BOUKUNDE III : ENVIRONMENTAL AUDIT AND RETROFIT

by

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"Organizational learning has been dissected by theorists Gregory Bateson and Chris Argyris into three levels: adjustment to a norm, change of the norm, and change of change."

"Might that layering be reflected in a building designed for multi-level adaptivity? Maybe thats what Architecture Department buildings should be designed to handle - triple-level learning. (Brand. 1994:219)

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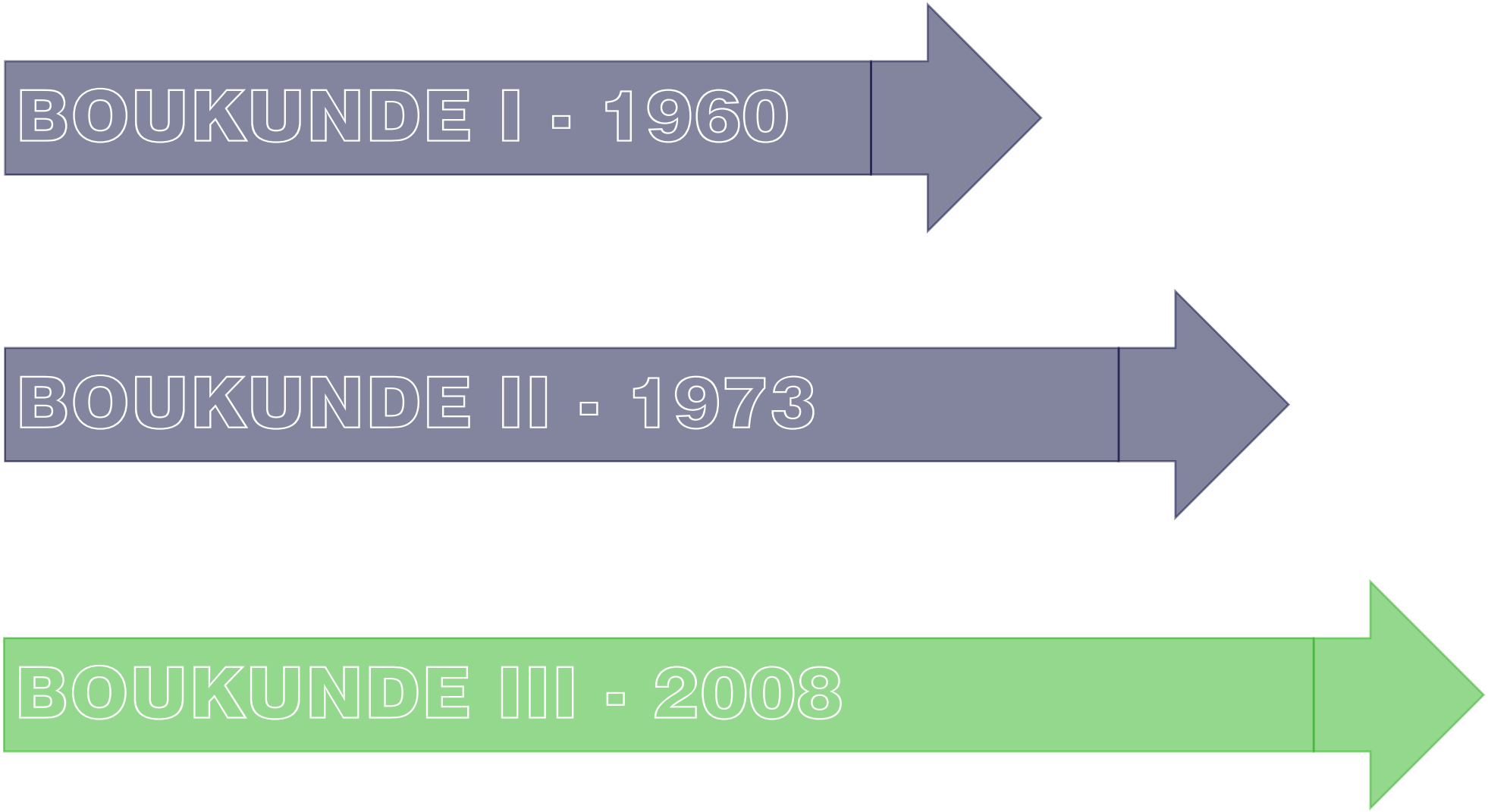
The Boukunde building - situated along the southern boundary of the University of Pretoria main campus - has housed the Architecture Department since the 1960's.

The building as it stands today has not seen many significant material changes effected over the past 3 decades, although it finds itself within a distinctly different era. We are now in an age where it is not only desirable or admirable to be considerate of the planets resources, but rather necessary to do so for an expanding catalogue of reasons.

The challenge is to situate this necessity within an array of traditional assignments and give it a greater measure of prominence as a driver of design.

The Boukunde building offers an ideal retrospective platform for investigation of an integrated approach to architectural design.

Where a building's history can be confronted by contemporary ideals, and assimilate through minor, measurable change.


BOUKUNDE I - 1960
BOUKUNDE II - 1973
BOUKUNDE III - 2008

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socio-economic context

002.1

"In the 1980's, the South African government took a policy decision to have more power stations than the country needed at that time so that we could offer investors the 'cheapest electricity in the world'. Eskom built so many power stations in the 1980's and early 1990's that we had 25-30% excess electricity capacity, but this was not accompanied by a meaningful expansion of the electricity grid for ordinary people. The fact that most electricity is generated from poor-quality coal has meant that South Africa is one of the worlds worst polluters. Its CO^2 emission per unit output per person in 1999 was 20 times worse than that of the US."

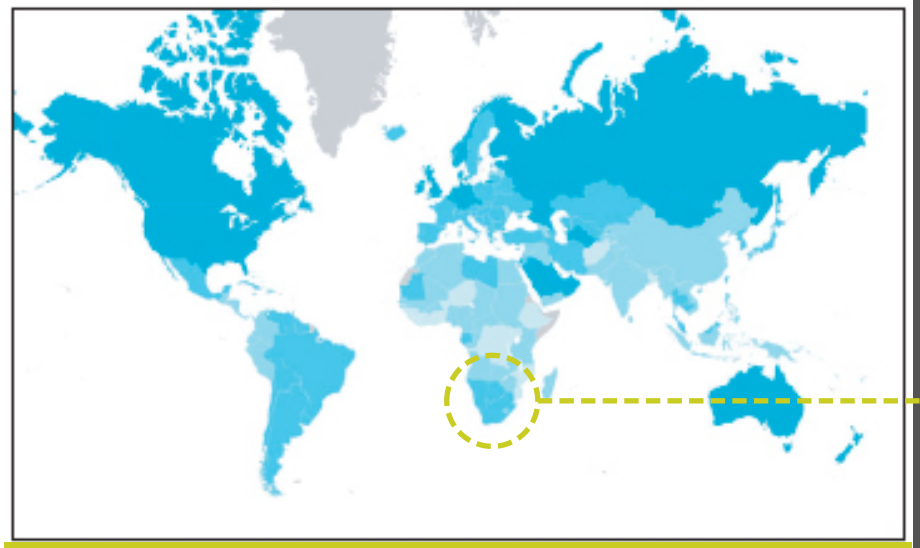


Figure 1 : Greenhouse gas emissions per capita (darker shades represent higher levels of emissions) (www.maplecroft.net)

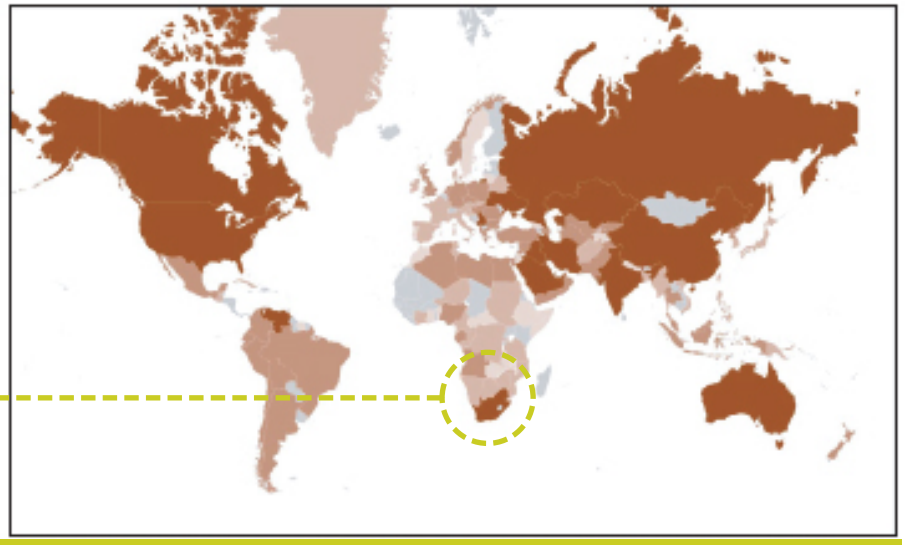


Figure 2 : Carbon resources - oil,gas & coal (darker shades represent higher levels of reserves) (www.maplecroft.net)

"South Africa contributes 1.8% of total greenhouse gases, making it one of the top contibutors world-wide. The energy sector is responsible for 87% of CO^2-, 96% of sulphur dioxide (SO^2)-, and 94% of nitrous oxide emissions. Due to the fact that our domestic economy is powered by coal, South Africa has experienced a five-fold increase in CO^2 emissions since 1950. South Africa accounts for 41.9% of Africa's CO^2 emissions, followed by Egypt (14.1%), Nigeria (10%), Algeria (9.9%), and Libya (4.8%)."

"Since 1970, South Africa has consistently consumed the most energy and emitted the most carbon per dollar of GDP among major countries. South African energy-intensity measured 33.5 K BTU per $ unit - nearly China's level." (Bond. 2006:3)

"The South African Government is bringing into action it's voluntary commitment to climate-change mitigation, and Cabinet has mandated the National Treasury to investigate the possible imposition of a tax on carbon-dioxide (C02) emissions. Under the Country's newly adopted strategic direction and framework for climate policy the Treasury would examine the most appropriate fiscal measures to support government's Long-Term Mitigation Scenario (LTMS), which could include escalating 'CO2 taxes', a 'cap-and-trade' system, as well as incentives to help place South Africa's economy on a low-carbon growth and development path."

"Under a cap-and trade system, government could set a limit, or cap, on the amount of CO2 that can be emitted, and companies needing to increase their emissions would have to buy credits from those who pollute less. Finance Minister Trevor Manuel, in his February Budget, announced a 2c/kWh tax on non-renewable energy, which is already a form of carbon tax, and should the tax be introduced from September as proposed, it would be the equivalent of R19/t of CO2 emitted. This, however, is relatively modest when compared with the €20/t-plus level at which carbon is currently trading on markets in Europe."

"The LTMS itself is a progressive step for a developing-country government, particularly given that South Africa is as yet not bound by any international legal obligations to make emission reductions. South Africa now joins only a handful of developing countries, including China, Brazil and India, in moving ahead with mitigation programmes under a so-called 'comparability of effort' framework canvassed at the recent global climate change gathering in Bali."

"South Africa has now also formally endorsed the emerging global aspiration to limit to 2ºC the change in temperatures from pre-industrial levels. Climate scientists calculate that the Earth's temperature had already increased by 0,7ºC from the start of the industrial revolution (approx. 1750), and there was also near consensus that CO2 emissions resulting from human endeavours - primarily from industrial activity, was contributing to these rising temperatures." (Creamer. 2008:23)

"Cabinet had also endorsed a proposal that electricity tariffs be 'smoothed' over a number of years so as to avoid a destructive price spike. Indeed, the National Energy Regulator of South Africa, on granting Eskom an additional increase for 2008/9, called on Treasury to review the implementation, given that it would add to the burden already faced by consumers. Although ESKOM's current coal-fired operations are being consolidated for the sake of operational continuity, energy-efficiency targets will soon be made mandatory under the Power Conservation Programme (PCP), with no future coal-fired power stations or coal-to-liquids facilities to be approved unless it could be shown that the development was carbon-capture and storage (CCS) ready."



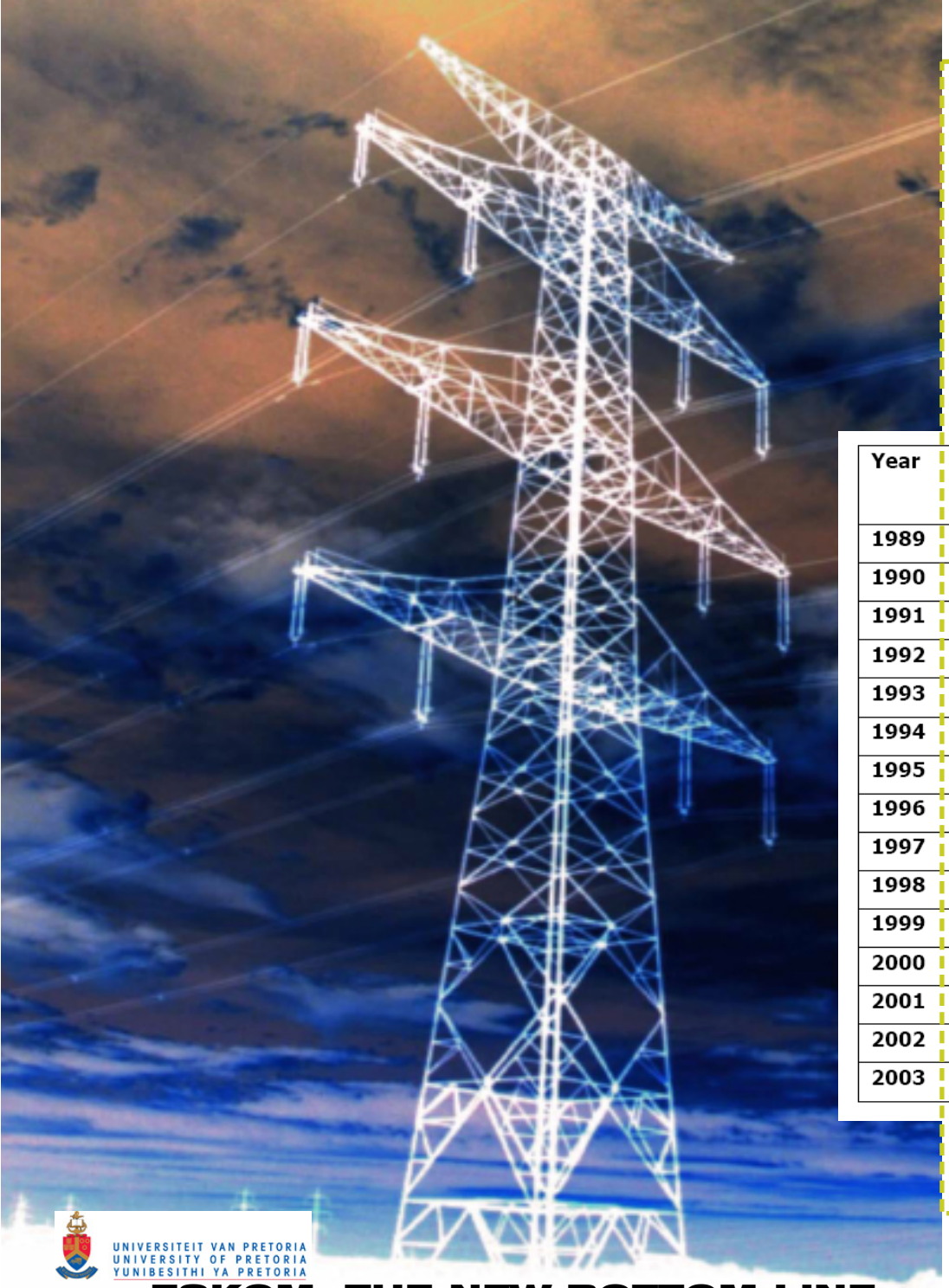
Figure 3 : Exposure to impacts of Climate Change (darker shades = higher levels of exposure) (www.maplecroft.net)



Figure 4 : Energy consumption from non-renewable resources (darker shades = greater reliance) (www.maplecroft.net)

"At present, South Africa's CO2 emissions stand at about 800-million tons/year, which is likely to climb to above 1.2-billion tons by 2025. Should the country succeed in reducing its absolute emissions from 2030, these could fall again to below 600-million tons by 2050. To achieve this, the Department of Environmental Affairs and Tourism is proposing that the country adopts a so-called "Reach for the Goal" strategic option, which entails not only the adoption of carbon-friendly technologies, but also regulatory mechanisms such as mandatory targets for energy efficiency and changes to building standards, to enforce the adoption of green-building technologies and materials."

"This also implied a major shift in South Africa's industrial-policy trajectory from one that had, hitherto, incentivised energy-intensive developments, to one that favoured sectors using less energy per unit of economic output." (Creamer. 2008:23)



South Africa has for decades enjoyed the advantage of being "the lowest cost global producer of electricity" (www.eskom.co.za), and powered our development upon the 'cheapest' electricity tariffs - relative to general expenditure. Consumer Price Inflation (CPI) is a benchmark against which to measure such expenditure, and the figures below show that - except for 1 year (2000) when CPI was relatively low - electricity tariff adjustments have always been below CPI, or at most - on par with CPI. This indicates, a 'comfortable' assimilation of energy costs into the economic landscape - irrespective of a sector cost variance.

Year	Average price (c/KWh)	Price Increase Announced (%)	Effective Price Increase (%)	Consumer Price Inflation (%)
1989	6.9	10.00	9.52	14.51
1990	7.88	14.00	14.25	14.29
1991	8.46	8.00	7.24	15.57
1992	9.16	9.00	8.31	13.67
1993	9.59	8.00	4.74	9.87
1994	10.32	7.00	7.55	8.82
1995	11.15	4.00	8.04	8.71
1996	11.30	4.00	1.38	7.32
1997	11.85	5.00	4.87	8.62
1998	12.29	5.00	3.72	6.87
1999	12.44	4.50	1.19	5.21
2000	13.23	5.50	6.35	5.37
2001	13.76	5.20	4.06	5.70
2002	14.98	6.2	8.84	10.10
2003	n/a	8.43	n/a	7.4

Table 1: Eskom tariff increases (1989 to 2003) (Khalil-Hassen. 2006: 31)

This picture has changed somewhat over the past 5 years...

Average CPI has grown from 3.4% in 2005 to 7.1% in 2007, and is heading upwards still, standing currently at 10.9% (year-on-year as at 30 June). (source: www.statssa.org.za) Whereas electricity tariffs, which had effectively increased by 4.1% through 2005, now rises 27.5% in 2008 (14.2% approved in December 2007 by the National Energy Regulator - NERSA, and a further 13.3% in June 2008). (source: www.nersa.org.za) This is less than the 60% total that energy parastatal ESKOM had requested, but still far in excess of CPI figures for the corresponding period.

Based upon this evidence it can be seen that electricity now consumes a greater proportion of budgetary allotments - whether residential, commercial or institutional - than it did in the not-too-distant past. It may have been forgivable in 'plentiful times' that a building's operational consumption and resultant expenditure weren't necessarily overt design concerns, but it is entirely indefensible to ignore these aspects in 2008. 'Times have changed' understates the current circumstance, and there has to be a significant response from the design profession.

It is not just South Africa that has experienced a rude awakening, but the world-at-large. The fact that the global energy sector is having to re-evaluate operations resonates our local difficulties and creates contemporary frames of reference, as well as opportunities to illustrate leadership and/or independence in approaching what is a global common purpose.

"The World Energy Outlook's Reference Scenario states that the world's energy needs will be more than 50% higher in 2030 than today, an average annual growth rate of 1.6%. More than two-thirds of growth in world energy use will come from the developing countries where economic and population growths are highest. In developed countries, electricity supply is struggling to cope with demand, and the International Energy Agency predicts there will be more outages such as those experienced in the US, Japan, and Canada." (www.eskom.co.za)



Figure 5: ESKOM Power Alert barometer (www.eskom.co.za)

"In line with the global picture, South Africa's marked economic growth in recent years has also propelled electricity peak demand to rise at around 4% a year in a high growth scenario (Eskom Integrated Strategic Electricity Plan). Consequently, unless something is done, peak-period demand will soon exceed Eskom's ability to supply electricity during these periods, and additional baseload capacity will be required. It is vital to have reliable and uninterrupted electricity for the South African economy to grow."

"ESKOM is addressing the South African electricity challenge by the expansion of supply options, by the return-to-service programme of mothballed power stations, and through promoting energy efficiency in its Demand Side Management (DSM) programme, which facilitates influence over usage patterns of electricity consumers." (www.eskom.co.za)

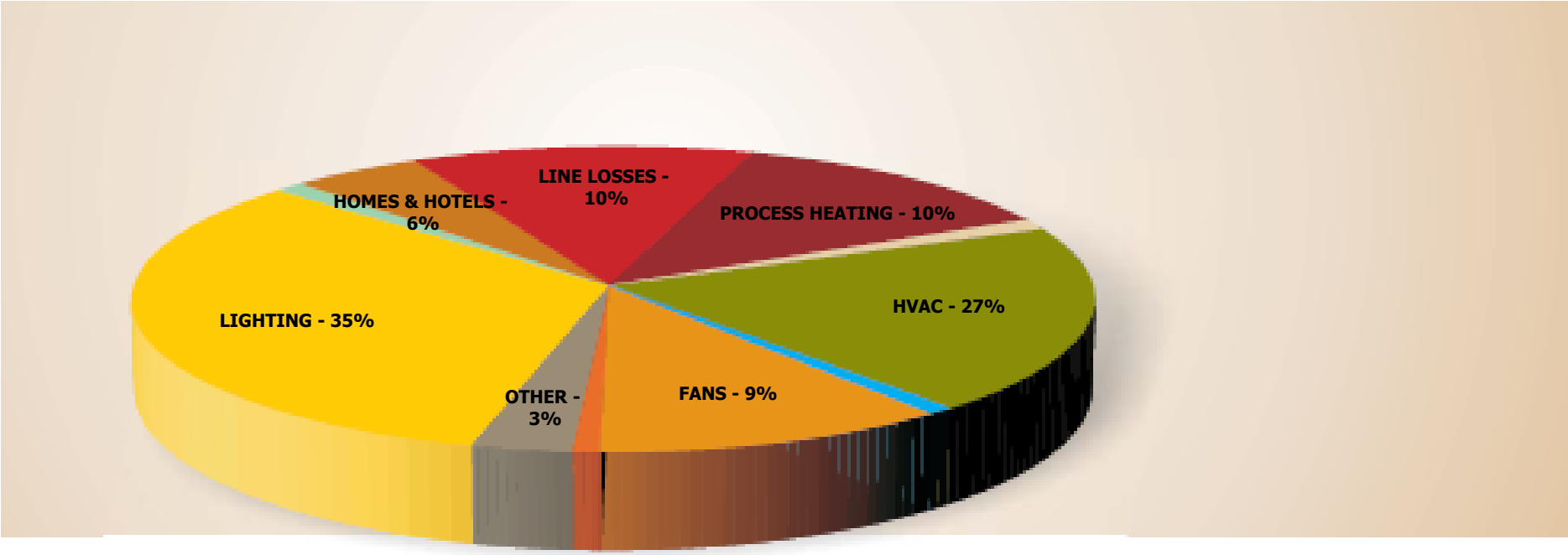


Figure 6 : Maximum energy demand in the Commercial Sector (www.eskom.co.za)

"DSM is being implemented in collaboration with the Department of Minerals and Energy (DME) and the National Energy Regulator of South Africa (NERSA), and comprises a dual approach:

- to reduce electricity demand at peak periods (07:00-10:00 and 18:00-21:00) by shifting load to off-peak periods
- and overall consumption reduction (24-hour reduction) by installing energy efficient equipment and optimising industrial processes."

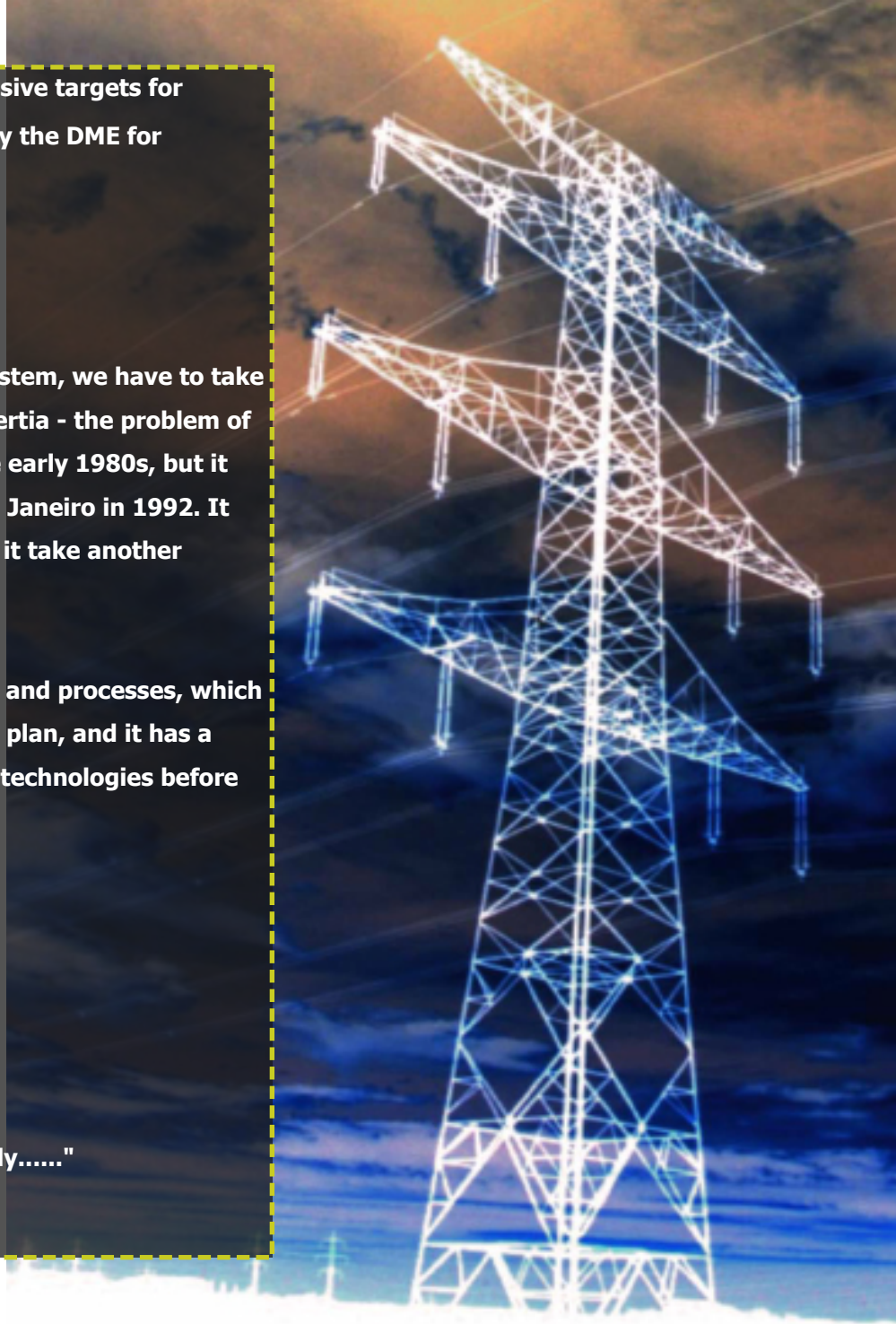
"South Africa is among a few countries worldwide that have set comprehensive targets for energy efficiency improvements. The Energy Efficiency Strategy compiled by the DME for South Africa proposes the following energy efficiency targets:

- A final energy demand reduction of 12% by 2015.
- The DSM long-term goal is to save 4 255MW over a period of 20 years."

"The climate system has a built-in inertia. Because of this time lag in the system, we have to take action before the changes take place. The second type of inertia is social inertia - the problem of getting people to respond in time. The climate change debate started in the early 1980s, but it took a decade before the UNFCCC was signed at the Earth Summit in Rio de Janeiro in 1992. It took another decade for the Kyoto Protocol to enter into force in 2005. Will it take another decade to mobilise people?"

"The third kind of inertia is technical inertia, for instance in energy systems and processes, which take 30-50 years to replace. An energy generation facility takes 10 years to plan, and it has a working life of 40 years. The costs to society of rapidly changing to cleaner technologies before the old plant needs replacement are massive." (Scholes: 2006: 7)

"Eskom will spend R450 million a year on energy-saving measures nationally....."
(www.eskom.co.za)



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historical context

"For a building, driving forces might include changes in technology, in the neighbourhood, in the economy, and in tenant use. The [planning] group ranks these driving forces in terms of importance and uncertainty, placing the most important and most uncertain highest, because it is the most important uncertainties that will drive the scenarios apart." (Brand. 1994:182)

One of the primary objectives of the Architect and Quantity Surveyors (Private) Act No.18 of 1927, passed by Parliament of the Union of South Africa, was to make dedicated facilities available for training professionals in these 2 fields. Due to the fact that a great concentration of activity relating to these professions was to be found in Pretoria and Johannesburg, it was decided that architects from the University of Witwatersrand and quantity surveyors from the Transvaal University College would henceforth be educated in Pretoria.

In 1929 Prof. Harry Bell-John, a quantity surveyor, was appointed to head up organization of the Department and the 1st students were enrolled. It was the Depression years and the University was financially threadbare. Student numbers were very low within the Department and, as such, there was no immediate need for a dedicated structure. Thus the faculty made use of existing lecture halls in the Old-Arts- (Ou Lettere), Physics-, and Old Clubhall buildings to deliver it's prospectus.

Upon the inauguration of the Merensky library next to the Old Arts building in 1939, the Department relocated to the southern hall of the Old Arts which helped establish a more secure tenure, but didn't appreciably improve the generally disjointed structure of the (then) UPAQA (University of Pretoria Architects and Quantity Surveyors Association).

Most of the students were registered for part-time diplomas in the 2 fields and were working full-time in offices located in the CBD. As a result, classes were held at night, which was the instruction format at the University's satellite facility in Vermeulen Street.

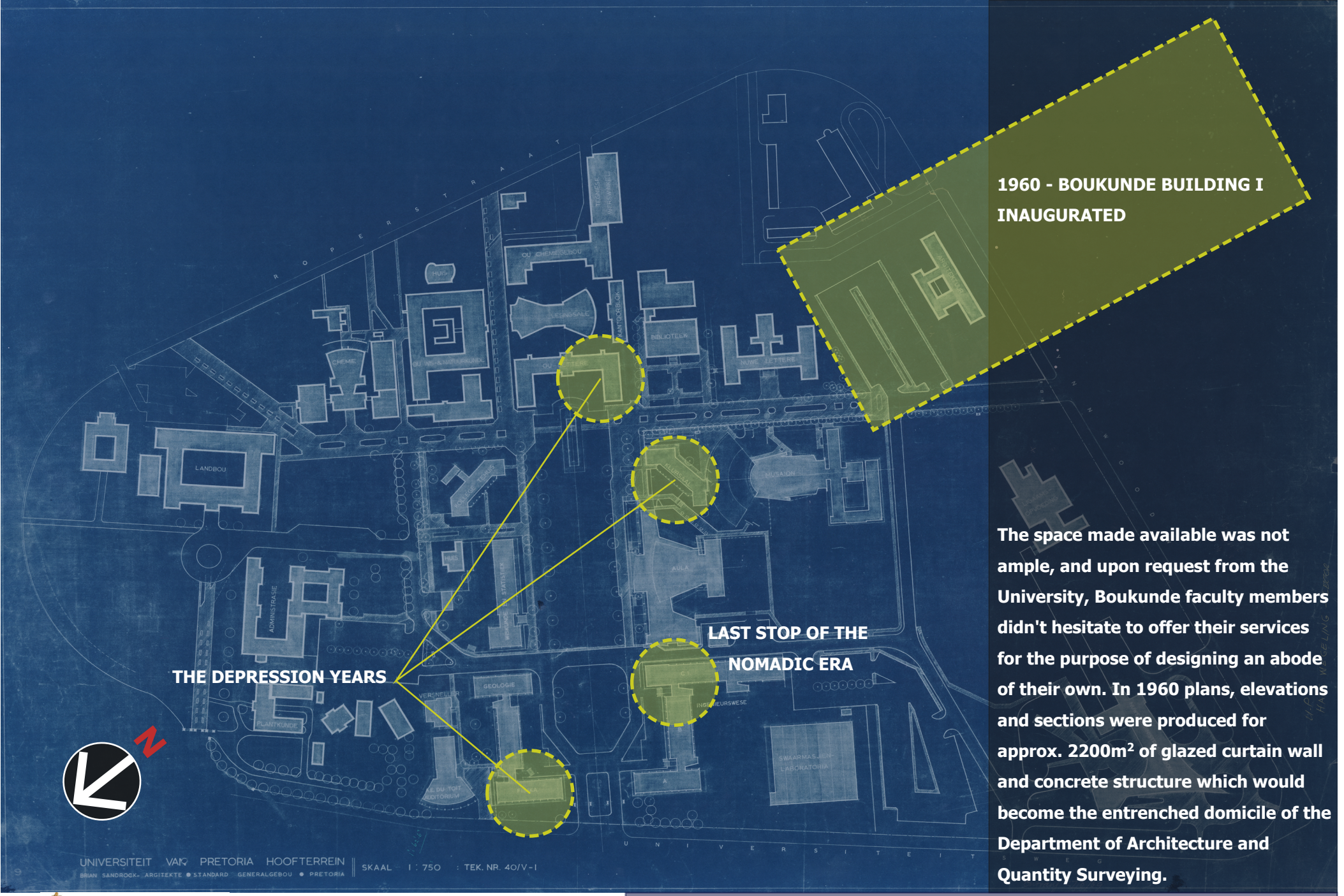
When the time came to extend the satellite facility - space was made available for the Department on the 2nd floor extension behind the MacFayden hall. The Department was now eventually able to foster a unique identity and solidarity amongst it's ranks. Faces became familiar when passed in the Department's halls, and the seeds of a collaborative 'studio culture' were sown.

The house of Boukunde (Building Science) was thus established and the Department made a successful appeal to the University governing body for 'a place at the table', and gained Boukunde students representation on the Student Council.

The years that followed however, came to be the most disruptive in the history of the Department.

Student numbers swelled considerably and various alternate accommodations were explored, with the Department eventually settling in the Kerry office building to the north of Vermeulen street - opposite the MacFayden building - where space was rented by the University for Boukunde use.

Clashes occurred between the building's incumbent private tenants and the academic newcomers - with the Department's sense of autonomy suffering as a result. The situation was deemed untenable & the Boukunde horde returned to the University main campus - to be hosted within the newly built Engineering building.



The space made available was not ample, and upon request from the University, Boukunde faculty members didn't hesitate to offer their services for the purpose of designing an abode of their own. In 1960 plans, elevations and sections were produced for approx. 2200m^2 of glazed curtain wall and concrete structure which would become the entrenched domicile of the Department of Architecture and Quantity Surveying.

Figure 7 : Campus Layout Plan - drawing no. 40/V - 1 (Brian Sandrock Architects)

BASEMENT PLAN / SECTION 4-4 / EAST & WEST ELEVATION

The curtain wall format was decided upon for reasons of stylistic preference and relative speed of construction. For the first time the Department faculty and students were to be found under one roof and productive discourse could be entered into on a daily basis.

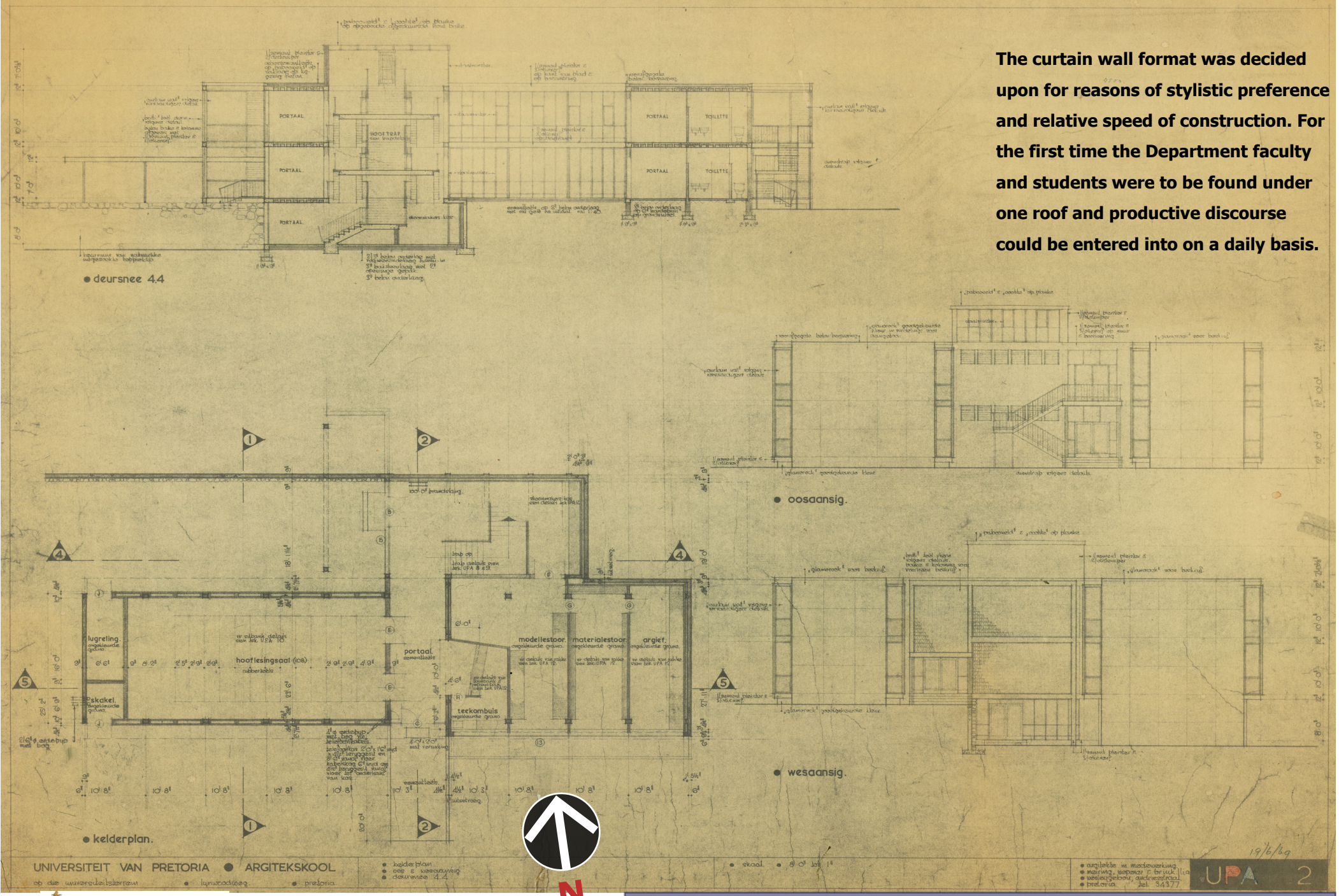
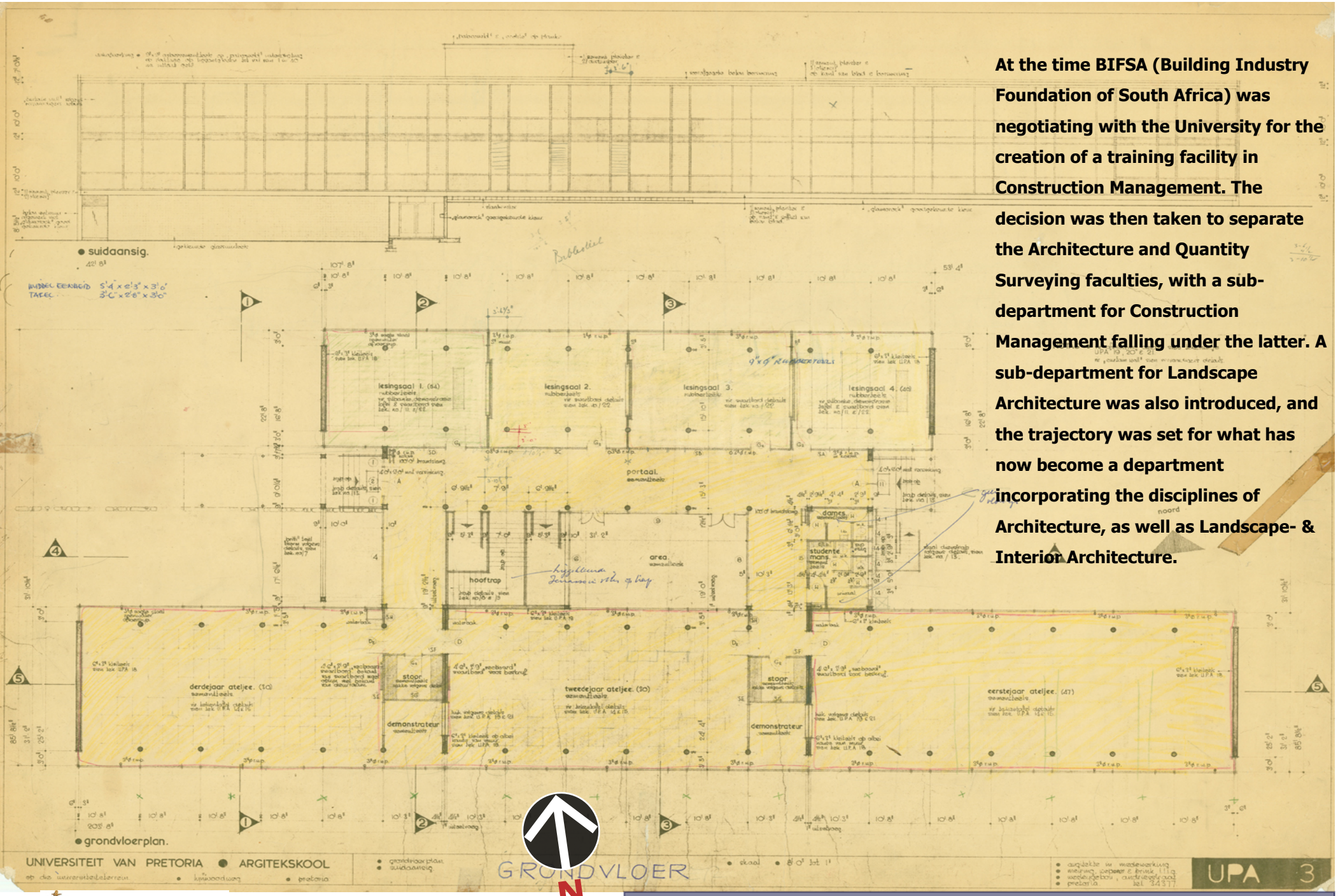


Figure 8 : Basement Plan - drawing no. UPA 2 (UP School of Architecture)



At the time BIFSA (Building Industry Foundation of South Africa) was negotiating with the University for the creation of a training facility in Construction Management. The decision was then taken to separate the Architecture and Quantity Surveying faculties, with a sub-department for Construction Management falling under the latter. A sub-department for Landscape Architecture was also introduced, and the trajectory was set for what has now become a department incorporating the disciplines of Architecture, as well as Landscape- & Interior Architecture.

Figure 9 : Ground Floor Plan - drawing no. UPA 3 (UP School of Architecture)

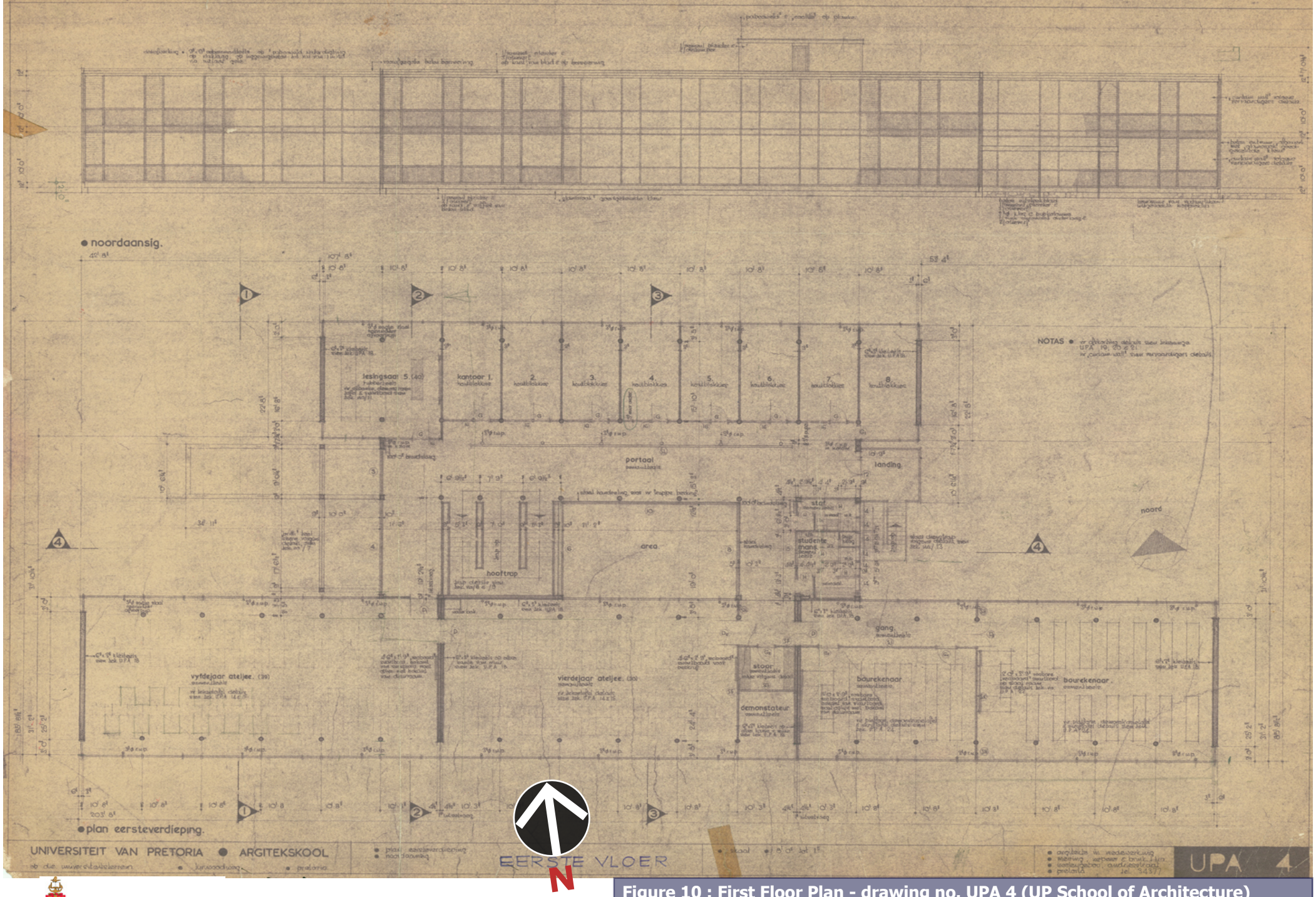
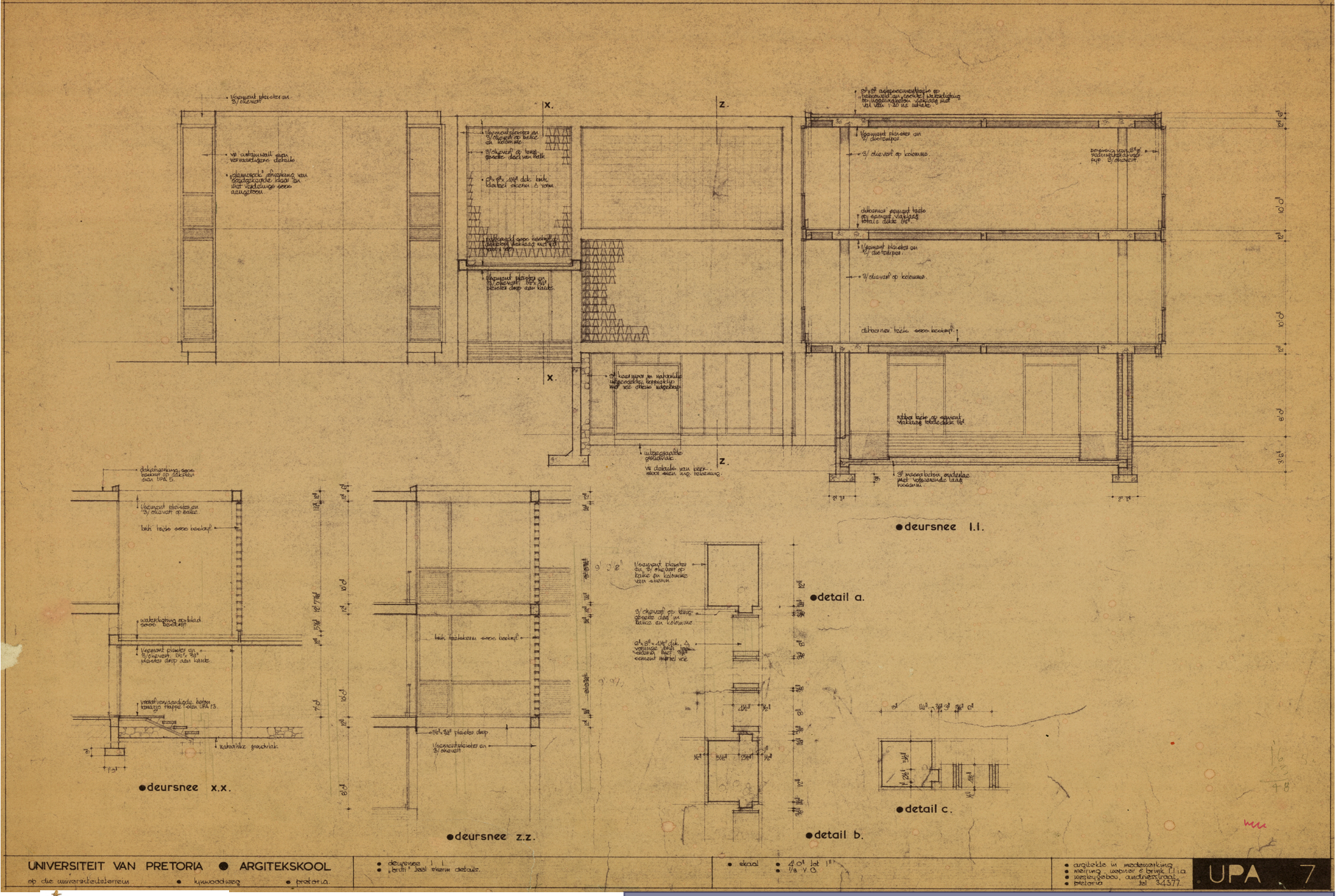


Figure 10 : First Floor Plan - drawing no. UPA 4 (UP School of Architecture)



SECTION 1-1 / x - x / z - z

Figure 11 : Section 1-1 / x-x / z-z - drawing no. UPA 7 (UP School of Architecture)

The history of Boukunde I has been translated from the original article "Die Boukundegebou" appearing in the Boukunde periodical. The article was written in afrikaans by Prof. J.T.B. Viljoen - August 1986.

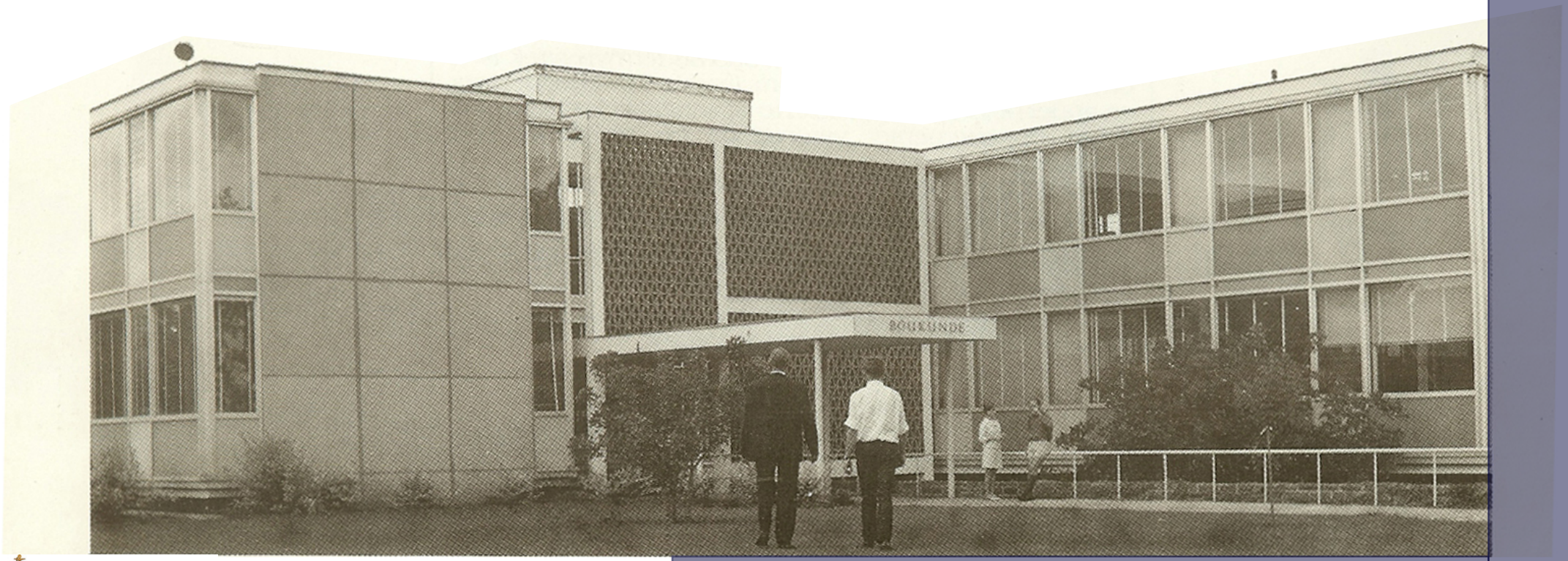


Figure 12 : Boukunde Building (Viljoen. 1986:2)

"The growing prestige of Walter Gropius's Modernist educational methods at the Harvard Graduate School of Design, along with Ludwig Mies van der Rohe's similar efforts at the Illinois Institute of Technology, seemed fatal to revivalist styles. After 1945 the vision of dreaming spires and insular cloisters seemed even less appropriate to the cultural powerhouses that American universities were poised to become. The cold war, which made American intellect into a weapon of global freedom, required major research universities to look - or seem to look - forward and outward, forming world citizens and not smug clubmen. Any university wishing to seem timely and remain prestigious now had to build to reflect positively stated ideals, not withdraw from them into cloisters and quads." (Samson. 2006: B17)

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institutional context

South African higher education has three primary sources of funding: about half is from government, a quarter from student fees, and the rest is generated through donations and entrepreneurial activities. The government spends over R10 billion a year on higher education, which is 13% of the education budget and 2.6% of total government spending. (www.studysa.co.za)

"Short of cash, and jostling colleges from America to China for the smartest students and staff, universities across the country are rethinking fund raising. The need is obvious: investment in British higher education stood at 1.1% of GDP in 2004, according to the most recent data from the OECD, while the U.S. spent 2.9%." "No matter which way you look at it, higher education is internationalizing and the competitive intensity is increasing."

"In late May (2008), Oxford launched the most ambitious fund-raising drive ever undertaken by a European university, aimed at boosting its coffers by at least $2.5 billion (approx. R19 billion). The eager among you have chipped in already - helping Oxford to more than $1 billion so far..." "The task before us is to guarantee Oxford's pre-eminence in a world now changing so fast that we must lead or fall behind, announced Vivian Duffield, chairman of the campaign."

"Money raised through Oxford's appeal will be poured into new facilities and the endowment. Scholars at Cambridge needn't feel outdone. Under its own campaign, launched in 2005 to mark the university's 800th anniversary next year (2009), Cambridge hopes to bring in $2 billion by 2012, and has already raised some $1.3 billion."

