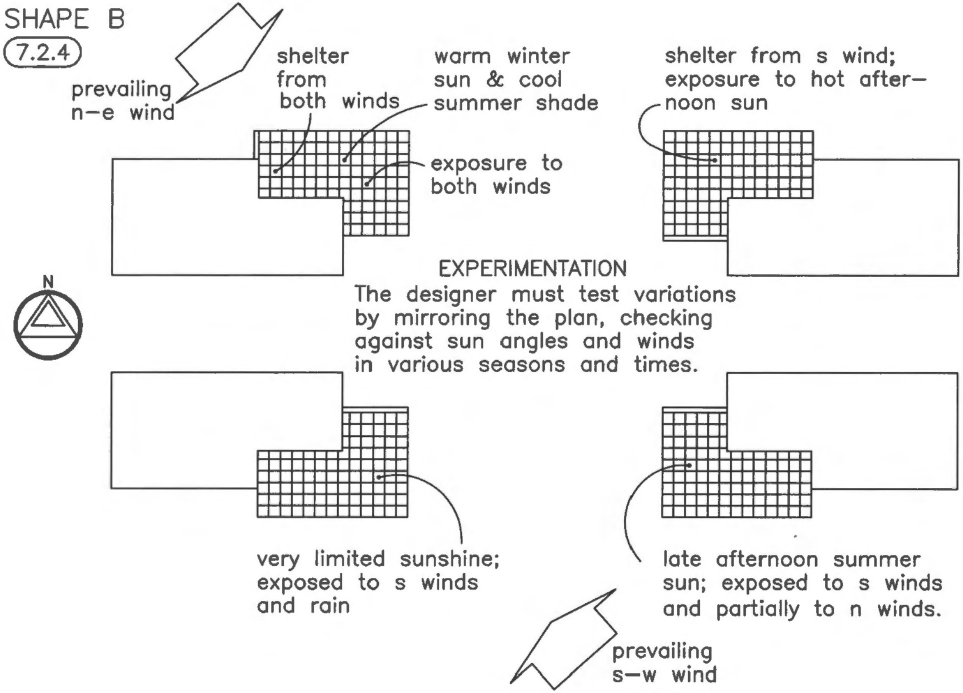


To obtain controllable conditions, a swinging screen would provide a number of useful options, both for wind exposure or shelter, and for sun control.

The screen at the hinge edge is pivoted at top and bottom, and the outer edge rides on a small wheel.



SHAPE B
(7.2.4)

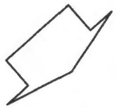


EXPERIMENTATION

The designer must test variations by mirroring the plan, checking against sun angles and winds in various seasons and times.

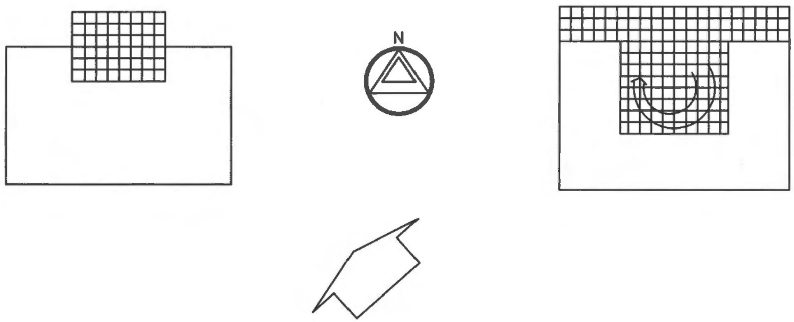
SHAPES C & D

(7.2.5)



A recess affords more shelter from winds and also becomes a heat trap, good for winter but not summer. The recess even shelters from the north wind provided there is an air block behind.

The almost–surrounded courtyard gives still more shelter from wind, and in cold winters is most appropriate. Wind as dotted will create air circulation to good benefit, and could be controlled by well–placed screening. Assume these areas are covered with plant–entwined pergolas.

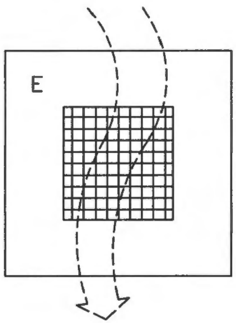


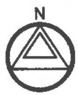
SHAPES E & F

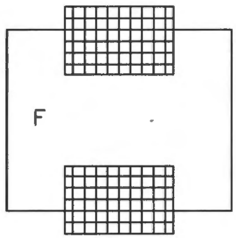
(7.2.6)

In a dry climate the internal courtyard works well, providing good plant shade and side wall shade. For a humid zone air movement is essential for cooling, and this arrangement is not suitable unless a generous air flow can pass through the building itself. In such a climate however, it is better to close up interiors during a hot day.

A recessed patio affords spaces sheltered from both sun and wind, while the projecting area allows exposure to sun, shade, air movement, as desired.
A second patio on the south is far cooler and even on a late summer afternoon, it is possible to find cool shade in the recess.
The internal space between the two patios can derive its temperature from either side, as desired — provided that the air flow is appropriately controlled.

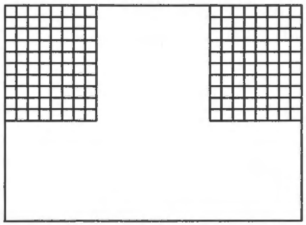


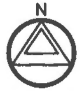




SHAPE G

(7.2.7)





As for the previous plan shapes, the T—plan affords sheltered corners on two sides of the building. For the orientation shown, the two patios provide pleasant conditions (a) for morning use, facing east and north, with shaded, cool conditions for the afternoon, and (b) for afternoon use, facing west, pleasant for winter, allowing the main walls of the building to absorb heat for the interior.

In conclusion, whatever shapes may apply to the outline of the main building, outdoor living spaces must be carefully analysed in the light of all typical seasons, of more severe weather conditions, especially of sun times and angles, prevailing winds and driven rain. Do not forget basic planning principles relating to views, a pool, privacy, relationships to interior spaces, security and harmony with the architectural character of the building as a whole.

SITE FUNCTIONS, PLANTING, PAVING, DEVELOPMENT

OUTDOOR ACTIVITIES The site on which a building rests is virtually an outdoor living space for the occupants or owners of the building. When one lists the experiences of being outdoors on a domestic site, it comprises, amongst other things: moving between vehicles and the dwelling; putting out the laundry to dry; fetching the post; putting out the refuse; watering the garden; gardening - for perhaps lengthy periods; cleaning the car; feeding the birds and refilling the bird bath; showing guests around the garden; sitting at the pool or tennis court.

For each, one must consider the experience of well-being while undertaking such tasks, and from one extreme example to the other, it may involve, on a hot day, walking over a large area of hot macadamised paving, or negotiating a muddy, slippery pathway in cold weather - neither of which will be pleasant. The designer must then treat the site to achieve as comfortable conditions as possible, especially for regular routines outdoors.

This section will not address landscape design in full, but will look at the climatic effects that need to be considered to make a garden more pleasing, and to address some of the important environmental issues.

INITIAL SITE PREPARATION If site levelling is necessary (it should be kept to a minimum) top soil (about 200mm - but ask a soil specialist for the particular site) must firstly be moved to a mound, (or spoil heap) and then returned where needed onto sub-soil that has been exposed. Secondly, all alien planting must be removed, and a policy of indigenous conservation and planting followed as part of the landscape design.

SITE DESIGN AFFECTS THE BUILDING At the outset, it should be realised that buildings on a given site are substantially affected by what surrounds them. A site with generous vegetation will provide cool air for the buildings, and one with large areas of heat-absorbing, dark-toned, paved surface will generate a good deal of warm air. It follows that for summer, the objective would be to produce cool conditions, and for winter, warm. For activities which generate body-heat, the aim would be to provide cool work spaces, and for lounging or low-activity work, in summer, moderately cool areas, and in winter, warm conditions.

SHADING PRINCIPLES The same shading principles as those used for patios will apply - and we think here of overhead shade in wide, dense leafy trees, and for side shade, hedges, fences, rows of tall trees and garden (or building) walls. The cooling effects of a tree will be appreciated when one remembers that (a) the tree itself is heat-absorbing, in that by photo-synthesis, the sun's radiation is turned into energy for growth. The temperature of leaves are usually cool to the touch - especially when comparing with that of artificial plants. (b) The ground below the tree is cooler being in shade. (c) Dampness in shade takes longer to dry out, making the air cooler. These same principles apply for shrubbery and even (partly) for grass.

SUPPORTING FRAMES In some instances, where vegetation is not adequate, supplementary devices are needed such as trellises, training planting over frames, over pergolas, up walls, and by using decorative wood screens (painted or natural) in horizontal or vertical slats, wattle poles, (or half-rounds), or even intricate "woven" timber work. The variations are endless.

ANALYSIS OF OUTDOOR NEEDS A careful analysis should be made of all the needs in a given design. Is the garage some distance from the house? Is the letter box and refuse-holding area far from the house?

SITE DEVELOPMENT

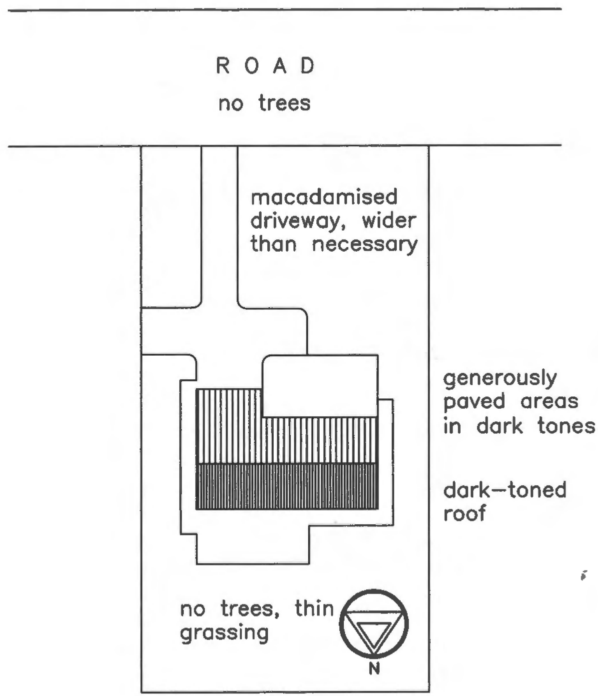
COMMON FAULTS

7.4.1

Domestic sites often have large areas of paving which absorb heat and warm the air immediately above, which then rises and is replaced by cooler air, which in turn is heated.

Dark–toned finishes absorb a large amount of heat in comparison with light–toned. Light tones reflect heat back into space. Dark tones cause atmospheric warming.

The same principles apply to a roof, but with limited thickness, retained heat after sunset is not serious when compared with concrete or macadamised driveways, which continue to give off heat because of solid mass.



How often is the car washed? Is laundry hung out to dry, or is there a tumble drier? Does the owner want to engage frequently in outdoor jobbing such as furniture making, handcrafts or painting? Analyses which reflect frequent or prolonged outdoor activities need provision in shading or exposure for given seasons, and for such as house hobbies, shelter from stronger winds - and also rain, if carport-type roofing is affordable. This may still be classified as outdoor area, as it is usually open on most sides.

Drying laundry demands generous sun and gentle breezes, and a worker handling this task will not be able to have shade - unless a mobile hanging device is invented. However a mobile apparatus has great advantages in enabling the washing to be placed in any position for drying more quickly.

Washing vehicles in summer is best done in shady areas, and in winter, in the sun - although the polish makers do not recommend this. Weaker winter sun will naturally have a less damaging effect. A carport is eminently suitable for this need, and is additionally useful for doing outdoor, under-shelter jobs, and finally shades an extra area of ground surface, which for summer assists in keeping the overall site temperature down. A carport is useful too for leaving the family vehicle out for short periods between outings, to save it from overheating.

NATURE OF PAVING SURFACES If a driveway is lengthy, it constitutes a fair proportion of site area, and to keep general temperatures lower, it should not be a heat generator - which tarmacadam is - as it has a high heat absorbency and retention. A light-toned finish is better, such as concrete (in-situ or precast). Concrete grille work laid with grass in the perforations is a good alternative, although it needs maintaining for some time as the soil in the perforations subsides, making the surface very uncomfortable for pedestrians. Grille work, paving slabs or bricks allow water to percolate into the ground, which is far more preferable than piping it away, as we shall see lower

SITE DEVELOPMENT (7.5.1)

A COOL SITE

Property owners should campaign for shady trees for the road.

Paving is kept to a minimum and finished in a light tone to reflect heat.

Paving is open–grille concrete or brick with grass planted in perforations.

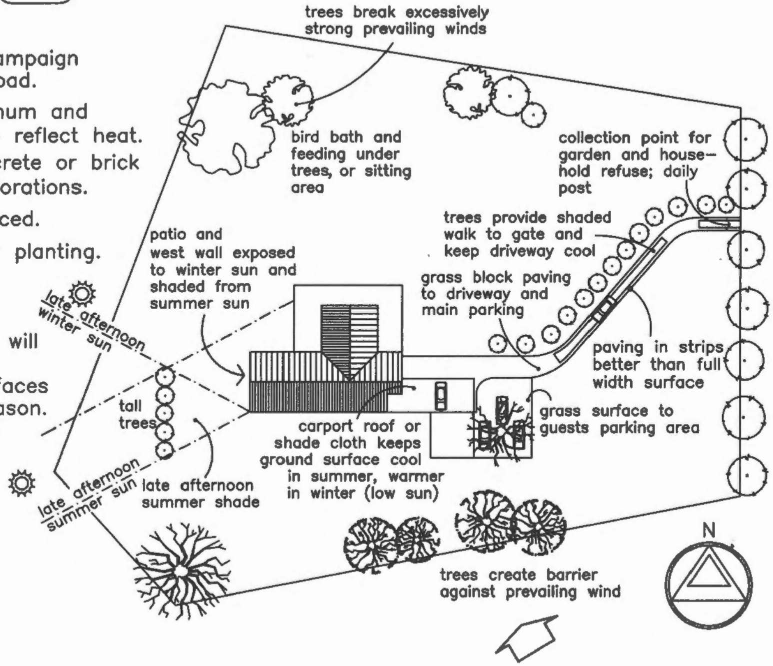
Trees are strategically placed.

Pergolas cover patios with planting.

Walkways around buildings are in small step–stones.

In winter, deciduous trees will reduce to their skeleton, allowing sun to warm surfaces —desirable in the cold season.

Roofing has a light–toned finish to reflect heat.



down. Vehicle manoeuvring area must be treated likewise.

TREES IN A PAVED PARKING AREA OR CARS IN A PARK? The design of driveways and parking areas may be approached from two standpoints. The first approach is to think of large areas of macadam or brick, and then to position trees where needed. This tends to be the conventional thinking for such as office parking areas. The second approach is to think of the site as covered in natural vegetation, and to provide, only where necessary, hardened surfaces for wheel tracks and parking. Parking areas which are seldom used may be grassed. The latter form of conceptualisation will result in a far less area of paving - a good objective. Trees must not shed damaging or staining fruit or leaves to vehicles.

The techniques for providing warm or cool areas are the same as for patios (or anywhere else for that matter) in that directions of sunlight, and those of prevailing winds must be managed to maximum advantage. It involves looking at directions of driveways, sizes and orientations of courtyards and their contingent buildings, heights of trees and their proportions, nature of trees - whether deciduous or otherwise - and so on.

A number of the above principles are illustrated with explanatory notes. Look at them analytically. Add your own solutions.

SITE WATER

TRADITIONAL ATTITUDES Going back to the 19th century or before, population densities in South

Africa were relatively low and the shortage of water was of little concern except for droughts. As time proceeded, dams and reservoirs were built for towns and cities. On farms, wind and motor pumps were used to draw water from boreholes. Rainwater from roofs was often stored in tanks where a municipal or other supply was not reliable. Even well into the 20th century water was inexpensive in towns, (sometimes *free*, except for municipal rates), and in the country, folk relied again on stored water or supplies direct from rivers. As a national concern, the alarms only began ringing in the middle of the century when it was realised that, in comparison with many other developed countries, the basic natural occurrence of water in South Africa was conspicuously lower, and with the future potential expansion of industry, very careful management was necessary.

DOMESTIC ATTITUDES In the domestic sector, wastage of water was of little concern, and surface rainwater was most conveniently disposed of by gutters, rainwater pipes, channels, underground pipes and eventually sewers - all ultimately taken either to river courses or to the sea. When considering the impervious areas of a typical site, i.e. roofing and paving, the sum total of such areas including those of paved roads in a neighbourhood is alarming. Surface water is simply ducted away without soaking into the ground. Over time, with deforestation, increased paved areas, pumping water from boreholes, damming of rivers, the natural underground reservoirs became depleted. Vegetation deteriorated. Piping water to rivers caused uneven flows, damaged ecosystems, caused erosion, muddied rivers, and in turn caused deterioration to river estuaries and marine life at river mouths.

NATURAL UNDERGROUND RESERVOIRS A river is not simply a channel that carries run-off water when it rains. The proportion of water in a river derived from surface rainwater is small compared with that from springs. When rain falls it is firstly prevented from surface flow by plants and their roots. It then permeates downwards by gravity and remains as subterranean water sometimes for a very long time - since it cannot always escape nor can it evaporate. Nor does it deteriorate, and the typical cycle is for it to be stopped in its downward penetration by an impervious stratum of rock or clay, whereupon it again flows down the slope of such a stratum eventually emerging to the surface, often on the side of a hill or mountain, where it appears as a spring, then a small rivulet, joining others from nearby to form streams and rivers, larger and larger until reaching the ocean. Sometimes where the geological formation allows, underground rivers occur, where the borehole provides a plentiful supply.

From this picture, it can be seen that the ground is really an enormous reservoir, (or aquifer), which stores such a large volume that even through dry seasons, rivers continue to flow. In many residential areas, where elderly people recall rivers to have been either of a generous size, or with a perennial flow, they now only see a trickle, drying up in the dry season. This is simply because the natural cycle has been tampered with, and surface water has been channelled away, or allowed to evaporate, without percolating through the ground.

SITE WATER MANAGEMENT For these reasons it is imperative that designers give constructive thought and control to water management on building sites, however small, because the sum total of all makes both a necessary and worthwhile effort. Some local authorities have guidelines available to the public for site development, and in time, these will become law. Whether legally required or not, the quality of the environment in many areas demands that we all put maximum effort into doing the right thing. The happy results will soon be there to enjoy in the form of clear, flowing streams, greener dry seasons, and rivers with improved natural nutrients for the ecosystems that they support.

PERCOLATION THE SOLUTION It follows then that the worst thing to do is to collect all surface

SITE WATER (7.8.1)

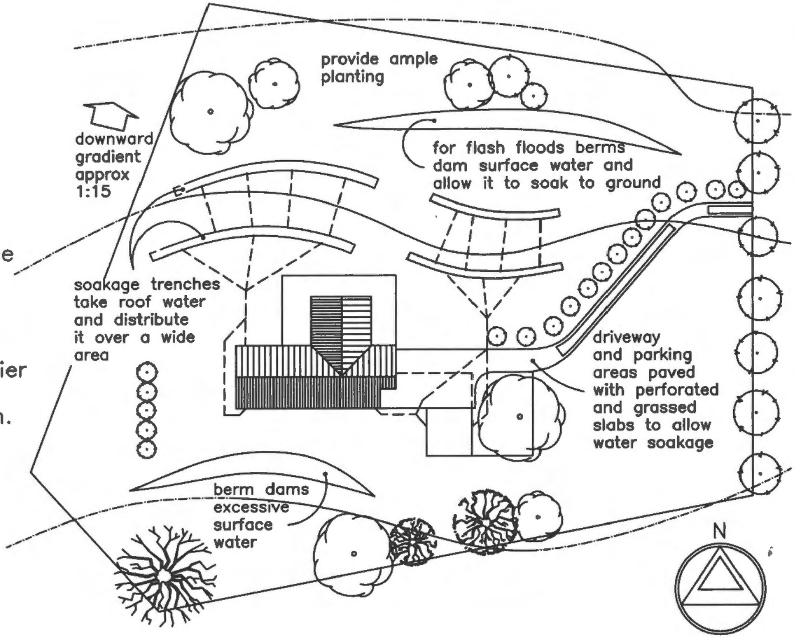
Provide ample planting to reduce flow of surface water.

Trees reduce impact of heavy rainfall on surface, cutting down erosion.

Trees keep ground damp longer and reduce evaporation.

Soakage trenches are spread over a wide area to cope with heavier downfalls; to give good subterranean distribution.

Berms dam excessive surface water allowing it to percolate over a longer period.



water from a generously paved site and to lead it to the street drainage system. Alternatively, where such connections are not available, all water is drained into one large soak pit. These are the conventional solutions.

Water from impervious surfaces may simply run off at the edges onto soil, and the concentration causes erosion, leading to ugly ground surfaces and the silting up of rivers. In both this case and the previous, contaminants from vehicles, weed-killing and others eventually wash into rivers, bringing deterioration.

The better alternatives however are as illustrated under Site Water, where firstly, impervious paved surfaces are avoided as far as possible - by using such as perforated concrete paving blocks, or loose crusher-run stone driveways. Then for run-off, or roof rainwater, distribution is taken through a soakage system, well spread over a large area, and where sudden heavy storms are characteristic, small berms or dams hold excessive volumes of water, allowing soakage to take place over a longer time. There are techniques for using such subterranean water for growing vegetables, details of which need to be obtained from horticultural specialists. In any event, it is wise to promote generous planting over the entire site, inducing a natural soakage into the ground. Ample shaded ground will minimise evaporation caused by radiant sun.

