materials & technical studies

“Architecture is the masterly, correct and magnificent play of masses brought together in light. Our eyes are made to see forms in light; light and shade reveals these forms…”

Le Corbusier: Towards a New Architecture – 1927.

light as a material of architecture

"Qualities of light have profound responses within us: they are the wellsprings of feeling… with light as the palette, architecture can be supreme in the arts. It is a source of expression that we tend to ignore and the one aspect of architecture that we cannot divorce from meaning in our determined nihilism as long as night and day and the sun and moon work their pattern upon us. It is with light that we can bring soul and spirit back into architecture and perhaps find our own souls in the process."

(Erickson, Arthur.1975: 33)

Light is fundamental to our existence and to our perception of the world. Light is a life-giving force fuelling processes such as photosynthesis that allows flora and fauna to survive and thrive. It reveals our environment to us; it warms us; it affects our moods and senses of well-being Light is the medium by which we directly experience our surroundings, without light it would be impossible to comprehend and appreciate color, depth, space and volume

The history of architecture is a story of the way light enters into buildings and reveals the spatial composition and the forms within. Sunlight and moonlight, artificial light and fire or candlelight has a great effect on our perception of space and surfaces. The materials of light; brightness, shadow, color whiteness, are also materials of architecture through which we can appreciate the nature of space, colors, textures and objects. Textures and objects are felt just as much through the eyes as through the skin. We experience light mainly because we work in it. We are very acutely aware of light when there is not enough of it, or too much, to be able to comfortably do what we want to

Incorporate high efficiency fixtures, lamps and controls. Strive to reduce watts-per-square-foot design targets and actual connected loads.

Enable occupant control of individual workstations or small work areas with task-ambient lighting systems, as opposed to large, uniformly lit interior areas.

Include lighting systems in regular maintenance procedures to ensure optimum light output and energy efficiency.

Begin with an effective day lighting scheme that optimizes the use of natural light.

Design controls to balance available daylight with the secondary need for electric light.

Create environments that are visually interesting or stimulating by integrating overall illumination, ambient and task lighting.

Design lighting to serve the needs of building occupants. Uniform lighting seldom serves well as both ambient and task lighting

It is exactly this kind of metamorphic thinking about light that can make buildings the places that have special meaning for us, extending their value beyond functional use.

Interior of Villa Mairea.

The screens of poles that enclose the stairwell echoes the forms of the tall straight trunk of trees outside. They break up and filter the daylight and evoke the light quality of the Finnish woods inside the house.

(Millet, M. 1996: 9)

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The pines outside the Villa Mairea. (Alvar Aalto Architect, 1937-39) in Noormarkku, Finland.

(Millet, M. 1996: 9)

Creating a certain setting in a particular place either inside or outside starts by fitting it gracefully to its location and providing comfort to the people, who inhabit the space. These intentions all fit under the same umbrella of experience: our experience of the world, and our culture and sensory associations. Our experience of light is connected to specific places where light contributes to the identification of genius loci: the peculiar character of a place as it is impressed upon our minds. By responding to the sensitivity of light one can also convey the spirit of a place.

Forests provide a complete pallet of colors and textures in light and each one is particular to its own part of the world.

"Our eyes are constructed to enable us to see form in Light"

(Le Corbusier.1974: 8)

Climate is also a very important aspect in the element of genius loci. The use of light in a building affects our feelings of comfort in relation to the thermal variables in each climatic zone. Light is connected to time in our experience and can express or stifle the expression of changing time in buildings. Light does not only provide us with illumination for visual activities, it also enriches our experiences.

There are also thermal realities associated with the introduction of light into a building that cannot be avoided.

- The introduction of heat along with direct sunlight
- Heat loss through glazing when the temperature outside is lower than the temperature inside
- The addition of heat to the interiors when electric lighting fixtures are operating.

Any building that wants to provide both comfort and delight must respond to there realities.

The connection with light and heat is evident in small rooms with large windows that are facing south. The occupants are unable to escape neither the dazzling light nor the high temperatures produced by the trapped heat from sunlight.

The definition of enclosure is the definition of architectural space in which light plays a major role. Our sense of space is dependant on the way light reveals an enclosed space to us. A white room with a mirror on one wall appears open and spacious when flooded with daylight; and mysterious at night with one candle burning, the corners and the edges of the room obscured, the image of the candle reflected in the glass, which appears to cover endless black space.