"Lower revenues mean lower spending, and the result is bleakly evident in rankings of the world's best universities. In the highly regarded table published annually by China's Shanghai Jiao Tong University, European institutions fill just four of the top 25 places; wealthy North American institutions account for almost all the rest." (Smith, A. 2008: 35)

Naturally, economies of scale would indicate that there is no relation between South African- and U.S. or U.K. universities competitive aspirations and/or capacity to fullfil such ambition, but a pro-active approach to consolidation of assets and a deliberate policy regarding resource efficiency should be standard operating procedure for institutions worldwide.

Education and skills development is one of the 6 selected areas of intervention identified under the Accelerated and Shared Growth Initiative of South Africa (ASGI-SA), which was launched in 2005 to address the concerns of inequitable national growth. The significance thereof is that it demonstrates an awakening amongst policy-makers at the highest level to the realities of there is no growth without education and skills.

"The resources to make this happen are there, although more funds are needed. Finance minister Trevor Manuel allocated R600 million to further education and training colleges for more student bursaries. He also allocated an extra R2.2 billion to universities to increase enrollment and produce more science, engineering and technology graduates." (Jacks, 2007:2)

With an increase in student numbers there will ultimately come a point where the existing tertiary facilities will burst at the seams. Universities countrywide will face the prospect of infrastructure expansion and/or consolidation in terms of existing building stock, and whilst it is infinitely more exciting to conceive of shiny new complexes - it is seemingly more responsible to dust off the old ones and initiate them into the 21st century.

Assuming that these structures have stood the test of time - their robustness can't be questioned, but their agility in serving a revised set of circumstances could be the characteristic that extends their longevity beyond expectations.

The tertiary architecture programme has evolved over the past 80 years since the first students were enrolled in the Transvaal University College (Transvaal Universiteitskollege, or TUKS) Architecture Department. The acronym remains, although the University has a new official name and is privy to a vastly different era.

The building that hosts the programme has seen it expand substantially. What was once a singular 5 year Bachelor of Architecture degree has now become a 3 year body of undergraduate coursework in the subjects of Architecture, Landscape Architecture & Interior Architecture. Supplementary to this are a further 2 years, being Honours and Masters in the respective coursework fields, as well as research Masters and PhD offerings.

Academic programmes have to respond to the demands that society and economy place on them. The various fields of application that are ultimately underpinned by the tertiary graduates will also have evolving expectations informed by specific needs. These needs will take the form of certain qualitative aspects of the product, as well as quantitive - depending generally upon the 'colour' of the economy. When we are 'in the red' graduates might struggle to find work prospects, whereas a buoyant economy will absorb competent, qualified recruits like water to a thirsty sponge.

The University of Pretoria Architecture Department is set to expand its girth with an extension of the post-graduate research programme, as well as an increase in undergraduate enrollment numbers. This population explosion is expected to surpass the carrying capacity of Boukunde II, and thus the building should offer a proportionate response. Given that the content of the coursework degrees is not likely to change - the number of tenured staff is not expected to increase proportionally, and thus the primary programmatic concern is for an extension of studios and related facilities.

STUDENT NUMBERS: (including architecture / landscape- & interior architecture - where applicable)

1986 = 180 (excluding research degrees)

1st Year - approx. 60

2nd year - approx. 40

3rd year - approx. 30

4th year - approx. 30

5th year - approx. 20

2008 = 400 (excluding research degrees)

1st Year - approx. 110

2nd year - approx. 100

3rd year - approx. 80

4th year - approx. 60

5th year - approx. 50

1st year enrollment is mandated to increase by approx. 30% by 2010, which will swell subsequent years by the same margin. Therefore, by 2015 Boukunde will serve as domicile for approx. 520 coursework conscripts, as well as a further indeterminate number of research students. The building has no spare capacity available and there is no foreseeable re-assignment of space that could serve to accommodate the looming influx.

The 'tools of the trade' have evolved, and although a drawing board and pencil are not considered alien to contemporary studio culture - spatial appetites are generally less voracious than they were in the not-too-distant past. An education in architecture revolves largely around 'studio culture' though, and it is not uncommon for students to spend an inordinate proportion of their waking hours in a building like Boukunde. This fact dictates that the space made available to them should be of a certain functional quality.

According to the Metric Handbook chapter on Education facilities - an architecture department should be allocating "approx. 6.55m^2 of specialised accommodation" (Adler3. 1999:5) to each member of its student populace. Translated from the original drawings, which had apportioned the second floor studios of Boukunde II to 135 students (75 x 2nd year/ 60 x "senior") - the space available per capita would have been approx. 5.55m^2. The building at that stage was also hosting the Construction Management and Quantity Surveying faculties, and thus there wasn't necessarily an abundance of architecture studio space available throughout the structure.

The projected head count has changed since then, and so too the spatial assignments. The Construction Managers & Quantity Surveyors have left the building, and the second floor studios have subsequently become the 1st years domain.

ACCOMMODATION SCHEDULE (studios):

2008 (excluding research)

1st Year - 110 within approx. 700m^2 = 6.36m^2 / head

2nd year - 100 within approx. 440m^2 = 4.40m^2 / head

3rd year - 80 within approx. 400m^2 = 5.00m^2 / head

4th year - 60 within approx. 260m^2 = 4.33m^2 / head

5th year - 50 within approx. 260m^2 = 5.20m^2 / head

2015 (projected - excluding research)

1st Year - 140 within 700m^2 = 5.00m^2 / head

2nd year - 130 within 440m^2 = 3.40m^2 / head

3rd year - 100 within 400m^2 = 4.00m^2 / head

4th year - 80 within 260m^2 = 3.25m^2 / head

5th year - 60 within 260m^2 = 4.33m^2 / head

Working upon the premise that each student should have a drawing board in their workspace - the current studio rations do not- and will not-suffice. However, the architecture studios currently resemble a hybrid workspace - fitting somewhere between the archetypal studio and an open plan office environment. It is thus debatable whether the 6.55m^2 per capita requirement is still valid.

Irrespective of the what the precise spatial quota needs to be - the general consensus would seem to be that additional space is required to avoid significant departmental growing pains in the medium- to long term.

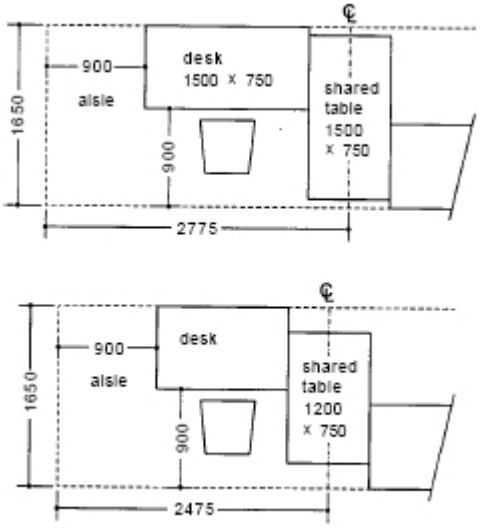


Figure 13 : Desk with shared table - spacing & layout (Adler2. 1999:13)

Type of board	Size	Width (mm)	Length (mm)
Parallel motion unit only or parallelogram type drafting machine	A2	470	650
	A1	730	920
	A0	920	1270
	2A0	1250	1750
Track or trolley type drafting machine requiring additional 'parking' area to one side	A1 extended	650	1100
	A0 extended	920	1500
Parallel motion unit with drafting head requiring additional 'parking' area at bottom of board	A1 deep	730	920
	A0 deep	1000	1270

Table 2 : Nominal sizes of drawing boards (Adler1. 1999:3)

CLIENT: Architecture Department - University of Pretoria

PROJECT DESCRIPTION: Alterations and additions to existing Boukunde building to facilitate an extension of workspace (studios, labs, open plan office), as well as formal exhibition space. Investigate opportunities for integration of modern services technology to reduce energy consumption, make better use of available resources and liberate the buildings space plan for current and future expansion prospects. Analyse existing building envelope daylighting and thermal performance - with practicable retrofit interventions to improve where necessary.

SPATIAL QUOTAS:

CURRENT	STUDIO/LAB SPACE	EXHIBITION SPACE (formal)	EXHIBITION SPACE (informal)
Basement	$0m^2$	$0m^2$	$210m^2$ (amphitheatre + basement store)
Ground floor	$660m^2$	$172m^2$	$60m^2$ (passage ways)
1st floor	$700m^2$	$150m^2$	$110m^2$ (passage ways)
2nd floor	$700m^2$	$0m^2$	$800m^2$ (1st year studio + passage ways)

With a projected 30% increase in student numbers, a general assumption can be made in respect of required floor area increase. A minimum 30% increase in formal work- and exhibition space would theoretically be required to service the departments short term requirements.

Additionally, space will be set aside for the exploitation of commercial potential. Amongst the Universities stated goals - listed in the Strategic Plan 2007-2011 (www.up.ac.za) - is the generation of funds via private initiatives. One such proposed initiative is for a printing facility to be set up, which would include the capacity to provide specialised services such as 3-dimensional printing. Such prototype modelling systems would be useful for the Architecture Department itself, as well as many other faculties or commercial entities who deal with the design and production of solid objects. Thus, a function that is directly relevant to the Departments activities could be leveraged for the financial benefit of the University itself.

"For a building, driving forces might include changes in technology, in the neighbourhood, in the economy, and in tenant use. The [planning] group ranks these driving forces in terms of importance and uncertainty, placing the most important and most uncertain highest, because it is the most important uncertainties that will drive the scenarios apart." (Brand. 1994:182)

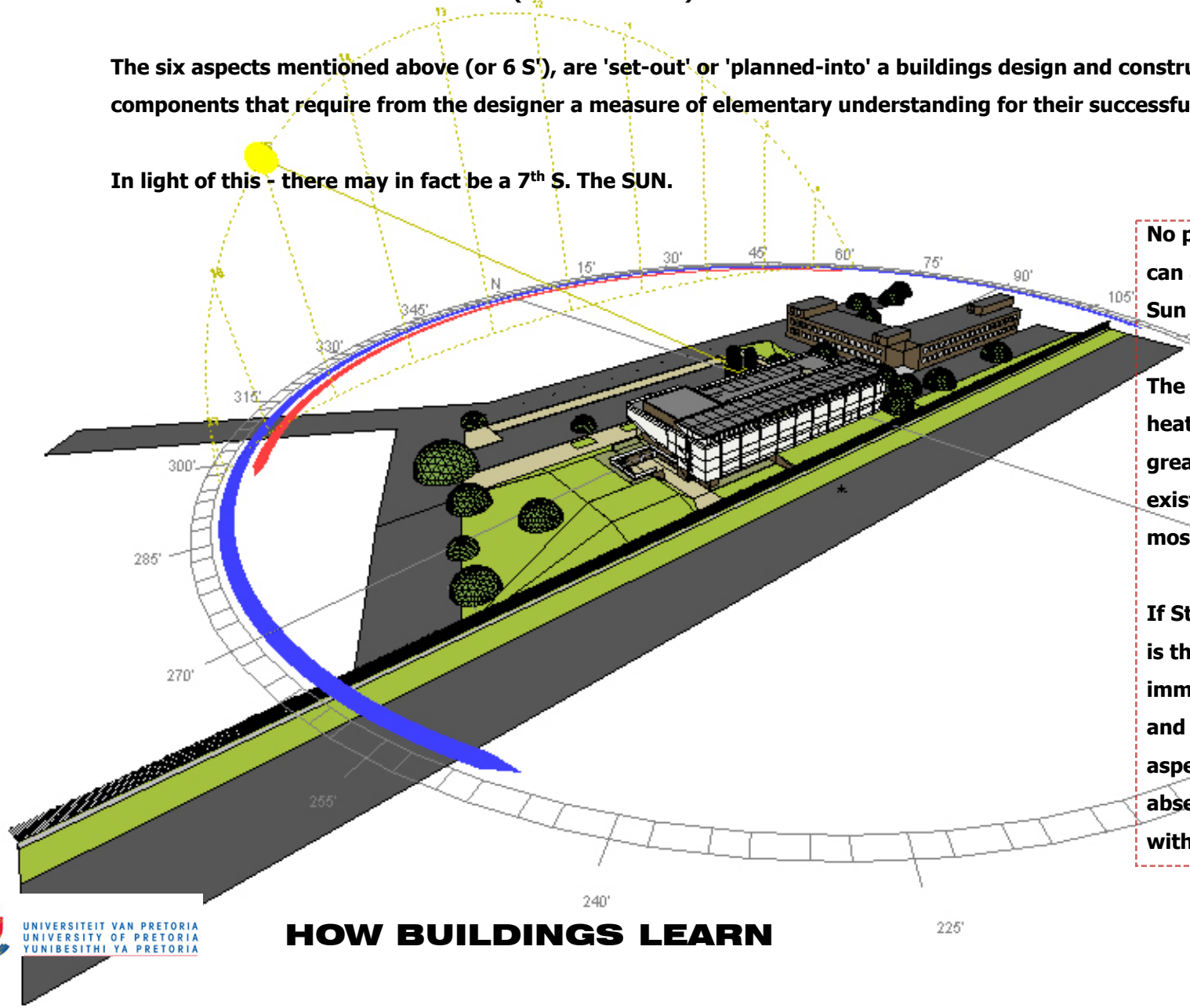
theory

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In his book "How buildings learn: what happens after they're built", Stewart Brand describes a list of Shearing Layers comprising (in order of temporal robustness) SITE, STRUCTURE, SKIN, SERVICES, SPACE PLAN, and STUFF. "This Time-layered perspective is fundamental to understanding how buildings actually behave." "Likewise the construction sequence is strictly in order: Site preparation, then foundation and framing the Structure, followed by Skin to keep out the weather, installation of Services, and finally Space plan. Then the tenants truck in their Stuff." (Brand. 1994:17)

The six aspects mentioned above (or 6 S'), are 'set-out' or 'planned-into' a buildings design and construction. They are parts of a whole - components that require from the designer a measure of elementary understanding for their successful integration into a bigger picture.

In light of this - there may in fact be a 7th S. The SUN.



No project in the built environment can afford to ignore the impact of the Sun on the other 6 S'.

The Sun is the provider of life, light, heat, energy and fuel - which, to greater or lesser extents - facilitate the existence of human-kind, as well as most other forms of life on this planet.

If Stuff is the most transient, and Site is the most persistent - then Sun is the immovable, unwaivering, unforgiving and obstinate of the 7 S'. It is also the aspect that is most conspicuous by it's absence- or overbearing presence within our buildings.

"The diameter of the Sun is about 1.4 million km, 109 times that of the Earth."

"Its volume is big enough to hold over 1 million Earths."

"Temperature in the centre of the Sun = 1.5 million°C."

"The Sun converts 600 million tons of hydrogen into 596 million tons of helium every second - the extra 4 million tons is converted into energy in the form of gamma rays."

"You can imagine the enormity of the energy generated when you realise that, given Albert Einstein's $E=MC^2$, the 4 million ton differential is multiplied by the speed of light.....squared."

"The Sun gives off 6200 watts of light from every square centimetre of its surface."

"The average distance from the Earth to the Sun is 150 million kilometres, which takes sunlight around 8.5 minutes to travel."

(www.naturalfrequency.com)

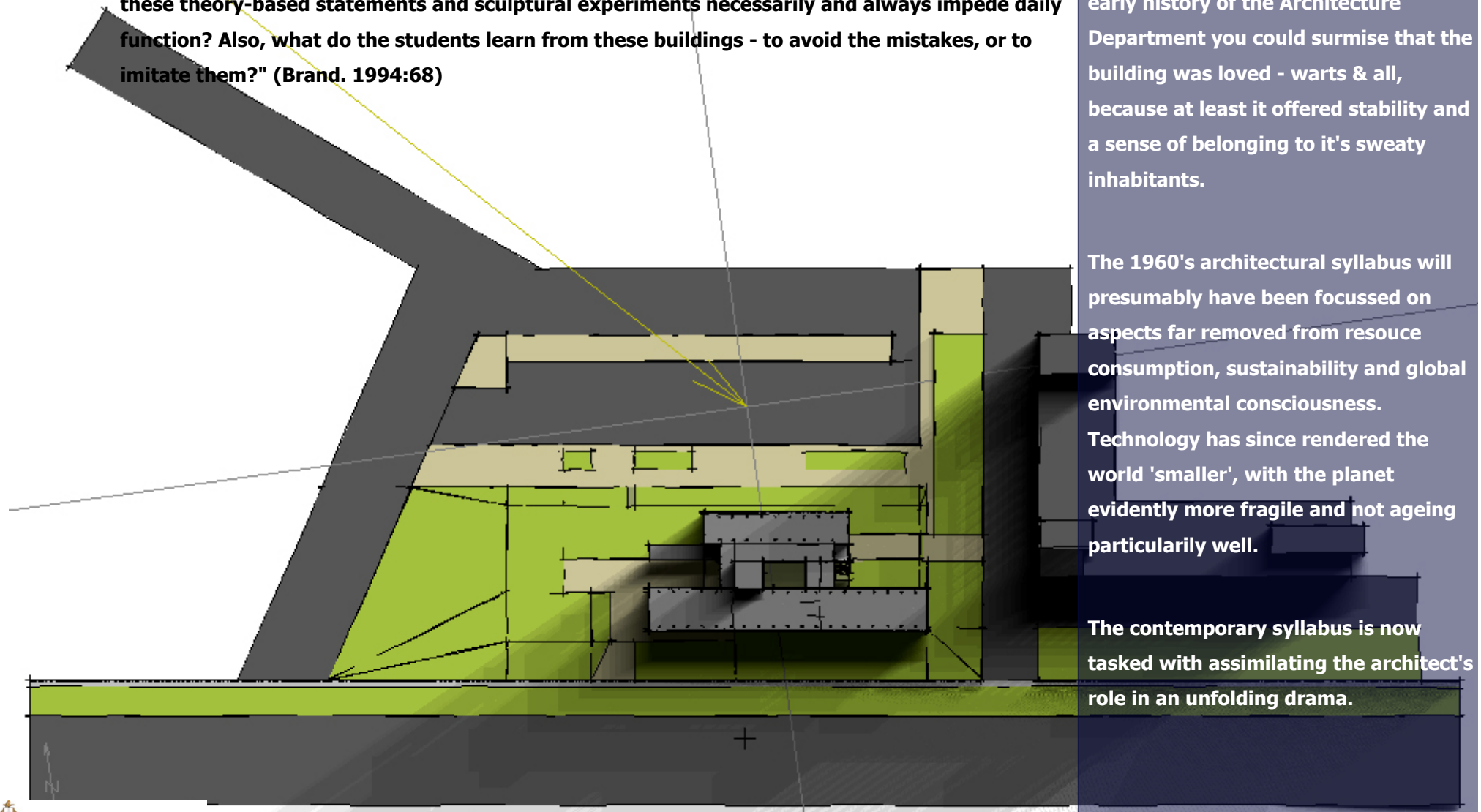
In an age where mankind is having to explore alternate conduits for the sun's energy by way of necessity - it has brought the 7th S into sharper focus. We are looking skyward to secure our resource future, and whilst market forces are more than likely the primary drivers of this awakening, solar profits are in fact available to everyone.

This is not revolutionary thinking by any stretch of an imaginative mind, but the penny truly drops when the cost of artificially maintaining comfort levels within our buildings becomes virtually unsustainable.

"Dewey pointed out that learning takes place by doing, and refers to two aspects: continuity, where a student would connect new knowledge with previous experience, and interaction, where the student will be actively involved in learning in her/his environment. Individuals construct their own meaning through reflecting on their interaction with their surroundings." (Constandius. 2006:2)

didactic value

"A cruel but pointed project would be a systematic study of the failings of the buildings that house university architecture departments. Invariably designed and built with great fanfare, as a class they are perhaps the most loathed of all academic buildings. From Paul Rudolphs infamously brutalist Art and Architecture Building at Yale to the harsh Wurster Hall at Berkeley, the buildings are exciting and unworkable. Are they unworkable because they are exciting? Do these theory-based statements and sculptural experiments necessarily and always impede daily function? Also, what do the students learn from these buildings - to avoid the mistakes, or to imitate them?" (Brand. 1994:68)

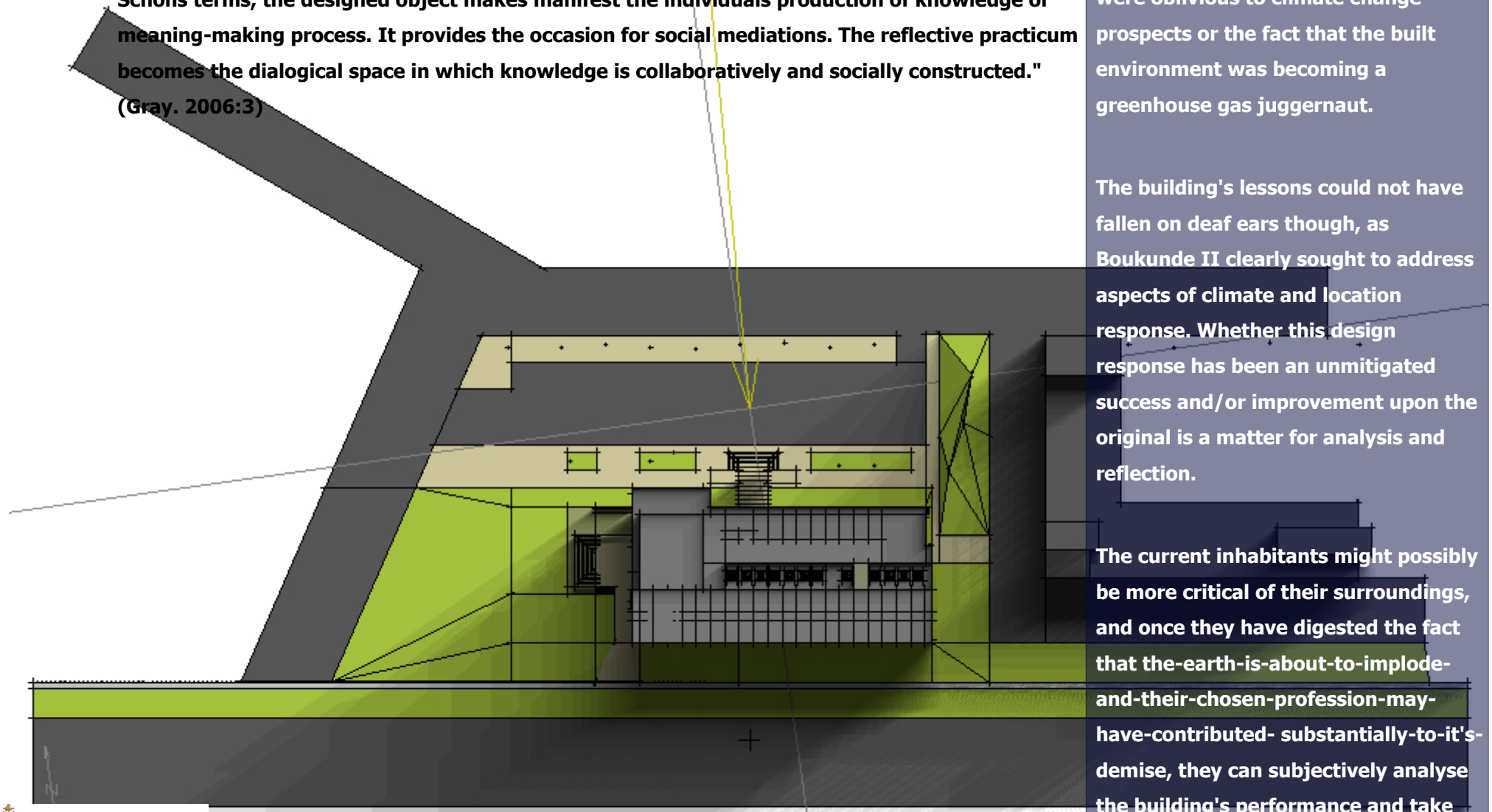


Boukunde I was essentially a 'glass box' that adopted no obvious measures to protect itself against the elements - most notably the harsh summer sky. Based upon the tortured early history of the Architecture Department you could surmise that the building was loved - warts & all, because at least it offered stability and a sense of belonging to it's sweaty inhabitants.

The 1960's architectural syllabus will presumably have been focussed on aspects far removed from resouce consumption, sustainability and global environmental consciousness. Technology has since rendered the world 'smaller', with the planet evidently more fragile and not ageing particularily well.

The contemporary syllabus is now tasked with assimilating the architect's role in an unfolding drama.

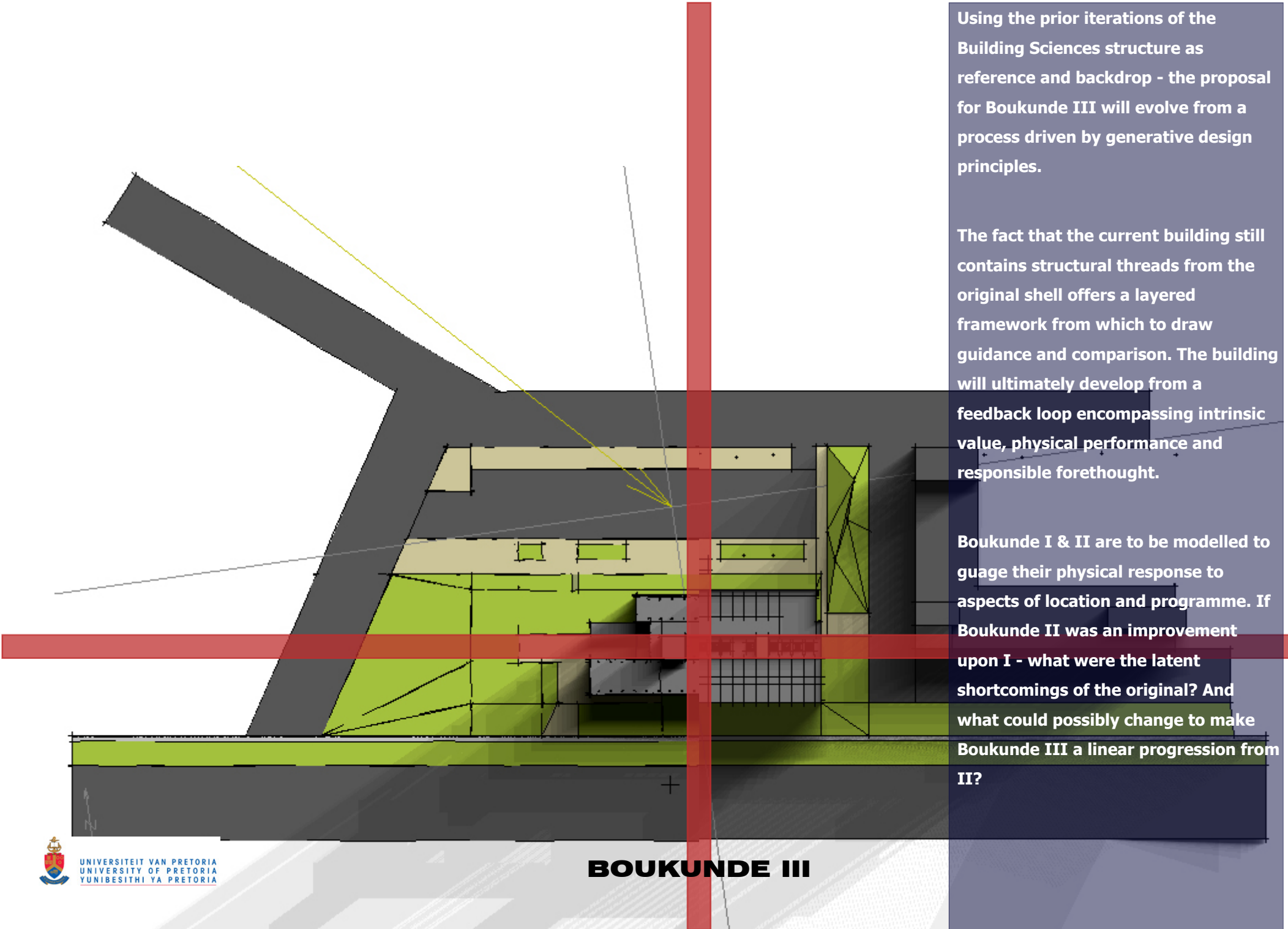
"Knowledge is only perceived as knowledge, by designers, when it is instrumentalised in specific appreciative contexts. It is for this reason that constructivism does not prescribe methods of teaching and learning. Artistry cannot be taught because definitions of artistry are contingent. Further, knowledge constructs are unique to individuals and cannot exist in a pure form outside of their own experience. This however does not preclude the mediation of individual learning. In Schöns terms, the designed object makes manifest the individuals production of knowledge or meaning-making process. It provides the occasion for social mediations. The reflective practicum becomes the dialogical space in which knowledge is collaboratively and socially constructed." (Gray. 2006:3)



Boukunde I possibly resembled an artists colony that revelled in the absence of modern-day fatalist concerns. One can assume that most, if not all - 1965 architecture graduates were oblivious to climate change prospects or the fact that the built environment was becoming a greenhouse gas juggernaut.

The building's lessons could not have fallen on deaf ears though, as Boukunde II clearly sought to address aspects of climate and location response. Whether this design response has been an unmitigated success and/or improvement upon the original is a matter for analysis and reflection.

The current inhabitants might possibly be more critical of their surroundings, and once they have digested the fact that the-earth-is-about-to-implode-and-their-chosen-profession-may-have-contributed- substantially-to-it's-demise, they can subjectively analyse the building's performance and take it's lessons into practice.



Using the prior iterations of the Building Sciences structure as reference and backdrop - the proposal for Boukunde III will evolve from a process driven by generative design principles.

The fact that the current building still contains structural threads from the original shell offers a layered framework from which to draw guidance and comparison. The building will ultimately develop from a feedback loop encompassing intrinsic value, physical performance and responsible forethought.

Boukunde I & II are to be modelled to guage their physical response to aspects of location and programme. If Boukunde II was an improvement upon I - what were the latent shortcomings of the original? And what could possibly change to make Boukunde III a linear progression from II?

"The situative perspective claims that learning takes place while you are in the process of participation in a community or with objects like technology. The focus is on meaningful interaction." (Constandius. 2006:6)

The primary computer modelling and analysis platform being used is ECOTECT, which will offer generative feedback on the performance of the existing- and pre-existing constructions. It will also then be used to validate the responsiveness of the proposal that emanates.

"...at the earliest stages of design it is only really possible to work with subjective issues as there is insufficient hard information about the building to calculate many of the objective criteria. Computer systems tend to be of little use in tasks that involve subjective or unquantifiable parameters, but excel at objective tasks with clearly defined and quantifiable parameters, and highly repetitive or iterative problems." (Haghparast. 2004:1)

In this instance however, there is sufficient "hard information" to base the modelling upon. The process of design is thus informed from the onset by an inventory of subjective- as well as objective criteria.

"Site dominates the Structure, which dominates the Skin, which dominates the Services, which dominate the Space plan, which dominates the Stuff." (Brand. 1994:17)

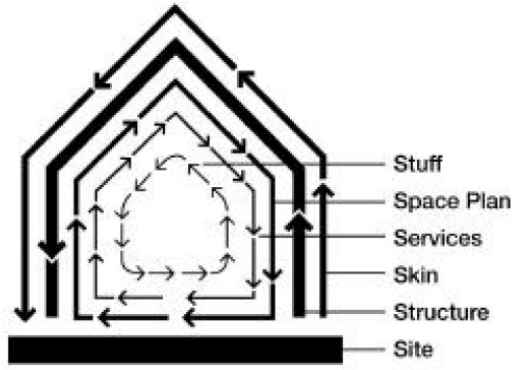
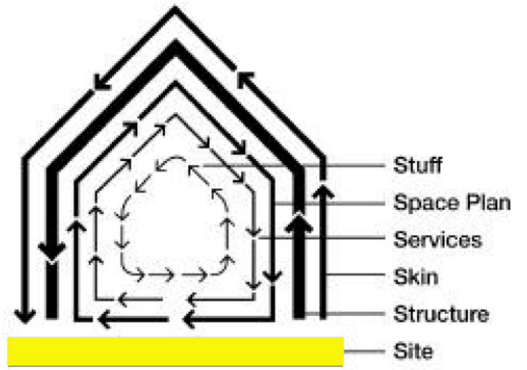


Figure 14 : Shearing Layers of Change (Brand. 1994:13)



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analysis : site

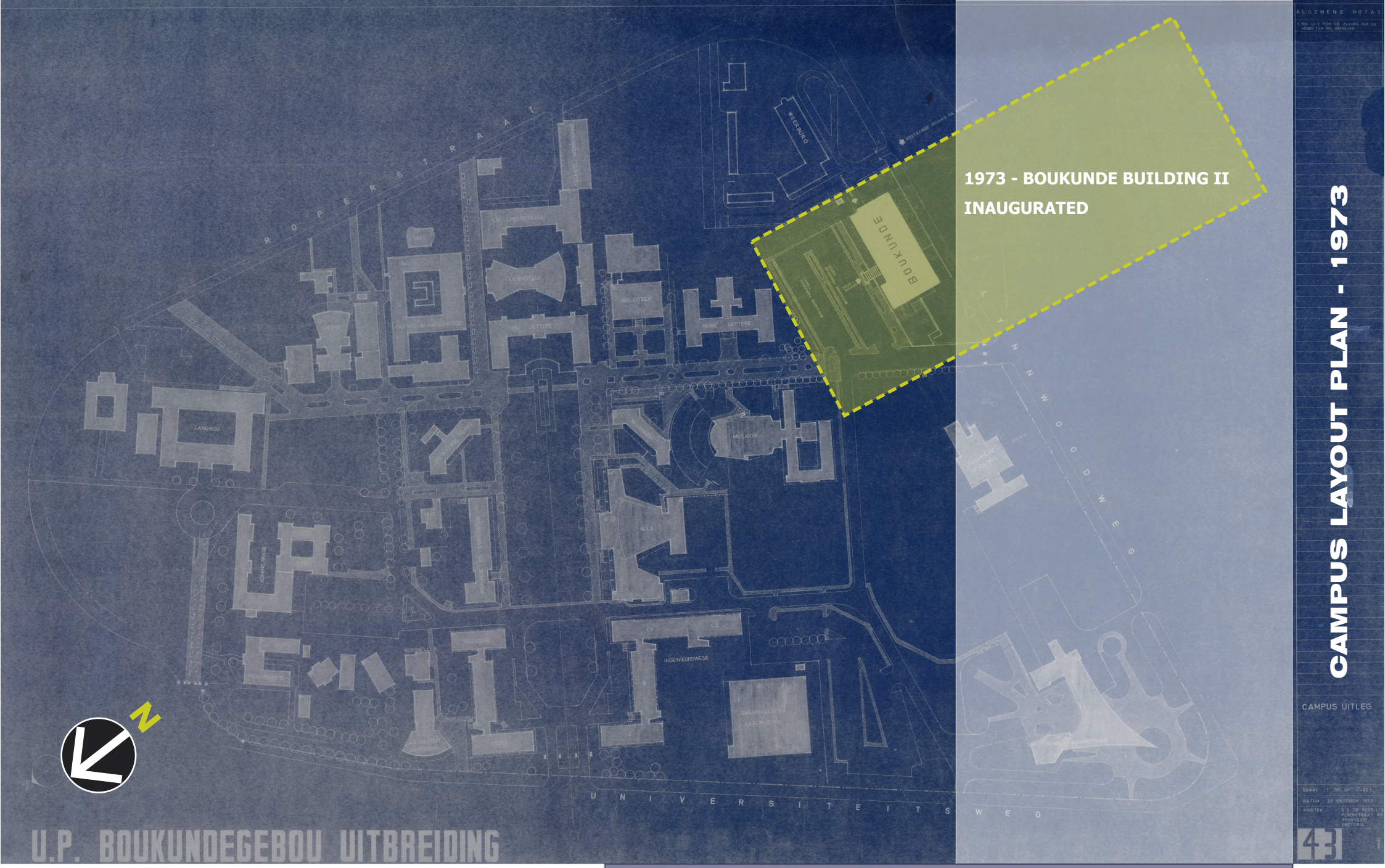
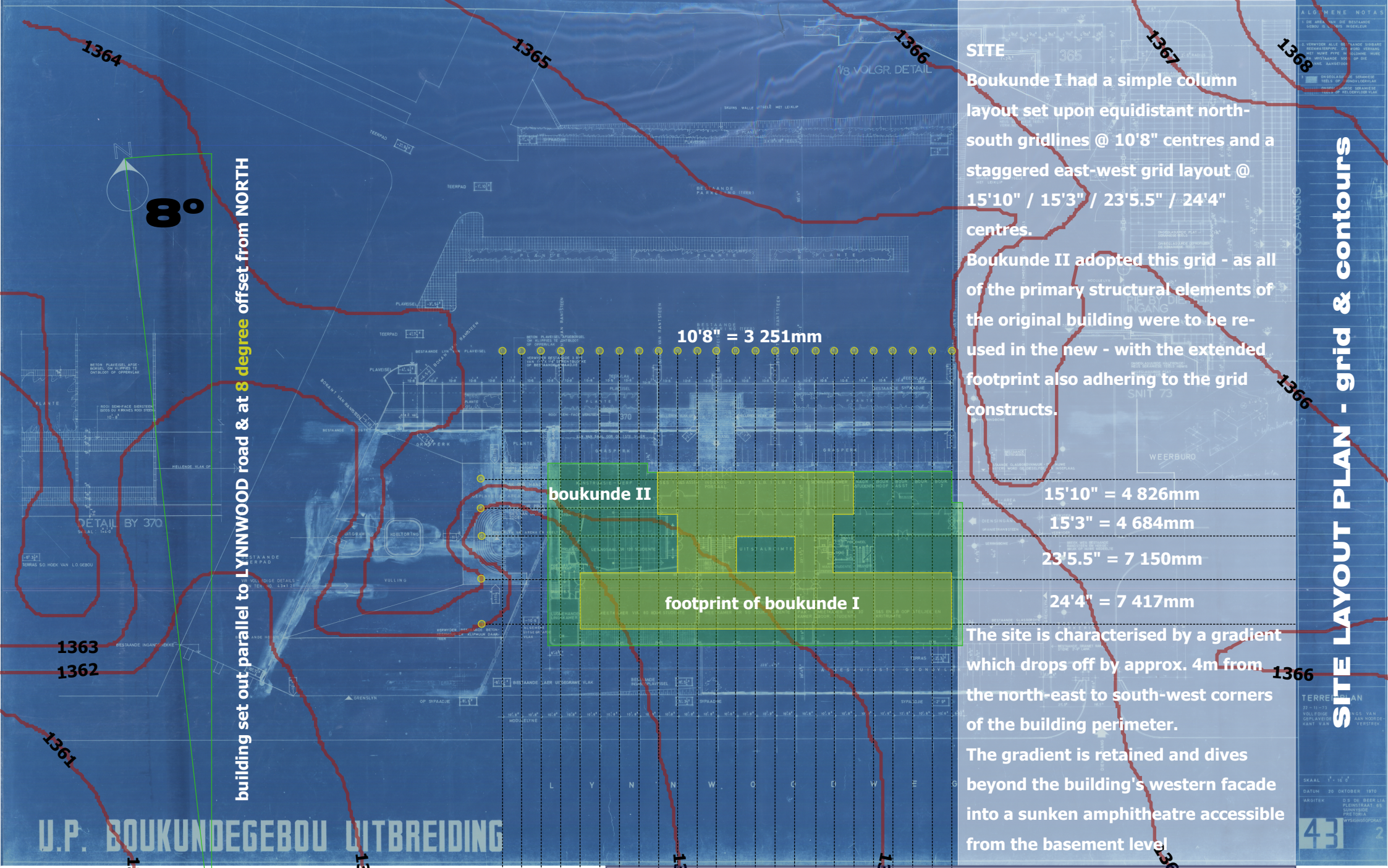


Figure 15 : Campus Layout Plan - drawing no. 43-1 (D.S. De Beer Architects)



SITE

Boukunde I had a simple column layout set upon equidistant north-south gridlines @ 10'8" centres and a staggered east-west grid layout @ 15'10" / 15'3" / 23'5.5" / 24'4" centres.

Boukunde II adopted this grid - as all of the primary structural elements of the original building were to be re-used in the new - with the extended footprint also adhering to the grid constructs.

15'10" = 4 826mm

15'3" = 4 684mm

23'5.5" = 7 150mm

24'4" = 7 417mm

The site is characterised by a gradient which drops off by approx. 4m from the north-east to south-west corners of the building perimeter.

The gradient is retained and dives beyond the building's western facade into a sunken amphitheatre accessible from the basement level

Figure 16 : Site Layout Plan - drawing no. 43-2 (D.S. De Beer Architects)



SITE

Most of the pre-existng vegetation on the east- & west flanks of the building has been kept as is, with minor planting of new vegetation directly against the northern- & southern extents of the buildings footprint.
Planters have been added to divide the paving expanse in front of the building, as well as the parking area pedestrian island.
The tarred parking area is largely exposed to the northern sun, and the 'heat island' effect that it generates in summer is scarcely attenuated by the plants to the building's north.
The large trees to the west offer no overshadow for the western facade, whereas the trees to the east do significantly overshadow the eastern face.

SITE LAYOUT PLAN - hard & soft landscape

Figure 17 : Site Layout Plan - drawing no. 43-2 (D.S. De Beer Architects)

park street

railway line

burnett street

university road

lynnwood road

duncan road

SITE

Certainly urban campus development presents a dichotomous institutional agenda, which needs to negotiate the prospects of open engagement and the campus as an academic refuge designed for the contemplation, analysis and resolution of "...lifes great problems". According to Blaik, this quest for cloistered serenity results in three problematic physical characteristics namely "inward-looking orientation, zones of separation and defensive building design". (Blaik. 2006:B25)

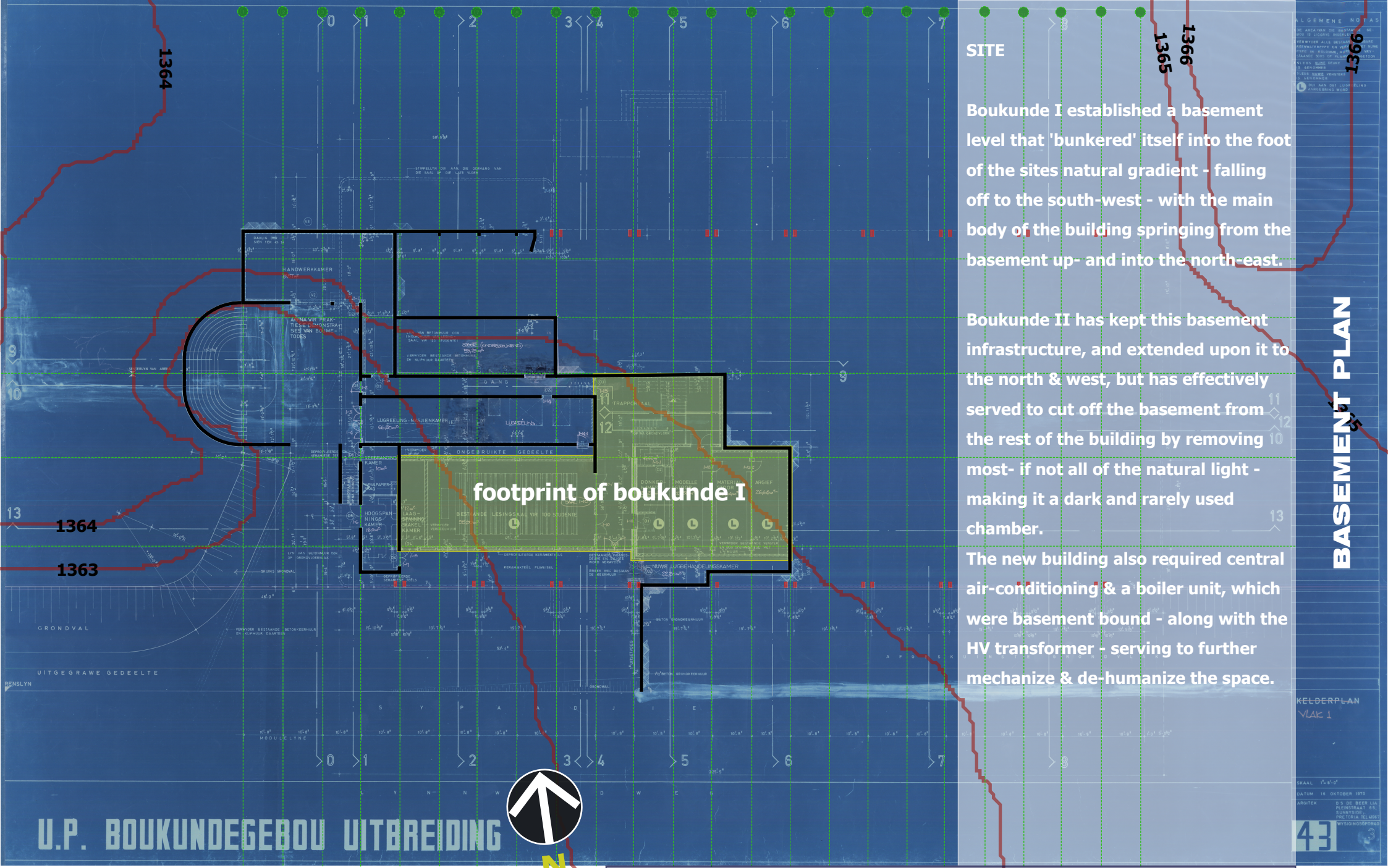
Boukunde II has made a conscious effort to orientate itself inward, and employs defensive design on its southern elevation by displaying a solemn, protective concrete facade to lynnwood road.

Boukunde I had some measure of connection to the south with its main entrance being to the west, whereas currently the building is entered from the insular north side of the building.

Figure 18 : Aerial View over UP Main Campus (Google Earth)

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Image © 2008 DigitalGlobe
Streaming 100%
Pointer 25°45'10.61" S 28°13'53.56" E elev 1379 m
Eye alt 2.85 km



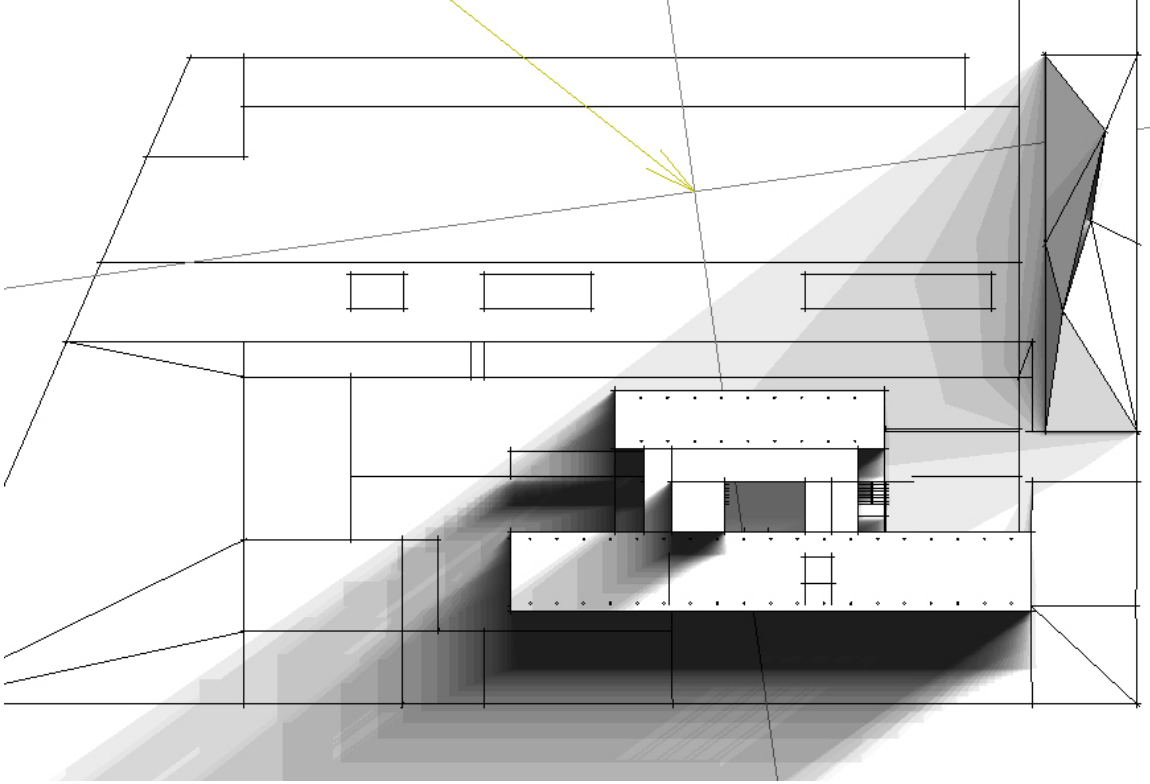
SITE

Boukunde I established a basement level that 'bunkered' itself into the foot of the sites natural gradient - falling off to the south-west - with the main body of the building springing from the basement up- and into the north-east.

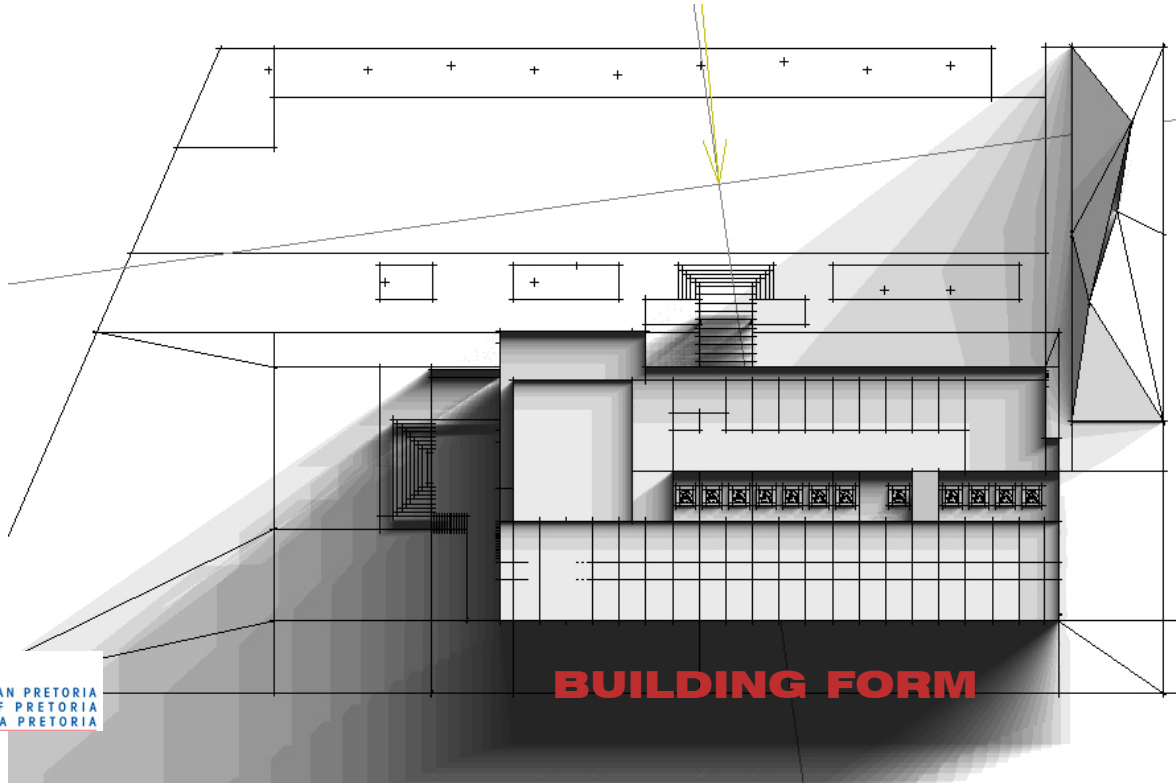
Boukunde II has kept this basement infrastructure, and extended upon it to the north & west, but has effectively served to cut off the basement from the rest of the building by removing most- if not all of the natural light - making it a dark and rarely used chamber.

The new building also required central air-conditioning & a boiler unit, which were basement bound - along with the HV transformer - serving to further mechanize & de-humanize the space.

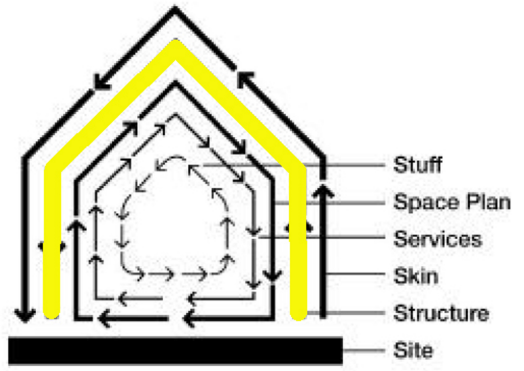
Figure 19 : Basement Plan - drawing no. 43-3 (D.S. De Beer Architects)



BOUKUNDE I building form comprised 2 east-west oriented flanks with north-south passage connections between the 2. The resulting central space was turned into an open-air courtyard with visual connection to the building's internals on all 4 sides. This transparency translated into exposure of the floor plan to unfavourable east & west daylight conditions. The courtyard and circulation routes served to separate the northern office / classroom flank from the southern studio / workshop flank.



BOUKUNDE II has substantially increased the floor surface area with the additional level (2nd floor) as well as the supplementary lecture halls (2-6 & 3-3) on the western flank of the building. The result is effectively an inward-looking closure of the building - relieving east & west daylight exposure. The central courtyard has remained in principle, but is no longer exposed to the elements. The circulation routes and segregation of functional space remains generally as it was, but with increased studio space and office allocation.



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analysis : structure

STRUCTURE

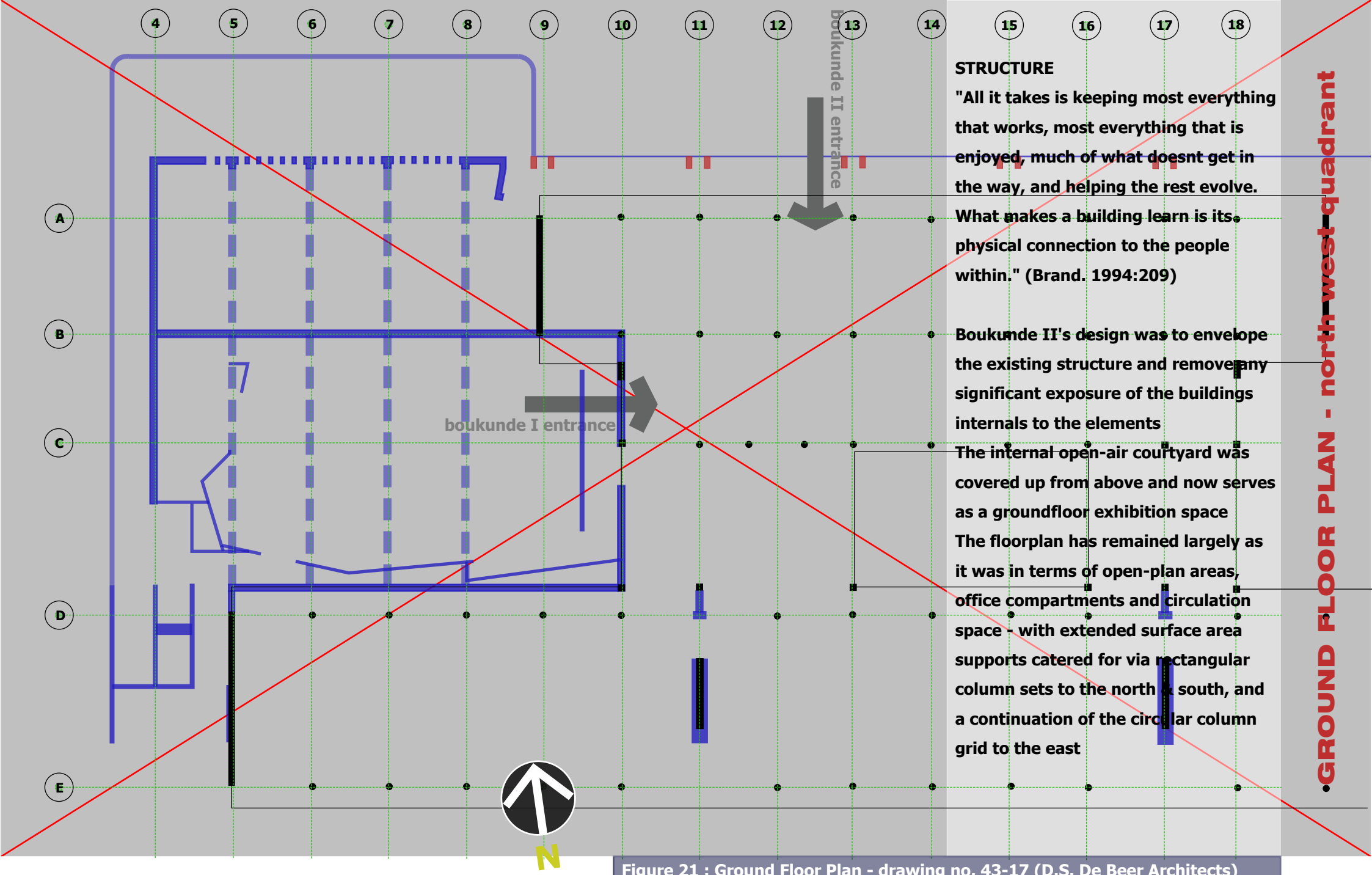
"After Site comes Structure, at the base of which is the all-determining foundation. If it is out-of-square or out-of-level, it will plague the builders clear to the roof line..." "If it is weak, it permanently limits the height of the building." (Brand. 1994:19)

Due to the fact that Boukunde II was essentially built upon the pre-existing footprint, the original foundation layout and construction is pertinent in evaluating future prospects.