TASKS

1 OBJECTIVE To monitor the efficiency of existing patios and to record findings.

Consult 2 or 3 friends who have patios and use them for outdoor leisure and entertaining. Interview each as to how they use them in regard to normal hot sunny weather, in wind (of differing directions), in rain. Plot shape and highlight advantages of recesses, screens, trees or other. Record information which will be useful for your own designs of the future.

2 OBJECTIVE To discover practical steps already in hand which have been implemented by local authorities for environmental improvement.

Contact your local authority (or another near by) and make an appointment to interview an official regarding conservation measures being implemented. Take their information and illustrate it in poster form for an exhibition by your academic department, or at an environmental function. Also try to get information on soakage (percolation) principles and actual measures being taken or specified in this regard. Record information covering run-off areas, sizes of soakage spaces, construction, pipes, and all other details.

3 OBJECTIVE To observe whether deterioration or improvement of a local environment has taken place over a period of 5 or 6 decades.

Interview elderly friends (over 60) who remember, from their childhood, your area - or any newly built-up area - as open space and ask them to compare conditions then and now with respect to: water running in streams; bird life; marine life (if applicable); vegetation; noise; general pollution, other aspects.

8 ● PLANNING AND DESIGN - METHOD

This section deals with the practical and conventional procedure for planning small buildings, with emphasis on climatic issues. The dwelling is used for illustrations.

USE PREVIOUS INFORMATION In previous sections a wide range of information and guidelines has been covered, with suggested techniques for moderating the power of sun and wind, (with brief reference to other weather elements), as seen in individual building elements, be they walls, roofs, openings or outdoor living areas.

While studying this section it is important to refer systematically and *frequently* to the past material, and more especially so when eventually undertaking your own designs. In so doing, you will become familiar not only with the principles which have a bearing on design, but with the process of designing, step by step, applying as many of the aspects learnt as possible. The list of headings at the beginning of each section should be used as a checklist, to ensure that you are actually applying the best solutions. Not to do so is to fall short of the best answers, which will reflect in the assessment given to you by your studio tutor or employer, whichever applies.

PROVEN PRINCIPLES OF PLANNING If you look at good designs for dwellings say in periodicals, or in real life, you will see the principles of proven planning incorporated, no matter what shape the plan, what finishes apply, or what style of architecture. Once these are appreciated, and then put into some order of priority, and *applied* to your own designs, you are sure to have a good measure of success. Planning is *not* easy, and the more you practise the method the less difficult the process eventually becomes. It is a refined art in the end to be able to create a design to meet the needs of the future owner - the mature trick being to think of *everything* at the same time, as the plan emerges. This is not possible as a student, and scrapping your failures and redrawing must be taken as routine. Working on a computer makes this process much easier. When revising a plan or detail, never erase it or modify it too much. Rather create a copy, then modify the copy. Then compare it with the preceding solution, then scrap the old one only when really sure it is superseded by the new.

CONVENTIONAL DESIGN APPROACH

What are the conventions?

This book focuses upon design as related to climatic issues, but the general principles will be listed as well so that the climatic and energy-related aspects are seen in context with the whole.

WHERE TO START How does one really start when a client wants a small 2-bedroomed house? You have a blank sheet of paper or screen in front of you. You know the site - its topography, road access, dimensions. You know the budget restrictions, you know that bye-laws apply, you know where the service connections will be - stormwater, sewerage, electricity and perhaps gas. You know the clients' requirements in accommodation, their lifestyle and the character of solution they would prefer.

It remains then to apply the principles or conventions directly connected with the design of the building - its plan form, its sectional qualities and its elevational treatment.

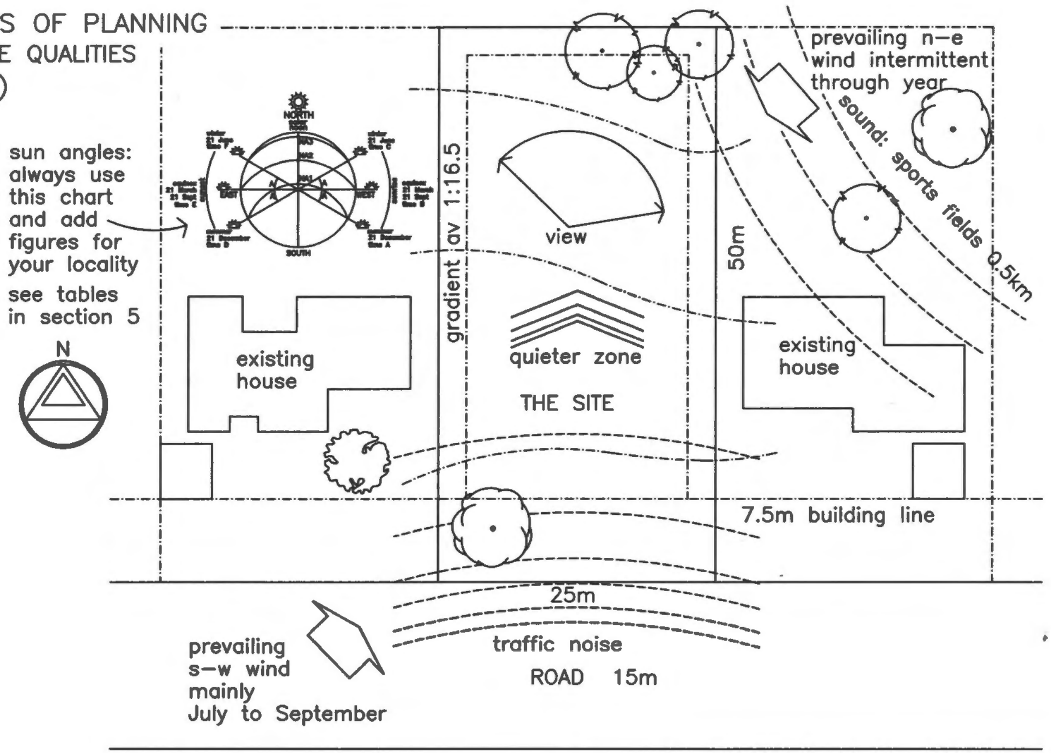
METHOD The design procedure is as follows:

1 KNOW YOUR SITE THOROUGHLY Analyse the site and note, amongst other things, neighbouring features, views, gradients, topographical qualities (trees, rocky outcrops, water), north point - and therefore direction of sun angles, prevailing winds, storm directions. Also take cognisance very carefully of seasonal variations by studying climatic statistics, maps, and note altitude and latitude if working on a job away from "home". Also note sources of noise, atmospheric pollution (related again to prevailing winds) which are generated from *all* sources - such as traffic, industry, sport, air ports, schools - even tourists. Knowledge of round-the-clock activities of the area needs to be known whether in church bells, muezzin calls, and home craft industries - which may border on the illegal but will still be a potential nuisance.

2 DRAW UP WHAT YOU KNOW Draw a site plan to a large scale, and as a form of checklist, add the above in annotations, diagrams and arrows, or whatever reminds you strongly of the issues to be considered. There are so many that it is easy to forget some, and find at the end of a long time designing, one has to make a new start.

3 PRIMARY THOUGHTS when undertaking a design are as below. Order of importance does not necessarily apply since a number of principles share equal priority, and some affect the other and overlap with the other. However note comment on importance for 3.5.

STAGES OF PLANNING
1 SITE QUALITIES
(8.3.1)



3.1 SITING - think of proximity to road - access versus noise; relation to street line, i.e. adjacent buildings and streetscape; proportion of private and "public" areas (the building often cuts site into "front" and "back" areas); elevation - where contours apply, height may affect wind forces etc; relation to topography in trees, gullies, other; elevation most affects quality of view.

3.2 ORIENTATION - i.e. which way the building faces. This affects views, response to climate, privacy, relationship to neighbours. Carefully check neighbours' entertaining and leisure areas - potential noise sources.

3.3 ZONING - means grouping and placing of various rooms, e.g. bedrooms are normally together; living, dining, and kitchen are more "public" areas and are in their zone, workshop and vehicle garage go together, with noise and smells, then, when positioning in relation to each other, the main, most used and prestigious spaces take the best, with service areas (bathrooms and toilets, stores) relegated to the less benefited zones.

3.4 CIRCULATION - from one area to another must be of minimal distance and must not cross another important circulation route. Kitchen and dining areas have a well-used circulation path, and it must be short to save time and effort for the occupants. And so for other linked spaces.

3.5 CLIMATIC CONSIDERATIONS - by far the most important of all. Architects often begin their first sketches with this important aspect in mind, and it is never left out of the equation, and never compromised. The main rooms, such as bedrooms and living rooms, are given a sunny aspect.

THE SUN HAS MANY QUALITIES Sun is not only used to warm interiors in colder seasons, but it imparts a sense of life, gives sparkle to edges, provides contrast, and subconsciously imparts a strong sense of well-being and cheer.

A north-facing room, even without sun entering, opens onto an immediate vista which is sunny, with the same qualities just mentioned. Compare this with the south-facing window, where there is shadow from the building, especially in winter, and it gets light later and dark earlier.

To reason that (a) people *only* sleep in a bedroom, and / or (b), the building is in a mild climate, and it is therefore unimportant to have sunlight is seriously erroneous. A sunless room becomes colder, damper, with resultant mildew in clothing, with accompanying odours. Bedrooms are used during daylight and at night time for study, hobbies, reading, and for the sick.

Take note, that if a room faces *away* from the sun, it is impossible, once occupied, to let it shine in - (unless the roof is altered, or something else drastic is done). However, if a room faces the sun and after occupation it is *not* wanted, shading can relatively easily be applied. The latter provides an *option*, the former does not. It is easier to change a plan on paper than after building. That is why it is imperative to do battle, no matter how difficult or time-consuming, to solve *all* the problems at the drawing board, or keyboard. This part of climatic design must also consider such as prevailing wind directions, which winds bring rain, whether hail, snow, or lightning are to be considered.

THINK OF ALL TIMES AND SEASONS Under these considerations, every season, every time of the day, and every form of typical weather must be catered for, especially when extreme conditions apply - whether gale force winds, torrential rain, hail or snow, fierce lightning storms, baking dry summer heat, or bitterly cold nights.

As intimated earlier, this work deals with the environmental issues of design, and here the better the design the less energy used in air-conditioners, fans, or heaters, and likewise the use of hot baths, electric blankets, hot drinks and so on. Where for example Circulation is listed above, a whole book may be written on this topic, and your studio tutor should be developing your knowledge therein. Similarly for zoning, views and others.

THE MOST FAVOURABLE SITE The following steps are given assuming a more amenable site applies, i.e. the site faces favourably away from the road, towards the north, so that when a house is placed on it, its main accommodation faces away from the road, giving a private quiet garden. The garage is on the road side, with a short driveway, easily accessible. More difficult situations are handled lower down. All are illustrated.

4 BUBBLE DIAGRAMS With the above in mind, work with successive "bubble diagrams" - where in rough circles, one places first the main rooms in their best positions, then the rest, working down the priority list. On this, show important circulation routes, and think of all the other aspects listed - specially zoning, but here we are looking more specifically at climatic issues, and all main rooms must be on the north side. (Or the equator-facing side - if you happen to be in the northern hemisphere). Some areas such as dining spaces or kitchens may, if need be, be placed on the east side to catch early sun in colder weather.

A number of bubble diagrams are done, if using paper, on tracing paper, placing one layer upon the previous, making refinements, and experiments with alternative layouts as you go. If working on a computer, do not delete previous experiments, as they may prove to be better than later attempts. Keep progressive arrangements on the screen. It is worth at this stage to go away, spend time doing

STAGES OF PLANNING

2 BUBBLE DIAGRAM

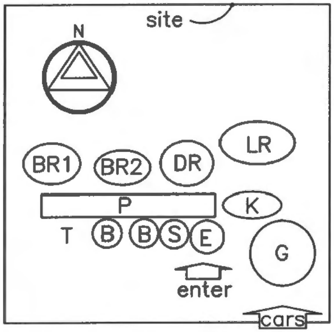
(8.6.1)

Clearly it is preferable for the main rooms to be on the north side, to take advantage of the sun. Further benefits are a private front garden (to the north), privacy, less noise, a good view and on the south side, easy access to the garage and main entrance to the house.

This means that every effort must be made to give as many rooms as possible a northerly aspect.

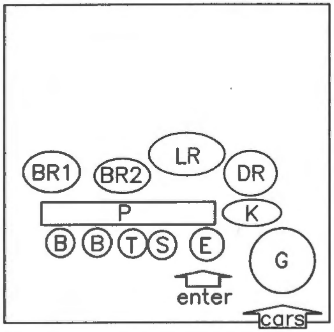
For a larger house on an average sized site, this is difficult, but on a larger site the house would be lengthy with its rooms in a row.

Always remember, if no other factors forbid it, a double storey provides double frontage.



THE PROBLEM is to design a two-bedroomed house for the given site.

Kitchen lacks any view. Route to LR via DR not good. Toilet must be moved.



Kitchen may get a view. Access to LR better. DR on morning sun side (east). Toilet nearer for guests.

No sense of scale using bubble diagrams. These are only useful for the very first sketches.

something quite different, and then returning, even a day later, to look at your "solutions". Check your site plan with the analysed features shown, and see that everything has been considered. In the back of your mind think about scale, and whether your rows of bubbles, when added up as dimensions will fit the width of the building lines of the site.

PAPER CARD CUT-OUTS An alternative to the bubble diagram form of sketching, is to cut out paper or card rectangles, *to scale*, representing room sizes - which added together (remembering corridor space) more or less suit the overall budgeted area of the scheme. These are arranged as close as possible to a workable plan, again with the main rooms on the sunny side, as above. Yes, it takes longer to do this, but once done, time is gained later on as it is far easier to arrive at a solution, and to experiment with alternative layouts, guaranteeing a better result. Note that when you arrive at an acceptable layout, *jot it down very roughly as a sketch*, otherwise it will be forgotten when playing with alternatives. At this stage, it does not matter that all rooms do not fit snugly together. That comes later when room proportions are manipulated so that a neat overall arrangement is achieved. The cut-out rectangles system is easily applied on a computer, where rectangles are moved about on screen. When a good arrangement comes up, copy and "store" it, and continue with other layouts and see if any improvements can be made. Try mirroring plans, east to west and vice versa, (but *not* north to south!)

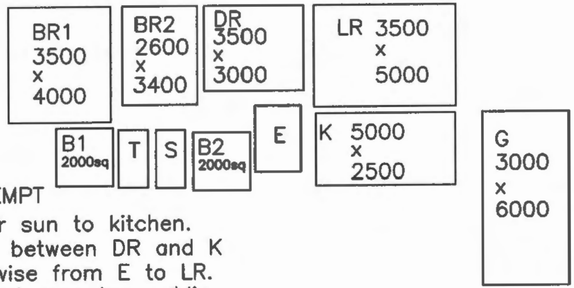
(The cut-outs may be stored in an envelope, named and filed for use later on. They should each have marked on, the dimensions and floor area as well as the room name. On the reverse side, another room name may apply, such as a board room, office for 2 or whatever. Likewise for computer images, a "kit" of accommodation may be filed and brought up whenever required for planning.)

STAGES OF PLANNING

3 CUT-OUTS AS AN ALTERNATIVE TO BUBBLE DIAGRAMS

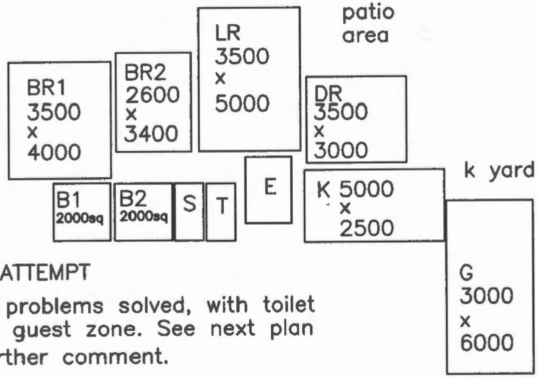
(8.7.1)

Thin card rectangles are cut out representing room sizes to scale.
They are then moved about until a suitable plan is worked out.
Room proportions are then manipulated to afford a tidier fit i.e. on a rough drawing, but to scale.
This system while taking more time at the start, affords more experimentation and one is forced to work to scale from the beginning.
This can be done on CAD as well, and makes it still easier, as has been done here.



FIRST ATTEMPT

No view or sun to kitchen. Circulation between DR and K poor. Likewise from E to LR. Kitchen yard area too public.



FINAL ATTEMPT

Above problems solved, with toilet nearer guest zone. See next plan for further comment.

A ROUGH PLAN TO SCALE At this stage you should have a very rough plan layout of a house with the lounge, all bedrooms and if at all possible, the dining space receiving the north sun. As a compromise, as stated earlier, the dining area may have east sun, and the kitchen should have if possible north sun, and definitely east sun. Secondary sitting rooms (for TV or as a rumpus room or other) depending upon the restrictions of the site, may have to be on the south side.

SHORT CUTS COST TIME As your plans progress, honestly check dimensions and site size. An appropriate and valuable warning here is to avoid drawing your experimental plans in tiny freehand sketches, "by sight" and out of scale. Wonderful solutions come to light, excitement builds, and one launches into final stages, even in section - only to find it simply does not fit together, it does not fit the site plan, whereupon one begins to "cheat" hoping that lengthy stretched out rooms can be made to work, that narrow doors are in fact acceptable, that two toilets are not really required - and so on, only ending in disappointment, having to begin again, wasting a good deal of valuable time. It is better in all honesty to face the real problems early on, and to work on ways to overcome them. Once the true scale and proportion of the scheme is embedded in the mind one can only *then* venture into drawing "by sight", with a fair degree of accuracy.

In climates with cold winters, it is desirable to have bedrooms with solid west facing walls, to warm up in the afternoons and to give heat to the interior well into the night. A living room may project out from the general front line of the house, allowing west sun into the interior in the afternoons, warming the floor slab, again, keeping warm into the evening. This would be shaded in the summer heat, and sun angles used to good advantage. Look at the plans which are annotated with the type of issues to think about. The plans are not intended for copying. They show principles of climatic planning, and your own problems need to be thought out from the start, applying these principles.

At the same time, think about accommodating one or two patios, whatever the budget allows, as long as outdoor paved space works well both in the hot summer months and evenings as well as the cold winter days. Again, think of all seasons and weather conditions. A warning here is necessary, because if your plan is being worked out on a warm summer day, it will be difficult to imagine what is needed for really cold weather, and the needs in design are inclined to be overlooked. The reverse also applies, and logic needs to be strictly applied, and not personal feelings on the day, or at the place.

5 A TIDY REALISTIC PLAN Your next stage is to tidy up the plan to give it a neat outline, to line up internal walls, and most especially one which is economical to roof with a sloping roof. It is essential to be honest with oneself when assessing qualities of planning here, because if not, problems are sure to catch up at a later stage - when it is far more difficult to make changes. Then think about three dimensional effects to the interior, notably where spaces inter-lead. Likewise think of interior privacy, where sight lines from one room into another should be screened. No one enjoys seeing a toilet suite, no matter how smart, from a dining room or kitchen.

THINKING IN THE THIRD DIMENSION Then it is a matter of working in section, together with the plan, to decide on heights, widths and positions of windows to each space, and likewise doors. Think of views, of sun angles, of different times of year, of positions of trees in the garden (casting shadows), and how morning light and warmth affects the ease or otherwise of getting out of bed and to work. Is the dining space inviting for an early breakfast and an inducement to leave bed? Is the house reasonably warm so that getting up in winter is not too traumatic? Will the bathroom have generous sun?

STAGES OF PLANNING

4 A TIDY FUNCTIONAL PLAN FORM

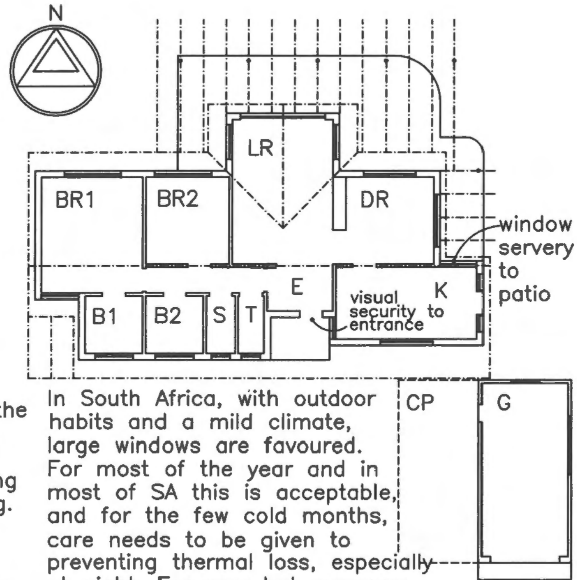
(8.9.1)

CLIMATIC DESIGN

1 Main rooms face north and view.
2 Kitchen has a window facing north and part view.
3 BR1 has good cross-ventilation, as does LR and K.
4 LR has windows with 3 orientations – east, north, west – advantage for all seasons.
5 DR and K on east for morning sun.
6 Patio opportunities are plentiful – for all seasons and weather conditions.

NOTE With generous zig-zag walling on the east end, the plan is suitable for areas with cold winters. For a sub-tropical location, these areas would need shielding from morning sun to prevent overheating. This could be provided by trees, placed strategically on east side.

WINDOWS are designed in conjunction with roof projections and follow principles as in section 5.
See next drawing for further general guidelines.

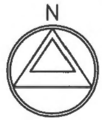


In South Africa, with outdoor habits and a mild climate, large windows are favoured. For most of the year and in most of SA this is acceptable, and for the few cold months, care needs to be given to preventing thermal loss, especially at night. For very hot summers, (Karroo) and for prolonged cold wet spells in winter (Western Cape) smaller windows are preferable, unless special (and costly) measures such as double glazing are used.