"When we manipulate light we are able to manipulate our perception of architectural space. Space, as we experience it in architectural settings, is the result of our entire perceptual system: "One sees the environment not with the eyes but with the eyes-in-the-head-on-the-body-resting-on-the-ground."
(Gibson, James. J. 1986: 205)

As we walk through a room our visual perceptual system tells us both about the invariant structure of the environment and also about our movement in relation to it. The light is structured according to its source and also by the surfaces of the environment, resulting in the illumination of the rooms' surfaces informing us about the room.

The definition of architectural space in light has many aspects. It is especially evident at exterior walls, where the inside and the outside meet, here light can be used to emphasize connection or separation between the two. Internally the way that light interacts with light can be unify of differentiate the space. Light is also capable of connecting interior spaces or separating them. Light is also a very powerful device in providing orientation in a building by providing focus or developing a hierarchy or suggesting movement.

Light contributes to the definition of space. The only clue that we have of the vastness of outer space is the perpetual presence of the stars in the galaxies. There may be much more beyond than which we can see, but we can only know what we can perceive. Starlight defines the extent of our perceptible habitat. In the same way in the desert, in the wood, in the countryside, in cities, and in buildings, light defines the space we inhabit.

"If architecture is the art in science of conceiving form, the architectural lighting is the art in science for revealing the from in light. Light directly influences on how we design interior and exterior realms. It influences the form of the spaces and the materials from which they are composed." Spiers and Major Buildings and landscape are not only to be enjoyed during the day but must also function after darkness therefore they should not only provide light but must also be seen in light.

"Space remains in oblivion without light. Light's shadow and shade, its different sources, its opacity, transparency, translucency, and conditions of reflection and refraction intertwine to define or redefine space. Light subjects space to uncertainty, forming a kind of tentative bridge through fields of experience." (Holl, Steven. 1989: 11)

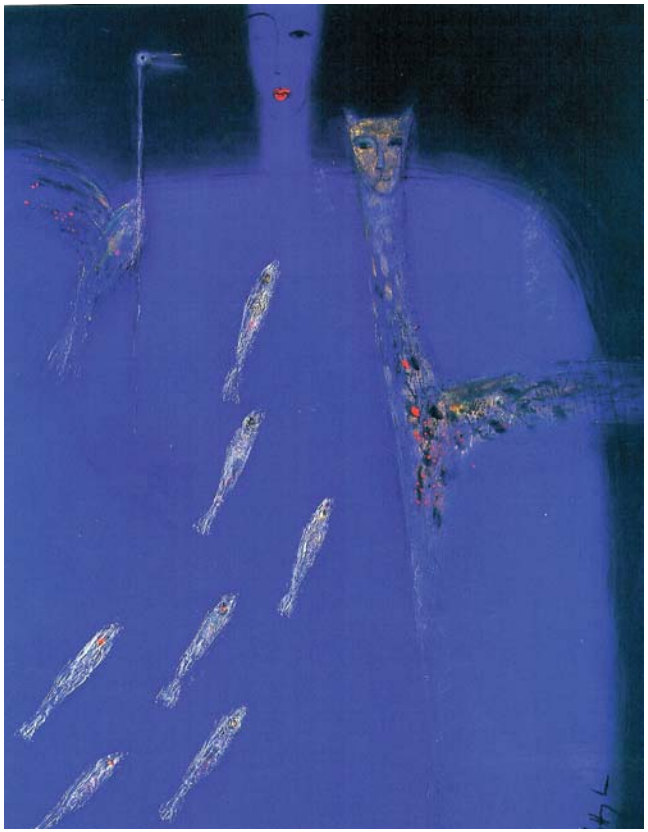
The effects of light and colour

The source of light is the sun. In plants the energy from natural daylight is captured by chlorophyll (the green pigment that gives most plants their colour) and is used to make up complex organic molecules within the plants cells. This process is commonly known as photosynthesis and emphasises the close links between light and life, since directly or indirectly it feeds us all. Without light plants turn yellow or whitish in colour and usually have underdeveloped leaves as a result of chlorophyll deficiency. In 1095 C. Flammarion discovered that red light offered the best effects for growth in plants. He noted that plants under red and orange light seemed to become taller plant with thinner leaves than those exposed to blue light, which causes them to grow relatively weak and underdeveloped in comparison. Just as insufficient light causes deficiencies in plants and humans, so too the over-exposure of intense light upon plants can cause adverse affects. The long wavelengths of the infrared and the short wavelengths of the ultraviolet have both been found to be detrimental to, and will eventually destroy, plant life. Yet these same rays have been accepted to be of therapeutical value to human beings.