All of the original structural elements still stand today and have been reinforced via 'gunite' or extra brickwork layering, and ultimately supplemented by new column sets where necessary.

The building's levelling and construction has been set into the existing land profile, which means that there has been minimal excavation disturbance of the existing terrain and a sound structural legacy is the result.

Figure 20 : Foundation Plan - drawing no. UPA 1 (UP School of Architecture)



STRUCTURE

"All it takes is keeping most everything that works, most everything that is enjoyed, much of what doesnt get in the way, and helping the rest evolve. What makes a building learn is its physical connection to the people within." (Brand. 1994:209)

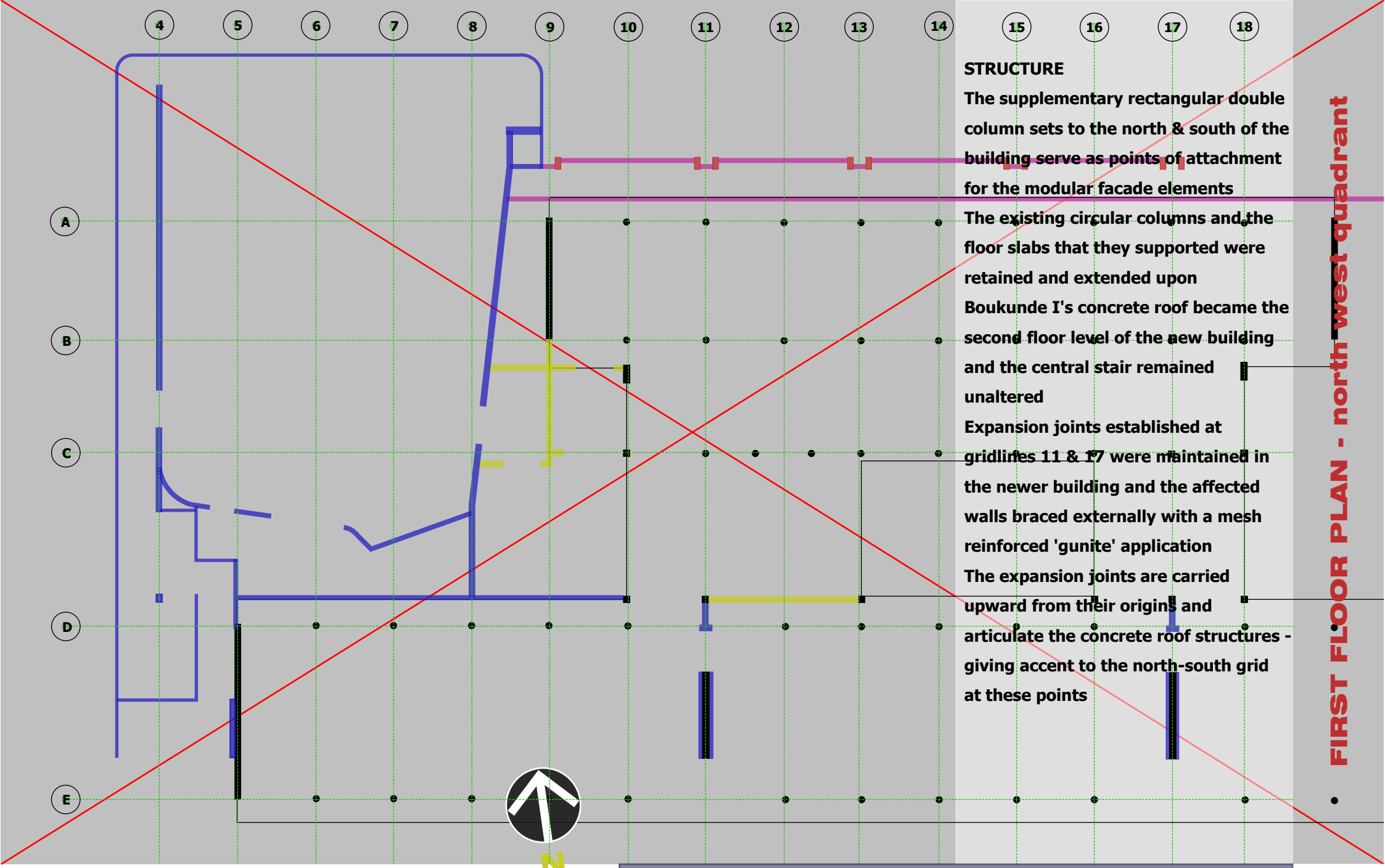
Boukunde II's design was to envelope the existing structure and remove any significant exposure of the buildings internals to the elements

The internal open-air courtyard was covered up from above and now serves as a groundfloor exhibition space

The floorplan has remained largely as it was in terms of open-plan areas, office compartments and circulation space - with extended surface area supports catered for via rectangular column sets to the north & south, and a continuation of the circular column grid to the east

GROUND FLOOR PLAN - north-west quadrant

Figure 21 : Ground Floor Plan - drawing no. 43-17 (D.S. De Beer Architects)



STRUCTURE

The supplementary rectangular double column sets to the north & south of the building serve as points of attachment for the modular facade elements

The existing circular columns and the floor slabs that they supported were retained and extended upon

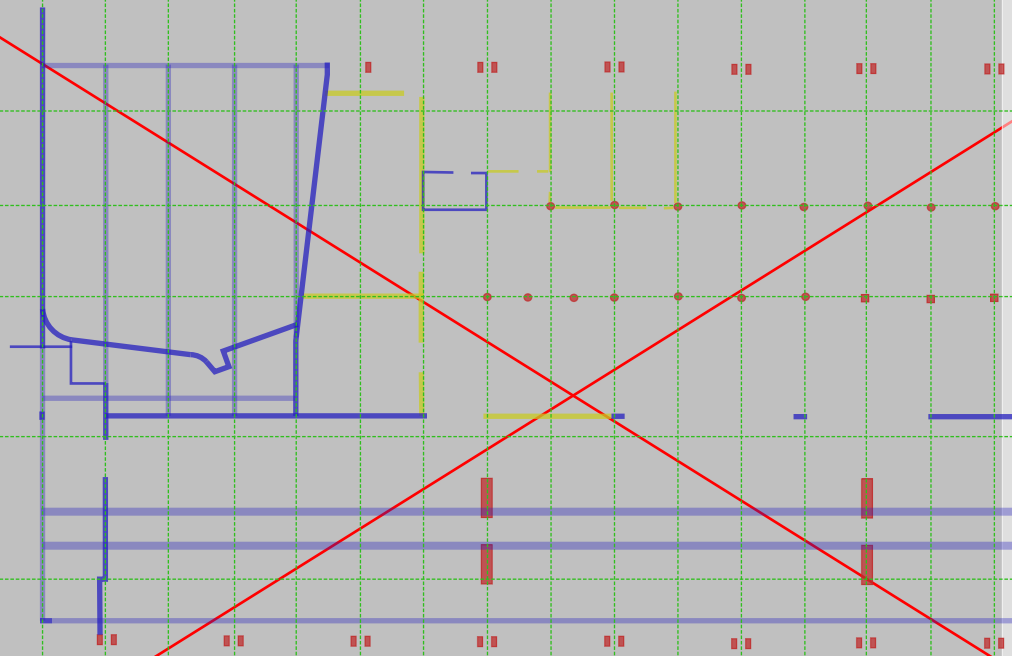
Boukunde I's concrete roof became the second floor level of the new building and the central stair remained unaltered

Expansion joints established at gridlines 11 & 17 were maintained in the newer building and the affected walls braced externally with a mesh reinforced 'gunite' application

The expansion joints are carried upward from their origins and articulate the concrete roof structures - giving accent to the north-south grid at these points

FIRST FLOOR PLAN - north west quadrant

Figure 22 : First Floor Plan - drawing no. 43-19 (D.S. De Beer Architects)



STRUCTURE

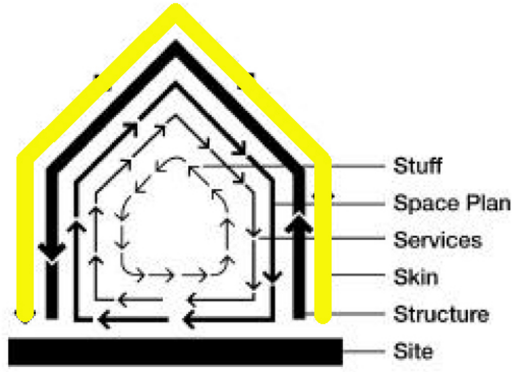
The second floor of Boukunde II is in effect the roof of Boukunde I, with the roofs of the newer building supported by the new north & south rectangular column sets - supplemented by new internal columns and concrete wall structures set onto the grid

The new roof elements introduced by Boukunde II - which are the roof over lecture hall 3-3 and the 'flying' clerestory over the second floor studios are supported via their own independantly founded concrete structures with non-structural brick infill making up the remainder of the partitioning on this level

SECOND FLOOR PLAN

N

Figure 23 : Second Floor Plan - drawing no. 43-53 (D.S. De Beer Architects)



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analysis : skin

west & east facades: 6" (152mm) thick off-shutter concrete shell minimal fenestration

decisive aspect: general noise attenuation

positive consequence: noise is successfully excluded from the studios & lecture halls on all 3 levels

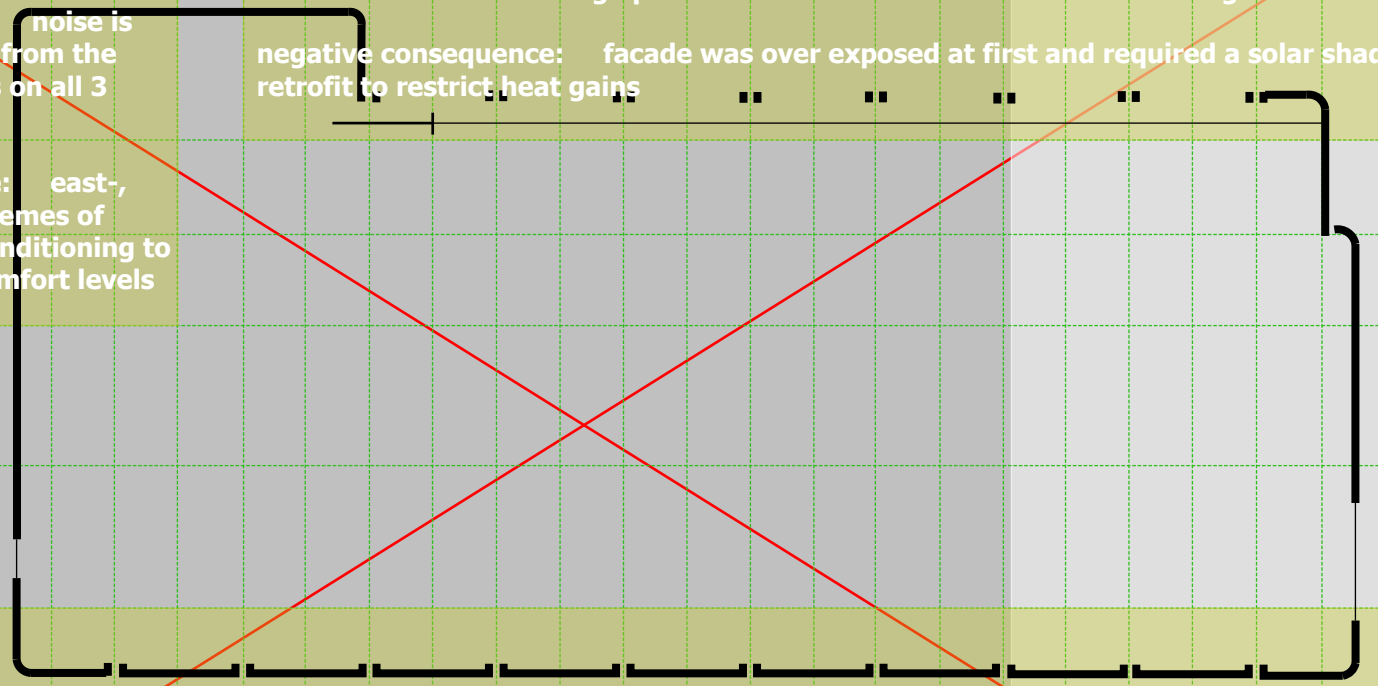
negative consequence: east-, west- & southern extremes of building require air conditioning to maintain perennial comfort levels

northern facade: 5'1" (1 550mm) deep balcony offset from external facade with 1:2 ratio of brick : glazing over full vertical surface area

decisive aspect in choice of materials / construction: allowing natural light and ventilation to enter building through office areas

positive consequence: offices along northern perimeter act as light shelves and do facilitate limited air change potential for the northern half of the building

negative consequence: facade was over exposed at first and required a solar shade retrofit to restrict heat gains

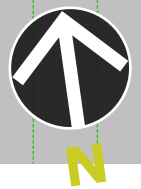


southern facade: 7" (178mm) thick off-shutter concrete panels spanning 21'4" (6 502mm) centres

decisive aspect in choice of materials / construction: lynnwood road traffic noise attenuation

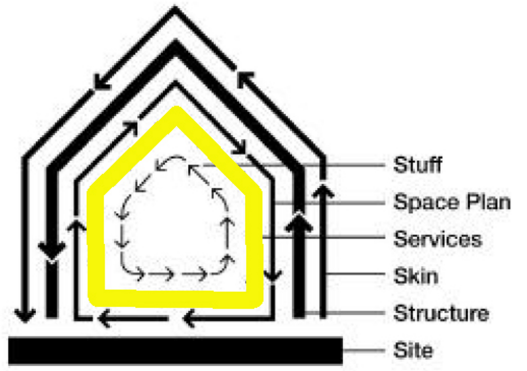
positive consequence: traffic noise is successfully excluded from the studios on all 3 levels

negative consequence: narrow double glazed window units of 1'8.25" (515mm) width provide negligible natural light and ventilation to the studios



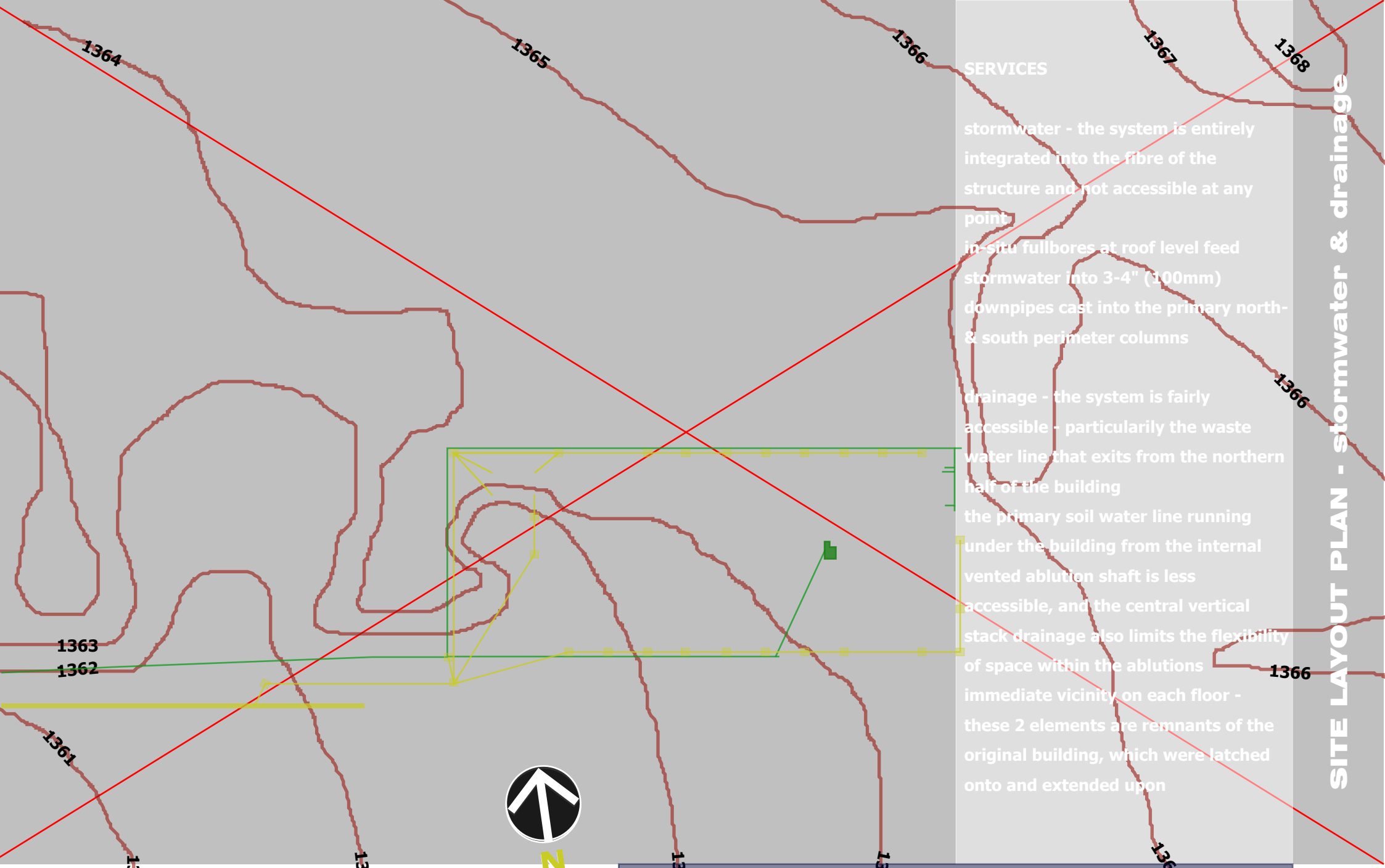
SECOND FLOOR PLAN

Figure 24 : Second Floor Plan - drawing no. 43-53 (D.S. De Beer Architects)



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nalysis : services



SERVICES

stormwater - the system is entirely integrated into the fibre of the structure and not accessible at any point
in-situ fullbores at roof level feed stormwater into 3-4" (100mm) downpipes cast into the primary north- & south perimeter columns

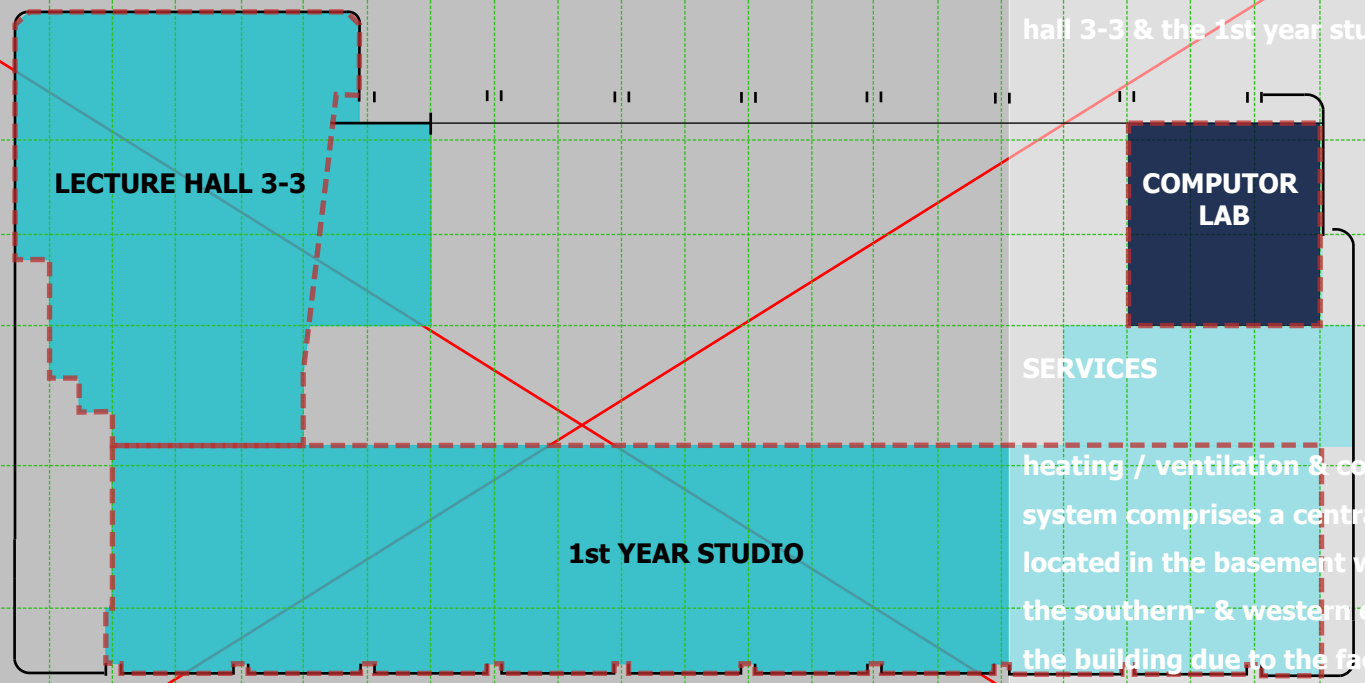
drainage - the system is fairly accessible - particularly the waste water line that exits from the northern half of the building
the primary soil water line running under the building from the internal vented ablution shaft is less accessible, and the central vertical stack drainage also limits the flexibility of space within the ablutions immediate vicinity on each floor - these 2 elements are remnants of the original building, which were latched onto and extended upon

SITE LAYOUT PLAN - stormwater & drainage

Figure 25 : Site Plan (drainage) - drawing no. 43-49 (D.S. De Beer Architects)

building drainage to municipal offtake | stormwater runoff to municipal sewer | contoured natural site gradient

SECOND FLOOR PLAN - air conditioning



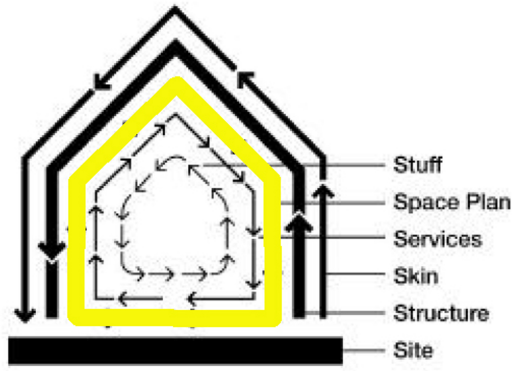
The 2 largest consumers of conditioned air - due to their high ceilings, large volumes & potentially high dynamic heat loads - are lecture hall 3-3 & the 1st year studio.

SERVICES

heating / ventilation & cooling - the system comprises a central a/c unit located in the basement which serves the southern- & western extremes of the building due to the fact that fenestration is limited in these areas - to reduce traffic noise in the studios and lecture halls.

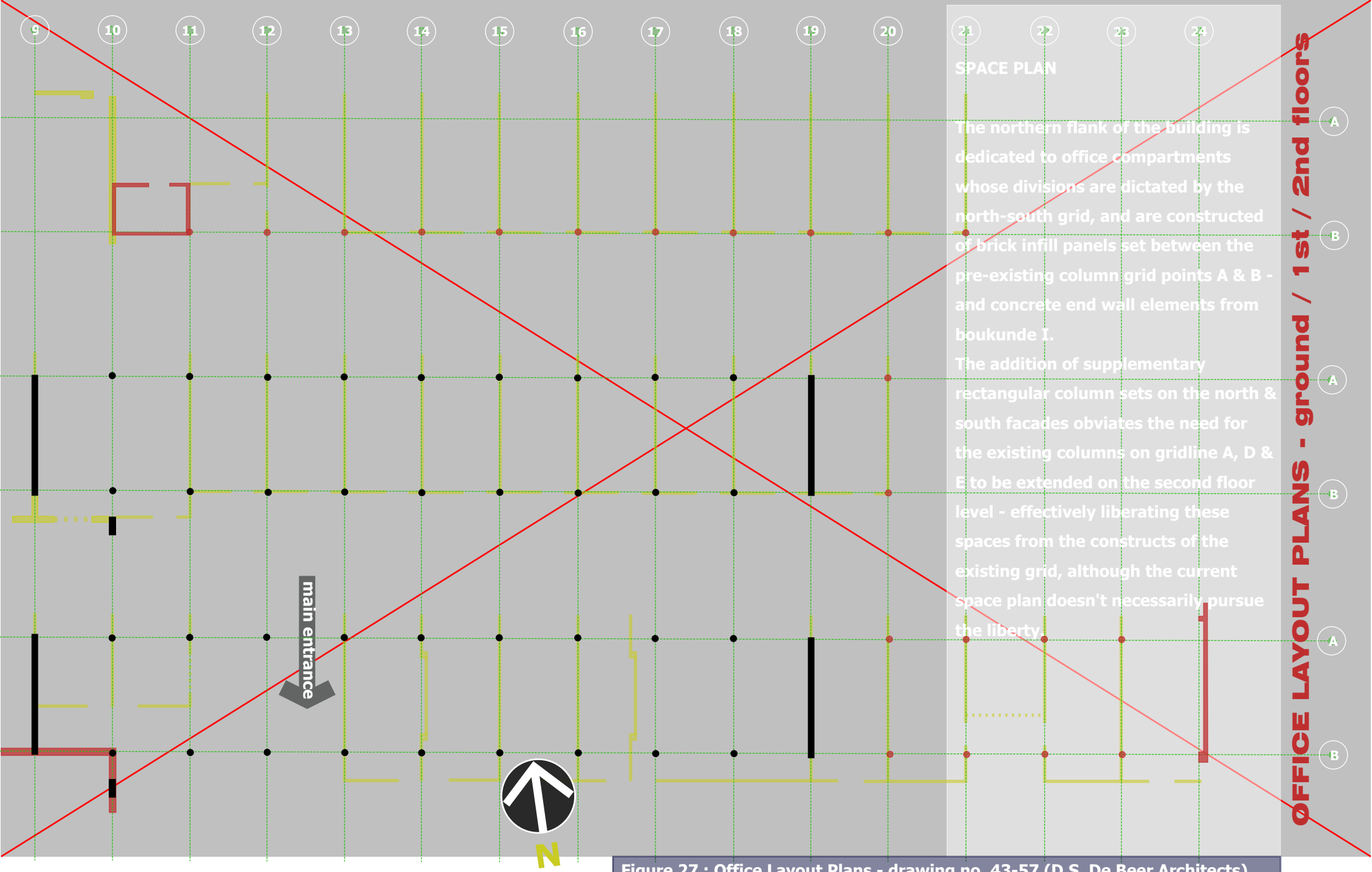
The 2nd floor computor lab is also mechanically ventilated via split units located on the roof - an afterthought due to the fact that in 1973 architectural computor labs were probably considered science fiction.

Figure 26 : Second Floor Plan - drawing no. 43-53 (D.S. De Beer Architects)



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lysis : space plan



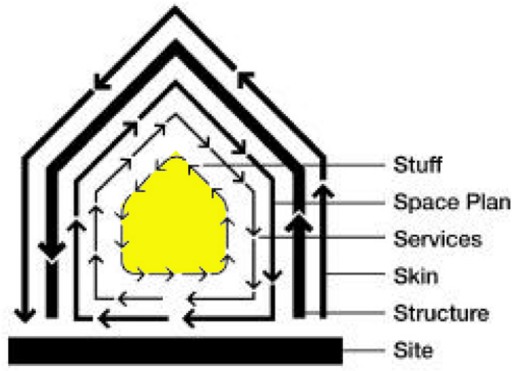
SPACE PLAN

The northern flank of the building is dedicated to office compartments whose divisions are dictated by the north-south grid, and are constructed of brick infill panels set between the pre-existing column grid points A & B - and concrete end wall elements from boukunde I.

The addition of supplementary rectangular column sets on the north & south facades obviates the need for the existing columns on gridline A, D & E to be extended on the second floor level - effectively liberating these spaces from the constructs of the existing grid, although the current space plan doesn't necessarily pursue the liberty.

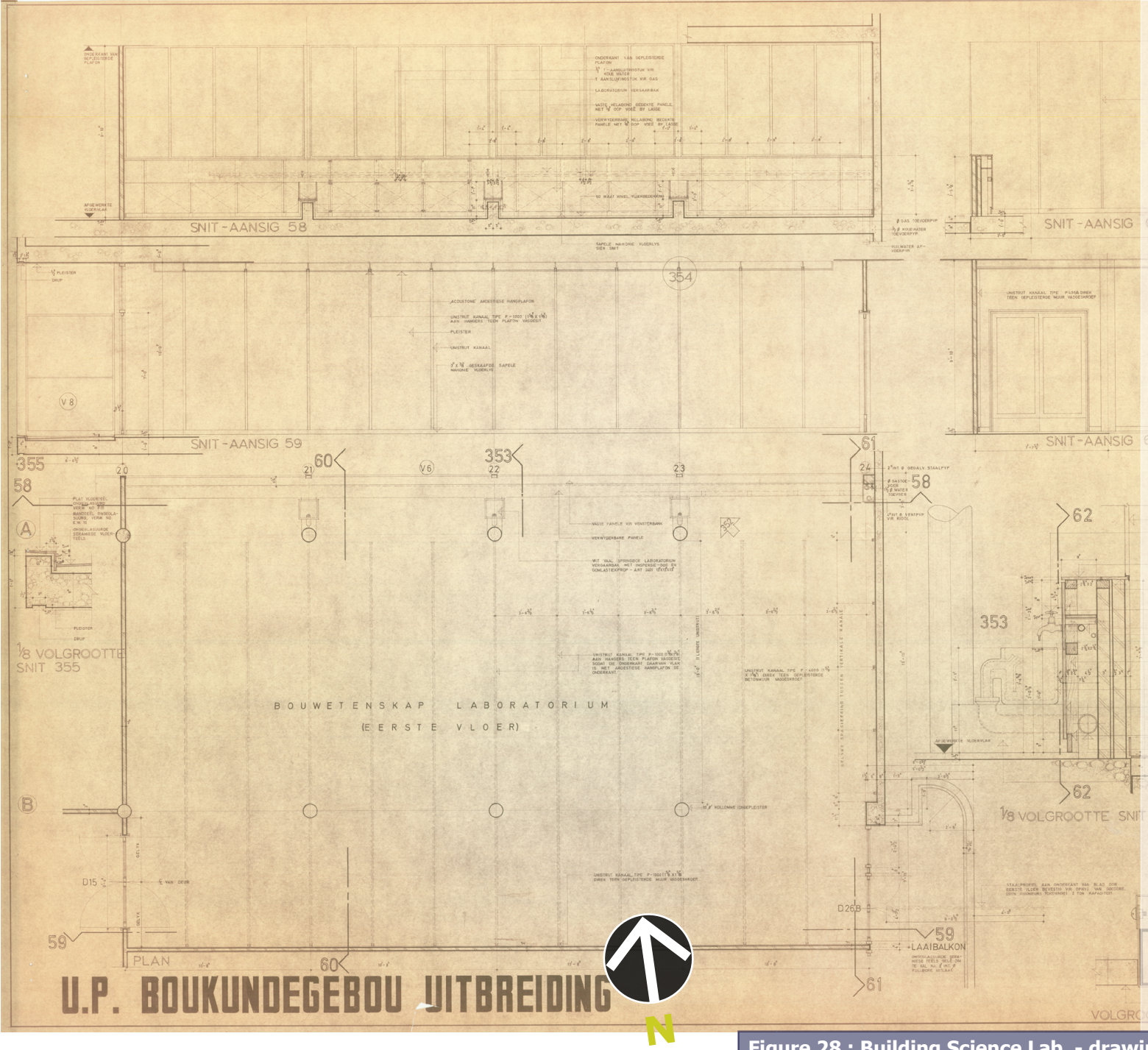
ØFFICE LAYOUT PLANS - ground / 1st / 2nd floors

Figure 27 : Office Layout Plans - drawing no. 43-57 (D.S. De Beer Architects)



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analysis : stuff



"Inherent to the Modern movement is the German idea of gestalt - totality. Its Bauhaus. Its a terribly powerful word that was interpreted by architects as the power to determine every detail of the building. And you cannot touch anything once its there." Brand, quoting Frank Duffy. (Brand. 1994:63)

"A second major challenge is to understand and plan for a learning environment relevant for the future. The current model of spending primarily to construct new classrooms and labs to meet learning needs may not be the best investment. We need to consider new pedagogical trends carefully before building more structures based on yesterday's learning styles."

BUILDING SCIENCE LAB - details

UITBREIDING
BOUWETENSKAP
LABORATORIUM

11 FEB 1970

Figure 28 : Building Science Lab - drawing no. 43-62 (D.S. De Beer Architects)

"Students and faculty members are increasingly aware of the benefits of a group collaborative approach to learning. We constantly hear students talk about the challenge of finding appropriate group-study space, particularly during the late-night hours. Technology-savvy students can increasingly afford laptops and personal-data assistants; a wireless campus will mean that learning can, and will, happen anywhere." (Kenney. 2006:B28)

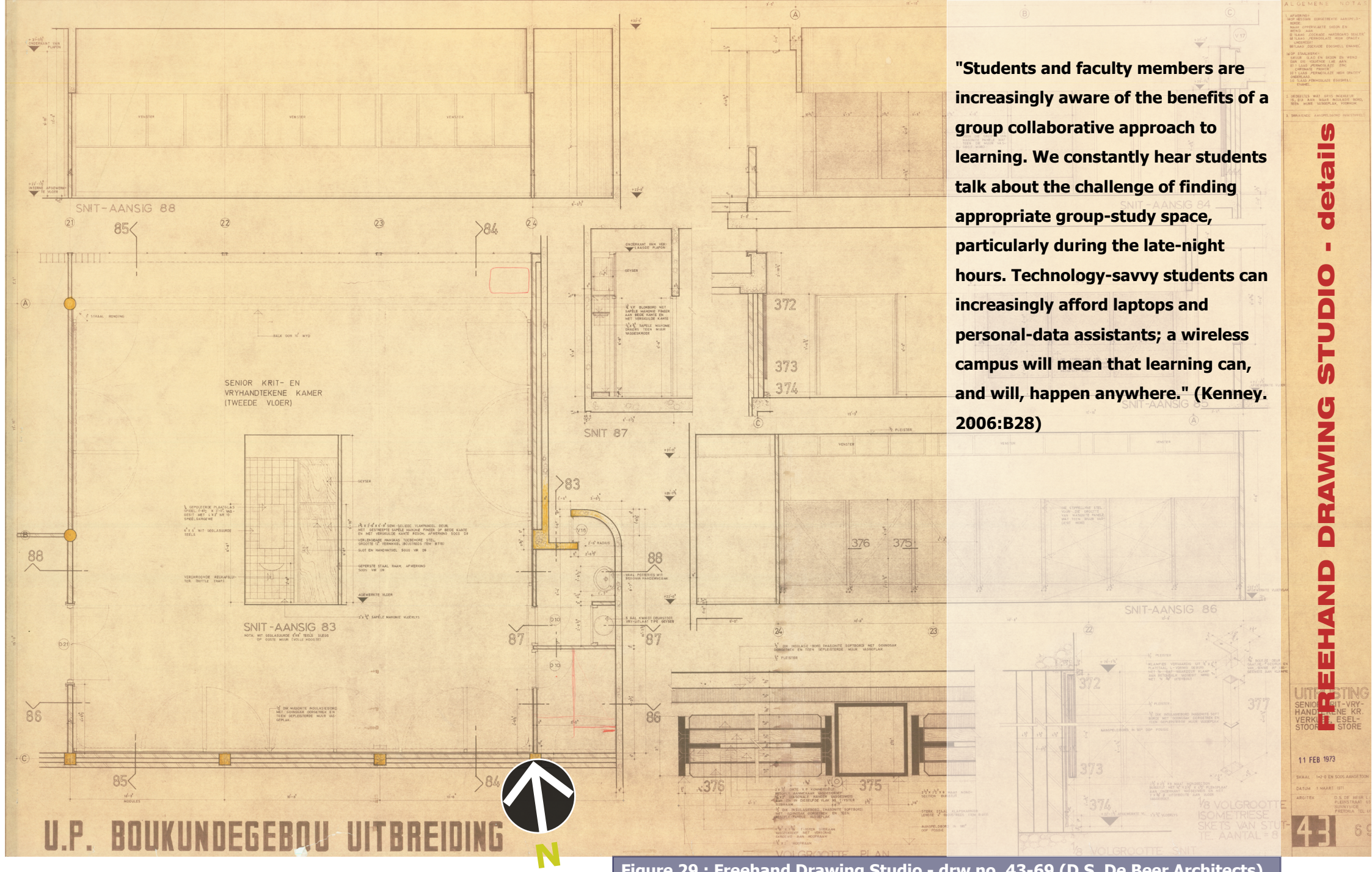


Figure 29 : Freehand Drawing Studio - drw no. 43-69 (D.S. De Beer Architects)



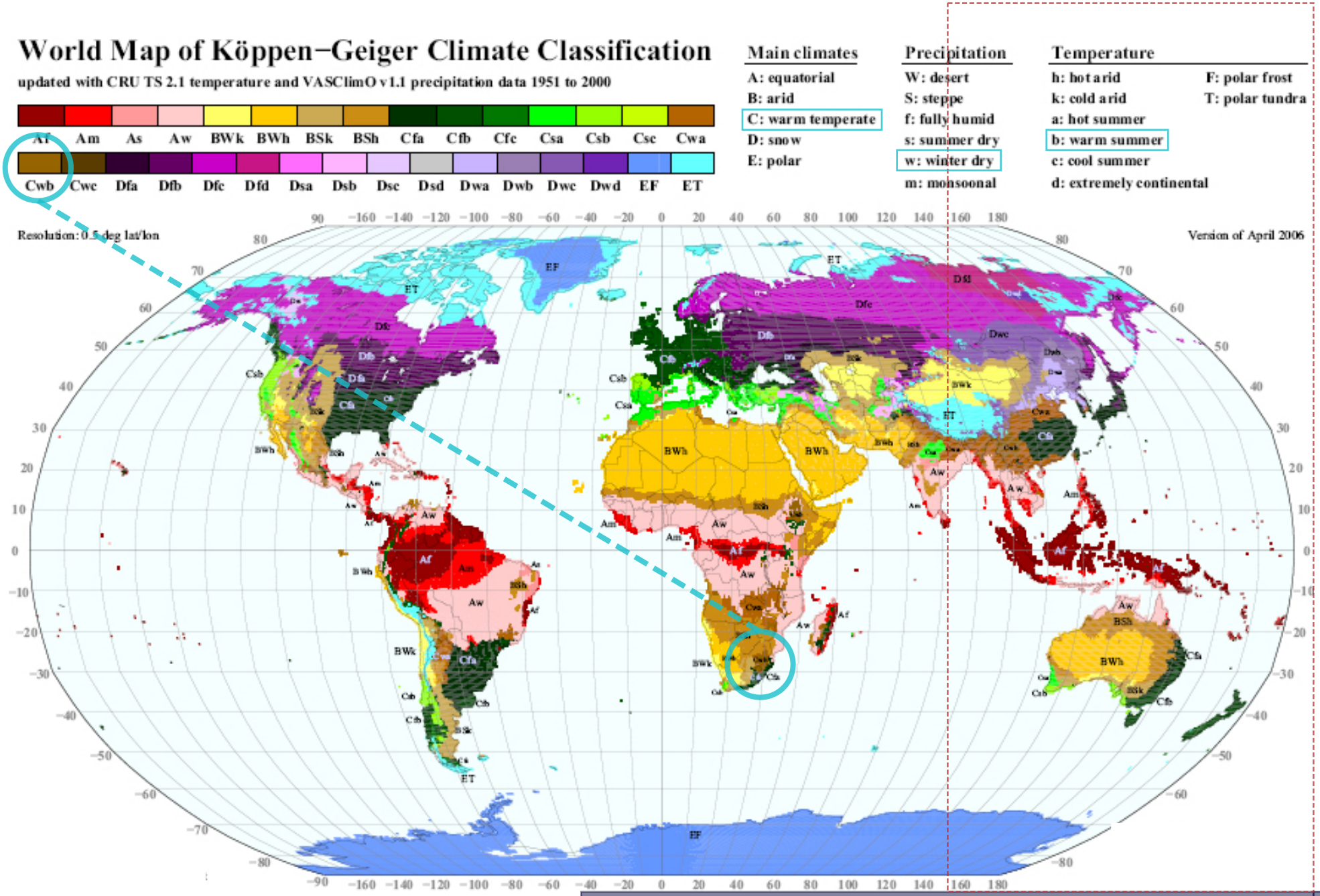


Figure 30 : Koppen-Geiger Climate Classification (http:koeppen-geiger.va)

Climate data

Pretoria

Position: 25° 44' S 28° 11' E
Height: 1330m
Period: 1961-1990
This climatological information is the normal values and, according to World Meteorological Organization (WMO) prescripts, based on monthly averages for the 30-year period 1961 – 1990

Month	Temperature (° C)				Precipitation		
	Highest Recorded	Average Daily Maximum	Average Daily Minimum	Lowest Recorded	Average Monthly (mm)	Average Number of days with >= 1mm	Highest 24 Hour Rainfall (mm)
January	36	29	18	8	136	14	160
February	36	28	17	11	75	11	95
March	35	27	16	6	82	10	84
April	33	24	12	3	51	7	72
May	29	22	8	-1	13	3	40
June	25	19	5	-6	7	1	32
July	26	20	5	-4	3	1	18
August	31	22	8	-1	6	2	15
September	34	26	12	2	22	3	43
October	36	27	14	4	71	9	108
November	36	27	16	7	98	12	67
December	35	28	17	7	110	15	50
Year	**36**	**25**	**12**	**-6**	**674**	**87**	**160**

Table 3 : Climate data - Pretoria (www.weathersa.co.za)

According to the Koppen-Geiger Climate Classification system Pretoria is located within a Cwb climate zone, although it can be seen to share some of the charactersitics of a BSh zone.

KOPPEN CLIMATE TYPE C - MILD MID-LATITUDE

Definition: Coldest month above 0°C, but below 18°C, warmest month above 10°C.

w - denotes dry winters

b - denotes warm summers

KOPPEN CLIMATE TYPE B - HOT DRY

Definition: Receive less than 86cm of precipitation per year.

S - denotes Steppe precipitation pattern (dry & barren most of the year, but revitalised by spring rains)

h - denotes hot arid conditions

South African Renewable Energy Resource Database - Annual Solar Radiation

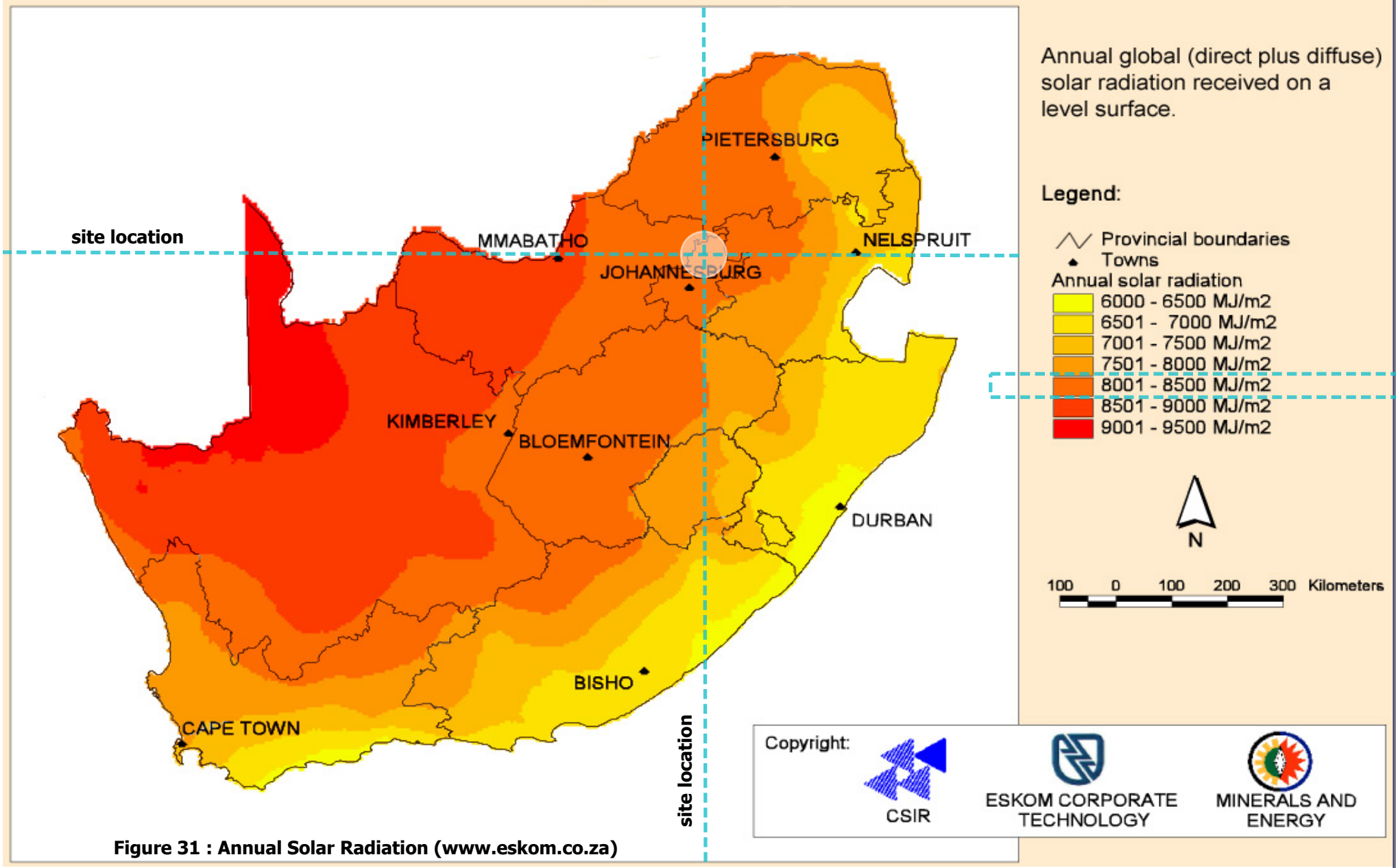


Figure 31 : Annual Solar Radiation (www.eskom.co.za)

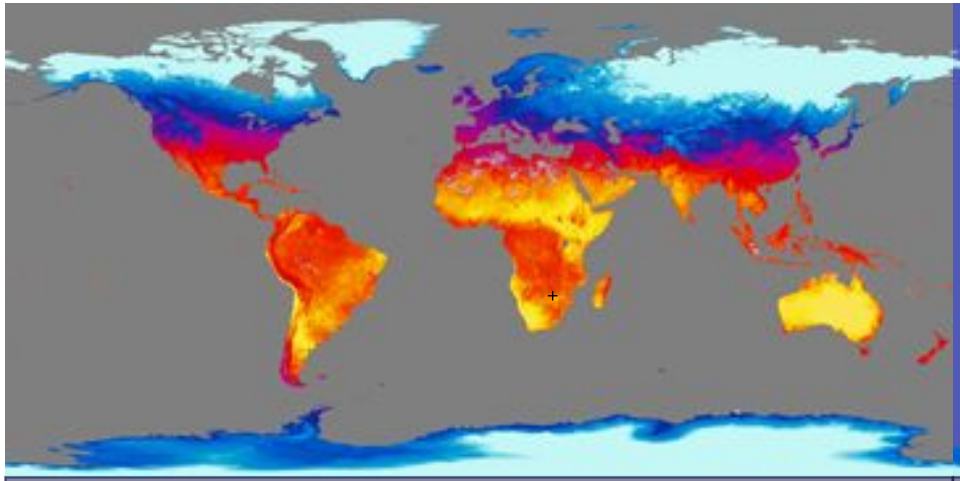


Figure 32 : Daytime Land Temperature - January 2006

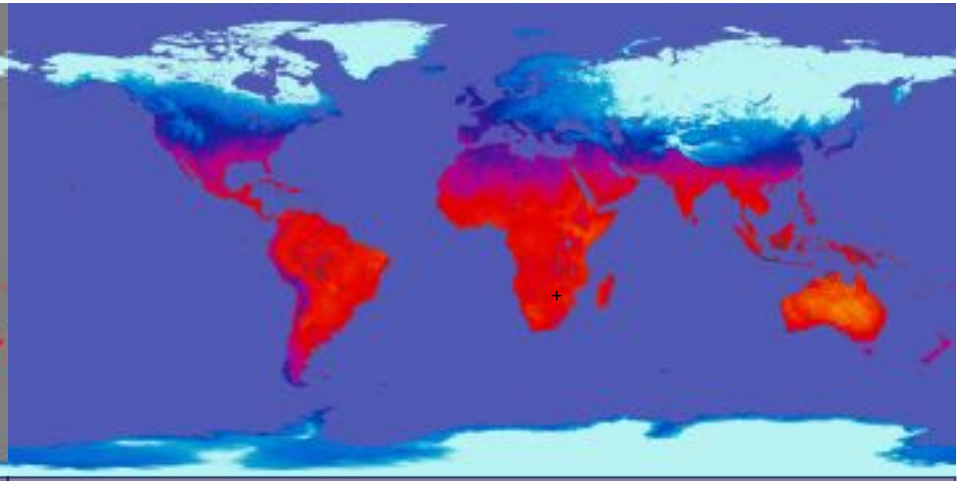
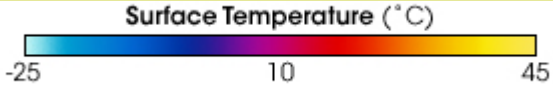


Figure 33 : Night-time Land Temperature - January 2006

"Land surface temperature is a good indicator of the energy balance at the Earth's surface, and serves as an important indicator of the greenhouse effect. "



The graphics illustrate the release of heat energy back into the atmosphere during the middle months due to lesser cloud cover being present in the southern hemisphere winters, and the retention of this radiant heat under cloud cover during the summer months - consequently raising night-time land temperatures and possibly necessitating a night-cooling strategy for buildings.

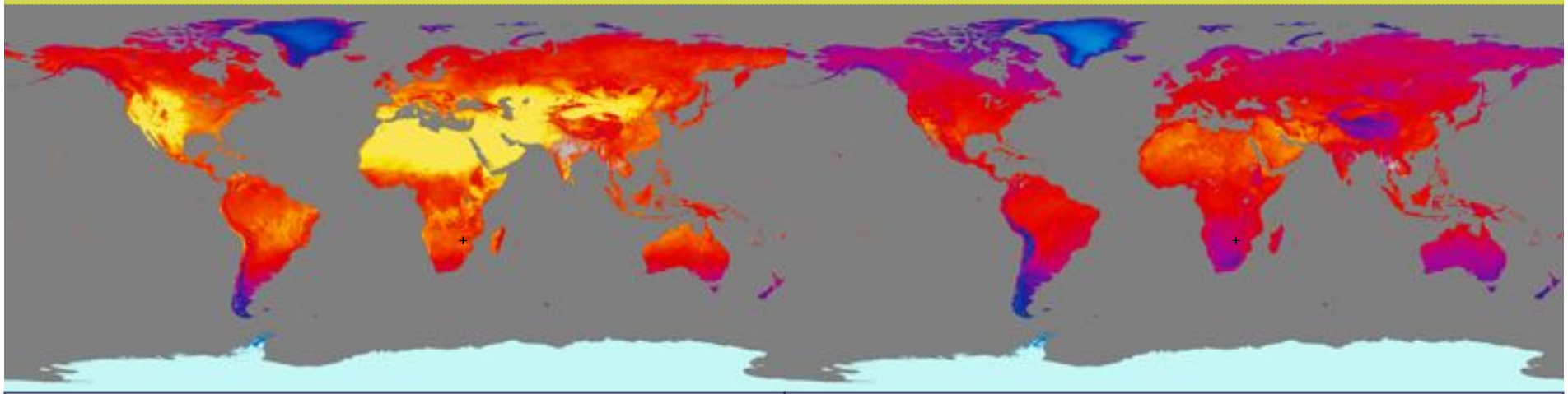


Figure 34 : Daytime Land Temperature - June 2006

Figure 35 : Night-time Land Temperature - June 2006

(source : NASA Earth Observatory)

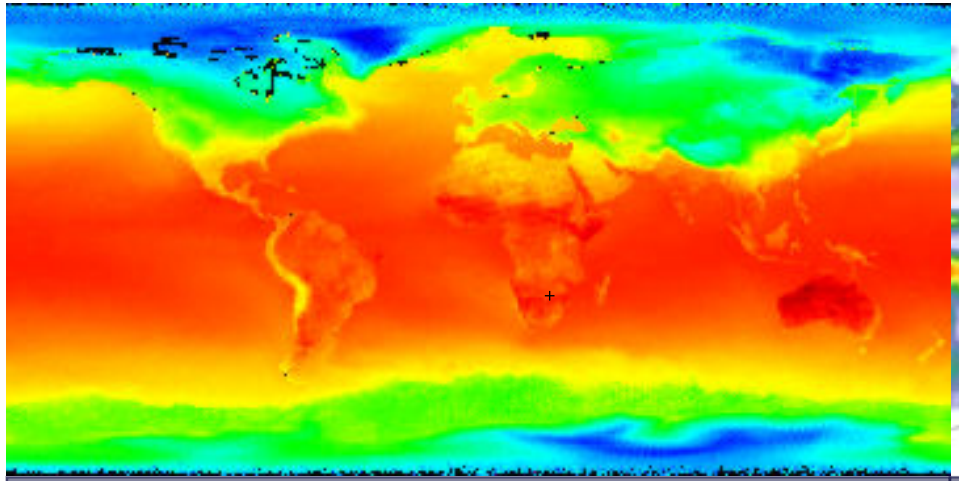


Figure 36 : Surface Temperature - January 2006

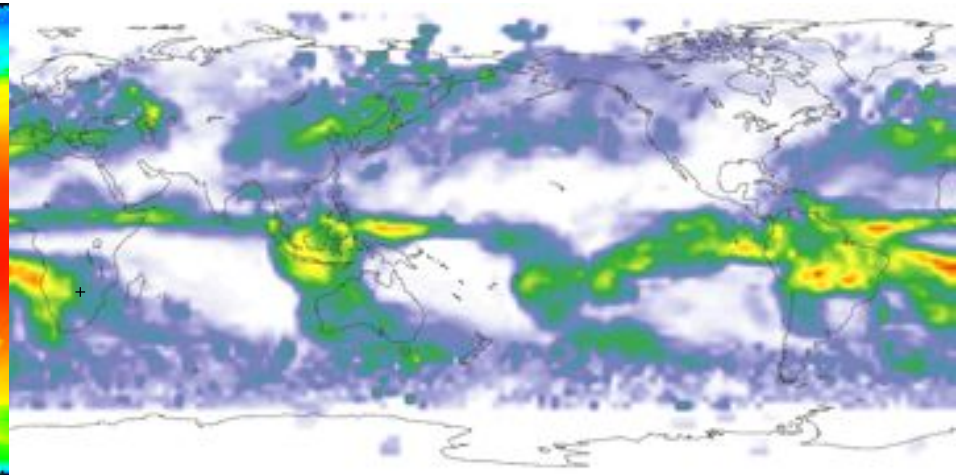
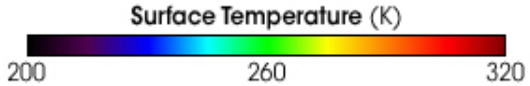
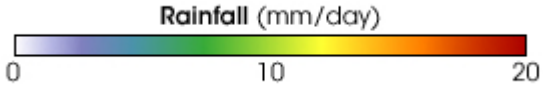


Figure 36 : Rainfall - January 2006

"Surface temperature influences the rate at which water evaporates, as well as wind & precipitation patterns and cloud formations."