STAGES OF PLANNING

5 FURTHER COMMENTS ON CLIMATIC FEATURES

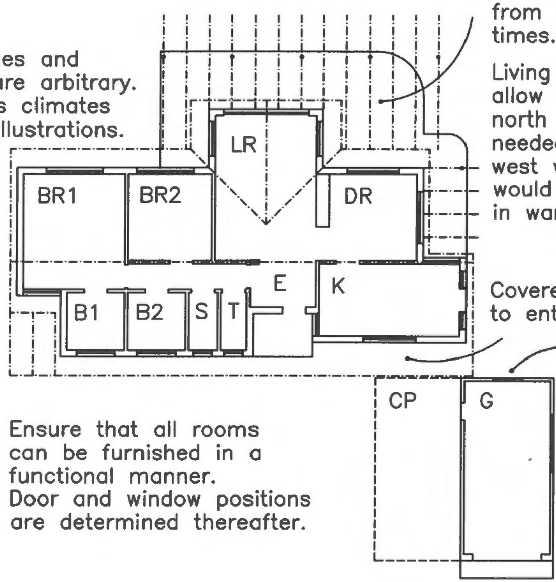
(8.9.2)



Pergola either with deciduous plant or controllable shading protects patio.

Light toned patio finish reduces heat absorption and reflects skylight to interior. Needs shading from direct sun in warm times.

Window sizes and positions are arbitrary. For various climates see later illustrations.



Living room windows allow sun from east, north and/or west as needed. Screening to west window externally would be appropriate in warm times of year.

Windows need to be placed for
(a) good view from chair or bed positions
(b) good ventilation
(c) light to desks or other work positions
(d) sun to warm floor or work positions — for winter time.

Covered walk to entrance

Window for light to workshop area and engine of vehicle.

Ensure that all rooms can be furnished in a functional manner.
Door and window positions are determined thereafter.

Optional east window warms vehicle on cold mornings.

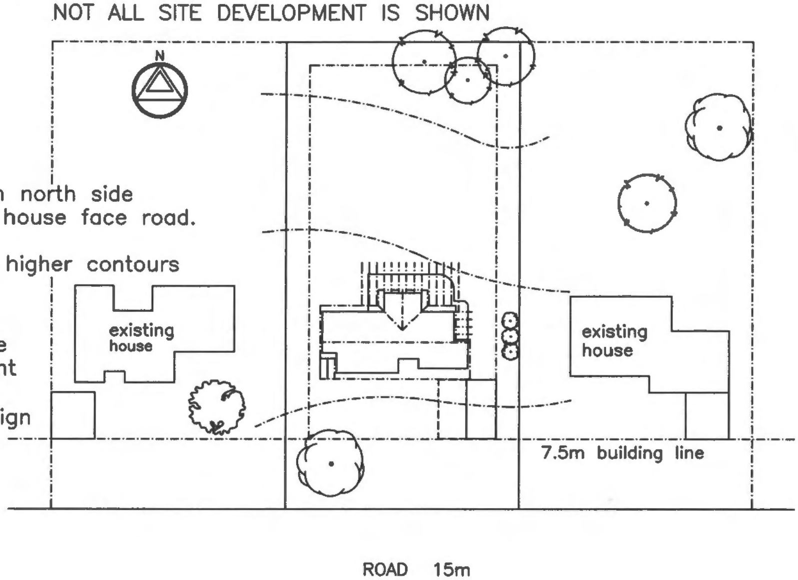
HOUSE IS POSITIONED ON SITE

(8.9.3)

ADVANTAGES

North orientation.
Private garden on north side
Service areas of house face road.
Short driveway.
Better view from higher contours

NOTE: All site considerations are taken into account during entire planning and design process.



PLANS EVOLVE FROM FURNISHING Furniture layout will often determine where windows and doors are placed, as well as other elements. Rooms need to be furnished to take maximum advantage of the weather elements. It is not possible to achieve the ideal, but with repeated planning experiments, much *can* be achieved. One should never stop refinements to planning when an "adequate" solution is achieved, i.e. a layout which has to be made to work. It needs to be a solution which will make the occupants enjoy their existence there in every respect. While thinking on section, look at eaves projections, steepness of roof and other aspects affecting the climatic performance, mainly sun angles, but also air movements. *All* aspects must be thought about in three dimensions. Clear thinking will come when problems are sketched in plan, section and elevation *at the same time*. It is frustrating and time wasting to try to *imagine* what happens in section when a small sketch will clarify it and most likely bring the unexpected to light.

MENTAL BREAKS When reaching important stages, give your mind a rest and to do something else. Come back later and again, be honest with yourself about the qualities of what you have done so far. It is remarkable too what the subconscious mind works on while doing other tasks or during leisure hours. That is why it is significantly important to get to work early on when handed a project. Look immediately at the central issues, getting through the chores of drawing site characteristics, familiarising oneself with room sizes, being specific with dimensional limitations whether of site or otherwise.

OTHER ORIENTATIONS - TECHNIQUES FOR GAINING SOLAR ADVANTAGE

We aught at this juncture to remind ourselves of the value of radiant sun entering residential dwellings, and it is worth reading point 3.5 - Climatic Considerations again.

The preceding exercise was related to an easier set of problems, which explains why sites like this command the best prices. The site will cost more, but the climatic advantages, together with a generally easier planning process afford a less costly building.

ROAD ON THE NORTH SIDE OF SITE The next most popular site is as the previous one, but with the road at the north end. In this case there are two changes that apply and they are (a) the garage position has to placed elsewhere, and (b), the entrance to the building will be on the other side. An example is illustrated of a popular economical plan, and it is worth making a comparison of all aspects with the previous type of plan. This form of planning is also relatively straight forward, and many variations are possible.

VIEW AND NORTH POINT IN OPPOSITE DIRECTIONS

What are the techniques then for designing a dwelling (or any small building) where for example (a) a very good view is to the *south* demanding that all main rooms face that way, and the sun still has to be admitted to the maximum degree, and (b) where the slope or *any other dominating* feature demands the same treatment?

ON PLAN The methods, as illustrated, on plan, are (a) for as many rooms as possible, to project them beyond the sides of the rooms to their north, so that a window can be placed to get north light; (b) for other rooms, such as the living room to span the width of the building so that they have a dual orientation, one south, for the view, the other north, for the sun. In such situations, open planning which allows the dining space to lead off the living space provides a good compromise. Even a kitchenette with open plan leading from a large room with sunlight will benefit. The purpose is for the occupant to *at least* see that the sun is penetrating, and to see on to a sunny patch of garden,

ROAD ON NORTH SIDE
OF SITE

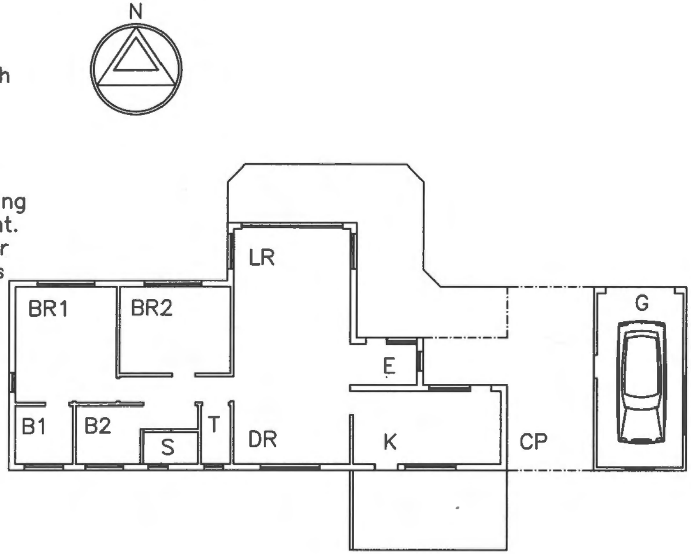
(8.11.1)

The main rooms still face north but access from the road enforces the vehicle and pedestrian entrances to face the road.

The kitchen is given a controlling and functional view to the front. The carport provides shelter for outdoor leisure activities and is within reasonable proximity to the front patio area.

Internal circulation from E to the bedroom area across DR is not ideal, but works well for circulation from vehicles to E and LR, to which guests circulate. Pedestrians to and from front gate may walk on driveway saving a dedicated pathway.

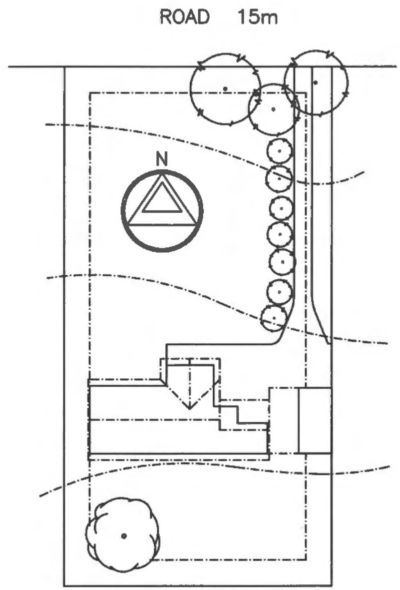
Cross ventilation is good for BR1, LR/DR and K.



SITING (8.11.2)

The position of the house will be governed primarily by considerations of noise from the road, and privacy also from the road. Thereafter priorities have to be established for such as site topography (trees, contours) and the owner's balance between activities in front and back garden. The former is good for leisure (pool, croquet), flower and shrub gardening, and the latter for vegetable gardening, and work on hobbies such as boating.

Some house owners are sensitive to the public on the road, depending upon its busyness, but with the use of vegetation, from tenuous shrubs to densely leafed trees, screening is not difficult.

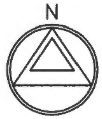


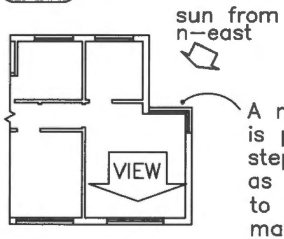
DIFFICULT ORIENTATIONS

THE VIEW AND THE SUN IN OPPOSITE DIRECTIONS

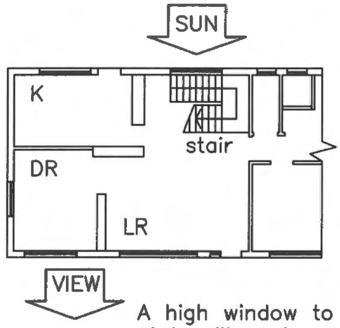
SOLUTIONS ON PLAN

(8.11.3)



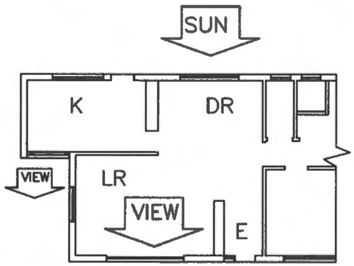


A northerly window is possible with a step in the outline as shown. The view to the south is maintained.



For a double storey house advantage may be taken in placing the stair to gain north sun for rooms on the south side.

A high window to the top of the stair will cast northerly winter sunlight well into the living room. An open stair is required to achieve this — or internal glazing between stair and living room.



Sun entering the dining space is appreciated from the living area. The south view is maintained for the kitchen and is also visible from the dining area.

Note that an automatic result of planning for solar advantage in these plans leads to better cross ventilation for many of the rooms concerned.
Should this lead to a loss of heat in cold temperatures, folding or accordion doors may be used.

especially valuable in winter. (c) If a double storey arrangement is otherwise fully acceptable, it will allow easier planning of rooms with windows to the north as well as the south. (d) In such a situation the stairs will be on the north side (as rooms take priority for the view to the south) and here is an opportunity to glaze the stair liberally to allow sun into the stair space, and through to the living areas on the lower level.

ON SECTION The methods on section are to provide glazing (a) on the clerestory principle, i.e. a window is placed above one set of accommodation and lights up another next to it. (b) An alternative to this is to use a sky light, which however has to be very carefully controlled, as overheating (and glare) can happen very easily. (c) Areas such as corridors, bathrooms and store rooms may have lower ceilings than living spaces. For adjacent living spaces, the ceiling dimension may be raised, quite attractively for example with a sloping ceiling, and the difference utilised to accommodate a clerestory window. See illustrations.

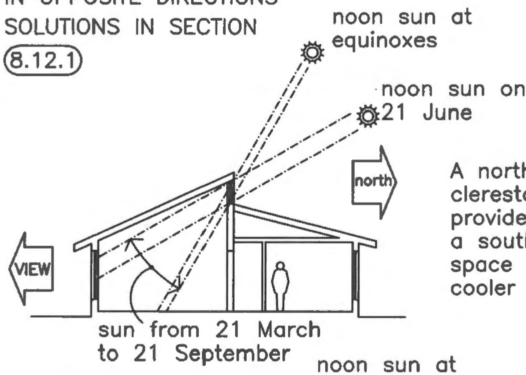
EAST AND WEST ORIENTATIONS While it appears that east and west orientations are equally problematic, note that the westerly problem is far more serious for reasons previously mentioned, i.e. for the east, temperatures are still far lower from the previous night than the west, where after half a day of sunshine, the ambient temperature has risen significantly. However, on the east coast of SA, especially at lower latitudes, (nearer the Equator), humidity aggravates discomfort at higher temperatures, and at the same time, the sun, (on clock time), rises earlier, warming ambient conditions. Radiant solar heat can be practically intolerable by 09.00 after the sun has risen at 05.00. The designer must think with care, as will be seen in a later section, about what actually happens in the particular locality affecting the design in hand. Morning heat for Cape Town and Durban, due both to latitude and longitude, is very different.

DIFFICULT ORIENTATIONS

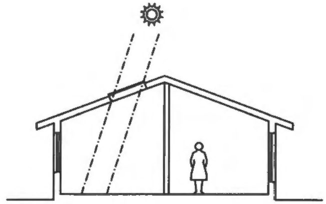
THE VIEW AND THE SUN IN OPPOSITE DIRECTIONS

SOLUTIONS IN SECTION

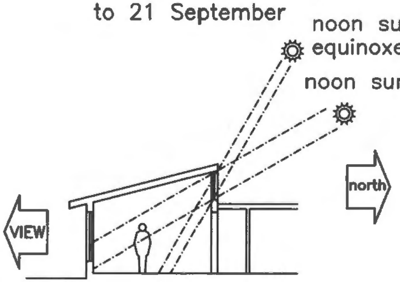
(8.12.1)



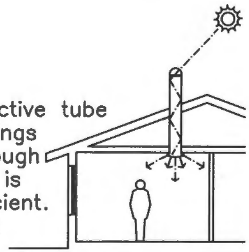
A north facing clerestory window provides sun to a south facing space in the cooler seasons.



A roof light admits a profuse amount of light and heat, and easily causes dangerous over–heating. If it really has to be used, it must be protected externally with louvres or a shading device.



The lower ceiling of adjacent service areas makes a larger clerestory window feasible. Lower ceilinged areas must be well ventilated.



The reflective tube which brings light through the roof is very efficient. Its effect however is not as strong as direct solar radiation.

A VIEW TO THE WEST Elevations which face east or west to obtain a good view, or because the site determines such orientations, should be planned as far as possible with minimal glass facing these directions. A room on a corner should preferably have a larger window for light and ventilation on the less problematic wall, and then on the east or west, as small a window as possible, strategically placed for maximum advantage to the view. Remember that splayed reveals open up the width of angle for the view out - which unfortunately also allows more radiant sun in. But if the sun can be shielded for summer angles while leaving the view available, then a good compromise is being achieved. Large west-facing windows without any shading and with internal curtains or blinds can make a space virtually unliveable for a good number of months over the summer.

THE INTEGRAL APPROACH Illustrated are two "integral" designs (i.e. no *applied* devices) where the wall is offset or projects out to accommodate small north- and south-facing windows. The notes explain the objectives of the various features, and it is stressed that the given examples are simply diagrammatic to show the principles, and the student should not copy directly what is seen but develop what is suited to the design of any given project in hand by changing window dimensions, angles of walls, and general arrangement of various elements. There is no limit to innovation, and deliberate exploratory thinking along possibilities available through conventional techniques will soon bring new applications to light. These projections are most effective as wind scoops as well as providing a further angle of view.

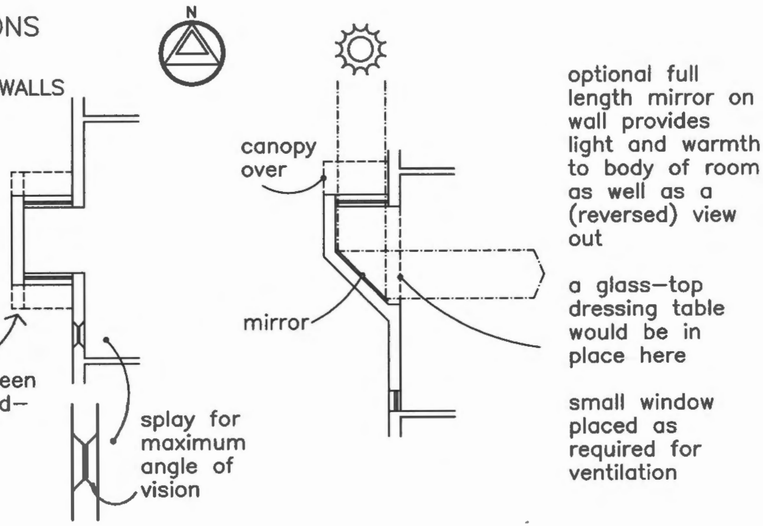
SHADE FROM TREES OR BUILDINGS Every effort should be made to seek shade from trees, strategically positioned not to interfere with the view and to cast shade on summer afternoons Existing trees will be useful for this if available, and likewise existing buildings - depending upon the direction of the view and the westerly sun. While this has been previously illustrated for siting purposes, the principle is repeated here for a window.

DIFFICULT ORIENTATIONS

EAST AND WEST

INTEGRAL DESIGN: OFFSET WALLS

8.13.1

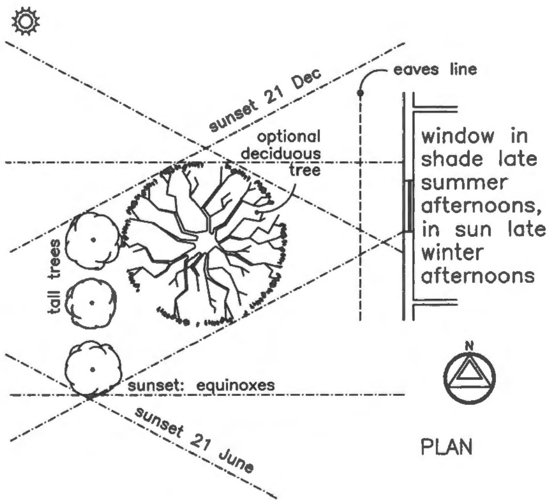


These solutions do not provide for a view due west. A tall slot window will provide a compromise, in allowing an occupant to see out if near the window. Note detail.

DIFFICULT ORIENTATIONS

EAST AND WEST (8.13.2)

TREE SHADING

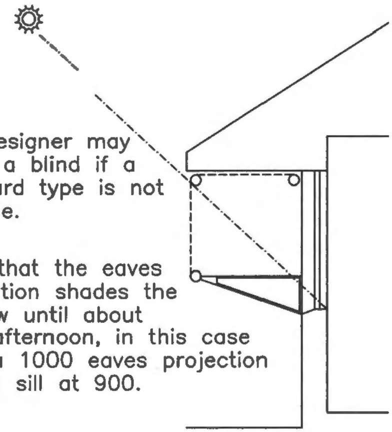


PLAN

DETAILED RETRACTABLE FABRIC SUNBLIND

The designer may detail a blind if a standard type is not suitable.

Note that the eaves projection shades the window until about mid–afternoon, in this case with a 1000 eaves projection and a sill at 900.



SECTION

It is worth, for the locality concerned, to plant suitable shrubs or trees that are fast-growing for the more immediate future, and the slow growers for the longer term. Whether several tall trees are used (as cypress or poplar) or a large deciduous, will depend upon other factors such as space available, the owner's tastes or perhaps a careful analysis of sun angles for the particular job in hand.

FABRICS FOR SHADING For a single storey building in which the major rooms have to face west, the eaves provides a very useful structure on which to support shading devices, whether roll-up, fold-up or slide-along. The designer may wish to detail a shading device since shade cloths and long-lasting nylon fabrics are commonly available. As shown, a good eaves projection will protect a west facing window for a number of hours after midday. However as a stand-alone device it is not adequate for interior comfort, as the later hours with lower sun are the hottest. Note that seasonally, the winter sun will shine on a west-facing wall from 12.00 (on the 30 east meridian) to 17.00, i.e. 5 hours, while in summer it is from 12.00 to 19.00, 7 hours - a substantial difference. (The *duration* of exposure will be practically the same for all parts of the country from season to season, even though clock:solar times differ.)

With new nylon fabrics or relatively cheap shade cloth, it calls for some innovation to produce a very simple but efficient screening system which may be a folding frame and fabric device, a roll up blind or a side-sliding screen on guides, operable from the interior. Whichever applies remember the principle of keeping the shield away from the glass so that the heat it collects does not enter the window directly. The material needs ideally to be reflective to reduce this particular problem.

CLERESTORY WINDOWS Illustrated is a plan and sections (1:1 & 2:2) with emphasis on clerestory windows.