One thing is for certain human bodies respond to light. Infrared light produces heat within the body, which is used for the treatment of neuralgia. Ultraviolet light also helps to keep the skin healthy and is recognised for the vital production of vitamin D in the body, and the destruction of germs. Too much exposure to ultraviolet light causes malignant skin tumours at worst and to a lesser degree encourages wrinkles and tends to quicken the aging process. Light and colour therefore seem to have 'nutritional' value providing us with vital elements to sustain and nourish our bodies, and they have the potential to effect subtle chemical changes within our bodies to help the healing processes of certain diseases.

Ordinary fluorescent lighting comes in basically two types: warm (red) biased and cool (blue) biased. The warm type give out a yellowish light, and the cool types a blue\white light. In recent years fluorescent lighting has been linked to various health disorders, especially where people are exposed to it over along period of time. Apart from the incorrect colour balance flickering effect, the sheer volume of artificial light to which it exposes us can promote stress, headaches, tiredness, irritability, an inability to concentrate and nausea. Their inventors never intended them to be used on the scale they are today. In fact he judged then unsafe for use over long periods. They spread largely because of the need for cheap electricity during the last world war. The ordinary house hold bulb has been improved to that of a daylight bulb, which is suppose to simulate natural light in artificial form. It consists of natural blue-coloured glass filters with excess red light to improve alertness and concentration, reduce eyestrain and to aid against stress, headaches and depression. People experience this type of lighting as being softer and more restful on the eyes. It also seems to have a great benefit to plants as well as humans.

Using coloured light is one of the most powerful ways of using colour as it works on the whole body through the entire nervous system. Robert Gerard, an American scientist, undertook one major research project in to effects of colour and light on humans. In 1932 he experimented on prisoners using coloured lights. First he exposed them to red light and found they became restless, agitated and even aggressive in behaviour. Red, he documented in his report, created feelings of anxiety and tended to stimulate the heartbeat and respiration rate as well as muscular activity. The prisoners generally experienced an increase in physiological activity and mental activity. Blue light on the other hand created calming and tranquillising effect. Blue had the reverse effects to those of red, creating feelings of sedation and relaxation. Physiologically the blood pressure was decreased, and respiratory and muscular activity were reduced compared with using red



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How coloured light effects our bodies

Red is the most physical of all colours and has the slowest vibratory rate and longest wavelength. It is the colour of blood and has stimulating action on our heart and circulation; red light will raise the blood pressure. Our body system is fortified by red, which helps build up the red blood cells. It also stimulates the adrenal glands, helping us become stronger and building up our stamina. Pink, which is a mixture of red and white, is gentler in its stimulation than red and helps muscles relax.

Orange stimulates the sexual organs and has a strong effect on the digestive system. It also strengthens the immune system, including the spleen, and the lungs and pancreas. It has a releasing action on the body fluids.

Yellow wavelengths of light stimulate the brain, making you alert, clear-headed and decisive. Yellow also strengthens the nervous system generally. It creates energy in the muscles by activating motor nerve. It also activates the lymph system and cleanses the digestive tract. It has a sympathetic resonance with the pancreas, the liver and the gall bladder.