The surface temperature values can be seen to be fairly moderate during the southern hemisphere winter months, and dramatically high close to the equator virtually all year through. (Australia's torturous drought conditions are evidenced in the southern summer). The dry, clear sky southern hemisphere winters and wet, cloudy summer months are also apparent in the rainfall graphics

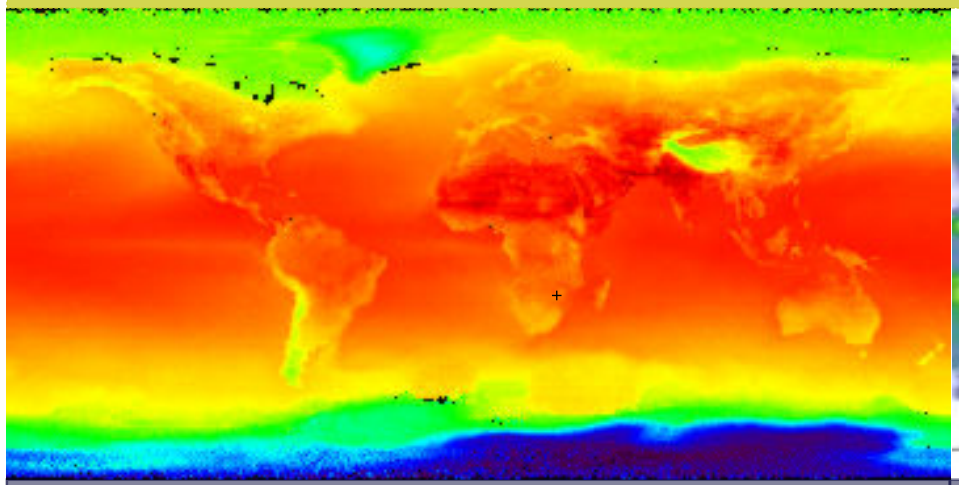


Figure 37 : Surface Temperature - June 2006

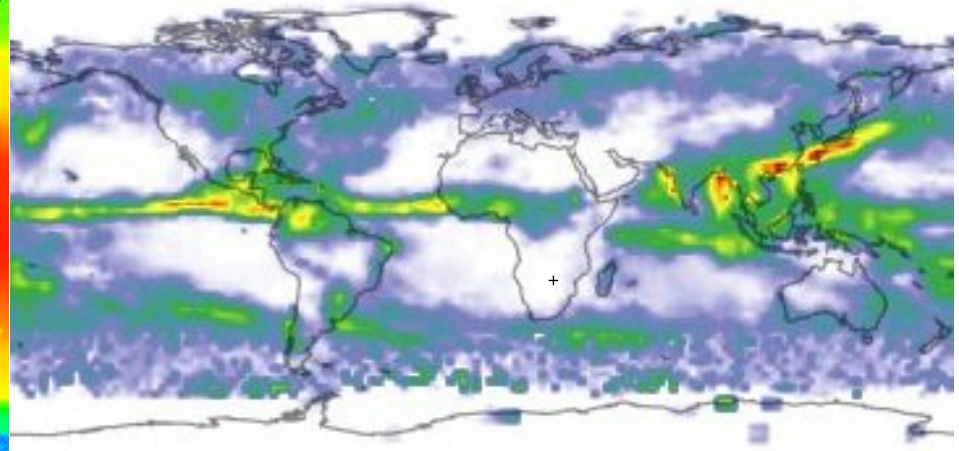
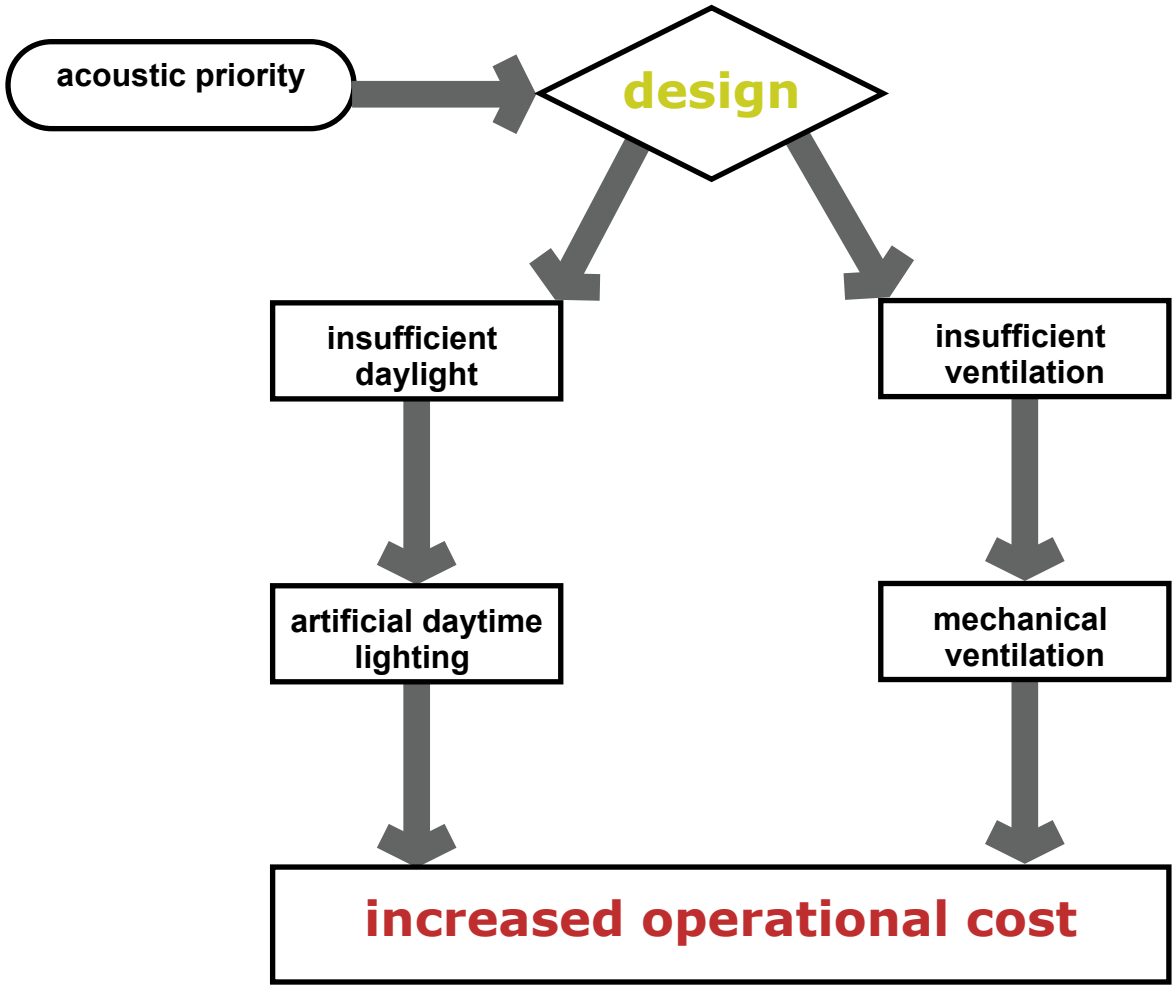


Figure 38 : Rainfall - June 2006

(source : NASA Earth Observatory)



The southern facade of Boukunde II bears the characteristics of an acoustic enclosure - with 7" thick concrete panels punctuated by narrow 'slivers' of fenestration which are not sufficient in terms of daylight or natural ventilation requirements.

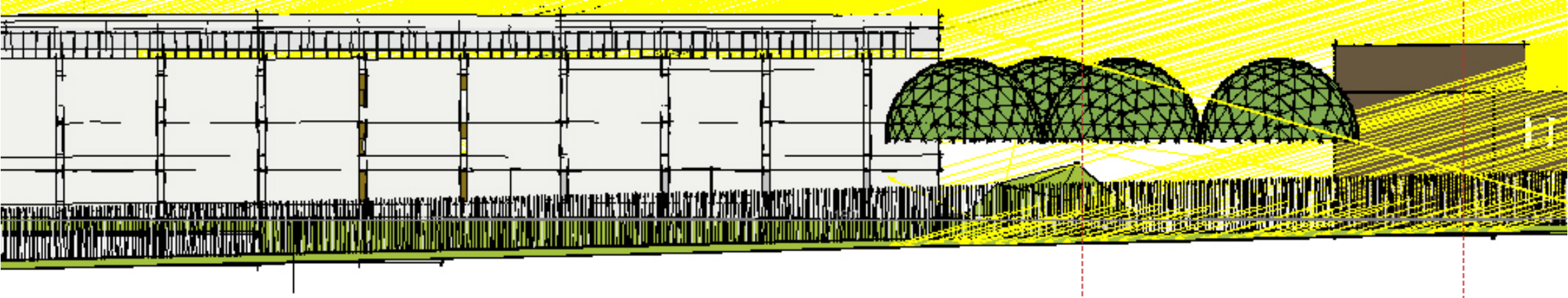
The sacrifice of these 2 elements has been offset by the provision of artificial lighting and mechanical ventilation, which to all intents are not remiss by virtue of their existence in the building, but rather by their requirement to serve beyond the 'call of duty'.

The fluorescent lights in room 2-25 (on the groundfloor) or the 4th year studio (1st floor) are called upon to provide adequate task lighting virtually 24/7 - 365 (or approx. 10/5 - 300 as the academic programme might require). Nonetheless, even an educational institution has to concern itself with the bottom line and/or triple bottom line as it were.

The lack of natural ventilation on all levels of the southern flank is catered for by the central HVAC unit, which is not entirely relied upon to maintain comfort levels within the zones it serves. The double-glazed studio 'sliver' windows on the ground- & first floor levels are invariably left open when these spaces are consistently inhabited, indicating either a lack of faith in- or a lack of perfomance by- the HVAC system.

For the building to be considered sustainable in it's current form it needs to evolve from being a product of a consumptive era to an exemplar of contemporary ideals. However, there cannot be a wholesale sacrifice of functionality nor an abandonment of the original design intent and constructs of the brief.

To enact this statement is to investigate the prevalent conditions - and the existing building's response thereto.



TRAFFIC NOISE

The primary consideration for the design of the southern facade.

ESTIMATING VEHICLE NOISE LEVELS

L10 denotes the level in dB(A) which is exceeded for one-tenth of any specified hour. The levels experienced are indicative for a distance of 10m from the road verge.

No. of vehicles/hour:

q = average number of vehicles using this particular section of lynnwood road per hour from 8:00am - 10:00am (weekdays) - as surveyed by the author (12/03/2008).

L10(1 hour)

= 41.2 + 10log q dB(A)

= 41.2 + 10log (1480) dB(A)

= 41.2 + 31.70 dB(A)

= 72.90 dB(A)

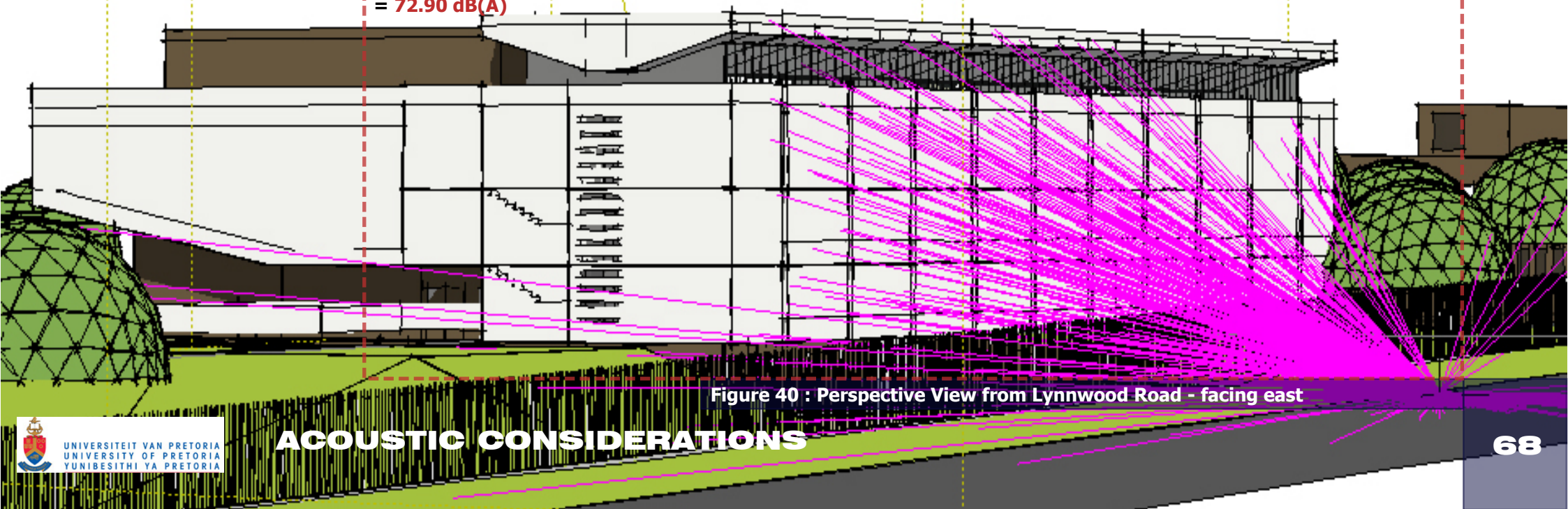
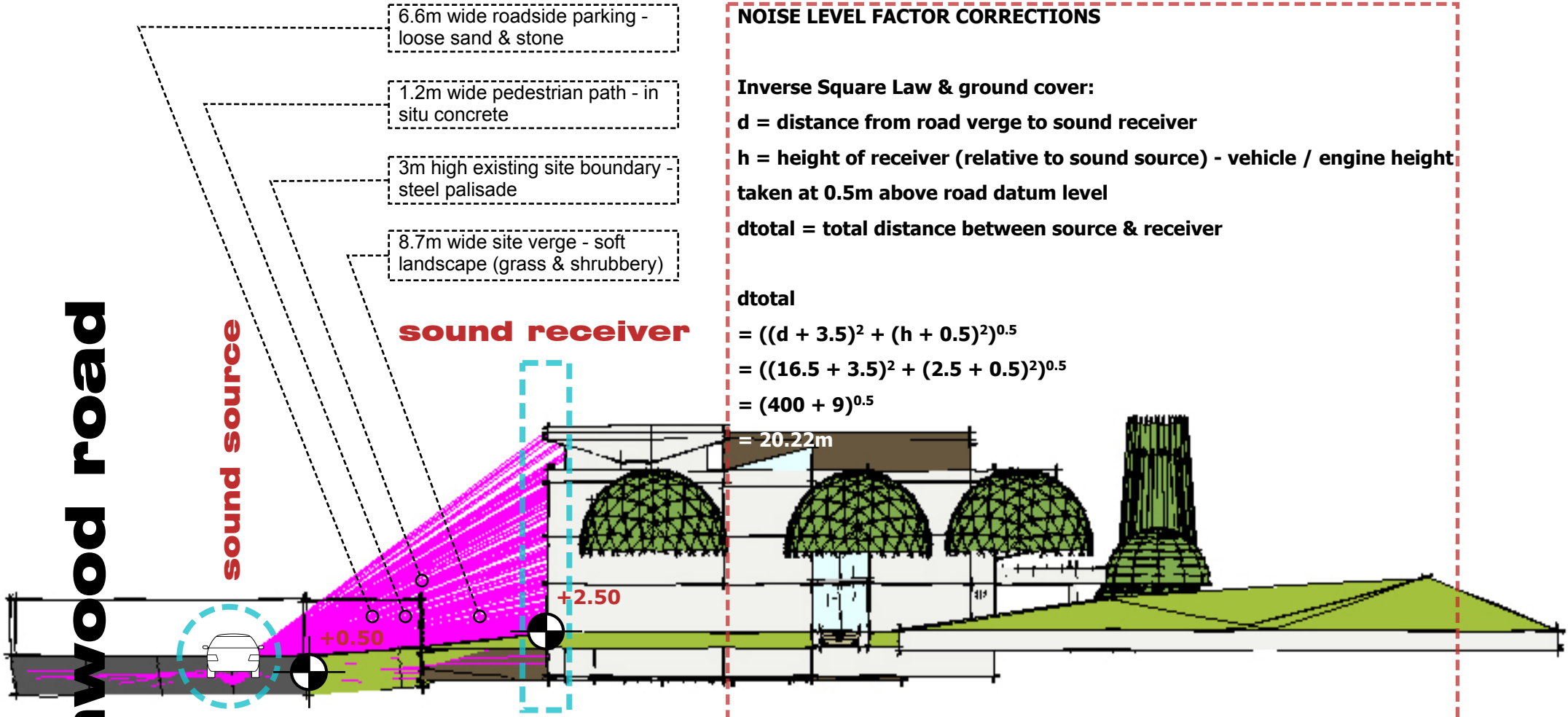


Figure 40 : Perspective View from Lynnwood Road - facing east



NOISE LEVEL FACTOR CORRECTIONS

Inverse Square Law & ground cover:

d = distance from road verge to sound receiver

h = height of receiver (relative to sound source) - vehicle / engine height taken at 0.5m above road datum level

dtotal = total distance between source & receiver

dtotal

$= ((d + 3.5)^2 + (h + 0.5)^2)^{0.5}$

$= ((16.5 + 3.5)^2 + (2.5 + 0.5)^2)^{0.5}$

$= (400 + 9)^{0.5}$

= 20.22m

Factor correction (soft ground)

= -10log (dtotal/13.5) + 5.2log (3h/(d + 3.5)) dB(A)

= -10log (20.22/13.5) + 5.2log (3x2.5/(16.5 + 3.5)) dB(A)

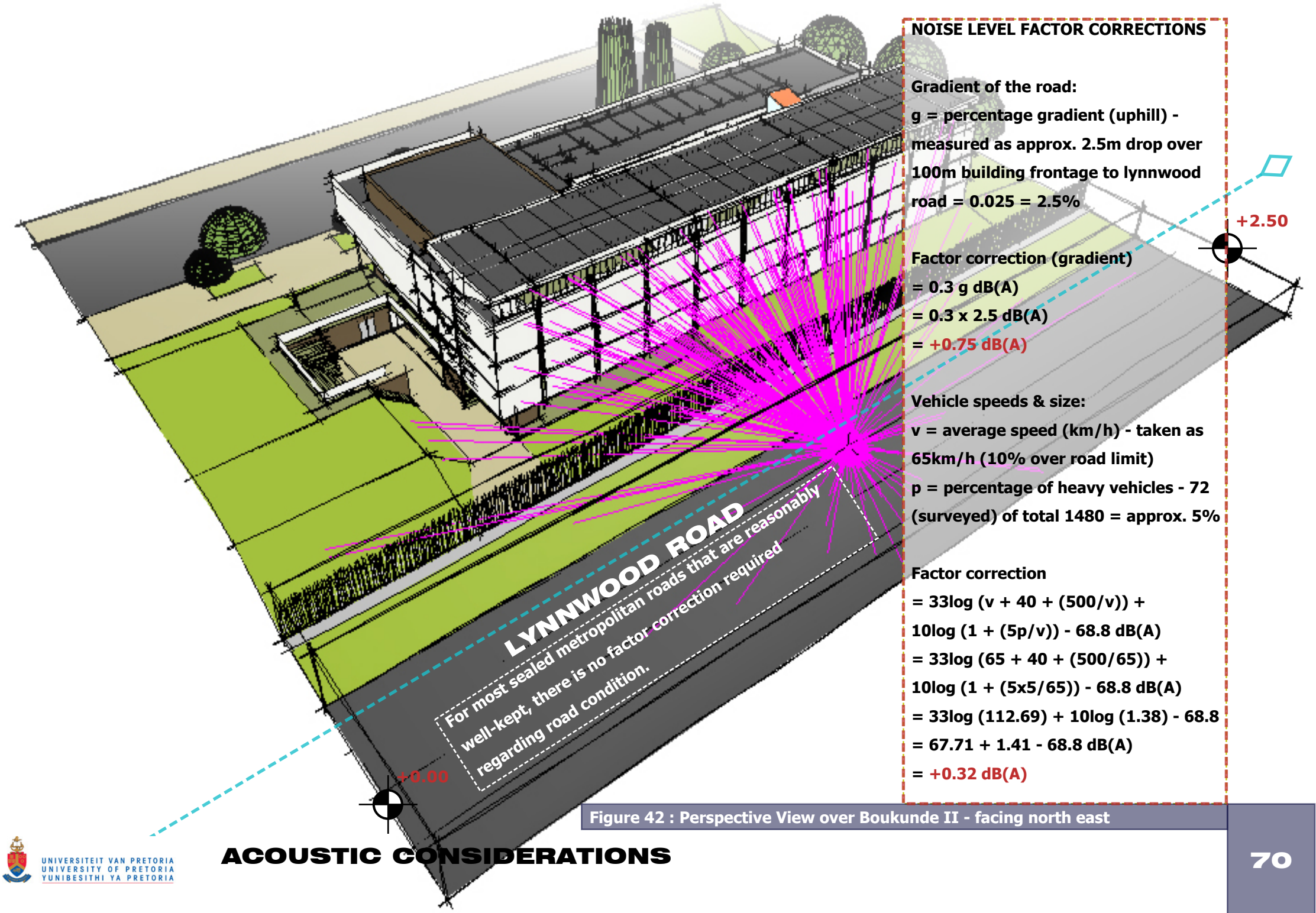
= -10log (1.5) + 5.2log (0.375)

= (-1.76) + (-2.21) dB(A)

= -3.97 dB(A)

The predominant ground cover between the source & receiver is soft & the barrier will have no effect i.to. absorption (being steel palisade), and negligible deflection (being situated approx. midway between the 2

Figure 41 : Boukunde II - East Elevation



NOISE LEVEL FACTOR CORRECTIONS

Gradient of the road:

g = percentage gradient (uphill) - measured as approx. 2.5m drop over 100m building frontage to lynnwood road = 0.025 = 2.5%

Factor correction (gradient)

= 0.3 g dB(A)

= 0.3 x 2.5 dB(A)

= +0.75 dB(A)

Vehicle speeds & size:

v = average speed (km/h) - taken as 65km/h (10% over road limit)

p = percentage of heavy vehicles - 72 (surveyed) of total 1480 = approx. 5%

Factor correction

= 33log (v + 40 + (500/v)) + 10log (1 + (5p/v)) - 68.8 dB(A)

= 33log (65 + 40 + (500/65)) + 10log (1 + (5x5/65)) - 68.8 dB(A)

= 33log (112.69) + 10log (1.38) - 68.8

= 67.71 + 1.41 - 68.8 dB(A)

= +0.32 dB(A)

Figure 42 : Perspective View over Boukunde II - facing north east

No factor correction is considered for noise reflectance from structures on the opposing side of Lynnwood Road, as these structures do not exceed 5m in height & their effect is therefore classified as negligible.

TRAFFIC NOISE

TOTAL ESTIMATED NOISE LEVELS

L10(1 hour):

72.90 dB(A)

Factor correction (soft ground):

-3.97 dB(A) - ground floor

-2.33 dB(A) - first floor

-1.54 dB(A) - second floor

Factor correction (gradient):

+0.75 dB(A)

Factor correction (speed & size):

+0.32 dB(A)

TOTAL AS AT BOUKUNDE SOUTH FACADE:

(ground floor) = 70.00 dB(A)

(first floor) = 71.64 dB(A)

(second floor) = 72.43 dB(A)

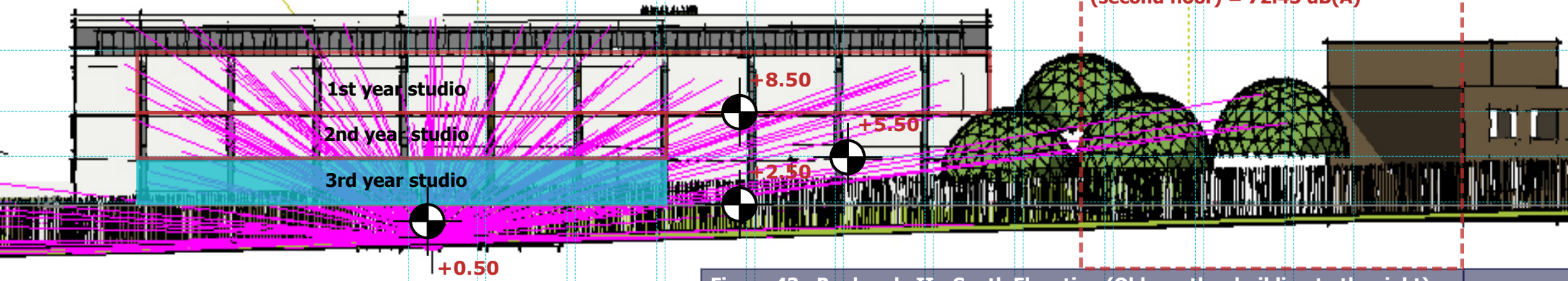


Figure 43 : Boukunde II - South Elevation (Old weather building to the right)

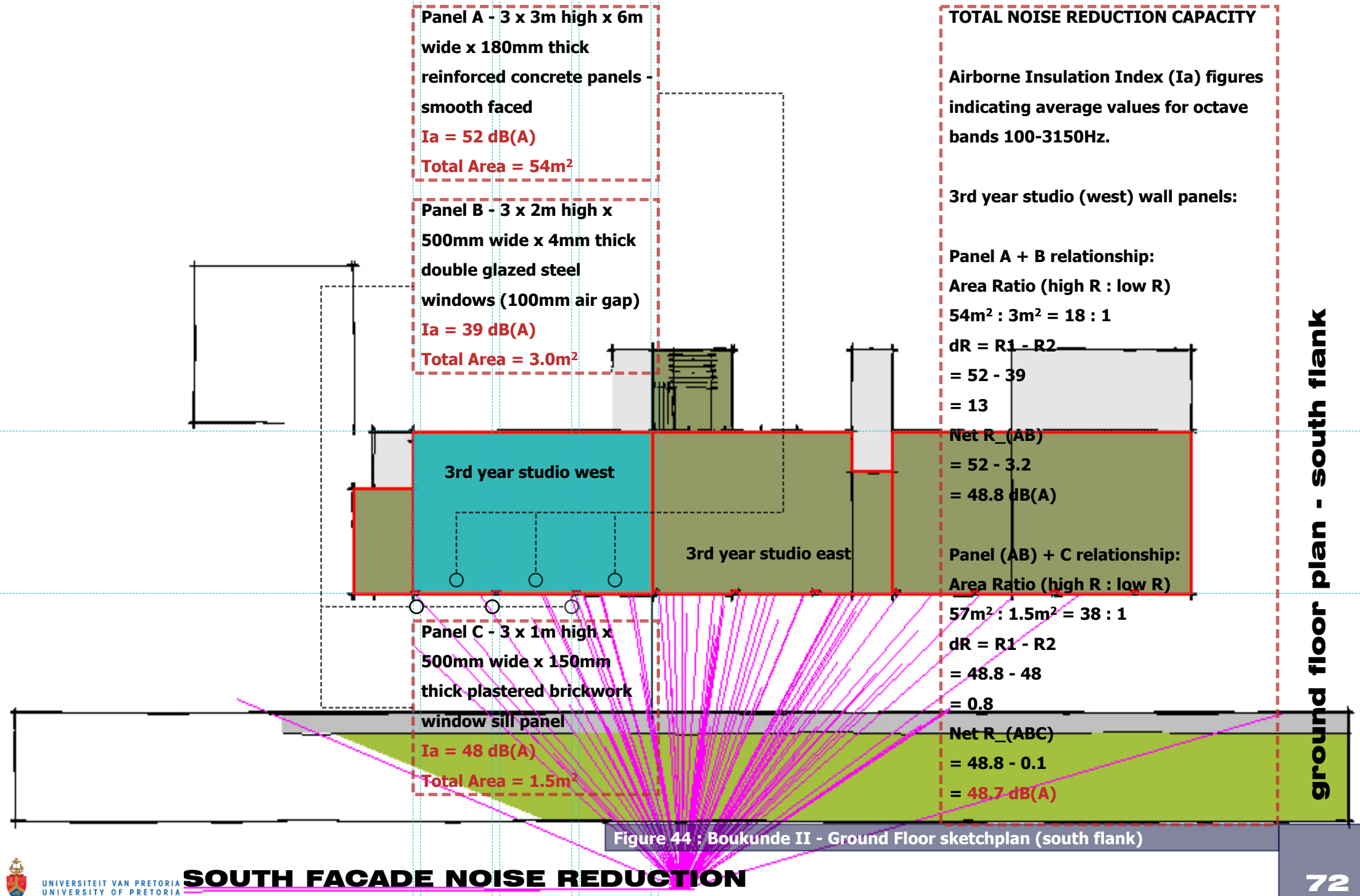


Figure 44 : Boukunde II - Ground Floor sketchplan (south flank)

A post-occupancy evaluation of Boukunde I would presumably have informed decision-making in the design of Boukunde II.

The fact that the 2nd building was realised as robustly as it is - with specific attention given to certain aspects of location and environment - would seem to indicate perceived shortfalls in the first design.

The latter's acoustic fixation might have been an overt response to the former buildings inability to keep noise out.

Panel A - 2m high x 2.1m wide x 6mm thick single glazed steel window (fixed pane)

Ia = 27 dB(A)

Total Area = 4.2m²

Panel B - 2m high x 1.1m wide x 4mm thick single glazed steel window (side hung - 30° open)

Ia = 9 dB(A)

Total Area = 2.2m²

TOTAL NOISE REDUCTION CAPACITY

Boukunde I south facade is comprised of curtain wall glazing exclusively - resulting in a noise reduction capacity as follows:

Panel A + B relationship:

Area Ratio (high R : low R)

4.2m² : 2.2m² = 1.9 : 1

dR = R1 - R2

= 27 - 9

= 18

Net R_(AB)

= 27 - 17

= 10 dB(A)

The current version of the Boukunde building performs markedly better in excluding traffic noise than the 1960's "glass box".

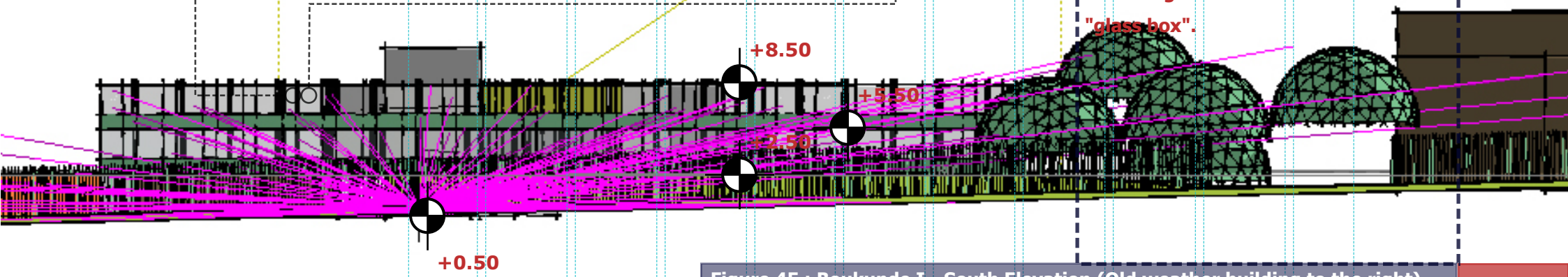


Figure 45 : Boukunde I - South Elevation (Old weather building to the right)

"The Darwinian mechanism of vary-and-select, vary-and-select has one enormous difference from the process of design. It operates by hindsight rather than foresight. Evolution is always away from known problems rather than toward imagined goals. It doesnt seek to maximize theoretical fitness; it minimizes experienced unfitness. Hindsight is better than foresight." (Brand. 1994:188)

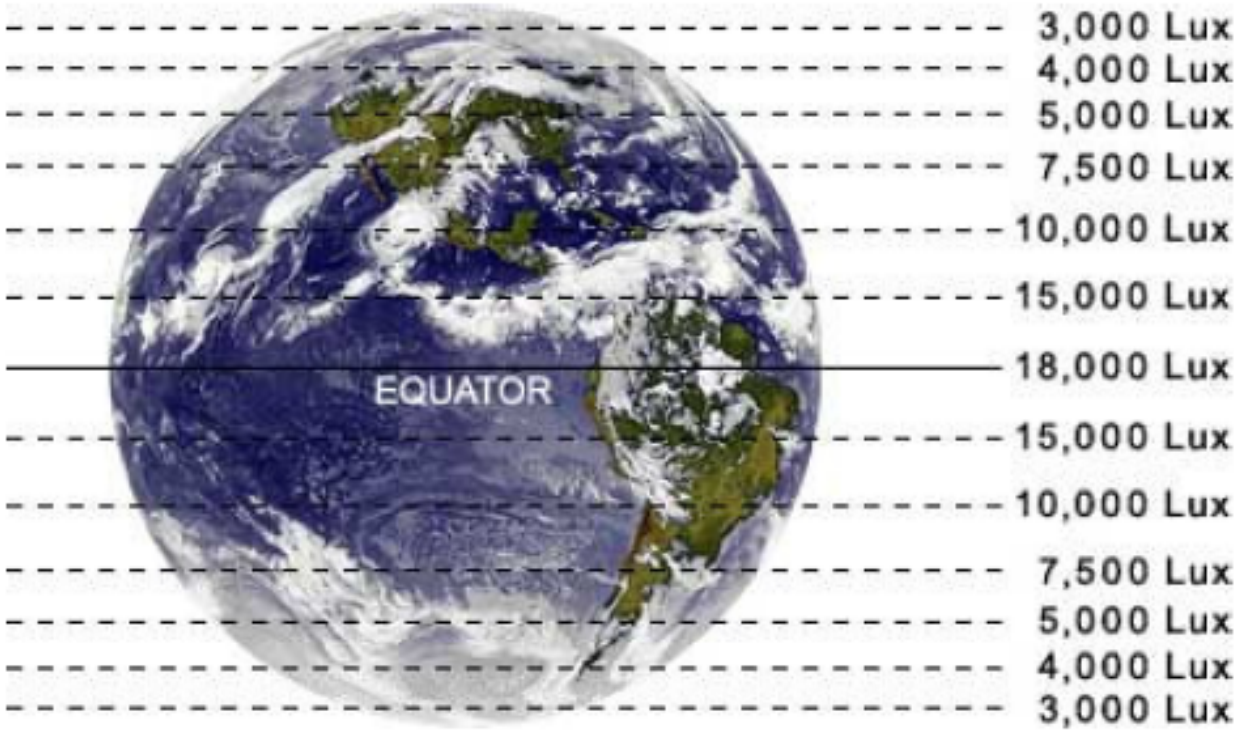


Figure 46 : Design sky illuminance values as function of latitude (www.squ1.org)

"Design Sky values are derived from a statistical analysis of dynamic outdoor sky illuminance levels. They represent the horizontal illuminance value that is exceeded 85% of the time between 9am - 5pm throughout the working year and provide a 'worst-case scenario basis for building design light levels." (www.squ1.org)

Site Location - Pretoria, South Africa
Latitude - 25' 7° South
Design Sky Illuminance - Approx. 10 500 lux

DAYLIGHT FACTOR:

"The amount of daylight entering and bouncing around a space is broadly a function of the size of each window aperture, the amount of sky visible from each window and the reflectance of internal surfaces." (www.squ1.org)

Average daylight factor equation:

$$DF_{avg} = \frac{\sum (W\,T\,\phi\,M)}{A\,(1-R^2)} \quad \%$$

W = area of each window (m²)
T = Transmittance of each glazing material (0.8 for clear single glazing or 0.7 for clear double glazing)
ɵ = Vertical sky angle (as from the centre of each window)
M = Maintenance factor (based upon glazing angle & the cleanliness of its environment)
A = Total internal surface area of the space (including walls, floors, ceilings and windows - m²)
R = Area weighted average reflectance of all surfaces making up A

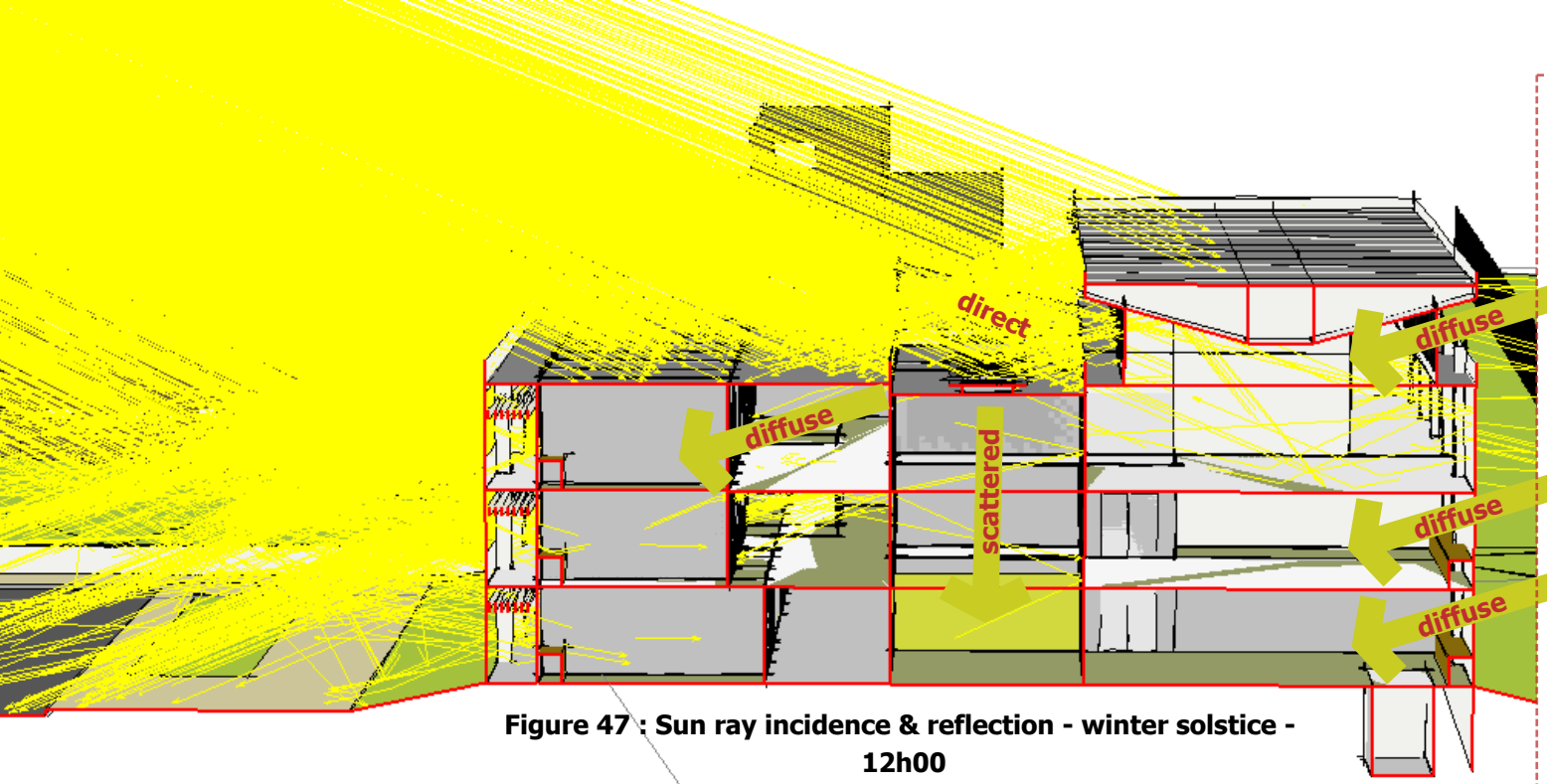


Figure 47 : Sun ray incidence & reflection - winter solstice - 12h00

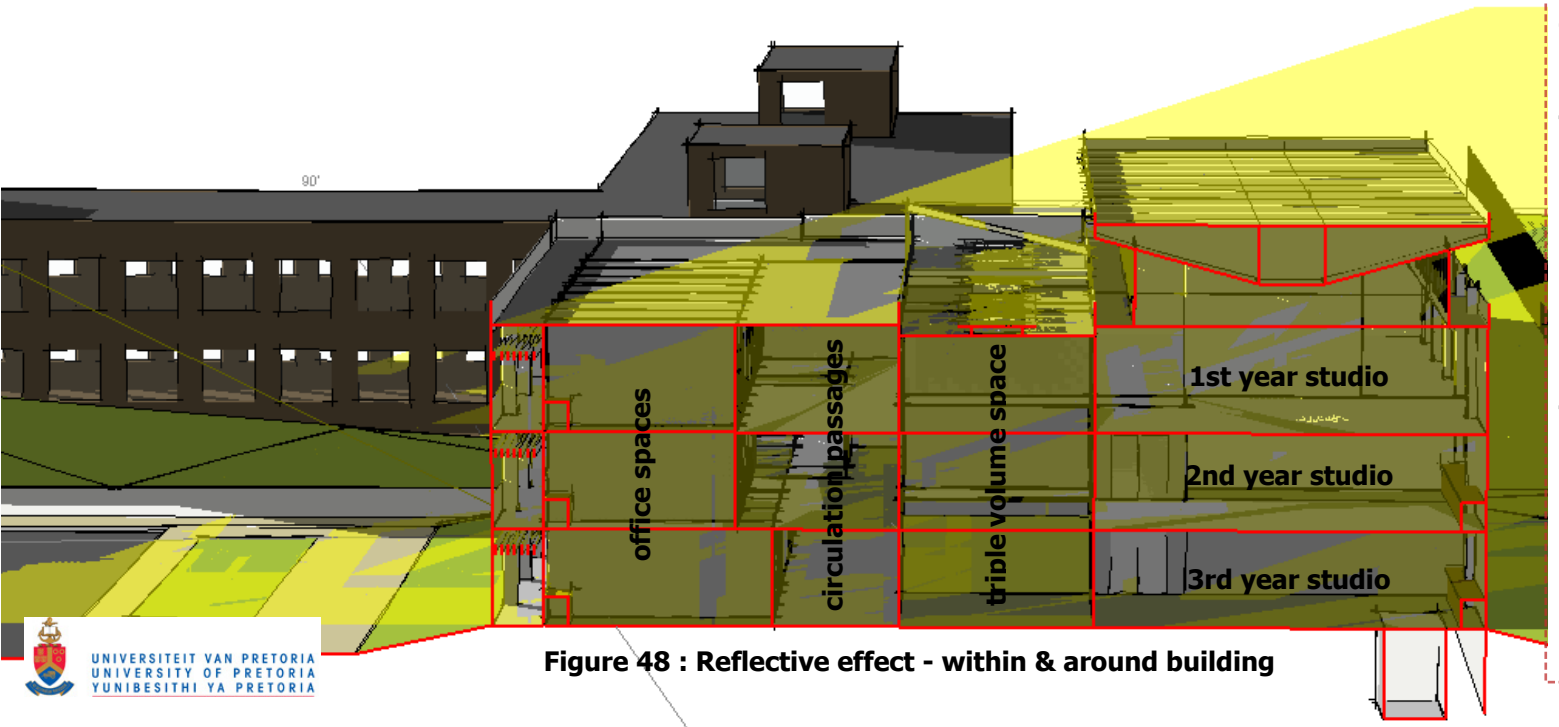
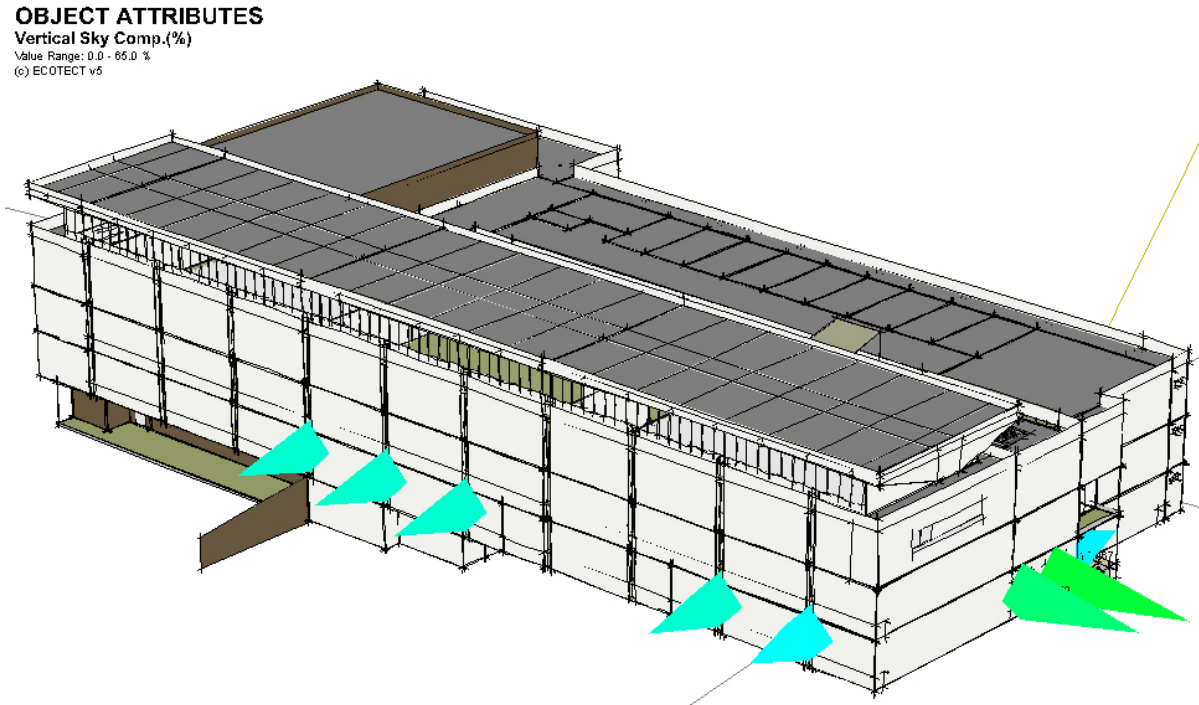


Figure 48 : Reflective effect - within & around building

The 1st year studio on the uppermost level (2nd floor) does benefit from significant daylight levels by virtue of it's clerestory band to the north (and south), but the ground- & first floor studio spaces have no such access to direct northern exposure. They rely primarily upon the minimal amounts of scattered diffuse light available from the shaded south and the sunken clerestory bands & skylights above the triple volume gallery space.

Based upon the solar exposure data for the southern facade windows, there is clearly scarce benefit to be derived from pursuing an improvement in daylighting conditions from the south. The building is divided into 4 structural 'slices' along the east-west grid for all but the western-most end. The middle 2 being a combination of circulation & exhibition / ablution facilities.

The potential for extracting daylighting gains via this mid-section is a factor of solar availibility + the relative 'loose-ness' of the construction + the localised effect to be borne by these 'relay' spaces.



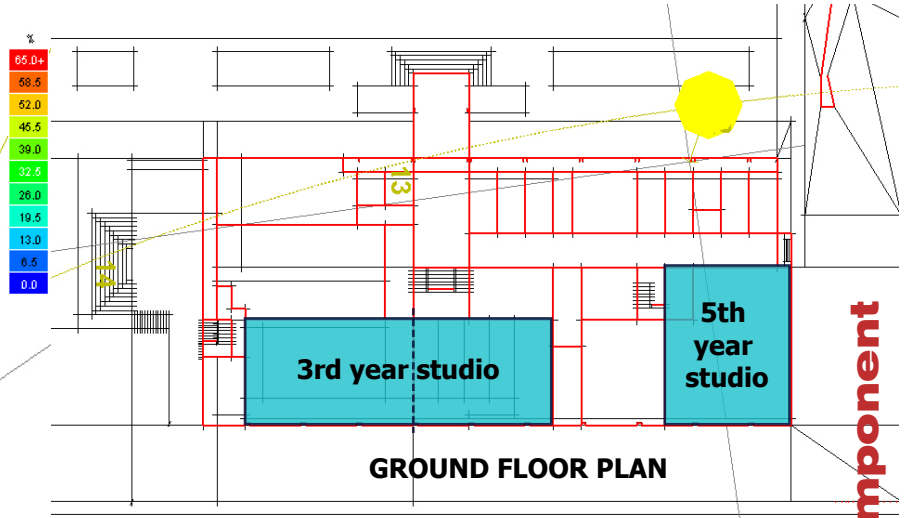
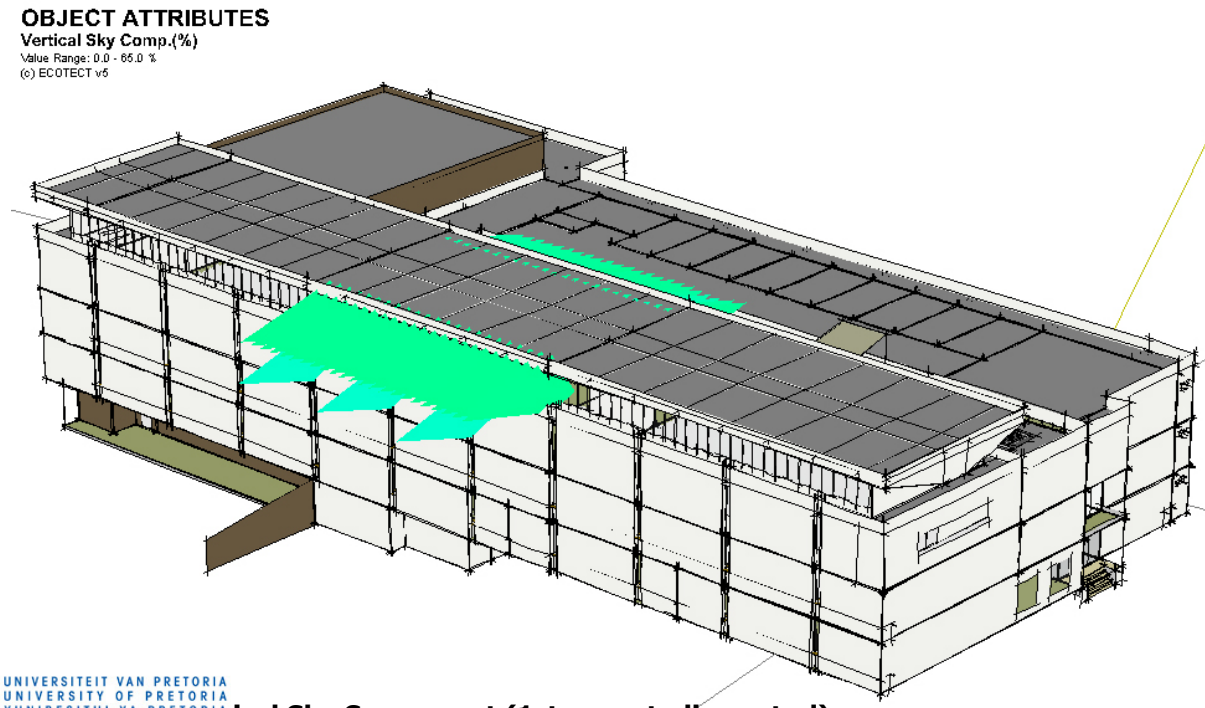
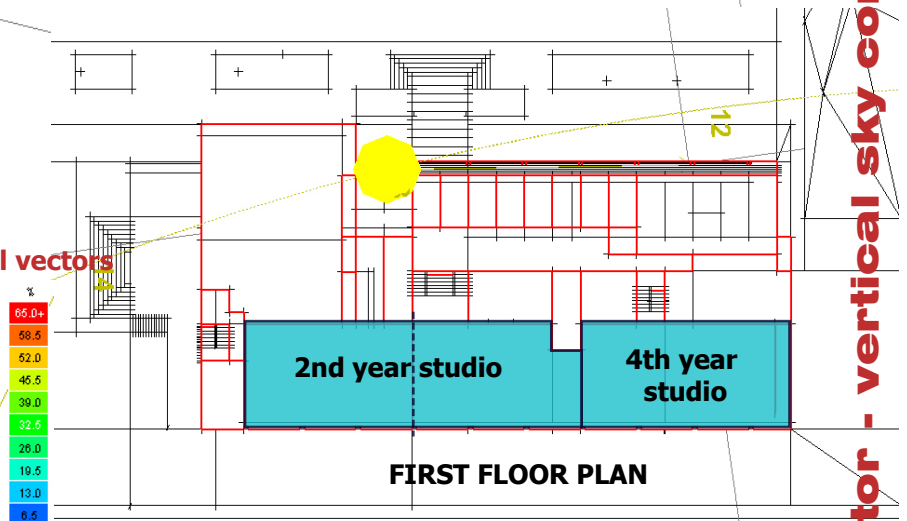


Figure 49 : Vertical Sky Component (3rd year studio east & 5th year studio)

*sky percentage visible from each window in the various zones represented as directional vectors





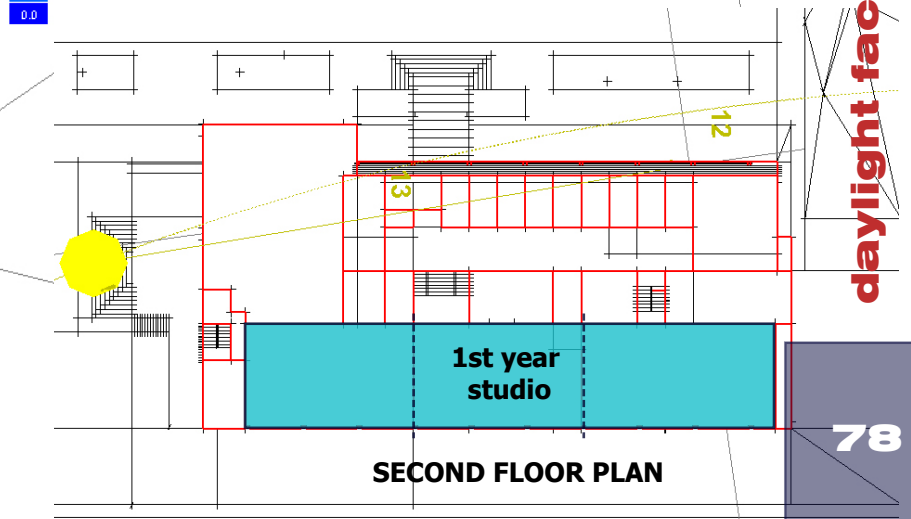


Figure 50 : Vertical Sky Component (1st year studio central)

daylight factor - vertical sky component

SECOND FLOOR	FACTOR
1st year studio (central)	5.34
1st year studio (eastern)	4.19
1st year studio (western)	3.41
FIRST FLOOR	
4th year studio	0.25
2nd year studio (eastern)	0.29
2nd year studio (western)	0.24
GROUND FLOOR	
5th year studio	1.01
3rd year studio (eastern)	0.17
3rd year studio (western)	0.15

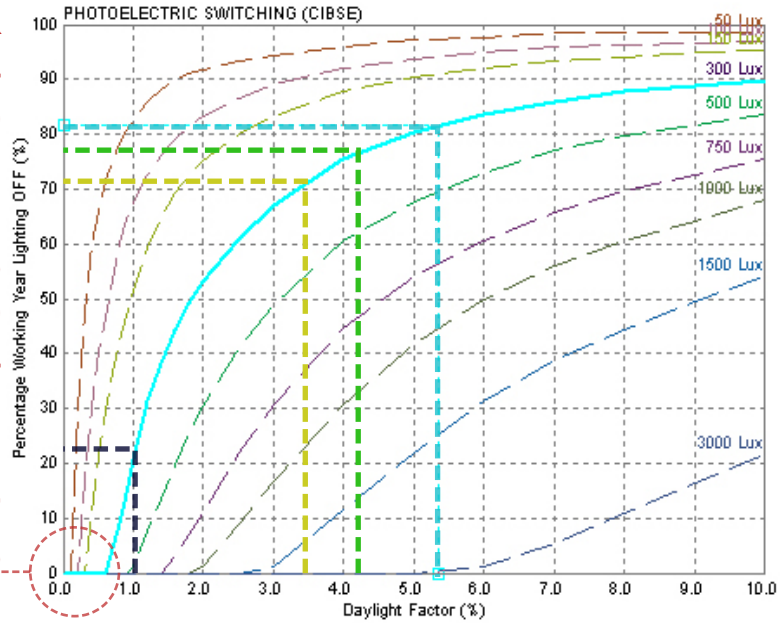


Table 3 : Average Daylight Factor - existing studios

2nd / 3rd / 4th year studio average daylight factor values don't register on the graph as they never reach a level sufficient to completely exclude artificial lighting from these zones.