These face north and east on an L-shaped plan. These configurations are used only when one is forced to face the main rooms westward due to a very good view, or because of other constraints such as site shape and orientation, because of neighbouring houses and so on. All rooms face, in this example, a supposed view to the west, and the dining area shares that view, albeit somewhat set back. The patio is taken round to the south side for warm days while the west facing area in cold weather will be welcome, and has blinds hung from the pergola if needed. The sections indicate the need for thinking in section *at the same time* as on plan. Ideally the mono-pitch span, for both legs of the L should be the same, but as room functions are very different, one can take at least some liberties with eaves projections, so that the overall outline of the two roofs is tidy, as shown on the roof plan.

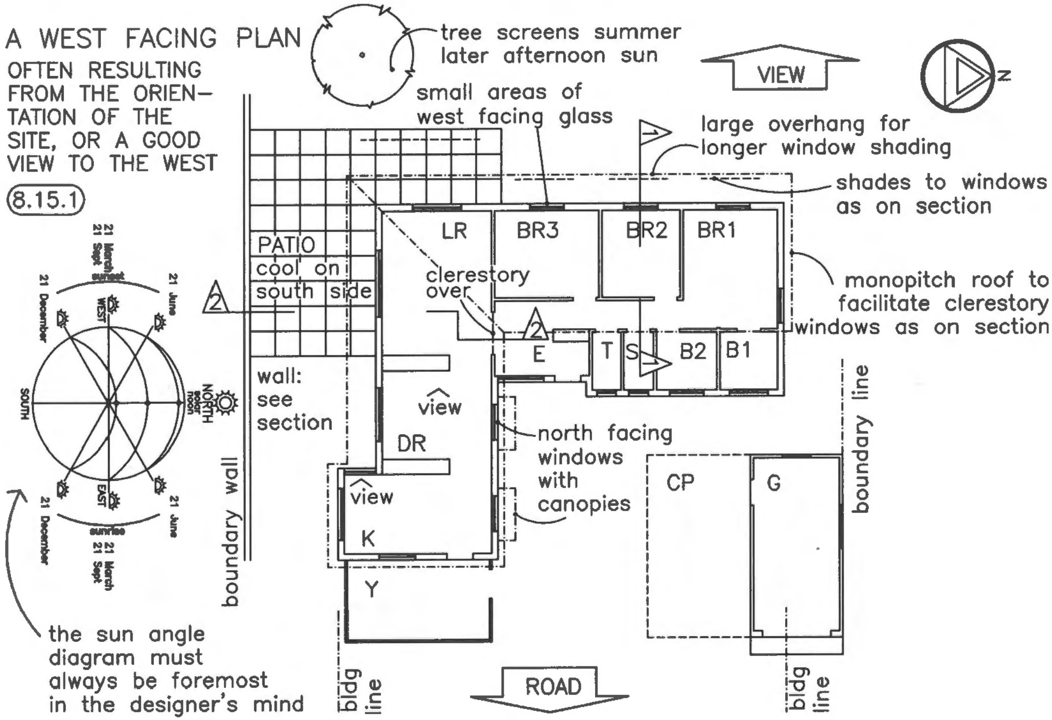
On section, where clerestory windows have a small vertical dimension, the sun is cut off more quickly, and it is needful to think about just how much sunlight is wanted - and the internal sills can be sloped to gain more sun if desired. The house owner here will be concerned about visible dust on these slopes, and it will perhaps be wise to simply paint them a darker tone to avoid this. The other problematic aspect of cleaning is gaining access to the glass, and here again it is wise to choose a well textured obscure glass with vertical striations. The inside face does not become seriously soiled, and the outer face can be easily hosed off.

Section 2:2 is used to show light reflected from an external wall to illuminate interior spaces. Remember that this applies in winter where the sun, at noon is lower, and the pergola, either with deciduous creeper or controllable shading, allows sunlight to act as indicated. Since these rooms have supplementary clerestory lighting, the reflecting system will not be needed under normal circumstances, but where the site is heavily vegetated or perhaps the surrounding mountains make for darker conditions, this method is most effective.

A WEST FACING PLAN

OFTEN RESULTING FROM THE ORIENTATION OF THE SITE, OR A GOOD VIEW TO THE WEST

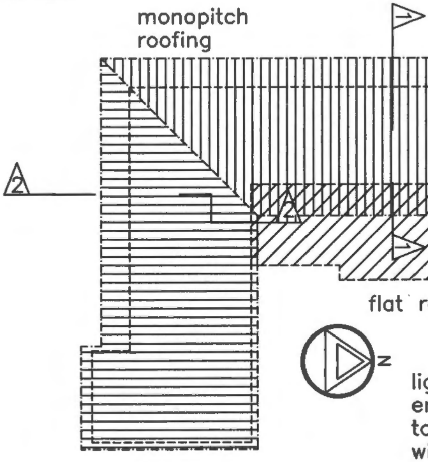
(8.15.1)



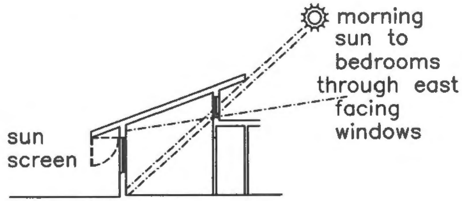
THINKING IN SECTION IS AS IMPORTANT AS ON PLAN

(8.15.2)

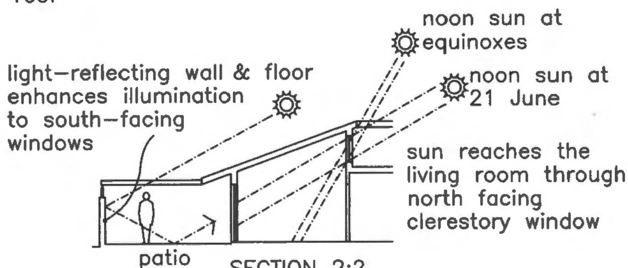
For cold winters, radiant sun passing through clerestory windows is most valuable for heating. They also provide a useful supplementary light source for darker days.



ROOF PLAN



SECTION 1:1



SECTION 2:2

(NOTE: Brickwork at the clerestory level is shown to be a full brick thickness, while the supporting wall below is half brick. This is structurally quite feasible, as the height of brick at the upper level is limited. One only has to think of double storey structures where the first floor slab as well as the walls above (full storey height) are supported on half brick walls below. Naturally the quality of mortar and bricks at the lower level have to be of a normal good standard.)

TASKS

1 OBJECTIVE To assess the performance of existing dwellings with differing orientations.

Find a number of existing houses (group housing also acceptable) and in the knowledge of what you have learnt from this section, assess plan forms which (a) have their main rooms facing north, and (b) have their main rooms facing south and (c) have their main rooms facing west. Occupants need to be interviewed with respect to indoor comfort for all times of day and night, and for the four seasons.

They should receive from you a check list which carries evaluative questions and answers, e.g. whether rooms get the right amount of sun, at the right time; the patios are adequately sheltered; the rooms are well ventilated and so on. For double storey houses, check if the lower level windows are properly shaded from the sun. (Many alternative or additional issues may be relevant. Only a few items are listed here.)

2 OBJECTIVE To develop analytical skills, to record information for future reference; to experiment with alternative solutions.

Draw rough proportionate plans of the dwellings visited, and mark up all weaknesses and merits. Draw up corrective suggestions in plan and section (a) as possible building alterations (i.e. minimal work, optimum results) and (b) redesign as if the project were starting as a new scheme. Annotate your improvements and make clear how they work.

3 OBJECTIVE To think systematically through every aspect of detailing: (a) visual design; (b) good functionalism and (c) practical, economical construction.

Design and detail a suitable sun blind (or screen) for an existing west-facing window to a bedroom. It needs to be inexpensive, to use commonly available materials, and able to be constructed by an average handyman. It needs also to be stable in wind and operable from the interior, even if reached through an opening window. If time, build it, photograph it, with shadows, as proof of its success.

9 ● CLIMATIC REGIONS AND APPROPRIATE DESIGN

ARCHITECTURE AND CLIMATIC CYCLES

We have seen that architecture is strongly related to such as sun angles and prevailing winds, and then how to design to suit these conditions accordingly. Such conditions, for given regions, work on seasonal cycles and are highly predictable except for occasional extremes which go beyond the average as well as their common deviations. For example, it is predictable that summer Karroo days often reach the mid 30's, (degrees Celsius) with fairly frequent deviations to the upper 30's. Extreme conditions may bring readings up to 42 or even 45. While we are not concerned with building costly structures to meet extreme conditions - which are tolerable for short periods, we certainly are concerned with designing for average and even commonly deviant readings. It is important then to have a knowledge of the main climatic regions of our country, and what their seasonal characteristics are.

MAIN TOPOGRAPHICAL FEATURES IN SA South Africa is a large country with pronounced topographical features which produce a variety of climatic regions. The first map shows, in simplified form, the chief factors influencing the climate. These are: (a) Latitudes - where the northern parts of the country are within the tropics (note the tropic of Capricorn) and have comparatively warmer seasons. The southern parts, at 35°S, with mountains produce snow in winter. (b) Altitudes - where the main mountain ranges (shaded) generate rain, and the elevated inland plateau has a wider range of temperatures. Higher mountains have cold conditions in winter, with rain, snow and hail. (c) Oceans - where firstly on the east coast, the Agulhas current comes from the Equator and is warm, creating a moderate, humid, warm eastern seaboard, and secondly, on the west coast, the Benguela current sweeps up from the polar south, and is cool, bringing cooler and less humid conditions.

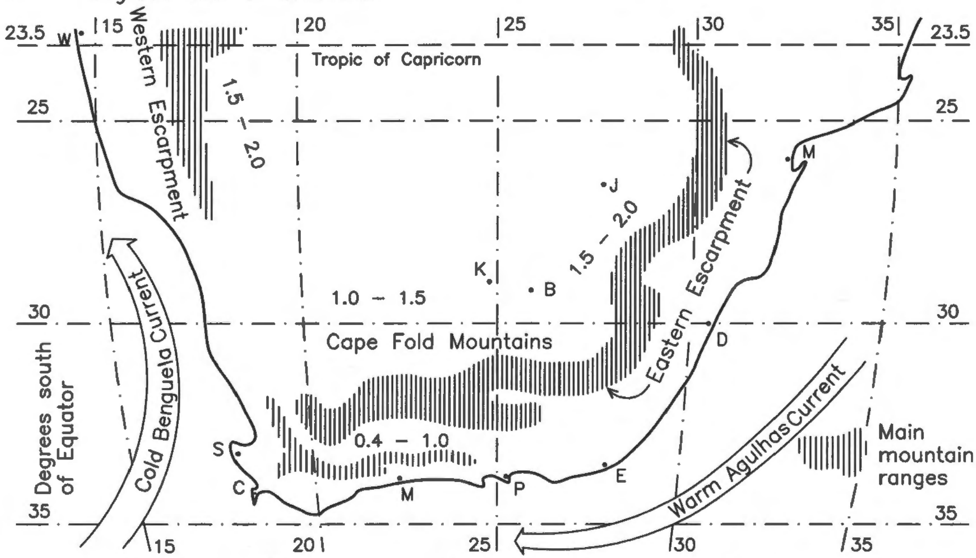
Each of these, together with wind directions and air conditions (not seen on the map), create, with other lesser factors, the cycle of the seasons in South Africa.

CLIMATIC REGIONS With reference to the next map titled Climatic Regions, salient conditions which affect architectural design are listed below. Note that these are not intended as comprehensive descriptions. In any event, the designer should always take sufficient interest in climatic conditions to look at geographical maps and statistics, if possible to visit the location in hand, to contact meteorological stations for information, to speak to local residents for details. Finally, the micro-climate can drastically modify the general climate, and the particular site in hand needs to be thoroughly investigated and understood before design can begin. A sub-section later on is devoted to this, and it is imperative to take cognisance of the factors that make vital differences. Local conditions can change dramatically from one side of a valley to the other, because the effects of both sun angles, and wind directions can amplify expected outcomes.

SOUTH AFRICA: MAIN TOPOGRAPHICAL FEATURES

(9.2.1)

Altitudes are in 1000's e.g. 1.5=1500m above sea level.



Mountains, altitudes, land mass, and ocean currents are some of the factors influencing climate. Wind directions are given in the text in relation to the next map of climatic regions.

Information and names of regional areas are adapted from the Reader's Digest Atlas of Southern Africa.

REGIONAL CHARACTERISTICS

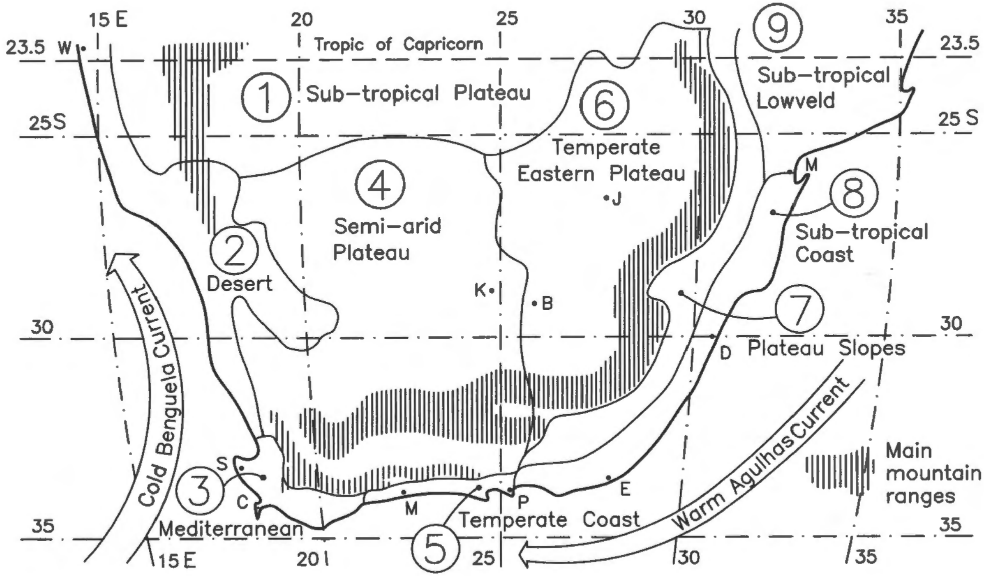
THE GENERAL PATTERN Before analysing each region, note that the sub-continent has its wettest region on the east coast. Moving westward, rainfall decreases until on the west coast, arid to very dry conditions prevail. Then on the southern coast, including the Peninsula zone, we have rainy conditions, and moving north just beyond the first range of mountains, rainfall figures plummet, giving semi-arid conditions, and moving further north, there is still a further decrease in rain. This overall pattern is due mainly to the cycle of air movement which, south of the continent, sweeps across from west to east, and in cyclonic and anti-cyclonic phases of low and high pressure zones, carries moist air from the ocean onto the land from the south west. Air moving over a warm ocean has a far higher absolute humidity than that passing over a cool ocean. It is interesting that the above general pattern also applies to the continents of Australia and South America.

While climatic regions are indicated by linear boundaries, in nearly all cases the transition from one area to the next is gradual. The exception is where mountains are high and precipitous, such as the Drakensberg, or the Cape fold formations.

Information is presented in semi-tabulated form for easy reference, and figures represent averages. Averages are partially deceiving in that they are derived not only from the 24-hour cycle of day and night, but also from both warm and cool periods of several days. Therefore when one sees a January

SOUTH AFRICA: CLIMATIC REGIONS

9.3.1



average temperature of 25°C, it must not be read as a "comfortable" figure, because frequent hot spells will climb well into the mid-30's and in cool periods, especially at night, readings could drop to well below 20. One needs to see charts indicating *frequencies* of given temperatures to make a realistic assessment. Noting TV weather forecasts over 2 weeks at cardinal seasons will help a lot.

Seasonal readings are not "symmetrical" about given mid-winter or mid-summer dates. For example, in the eastern parts of the country, October or February, which are each about 2 months away from 21 December, have differing temperature readings. October is a wet month, while February is not as wet. This, with residual ocean temperatures makes October a cooler month than February. Designers should obtain detailed relevant information from their nearest meteorological authority if they are not familiar with local climatic patterns.

ABBREVIATIONS used below: < = Less than   > = More than   N, E, S, W = north, east, south, west. Where two figures are given for say, temperatures and rainfall, it represents the range contained within that region. (A single figure would apply to one particular location.)

1 SUB-TROPICAL PLATEAU

SUMMER RAINFALL mm	62 in W to 375 in E
WINTER RAINFALL mm	<62 in W to 125 in E
SUMMER TEMPERATURES °C	15 in W to 27 in E
WINTER TEMPERATURES °C	7 in W to 12 in E
PREVAILING WINDS	S in summer; N-E in W

RELATIVE HUMIDITY (%)	<30
HOURS SUNSHINE (%)	>80
GENERAL COMMENT	Vegetation is sparse, with desert grasses and shrubs growing on sandy and stony surfaces. Conditions are very hot in summer, and in winter, cold at night especially at higher altitudes. Comparatively dry all year round, with greater precipitation in summer.

2 DESERT

SUMMER RAINFALL mm	<62
WINTER RAINFALL mm	<62 in N to 250 in S
JANUARY TEMPERATURES °C	15 at coast to 25 in E
JULY TEMPERATURES °C	<7 to 10
PREVAILING WINDS	S in summer and N in winter
RELATIVE HUMIDITY (%)	<30 inland to >70 at coast
HOURS SUNSHINE (%)	70 - 80
GENERAL COMMENT	With a cold sea current, land adjacent is affected in temperature and humidity, with dramatic changes inland at high altitudes. Desert to semi desert generates very high summer temperatures and in winter, cold night time readings. The high humidity at the coast is not uncomfortable because of lower temperatures from the sea. Fog patches are frequent.

3 MEDITERRANEAN

SUMMER RAINFALL mm	62 to 250 in S
WINTER RAINFALL mm	250 to >750 at Peninsula
JANUARY TEMPERATURES °C	20 to 23
JULY TEMPERATURES °C	7 to 10
PREVAILING WINDS	S to S-E in summer & W to N-W in winter
RELATIVE HUMIDITY (%)	50 inland to >70 on coast
HOURS SUNSHINE (%)	<60 in S to 80 in N
GENERAL COMMENT	This zone is noted for its variety of fynbos and evergreen shrub. Winter rainfall gives the name "Mediterranean", and winds, especially from the s-e can be very strong, commonly reaching gale force. Prolonged cold wet spells mark the winter while hot persistent sun dominates the summer months.

4 SEMI-ARID PLATEAU

SUMMER RAINFALL mm	62 in E to 500 in W
WINTER RAINFALL mm	<62 in W to 250 in W
JANUARY TEMPERATURES °C	20 in S to 27 in N
JULY TEMPERATURES °C	<7 in central plateau to 12 in S & N
PREVAILING WINDS	N & S in summer & N-W in winter

RELATIVE HUMIDITY (%)	<30 in N to 50 in S
HOURS SUNSHINE (%)	60 in S to >80 in N
GENERAL COMMENT	This region envelopes most of the Little and Great Karroo and the sparse vegetation is mostly scrub and grass. Rainfall is low, with the greater proportion falling in summer. Summer temperatures climb high on summer days, and in winter, nights are cold to very cold. Summer wind storms drive dust, being lifted by whirlwinds.

5 TEMPERATE COAST

SUMMER RAINFALL mm	250 to 500
WINTER RAINFALL mm	250 to 750 on coast
JANUARY TEMPERATURES °C	20 to 23
JULY TEMPERATURES °C	12 to 17
PREVAILING WINDS (N-E = north east etc)	S to W in summer & W & E in winter
RELATIVE HUMIDITY (%)	60 to >70
HOURS SUNSHINE (%)	60 to 80 inland
GENERAL COMMENT	This narrow strip is distinctive in having a year round rainfall. Vegetation is therefore profuse, with dense indigenous forest under preservation. The area is in close proximity to the Karroo and the climates are in strong contrast because of the dividing mountain ranges as related to wind directions.

While relative humidity is high, temperatures are moderate (because of latitude and a moderating ocean) and comfort standards are not unpleasant.

6 TEMPERATE EASTERN PLATEAU

SUMMER RAINFALL mm	125 to 375
WINTER RAINFALL mm	62 to 250
JANUARY TEMPERATURES °C	20 to 25
JULY TEMPERATURES °C	10 to 15
PREVAILING WINDS	N-E in summer & N-E to N-W in winter
RELATIVE HUMIDITY (%)	30 to 50 in E
HOURS SUNSHINE (%)	60 to 80 in W
GENERAL COMMENT	The Highveld is predominantly grassland with scattered trees in the wetter parts. Summers are warm to hot, with fairly dry air, relieved by thunder storms generated from thermal air movement. Hail is not uncommon. Winter days are pleasantly sunny with clear cold to very cold nights. NOTE The eastern portion of this region comprises the Drakensberg which generate their own climatic patterns dependent upon the topography of the particular location. Differences from the rest of the region are mainly colder winter temperatures bringing occasional snow, hail and more pronounced thunder storms.

7 PLATEAU SLOPES

SUMMER RAINFALL mm	750 to >1000
WINTER RAINFALL mm	250 to 375
JANUARY TEMPERATURES °C	20 to 25
JULY TEMPERATURES °C	7 to 12 at lower altitudes
PREVAILING WINDS	S-E in summer & S-W in winter
RELATIVE HUMIDITY (%)	50 to 60
HOURS SUNSHINE (%)	<60
GENERAL COMMENT the	The foothills of the Drakensburg benefit from generous orographic rain brought from warm Indian Ocean, resulting in rich grassland with trees in isolated patches. High rainfall gives longer protection from sun, but summer days are often warm to hot, relieved by thunder storms as well as more prolonged rain spells, the former bringing hail periodically. Winter days are pleasant with nights cold to very cold.