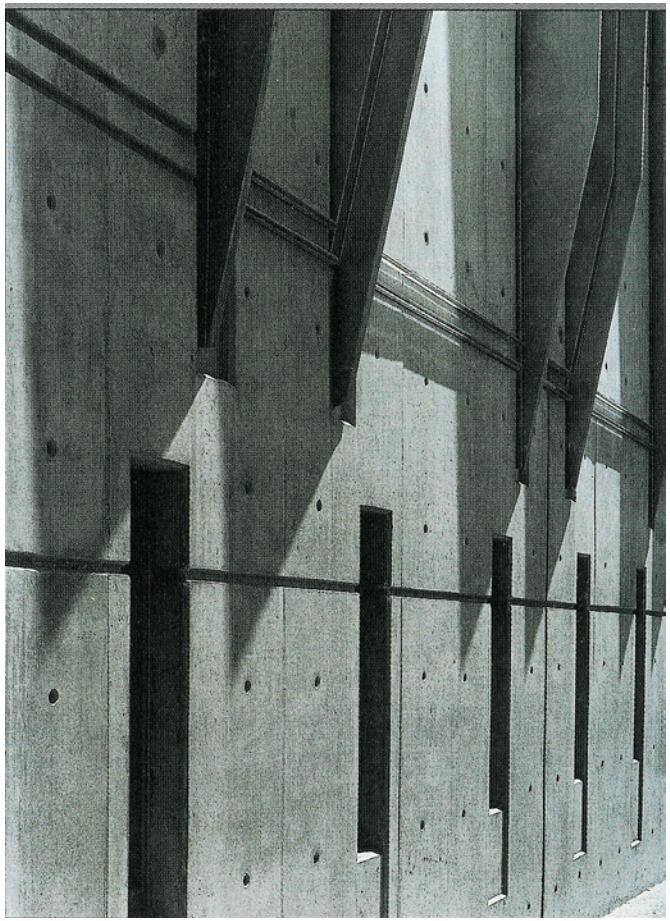
Green is good for the heart on a physical and emotional level. It brings physical equilibrium and relaxation. It has a balancing quality and help regulate our circulation. It also stimulates the pituitary gland. It works through the sympathetic nervous system, relaxing the muscles in our chest to help us breath more deeply and slowly.

Blue is linked to the throat and the thyroid gland and is very soothing, cooling and calming. Blue light has been shown to lower blood pressure by calming the autonomic nervous system. It has a constricting action and is ant-inflammatory. Deep blue stimulates the pituitary gland, which regulates our sleep patterns. Dark blue has wonderful pain-healing properties. It also works on our skeleton, keeping the bone marrow healthy.

Turquoise has a sympathetic resonance with the thymus gland; this gland performs a major role in warding off infections. If you suffer from frayed nerves and a weakened immune system, turquoise acts like a refreshing tonic. It also stimulates the thyroid gland and lungs.

Indigo has been found to have narcotic qualities, and some doctors in Texas have used indigo light to induse anaesthesia for minor operations.

Violet affects the brain and nervous system and has a purification and antiseptic effect. It cools the system and alleviates “hot” conditions such as heat rash and sunburn. Violet also suppresses hunger and balances the body’s metabolism



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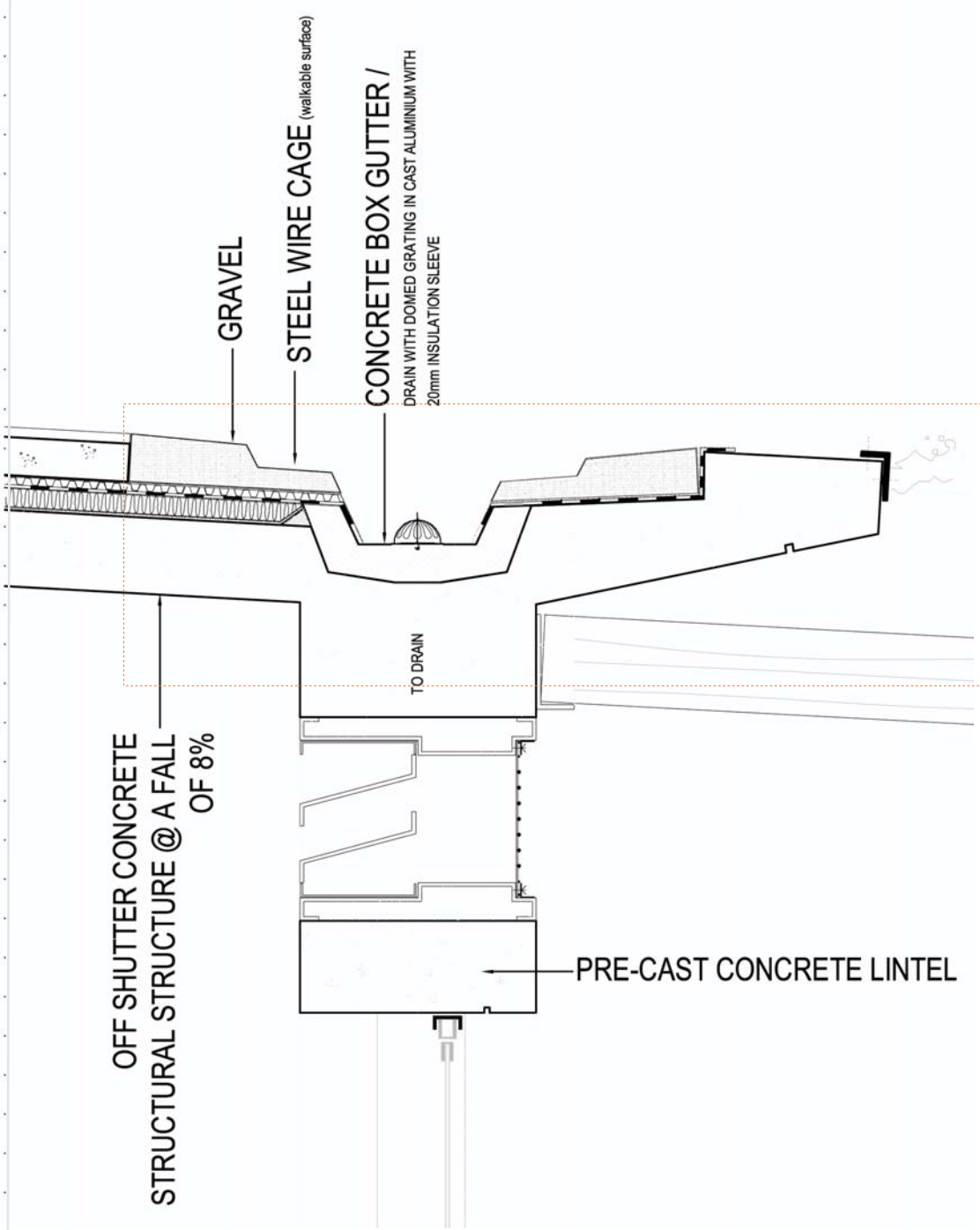
Concrete is basically a mixture of two components: aggregates and paste. The paste is usually composed of Portland cement and water, and it binds together the fine and coarse aggregates. Supplementary cementing materials may also be included in the paste. A typical mix is about 10 to 15 % cement, 60 to 75 % sand/aggregate, 10 to 20 % water and 5 to 8 % air. When freshly mixed, it is plastic and malleable, allowing it to be poured into place and finished. Then, through a chemical reaction called hydration, the mixture hardens and gains strength to form the concrete we see in buildings, sidewalks, bridges and other structures. Concrete is the most commonly used construction material in the world.