SECOND FLOOR	FACTOR
1st year studio (central)	22.71
1st year studio (eastern)	21.05
1st year studio (western)	20.18
FIRST FLOOR	
4th year studio	2.78
2nd year studio (eastern)	2.48
2nd year studio (western)	1.97
GROUND FLOOR	
5th year studio	1.64
3rd year studio (eastern)	1.81
3rd year studio (western)	1.97

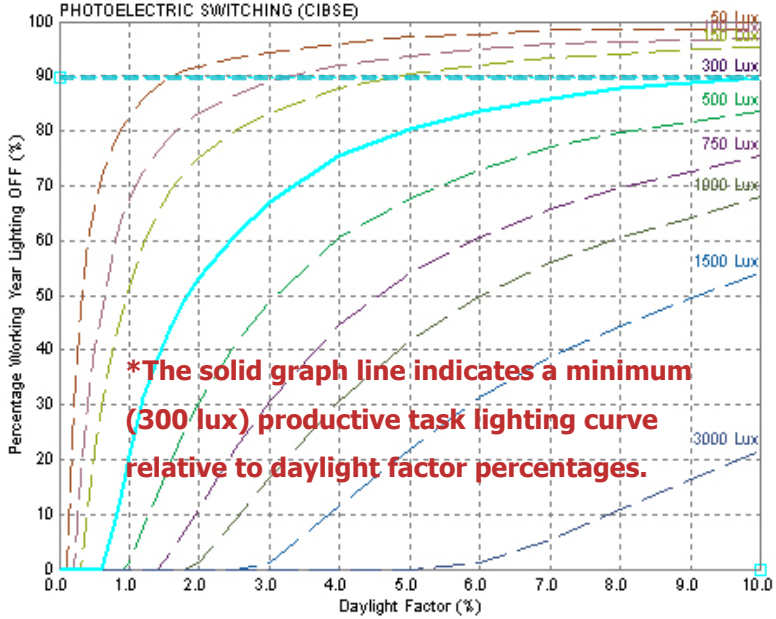


Table 4 : Mid-zone Daylight Factor - existing studios

Daylight Factor values are generated for each zones centre point, which offers a 'best case scenario' for levels in that zone based upon the sum total of all surface reflectance being measurable at this point. An average value is then derived to carry the impact of window size & location, as well as general zone orientation.

The graphs shown use the 1st year studio (central space) as base reference due to it's optimal orientation i.t.o. overshadowing from external elements (raised roof elements, trees, adjacent buildings etc.), and it's fenestration : floor surface area ratio being the greatest of all the studio zones.

The remaining zone values are plotted against this reference and the significance of the variation in daylight levels illustrated. The most important aspect of the analysis however, is the vertical axis which illustrates the percentage of operational time that artificial lighting in these zones can be excluded due to the presence of adequate daylighting conditions.

The fact that the building's southern locales are seemingly unable to offer sufficient lighting conditions during the daytime (when it is needed most) - independant of the national electrical grid, not only exposes these critical functional spaces to risk i.t.o. the unpredicability of supply. It also puts the entire institution under an unnecessary financial burden. The cost of this essential service is set to escalate at levels that bear no relation to the university's inflationary-linked cost recovery mechanisms - such as course fees.

Budgetary allotments from the Education Department would presumably be adjusted to cover any shortfalls, but money added into the operational column is invariably money subtracted from elsewhere in the balance sheet.

A pro-active approach to mitigate operational cost inflation would be to assess, rectify & reduce the problem in terms of it's localised cause and effect. In the case of Boukunde II, the starting point becomes the daylight

LIGHT SOURCE	EFFICACY (LUMENS/WATT)
Direct Sun (low altitude)	90 lm/w
Direct Sun (high altitude)	117 lm/w
Direct Sun (mean altitude)	100 lm/w
Diffuse Sky (clear)	**150 lm/w**
Diffuse Sky (average)	**125 lm/w**
Global (average of sky and sun)	115 lm/w
Incandescent (150 w)	16-40 lm/w
Fluorescent (40 w, CWX)	50-80 lm/w
High Pressure Sodium	40-140 lm/w

Table 5 - Efficacy of various forms of daylight & electric lamps (www.naturalfrequency.com)

In order of escalating retrofit cost - the elements that have direct impact upon a given zone's daylight factor comprise:

1 - Internal reflectance

2 - Maintenance factor (cleanliness, not glazing angle)

3 - Window area

4 - Vertical sky angle (possible obstacle removal eg. trees, light construction etc.)

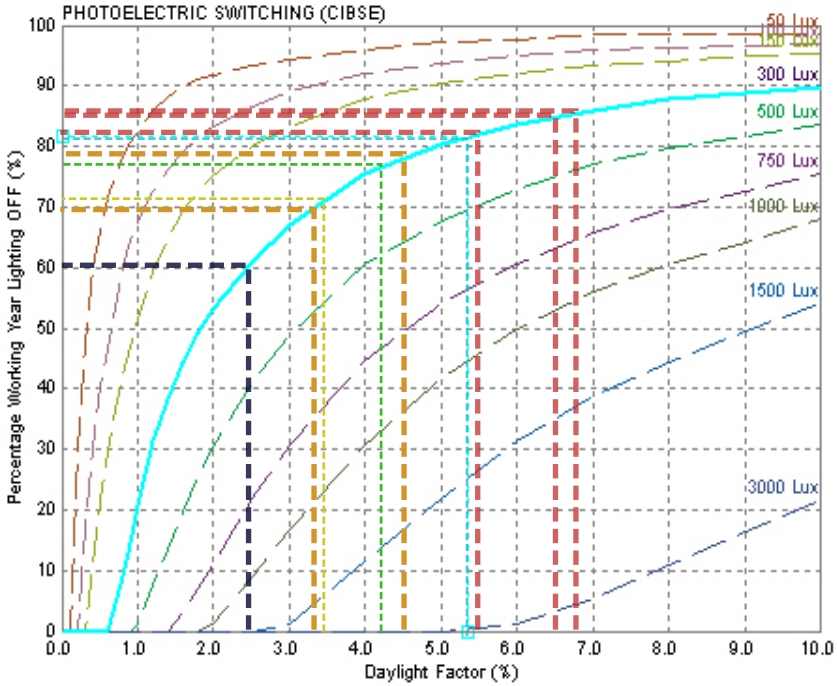
5 - Internal space surface area

Glazing transmittance values are considered suitable (unless a daylight reduction is required).

WINDOW AREA:	EXISTING	TEST PROPOSAL 1	FACTOR	TEST PROPOSAL 2	FACTOR
1st year studio (central)	81.12m²	81.12m²	5.34	81.12m²	5.34
1st year studio (eastern)	81.76m²	81.76m²	4.19	81.76m²	4.19
1st year studio (western)	53.40m²	53.40m²	3.41	53.40m²	3.41
4th year studio	4.00m²	4 x (2m x 1m) = 12.00m²	1.57	4 x (4m x 1m) = 20.00m²	2.80
2nd year studio (eastern)	3.00m²	3 x (2m x 1m) = 9.00m²	1.44	3 x (4m x 1m) = 15.00m²	2.58
2nd year studio (western)	3.00m²	3 x (2m x 1m) = 9.00m²	1.49	3 x (4m x 1m) = 15.00m²	2.66
5th year studio	8.48m²	2 x (2m x 1m) = 12.48m²	1.50	2 x (4m x 1m) = 16.48m²	1.97
3rd year studio (eastern)	3.00m²	3 x (2m x 1m) = 9.00m²	0.81	2 x (4m x 1m) = 11.00m²	1.38
3rd year studio (western)	3.00m²	3 x (2m x 1m) = 9.00m²	0.97	3 x (4m x 1m) = 15.00m²	1.73

TEST PROPOSAL 3

	SECOND FLOOR	FACTOR
81.12m²	1st year studio (central)	5.34
81.76m²	1st year studio (eastern)	4.19
53.40m²	1st year studio (western)	3.41
	FIRST FLOOR	
3 x (5.4m x 2m) = 36.40m²	4th year studio	5.42
3 x (5.4m x 2m) = 35.40m²	2nd year studio (eastern)	6.58
3 x (5.4m x 2m) = 35.40m²	2nd year studio (western)	6.79
	GROUND FLOOR	
1 x (5.4m x 2m) = 19.28m²	5th year studio	2.30
2 x (5.4m x 2m) = 24.60m²	3rd year studio (eastern)	3.36
3 x (5.4m x 2m) = 35.40m²	3rd year studio (western)	4.38



DAYLIGHT FACTOR INCREASE

Table 6 : Average Daylight Factor - test proposal 3

The existing building facade comprises 7" (180mm) thick off-shutter concrete panels of surface area 5.4m wide x 3m high - spanning between 250mm thick concrete column sets. Internally, beyond this 'skin' - the 'services' and 'stuff' are housed, and these need to be accommodated within the parameters of a retrofit proposal. In this instance, based upon the current premise that the a/c return ducting cannot be removed or relocated, the extent of the skin modification to facilitate increased ground- & first floor daylight values would be max. 5.4m wide x 2m high - spanning from approx. window sill height to flush under the floor slab above.

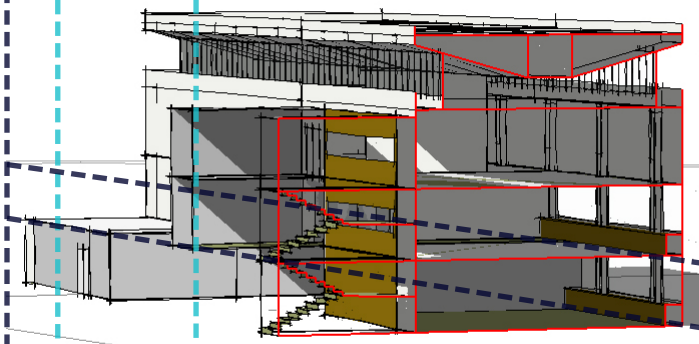


Figure 51 : Perspective section view - facing south east

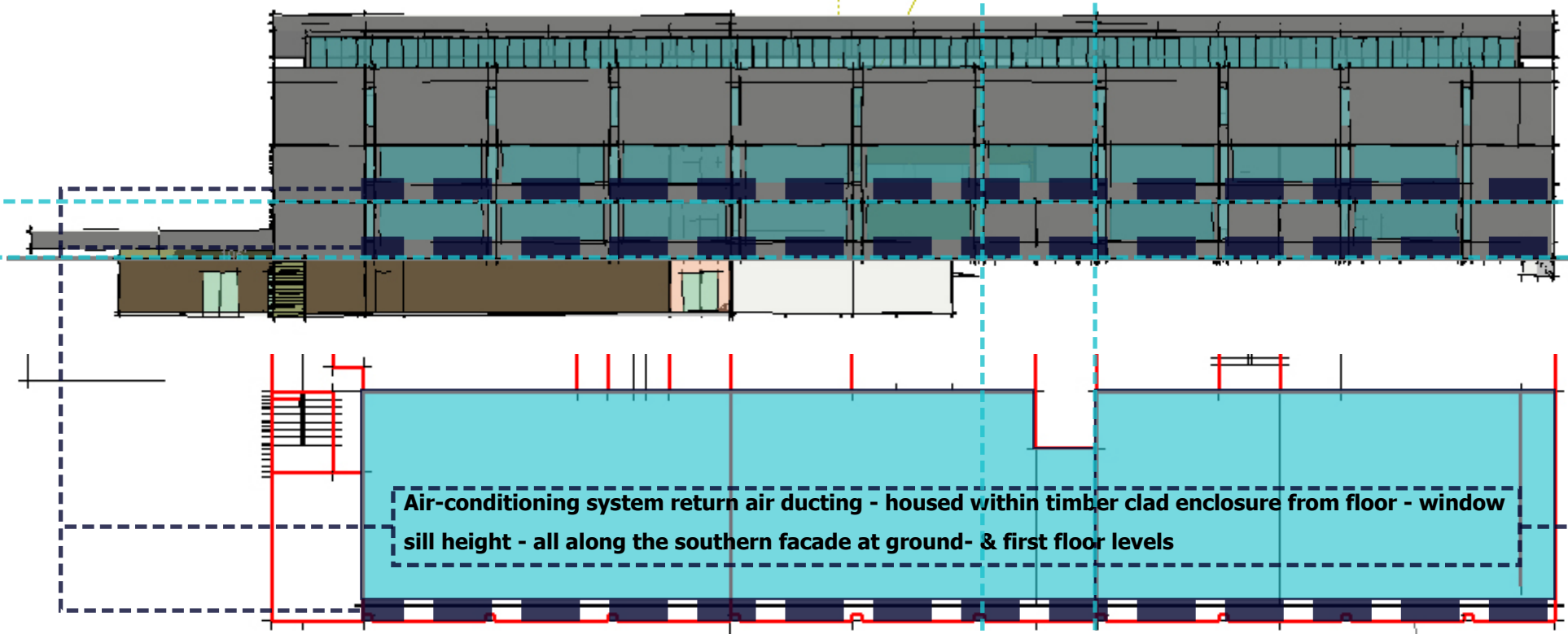


Figure 52 : Boukunde II - south elevation & sketchplan view - test proposal 3 - a/c ducting runs

TEST PROPOSAL 3					
	SECOND FLOOR	FACTOR		% lights off	
81.12m²	1st year studio (central)		5.34		82
81.76m²	1st year studio (eastern)		4.19		77
53.40m²	1st year studio (western)		3.41		72
	FIRST FLOOR				
3 x (5.4m x 2m) = 36.40m²	4th year studio	0.25	5.42	0	83
3 x (5.4m x 2m) = 35.40m²	2nd year studio (eastern)	0.29	6.58	0	85
3 x (5.4m x 2m) = 35.40m²	2nd year studio (western)	0.24	6.79	0	86
	GROUND FLOOR				
1 x (5.4m x 2m) = 19.28m²	5th year studio	1.01	2.30	23	60
2 x (5.4m x 2m) = 24.60m²	3rd year studio (eastern)	0.17	3.36	0	69
3 x (5.4m x 2m) = 35.40m²	3rd year studio (western)	0.15	4.38	0	78

Table 7 : Window retrofit daylight factor result - test proposal 3

The daylight factor correction yields a vast improvement in terms of natural light availibility to these previously disadvantaged spaces, and liberates them from the mercy of the electricity grid during daylight hours.

The retrofit strategy adopted has however, replaced a proven acoustic barrier with a less sound-proof composite panel. The focus now shifts to analysis of the result and a revised approach to noise attenuation.

Note - 2nd / 3rd / 4th year studios experience a significant change in their daylight factors, but the 5th year studio factor increase is of a lesser magnitude due to it's spatial arrangement - being 'deeper' through the north-south axis, as well as having relatively dense external foliage to the south and east (partially obstructing the vertical sky angle).

Panel A1 - 3 x 1m high x 6m wide x 180mm thick reinforced concrete panels - smooth faced

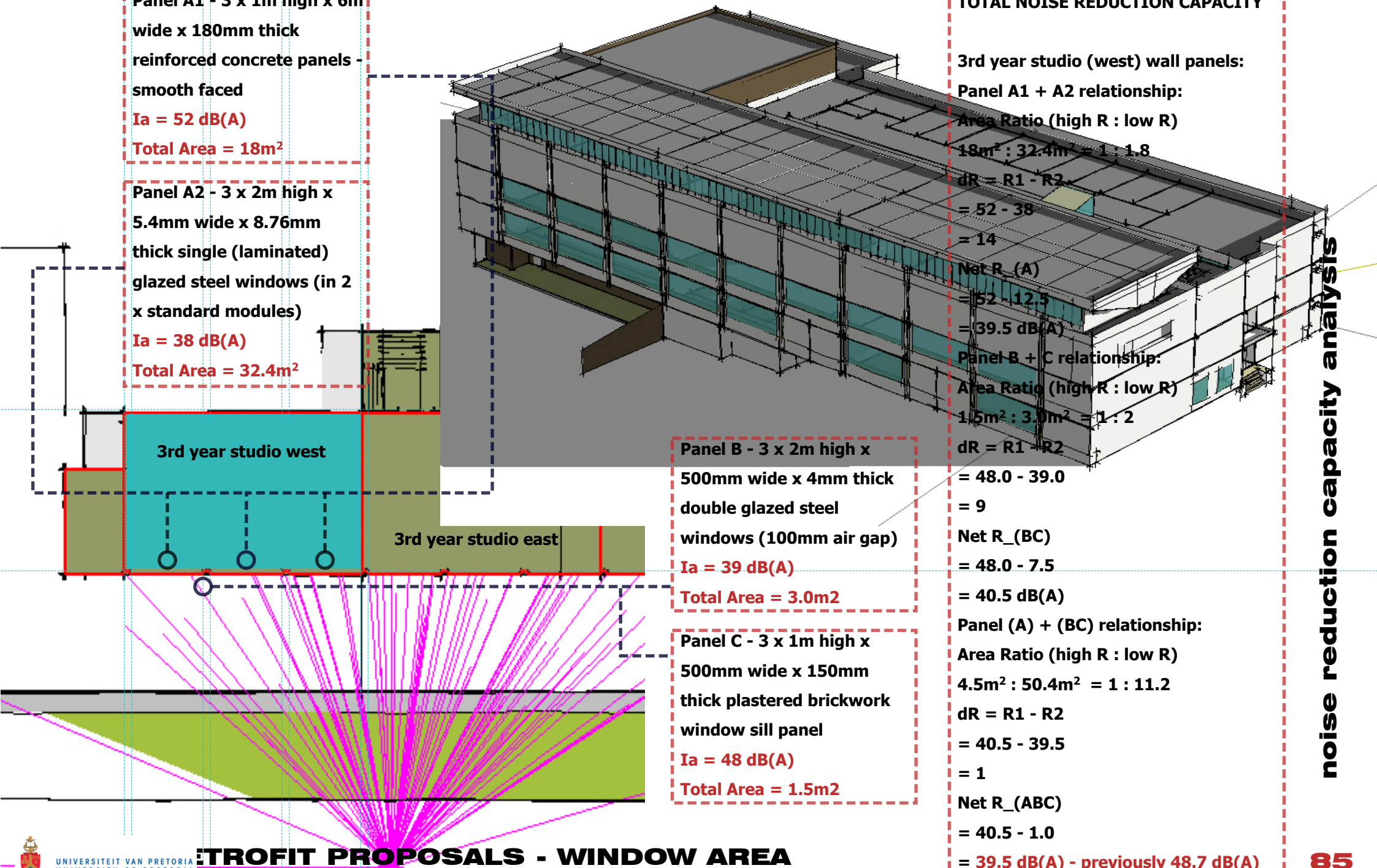
Ia = 52 dB(A)

Total Area = 18m²

Panel A2 - 3 x 2m high x 5.4mm wide x 8.76mm thick single (laminated) glazed steel windows (in 2 x standard modules)

Ia = 38 dB(A)

Total Area = 32.4m²



Panel B - 3 x 2m high x 500mm wide x 4mm thick double glazed steel windows (100mm air gap)

Ia = 39 dB(A)

Total Area = 3.0m2

Panel C - 3 x 1m high x 500mm wide x 150mm thick plastered brickwork window sill panel

Ia = 48 dB(A)

Total Area = 1.5m2

TOTAL NOISE REDUCTION CAPACITY

3rd year studio (west) wall panels:

Panel A1 + A2 relationship:

Area Ratio (high R : low R)

18m² : 32.4m² = 1 : 1.8

dR = R1 - R2

= 52 - 38

= 14

Net R_(A)

= 52 - 12.5

= 39.5 dB(A)

Panel B + C relationship:

Area Ratio (high R : low R)

1.5m² : 3.0m² = 1 : 2

dR = R1 - R2

= 48.0 - 39.0

= 9

Net R_(BC)

= 48.0 - 7.5

= 40.5 dB(A)

Panel (A) + (BC) relationship:

Area Ratio (high R : low R)

4.5m² : 50.4m² = 1 : 11.2

dR = R1 - R2

= 40.5 - 39.5

= 1

Net R_(ABC)

= 40.5 - 1.0

= 39.5 dB(A) - previously 48.7 dB(A)

noise reduction capacity analysis

Material	Thickness mm	Surface Density kg/m²	Transmission Loss * (TL) dB
Polycarbonate	8-12	10-14	30-33
Acrylic [Poly-Methyl-Meta- Acrylate (PMMA)]	15	18	32
Concrete Block 200x200x400 light weight	200	151	34
Dense concrete	100	244	40
Light concrete	150	244	39
Light concrete	100	161	36
Brick	150	288	40
Steel, 18 ga	1.27	9.8	25
Steel, 20 ga	0.95	7.3	22
Steel, 22 ga	0.79	6.1	20
Steel, 24 ga	0.64	4.9	18
Aluminium Sheet	1.59	4.4	23
Aluminium Sheet	3.18	8.8	25
Aluminium Sheet	6.35	17.1	27
Wood	25	18	21
Plywood	13	8.3	20
Plywood	25	16.1	23
Absorptive panels with polyester film backed by metal sheet	50-125	20-30	30-47

* Values assuming no openings or gaps in the barriers

Table 8 : TL values for common materials - tested for typical A-weighted traffic noise frequency spectra (www.epd.gov.hk)

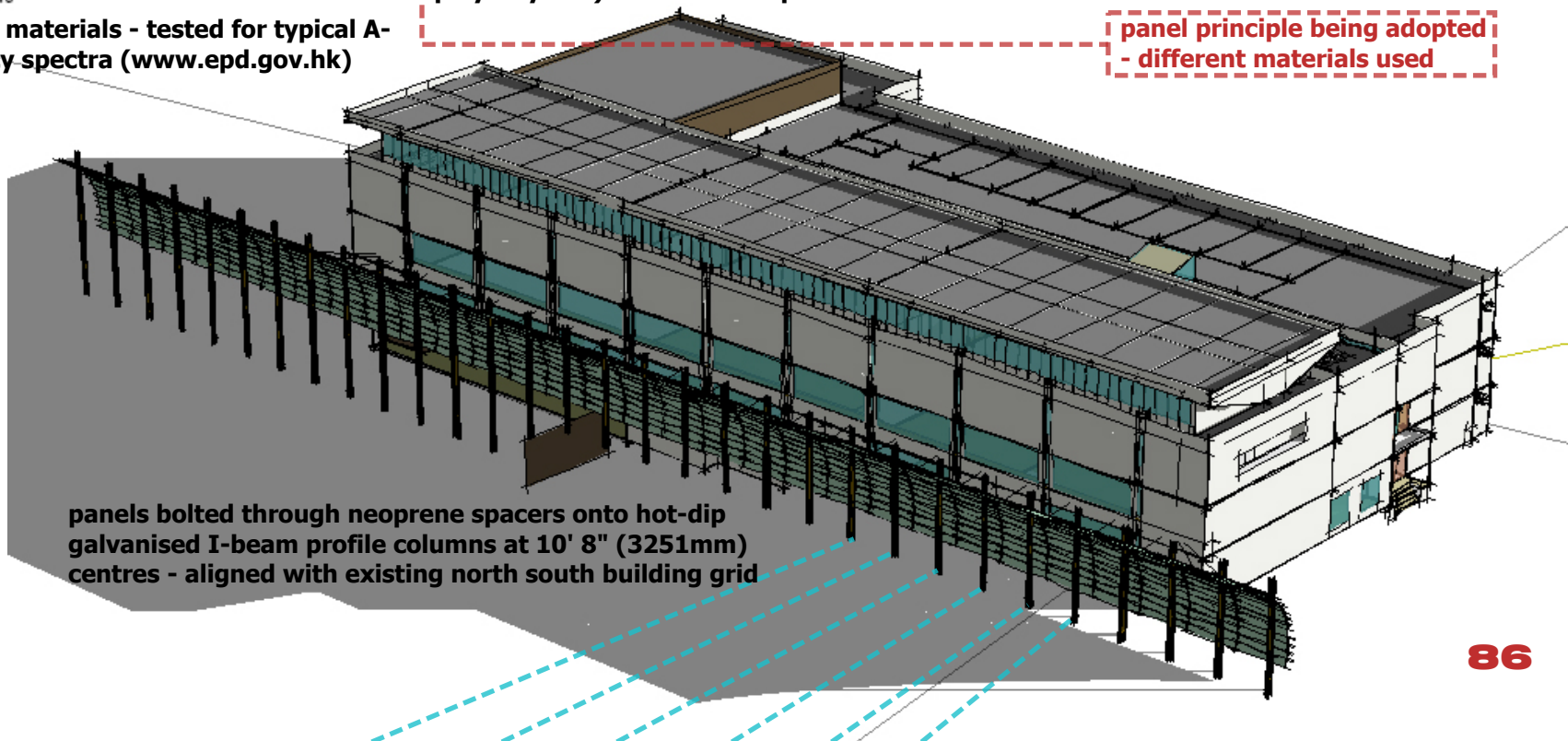
Boukunde II conceded a trade-off between daylight factor and traffic noise reduction - with the former sacrificed to the benefit of the latter. The merits of a 'daylight corrective' proposal are surely void if they are merely a reversal of fortunes.

The daylighting proposal as it currently stands, sees a noise reduction capacity drop. The previous concrete building skin, acting as a reasonably effective acoustic barrier construction has been compromised, and the noise attenuation strategy now changes from primary sound transmission loss via barrier design only - to a combination of transmission loss & external sound absorption.

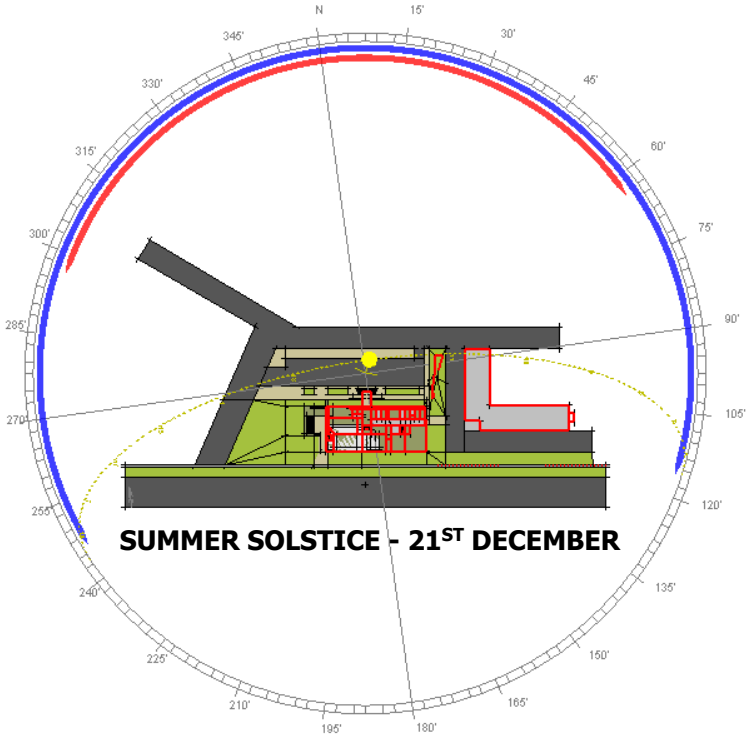
Having acoustically degraded the building skin by breaking through glazing panels (albeit glazing with a high Airborne Sound Insulation rating), the 'noise-proofing' of the southern facade could be supplemented via absorptive acoustic baffles. The proposed panels comprise a primary absorbent core material (low-density polyethylene) with an absorption co-efficient of 0.35-0.95 in the mid-octave bands.

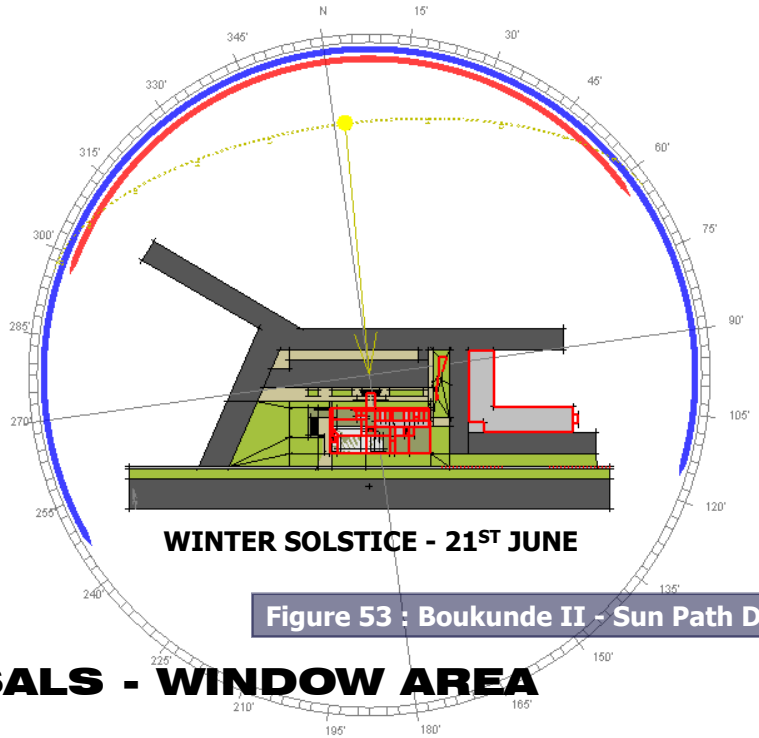
panel principle being adopted - different materials used

3m wide x 1.5m high x 50mm thick sandwich panel comprising stainless steel wire mesh outer skin with 50mm thick SONDOR Quash polyethylene foam panel mounted in a welded stainless steel 304 U-profile



panels bolted through neoprene spacers onto hot-dip galvanised I-beam profile columns at 10' 8" (3251mm) centres - aligned with existing north south building grid





The building is to be analyzed with reference to the solar positional extremes - winter & summer solstice. They represent annual set-points at which time a major climatic factor becomes measurable - the angle of the Sun relative to the project site.

These 2 dates do not necessarily represent climatic extremes i.t.o. temperature, rainfall, wind speed etc., but the analysis specifically relates to the impact of the Sun's position on the building in question.

The ultimate intent is to maximize passive design potential primarily driven by solar concepts - with the impact of climate factors and the building's operational profile viewed as supplementary elements.

The sum total of all these factors will then reflect an annual variation in conditions that need to be catered for in isolated zones- as well as through the length & breadth of the building.

Figure 53 : Boukunde II - Sun Path Diagrams - Summer & Winter Solstice

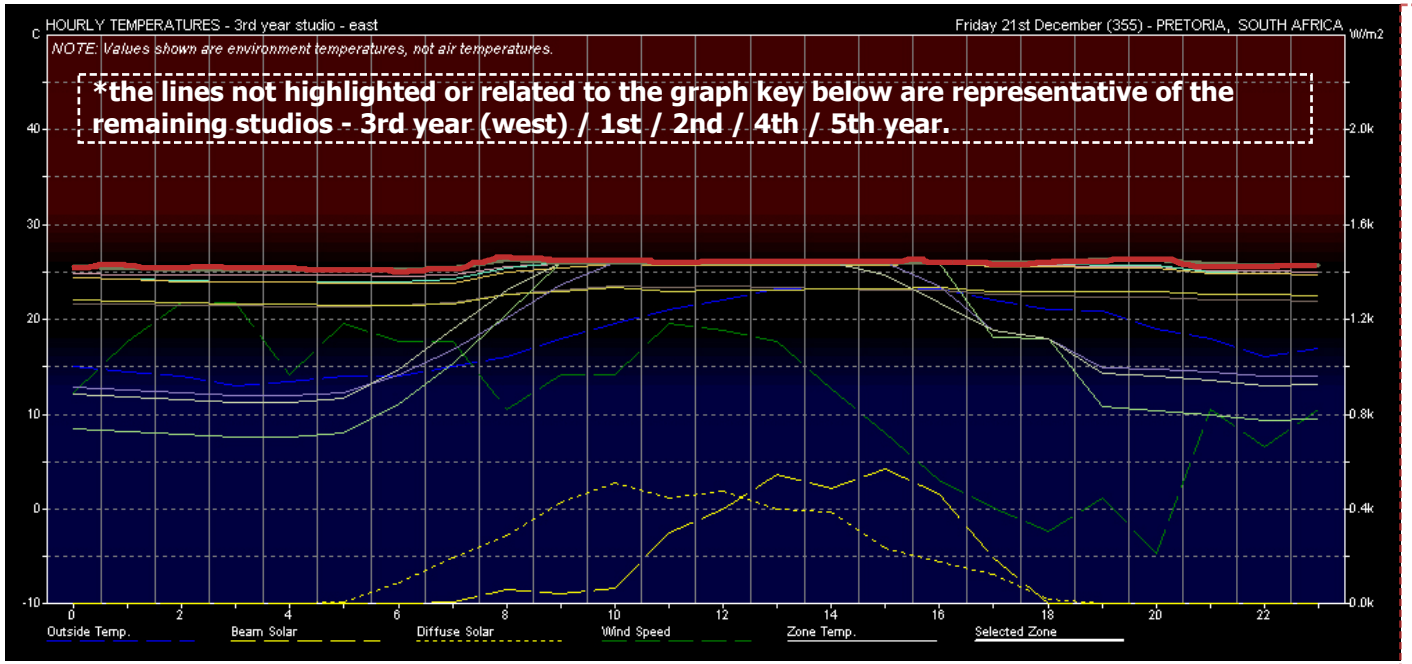
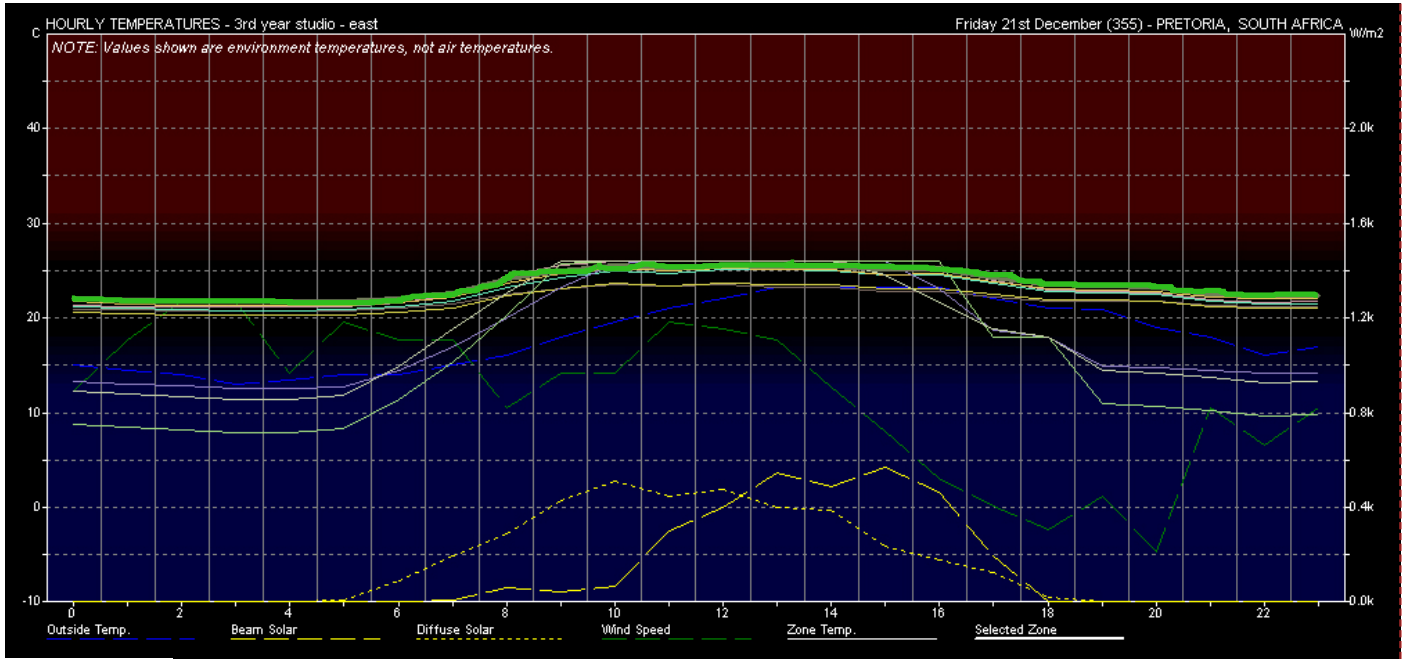


Table 9 : Environment Temperature (hourly) - summer solstice - 3rd year studio (east) - EXISTING



) : Environment Temperature (hourly) - summer solstice - 3rd year studio (east) - TEST PROPOSAL 3

All studio spaces have the following common characteristics:

- Mixed-mode air-conditioning (being a combination of natural ventilation during summer months & central air-conditioning to cover the set-points during summer and winter).
- Comfort zone a/c set-points from min. 18°C - 26°C (represented by the middle un-shaded band of the graph).
- Academic year programme from 01/02 - 30/06 & 15/07 - 30/09 & 08/10 - 20/12
- Operational weekday office hours from 08h00 - 18h00
- Operational weekend hours from 09h00 - 15h00
- Summer months from 01/02 - 31/04 & 01/09 - 30/11 (applicable to natural ventilation rates - windows being opened)
- Ventilation air change rate of 0.5 x zone volume per hour (0.5 ACH)

These aspects have been kept constant for the existing building condition as well as any retrofit proposals - so as to substantively analyze the retrofit impact on a zone-by-zone basis.

Table 11 : Hourly Temperature comparison - winter solstice

EXISTING

Zone: 3rd year studio - east
Avg. Temperature: 10.0 C (Ground 15.9 C)
Total Surface Area: 594.200 m2 (309.5% flr area).
Total Exposed Area: 77.556 m2 (40.4% flr area).
Total North Window: 0.000 m2 (0.0% flr area).
Total Window Area: 2.000 m2 (1.0% flr area).
Total Conductance (AU): 219 W/°K
Total Admittance (AY): 2966 W/°K
Response Factor: 9.74

HOUR	INSIDE (C)	OUTSIDE (C)	TEMP.DIF (C)
0	16	7	9
1	15.9	7	8.9
2	15.9	8	7.9
3	15.7	6	9.7
4	15.7	7.1	8.6
5	15.7	6.5	9.2
6	15.7	6	9.7
7	15.7	8.8	6.9
8	16.6	10.6	6
9	18	12.3	5.7
10	18	14.1	3.9
11	18	16	2
12	18	17	1
13	18	17.9	0.1
14	18	18	0
15	18	16.5	1.5
16	18	15	3
17	18	13.6	4.4
18	18	12.3	5.7
19	17	10.9	6.1
20	17	10.4	6.6
21	16.3	10	6.3
22	16.3	8.9	7.4
23	16.2	8.9	7.3

TEST PROPOSAL 3

Zone: 3rd year studio - east
Avg. Temperature: 10.0 C (Ground 15.9 C)
Total Surface Area: 594.200 m2 (309.5% flr area).
Total Exposed Area: 130.676 m2 (68.1% flr area).
Total North Window: 0.000 m2 (0.0% flr area).
Total Window Area: 23.600 m2 (12.3% flr area).
Total Conductance (AU): 333 W/°K
Total Admittance (AY): 2494 W/°K
Response Factor: 6.05

HOUR	INSIDE (C)	OUTSIDE (C)	TEMP.DIF (C)
0	13.7	7	6.7
1	13.6	7	6.6
2	13.7	8	5.7
3	13.4	6	7.4
4	13.4	7.1	6.3
5	13.4	6.5	6.9
6	13.3	6	7.3
7	13.6	8.8	4.8
8	14.7	10.6	4.1
9	18	12.3	5.7
10	18	14.1	3.9
11	18	16	2
12	18	17	1
13	18	17.9	0.1
14	18	18	0
15	18	16.5	1.5
16	18	15	3
17	18	13.6	4.4
18	18	12.3	5.7
19	14.8	10.9	3.9
20	14.8	10.4	4.4
21	14.2	10	4.2
22	14.1	8.9	5.2
23	14	8.9	5.1

Table 12 : Hourly Temperature comparison - summer solstice

EXISTING

Zone: 3rd year studio - east
Avg. Temperature: 18.4 C (Ground 15.9 C)
Total Surface Area: 594.200 m2 (309.5% flr area).
Total Exposed Area: 77.556 m2 (40.4% flr area).
Total North Window: 0.000 m2 (0.0% flr area).
Total Window Area: 2.000 m2 (1.0% flr area).
Total Conductance (AU): 219 W/°K
Total Admittance (AY): 2966 W/°K
Response Factor: 9.74

HOUR	INSIDE (C)	OUTSIDE (C)	TEMP.DIF (C)
0	25.5	15	10.5
1	25.4	14.4	11
2	25.3	14	11.3
3	25.3	13	12.3
4	25.2	13.4	11.8
5	25.2	14	11.2
6	25.2	14	11.2
7	25.3	15	10.3
8	26.3	16	10.3
9	26	18	8
10	26	19.6	6.4
11	26	21	5
12	26	22.1	3.9
13	26	23.2	2.8
14	26	23.2	2.8
15	26	23.2	2.8
16	26	23.2	2.8
17	26	22.1	3.9
18	26	21	5
19	26.3	20.9	5.4
20	26.3	19	7.3
21	25.8	18	7.8
22	25.8	16	9.8
23	25.7	17	8.7

TEST PROPOSAL 3

Zone: 3rd year studio - east
Avg. Temperature: 18.4 C (Ground 15.9 C)
Total Surface Area: 594.200 m2 (309.5% flr area).
Total Exposed Area: 130.676 m2 (68.1% flr area).
Total North Window: 0.000 m2 (0.0% flr area).
Total Window Area: 23.600 m2 (12.3% flr area).
Total Conductance (AU): 333 W/°K
Total Admittance (AY): 2494 W/°K
Response Factor: 6.05

HOUR	INSIDE (C)	OUTSIDE (C)	TEMP.DIF (C)
0	22.1	15	7.1
1	21.9	14.4	7.5
2	21.8	14	7.8
3	21.7	13	8.7
4	21.7	13.4	8.3
5	21.7	14	7.7
6	22	14	8
7	22.6	15	7.6
8	24.2	16	8.2
9	25	18	7
10	25.6	19.6	6
11	25.3	21	4.3
12	25.5	22.1	3.4
13	25.4	23.2	2.2
14	25.5	23.2	2.3
15	25.1	23.2	1.9
16	25.1	23.2	1.9
17	24.2	22.1	2.1
18	23.5	21	2.5
19	23.4	20.9	2.5
20	23.2	19	4.2
21	22.5	18	4.5
22	22.3	16	6.3
23	22.4	17	5.4

Winter Solstice Comparison: In winter the most evident trend is an increase in night-time heat losses through the glazed panels. Due to the fact that this glazing will not be exposed to any incident solar radiation in winter, it does not contribute to zonal heat gain through the course of the day. The daytime constants however, are deceptive as the zone is currently a mixed-mode volume that is served by a combination of natural ventilation (through the fenestration slivers) & central a/c which has a lower set-point of 18°C - the zone can never dip below this set-point during office hours according to the operational schedule assigned to it - only if the a/c is completely set aside will the zone operate under ambient conditions.

Summer Solstice Comparison: With the a/c upper set-point at max. 26°C the existing scenario illustrates the slight thermal lag capacity inherent in the concrete building skin from direct (beam) solar peaking at approx. 15h00, whereas the glazing proposal indicates a fairly rapid temperature drop commensurate with the external ambient conditions. Summer heat loss through the glazed skin is therefore seen to be in both seasons, with heat gain being negligible in summer & non-existent in winter.

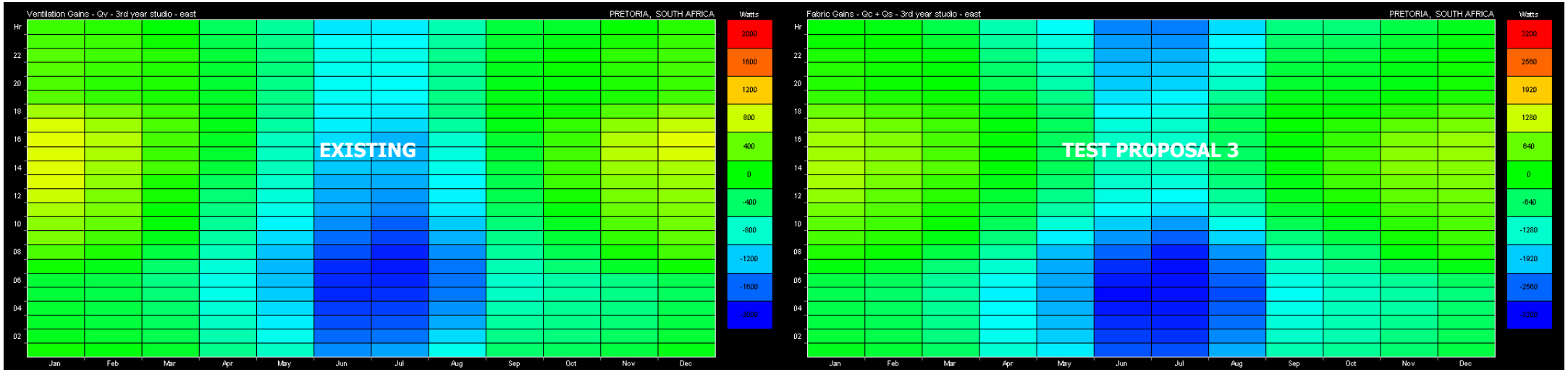


Table 13 & 14 : Fabric Gains / Losses (annual) - 3rd year studio (east)

COMPARISON:

(7 842 Wh gain) + (1 529 Wh loss) = 6 313 Watt hours nett heat loss - Mid-summer - (7 479 Wh gain) + (3 994 Wh loss) = 3 485 Watt hours nett heat loss

32 146 Watt hours nett heat loss - Mid-winter - 50 478 Watt hours nett heat loss

ANNUAL LOADS TABLE - EXISTING

Fabric Gains - Qc + Qs
3rd year studio - east - Monthly Averages

HOUR	JAN (Wh)	FEB (Wh)	MAR (Wh)	APR (Wh)	MAY (Wh)	JUN (Wh)	JUL (Wh)	AUG (Wh)	SEP (Wh)	OCT (Wh)	NOV (Wh)	DEC (Wh)
0	51	-49	-167	-550	-766	-1443	-1356	-928	-420	-367	-245	-76
1	-116	-191	-318	-680	-924	-1583	-1545	-1138	-536	-490	-378	-214
2	-168	-238	-366	-770	-1062	-1692	-1673	-1329	-618	-543	-458	-265
3	-187	-261	-407	-841	-1130	-1769	-1746	-1424	-688	-578	-503	-305
4	-225	-285	-463	-918	-1198	-1853	-1812	-1525	-772	-632	-521	-361
5	-210	-277	-518	-914	-1242	-1841	-1865	-1545	-790	-655	-512	-308
6	59	-90	-417	-850	-1275	-1830	-1907	-1537	-707	-448	-164	49
7	290	110	-258	-721	-1236	-1686	-1870	-1432	-611	-326	73	259
8	481	256	-95	-629	-1131	-1575	-1735	-1301	-529	-210	196	366
9	535	391	-32	-584	-1038	-1449	-1632	-1195	-474	-145	322	442
10	661	479	0	-512	-915	-1339	-1463	-1080	-373	-28	414	501
11	791	484	88	-461	-846	-1324	-1401	-1039	-304	87	464	555
12	871	563	98	-357	-794	-1307	-1317	-1013	-308	236	511	596
13	877	624	276	-221	-729	-1212	-1245	-914	-241	224	605	659
14	868	674	233	-183	-756	-1189	-1286	-874	-200	255	721	840
15	894	708	277	-139	-752	-1128	-1293	-817	-177	225	702	894
16	851	621	291	-91	-631	-1054	-1140	-623	-73	198	551	770
17	629	444	244	-106	-563	-1021	-1060	-516	-50	65	319	552
18	338	204	95	-166	-522	-962	-998	-517	-83	-40	108	255
19	293	163	118	-201	-530	-963	-986	-571	-90	-16	121	229
20	336	226	127	-201	-490	-934	-942	-551	-106	29	164	256
[illegible]	[illegible]	[illegible]	152	-234	-486	-917	-911	-550	-135	6	176	252
[illegible]	[illegible]	[illegible]	47	-310	-546	-983	-1008	-620	-191	-80	98	212
[illegible]	[illegible]	[illegible]	-11	-364	-609	-1092	-1073	-689	-238	-165	25	155

ANNUAL LOADS TABLE - TEST PROPOSAL 3

Fabric Gains - Qc + Qs
3rd year studio - east - Monthly Averages

HOUR	JAN (Wh)	FEB (Wh)	MAR (Wh)	APR (Wh)	MAY (Wh)	JUN (Wh)	JUL (Wh)	AUG (Wh)	SEP (Wh)	OCT (Wh)	NOV (Wh)	DEC (Wh)
0	-186	-337	-607	-1325	-1718	-2693	-2694	-2119	-1091	-934	-694	-414
1	-352	-467	-807	-1490	-1909	-2817	-2898	-2336	-1273	-1093	-803	-546
2	-409	-530	-881	-1558	-2019	-2924	-2997	-2502	-1360	-1132	-912	-609
3	-455	-587	-934	-1613	-2085	-3051	-3060	-2611	-1439	-1165	-1009	-673
4	-512	-642	-1000	-1671	-2154	-3156	-3098	-2727	-1531	-1210	-1017	-776
5	-421	-572	-957	-1504	-2143	-3033	-3091	-2618	-1423	-1161	-932	-606
6	-87	-244	-730	-1301	-2123	-2917	-3106	-2491	-1240	-885	-422	-109
7	202	54	-426	-1028	-2017	-2572	-3010	-2266	-1057	-701	-65	214
8	455	234	-123	-747	-1682	-2244	-2602	-1858	-766	-434	112	370
9	565	405	44	-553	-1353	-1901	-2221	-1471	-525	-195	281	489
10	715	518	132	-396	-1043	-1570	-1796	-1103	-304	5	454	571
11	901	582	267	-301	-851	-1427	-1583	-939	-178	199	604	688
12	1031	736	337	-134	-676	-1285	-1357	-779	-122	406	717	778
13	1073	844	536	-17	-558	-1137	-1171	-633	-54	424	833	836
14	1011	847	465	-19	-585	-1169	-1249	-619	-31	400	866	942
15	1001	818	454	-25	-594	-1247	-1273	-606	-16	333	788	932
16	936	683	389	-64	-575	-1373	-1277	-527	26	243	561	746
17	667	448	265	-180	-687	-1590	-1457	-646	-35	48	264	501
18	325	171	75	-360	-860	-1757	-1663	-924	-160	-157	-24	182
19	212	80	16	-538	-1083	-1926	-1868	-1242	-278	-238	-114	107
20	226	101	-36	-656	-1151	-2000	-1968	-1348	-376	-285	-121	88
21	177	84	-105	-809	-1259	-2094	-2080	-1465	-508	-404	-176	35
22	53	12	-329	-992	-1407	-2223	-2275	-1639	-663	-586	-337	-84
23	-22	-101	-451	-1105	-1554	-2372	-2418	-1807	-797	-747	-447	-177

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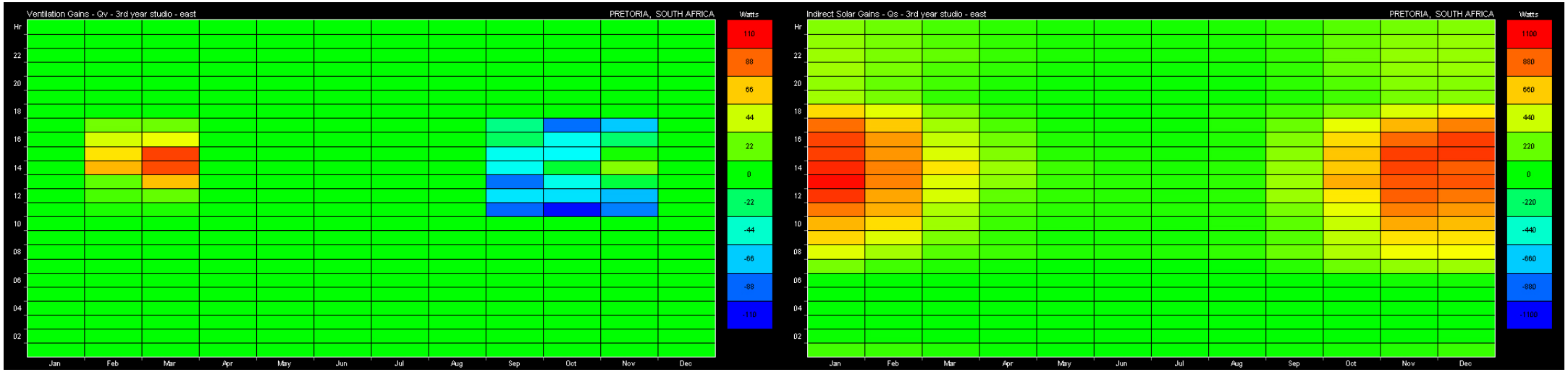


Table 15 & 16 : Ventilation / Infiltration Gains / Losses (annual) & Indirect Solar Gains (annual) - 3rd year studio (east) - EXISTING & TEST PROPOSAL 3

Ventilation / Infiltration : The gains & losses for both scenarios differ by an insignificant margin (less than 1 Wh) in most instances, which is attributed to infiltration via the less airtight glazed panels vs. homogenous full concrete panels - with ventilation rates identical due to new glazing being fixed pane.

Indirect Solar : The lesser capacity of glass to prevent solar gain or loss - even diffuse solar - is demonstrated, and the pattern of greater daytime gains coupled with greater night-time losses is evident for the glazing proposal over the existing concrete facade.