8 SUB-TROPICAL COAST

SUMMER RAINFALL mm	750 to >1000
WINTER RAINFALL mm	375 to 750
JANUARY TEMPERATURES °C	20 to 25
JULY TEMPERATURES °C	15 to 20

PREVAILING WINDS	S to SW & N-E
RELATIVE HUMIDITY (%)	>70
HOURS SUNSHINE (%)	<60

GENERAL COMMENT This coastal strip is noted for its combination of medium to high summer temperatures with high relative humidity, resulting in very uncomfortable conditions. The southern part of the region is relieved, being further south, with more frequent winds and lower temperatures. Winters are pleasantly warm, with nights cool but seldom cold. Summer nights are warm and humid, and the days, a challenge to architectural designers. Vegetation is mainly grass with sub-tropical bushland in patches, resulting from a high rainfall. The nature of rain for the earlier part of the season is 3 or 4 consecutive days of moderate to mild precipitation, and the latter part, thunder storms.

9 SUB-TROPICAL LOW VELD

SUMMER RAINFALL mm	750 to 1000
WINTER RAINFALL mm	500 to >750
JANUARY TEMPERATURES °C	25 to 27
JULY TEMPERATURES °C	15 to 20 in N
PREVAILING WINDS	E
RELATIVE HUMIDITY (%)	>70

HOURS SUNSHINE (%)	<60
GENERAL COMMENT	The description for this region is as that above, with more exaggerated temperatures, humidity, but lower rainfall. Without mountains creating a boundary (as in the previous region), a large sector of low-lying land has lush vegetation, but with a high humidity, shade provides little respite.

MICRO-CLIMATE AND OTHER ASPECTS OF THE WEATHER

The above tables represent climatic conditions for given regions, which are needed for principal decisions in architectural planning. However, as mentioned earlier, the word Micro-climate relates to conditions pertaining to a particular location. In architectural terms this would be a given building site. (For the occupant of a building it could even mean living on one side of a building as against another - where conditions can almost be like two different countries.) For a large site, say for an educational campus or a hospital, an analysis of various parts of the site would be done, as conditions from one part of the site to another could differ substantially.

Micro-climate is of particular interest because it often has exaggerated elements of the general climate. It comes about because of topographical forms in hills, mountains, valleys, trees, rivers, lakes, the sea and also man-made structures. Very often it is a *combination* of sun and wind - and perhaps other weather elements, that makes for a greater and unexpected exaggeration than normal.

The illustrations show the common forms of change which take place, and it is worth observing these in real life because they do make a difference to the qualities of a given site. The architecture which emerges from such conditions should specifically provide more agreeable buildings to live in.

The illustrations once again show a set of principles applied to a limited set of situations, and the student is urged to observe the principles, and then for a particular site in mind, work out what the micro-climate is - at all times of day and night, in all seasons.

AIR VELOCITY at high altitudes (relative to ground level), is astonishingly high, and lower down, it decreases, and may even alter direction. However at still lower levels, it drops drastically (comparatively) until at ground level, calm conditions, turbulence, funnelling - or a combination of these - takes place. As a practical observation, it is worth getting to the top of an isolated high-rise building on a windy day, and to sense the nature of air movement at that level, and compare it with that at street level. Even listening to the droning of the wind will make the point clear.

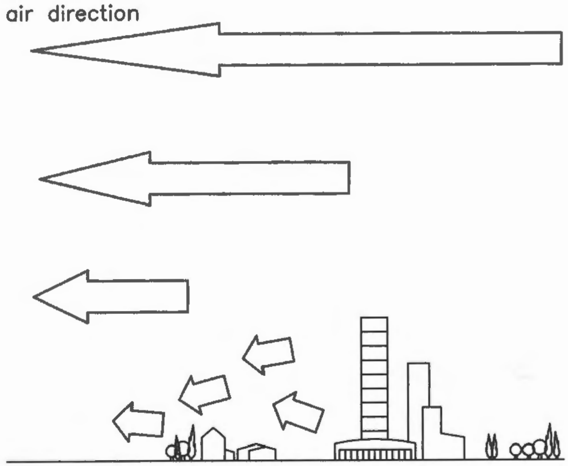
Not illustrated are two results from the above: (a) Wind on high levels of hills or mountains will be considerably stronger and (b), buildings which stand on the edges of large open stretches of water which face the wind, will receive much higher velocities. Precautions need to be taken.

TEMPERATURE INVERSION shows that placing a residence at the bottom of a valley is unwise as cool to cold air will filter in and make living very unpleasant. By observation, temperatures may be assessed by feel (or better by thermometer) for a given site in such a situation, but care must be taken to have calm conditions, and in the most aggravating circumstances. For example, one may make such an assessment in summer, where the coolness is rated as a great advantage, while in winter it will rate as no more than miserable.

AIR MOVEMENT ACROSS VALLEYS OR HILLS will impound upon the appropriate siting of buildings. For warm zones, more windy locations are preferred, while in a cold windy zone, protection will be the choice.

AIR VELOCITY

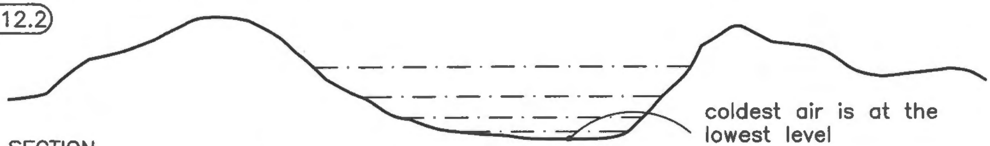
9.12.1



At higher altitudes, air speed is unimpeded and regular, and commonly has remarkably high speeds. Relatively small obstacles at ground level will reduce air velocity to a good height as shown above. Larger obstacles have yet more effect, and at ground level, air movement will be severely impeded, with turbulance and funnelling causing problems.

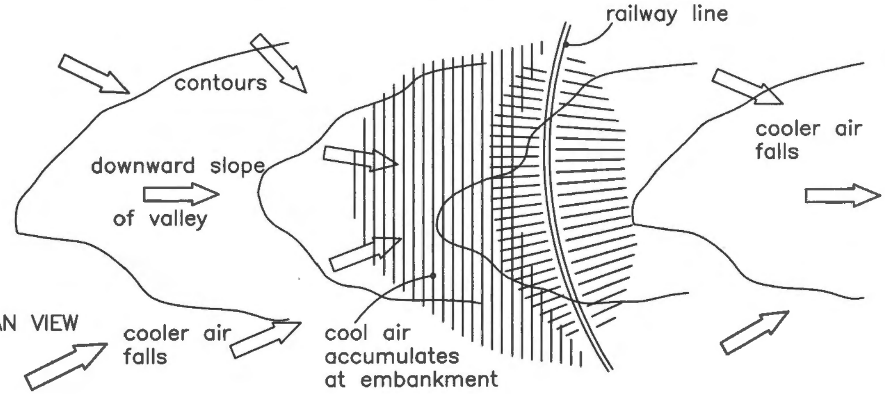
TEMPERATURE INVERSION

9.12.2



SECTION

Under calm conditions, when air cools – most commonly at night, the cooler air falls to the lowest level, with warmer temperatures above. Air will flow down a sloping valley as long as there are no damming obstructions. Such conditions are shown below.

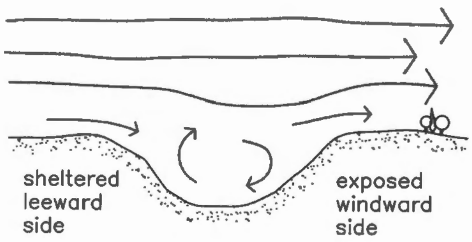


PLAN VIEW

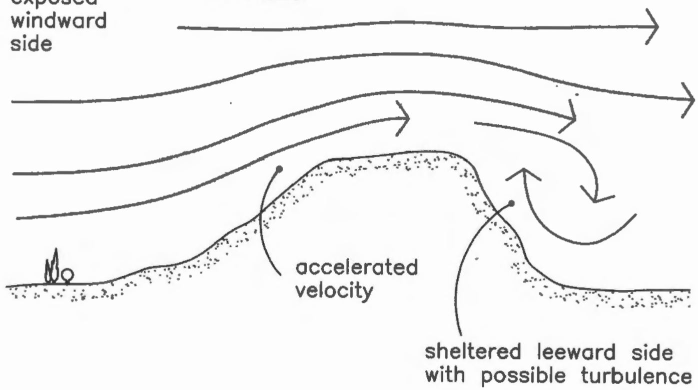
AIR MOVEMENT

1 ACROSS A VALLEY

9.12.3



2 ACROSS A RANGE OF HILLS



If there is little option, the building itself will have to be the more carefully conceived.

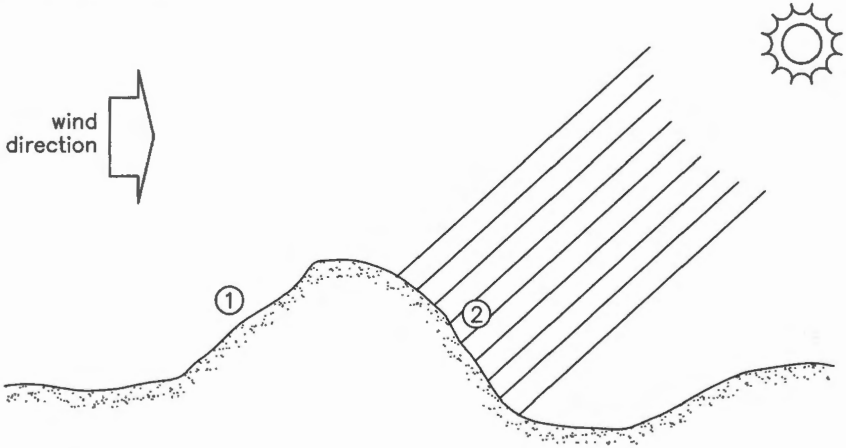
AIR MOVEMENT AND SUN combined can aggravate the situation where both together result in over warming, or over cooling - and the two may be in close proximity but on directly opposite sides of a small valley. Extremely careful thought is needed in all aspects of climatic design for such sites. It is one thing to live in a building for a number of years and learn about its weaknesses or merits - and apply these findings to your designs thereafter, but it is another learning equally well from *other* situations and using the information for later designs. One tends to be careless in the latter form of experience - and not to be too disturbed about the comfort of the clients concerned.

EAST-FACING AND WEST-FACING SLOPES present similar problems, and need careful observation to achieve good results. For all these situations, one must look at the overall climate, and also at particular seasons, and then assess whether one gains or loses advantage for the given combination of factors. In one case, protection from wind or sun may be needed, and in another, they may be desired - and the building needs to be designed to suit.

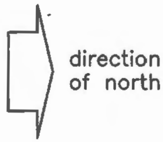
DIURNAL THERMAL CYCLES are very interesting and the illustration applies under calm conditions, which in any case is very often the case for nights and the earlier part of mornings. Where cool air settles in the evenings at the lower levels, it also has a higher humidity, as it passes over dew-covered grass. If a building is situated in the path of draining moist air, it filters through the building causing colder damp conditions, not a pleasant state for prolonged periods. Likewise it would be unwise to place a dwelling at the bottom of a valley where the coolest and most damp air constantly settles. Even in a warm climate this is not recommended, and it is preferable to choose higher ground for better results.

AIR MOVEMENT AND SUN

(9.13.1)



In the above situation note:
1 This face of a hill or mountain receives little sun and is exposed to wind. Conditions will therefore be distinctly cooler than on flat terrain.
2 In contrast, this face is exposed to the sun, and sheltered from the wind, and in normal South African conditions, will be warm to uncomfortably hot.

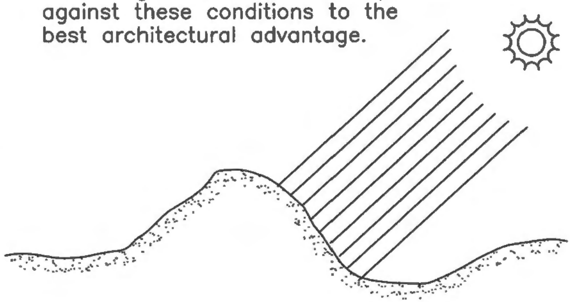


EAST–FACING AND WEST–FACING SLOPES

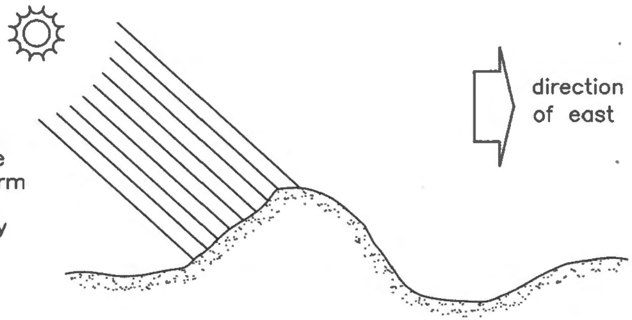
(9.13.2)

1 Morning sun warms east–facing slope, which has been cooled over the night before. The west–facing slope remains cool.

The designer must utilise or protect against these conditions to the best architectural advantage.



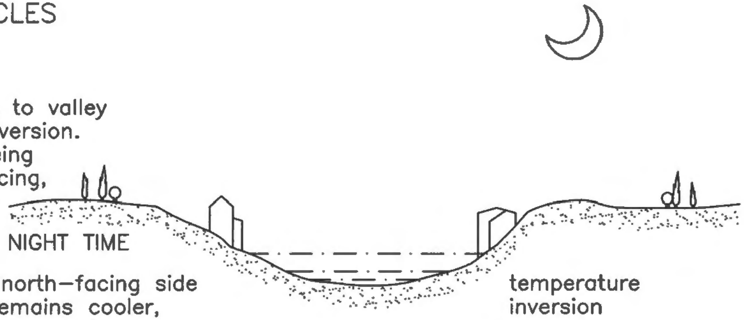
2 Afternoon sun warms the west–facing slope, which has been warmed by the atmosphere during the morning, creating warm to hot temperatures.
The east–facing slope is in early shadow and cools down.



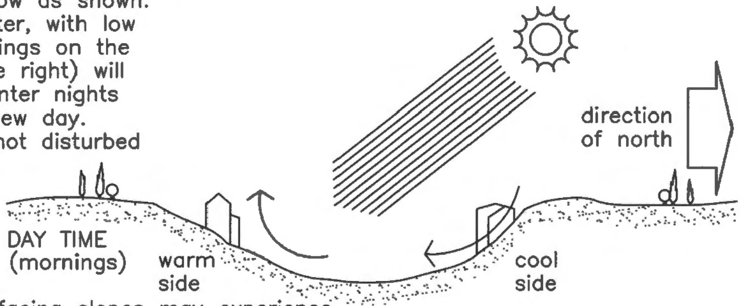
DIURNAL THERMAL CYCLES

(9.13.3)

1 At night, cool air drains to valley resulting in temperature inversion. The north–facing slope, being warmer than the south–facing, retains heat over a longer period.



2 During day, sun warms north–facing side first and the south face remains cooler, with resultant gentle air flow as shown. This is exaggerated in winter, with low northerly sun angles. Buildings on the south–facing slope (on the right) will experience cool to cold winter nights into earlier times of the new day. This cycle only applies if not disturbed by general winds.



NOTE: Buildings on south–facing slopes may experience flow–through of cool draining air at night. Low diverting walls may be built to prevent this problem.

DEW is condensed water on plants or on the ground surface, and is caused by air cooling at ground level at or just after sunset on a clear evening. As seen previously, air at a warm temperature holds more water vapour than when cool. As the sun sets, under a clear sky, the ground radiates its heat through the atmosphere to space. It cools to a lower temperature than the air. It then cools the air in contact, and it gives up its moisture to the surface as water. On a cloudy night the radiant heat is trapped or "blanketed" (by reflection) and the ground remains warm, and no dew forms. Another case where dew does not form is for example on a concrete slab which has been warmed by the sun, and it cools more slowly because of its mass, and the air at its surface is therefore not cooled. However later on the dew begins to appear.

HUMIDITY has a major effect upon personal comfort. Again, warm air holds more moisture than cool. There are two types of reference to humidity, the one being Absolute Humidity and the other Relative Humidity (RH). Absolute Humidity is a figure representing the mass of water vapour contained in a given volume of air at *any* temperature. It follows then that cool or cold air will have less mass of water than warm or hot air. Relative Humidity is the ratio of water vapour in a given volume of air as a proportion to the maximum amount of water vapour that could be contained in the same volume of air at the same temperature.

Accordingly a high RH *reduces* the rate of evaporation of perspiration from the skin, which is a cooling process, which prevents loss of heat from the body. The additional "stickiness" on the skin is a further irritation, and with higher temperatures it is not a pleasant or comfortable condition. Relief may be provided by moving air passing over the skin (to increase evaporation), causing cooling, even if to a limited degree. Hence the positive effect of fans. Note also that for very dry climates when it is hot, relief is not so effective using fans, although some air movement does give relief, even psychologically.

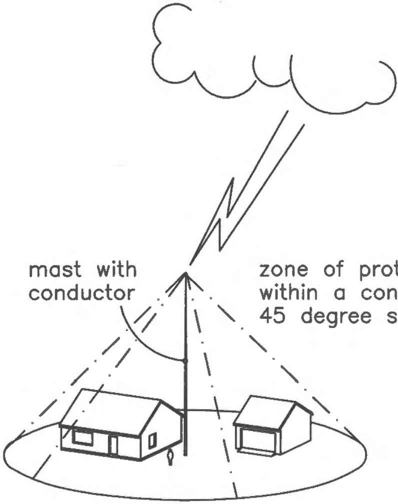
MIST AND FOG are simply understood as cloud at ground or sea level. The two terms have the same meaning, that is, they comprise fine droplets of water, causing dampness and restriction in vision. In general use, the word fog is associated with the sea, and is caused by the mixing of warm and cold air masses, while mist is associated with the land, and may be caused in the same way, or more often by masses of air being pushed up an escarpment, where it cools and water vapour turns into minute water droplets, restricting vision. Of interest is the term Mizzle which is the condition between mist and drizzle! Regions which experience this condition frequently suffer from mildew in fabrics, and storage spaces need to be well ventilated for drying out when atmospheric conditions allow.

LIGHTNING is the final weather element for this section. While its characteristics, both sound- and sight-wise are frightening, the most serious threat is that of being personally and fatally struck or alternately having one's property partly demolished in an instant, or burnt down. Since electric storms are fairly common to many areas in South Africa, a good proportion of the population remain unafraid of its presence and consequently do not take adequate precautions against potential damage or disaster. Likewise many individuals have either been struck or know someone who has, and still a casual attitude persists. Large buildings on high ground are struck by lightning remarkably frequently (at least once every year), i.e. in those regions where such storms exist.

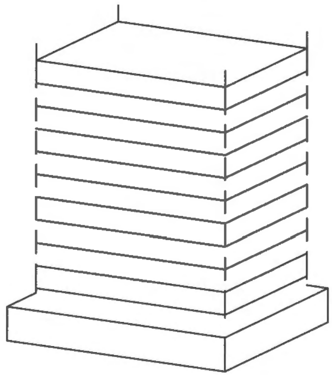
Scientifically, many aspects of lightning remain unknown, mainly how it is generated. Its performance and results are well known, with much research having been done. In its most normal form, it comprises a brilliant arc sometimes several kilometres long, coming from a negative charge at the base of a cloud which positively charges the ground below. When the charge builds up sufficiently to arc, (10 000v per centimetre) the flash or discharge takes place. Arcing often takes place between clouds as well. The air surrounding the arc expands instantly causing sound waves and thunder.

LIGHTNING

(9.15.1)



A large building or a long domestic building needs a number of arrestors which are interconnected and have leads straight down to the ground.



Personal protection is best afforded within a metal bodied shell such as a car. Being next to or under trees is dangerous, (especially tall trees), as they are good conductors and the arc could jump to a human (or animal) body, which, having a high proportion of water is also a good conductor.

However, a building is best protected by a lightning conductor (or arrester), which comprises a vertical metal mast projecting above the structure, and which has a conducting copper (or other good conducting material) lead running vertically in a straight line down to the ground, where it is connected to a non corroding metal mesh "mat" buried well underground, so that the charge is properly earthed. For large buildings (and even longer domestic buildings), a number of conductors are necessary, and these are connected by leads along the top edges of the structure. Reinforcing in concrete columns should not be used as conductors. The proper specification for such installations should be obtained from a specialist or electrical engineer.

For thatched houses, where ignition is potentially high, a number of separate masts spaced away and around the buildings are employed. The broad theory is that each mast protects a zone around it in the shape of a cone, the point at the top, and with a 45 degree side. Thus masts have to be designed high enough to protect the buildings adjacent. Thatching may be made fire-resistant by chemical treatment, naturally at a cost. Fire risk insurance on thatched buildings is high.

DESIGNS FOR SPECIFIC CLIMATIC REGIONS

Plans and sections are shown to highlight the main aspects which are incorporated in architectural design thinking which provide the greatest benefit from local prevailing climatic conditions. The suggestions are not concerned with views or where road access applies, nor with the aesthetics of architecture, but focus almost solely on climatic matters. There will be many alternatives to those shown, and the student is again encouraged to take specific notice of the governing principles, and then to approach their own projects without preconceived ideas drawn from this book. Only a few regions or climatic patterns are covered, and designs for those remaining need to be derived from the guidelines given.