EcoSmart™ Concrete

What makes EcoSmart concrete different from conventional concrete is that it uses a maximum percentage of supplementary cementing materials to replace cement in the mix. Depending on the application, from 30 to 60 % of cement can be replaced with supplementary cementing materials such as fly ash, blast-furnace slag, rice husk ash, and silica fume. These materials are industrial by-products, so EcoSmart concrete is generally cheaper and can lower construction costs. In laboratory tests and field applications, EcoSmart concrete often outperforms conventional concrete in strength development and durability. It also offers significant environmental benefits, since each tonne of cement replaced by a supplementary cementing material reduces CO2 emissions by approximately one tonne.

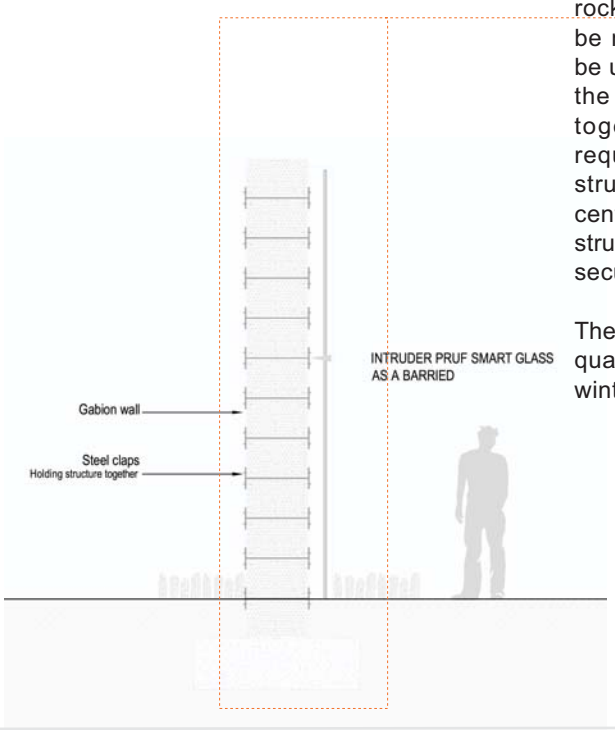
When properly proportioned, and especially in applications where high early-age strength is not crucial, using EcoSmart concrete can reduce construction costs. Supplementary cementing materials are generally cheaper than cement, since they are industrial by-products. A lifetime cost analysis may show the financial advantages of using EcoSmart concrete since it becomes stronger ad more impermeable with time compared to conventional concrete of similar 28-day strength.