ANNUAL LOADS TABLE - EXISTING & TEST PROPOSAL 3

Ventilation Gains - Qv
3rd year studio - east - Monthly Averages

HOUR	JAN (Wh)	FEB (Wh)	MAR (Wh)	APR (Wh)	MAY (Wh)	JUN (Wh)	JUL (Wh)	AUG (Wh)	SEP (Wh)	OCT (Wh)	NOV (Wh)	DEC (Wh)
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	6	6	0	0	0	0	0	-88	-107	-83	0
11	0	16	21	0	0	0	0	0	-60	-61	-69	0
12	0	20	68	0	0	0	0	0	-86	-51	-13	0
13	0	70	94	0	0	0	0	0	-52	-11	29	0
14	0	61	96	0	0	0	0	0	-52	-54	4	0
15	0	46	51	0	0	0	0	0	-21	-52	-24	0
16	0	24	23	0	0	0	0	0	-29	-86	-66	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0

ANNUAL LOADS TABLE - EXISTING & TEST PROPOSAL 3

Indirect Solar Gains - Qs
3rd year studio - east - Monthly Averages

HOUR	JAN (Wh)		FEB (Wh)		MAR (Wh)		APR (Wh)	MAY (Wh)	JUN (Wh)		JUL (Wh)	AUG (Wh)	SEP (Wh)	OCT (Wh)		NOV (Wh)		DEC (Wh)	
0	141	81	121	72	68	43	17	2	0	0	4	13	26	42	24	73	41	121	69
1	23	13	14	8	1	1	0	0	0	0	0	0	0	0	0	3	1	13	7
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	8	8	0	0	0	0	0	0	0	0	0	0	0	8	8	38	38	39	39
6	251	251	139	139	68	68	26	0	0	0	0	5	88	230	230	312	312	333	333
7	485	485	351	351	187	187	130	71	64	64	68	107	223	380	380	521	521	533	533
8	637	637	474	474	263	263	109	37	41	41	38	70	177	406	406	608	608	609	609
9	708	708	621	621	341	341	125	60	63	63	43	73	199	429	429	732	732	693	693
10	842	843	722	722	370	370	162	91	77	77	73	81	257	500	501	824	830	770	776
11	986	1019	742	762	463	474	206	104	80	80	58	90	331	596	630	896	936	845	884
12	1076	1129	820	863	480	510	302	115	87	106	67	98	336	727	776	918	978	921	976
13	1015	1088	819	882	605	643	332	129	73	82	56	88	321	665	716	957	1019	897	953
14	964	1009	776	843	472	513	279	84	60	73	42	66	297	673	699	966	1011	980	1006
15	956	981	767	815	421	451	241	68	38	51	28	68	278	627	644	875	903	968	971
16	862	881	663	695	346	372	163	38	25	37	21	71	224	501	524	704	714	822	810
17	631	648	489	504	264	277	94	19	12	21	25	69	145	270	306	469	461	584	564
18	345	335	256	260	108	128	43	22	17	22	16	21	68	140	153	253	242	294	258
19	308	257	218	200	142	126	62	27	20	22	15	26	93	177	170	284	253	283	235
20	342	273	259	218	163	134	100	43	32	29	27	40	105	224	188	308	250	323	259
21	334	259	262	206	209	151	116	59	42	38	39	51	111	223	175	315	235	321	248
22	311	221	253	176	176	126	106	58	50	44	48	56	111	212	148	292	201	317	221
23	280	175	231	144	154	98	93	56	48	45	49	59	104	184	111	244	142	280	168



Table 17 : Internal Gains (annual) - 3rd year studio (east) - EXISTING & TEST PROPOSAL 3

There is no difference between the scenarios in terms of internal gains, which are assigned the following characteristics :

General :

- Academic year programme from 01/02 - 30/06 & 15/07 - 30/09 & 08/10 - 20/12

- Operational weekday office hours from 08h00 - 18h00

- Operational weekend hours from 09h00 - 15h00

Zone Specific :

- 30 students resident during operational hours

- Each student generating 70 Watts of heat energy through sedentary activity levels

- Sensible heat gain of 5 watts/m^2 & latent heat gain of 2 watts/m^2 through small power and lighting sources in the zone

- Zone floor surface area = 192m^2

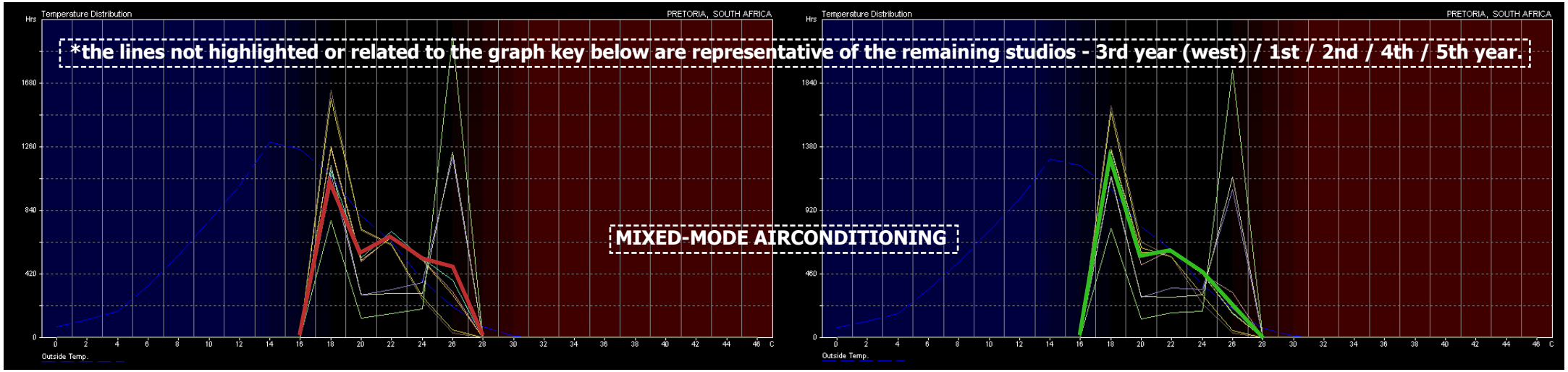


Table 18 & 19 : Temperature Distribution (annual) - 3rd year studio (east) - EXISTING & TEST PROPOSAL 3

Mixed-Mode: The impact of central air-conditioning on the zone is evident when the annual temperature distribution graphs are compared. The system 'overrides' environmental fluctuations to maintain comfort levels throughout the year, and the only noticeable difference due to increased glazing is a slight drop in the time spent at the higher comfort set temperatures (22-26°C) & more time within the lower comfort levels (18-21°C) - again, likely as a result of conductive heat loss through the glazing and not ventilation (the glazing is fixed).

Natural Ventilation: Same general trend - indicative of heat loss, but not of a significant magnitude.

*** SEE TABLE ON OVERLEAF FOR DETAIL BREAKDOWN OF GRAPH VALUES & MAGNITUDE OF VARIATION.**

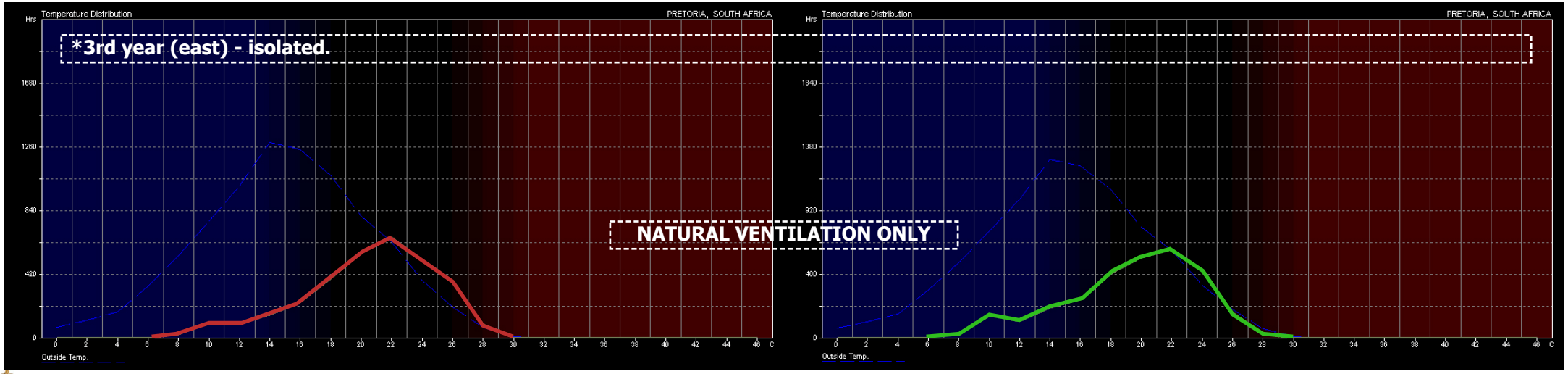


Table 20 & 21 : Temperature Distribution (annual) - 3rd year studio (east) - EXISTING & TEST PROPOSAL 3

Table 22 : Temperature Distribution comparison - mixed mode a/c vs. natural ventilation

3rd year studio - east
Operation: Weekdays 08-18, Weekends 09-15.
Comfort Band: 18.0 - 26.0 C

EXISTING Mixed Mode scenario In Comfort: 3234 Hrs (100.0%)			Natural Ventilation In Comfort: 2507 Hrs (77.5%)			TEST PROPOSAL 3 Mixed Mode scenario In Comfort: 3234 Hrs (100.0%)			Natural Ventilation In Comfort: 2366 Hrs (73.2%)		
TEMP.	HOURS	PERCENT	TEMP.	HOURS	PERCENT	TEMP.	HOURS	PERCENT	TEMP.	HOURS	PERCENT
0	0	0.00%	0	0	0.00%	0	0	0.00%	0	0	0.00%
2	0	0.00%	2	0	0.00%	2	0	0.00%	2	0	0.00%
4	0	0.00%	4	0	0.00%	4	0	0.00%	4	0	0.00%
6	0	0.00%	6	3	0.10%	6	0	0.00%	6	10	0.30%
8	0	0.00%	8	28	0.90%	8	0	0.00%	8	34	1.10%
10	0	0.00%	10	103	3.20%	10	0	0.00%	10	166	5.10%
12	0	0.00%	12	102	3.20%	12	0	0.00%	12	127	3.90%
14	0	0.00%	14	157	4.90%	14	0	0.00%	14	220	6.80%
16	0	0.00%	16	238	7.40%	16	0	0.00%	16	282	8.70%
18	1025	31.70%	18	395	12.20%	18	1304	40.30%	18	466	14.40%
20	565	17.50%	20	564	17.40%	20	585	18.10%	20	584	18.10%
22	666	20.60%	22	666	20.60%	22	636	19.70%	22	638	19.70%
24	511	15.80%	24	511	15.80%	24	486	15.00%	24	493	15.20%
26	467	14.40%	26	371	11.50%	26	223	6.90%	26	185	5.70%
28	0	0.00%	28	96	3.00%	28	0	0.00%	28	29	0.90%
30	0	0.00%	30	0	0.00%	30	0	0.00%	30	0	0.00%
32	0	0.00%	32	0	0.00%	32	0	0.00%	32	0	0.00%
34	0	0.00%	34	0	0.00%	34	0	0.00%	34	0	0.00%
36	0	0.00%	36	0	0.00%	36	0	0.00%	36	0	0.00%
38	0	0.00%	38	0	0.00%	38	0	0.00%	38	0	0.00%
40	0	0.00%	40	0	0.00%	40	0	0.00%	40	0	0.00%
42	0	0.00%	42	0	0.00%	42	0	0.00%	42	0	0.00%
44	0	0.00%	44	0	0.00%	44	0	0.00%	44	0	0.00%
46	0	0.00%	46	0	0.00%	46	0	0.00%	46	0	0.00%
COMFORT	3234	100.00%	COMFORT	2507	77.50%	COMFORT	3234	100.00%	COMFORT	2366	73.20%

As the graph would seem to indicate - there is a relatively minor variation in the amount of time spent in the designated comfort band owing to the additional glazing of the studio space. The lesser capacity of the glazed surface in keeping heat within the zone seems to be the primary factor to which the 4.30% difference can be attributed - as time spent below the comfort band temperatures is substantially more (208 hours) and time above the band is less (67 hours) - than those when the zone still had a concrete skin.

The extra glazing is currently assigned as fixed pane, and thus the projected air change rate has remained as it was. In both cases the variation in time spent within the comfort band seems to indicate an acceptable level of thermal comfort that could possibly reach fairly close to 100% air-conditioned levels with the addition of a less energy-intensive heating strategy.

Table 23 : Monthly Heating & Cooling loads comparison

Zone: 3rd year studio - east
Operation: Weekdays 08-18, Weekends 09-15.
Thermostat Settings: 18.0 - 26.0 C

Floor Area: 192.000 m2

EXISTING
Max Heating: 8672 W at 10:00 on 22nd July
Max Cooling: 6919 W at 15:00 on 2nd March

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	0	25653	25653
Feb	0	135714	135714
Mar	0	190403	190403
Apr	13305	17145	30450
May	16919	0	16919
Jun	154492	0	154492
Jul	459380	0	459380
Aug	44980	0	44980
Sep	5021	12210	17231
Oct	1145	55550	56695
Nov	0	93419	93419
Dec	0	92913	92913
TOTAL	695242	623007	1318249
PER M²	3621	3245	6866

TEST PROPOSAL 3
Max Heating: 6647 W at 10:00 on 21st July
Max Cooling: 10473 W at 13:00 on 6th February

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	0	67722	67722
Feb	0	174610	174610
Mar	0	188802	188802
Apr	12271	0	12271
May	31433	0	31433
Jun	202015	0	202015
Jul	466213	0	466213
Aug	41804	0	41804
Sep	988	0	988
Oct	0	76739	76739
Nov	0	117504	117504
Dec	0	26170	26170
TOTAL	754724	651547	1406272
PER M²	3931	3393	7324

Table 24 : Monthly Heating & Cooling loads comparison - varied orientation

Zone: 5th year studio - gf
Operation: Weekdays 08-18, Weekends 09-15.
Thermostat Settings: 18.0 - 26.0 C

Floor Area: 259.200 m2

Max Heating: 7164 W at 11:00 on 21st July
Max Cooling: 10534 W at 12:00 on 30th October

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	0	0	0
Feb	0	94184	94184
Mar	0	87109	87109
Apr	13048	0	13048
May	59599	0	59599
Jun	309761	0	309761
Jul	533259	0	533259
Aug	74877	0	74877
Sep	4185	0	4185
Oct	2825	57874	60700
Nov	0	0	0
Dec	0	0	0
TOTAL	997554	239168	1236722
PER M²	3849	923	4771

Zone: 1st year studio middle - sf
Operation: Weekdays 08-18, Weekends 09-15.
Thermostat Settings: 18.0 - 26.0 C

Floor Area: 230.400 m2

Max Heating: 38116 W at 18:00 on 20th July
Max Cooling: 341644 W at 13:00 on 9th February

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	0	10779658	10779658
Feb	0	11957398	11957398
Mar	0	12324979	12324979
Apr	81749	5212197	5293946
May	292025	10312901	10604926
Jun	790276	10495085	11285361
Jul	728061	12948470	13676531
Aug	233587	10736713	10970300
Sep	32474	4537664	4570138
Oct	45829	11159110	11204939
Nov	23734	10387669	10411403
Dec	0	9053516	9053516
TOTAL	2227735	119905360	122133096
PER M²	9669	520423	530092

From prior anaylsis it is clear that the presence of a central air-conditioning unit can correct most thermal imbalances within a building comprising varying zone conditions. The extent of these loads - being thermal losses and/or gains - will ultimately impact upon the building's energy consumption and it's reliance upon artificial conditioning of internal spaces. Illustrated by the monthly heating/cooling loads generated for the 3rd year studio (east) - as it currently exists, and upon breaking through the glazing panels - there is an increase in overall loads of approx. 7%. These loads are not directly related to kWh of electrical consumption, which becomes a factor air-conditioning efficiency (conversion of electrical - thermal energy), but they do offer a fair reflection of 'cause & effect.'

The 3rd year studio has been the reference in all thermal analyses as it was a locale in desperate need of daylight factor correction and is centrally located in relation to the remaining studio zones under analysis. Of these studios, it is worth noting that the existing 1st year studio (central) is the studio with the most favourable daylight conditions, but is also the space that requires the most energy to be expended in keeping it within the 18-26oC comfort band - just over 72x more energy/m² of floor area than the altered 3rd year scenario. The primary reasons for this are self-evident in the form of generous double volumes with clerestory exposure on both sides - and the merits of these aspects are not being questioned, but an alternative strategy to offset the resultant loads is needed. The existing 5th year studio condition illustrates the value of protected glazing on the eastern & northern facades (as well as the south facade), and renders a ...ate heating/cooling load in comparison - 44% less than the existing 3rd year studio condition.

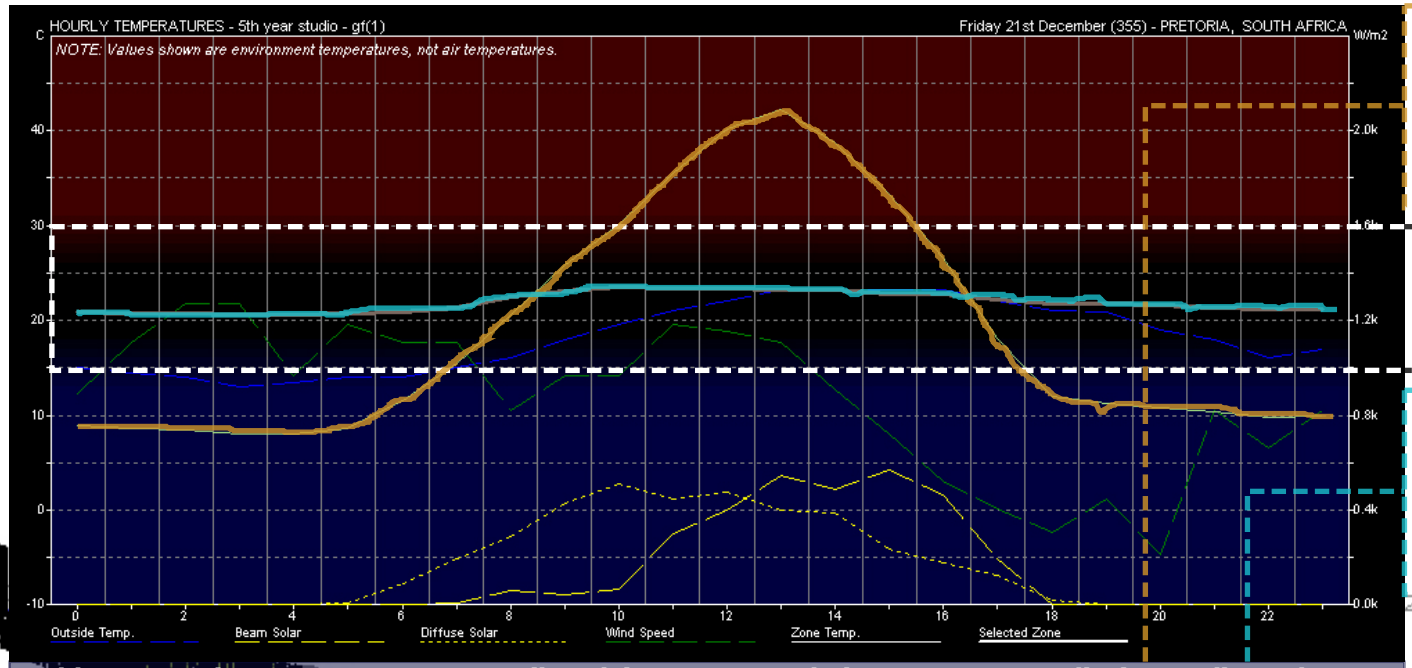


Table 25 : Environment Temperature (hourly) - summer solstice - 1st year studio (central) & 5th year studio - natural ventilation only

1st year studio (central):
- thermally in-efficient
- floor area = 230.40m²
- space volume = 1 474.59m³
- heating/cooling load = 530 092 Wh/m²
- north window area = 32.40m² (exposed)

COMFORT BAND

18 - 26°C

5th year studio:
- thermally efficient
- floor area = 259.20m²
- space volume = 777.59m³
- heating/cooling load = 4 771 Wh/m²
- north window area = 4.00m² (protected)

The graph illustrates the vast disparity in thermal performance between the 2 locales in summer. The 1st year studio is severely exposed via it's clerestory band and concrete roof, and being that the clerestory is all fixed pane - it serves to trap heated air for necessary extraction via the ceiling mounted a/c return ducts. Over-exposure works in the volume's favour during winter - with the large temperature swing being a perennial feature of the space, but a levelling out of this diurnal thermal trend would offer greater overall efficiency.

A thermal load comparision of these 2 adjacent zones of virtually equal floor area and similar elemental exposure reveals a disparate thermal response. The primary reasons being their differing operational profiles - with the computer lab having a greater internal heat load, and a greater exposed horizontal surface area on the part of the PC lab - all contributing to a greater overall cooling load/m^2, and virtually no heating load. The crit hall in turn, has a double volume which will see most of the internal heat generated lost via convective transfer to the upper reaches. Horizontal surface fabric gains (of benefit in winter) are also reduced due to the fact that the roof surface is sunk below the level of adjacent structures and is thus overshadowed. The sunken roof is also segmented by the raised panels with glass block inlays, which serve to 'break up' what would otherwise have been a continuous conductive roof surface.

Table 26 : Monthly Heating & Cooling loads comparison - varied orientation

Zone: Computer lab - sf
Operation: Weekdays 08-18, Weekends 09-15.
Thermostat Settings: 18.0 - 26.0 C
*Served by dedicated split units

Floor Area: 104.640 m2

Max Heating: 3530 W at 18:00 on 18th June
Max Cooling: 12813 W at 13:00 on 2nd March

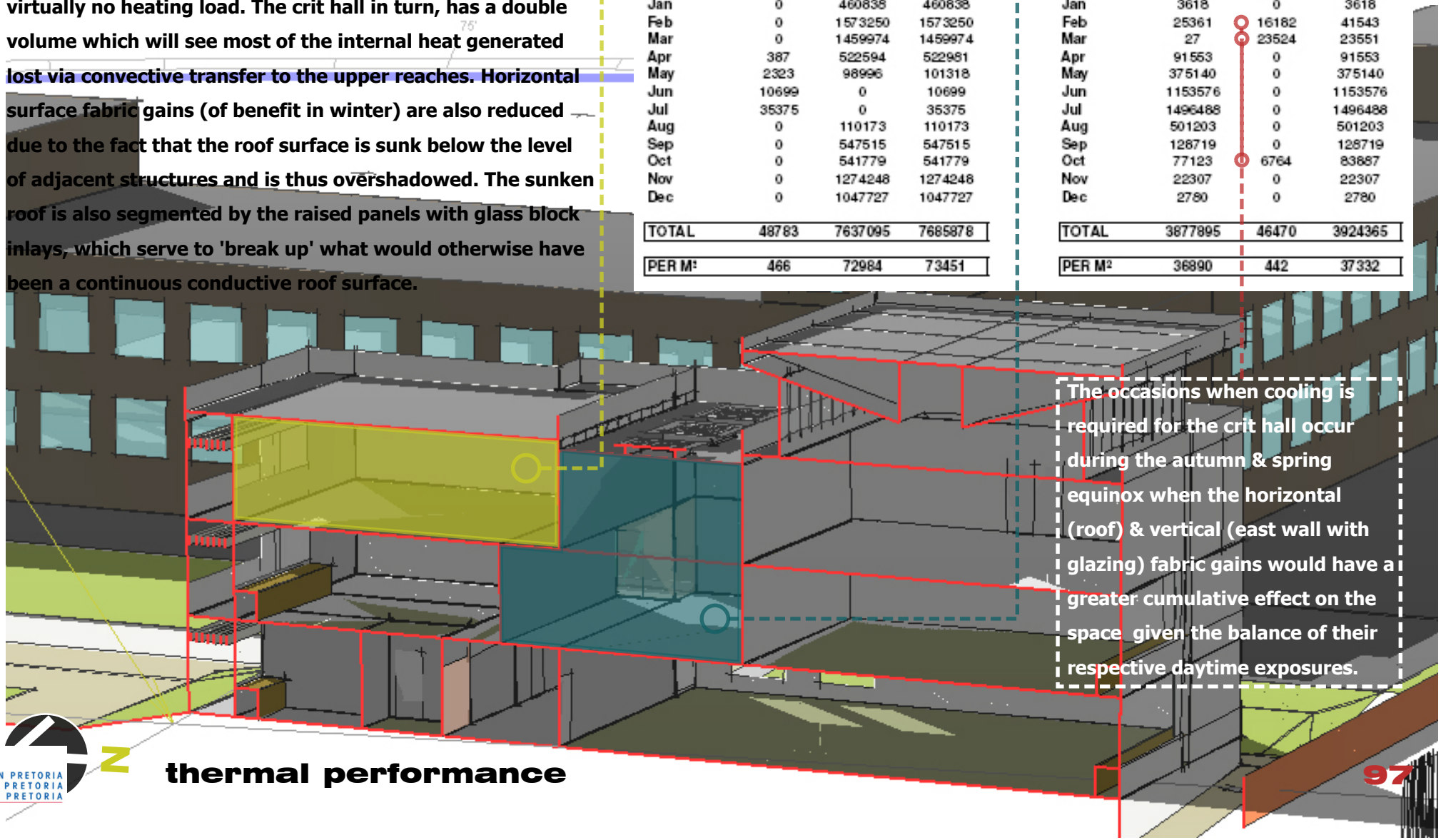
MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	0	460838	460838
Feb	0	1573250	1573250
Mar	0	1459974	1459974
Apr	387	522594	522981
May	2323	98996	101318
Jun	10699	0	10699
Jul	35375	0	35375
Aug	0	110173	110173
Sep	0	547515	547515
Oct	0	541779	541779
Nov	0	1274248	1274248
Dec	0	1047727	1047727
TOTAL	48783	7637095	7685878
PER M²	466	72984	73451

Zone: Crit hall - double volume - ff/sf
Operation: Weekdays 08-18, Weekends 09-15.
Thermostat Settings: 18.0 - 26.0 C
*Served by central air-conditioning

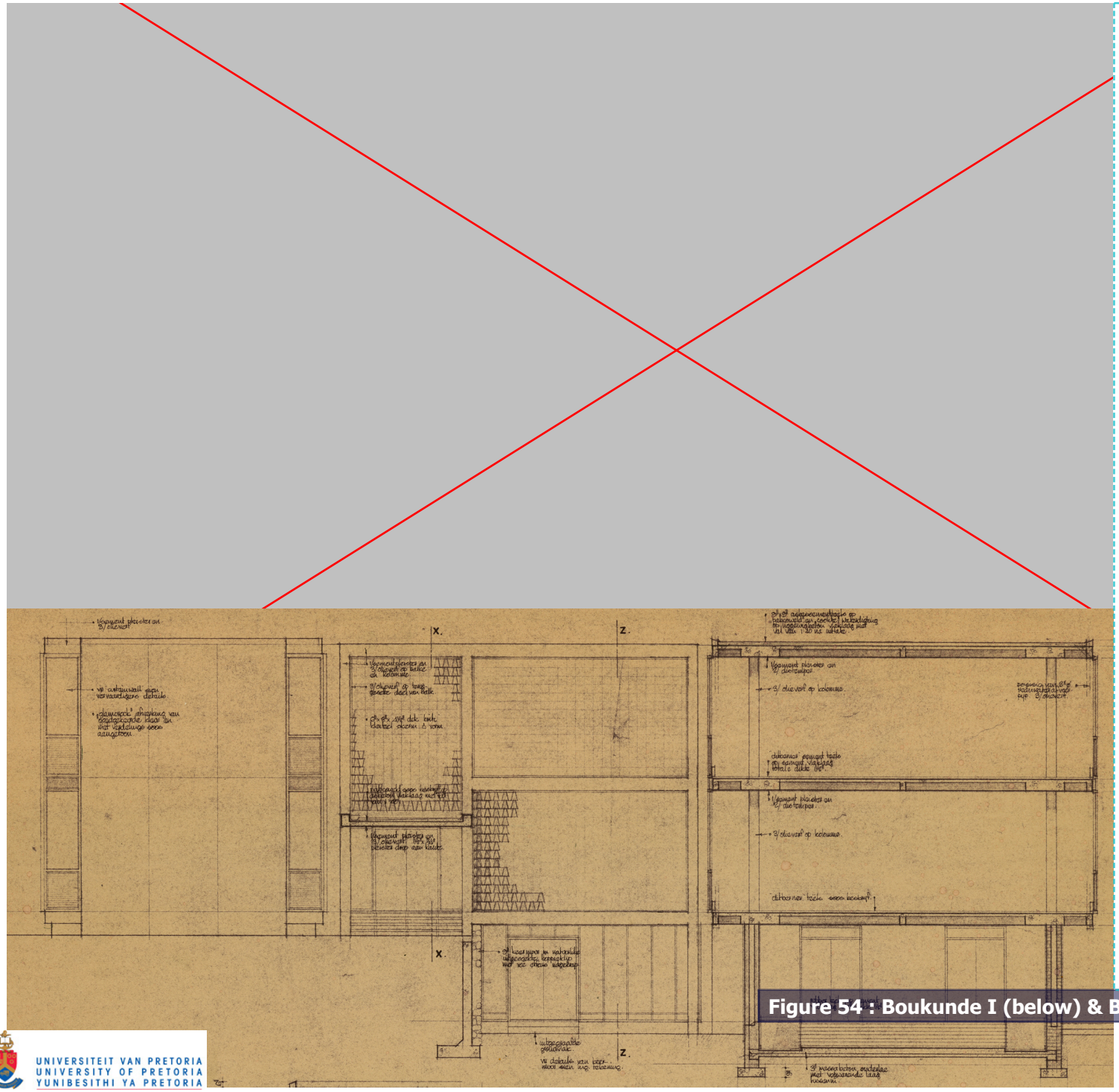
Floor Area: 105.120 m2

Max Heating: 9777 W at 10:00 on 21st July
Max Cooling: 2093 W at 15:00 on 2nd March

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	3618	0	3618
Feb	25361	16182	41543
Mar	27	23524	23551
Apr	91553	0	91553
May	375140	0	375140
Jun	1153576	0	1153576
Jul	1496488	0	1496488
Aug	501203	0	501203
Sep	128719	0	128719
Oct	77123	6764	83887
Nov	22307	0	22307
Dec	2780	0	2780
TOTAL	3877895	46470	3924365
PER M²	36890	442	37332



The occasions when cooling is required for the crit hall occur during the autumn & spring equinox when the horizontal (roof) & vertical (east wall with glazing) fabric gains would have a greater cumulative effect on the space given the balance of their respective daytime exposures.



According to Mitchell's Practical Thermal Design in Buildings, "Lightweight buildings respond quickly to control and when intermittent heating or night setback of temperature are employed their temperature will drop rapidly, thus reducing the heat loss compared with a more massive building." (Burberry. 1983:36)

In the case of Boukunde, it is possible to compare 2 buildings with distinctly variant construction - particularly in respect of building skins - which are subject to identical ambient conditions and operational profiles.

The 2 buildings had decidedly different environmental strategies. Boukunde II is a deep-set well insulated box that 'guarantees' thermal comfort via conditioned air. Boukunde I has a relatively shallow space format that is severely exposed to the elements, and relies on its capacity to effectively cross ventilate.

Figure 54 : Boukunde I (below) & Boukunde II - section view north-south

FIRST FLOOR	FACTOR
4th year studio	46.31
2nd year studio (eastern)	38.54
2nd year studio (western)	40.85
GROUND FLOOR	
5th year studio	51.65
3rd year studio (eastern)	48.66
3rd year studio (western)	52.87

* all the studios register values above the graph threshold - with set point @ 300lux

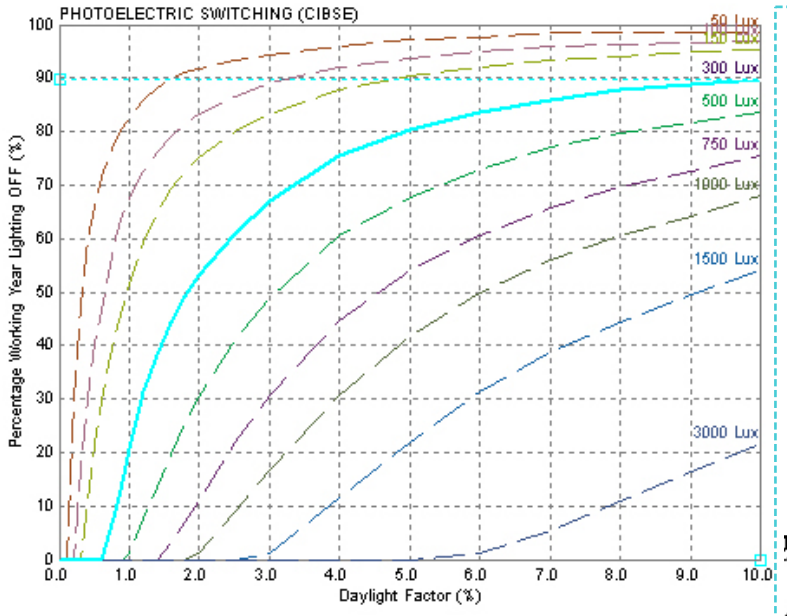


Table 27 : Average Daylight Factor - BOUKUNDE I

The studio zones of Boukunde II are simulated into the footprint and building skin of Boukunde I to determine the difference in average daylight factor that was available to the students almost 50 years ago.

The result indicates (as expected) that the studios on the southern flank of the building would have been working in a well-lit environment for approx. 90% of the working year (low winter sun angles accounting for the remaining 10%).

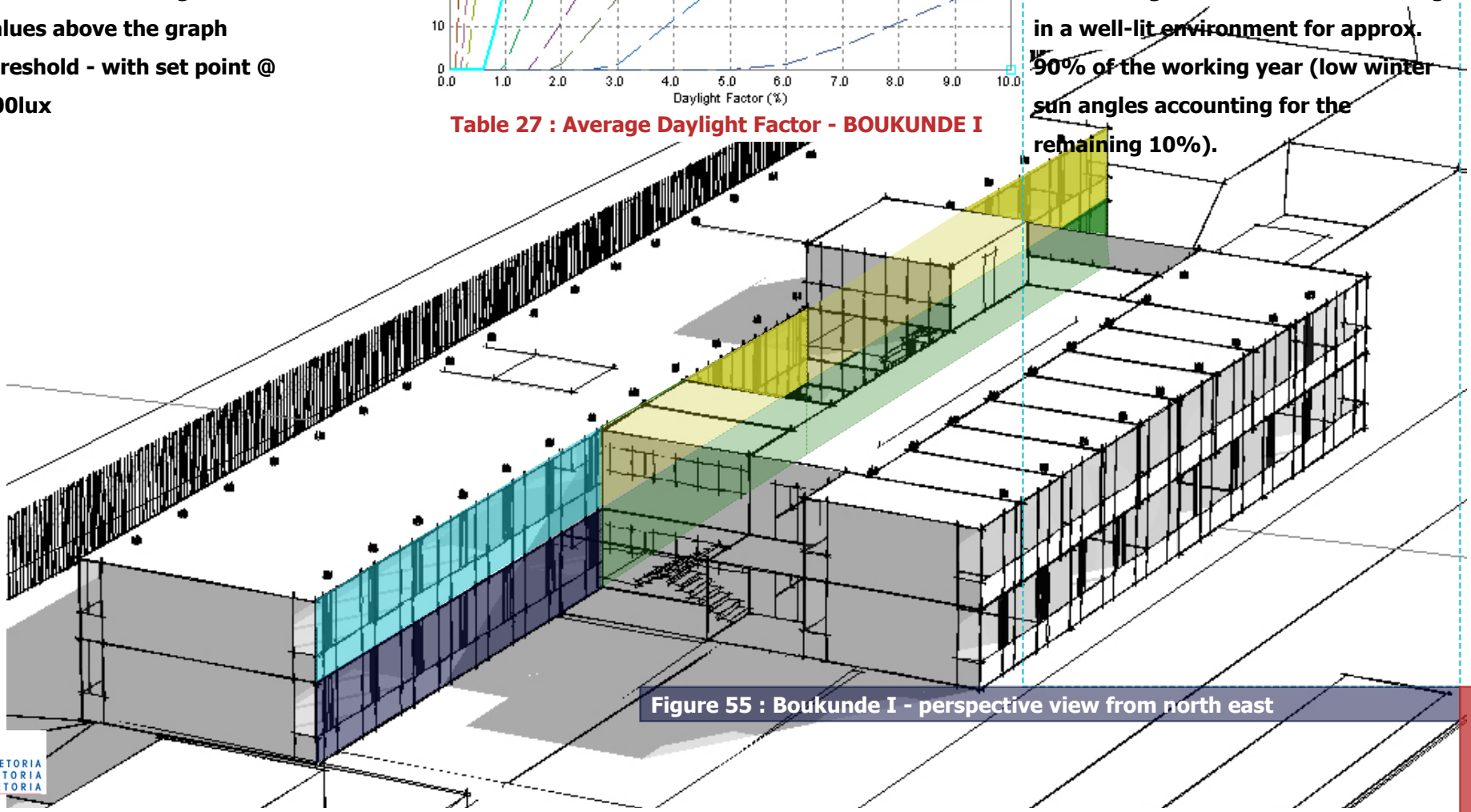


Figure 55 : Boukunde I - perspective view from north east

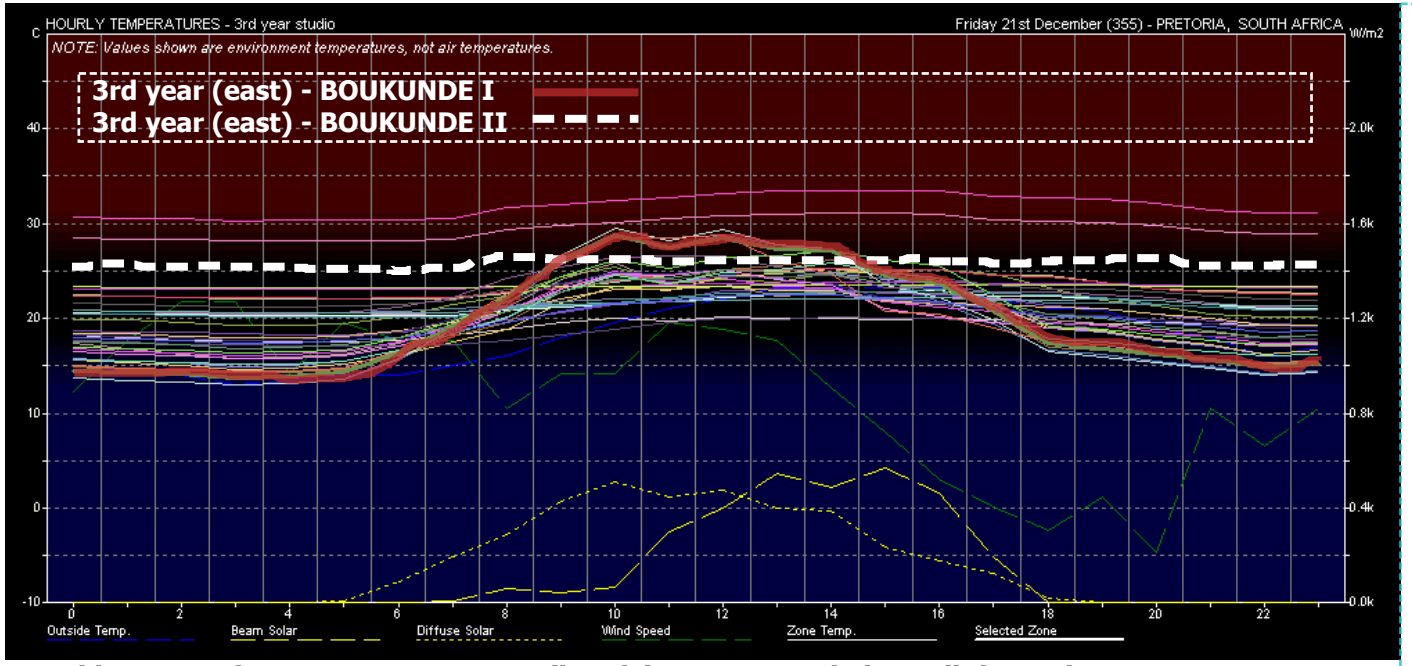
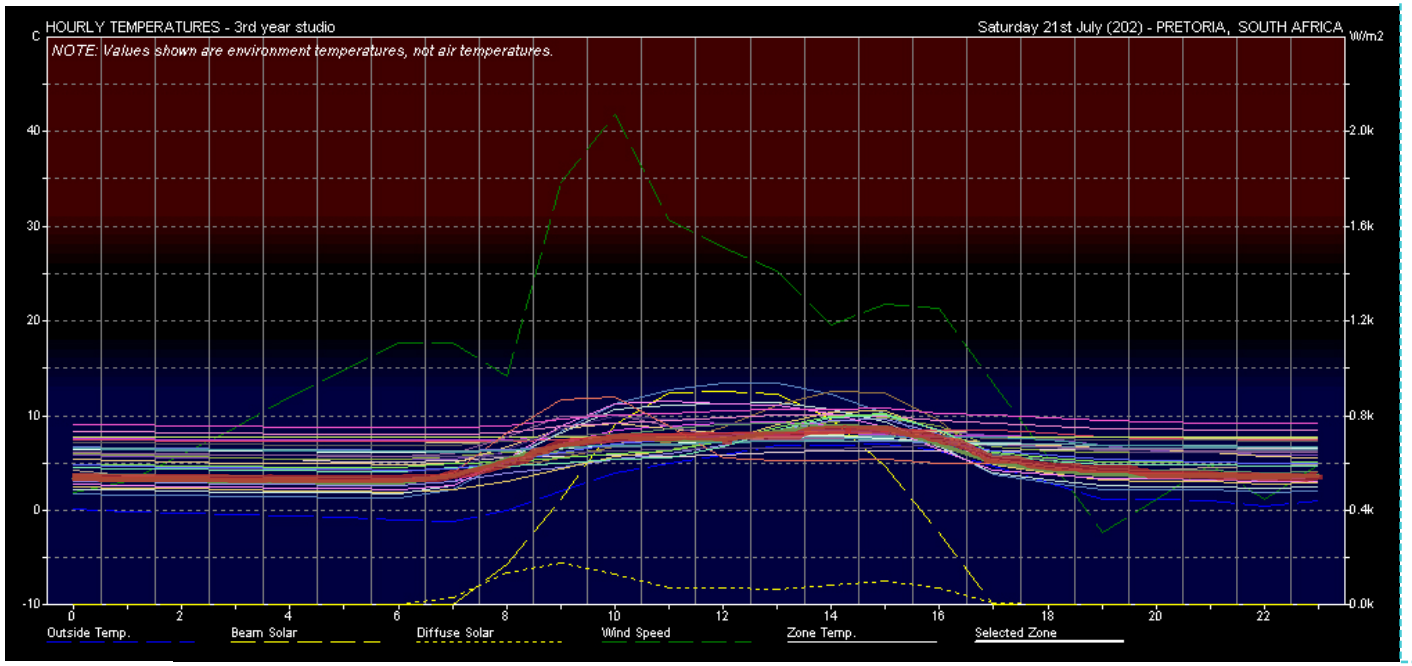


Table 28 : Environment Temperature (hourly) - summer solstice - all thermal zones - BOUKUNDE I



: Environment Temperature (hourly) - winter solstice - all thermal zones - BOUKUNDE I

The glass curtain wall construction provides more-than-adequate daylight conditions, but trades this benefit off against significant thermal 'leakage'. The glazed skin is at the mercy of the outside temperature condition and offers no protective lag in summer. The summer solstice graph relates thermal response for a diurnal range of min. 14 - max. 24°C, so any increase in this 'mild' range would push the response well into the 'red'. The same is true in winter, with the envelope incapable of 'hanging-on' to its heat - garnered via direct solar penetration or otherwise.

DISCOMFORT DEGREE HOURS

Zone: 3rd year studio
Zone is not air-conditioned.
Occupancy: Weekdays 08-18, Weekends 10-14.
Comfort: Band = 18.0 - 26.0 C

MONTH	TOO HOT (DegHrs)	TOO COOL (DegHrs)	TOTAL (DegHrs)
Jan	118	0	118
Feb	272	5	277
Mar	216	1	217
Apr	11	71	82
May	6	272	278
Jun	11	1017	1028
Jul	0	1057	1057
Aug	7	452	459
Sep	41	57	98
Oct	82	47	130
Nov	172	16	188
Dec	136	0	136
TOTAL	**1072.3**	**2995.3**	**4067.6**

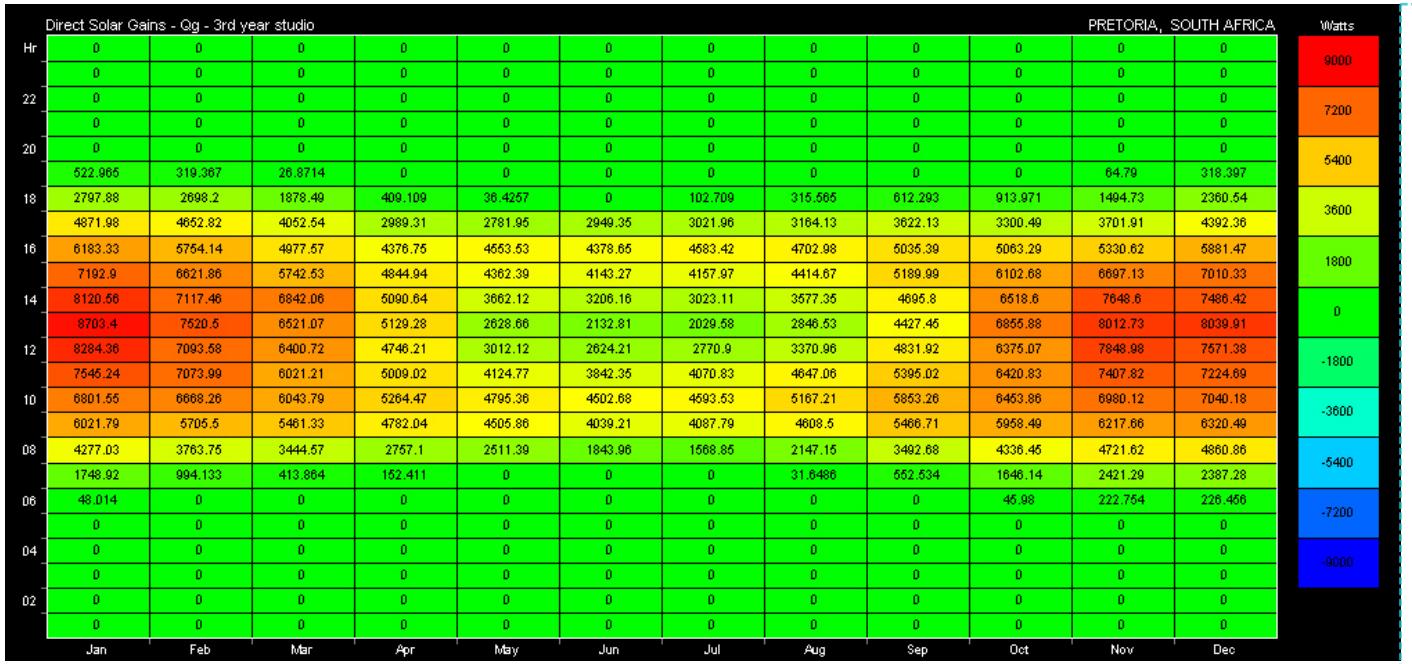


Table 30 : Direct Solar gains (annual) - 3rd year studio (east) - BOUKUNDE I

MONTHLY HEATING/COOLING LOADS - COMPARISON

Zone: 3rd year studio - east
Operation: Weekdays 08-18, Weekends 09-15.
Thermostat Settings: 18.0 - 26.0 C

Floor Area: 192.000 m2

BOUKUNDE I
Max Heating: 23179 W at 16:00 on 16th June
Max Cooling: 48669 W at 11:00 on 1st December

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	2899	1012246	1015145
Feb	3570	712039	715609
Mar	4449	840782	845231
Apr	87726	30913	118639
May	379608	0	379608
Jun	1208436	0	1208436
Jul	1434624	0	1434624
Aug	352414	0	352414
Sep	35198	9920	45118
Oct	54923	472322	527245
Nov	21059	821118	842177
Dec	0	1042995	1042995
TOTAL	3584907	4942335	8527242
	22732	31340	54073

BOUKUNDE II
Max Heating: 8672 W at 10:00 on 22nd July
Max Cooling: 6919 W at 15:00 on 2nd March

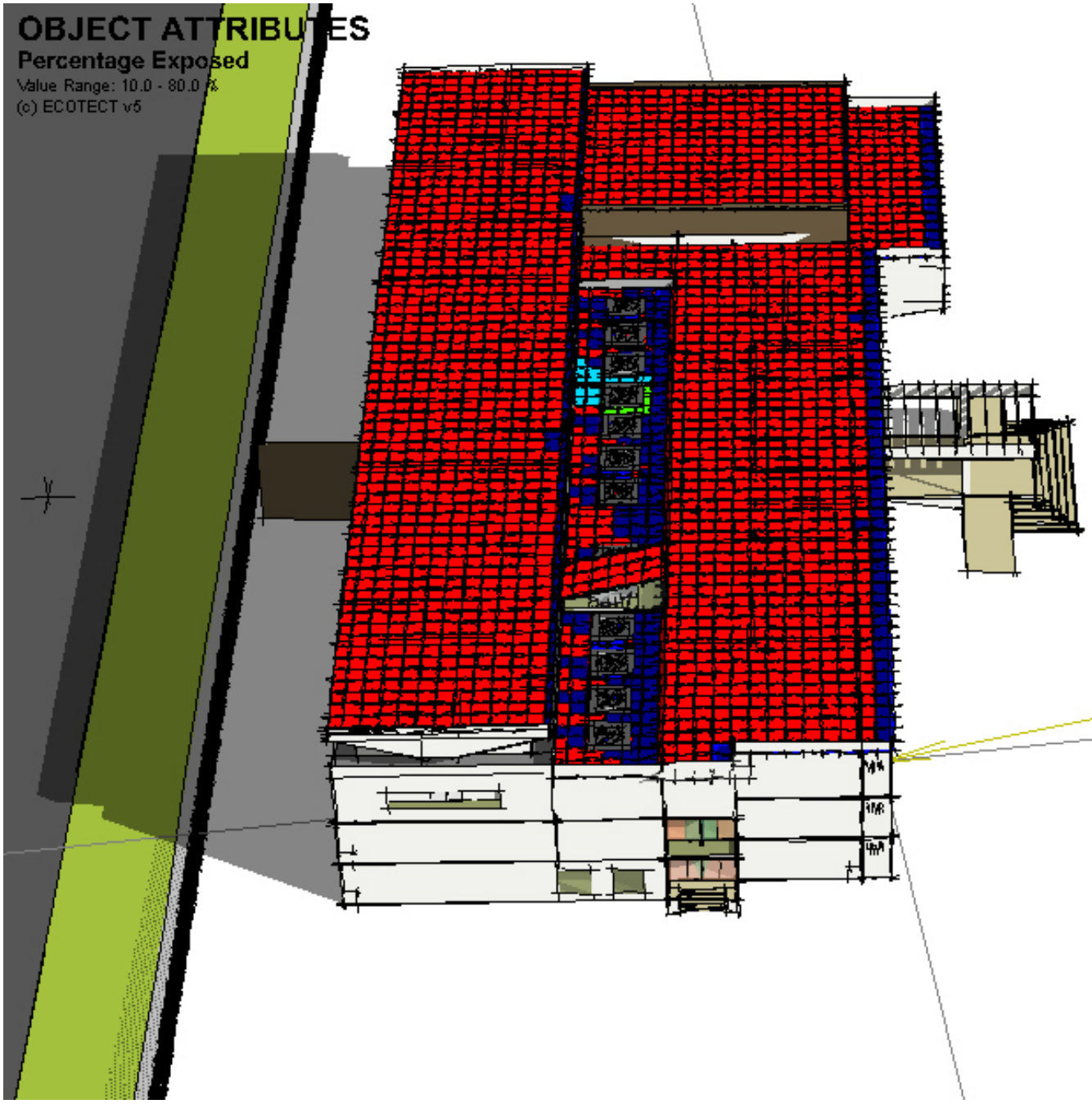
MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	0	25653	25653
Feb	0	135714	135714
Mar	0	190403	190403
Apr	13305	17145	30450
May	16919	0	16919
Jun	154492	0	154492
Jul	459380	0	459380
Aug	44980	0	44980
Sep	5021	12210	17231
Oct	1145	55550	56695
Nov	0	93419	93419
Dec	0	92913	92913
TOTAL	695242	623007	1318249
PER M²	3621	3245	6866

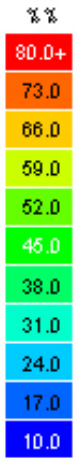
The solar gains graph is indicative of a building zone with little, or no thermal lag capacity. Heat from the sun is instantaneously projected through the building skin, and leaves the building just as quickly if the envelope is not absolutely sealed.

This fact is further demonstrated when comparing the heating & cooling loads applicable to the 3rd year (east) zone within the 2 versions of the building. The load that would be placed upon an air-conditioning unit in the older building would have been almost 6.5x the current loads.

The potential energy savings extracted via the substantially more favourable daylight conditions of the original building would be rendered insignificant by the far more energy intensive heating/cooling requirement to maintain comfort levels.

The solution then, must surely be found in a hybrid of the 2 building envelope extremes - a protected glass box, or a hard shell with holes punched through it...







The illustration and key attached indicates the typical level of solar exposure of the existing roof planes in the middle of winter.

Comfort levels on the upper levels of the building are primarily dependant on the thermal performance of this facet of the building envelope - more so than any of the remaining elements, and more so during summer than the winter conditions indicated.

And thus, in terms of overall thermal efficiency, the roof planes become a primary focal point.

Figure 56 : Boukunde II roof - Percentage exposure (10h00 - winter solstice)

The roof comprises an off-shutter concrete slab (12" - 305mm thick for all roofs except over 1st year studio) with cement screed laid to fall and a 'torched-on' thermally bonded waterproofing membrane coated with reflective aluminium paint.

The surfaces have weathered relatively well with minor maintenance upkeep, but there is evidence of fatigue - most notably the reflective paint covering, which has essentially dissipated.



Figure 58 : Boukunde II roof detail - view of main building roof surface - as at 23/08/2008

This has left the exposed surface a worn matt, charcoal hue - the colour of the original un-coated membrane.

Accordingly, the thermal profile of the roof covering has been altered from that of a heat reflector to an almost ideal absorber.

Absorption coefficients:
- Aluminium reflective coat = 0.3
- Charcoal matt surface = approx. 0.9
(www.naturalfrequency.com)

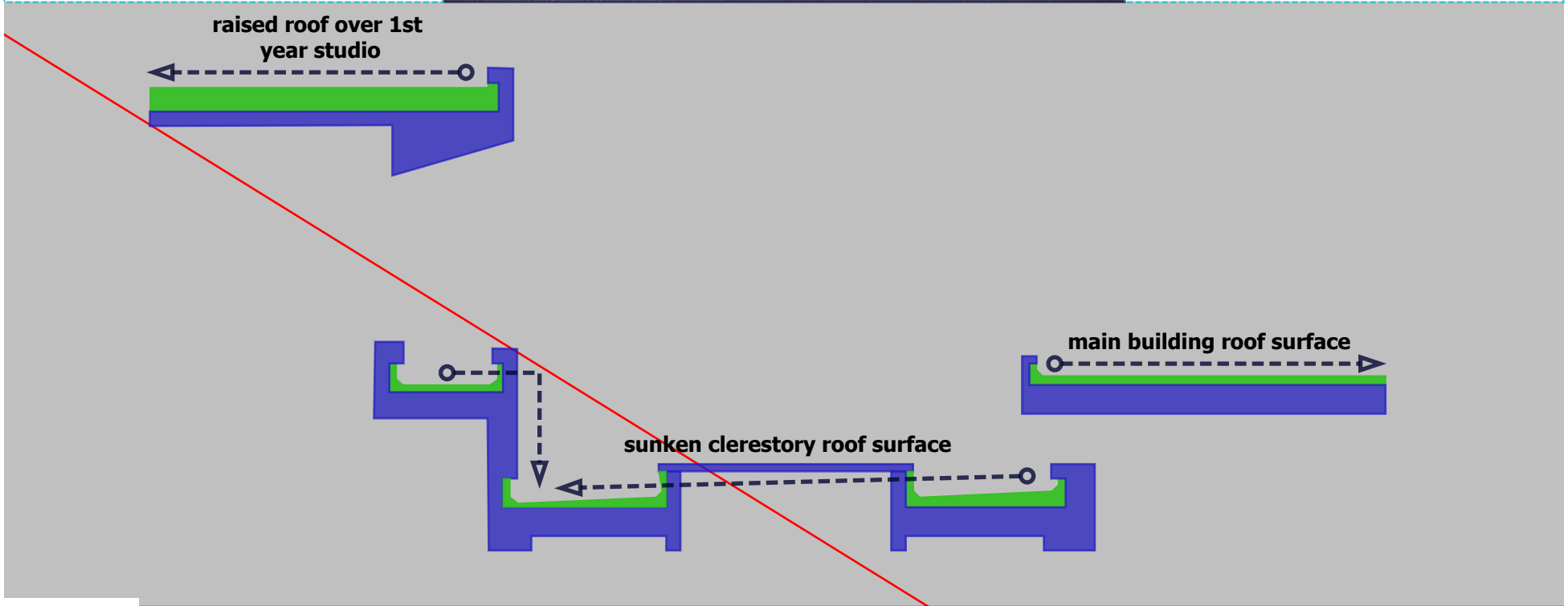


Figure 57 : Boukunde II roof detail - adapted from drawing number 43 - 32 - revised 3/2/1973 (D.S. De Beer Architects)



Figure 59 : Aerial View over Pretoria - facing west - circa 1986 (Sutherland. 1986:35)



Roof surface reflective coat still intact.