To clarify the process of logic, it is worth repeating that for a given zone, (or a micro-climatic location), the *most extreme* conditions must be considered, whether it be high or very low temperatures, strong winds or heavy rain. Ask yourself what you would do with each decision under those particular states. Clearly it will be one answer for one season and the opposite for another, and your design has therefore to cater for both, whether it involves using adjustable devices, or having a careful look at sun angles and wind directions - which have differing values at different times of day or year.

In addition, it is well worthwhile to revise on all principles covered in the earlier part of this book, (as a "checklist" procedure), as the guidelines below in most cases hint at some of these without explanation.

SEMI-ARID

On the map this is Region 4, and comprises mainly the Little and Great Karoos.

1 USE INFORMATION from the relevant paragraph under Regional Characteristics.

2 EXTREMES - in summer, very high temperatures; very low RH; very low rainfall; and in winter, very cold nights; less rain in winter. Apart from extremes, there are many pleasant conditions at the "between times" of day, and of season, making for good outdoor living and working. In summer, dust from whirlwinds (and simply wind) can be a problem.

3 THE SITE The choice of site calls for (as in most cases) an intermediate elevation relative to surrounding relief, to gain breezes for summer cooling, to avoid temperature inversion in valleys. Orientation must allow sun for winter warming. A south-facing gradient will be colder on winter nights. The site should have good indigenous vegetation - the more shady trees the better. It then needs to be developed with maximum shading vegetation to provide cool surroundings to the house. Indigenous planting demands minimum water. A small amount of irrigation will consequently foster denser growth, which actually cools and humidifies the air. Planting should ideally line up with the warmer prevailing wind to gain maximum cooling. Heat absorption by the surface of the site for summer should be reduced to the minimum, as previously covered. For winter, a good proportion of deciduous vegetation is needed to allow heat from the sun.

4 WALLS of the building should be thick (mass) to use the flywheel effect. Stone is very suitable. The external surface should be dark toned to gain solar heat in winter, (stored for the nights), and shaded with roof overhangs in summer.

5 WINDOWS should be small. A high air temperature externally will warm the glass and transmit heat to the interior. The aim is to reduce the area of glass as well as cut down, in summer, on radiant penetration. Tall windows (or the provision of low and high level ventilation) will allow, on summer evenings a quicker "fill up" of cooler air after sunset. The idea is to open up on summer evenings to enjoy cooler air. If small windows are not desirable, double glazing is recommended. Larger windows will help in winter months to warm floors and walls to carry heat into the night.

6 DOORS need to be shaded from radiant sun. In winter, gaps must be minimised, and "draught excluders" used to prevent cold air filling in from outside. (Take note - it is not just a cold breeze that enters, but cold dense air will filter in simply by virtue of its greater density than the warm air inside.) Weather lobbies are the ideal solution especially where doors are used more frequently. They also help in summer. For warm summer evenings, stable pattern doors or security grilles are effective, to admit cooler air.

7 FLOORS are better in mass concrete, to warm up from radiant heat in winter. Carpeting reduces the effectiveness of this process, and a dark-toned mass finish (such as quarry tiles) will help. Ideally, carpeting laid over these areas after sunset will allow the heat to dissipate over a longer period into the evening. However, this will figure as too much trouble for the average occupant.

8 CEILINGS AND ROOFS Ceilings are preferably high, but this is a large expense - raising the whole roof - simply to allow warm air to “drain” upwards. Sloping ceilings are the next option, provided the roof is well insulated. The next, and probably the most effective, is to increase roof space above a horizontal ceiling by using a steeper pitch. This enhances appearance, (externally) and cuts potential leaking, and is not so expensive, as lighter truss members may be used.

HOUSE PLANS
SEMI ARID
WARM TO HOT
(Region 4)
(9.19.1)

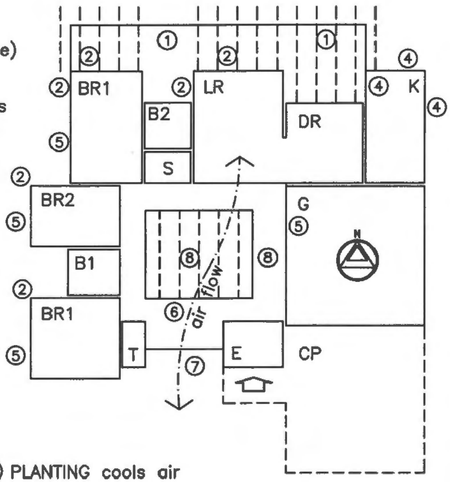
(1) NORTH PATIOS These are generously shaded from summer and equinoctial sun (by deciduous planting or adjustable shading).

(2) NORTH WINDOWS Allow north west WINTER penetration to warm thermal-reserving solid floors for night warming.

(3) RECESSES to patio allow shelter in wind or cold. All patios should have ample vegetation for cooling, and dark toned finishes to absorb winter heat. These are shaded in summer.

(4) NORTH EAST corner of kitchen allows early winter warming; like-wise west window onto patio – good for communication and access to that area.

(5) WALLS are in thick mass construction (stone is suitable) and for winter, on the west absorb heat for cold nights. For summer afternoons, trees strategically placed provide shade. Rooms have north-facing windows, and west, for controlled seasonal use.



(6) INTERNAL COURTYARD with glazing to south side prevents dank south zone of house at entrance.

(7) PLANTING cools air flowing to the interior.

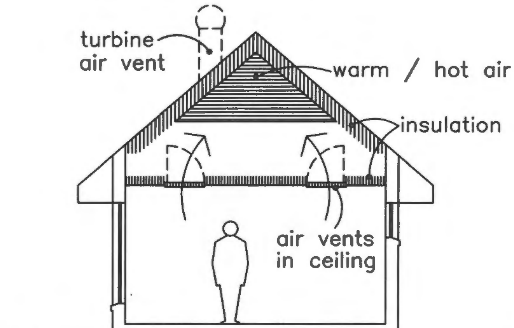
(8) INTERNAL COURTYARD This has summer shading. Note glass on south side to allow air move-ment. Likewise from the north via LR. Shelter from winter wind is afforded in this space. Glazing, with opening sections provides good flexible arrangements for all seasons. In winter, the floors and walls exposed to sun provide good thermal storage for cold nights. Warm air can be directed where needed by means of controlled openings.

(9) SITE DEVELOPMENT should provide generous indigenous planting for shade in summer and sun in winter.

(10) CEILINGS AND ROOF See section for principles of design.

ROOF DESIGN SEMI ARID
(Region 4)

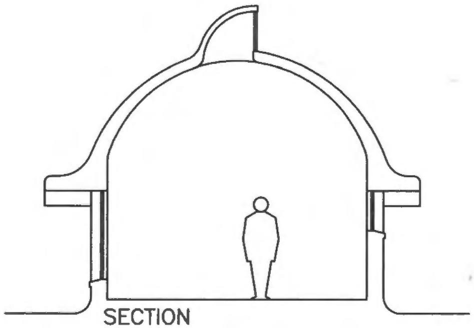
(9.19.2) IN SUMMER, a conventional roof allows warmer air to escape upward to the ceiling void via ceiling vents, providing a cooler living space. An additional turbine vent will be a further help.



SECTION

IN WINTER the ceiling vents are closed, keeping warm air in the living space. Additional insulation resting on the ceiling would reduce energy needed for heating.

A VAULTED ROOF is held to benefit from its mass using the flywheel principle. Without an eaves overhang windows need to be shaded. The high volume provides a cooler and comfortable living space at lower level. Warm air escapes through a roof vent, and in winter, it allows warm sun to penetrate.


SECTION

The roof space is used as a "drain" to receive warmer, less dense air, through vents in the ceiling. Generous insulation *must* be provided immediately below the roof covering. Air turbines or vents are needed to allow air from the roof space to escape. These must be positioned high up to prevent external warm air from entering. Roofing should be finished in a light reflective tone to reduce heat absorption.

The ceiling air vents are closed off in winter to prevent valuable warm air from escaping. If possible the roof space is closed off completely for the same reason.

ALTERNATIVE ROOF CONSTRUCTION Since mass structure is the answer to this region, a further alternative to roof construction is in solid concrete construction, (or hollow block-and-rib), which in turn may be flat, mono-pitch or two-pitch. In any event insulation is needed unless a thick dimension applies. Good waterproofing, especially if flat, and eaves overhangs, or canopies to windows, (and wall shading) must be provided. This turns out to be expensive. (If it was not, it would be commonly seen on domestic buildings in this area.) Another option is a vaulted roof of mass units in stone, precast concrete or clay, with concrete between, but again, rainwater disposal, window and wall shading remain for attention.

Opinions vary about the need for roof gutters, but as water is scarce it is common and good practice to lead all roof water into storage tanks for irrigation to the garden, and more important, to reduce borehole extraction.

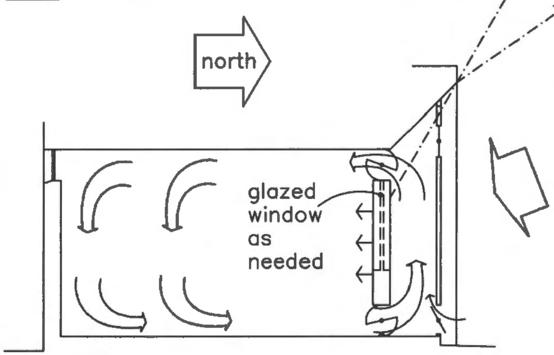
SOLAR WATER HEATING While dealing with roofs, the plentiful sunshine experienced in this region makes solar water-heating a positive proposition, and this is commonly practised for needs in the kitchen and the bathroom or shower. However, as water has such a high specific heat, it may be a proposition (as energy resources become more expensive), that extra solar thermal collectors be used to warm the interior. This could be achieved by means of water circulating through radiators. This would extend well into the night depending upon the capacity of water stored.

As convectional directions of water flow would vary from day to night time, a small pump would be needed to circulate the water. However, if the collector panels and an insulated storage tank were positioned at below floor level, (basement or on a lower level of the site), the flow would be convectional and non-energy consuming. It is not known whether such systems are marketed, but if not, it remains to be done. A number of variations are possible as in air-conditioning, such as having the system semi-indoors, with a heat exchanger used to take air over water radiators, again fed from a storage tank.

ADDITIONAL AIDS A well-known heating aid is the conservatory, traditionally installed to grow tropical plants, the purpose being to allow them to survive through cold seasons. The greenhouse principle quickly warms the interior, even on overcast days. If the plants deserve such treatment, then for human comfort, it is worth looking at ways to capture the benefits offered. The winter objective would be to warm to the maximum as much structural mass as possible, and to let this mass pass its heat to the interior of the main building when needed, i.e. at night. It follows then that mass materials be exposed to solar radiation (via glass), and that they have dark-toned, matt surfaces. At night, openings from this volume to the main building would allow a convectional flow. To avoid heat loss back through the hot-house glass, an insulating curtain would be drawn. This in principle is the Trombe wall effect, which naturally could be used as an alternative. But the greenhouse does provide pleasant additional living space. For summer, this space must be well shaded and have opening windows for ventilation.

THE TROMBE WALL

(9.21.1)

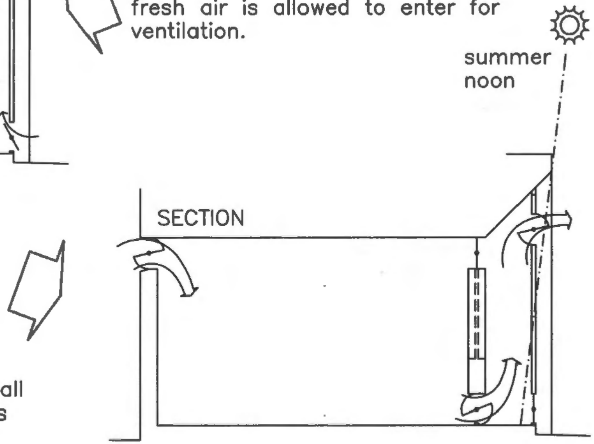


SECTION

IN WINTER the inner wall heats up by means of the greenhouse effect. It heats the air to its front, which convects to the main space, warming it up. Internal radiant heat from the wall also assists. A small amount of fresh air is allowed to enter for ventilation.

IN SUMMER the inner wall is shaded and whatever heat builds up in the space behind the glass rises and draws air from the interior. Openings allow cool air to enter from the south side.

In elevation, the glazing and mass wall are generous in width while the vents are comparatively small.

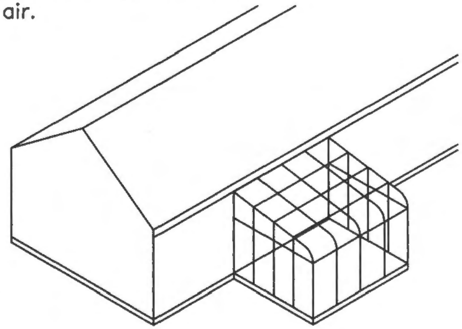


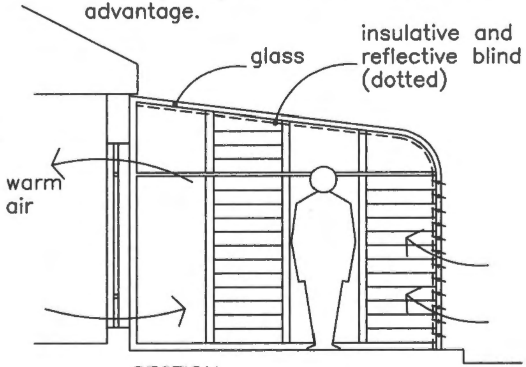
DEVELOPMENTS FROM THE TROMBE WALL (9.21.2)

The space behind the glass may be enlarged either as a passage or for other uses such as growing plants or as a summer house, This volume, with its contiguous internal space to the main building can be made to work to good advantage.

The glazed space has a system of windows and sun blinds which control solar penetration and movement of air.

The conservatory or summer house in glass provides warm air to the interior if needed. It is most suited to a dry cold winter as in the Karroo, but also helps for any cold winter regions. It is not of any value to the warm humid east coast.
At night the (dotted) insulative blind is drawn to contain heat. In summer, the blind provides shade overhead while the louvres or windows are opened to allow ample cross ventilation.
Planting may be used seasonally to advantage.





SECTION

ELECTRICITY It is becoming more common to use photovoltaic cells (PV cells) for low current electricity. This includes lighting, radio and TV, small pumps and computers. Battery storage is necessary. As this region has such abundant sunshine, it will be a natural development over the next few years, and systems will be created to make this a more viable proposal. Roofs already have the angle and elevation (above vegetation) to accommodate panels of PV cells. Placing them on the roof partly reduces the need for insulation.

OUTDOOR LIVING SPACE needs very careful positioning and design, and generous shade is needed for summer, with further relief by means of water features (if available) and planting. There are often times in summer when temperatures are too high to be outside but for those times when respite is possible such as at sunset, these areas are very valuable. In winter outdoor areas are most enjoyable and should be developed to their maximum advantage.

TEMPERATE COAST

On the map this is Region 5, and comprises the well known Knysna / George area, which is forested lake-land with a year-round rainfall, and a backdrop of mountains. Marine views abound.

1 USE INFORMATION from the relevant paragraph under Regional Characteristics.

2 EXTREMES to remember are: prolonged periods of wet weather; medium to heavy rainfall; changeable weather conditions; rain throughout the year; high RH; winds on the coast are very strong and often reach gale force. There is however ample opportunity for outdoor living.

3 THE SITE Because of abundant rain in this region, a site must be chosen for the maximum advantage from the sun. This is for warmth, for drying out and for psychological balance. Shelter from prevailing strong winds is also essential. While everyone enjoys luxuriant vegetation, this could be a drawback in this type of climate, and a moderate coverage of planting with strategically positioned trees would be ideal. Indigenous vegetation should thrive well and will draw associated bird and insect life. Deciduous planting is a great advantage to admit maximum radiant sun in winter, when the weather tends to be wet and dull.

4 WALLS traditionally are of brick cavity construction, and the surface needs to take advantage of sunshine for thermal storage. If the surface is water-absorbent (which normal brick is) it will offer far less opportunity for heat absorption and retention in wet conditions. (A damp surface will be cooler due to evaporation.) If a water resistant application is used, drying out will be quicker, and heat absorption restored. A roof overhang will keep a wall dry, but will also shade from the sun. A compromise is possible with the use of transparent roofing material for the outer part of the eaves projection, which will shelter from rain, but will admit solar radiation. Careful analysis of sun angles is needed.

5 WINDOWS may be of moderate size, but larger areas will admit much-needed light. Cleaning for wet climates is a problem, and again a generous roof projection will assist to reduce the use of cleaning agents and the cost of labour. Little can be done however against wind-blown rain. Opened casements or sashes, should keep out rain as far as possible, and windows in general must be positioned and hinged with the direction of strong wind in mind.

6 DOORS, when open, comprise large areas of exposure to weather elements. When considering heavy rain, wind-blown rain, and the removal of water-resisting clothing or umbrellas, it is clearly unwise to have a door without any form of protection. Firstly they should if possible be placed to be less exposed. If not, protection must provided, and in order of cost these will be: (a) a wide and ample roof overhang; (b) side screening from wind, and (c) a lobby and two doors, designed to allow the storage of rain wear. Each of these options will also care for the very warm days of summer and need to be designed accordingly. Remember the further options such as stable pattern doors, glazing and sidelights as needed.

Not everyone can afford remote controls for garage doors, and manual doors can be difficult in inclement weather and need the same attention to be properly efficient. There is the problem of the driver getting out of the vehicle and wanting to stay dry. A carport would afford reasonable shelter, but if feasible, a roof projection from the main building, for example in an L-shaped plan, might be workable. A sheltered link with the house is also very desirable, and a direct door is the most practical. Think in addition of the times when guests are passengers or arrive in their own vehicle.

One may ask again what the above has to do with energy and the environment. A wet, cold, shivering person entering the house will soon take several hot coffees, a hot bath, and turn on the heaters, all needing energy for heating.

7 FLOORS, as in the previous region, must be treated as good thermal collectors and reservoirs, and must be juxtaposed with windows for exposure to warm radiant sun at the appropriate times of year.

HOUSE PLANS (9.24.1)

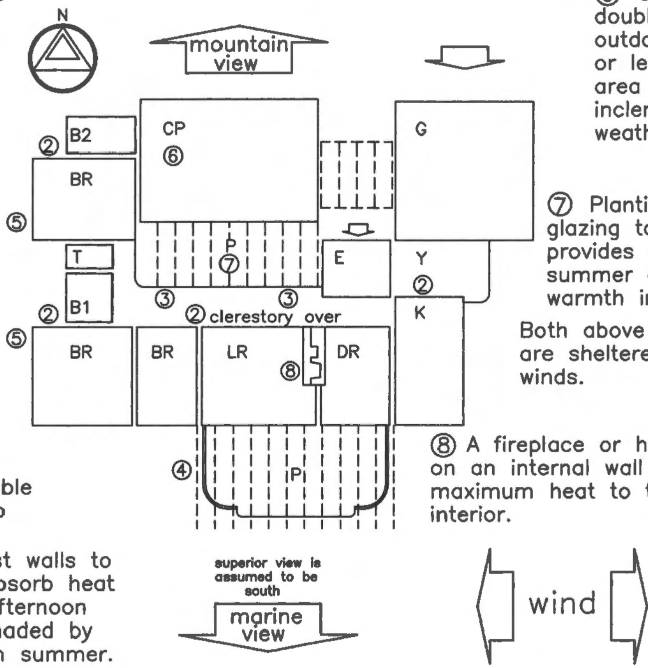
TEMPERATE COAST
(Region 5)

① In this region, many sites have spectacular views south and north with strong winds from east and west.

② Most main rooms have north sun with windows to good or partial views.

③ South wing has its north zone (floors and walls) warmed by north sun, and receives north light – see section.

④ South patio has openable glazing as wind screens to prevailing winds.



⑤ West walls to BR's absorb heat from afternoon sun; shaded by trees in summer.

⑥ Carport doubles as outdoor work or leisure area during inclement weather.

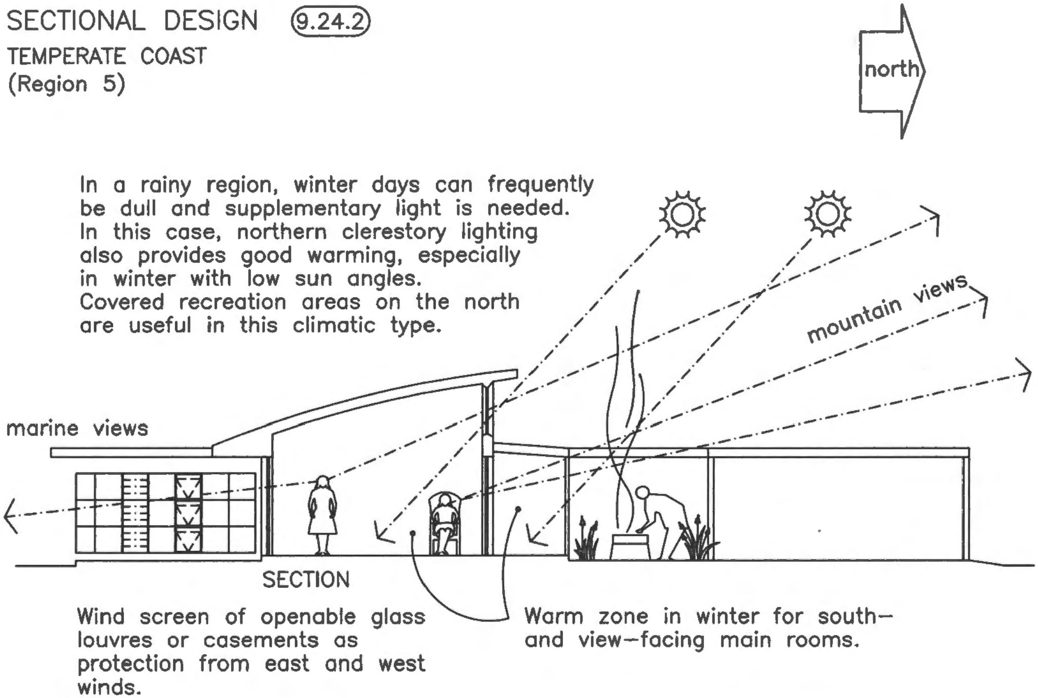
⑦ Planting with glazing to south provides cool in summer and warmth in winter.