Using EcoSmart concrete saves natural resources because fewer raw materials are extracted for cement production, reducing energy use and greenhouse gas emissions. Using industrial by-products such as fly ash reduces landfill costs.
Concrete is the most common construction material used in the world. Cement is the principal ingredient in concrete. Producing one tonne of cement results in the emission of approximately one tonne of CO2, created by fuel combustion and the calcination of raw materials. Cement manufacturing is a source of greenhouse gas emissions, accounting for approximately 7% to 8% of CO2 globally (1), and approximately 2.8% of CO2 emissions in Canada (2). The cement industry has made significant progress in reducing CO2 emissions through improvements in process and efficiency, but further improvements are limited because CO2 production is inherent to the basic process of calcinating limestone. There is an increasing demand for concrete worldwide, estimated to double within the next 30 years. How can that demand be met without a corresponding increase in greenhouse gases? By using (SCMs) to replace a maximum amount of the cement in concrete, we can reduce energy and resource consumption, reduce CO2 emissions, and lessen the negative environmental impact. There is a further environmental benefit in that most commonly used SCMs (such as fly ash) are waste products and would otherwise end up in landfills.



The fundamental qualities of concrete as a versatile, strong and easily applied building material make it the ideal basic structural element. Many of the walls are off-shuttered concrete structures, contrasted with stone gabion walling elements. The earth-topped roof is ideally supported by an in-situ concrete slab roof structure with provision for integrated drainage. The earth and planting structure completes the metaphor of the protected and secure role that natural elements play within the context of the scheme insofar as the earth embraces the structure integrating it with the landscape. What would ordinarily have been an aggressive concrete structure is clothed by nature, alive and ever changing. The juxtaposition of contrasting elements, stone, concrete, glass, timber and earth are played upon by the various permutations of sunlight throughout the day, creating visual and textural interest; a sense of optimism to young eyes.

stone (gabion wall) as a material of architecture



The gabion is rectangular basket stoutly made from steel wire strengthened by selvedges of heavier wire. Supplied as a flat pack, it is assembled on site and normally filled in situ with quarried stone or large round shingles. The site has a few rocky outcrops which if they have to be removed the removed rocks can be use to fill the baskets. Sections of the gabion wall are securely wired together in position to form the required retaining and anti-erosion structure. In the case of the visitors centre the Gabion walls are there for structural support, retaining walls and security division.

The gabion wall also has high thermal qualities and retains heat during the winter days and releasing it at night.