Figure 60 : Boukunde II roof detail - view of sunken clerestory roof surface - as at 23/08/2008

The sunken clerestory roof surface also seems to indicate that the raised 'glasscrete' panels have made the 'slope to fall' more complicated - resulting in surface staining from water that is not able to reach the fullbore outlets.

The entire roof surface then, may be deemed due for significant repair. At such time perhaps further benefit can be extracted via an alternative approach to the roof's thermal profile and general functionality.

The resultant retrofit proposal seeks to deal with the following aspects:
- rainwater re-routing to collection
- roof surface re-sealing & insulation
- roof surface protection & shading

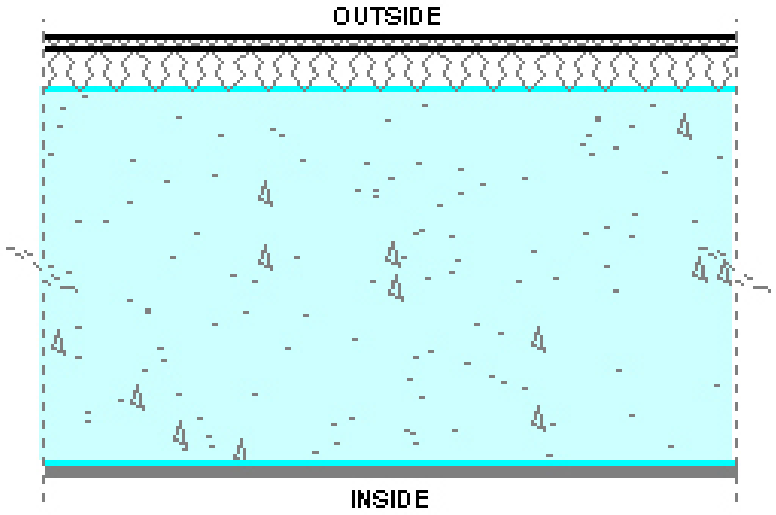


Figure 61 : Detail Section - Boukunde II roof - EXISTING

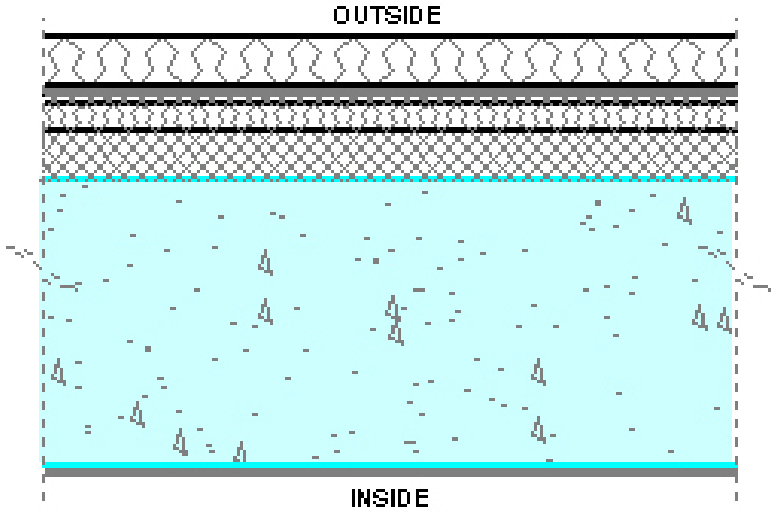


Figure 62 : Detail Section - Boukunde II roof - RETROFIT PROPOSAL

The existing roof surface is to be stripped to expose the original concrete slab and re-sealed according to the specification.

EXISTING ROOF SURFACE:

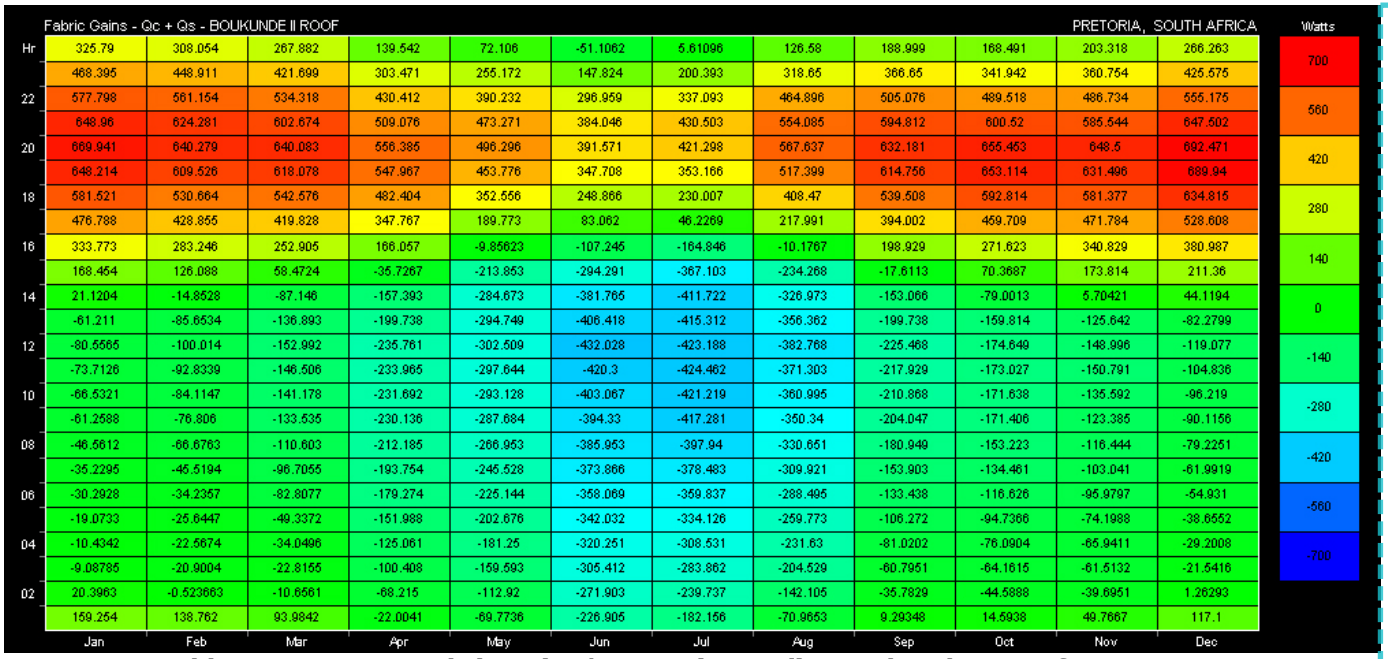
- 4mm thick waterproofing membrane (75mm side laps & 100mm end laps)
- min. 30mm cement screed - laid to fall
- 12" (305mm) thick reinforced in-situ concrete roof slab - existing

U-value : 2.27 (W/m^2.K)
Thermal Decrement : 0.23

RETROFIT PROPOSAL:

- 50mm thick sandstone gravel bed (25mm grade)
- 1 coat bituminous aluminium reflective paint
- 4mm thick waterproofing membrane (75mm side laps & 100mm end laps)
- min. 30mm cement screed - laid to fall
- 50mm thick expanded polystyrene rigid foam board
- 12" (305mm) thick reinforced in-situ concrete roof slab - existing

U-value : 0.49 (W/m^2.K)
Thermal Decrement : 0.06



Fabric Gains - Qc + Qs - BOUKUNDE II ROOF — PRETORIA, SOUTH AFRICA — Watts

Hr	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	325.79	308.054	267.882	139.542	72.106	-51.1062	5.61096	126.58	188.999	168.491	203.318	266.263
	468.395	448.911	421.699	303.471	255.172	147.824	200.393	318.65	366.65	341.942	360.754	425.575
22	577.798	561.154	534.318	430.412	390.232	296.959	337.093	464.896	505.076	489.518	486.734	555.175
	648.96	624.281	602.674	509.076	473.271	384.046	430.503	554.085	594.812	600.52	585.544	647.502
20	669.941	640.279	640.083	556.385	496.296	391.571	421.298	567.637	632.181	665.453	648.5	692.471
	648.214	609.526	618.078	547.967	463.776	347.708	353.166	517.399	614.756	653.114	631.496	689.94
18	581.521	530.664	542.576	482.404	352.556	248.866	230.007	408.47	539.508	592.814	581.377	634.815
	476.788	428.855	419.828	347.767	189.773	83.062	46.2269	217.991	394.002	459.709	471.784	528.608
16	333.773	283.246	252.905	166.057	-9.85623	-107.245	-164.846	-10.1767	198.929	271.623	340.829	380.987
	168.454	126.088	58.4724	-35.7267	-213.853	-294.291	-367.103	-234.268	-17.6113	70.3687	173.814	211.36
14	21.1204	-14.8528	-87.146	-157.393	-284.673	-381.765	-411.722	-326.973	-153.066	-79.0013	5.70421	44.1194
	-61.211	-85.6534	-136.893	-199.738	-294.749	-406.418	-415.312	-356.362	-199.738	-159.814	-125.642	-82.2799
12	-80.5565	-100.014	-152.992	-235.761	-302.509	-432.028	-423.188	-382.768	-225.468	-174.649	-148.996	-119.077
	-73.7126	-92.8339	-146.506	-233.965	-297.644	-420.3	-424.462	-371.303	-217.929	-173.027	-150.791	-104.836
10	-66.5321	-84.1147	-141.178	-231.692	-293.128	-403.067	-421.219	-360.995	-210.868	-171.638	-135.592	-96.219
	-61.2588	-76.806	-133.535	-230.136	-287.684	-394.33	-417.281	-350.34	-204.047	-171.406	-123.385	-90.1156
08	-46.5612	-66.6763	-110.603	-212.185	-266.953	-385.953	-397.94	-330.651	-180.949	-153.223	-116.444	-79.2251
	-35.2295	-45.5194	-96.7055	-193.754	-245.528	-373.866	-378.483	-309.921	-153.903	-134.461	-103.041	-61.9919
06	-30.2928	-34.2357	-82.8077	-179.274	-225.144	-358.069	-359.837	-288.495	-133.438	-116.626	-95.9797	-54.931
	-19.0733	-25.6447	-49.3372	-151.988	-202.676	-342.032	-334.126	-259.773	-106.272	-94.7366	-74.1988	-38.6552
04	-10.4342	-22.5674	-34.0496	-125.061	-181.25	-320.251	-308.531	-231.63	-81.0202	-76.0904	-65.9411	-29.2008
	-9.08785	-20.9004	-22.8155	-100.408	-159.593	-305.412	-283.862	-204.529	-60.7951	-64.1615	-61.5132	-21.5416
02	20.3963	-0.523663	-10.6561	-68.215	-112.92	-271.903	-239.737	-142.105	-35.7829	-44.5888	-39.6951	1.26293
	159.254	138.762	93.9842	-22.0041	-69.7736	-226.905	-182.156	-70.9653	9.29348	14.5938	49.7667	117.1

Watts: 700, 560, 420, 280, 140, 0, -140, -280, -420, -560, -700

Table 31 : Average Fabric Gains/Losses (annual) - Boukunde II roof - EXISTING

***The retrofit proposal graph legend range has been altered / reduced to register a visible variation.**



Fabric Gains - Qc + Qs - BOUKUNDE II ROOF — PRETORIA, SOUTH AFRICA — Watts

Hr	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	4.51426	3.84421	3.65961	0.726583	-1.33755	-7.98644	-5.77284	-0.372432	1.8002	1.0148	1.83543	2.89189
	6.17649	5.79448	5.88055	3.04997	1.3185	-3.93282	-2.4835	2.32572	3.96632	3.39594	4.24983	5.17541
22	7.51727	7.40493	7.29665	4.77852	3.22073	-0.930412	-0.397516	4.48085	5.62706	5.45441	5.92972	6.84607
	8.49062	8.28057	8.10661	5.83948	4.40266	0.761647	1.48344	5.82925	6.69993	7.15328	7.3345	8.01905
20	8.35681	7.99159	8.35846	6.23068	4.07099	0.0213403	0.0914763	5.22438	6.88113	7.49377	7.72404	8.292
	7.90092	7.1892	7.8776	5.88022	2.44072	-1.3765	-2.19642	3.60851	6.4431	7.01467	7.09521	8.19263
18	6.99641	6.07252	6.76107	4.81862	-0.180068	-3.76108	-5.4661	1.08422	5.24338	5.82038	6.10361	7.4794
	5.6078	4.70716	4.78718	2.35656	-4.32291	-8.22473	-10.7234	-4.0232	2.23714	3.26548	4.10805	6.21295
16	3.39465	2.62577	1.81371	-1.40973	-9.33586	-13.1113	-16.3817	-9.99039	-2.08754	-0.875461	2.10338	4.00177
	0.599533	0.263139	-2.29628	-6.17546	-14.6372	-18.1173	-22.1949	-16.1389	-7.30673	-5.16003	-0.649023	1.30254
14	-1.76013	-2.36315	-5.65293	-9.15326	-16.0302	-21.4976	-23.1845	-18.4725	-9.64102	-7.43998	-4.00758	-1.87083
	-3.53831	-4.82323	-7.7086	-11.2475	-16.5976	-22.8858	-23.3867	-20.0671	-11.2475	-9.08685	-7.49932	-5.0646
12	-4.53622	-5.63192	-8.61511	-13.2759	-17.0346	-24.328	-23.8301	-21.5541	-12.6964	-9.83466	-8.39012	-6.70535
	-4.15083	-5.22758	-8.2499	-13.1748	-16.7607	-23.6675	-23.9019	-20.9084	-12.2718	-9.74336	-8.4912	-5.90341
10	-3.74649	-4.73659	-7.94991	-13.0468	-16.5063	-22.6971	-23.7193	-20.328	-11.8742	-9.6651	-7.63534	-5.41819
	-3.44955	-4.32503	-7.51947	-12.9592	-16.1998	-22.2052	-23.4976	-19.728	-11.4901	-9.65206	-6.94796	-5.0745
08	-2.62191	-3.75461	-6.22818	-11.9483	-15.0324	-21.7334	-22.4084	-18.6193	-10.1894	-8.62815	-6.55709	-4.46125
	-1.98381	-2.56325	-5.44558	-10.9105	-13.8259	-21.0528	-21.3128	-17.452	-8.66642	-7.57165	-5.80232	-3.49083
06	-1.70582	-1.92785	-4.66299	-10.0951	-12.6781	-20.1632	-20.2628	-16.2455	-7.51404	-6.56731	-5.40472	-3.09322
	-1.07404	-1.44408	-2.77823	-8.55859	-11.4129	-19.2602	-18.815	-14.6281	-5.98428	-5.33472	-4.17821	-2.17671
04	-0.587561	-1.27079	-1.91737	-7.0423	-10.2064	-18.0337	-17.3737	-13.0433	-4.56234	-4.28473	-3.71322	-1.64433
	-0.511746	-1.17693	-1.28477	-5.65406	-8.98685	-17.1981	-15.9846	-11.5173	-3.42344	-3.613	-3.46387	-1.21303
02	0.132109	-0.658631	-0.651239	-3.84126	-6.35862	-15.3111	-13.4998	-8.00207	-2.01498	-2.51084	-2.35868	-0.535338
	2.0866	1.23297	1.17574	-2.07096	-3.99841	-12.7772	-10.463	-4.60198	-0.808964	-1.11487	-0.495	0.97974

Watts: 30, 24, 18, 12, 6, 0, -6, -12, -18, -24, -30

32 : Average Fabric Gains/Losses (annual) - Boukunde II roof - RETROFIT PROPOSAL

As the graphs illustrate - the repair & re-layering of the roof's surface will have a dramatic effect in terms of it's efficacy as a heat barrier. The existing roof condition accommodates a far larger gradient of thermal gain / losses than the refurbished model.

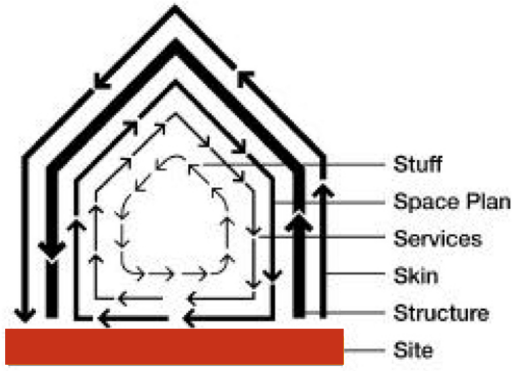
Both graphs would seem to indicate an approx. 8 hour thermal lag, but the primary distinction remains in terms of the massive disparity in heat energy that ultimately passes through the skin of the building.

The seasonal variation is also apparent - with the protected roof experiencing a relatively insignificant differential between peak winter- & peak summer conditions, whereas the existing roof will suffer through relative extremes in the space of 52 weeks.

Considering the fact that the core component in the roof's construction is concrete - which has a determining influence on thermal performance, the surface treatment is employed to extract maximum benefit from the roof as a unit.



design development

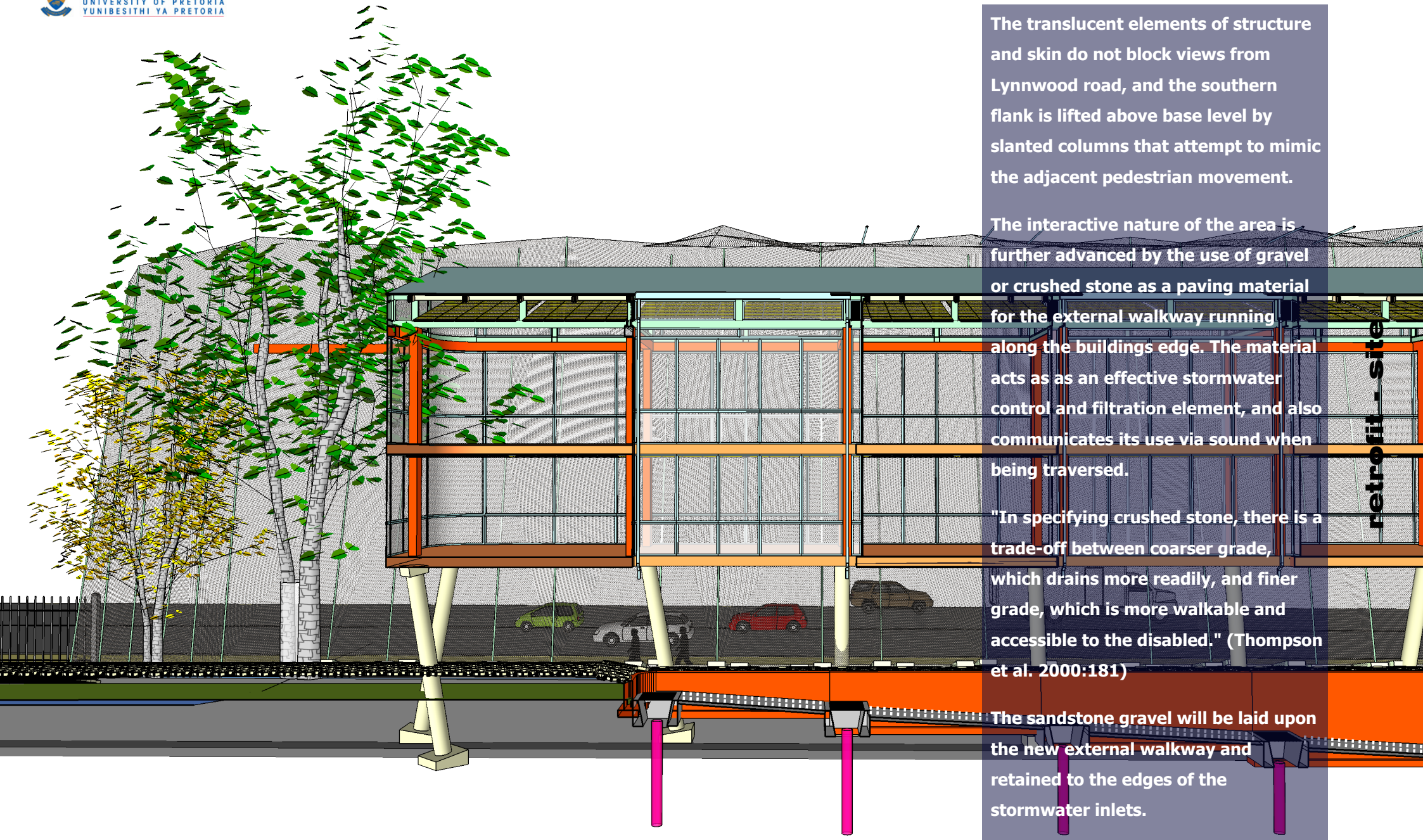


retrofit : site



The once insular orientation has now been exposed to the west, south & east - offering a greater degree of connectivity to the campus surrounds.

Figure 63 : Aerial View over BOUKUNDE (Google Earth)



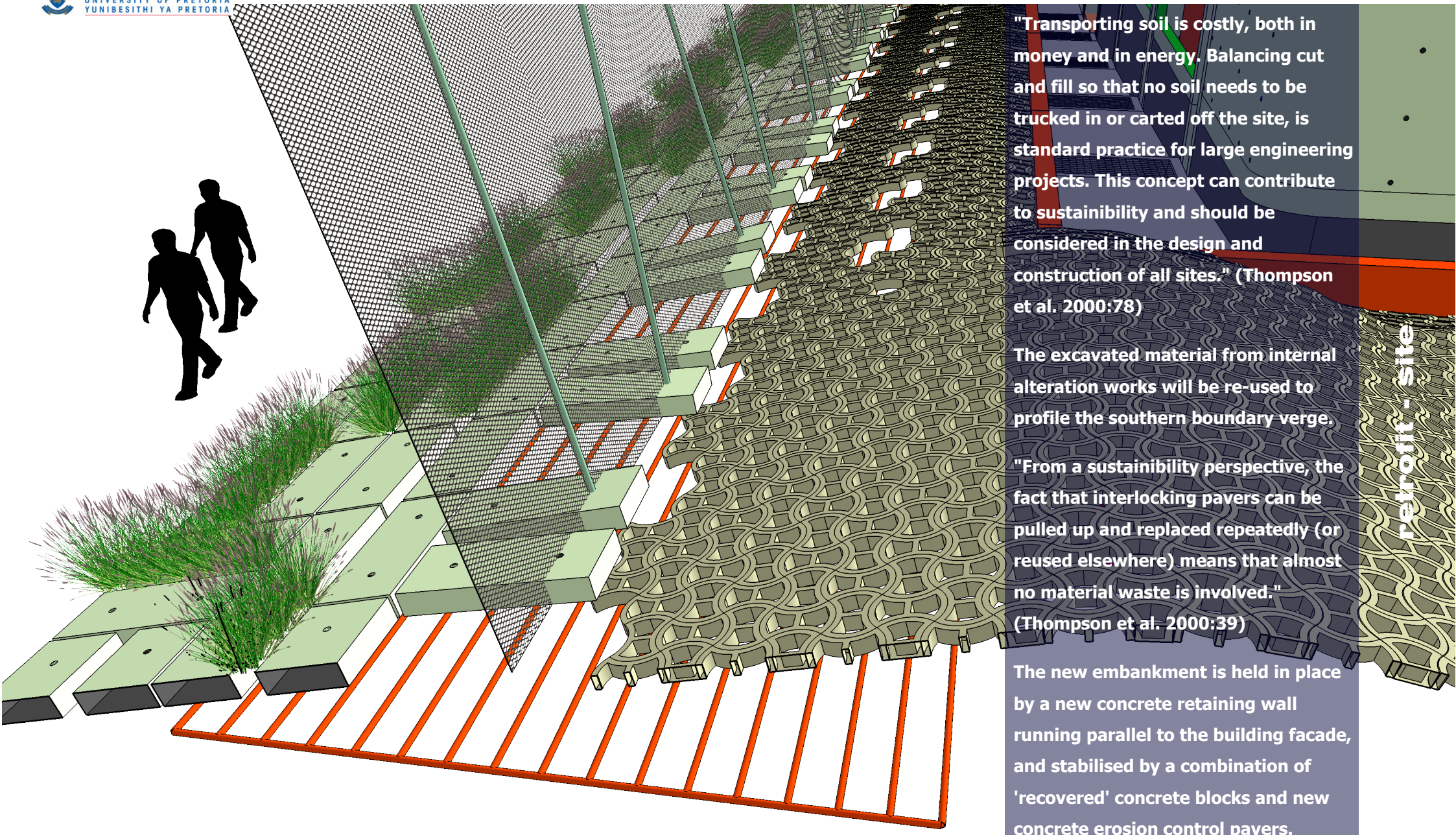
The translucent elements of structure and skin do not block views from Lynnwood road, and the southern flank is lifted above base level by slanted columns that attempt to mimic the adjacent pedestrian movement.

The interactive nature of the area is further advanced by the use of gravel or crushed stone as a paving material for the external walkway running along the buildings edge. The material acts as as an effective stormwater control and filtration element, and also communicates its use via sound when being traversed.

"In specifying crushed stone, there is a trade-off between coarser grade, which drains more readily, and finer grade, which is more walkable and accessible to the disabled." (Thompson et al. 2000:181)

The sandstone gravel will be laid upon the new external walkway and retained to the edges of the stormwater inlets.

Figure 64 : Section view through structure towards Lynnwood Road



"Transporting soil is costly, both in money and in energy. Balancing cut and fill so that no soil needs to be trucked in or carted off the site, is standard practice for large engineering projects. This concept can contribute to sustainibility and should be considered in the design and construction of all sites." (Thompson et al. 2000:78)

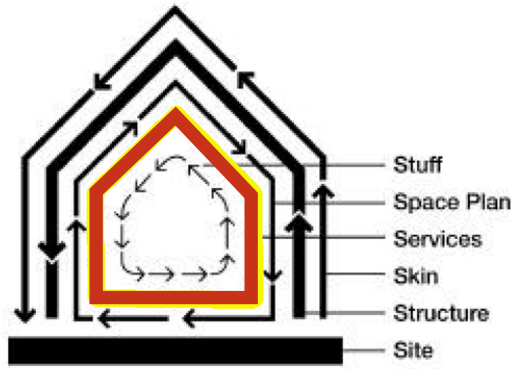
The excavated material from internal alteration works will be re-used to profile the southern boundary verge.

"From a sustainibility perspective, the fact that interlocking pavers can be pulled up and replaced repeatedly (or reused elsewhere) means that almost no material waste is involved." (Thompson et al. 2000:39)

The new embankment is held in place by a new concrete retaining wall running parallel to the building facade, and stabilised by a combination of 'recovered' concrete blocks and new concrete erosion control pavers.

retrofit - site

Figure 65 : Section view over new landscaping elements - facing west



retrofit : services

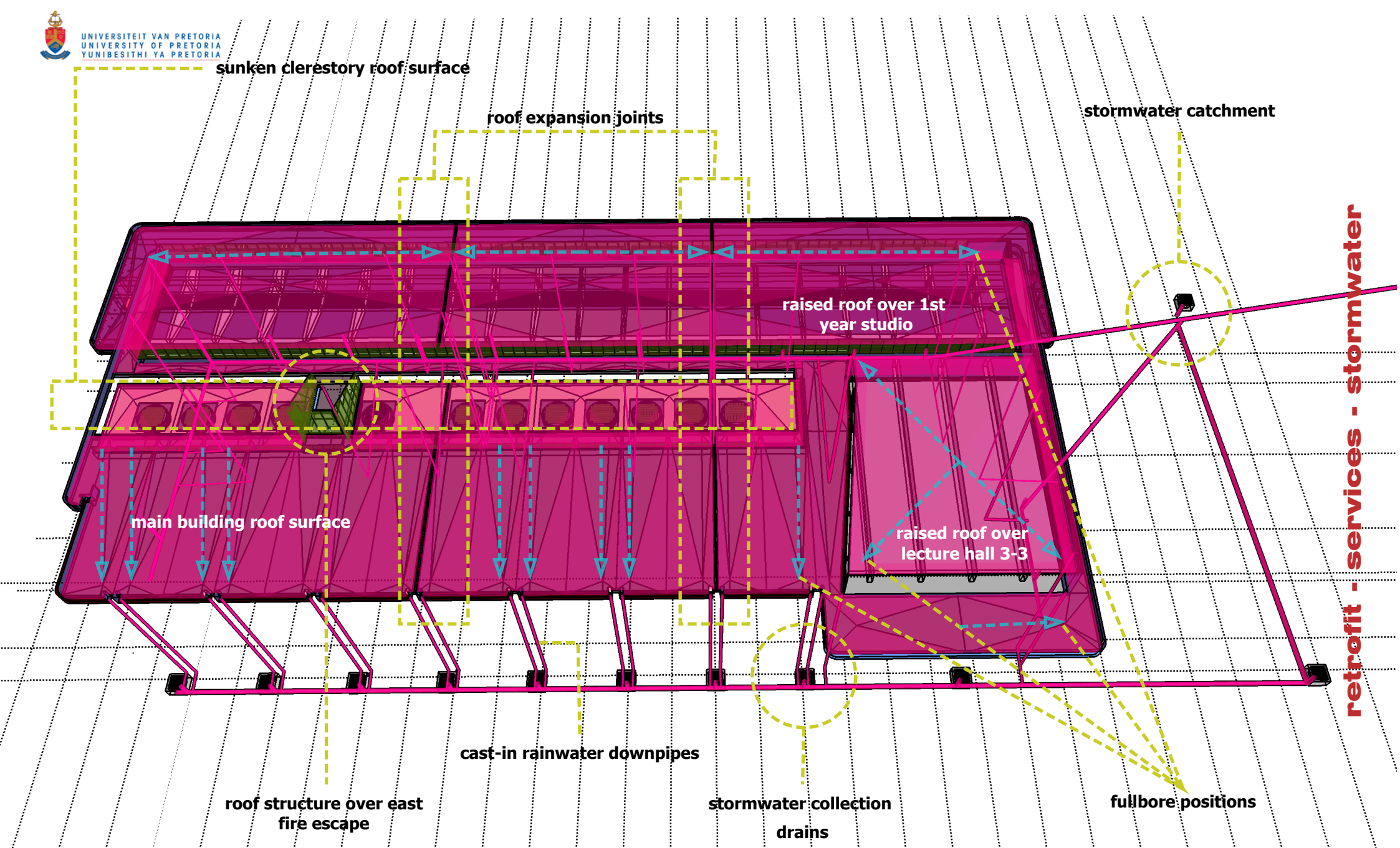


Figure 66 : Boukunde II - Perspective view from north - stormwater

Currently, rain water is collected on the concrete roofs and dispatched via fullbore outlets through the stucture to stormwater drains located on the buildings perimeter, and then brought to a catchment point at the site's south-west corner from where it is delivered into the municipal sewer. The downpipes are cast into the main structural components of the building (perimeter columns and internal concrete structural walls) and as such, cannot be modified or diverted throughout their vertical travel. The rainwater catchment proposal that follows, attempts to circumvent most of the existing stormwater infrastructure.

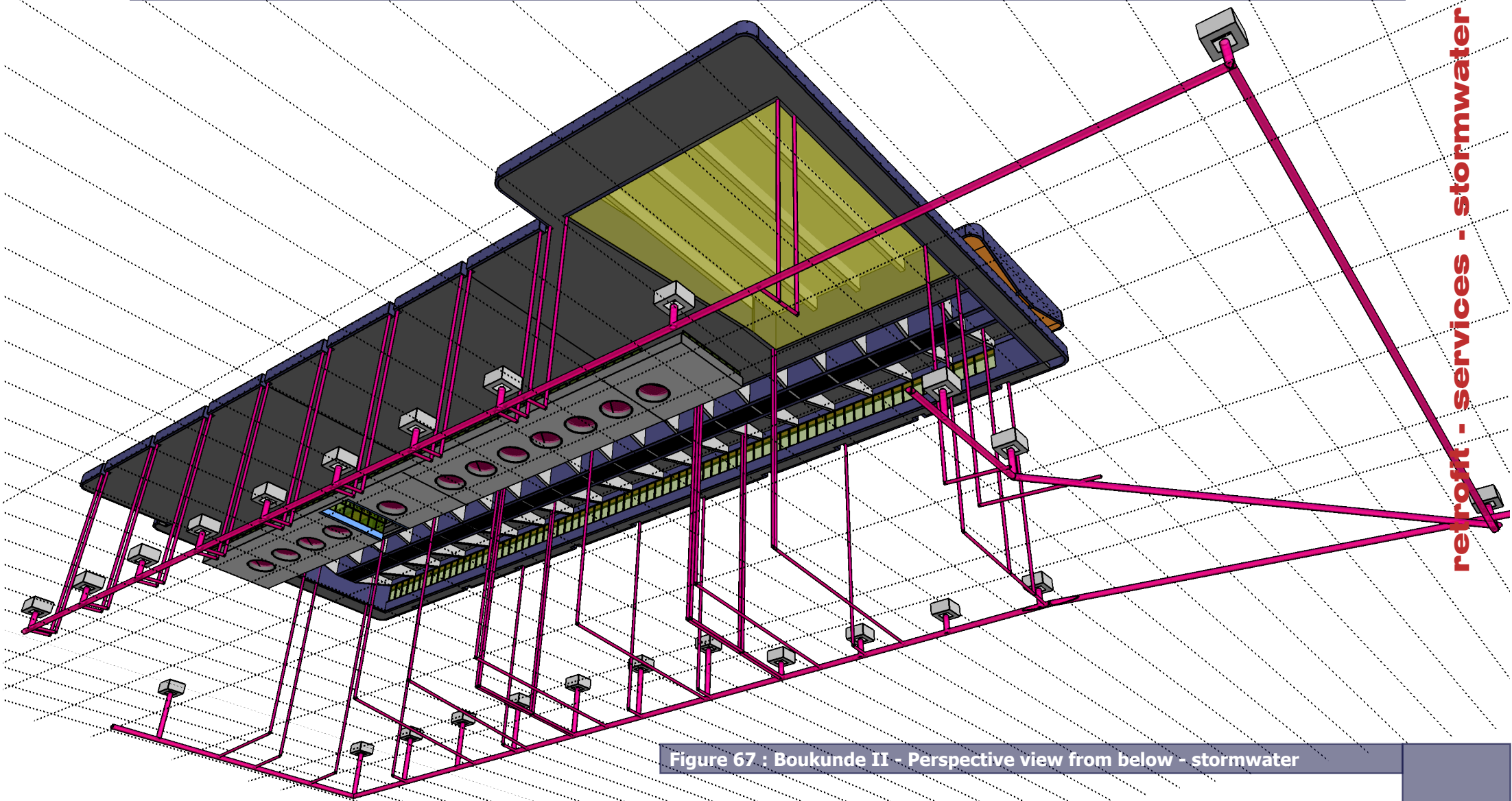
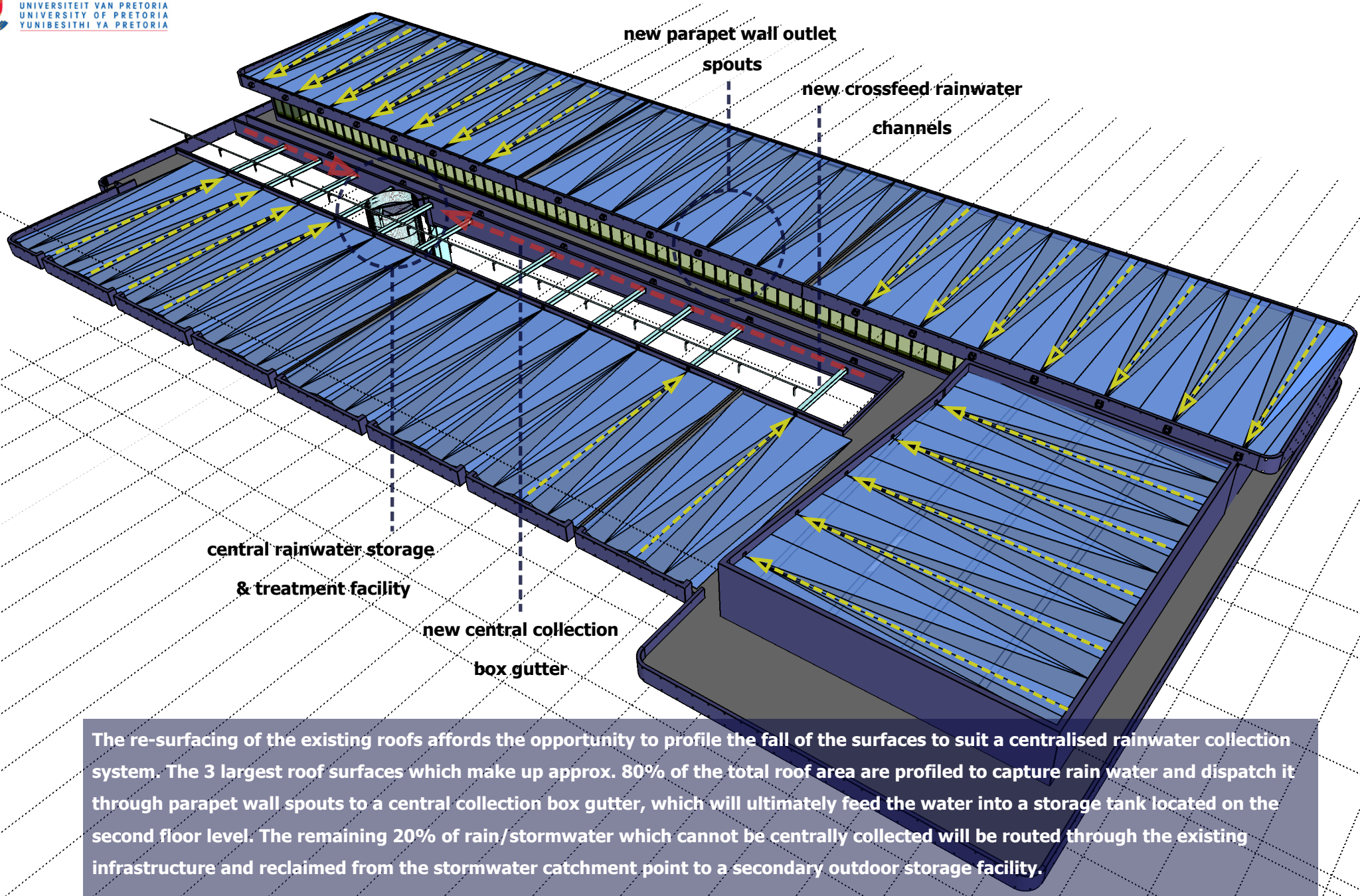


Figure 67 : Boukunde II - Perspective view from below - stormwater



The re-surfacing of the existing roofs affords the opportunity to profile the fall of the surfaces to suit a centralised rainwater collection system. The 3 largest roof surfaces which make up approx. 80% of the total roof area are profiled to capture rain water and dispatch it through parapet wall spouts to a central collection box gutter, which will ultimately feed the water into a storage tank located on the second floor level. The remaining 20% of rain/stormwater which cannot be centrally collected will be routed through the existing infrastructure and reclaimed from the stormwater catchment point to a secondary outdoor storage facility.

Figure 68 : Boukunde II - Perspective view from north west - stormwater

The existing sunken clerestory roof structure is removed to free up the central volume . The largest components of the rainwater treatment & storage system are the header tank where the filtered water is stored for distribution, and the filtration tanks which will remove debris and large waste particles first, and then chemically treat the water for removal of toxins. The system is fed directly from the collection infrastructure, with a first flush bypass channel to avoid overburdening the filtration system with the first wave of rainwater that essentially serves to clean the roofs and flush the feed- & collection channels.

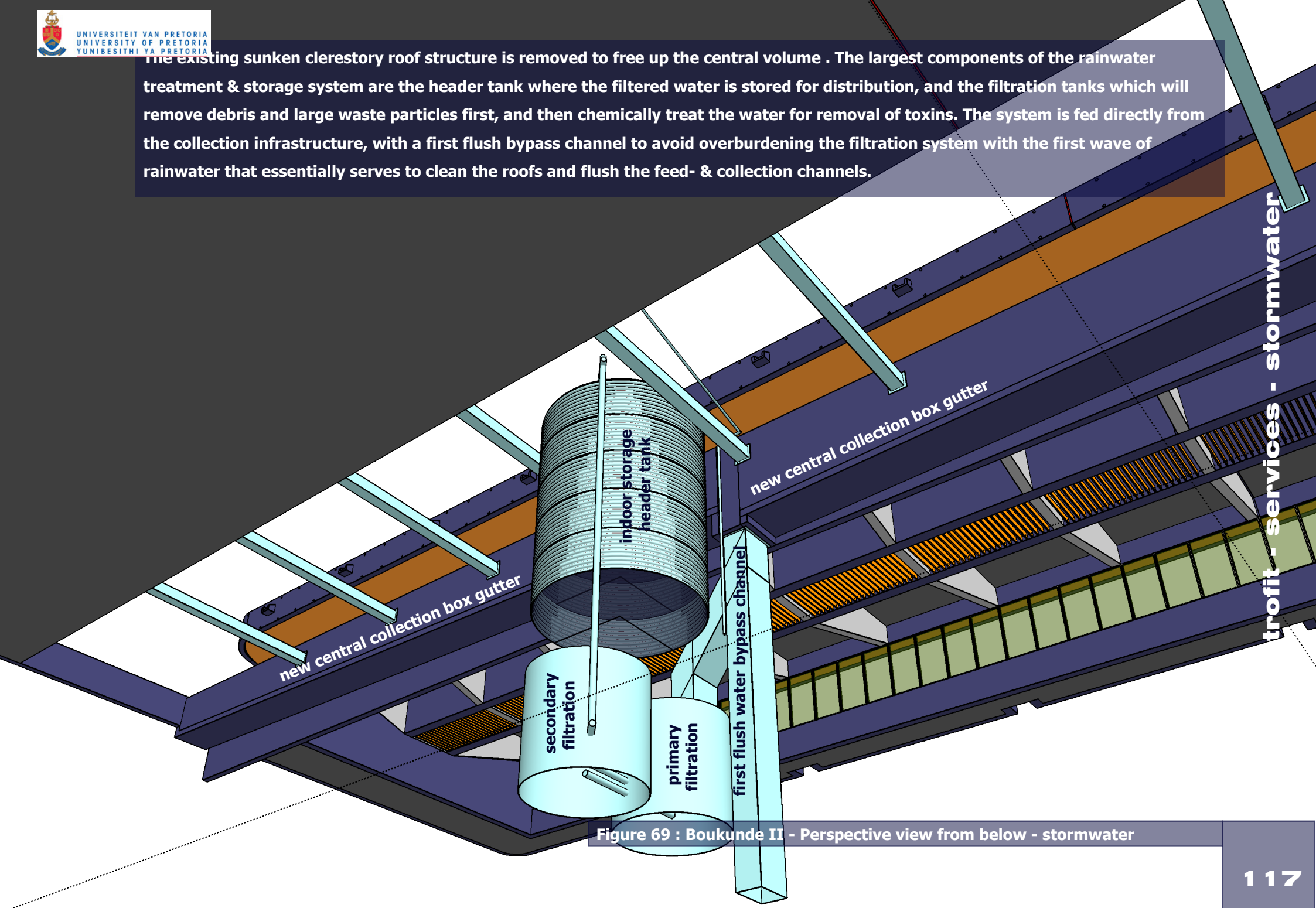
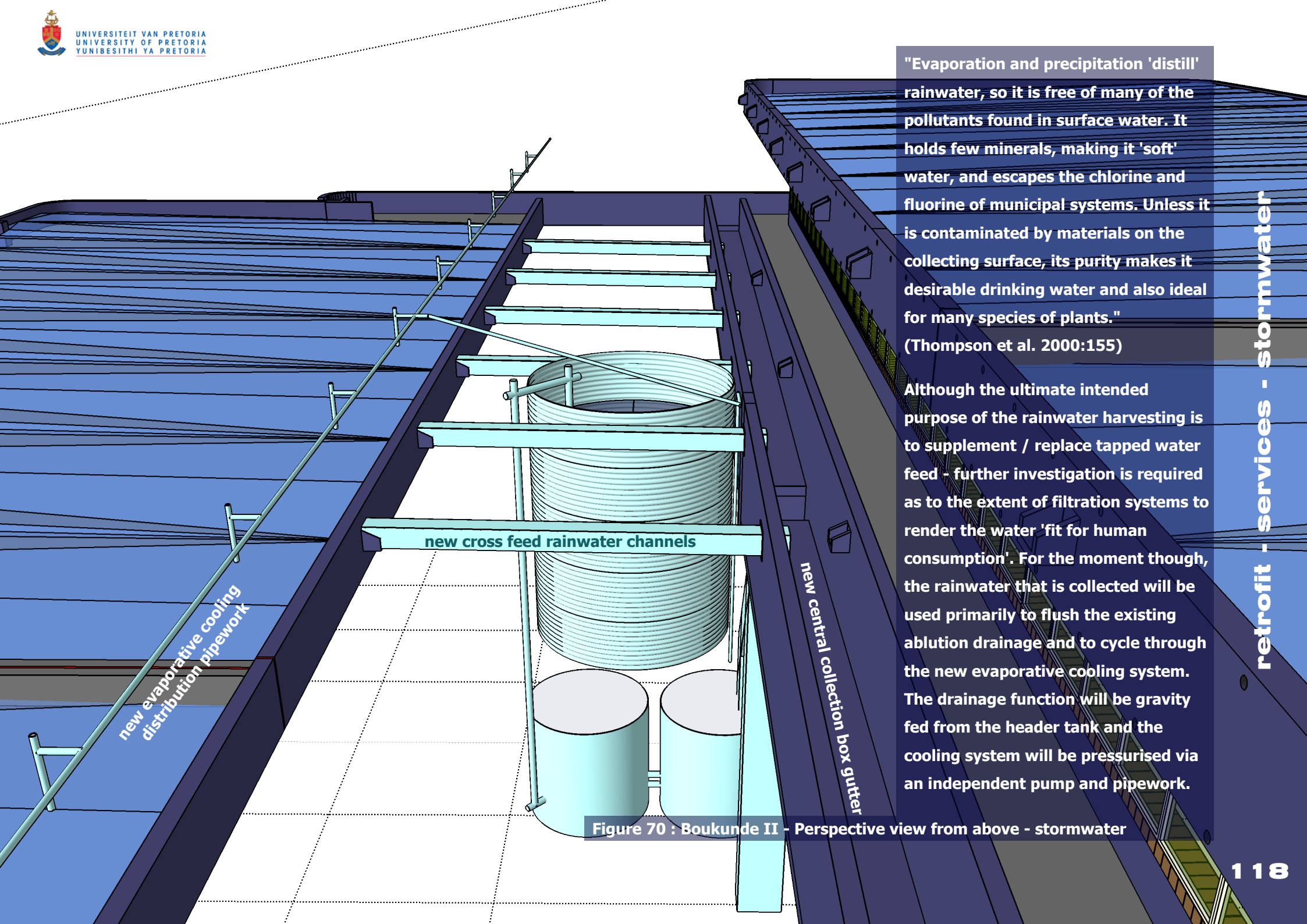


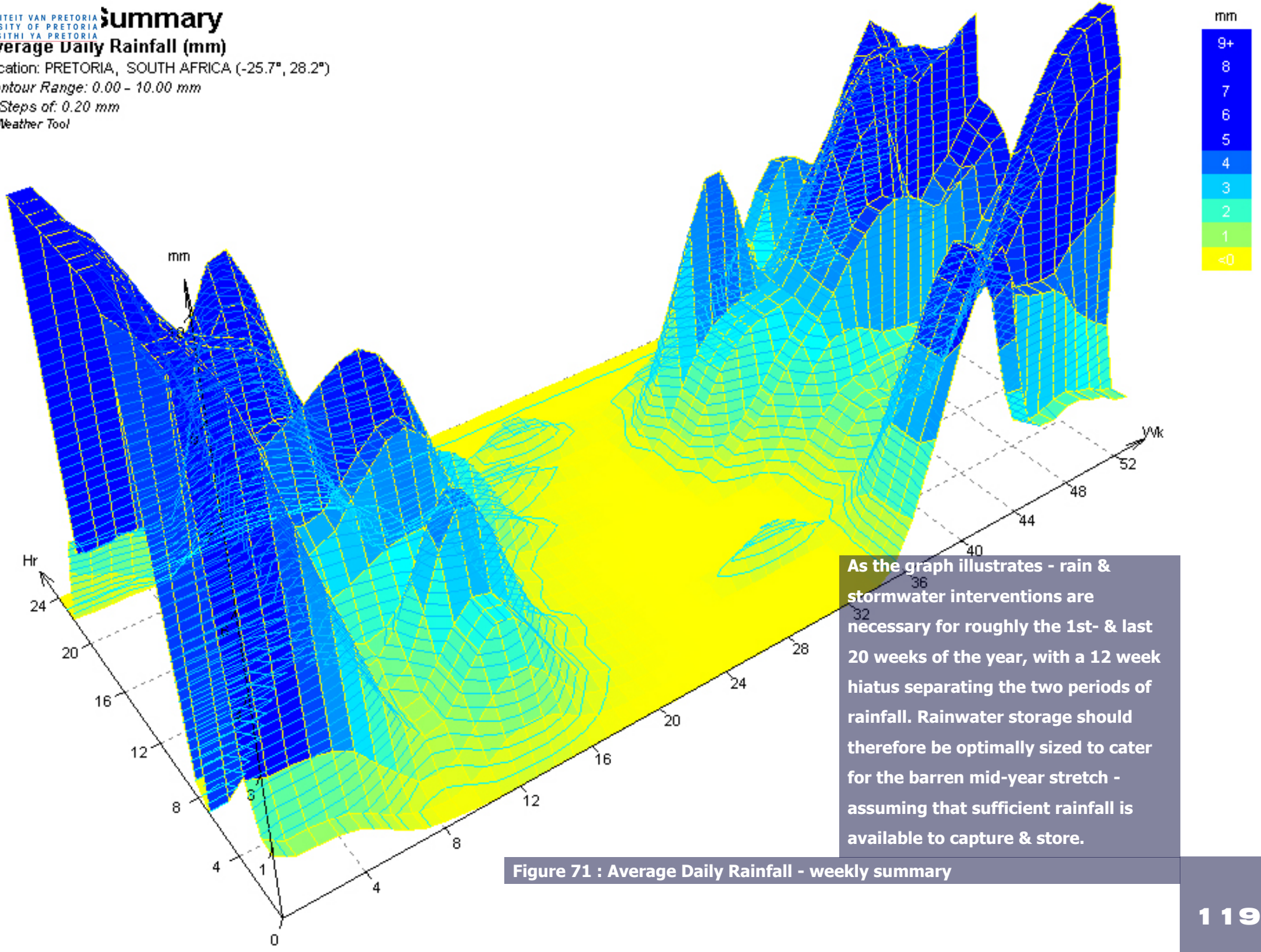
Figure 69 : Boukunde II - Perspective view from below - stormwater



"Evaporation and precipitation 'distill' rainwater, so it is free of many of the pollutants found in surface water. It holds few minerals, making it 'soft' water, and escapes the chlorine and fluorine of municipal systems. Unless it is contaminated by materials on the collecting surface, its purity makes it desirable drinking water and also ideal for many species of plants." (Thompson et al. 2000:155)

Although the ultimate intended purpose of the rainwater harvesting is to supplement / replace tapped water feed - further investigation is required as to the extent of filtration systems to render the water 'fit for human consumption'. For the moment though, the rainwater that is collected will be used primarily to flush the existing ablution drainage and to cycle through the new evaporative cooling system. The drainage function will be gravity fed from the header tank and the cooling system will be pressurised via an independent pump and pipework.

Figure 70 : Boukunde II - Perspective view from above - stormwater



As the graph illustrates - rain & stormwater interventions are necessary for roughly the 1st- & last 20 weeks of the year, with a 12 week hiatus separating the two periods of rainfall. Rainwater storage should therefore be optimally sized to cater for the barren mid-year stretch - assuming that sufficient rainfall is available to capture & store.