Both above areas are sheltered from winds.

⑧ A fireplace or heater is on an internal wall to give maximum heat to the interior.

SECTIONAL DESIGN (9.24.2)

TEMPERATE COAST
(Region 5)



8 CEILINGS AND ROOFS in traditional construction, with good insulation are acceptable, and a generous gradient to the roof, with ample guttering is appropriate.

GUTTERS NECESSARY A comment on guttering and down-pipes (or rainwater pipes) is needed here against a popular perception that they are not really needed. A survey of older buildings (or even newer) without gutters soon reveals a deterioration of the wall area below, even when a normal eaves projection is provided. The ground, where the water falls, erodes, and mud splashes onto surrounding surfaces, whether on building or plants, with unsightly results. To lay channels or stone-filled trenches to catch the water ends up more expensive than guttering.

Again, the retention of water in gutters leads to mosquito infestation, calling for the use of aerosol insect repellents and toxic sprays - all making for a deterioration of the atmosphere and ground water, and piling the waste heap high. Gutters cannot work efficiently when laid level, as distortion eventually takes place. They need to be (a) laid either with an effective gradient or (b) provided with more frequently spaced down pipes or (c) the eaves line needs to be positively or visibly sloped down to the rainwater pipes, which is a challenge to the designer, but can be made to be attractive.

ADDITIONAL AIDS As for the previous region, the conservatory is a wise investment for this region, and is also useful for drying out.

ELECTRICITY would in limited locations be available through (a) water turbines, on river courses, provided the water was immediately returned to the water course, and (b) wind generators, on the coast, and for both situations, battery storage is needed. Wind turbines of a larger scale, no matter how beautiful, can scar a very beautiful landscape, and siting is very difficult, because they function best on high, exposed locations - which are the most visible. There are differing opinions worldwide, where for example in Denmark, the national attitude supports their use, with the perception that they enhance the landscape, whereas in Britain, they are regarded as spoiling the landscape, they create noise, and are a hazard to bird life.

OUTDOOR LIVING A good proportion of days and seasons makes outdoor living most desirable, and the principles given earlier in the book need to be observed. With changeable weather, outdoor barbeque space, as well as relaxing sitting space, for summer, needs adjacent covered area in the form of roofing or wide eaves projection. Even a dimension of 1200 to 1500 is adequate to move to in an emergency, but a larger covering would be appropriate. This space is also most useful for outdoor hobby work or house maintenance jobs, when it is raining or threatening to do so.

SUB-TROPICAL COAST

On the map this is Region 8, and comprises a very humid coastal strip, with an undulating interior with a comparatively high rainfall. Note: Most of the commentary below relates to the northern part of this region, and for the southern part, allow for cooler temperatures and for stronger wind conditions along the coast.

1 USE INFORMATION from the relevant paragraph under Regional Characteristics.

2 EXTREMES comprise hot and humid weather in prolonged periods in summer, especially in the northern parts of the region. There are no very cold areas except at higher elevations in the south. For cold extremes, see commentary under other regions.

3 THE SITE The priority in choosing a site is to look for higher ground which is exposed to air movement. As a reminder, it is not logical to prefer south orientations nor to choose low-lying ground, as humidity exaggerates any presence of dampness, growth of (slippery) moss on paved areas, or other associated drawbacks. Shading and cooling vegetation is a major advantage and if not on the chosen site, should be introduced immediately, again of the indigenous variety. While some have the not-unreasonable perception that natural flowing water will increase humidity, the average individual has a greater sense of cooling with the presence of water than without. (The amount of water vapour coming from a fountain or pond is of no consequence when compared with an adjacent warm ocean.) All developed site features should aim at cooling, as the major part of the year needs cooling and not warming.

4 WALLS A popular theory holds that walls, and indeed the whole structure, should be light- weight with minimal thermal storage capacity. The idea is that at night, the structure cools quickly, and that ventilation keeps the interior cool and comfortable. This principle will be followed for this region, with an alternative argument in favour of mass structure, the reason being that both are technically viable, but attitudes in South Africa do not favour light-weight construction for a number of good reasons. There are some areas where timber frame housing is becoming popular and also competitive, but there are other areas, traditionally well-wooded (indigenously) where elitist homes are built in timber, the cost being substantially higher than brick or concrete block.

For framed walling, normally in timber, effective insulation is required and choice of external and internal cladding needs to be robust. There is a higher potential for fire hazard. Cladding in fibre cement products is popular, but greater frequency of painting as well as the application of wood preservatives is not in favour of environmental care. Comparisons of the two systems (framed or heavy mass materials) needs to be considered in regard to *embodied energy* (but is outside our present scope), together with the effects of production on the environment, and the possibilities for recycling. There are a number of alternatives in both areas but the issue, as intimated, becomes complex and too lengthy to deal with at this level.

5 WINDOWS need to have generous areas of opening sections to allow good air movement to the interior. This is because humid air restricts the process of skin cooling by perspiration, and greater movement provides relief. Even during rain, (which is plentiful, with the greater proportion falling at night), windows should be sheltered by good roof overhangs or canopies, and the opening sections designed to shed water in the event of getting wet. Tall windows (or low and high level vents) will increase the stack effect which is beneficial to the evenings. If privacy is a problem remember that the lower part of a window can be draped with net curtaining which allows air through, though slightly limited, but becomes opaque to outside viewers, at least at day time.

For the heavy mass approach, the same procedure as for the semi-arid regions should be followed. In summer there is frequently a 10-degree difference in temperatures from night to day, and if the mass is properly designed to absorb and release heat effectively, the flywheel effect can be put to good use. While windows will be closed during the day, they will need to be opened in the evenings for ample air movement, the need being greater than in the semi-arid region, and hence larger window areas. For calm times, ceiling fans provide very effective relief, are quiet and use little energy.

6 DOORS are normal, but for good air movement, the stable pattern affords good relief, and alternatively, security gates are the same, as detailed earlier on. Sidelights with ample opening sections are recommended. Draught excluders or other similar precautions are not needed.

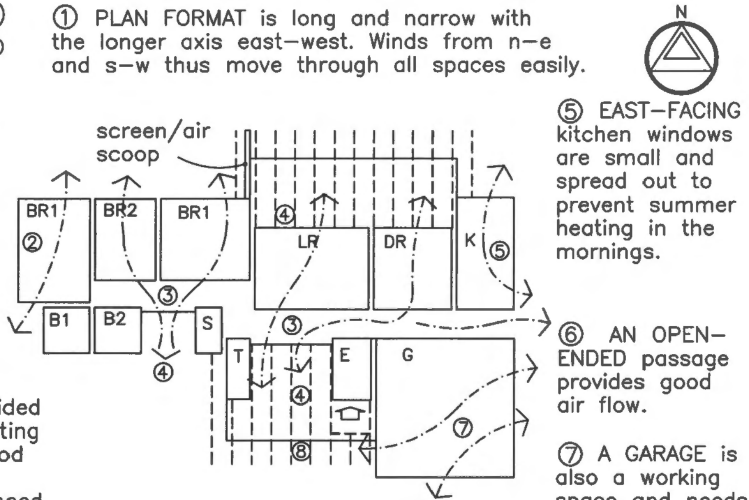
HOUSE PLANS (9.28.1)
WARM TO HOT AND HUMID
(Region 8)

① PLAN FORMAT is long and narrow with the longer axis east–west. Winds from n–e and s–w thus move through all spaces easily.

② WEST-FACING walls are light in tone or shaded to keep the interior cool.

③ CROSS VENTILATION is the crucial design factor, and planning must provide for openings in two or more walls. Opposite walls are best.

④ AIR SCOOPS are provided with recesses. The projecting garage wing makes a good scoop for s–westerly air movement. These areas need to be well planted to cool air passing through.



⑤ EAST–FACING kitchen windows are small and spread out to prevent summer heating in the mornings.

⑥ AN OPEN–ENDED passage provides good air flow.

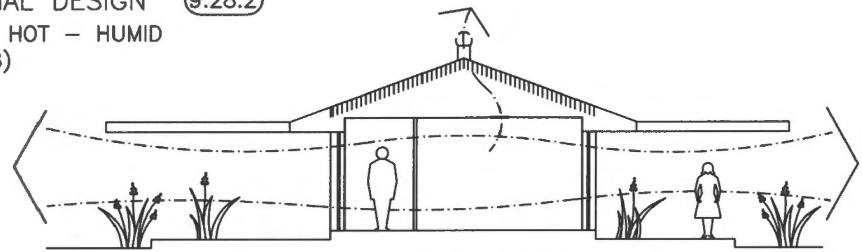
⑦ A GARAGE is also a working space and needs good ventilation.

⑧ A WELL PLANTED south patio doubles as a pleasant entrance to the building. Glazing to the south wall of the LR provides for generous openings and visually integrates out and indoor areas.

⑨ FURNITURE should be of open frame design to allow maximum air movement

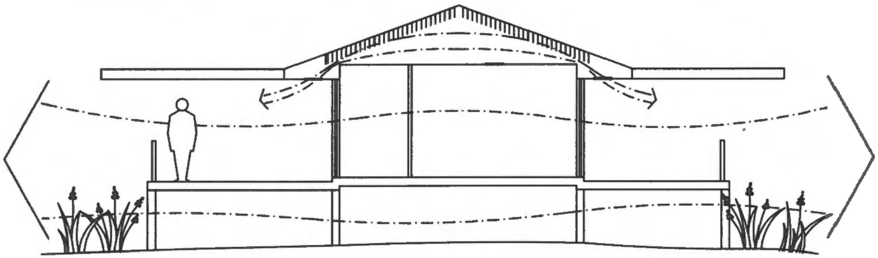
SECTIONAL DESIGN (9.28.2)

WARM TO HOT – HUMID
(Region 8)



SECTION – MASS CONSTRUCTION

1 Ample cross–ventilation 2 Windows vent at high AND low levels 3 Warm air escapes through ceiling and roof 4 Generous planting to cool incoming air 5 Generous shaded outdoor space; light–toned paving



SECTION – FRAMED CONSTRUCTION – WOOD OR STEEL AND INFILL

7 FLOORS, for the light-weight theory, should be in timber, and suspended above ground to allow quick cooling in the evenings. To lessen day time warming, as with walls, the floor needs to be insulated, but not to the same degree, as walls are exposed at times to the sun.

The mass approach works as for the semi-arid zone, but the emphasis is on cooling, and in winter, the need for thermal storage during the day is not necessary (except in the cooler south). Hence mass flooring (especially suspended) if cooled during the night will give a cool interior during the day.

8 CEILINGS AND ROOFS Traditionally, low ceilings are recommended to promote quicker air flow through rooms. As ceiling heights are regulated by law, designers have to make the regulated dimension work as well as possible. As for semi-arid conditions, upward air drainage does help, and this is afforded either in low and high level outlets (in windows or vents), or through ceiling and roof vents. A double-storey dwelling will always have a cooler lower floor than that above, and in any event, liberal insulation is necessary. The guidelines given for the semi-arid zone are applicable in full except for the need for closing ceiling vents for winter time. Roofing should be finished in a light reflective tone and eaves projections generous. There is little or no need for walls to be warmed by the sun in winter, although some sun through the windows is very acceptable, and again, assists in drying out in high humidity.

As rainfall is plentiful, mosquitoes are a problem, and gutters should receive the same treatment as for the temperate coastal area.

ADDITIONAL AIDS Wind scoops, in the form of projecting brick or timber screen walls to increase pressure at air inlets boost air flow very noticeably. An alternative is to juxtapose buildings or to shape buildings to naturally catch prevailing air flows to the same end. Neighbours' boundary walling, or even their buildings sometimes form pressure zones which may be taken advantage of. Planting adjacent to air inlets (windows and doors) will help cool the air.

As the east coast receives an earlier sun rise, accommodation warms up more noticeably at business starting times. Precautions need to be taken to reduce this effect. If daylight saving had to be introduced, it would assist considerably in air-cooling costs. The end of the day which is warmer would turn into leisure time, which is an added saving on office cooling, whether in the home or in town.

OUTDOOR LIVING More than elsewhere, relief is provided in moving outdoors, especially in the late afternoon or evening in summer, and at any time of day in winter. Exposure to breezes is a great advantage, and likewise, shade from sun, and proximity to sub-tropical growth.

TASKS

1 OBJECTIVE To look at realistic constraints for a studio project and to record systematically.

For a studio project which has a "real" or known site, draw up a fully detailed analysis of its climatic qualities in accordance with the purposes mentioned in this chapter. This will include information on prevailing conditions for the four seasons, sun angles and times, the micro-climate with potential opportunities available through adjacent buildings, walls, trees or other elements. Indicate these on a large scale site plan (or several smaller scale plans). Working through a check list of windows, doors - as in this chapter, make recommendations in brief note form of how these items would best be incorporated in a design for the building in hand.

2 OBJECTIVE To observe the temperature changes and differences at given locations in a north-south valley; to record temperature ranges in the "temperature inversion" state after a night of calm.

Find a valley which runs north-south with fairly steep slopes to both sides. With a colleague, take temperatures on the opposite slopes of the adjacent hills beginning in the morning well before the sun reaches the west-facing slope, then for the same locations, at 2-hourly intervals to late afternoon, to well after the sun goes behind the east-facing slope. Try to choose a non-windy season and a calm time, and observe carefully air movement at each location and time.

Return to the valley after sunset, and again at say 2-hourly intervals, until about 22.00 take temperatures at (a) the valley bottom, (b) the hill sides and (c) nearer the hill tops. If possible, do the same at an hour or half an hour before sunrise next morning. Record your observations, make notes of the reasons for those conditions.

10 ● SERVICES, EMBODIED ENERGY, THE CONTRACT AND CLIENT

FURTHER MEASURES

DESIGN DRAWINGS This book has covered detailed aspects of the design of building as normally handled in an architectural practice or drawing office. That is to say, the process of decision-making by the designer is put down as information on drawing paper. At this stage, detailed concepts need to have been properly processed and a good set of preliminary sketch or presentation drawings produced for discussion with the client. These drawings will have detailed sections, with sun angles, shadows, wind directions and various prevailing local, micro-climatic conditions, well illustrated to provide a basis for understanding by the client, and to reach satisfaction and even conviction about the project. (A client, when hearing the detailed reasons for the designer's decisions, will be far happier and less inclined to make alternative suggestions. The worst a designer can do is to parade as a Specialist and to tell the client to accept the plan as drawn!)

Next comes the working drawing (or production drawing) stage, and this calls for final decisions as well as a number of other "smaller" but equally important choices to be made. Along with these, specialist drawings will also be generated, and what follows will also call for well considered decisions.

HOT WATER GEYSERS An extremely wasteful practice is the remote positioning of hot water taps in relation to hot water geysers. Five decades ago, the general public was far more economy-conscious, and for a normal 3-bedroom house, a single hot water geyser was used, and all plumbing fitments placed as close as possible. There were some ingenious solutions. As affluence invaded, no one was concerned that the *single* geyser prevailed (for economic reasons), but sanitary fittings spread - in such as baths-ensuite, guest toilets, and out-buildings. Supply pipes were not lagged, and with low energy costs, it was of no concern. To run a hot water tap for some minutes was of more concern time-wise than an energy-wise. A similar attitude unfortunately continues, but attitudes are being changed by education. A simple home demonstration will reveal the situation if a measuring vessel is used to hold run-off water from hot water taps, and then estimating or observing how often those taps are used for hot water - especially in colder seasons in colder regions.

Take additional note that if, as often happens, a hand-basin or sink bowl is filled with water using the hot tap *only*, the user is normally unconcerned and unaware of energy waste. However, if geyser water at say 65 degrees Celsius was put *directly* into the basin or sink, cold water would have to be mixed to prevent scalding. This has been done unawares in the first case by cooled-down water in the hot water pipe. This volume has had to be replaced in the geyser and in turn is then heated. So there *is* waste of energy. If, as is often the case, the plug has to be left open for *further* run-off to get the right temperature, this is waste of both water *and* energy.

Hot taps then need to be as close to the geyser as possible. If there are separate sets of plumbing spaced some distance apart, separate smaller geysers are better, even if the installation costs are higher. (A spin-off benefit here is having one as stand-by in the event of failure. Further, if one is a gravity-feed type, an emergency water supply is available when the municipal supply is cut off.)

Pipes need to be properly insulated, as do the geysers - which often are not adequately protected against thermal waste. A 19mm pipe contains a litre of water for about every 3.5 metres. Water has a high specific heat and takes a good deal of energy to heat up. A simple calculation will reveal that hundreds of rands can be wasted per home per year, and nationally, that is a lot of extra burnt coal-gas put into the atmosphere. Present costs to the home are in the region of 25 cents per kilowatt hour.

A popular solution, especially where high heat wastage applies in existing buildings, is the instant water heater. This allows water to flow slowly over a heating element and then passes into a basin or sink. A question hangs over the real benefits of these units, as they are often an additional fixture, and the energy required for their manufacture and installation may well offset their superficial benefits. A complex calculation will provide the answer. Claims by sales organisations, as in all fields, need to be backed by independent scientific proof.

(Eskom's "Elektrowise" information pamphlets state that water heating accounts for 30% to 40% of the electricity consumption of a typical home. Hot water systems are often only 60% efficient, and then some 40% of geyser power is lost to the benefit of the household. 25% Of the electricity consumed by a household heating system can leak out of the geyser due to standing losses and another 15% in the hot water pipes. An extra insulation blanket is worth the investment.)

And what about keeping water cool? In South Africa water is a precious and scarce commodity. We frequently slake our thirst, rinse our hands, and replenish the refrigerator supply - all from the cold tap. Often warm water has to be run off because the pipes externally are exposed to radiant sun. These need to be kept on shaded routes, and if not, to purposely provide shade, whether as a brick nib, placed in a recess or insulated. The supply to the geyser naturally could be left exposed. Waste of water on a national or even municipal scale demands more and larger dams, which require energy for their construction.

LIGHTING Illumination of spaces needs to be systematically worked out with appropriate intensities for given tasks as well as for general background lighting. The temptation by many house owners is to select the latest designs that suit a personal taste, and functionality is given little space for thought. This topic is enough to fill another book and the student should make a personal study from available literature as well as visiting suppliers' displays, making a point of conversing with knowledgeable people as to the basic principles - making clear that the enquiry is educational only. This way less sales pressure is applied, and more scientific information is given.

The lamp. Briefly, and working from first principles, a naked lamp gives a very good light. But it is hard on the eye when seen directly, creates glare, and very strong shadows, and is rather rudimentary for a furnished interior of any kind.

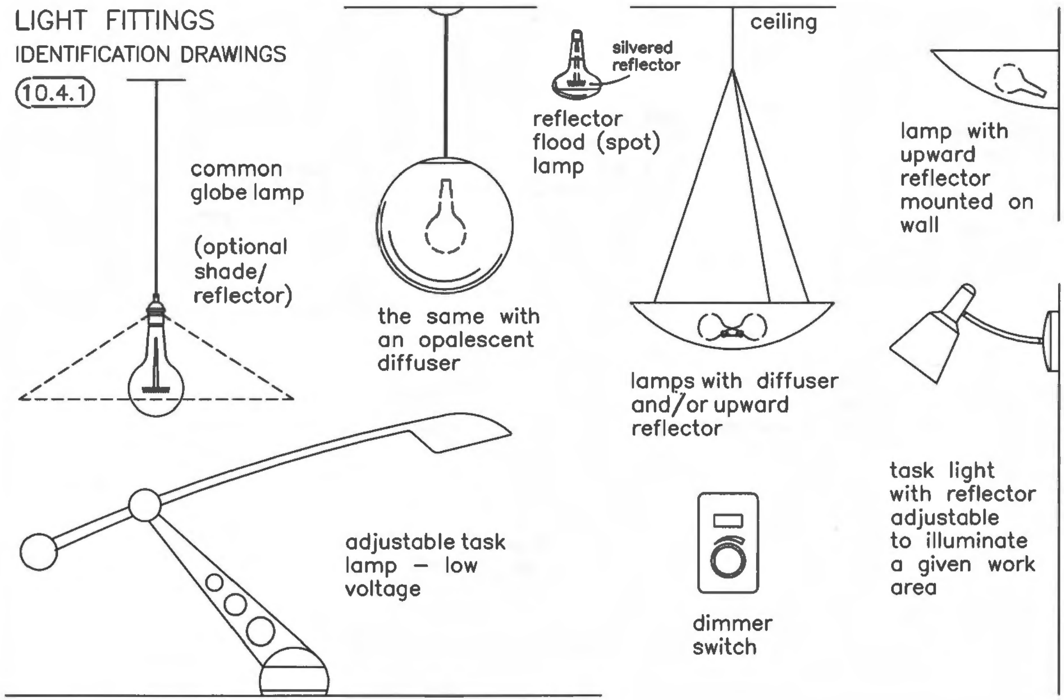
Diffuser. A solution is to cover the lamp with a diffuser, softening these negative effects. Diffusers are of various shapes, and usually of opalescent glass. Light intensity is less than that of a naked lamp.