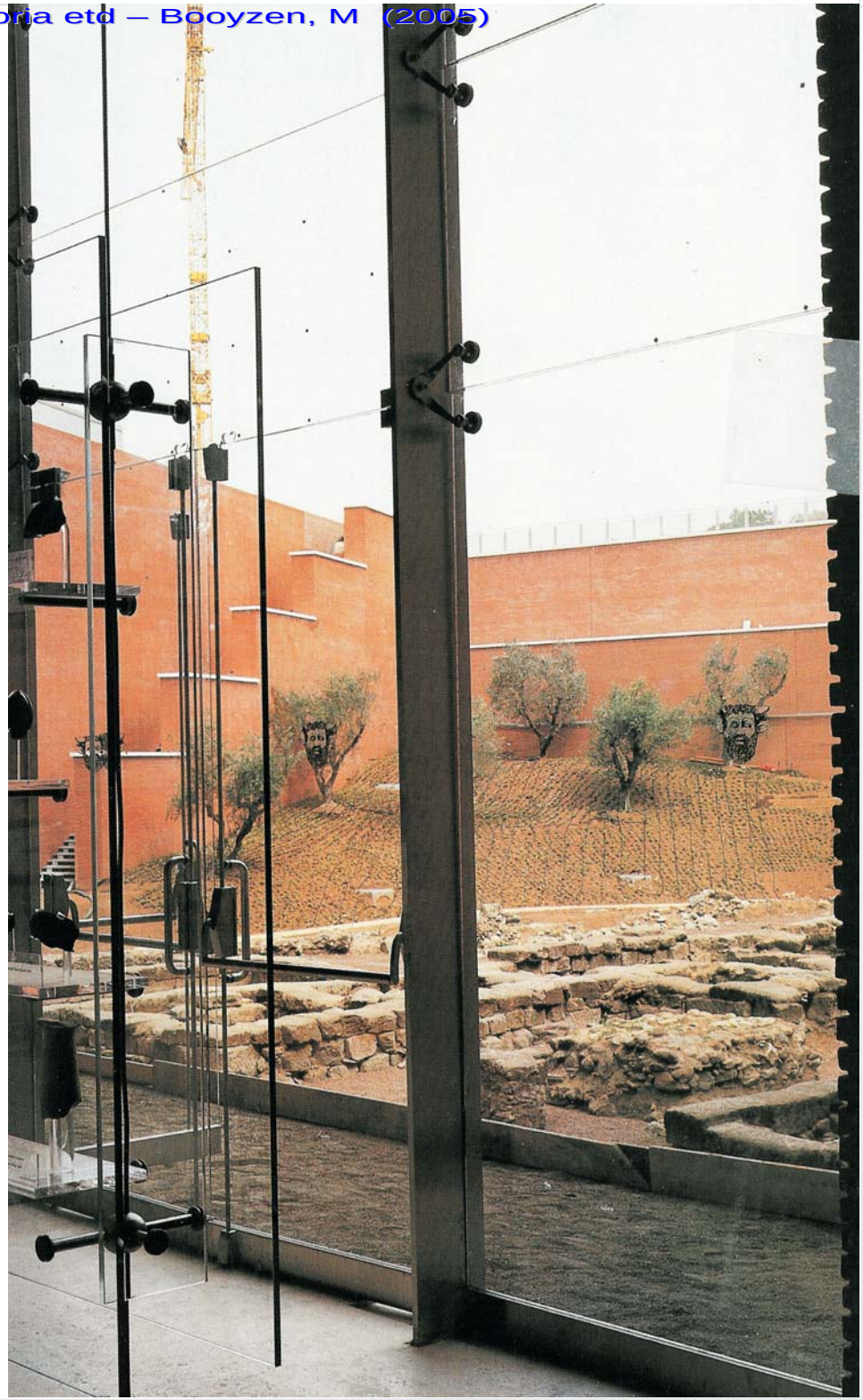
Stone is applied in such a manner so as to establish a visual and textural contrast from the other principal materials, concrete and glass. The stone is applied in the form of gabion walls which define axial and dividing walls, inside and outside the scheme, thus creating a visual dialogue between interior and exterior. Stone, while adding natural color and warmth, thus creating a refreshing departure from the austerity of the concrete walls, also imparts a tone of strength, authority and dignity to the spaces. The innate qualities of this natural material, maintain constant metaphorical references to nature and its associations of purity and freedom. The gabion walls are also often utilized in combination with laminated glass screen, for security purposes. The use of stone is also present in the underground cooling troughs which form a fundamental part of the ventilation/cooling system. The stone walls, thus, in a sense, take root in these troughs.