Partial diffuser or bowl. Alternatively, the diffuser may screen the lower part of the lamp so that occupants of the space do not directly see the lamp (or lamps), but they shine without obstruction upward to the ceiling, where the light is then reflected for general dispersion. A variation on this design is to have an opaque lower shade in the form of a wide bowl, and the lamps have all their output reflected onto the ceiling giving a very pleasant dissemination of soft light with virtually no shadow or glare.

LIGHT FITTINGS

IDENTIFICATION DRAWINGS

(10.4.1)



For strong enough task lighting (reading, sewing, drawing) this demands a good deal of wattage and is wasteful. All these fittings are supported in various ways, from suspension from the ceiling to wall brackets, to free-standing fittings. Ceiling fittings may be adjustable in height by means of springs or pulleys and counter weights.

Task lighting. Fittings are also designed as task lighters, where a lamp is within a reflector which directs the light in a specific direction and to a specific area. The fitting may be fully adjustable on sprung or counter-balanced arms, on a swivel base suitable for a desk or drawing board, sewing machine or hobby table. Lesser adjustable fittings come as wall brackets fixed in one position. Reflector task lights are very economical for energy output as they can be positioned in close proximity to the task area. They are also used, as fixtures, but adjustable, for lighting pictures or ornaments. Finally, they may be recessed into a false ceiling as down-lighters, also adjustable but within limits, and this type of fitting is more suited to commercial or public spaces where once adjusted for a particular need, are left permanently in that position. They are popular because a neat ceiling surface is achieved. They are generally unsuited to domestic areas.

Tube lighting. For zones such as garages, kitchens, studies or hobby work areas, straight fluorescent or other tubes are appropriate. They are not popular for sleeping or living areas as the resulting furnishing colours tend to be harsh. Again they come either with naked tubes or with diffusers or louvres as the particular need applies. Light output is very good for energy consumption.

Small fluorescent. The small diameter, shaped tube lamp which plugs into a standard lamp socket offers the same economy, has softer colouring and is more suited to domestic interiors.

Low voltage. Then there are the low-voltage fittings which have a 12 volt supply, and can thus have bare electrical leads, which are not harmful to humans, but are open to mischief should anyone deliberately create a short-circuit. These come as very small halogen or other types of lamp bulbs, have dichroic reflectors which bend the light outward and the heat rearward, so a white, cool light is seen, and is most effective in illuminating specific objects or work areas. They are so small as to be unobtrusive, but are limited in output and need to be very carefully placed and chosen. They are low energy-users. They need good rear ventilation because of heat, and need space for transformers, which need careful placing not to be obtrusive. A single transformer may serve one or several lights.

Exterior lighting. Exterior lighting comes commonly in lamps or tubes housed in water-proof bulkhead fittings, and with metal covers, are reasonably vandal-proof. They may be mounted on a vertical surface or the soffit of a slab or ceiling.

There are numerous variations on the above range, and again it is stressed that for economy in energy, problems and solutions need to be carefully matched. Dimmer-switches not only provide desired illumination levels but are good energy savers. A further device which is being more widely used is the automatic timer which may be set, for example for exterior lighting (an important security factor), creating savings, especially in summer when natural light appears as early as 05.00 on the eastern part of the sub-continent.

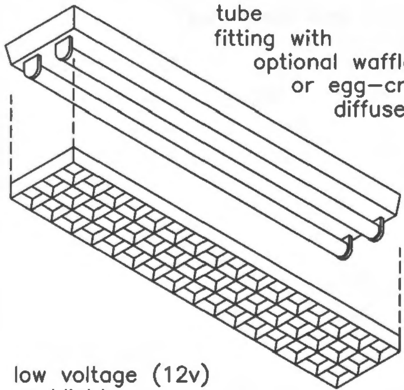
Clients should be persuaded to employ task-lighting, which means providing adequate light just where it is needed. This is the alternative to lighting up the entire space to task level, which needs a much lower general illumination. For task fittings, smaller light bulbs may be used, as well as low-voltage halogen lamps, and being at hand, they are more easily switched off when not in use.

CEILING FANS are highly suited to typical domestic spaces. The effectiveness of fans of any kind are not to create a strong wind to cool, but a gentle movement of air, which varies in intensity and direction, and caused evaporation of sweat from the skin. Ceiling fans provide a wide zone of air movement, are very quiet and have a long life. Most makes have a 3 to 5-speed control, and some have their axis of rotation on an angle which itself rotates (or gyrates), spreading moving air over a wider area. For spaces with high ceilings, these fans tend to bring the warmer air down to the zone of occupation, and lose their benefit as a result. They thus need to be suspended down at an effective level. For large areas, a suitable number of fans must be used, and each are typically effective over a circle of 4 to 5 metres diameter, depending upon the size and positions of fan.

DESK FANS Desk or standard oscillating fans work well for specific and limited areas of activity, and have the advantage of being adjustable in speed, in vertical angle and may be set for a fixed direction. The conventional oscillating type is better than the "box" design with rotating angled louvres, which although having some advantages, tend to be more noisy, less effective, and with the extra rotating mechanism, tend to rattle or vibrate. Any fan with a fine mesh shield, while safer against accidental injury, generates more noise and lessens efficiency. The radiating wire cage type is the better choice unless in areas where small children are in close proximity. As for task lighting, fans closer by may be set at lower speeds, saving energy.

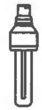
LIGHT FITTINGS (10.7.1)

IDENTIFICATION DRAWINGS

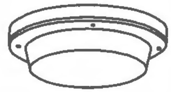


tube fitting with optional waffle or egg–crate diffuser

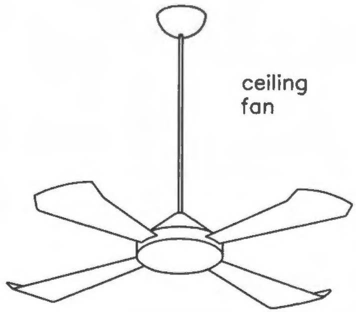
low voltage (12v) spot light may be exposed or recessed; the dichroic reflector directs light forward and heat rearward; the front diameter is only about 60mm



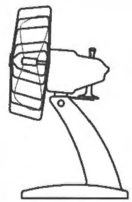
compact lamp with bayonet or screw cap



bulkhead or waterproof fitting for exterior use



ceiling fan



desk fan

AIR-CONDITIONING Air-conditioning units should only be used as a last resort, in such as home office areas and in very hot or humid regions. They all comprise a fan and a cooling unit (as in a refrigerator). The fan simply drives air to the interior (at a pre-set speed) and the cooling unit cools the air, and consequently gives off the heat absorbed from the air. This is blown to the outside. They range from the portable type on wheels, to the window unit, to the console unit and then the split unit. *Window units* are more noisy and the least expensive of the fitted type. *Console units*, normally fitted below window sills, are quieter but the compressor is still one within the unit, and hence does make a noise. The *split system* has the cooling unit fitted remotely outside the building and has a feed and return pipe for the coolant to the fan unit, which is within the space to be cooled. The fan (or air handler) may be fitted at ceiling cornice level, at mid-wall level or concealed above a ceiling. These are the least noisy and are more costly. All fitted units are neatly designed and temperature as well as fan speed can be controlled - with remote control (as for TV) if desired. All units need a power point, and a nearby drain for condensed water to drain away. (Cooled air gives up its moisture for reasons given earlier.) There are many variations on the above, and these apply to smaller building use only. Large buildings have centralised systems.

EVAPORATIVE COOLERS For regions which have lower relative humidity readings, the evaporative cooler is both less costly to buy as well as less costly to run. The principle is to have a water spray or frame with dripping water, where water droplets are exposed to air, driven by a fan, thus cooling the air. This is not as effective as the air-conditioner, but is more enviro-friendly. It is not suitable for use in zones where high humidity is a problem, because firstly the system does not cool the air to the same degree (less evaporative effect), and secondly it adds more water vapour to the air, giving a higher relative humidity.

SPACE HEATERS Space-heating devices come in many forms, the simplest being the *cylindrical bar reflector* with metal element wound around, with reflector behind, often referred to as the infra-red radiator. This heats a given object - usually a person, or perhaps clothes for drying. Then an *air-heater* comprises a heating element with a fan, which blows warm air into the space or onto a given target. The fan speed and the element heat are controllable. Many shapes and sizes are available. A similar principle applies to a *convector heater*, which has no fan, but usually comprises a fixture on a wall, with element enclosed and rising air ducted over the heater warms the space concerned. A popular heater is the *fibre-cement (or resin) panel*, which has a concealed heating element within a panel, and with a low warmth, but a large surface area, warms the space efficiently, and is no hazard to children or pets. It may be free-standing or fixed. *Oil heaters*, with vertical vanes, are also popular, but more expensive. These are also electrically heated. Finally, *central heating* may be used, and comprises either electrical heating elements cast into the floor slab, or pre-heated water or liquid, passing through pipes in the floor slab. These are for regions with prolonged cold spells. For the liquid type, heating may be electrical, gas or oil. The long time taken for heating makes them suitable for limited applications, but where needed, provide a very comfortable interior, and are energy-economic, provided the whole interior needs to be heated. All the above come in many variations, and proper fact-finding is needed for particular applications.

The designer also needs to know the latest technology in comparative costs of fitted or free-standing equipment, automatic geyser economy-switching devices, solar water heating, as well as any new technologies on the threshold of introduction.

While many of the above items do not normally form part of the building contract, fixed units do, and decisions need to be made early on to accommodate the necessary services. For those units not comprising part of the contract, the designer should pass on information to the client and encourage the use of the most economical and suitable systems, whether for heating or cooling.

Some of the above items will be incorporated on specialists' drawings, and the architect or designer needs to oversee the thinking given by the specialist concerned, and should indeed be chosen in the first place for expertise related to environmental issues.

PUTTING AUTHORITY TO BENEFICIAL USE The architect or designer, with the client, is the initiator of the building process, and with that authority, conditions relating to all participants in the contract are stipulated. An example is that the contractor will sign, as part of the agreement, that the entire works are to be kept tidy, safe and clean (and so on) and this is simply for the sake of efficiency, for appearance and the good of all concerned. It is a human "comfort" or safety requirement. It follows therefore that for environmental issues, the *designing office* must take the initiative in introducing specific controls to make a better world for all to live in. It calls for those responsible to look at every aspect of their contracts, from concept to completion, and include wherever reasonably possible, any changes necessary to improvement. While this in itself could occupy voluminous works of writing, the fundamental principles are covered below for introductory knowledge, for reflection, for perhaps modification or expansion.

DEVELOPING AN ENVIRO-SENSITIVE CULTURE As a reminder, change in attitudes and in business routines often take place in the following stages: 1 Concepts appear in print - to draw the public eye, with warnings, to the importance of the subject. 2 Specific guidelines and recommendations appear by specific bodies, whether by local authorities or through advertising by concerned commercial groups. 3 Associations of people form to promote adoption of the new ideas -

and arrange meetings, fairs, marches and sit-ins if needed. 4 Concerned politicians take on responsibility and with the above backing, campaign or introduce the processes needed to promulgate law. This is for the sake of improving the environment whether within the field of this book or elsewhere in other industries. Less costly than legislation and the resultant policing, is to create incentives, whether in tax benefits or rewards of other kinds. The least costly would be for everyone to do what is right, without law, i.e. within the architectural, building, and related professions, and it behoves the individual to initiate wherever possible, such improvements. An immediate reactive thought is that only *one* person, or practice, will make little difference, so why do anything? However, a mass endeavour *will* make a difference - between a good or a bad environment. It has taken *single individuals* to produce regions in South Africa with the worst atmospheric pollution in the world - in generating electricity from coal.

EMBODIED ENERGY While the subject of Embodied Energy will be covered in a more advanced work, it is worth thinking about the basic processes by which we receive all building products which are so readily specified from glossy literature. This important topic has become the subject of major publications in many developed countries, and is being adopted by architects, engineers, town planners and other related disciplines.

For every building component installed there is a "cradle-to-grave" history which in very brief terms is: 1 raw material is extracted; 2 it is processed into workable material for industry; 3 it is made into components, and assembled into products; 4 these are installed and remain in position as long as they last, or are needed; 5 they are removed (by demolition) and dumped or sold; 6 at every step listed here, add *transport*, an important part of the picture. In addition, add *storage*, where materials are housed in buildings, which need cleaning, heating and cooling and other services.

Detailed studies have been made to assess the energy taken to bring materials and components to their final position on site - called Embodied Energy - and included in the equation (in cost to the builder - and hence energy) is whether materials are installed at ground floor level or at say 25 storeys up. A material which has to be transported from the other side of the world, even if less costly, will demand much more energy in transport than from a local source. In fact, it should not be cheaper in a free-enterprise world, and hence world authorities need to standardise labour laws and other practices to address this particular problem.

Likewise, studies reveal the damaging effects or otherwise of given industries as related to given products, and there are varying degrees of damage to the environment. If a suitable alternative product which is less damaging can be found it should be used. This will in turn make the offending industries look at their processes to improve them. Some manufacturers will promote a pro-environmental stance and sponsor large financial support in this field while being guilty of damage themselves. Just one example among many is the merits of aluminium, which is so easily recyclable, and is such an attractive material - saving on transport because of its light weight, and needing no painting, a further environmental advantage. However the designer who consequently falls in love with the material and uses it everywhere also needs to know that the actual process of making aluminium itself has a voracious consumption of electricity. New processing techniques are being introduced. The designer also needs to know something about the good or bad aspects of mining bauxite, transport costs of raw materials and so on. This is not to say that aluminium is a product to be avoided, but the negative aspects of *any* product are never revealed in advertising. Perhaps legislation will eventually be promulgated as has been done for the hazards of smoking.

REUSE, REMODEL OR DUMP? Of direct interest here, from the cradle-to-grave list above, is the final stage, and that is what happens to materials or products that reach the end of their lives. In the past, commerce has laid hands on items that are recoverable and saleable for profit. The environment was not an issue. Now that the public is universally developing a consciousness about these matters, prices of used components and materials should increase, which will help. Incentives in reducing value-added-tax (or other) would also help. However, students should be aware that dumping is detrimental to the environment, that recycling drastically reduces the industrial process, and also fosters an interest in our historical heritage.

Materials or products, when due to be removed from their initial place of use, may: 1 be directly re-used (such as ironmongery, brass foundry, glass, roof tiles); 2 be remodelled or renovated and re-used (timber trim or boarding, panelling materials, fitted furniture, bricks); 3 be reconstituted after melt-down or other (steel, aluminium, timber to particle board, rubble as aggregate); 4 be dumped.

MAKING WISE MATERIAL CHOICES It behoves the designer therefore to choose materials that are easily recyclable and to best environmental advantage. At this level, try to research those materials that are obviously damaging to the environment by reading, even in encyclopaedias under such headings as Sick Building Syndrome, industrial health regulations and others. In the future, one will be able to order materials according to a code which will give the "values" of each as a factor of its environmental effects. This is something like ordering health foods from appropriate shops, and where all products have a specification of contents, with perhaps suggestions, for building materials, how they may be used in an "after life".

In later studies it will be seen that for large new-building contracts in Europe and elsewhere, building owners, before projects are officially approved, have to submit policy proposals related to materials and building methods as related to the environment, as well as for the eventual demolition of the building. Similarly, in Britain, studies have been done on demolition projects where strict supervision by architects have ensured that maximum measures have been taken for the benefit of the environment. Reusable components and materials have been listed and audited in their proper eventual use. Removed materials are *checked* to have gone to their specified destinations or uses. The actual process of demolition is planned beforehand to reduce dust generation and noise pollution, as well as minimising energy use.

EXISTING BUILDINGS A major contribution to this process (recycling) is simply the adaptation of existing buildings for reuse. In past decades it was normal practice to demolish the old and build new. The saving in using existing "stock" is enormous, and at this level of study, the student should, as a project, list all elements of say an old house or office, eyeing every single item, and suggesting ways of re-use. Even old floor boards which are thin from repeated sanding will look beautiful when removed and remodelled for wall or ceiling panelling. Elements such as windows, doors or electric light fittings are easily adapted even if needing modification. The object here is not to use just the specially valuable items (whether sentimental or marketable) but the common ones too. This is an interesting design challenge in its own field.

REWRITING CONTRACTUAL DOCUMENTS It will be needful to look at every aspect of contract documents, comprising, in addition to drawings, the contract agreement, the bill of quantities and the specification.

A contract agreement needs to be worded so that environmental issues are included in clear terms, with, if deemed necessary, hints at universal trends and benefits which will induce co-operation.

These will insist on matters covered in the specification or bill of quantities (or both) which in turn will detail general issues of environmental pollution as well as those specific to the building process. The former require proper maintenance of machinery to avoid exhaust pollution, draining engine oil, and dumping rubble or other waste products, onto vacant land. A system of records, inspection and accountability is needed here. Workmen need to be properly protected against dangerous fumes, harmful dust and excessive noise - which are covered by industrial law - but since the client or designer or architect is the most frequent site visitor, supervision should be taken into their hands, and possibly as a last resort, to report to the relevant authorities. Lesser issues mean proper control against wastage in such as water, leaving machinery running during breaks, using machinery efficiently, wasting electricity, and employing reusable systems such as form-work. Contractors have, due to the behaviour of a proportion of their number, developed a reputation for dumping materials on adjacent vacant sites. Within the building industry, there is a significant move towards environmental awareness (in other countries) and it is now gradually taking root in South Africa. This awareness needs to be cultivated within design offices and passed along to such as use their technology. Wider influence is possible in voicing the message at committee meetings, at professional institution functions, on municipal committees, and by issuing policy flyers to any associated groups. Education should be promoted within offices through recommended reading, passing on latest periodical articles and attending lectures by visiting specialists or inviting them to the office.

An example of the general attitude is seen in many vehicle owners, (from all professions) who are little concerned about driving unnecessarily long distances to cover their duties. Their vehicles are sponsored by their employers, are tax-deductible, and are a joy to ride, (check the TV advertisements), so exhaust pollution escalates and our atmosphere becomes more and more filled with gases which cause warming from the greenhouse effect.

GIVING THE MESSAGE TO THE CLIENT As the client is the ultimate user of the building that has passed through the above processes, it is wise to provide the relevant educative knowledge as to *how* the building has been designed, and *how* to utilise the principles incorporated. Where knowledge is needed in such as high level openings, ceiling vents, the appropriate choice and placing of planting in vegetation, or seasonal expectations and adjustments, it is worth issuing written guidelines as a User Manual for the occupants to read. This would include tips issued by such as Eskom on the economical usage of electricity (as outlined earlier), guidelines issued by local authorities on water usage, on landscape development, on waste management, and giving sources of information on latest technology on the environment. In certain parts of the world, house owners may feed electrical power back into the supply grid, which reduces their month-end account. This may be from wind or solar power, or other techniques.

Too many house owners live by the moment, and pay little attention to the technology and effort invested by the designer of their dwelling and life time investment. It is a simple matter to pass the information on instead of having it sit on the office shelves!

TASKS

1 OBJECTIVE To appreciate, and try to quantify heat wastage in a hot water system.

For the building where you reside (or another suitable of your choice), measure the distance between the hot water geyser and all the taps it supplies. Calculate the volume of water that has to be run off for each outlet before hot water is delivered - or, far easier, measure it in a measuring jug. Write down how the number of times the outlets are used each day. Consider the waste of water and energy (or calculate energy cost at about 25c per kilowatt hour). Also record if piping is insulated or not. List methods of how the designer could originally have cut down on this wastage.

2 OBJECTIVE To observe unnecessary water wastage; how to rectify.

Find cold water supply pipes exposed to sun and feel the heat (or take the temperature) of the water supply at the tap after being exposed for at least half an hour. Wrap or shield the piping in aluminium foil, leave exposed again, and test and record temperature.

3 OBJECTIVE To think expansively about wastage on building sites.

Visit a building site, preferably of a cluster group of housing or larger, and spend time observing *all* ways in which the contractor could reduce energy consumption, reduce waste from breakages, and use any techniques to assist in the environmental cause, whether locally or wider afield and in the longer term.

4 OBJECTIVE To invent new ways of conserving materials in old buildings.

Find an old residential building which is suitable for conversion to a small office. List all main building materials and components (whether visible or hidden) that may be reused in some way or other to (a) reduce waste, (b) reduce environmental deterioration (locally), and (c) save energy through minimising industrialisation. Tabulate your findings and state whether each item is directly reusable, whether it needs considerable refurbishing for reuse, or whether it may be sold for melt-down or reconstitution for manufacturing other components, or needs to be dumped. Suggest ways in which materials, for example, may be removed and used again on site after reconditioning. Your exercise may be confined to the interior only, or include the exterior as well.

5 OBJECTIVE To think about comparative energy uses in traditional, rudimentary structures and a tent.

Think about the construction of a mud-walled shelter with thatch roof and fruit-pip floor. What type of energy is required for its production - including gathering, transport and preparation of materials? What of the eventual disposal or reuse of materials? Do these processes have a negative impact on the environment?

Follow the same processes of thinking and answer the same questions for a three-person fabric camping tent - even if it *does* serve a different purpose.

6 OBJECTIVE To learn to pass knowledge on to where it will continue to be effective.

For a design project set for studio work for say a small residence, as you work, jot down the climatic and energy-saving innovations that you incorporate. Imagine that you have to pass these on to the eventual occupant or owner so that the accommodation is efficiently used. Draw up an instruction pamphlet, with diagrams if needed, which would be handed over before moving in. This would include recommendations on his or her responsibilities in such as fitting suitable curtains, choosing heating and/or cooling devices, and further development of the site.

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