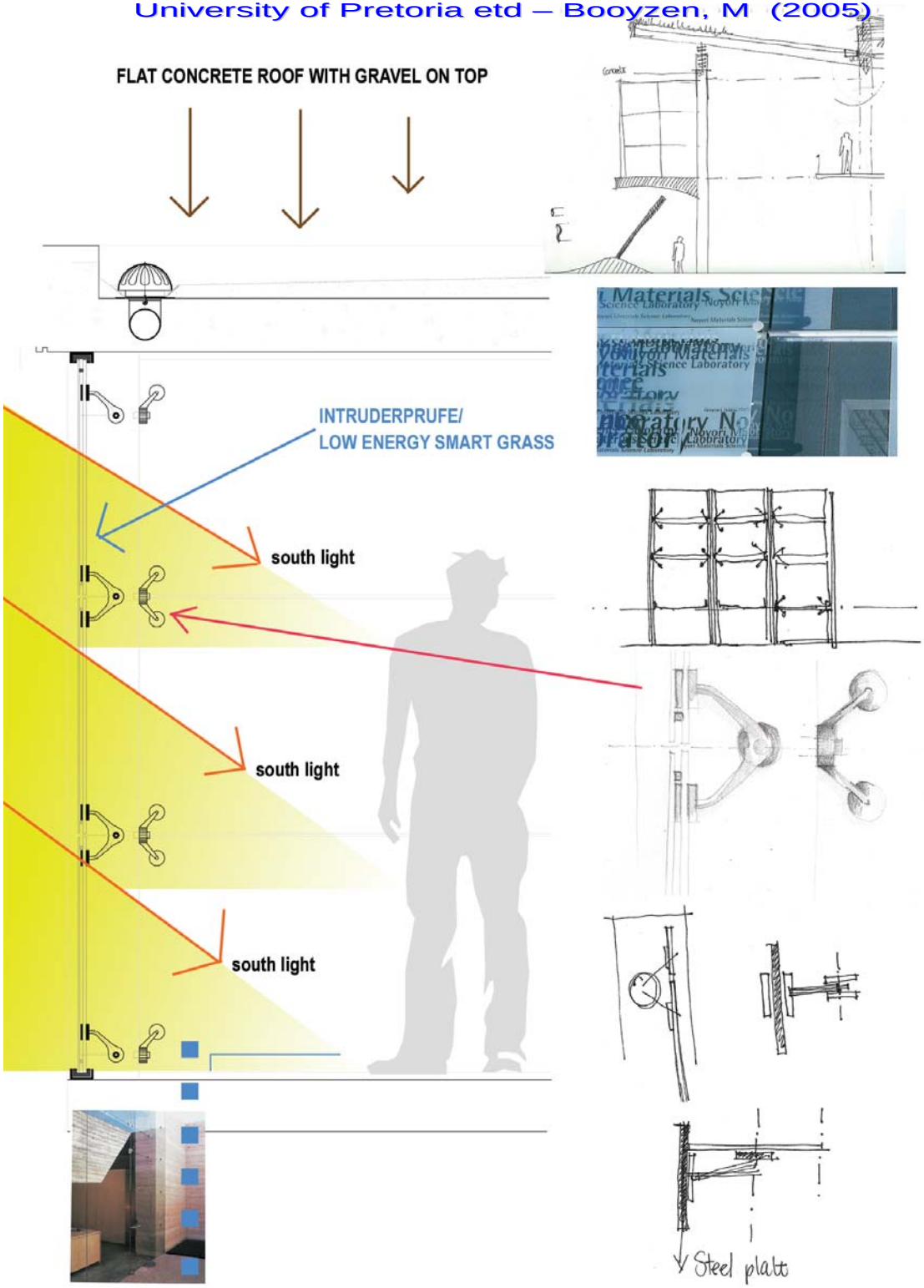
planting (green roof) as a material of architecture

The natural landscape is an integral part of the building design. The landscape is not only brought right into the building but actually passes over the building, forming a planting carpet on the roof. This landscaped roof structure does not only affect the visual effect of the building, it also assist in the thermal cooling if the building.

timber as a material of architecture

Large laminated timber lattices are applied to various large openings for the purpose of sun screening. These take the form of natural, sealed, laminated 280mmx75mm battens, arranged to form a lattice screens over large widows. These screens serve the dual purpose of controlling the penetration of excessive sunlight while creating diverse and interesting shadows on the respective interiors, once again adding interest. On the elevation, this new element accents and articulates the façade with forest-like configuration of vertical elements and completes the language of contrasting densities.




FLAT CONCRETE ROOF WITH GRAVEL ON TOP
INTRUDERPRUFE/
LOW ENERGY SMART GRASS
south light
south light
south light
Steel plate

glass as a material of architecture

Intruderprufe Smart glass

Intruderprufe is a clear laminated glass, made from two layers of clear float glass, permanently bonded together by pressure and heat with one or more Polyvinyl Butyral (PVB) plastic interlayers.
Intruderprufe offers in blocking the intrusion of unwelcome noise and UV light. It also prevents a simple fall against a large window from turning into a tragic accident. The result is a SABS approved safety glass that can withstand many blows. High Penetration Resistant (HPR) for additional security - 0.76mm PVB

Laminated glass is used to open the interiors to the outside and allow the healing aspect of light to permeate the spaces. A pervasive and interesting application of light in an interior engenders an atmosphere of positively and optimism. This is particularly pertinent to the application of a youth facility as the atmosphere influences, not only inmates, but staff, teachers and visitors. The fenestration thus plays an important role in the application of interesting and varied daylight penetration. Glazing is also utilized to screen gabion walls so as to prevent prisoners from concealing objects within the stone-work

performance data

solarshield + 12mm air gap +intruderprufe low-e