Figure 71 : Average Daily Rainfall - weekly summary

average annual rainfall : 674mm

existing roof surface area : 1968.35m^2

new roof surface area : 1256.40m^2

total roof surface area : 3224.75m^2

rainfall to indoor storage:

2374.35m^2 x 674mm = 1600.31m^3

= 1600.31 kilolitres / year

storage tank capacity : approx. 30kL

rainfall to outdoor storage:

850.4m^2 x 674mm = 573.17m^3

= 573.17 kilolitres / year

stormwater to outdoor storage:

734.2m^2 x 674mm = 494.85m^3

= 494.85 kilolitres / year

average consumption = 1.125 kL/m^2/year

highest 24 hour rainfall = 160mm

*the highest rainfall incidence needs to be factored in for system overflow requirements

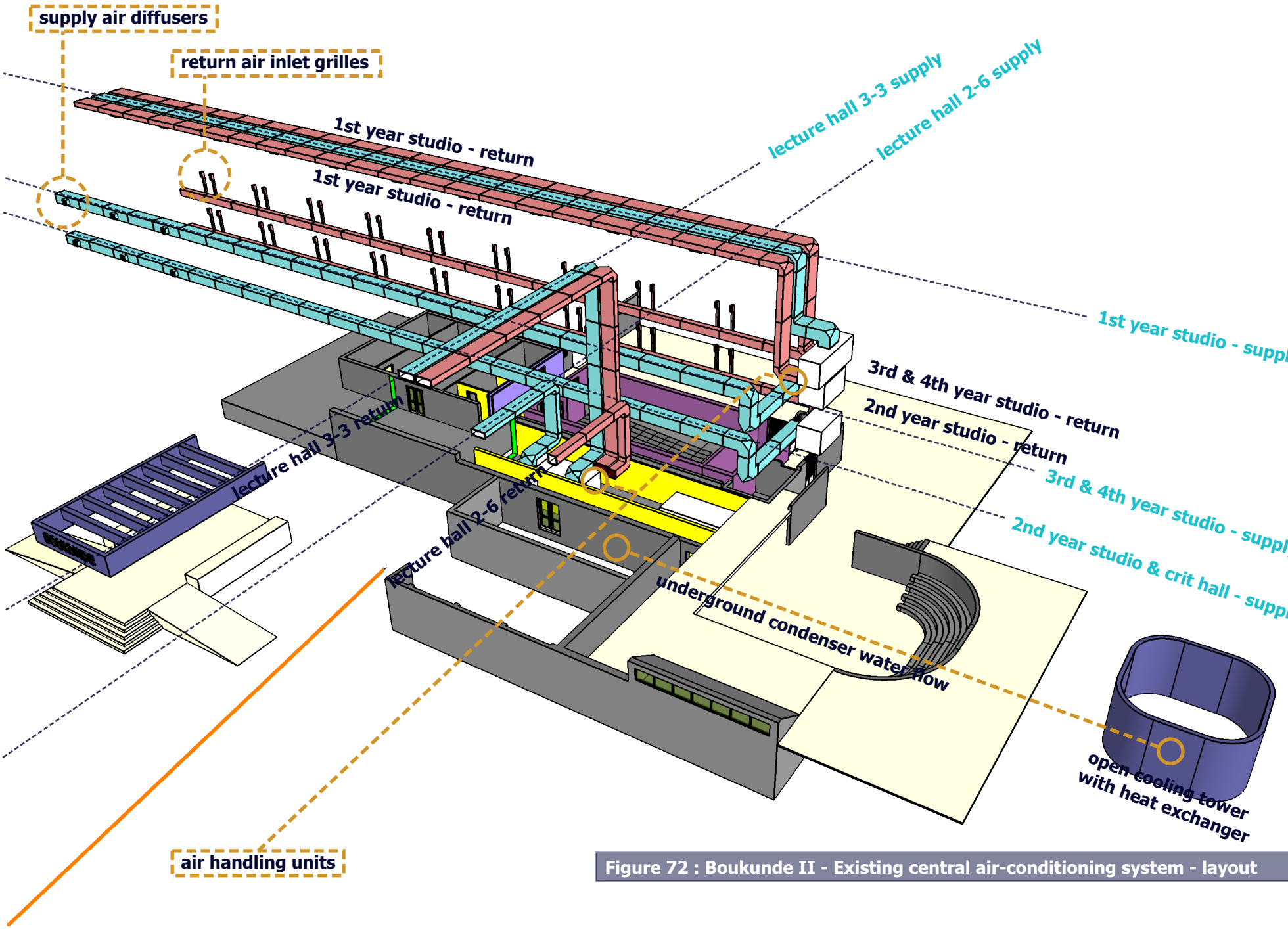
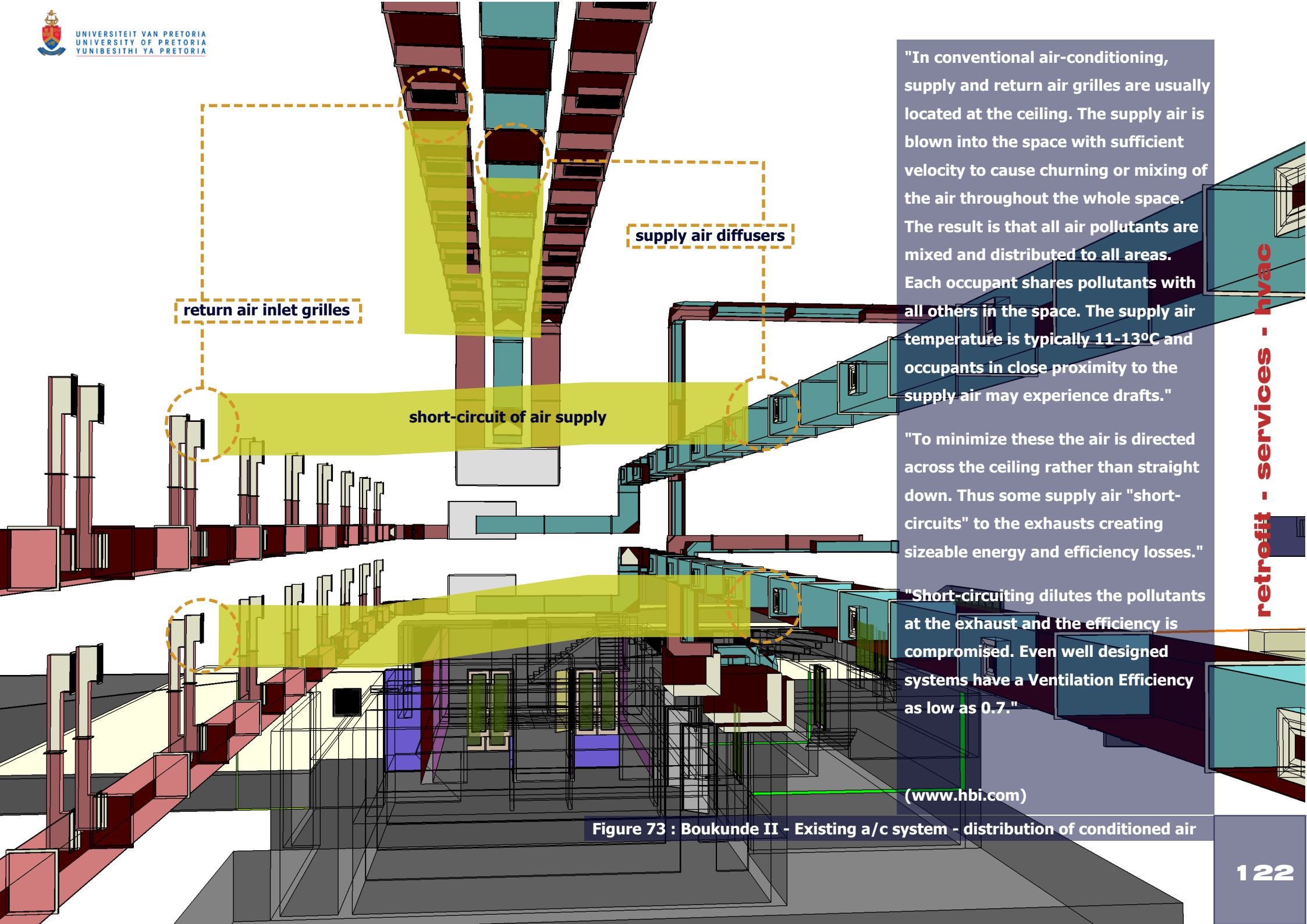


Figure 72 : Boukunde II - Existing central air-conditioning system - layout



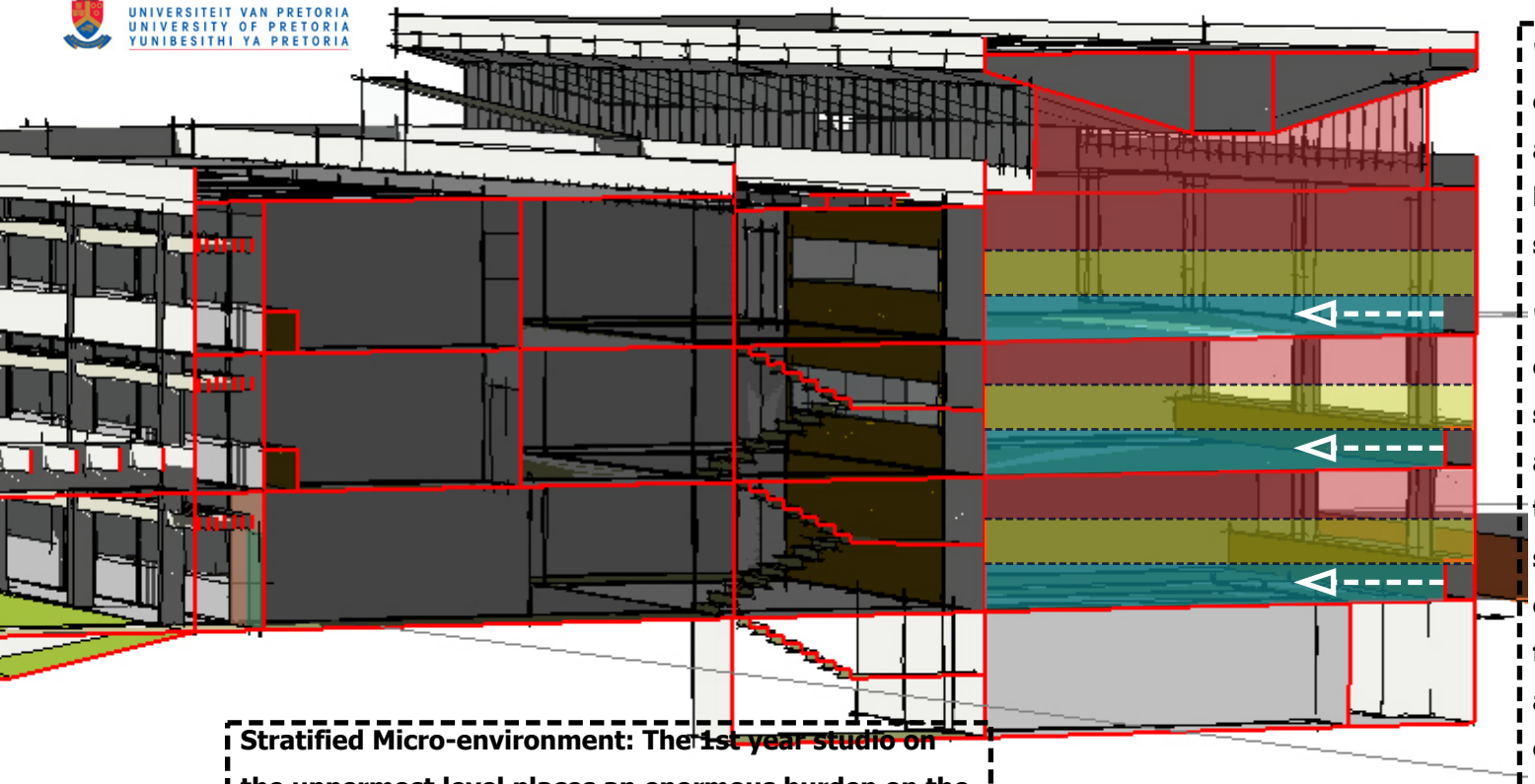
"In conventional air-conditioning, supply and return air grilles are usually located at the ceiling. The supply air is blown into the space with sufficient velocity to cause churning or mixing of the air throughout the whole space. The result is that all air pollutants are mixed and distributed to all areas. Each occupant shares pollutants with all others in the space. The supply air temperature is typically 11-13ºC and occupants in close proximity to the supply air may experience drafts."

"To minimize these the air is directed across the ceiling rather than straight down. Thus some supply air "short-circuits" to the exhausts creating sizeable energy and efficiency losses."

"Short-circuiting dilutes the pollutants at the exhaust and the efficiency is compromised. Even well designed systems have a Ventilation Efficiency as low as 0.7."

(www.hbi.com)

Figure 73 : Boukunde II - Existing a/c system - distribution of conditioned air



Stratified Micro-environment: The 1st year studio on the uppermost level places an enormous burden on the existing air-conditioning unit due to the mixed-air principle, which requires that the full volumetric extent of the studio's air be 'turned-over' via overhead intake- & return ducting. The displacement principle would result in this large volume being theoretically considered the same as the 2 studios below by virtue of the fact that the warm, 'used' air above approx. 2m height is left to rise of it's own accord. Also, any internal heat loads located above 2m height don't impact upon the system's design load, unless they are significant sources of radiant heat transfer to objects below 2m.

"With displacement air-conditioning, cool air is supplied at a low level and at a low velocity into the space. Gravity holds the cooler air down and it spreads across the floor in a "pool".

"At heat sources (people, computers, equipment, etc) the heat warms the surrounding air which rises in a plume and "draws" the cool air at floor level to the heat source. Because the heat sources in a space are usually the contaminant sources, the vertical air flow conveys those contaminants above the sources directly to the exhausts."

"The objective is to separate the room into a stratified micro-environment, with a warm polluted region above the occupants and a cooler, cleaner region around the occupants."

(www.hbi.com)

Figure 74 : Displacement a/c & stratified micro-environment

The intake ducting located in the roof structure of the 1st year studio on the uppermost level will be rendered obsolete with intake ducting to be placed at floor level to match the air-conditioning profile of the 2 lower levels. The proposal for a conversion of the central a/c system to a hybrid - begins with a reversal of the of the air intake lines for the 2nd & 3rd year studios. The position of the existing return ducting remains as is, but is now used for air intake to facilitate a floor level infeed which is more suited to the displacement air-conditioning principle. The existing 'periscope' return air grilles will be removed and existing diffuser sections will be fitted to the ducting run at floor level.

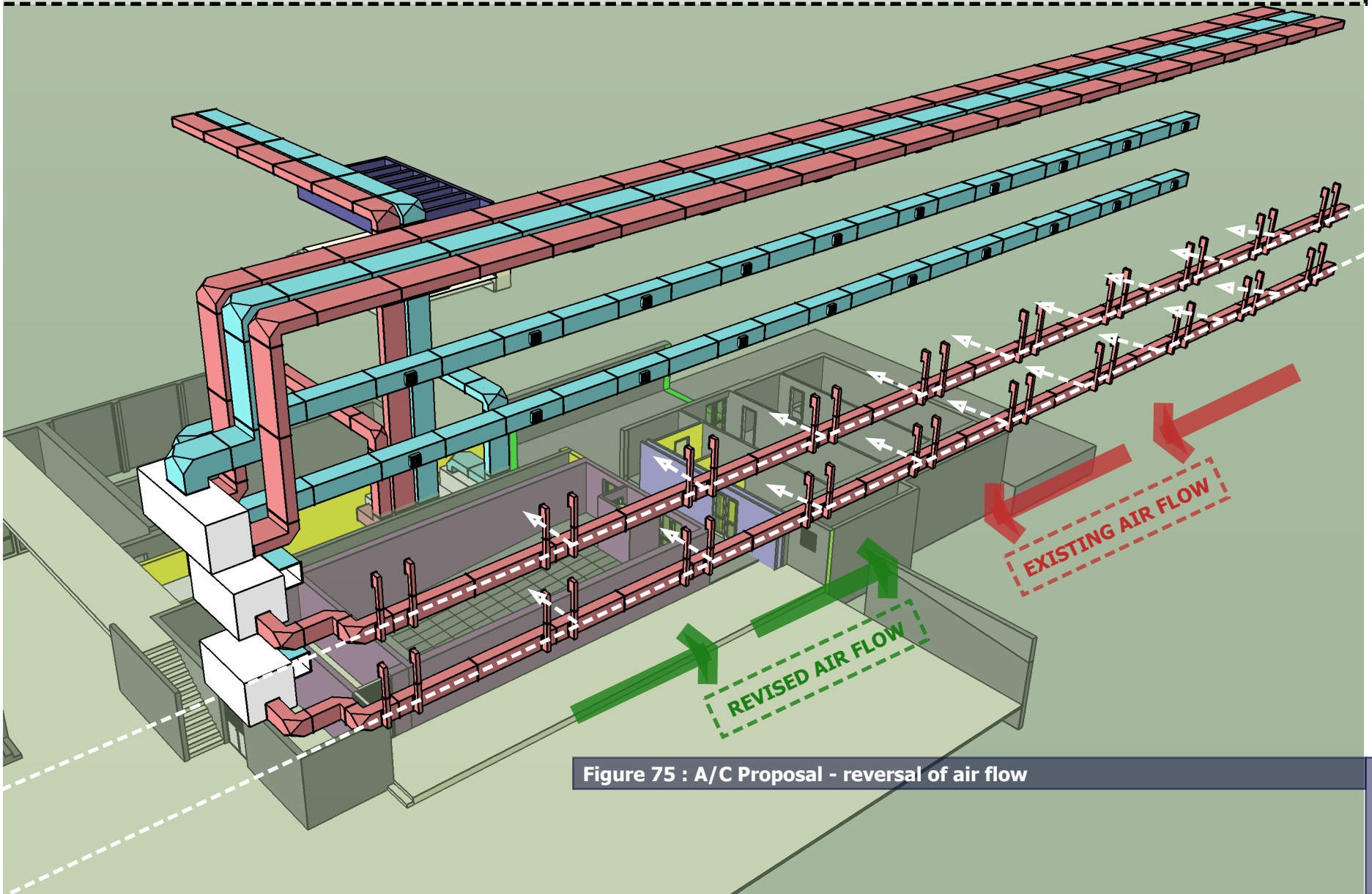
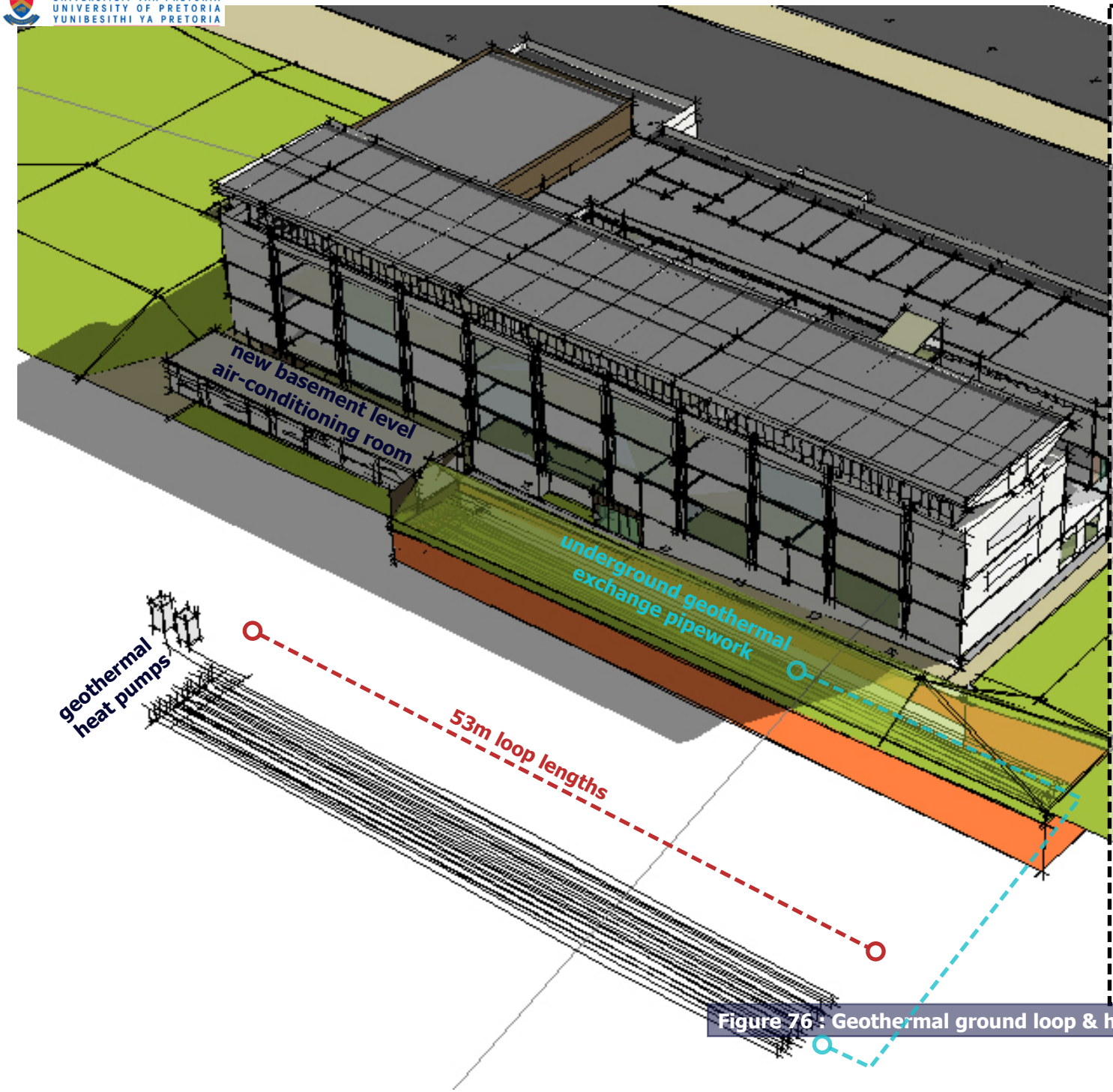


Figure 75 : A/C Proposal - reversal of air flow



The second element of the hybrid air-conditioning system is a closed loop horizontal geothermal unit.

The system design is based upon the following parameters:

- ground temperature = 16°C (at 2m+)

- total loop length = 1380m

- total loop capacity = 23tons (heating / cooling) @ approx. 1 ton/60 running metres loop length

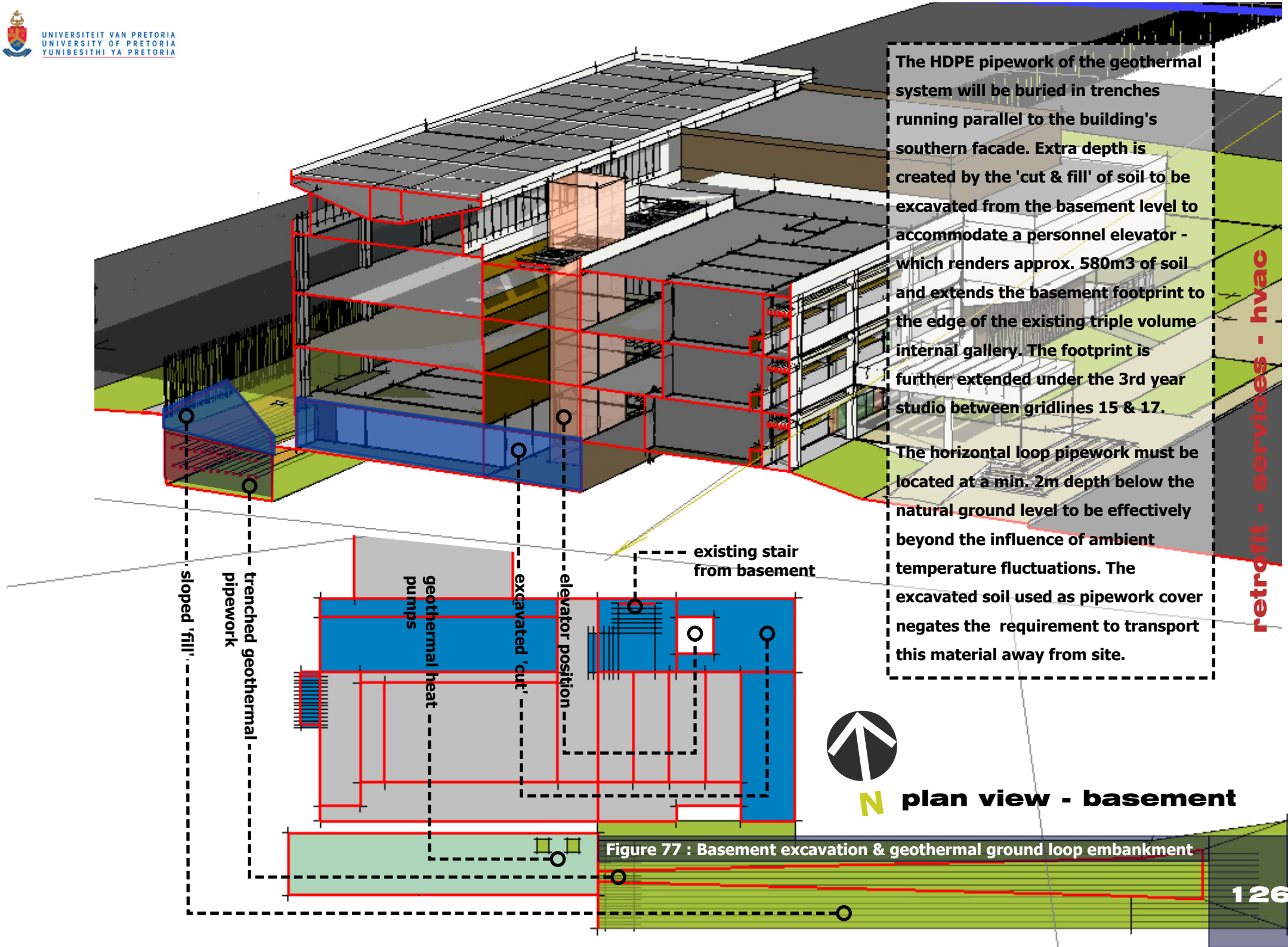
- loop arrangement in 13 pipe runs @ 0.5m centres

The loop pipework will feed through the existing retaining wall into the new air-conditioning room where the geothermal heat pumps will be located.

"A ground loop is a heat exchanger that either extracts or adds heat to the ground."

source : geothermal heat pump - design manual - application guide AG31-008 - McQuay Airconditioning

Figure 76 : Geothermal ground loop & heat pump layout



The HDPE pipework of the geothermal system will be buried in trenches running parallel to the building's southern facade. Extra depth is created by the 'cut & fill' of soil to be excavated from the basement level to accommodate a personnel elevator - which renders approx. 580m3 of soil and extends the basement footprint to the edge of the existing triple volume internal gallery. The footprint is further extended under the 3rd year studio between gridlines 15 & 17.

The horizontal loop pipework must be located at a min. 2m depth below the natural ground level to be effectively beyond the influence of ambient temperature fluctuations. The excavated soil used as pipework cover negates the requirement to transport this material away from site.

retrofit - services - hvac

Figure 77 : Basement excavation & geothermal ground loop embankment

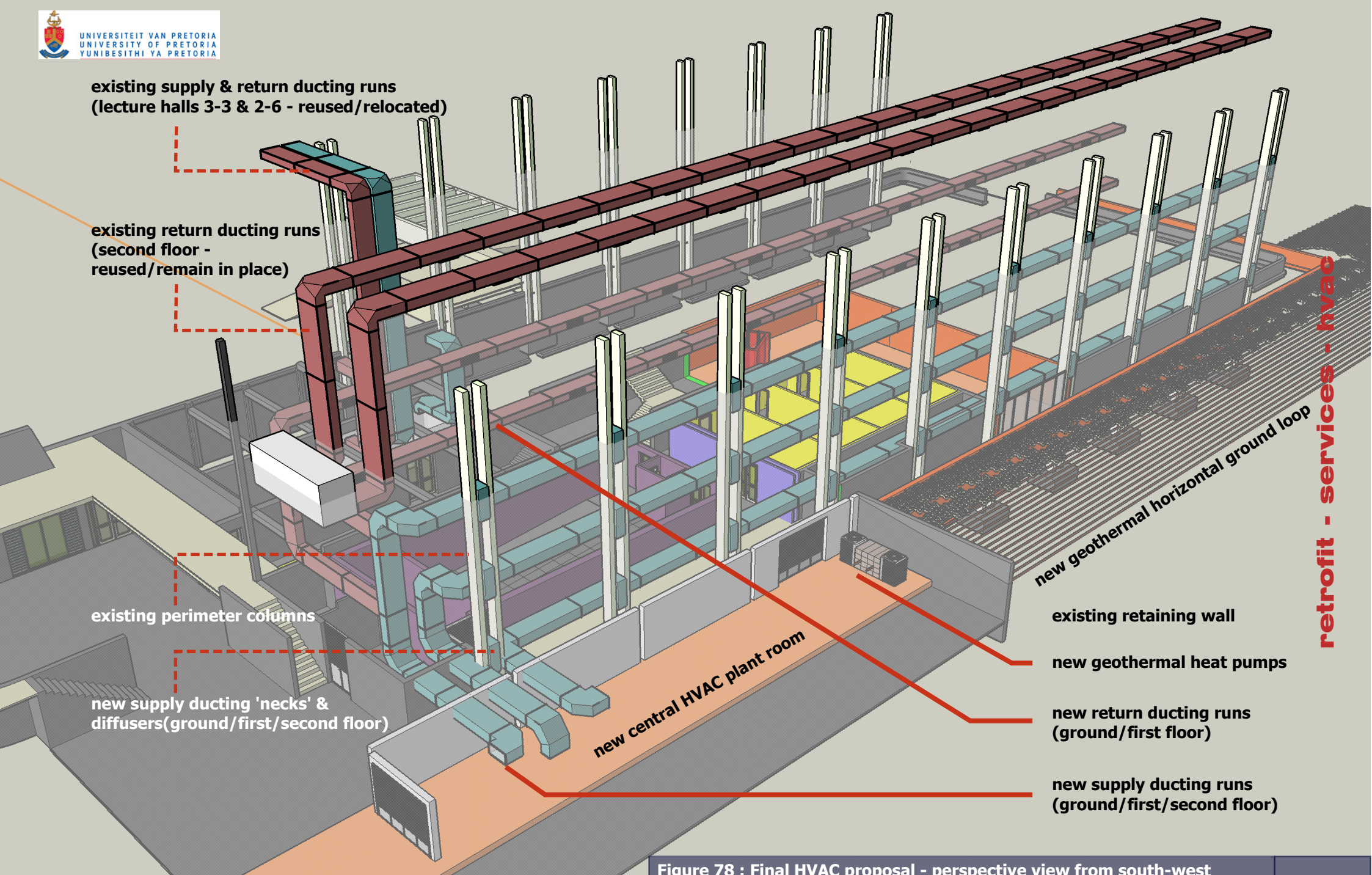
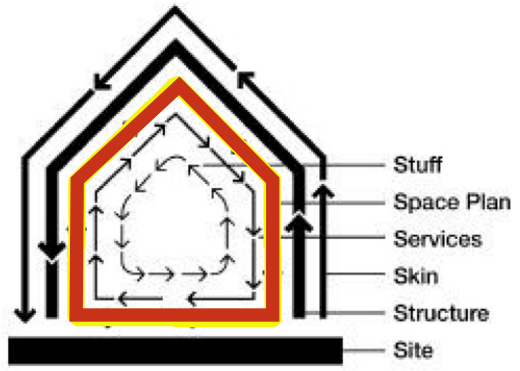


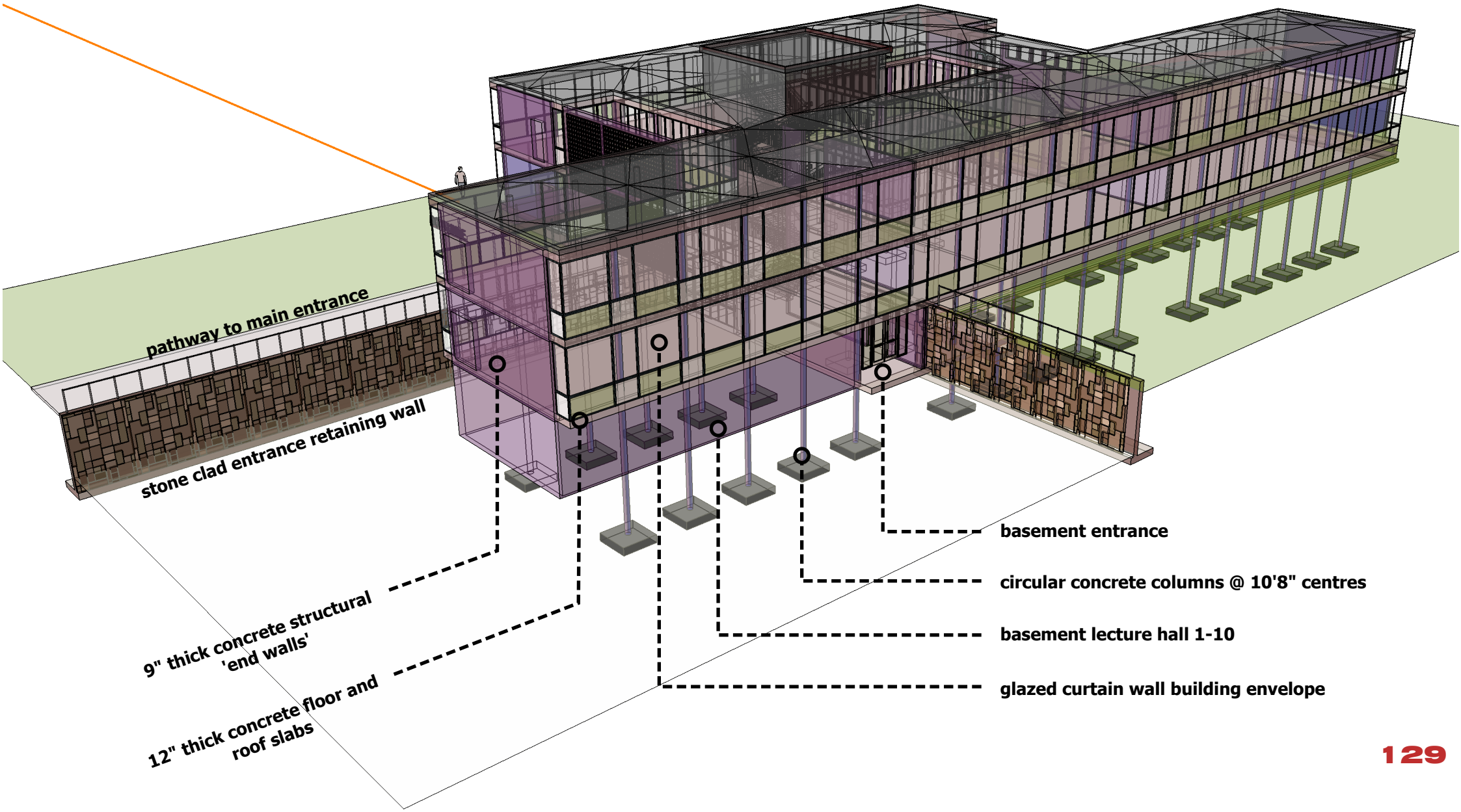
Figure 78 : Final HVAC proposal - perspective view from south-west

"The longevity of buildings is often determined by how well they can absorb new Services technology." (Brand. 1994:19)



retrofit : space plan

Figure 79 : BOUKUNDE I - perspective view from south-west



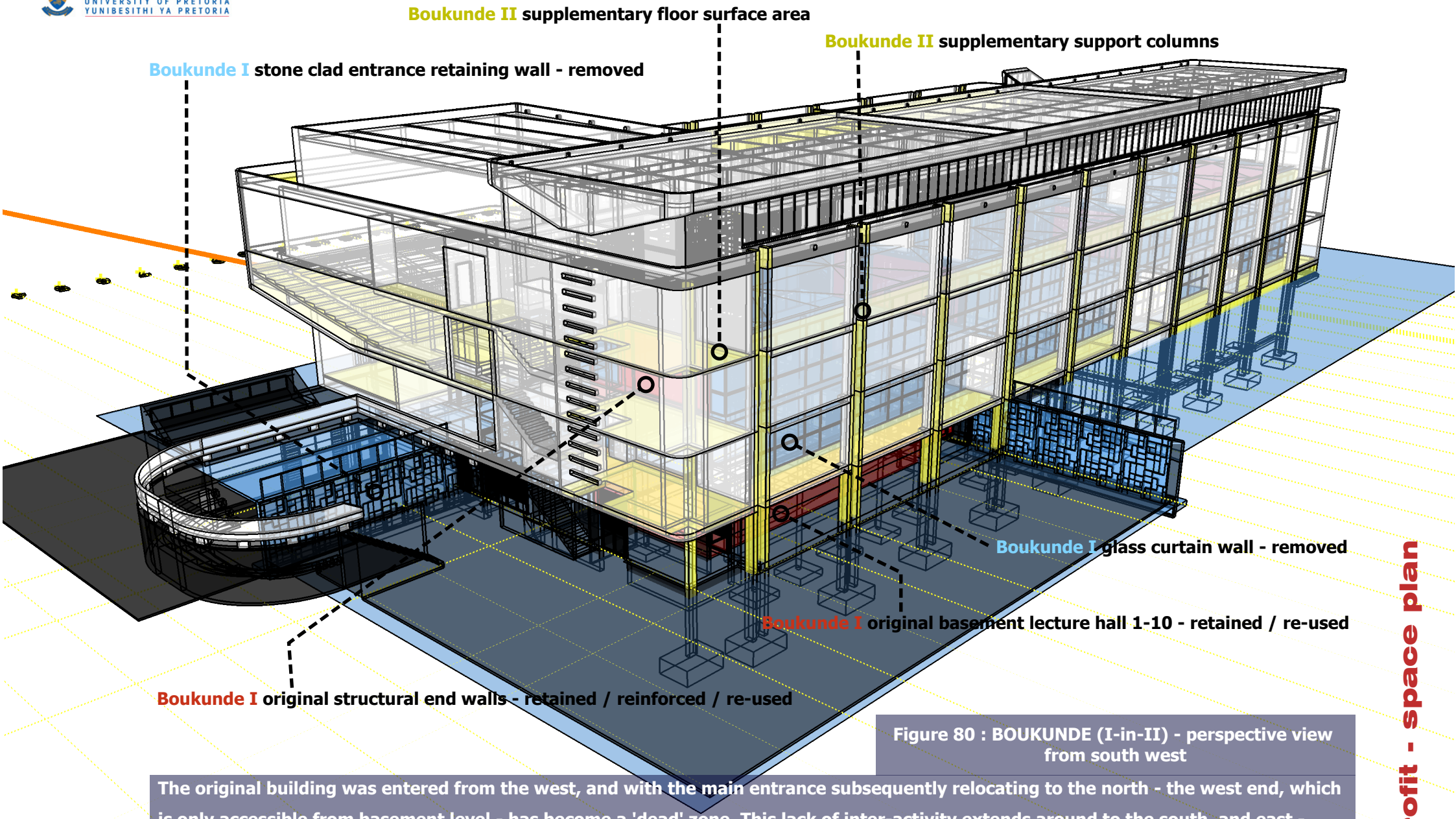


Figure 80 : BOUKUNDE (I-in-II) - perspective view from south west

The original building was entered from the west, and with the main entrance subsequently relocating to the north - the west end, which is only accessible from basement level - has become a 'dead' zone. This lack of inter-activity extends around to the south, and east - where the first significant perforations in the building's envelope are to be found. The western end of the building is endowed with sculptural qualities and significant design detail that is lost upon the occupants who scarcely visit the amphitheatre level due to the predominance of services infrastructure.

t footprint extended beyond existing stair to accommodate new personnel elevator and exhibition space beyond

existing air-conditioning room wall to be broken out to form wide passage / exhibition space in concert with existing basement passage

removal of infill walls made possible by virtue of concrete structural beams that distribute loads to column loading points

existing basement amphitheatre with connection to building core via new basement circulation axis - as per BOUKUNDE I basement entry

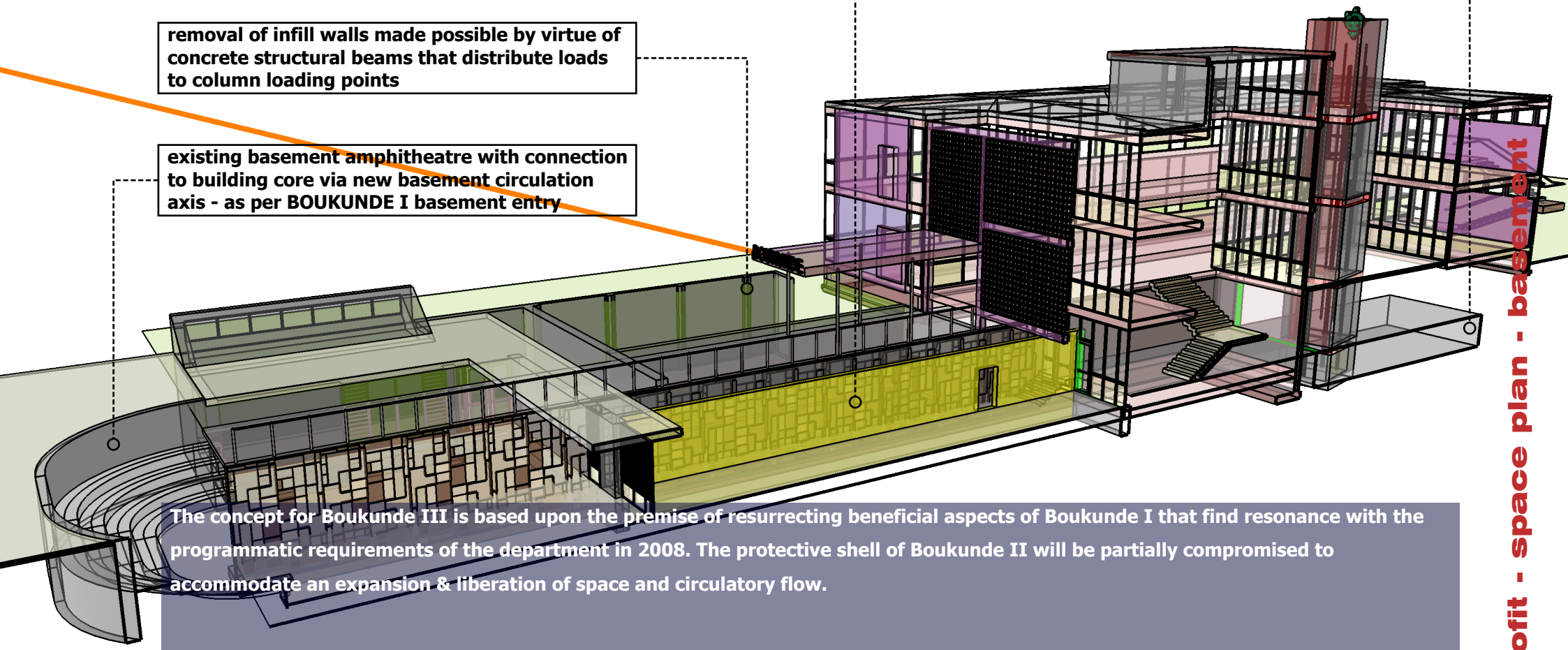


Figure 81 : BOUKUNDE II basement - perspective section view from south-west (overlaid with BOUKUNDE I)

The concept for Boukunde III is based upon the premise of resurrecting beneficial aspects of Boukunde I that find resonance with the programmatic requirements of the department in 2008. The protective shell of Boukunde II will be partially compromised to accommodate an expansion & liberation of space and circulatory flow.

The starting point is at the most neglected sector of the current building - being the western basement area. The reconfiguration of the hvac system - from primarily a central mixed-air system to a hybrid of geothermal heat exchange, displacement air-conditioning and natural ventilation will afford the opportunity of relocating- & scaling down the bulk of the current system. This action will create the opportunity for new circulation paths to develop from the derelict nether-regions of Boukunde.

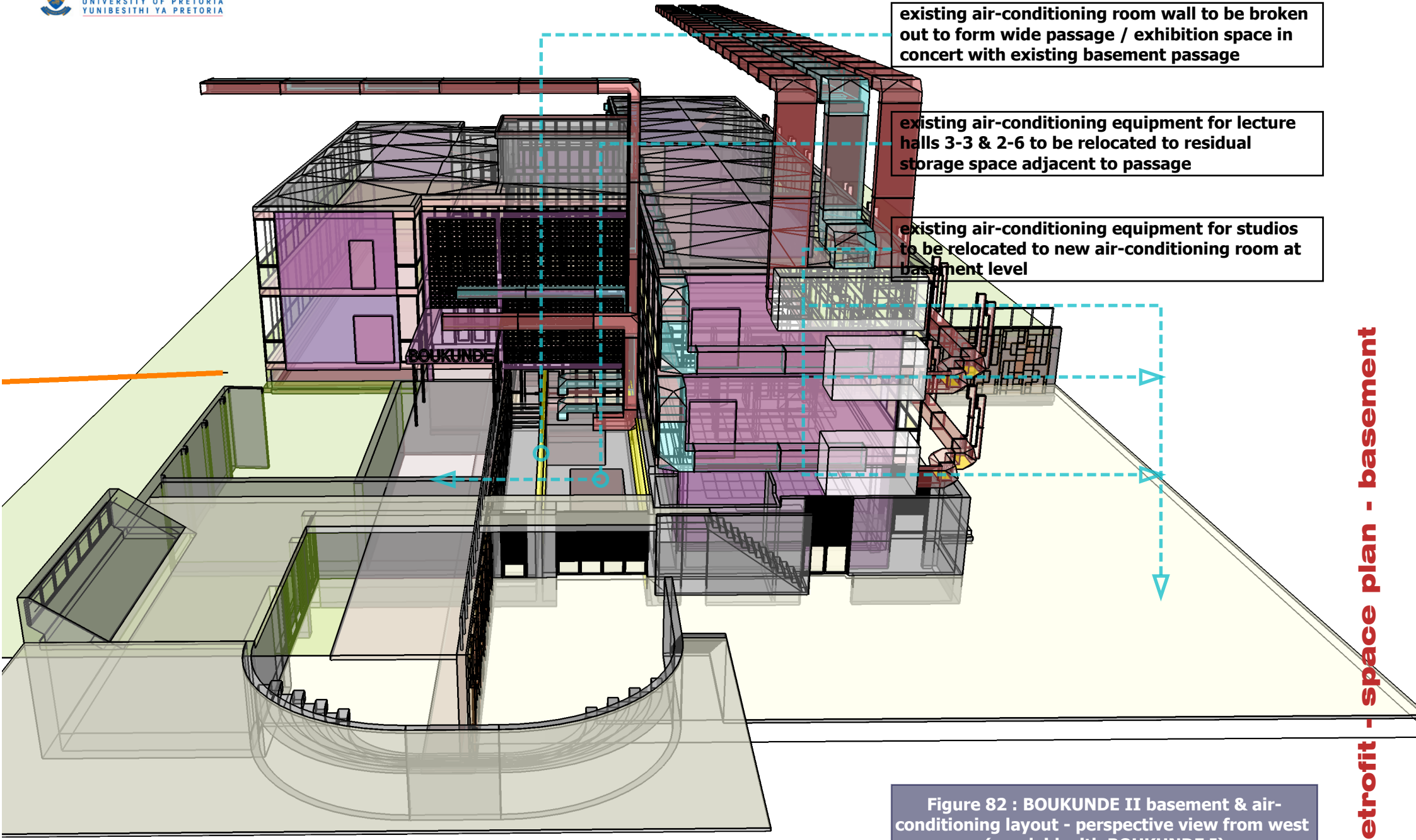


Figure 82 : BOUKUNDE II basement & air-conditioning layout - perspective view from west (overlaid with BOUKUNDE I)

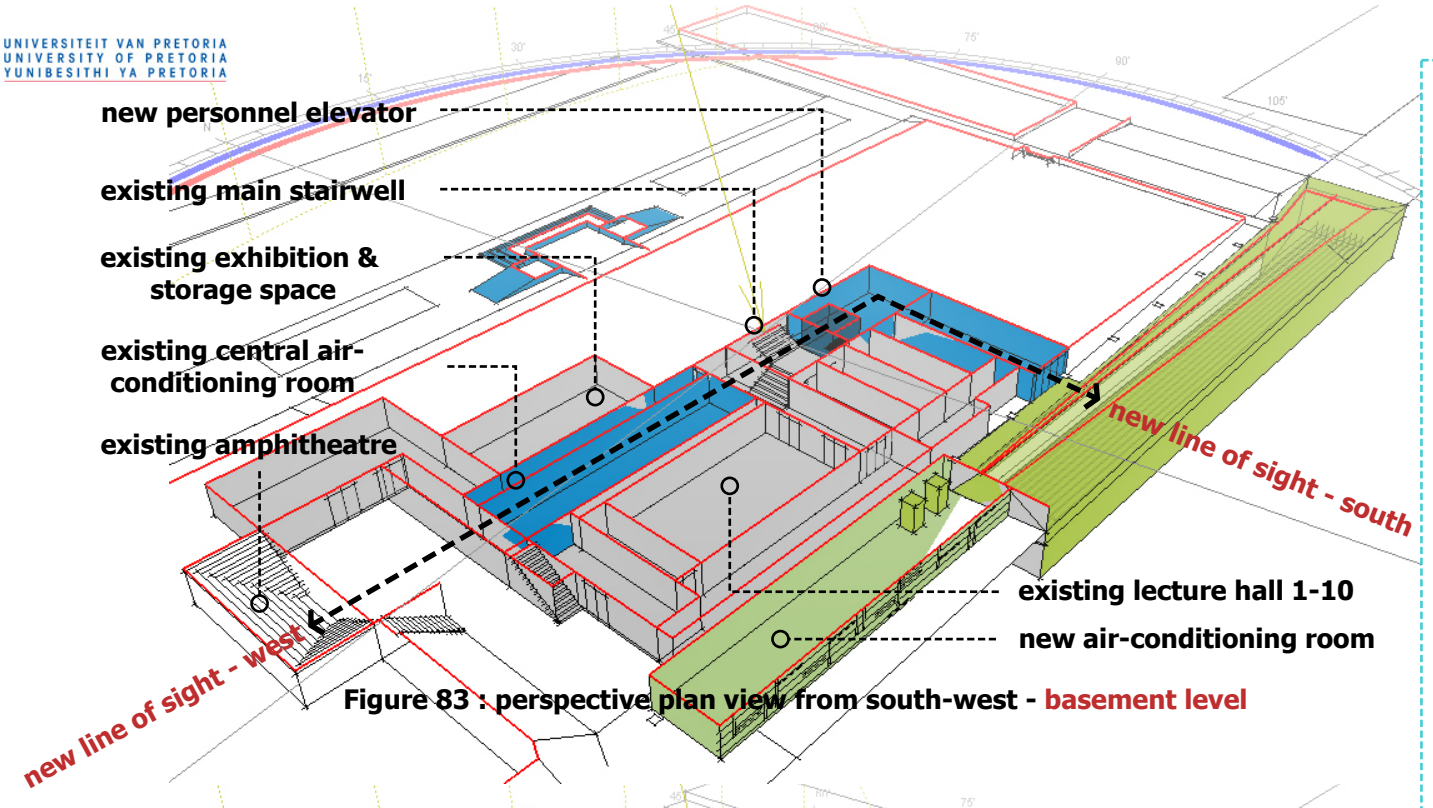


Figure 83 : perspective plan view from south-west - basement level

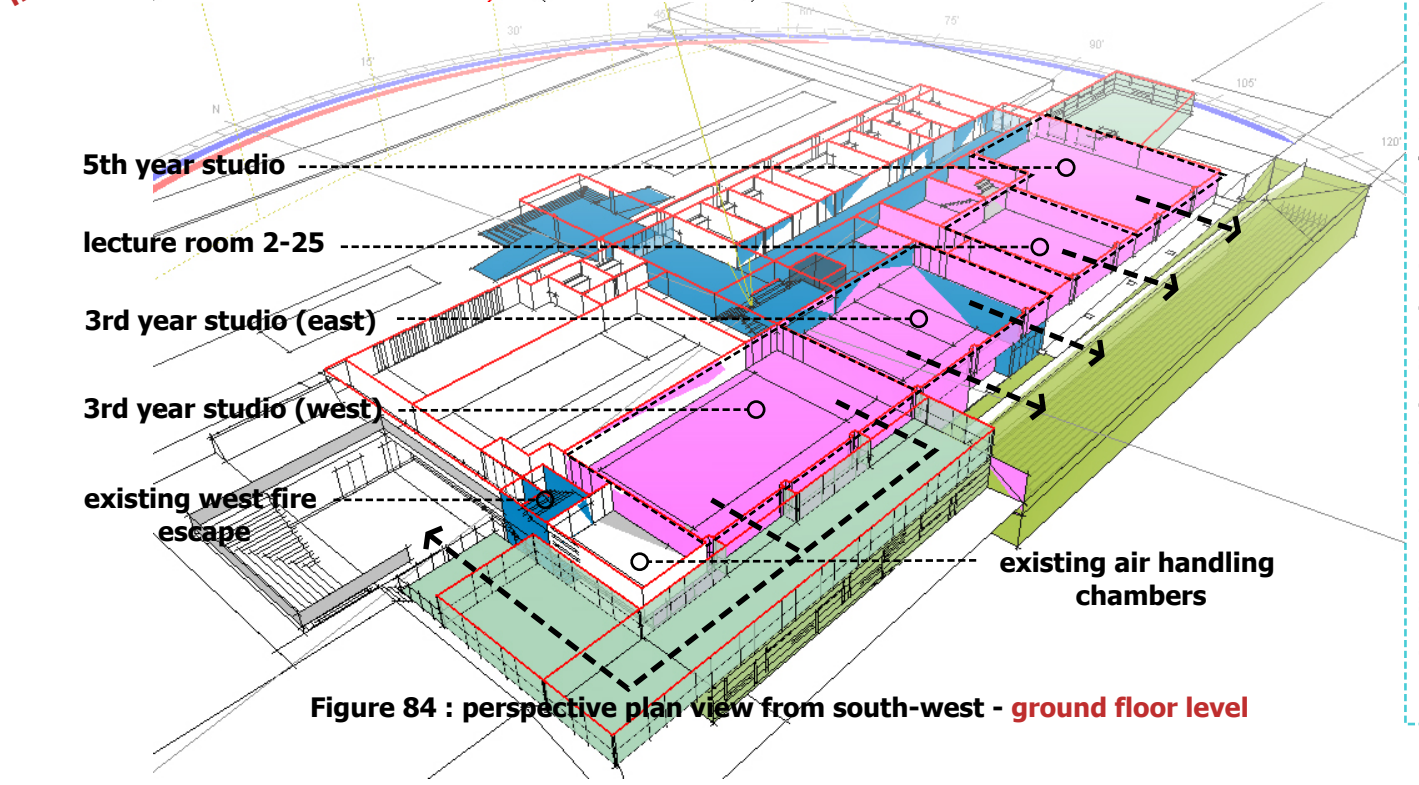


Figure 84 : perspective plan view from south-west - ground floor level

BASEMENT LEVEL:

The intention is to open up a line of sight from the buildings core to the south & west. The 2 new basement spaces will be designated as circulation / exhibition space. The west break-through will be via the existing central air-conditioning room, which will be relocated to a new external construction. The south break-through will travel under the existing 3rd year studio (east) between north-south grid lines 15-17. The 2 spaces will connect at the buildings central circulation node comprising the existing main stairwell and a new personnel elevator.

GROUND FLOOR LEVEL:

The entire facade is opened up to improve the daylight factor and connect visually with lynnwood road to the south. The 3rd year studio (west) space is extended to the south above the new air-conditioning room, and around to the west - overlooking the amphitheatre. The existing air handling chambers located at the south-west corner of the building on each level remain in place as transition points for conditioned air.

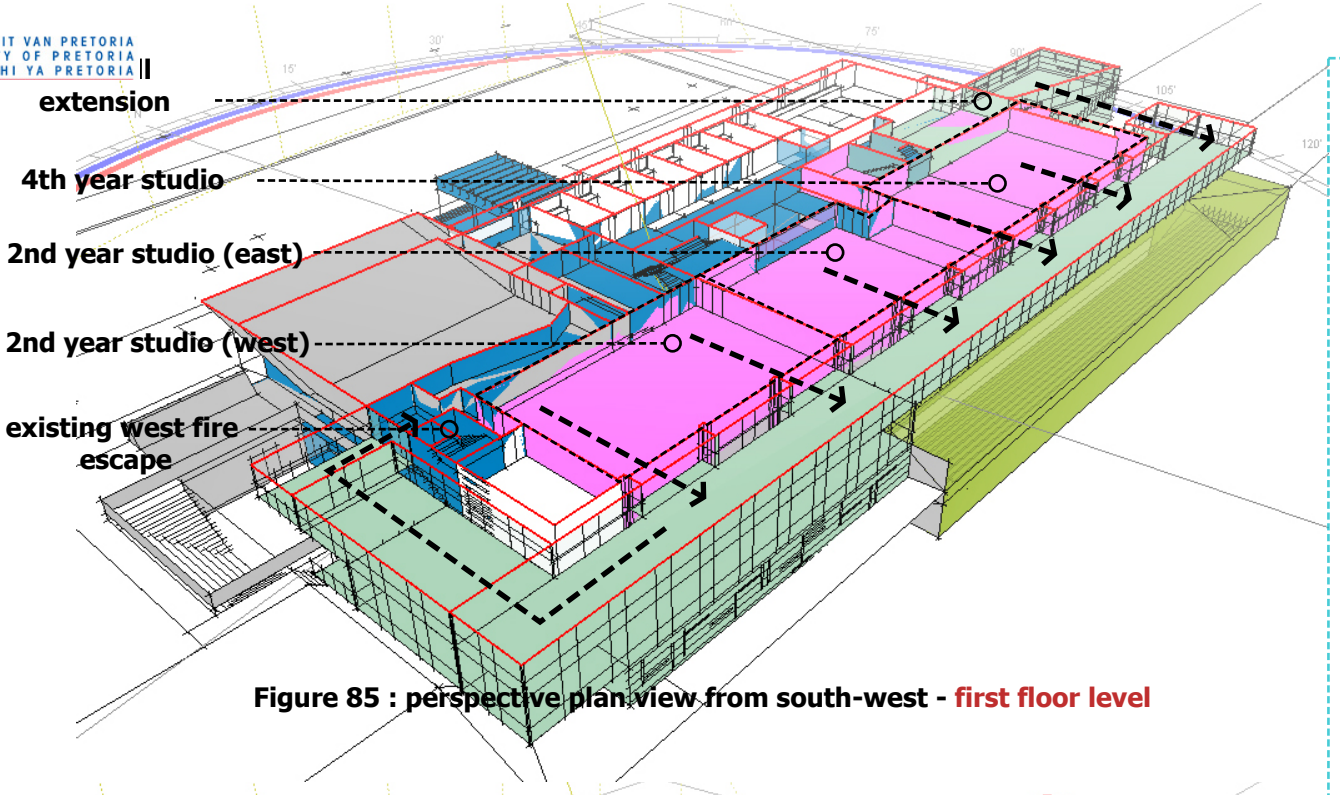


Figure 85 : perspective plan view from south-west - first floor level

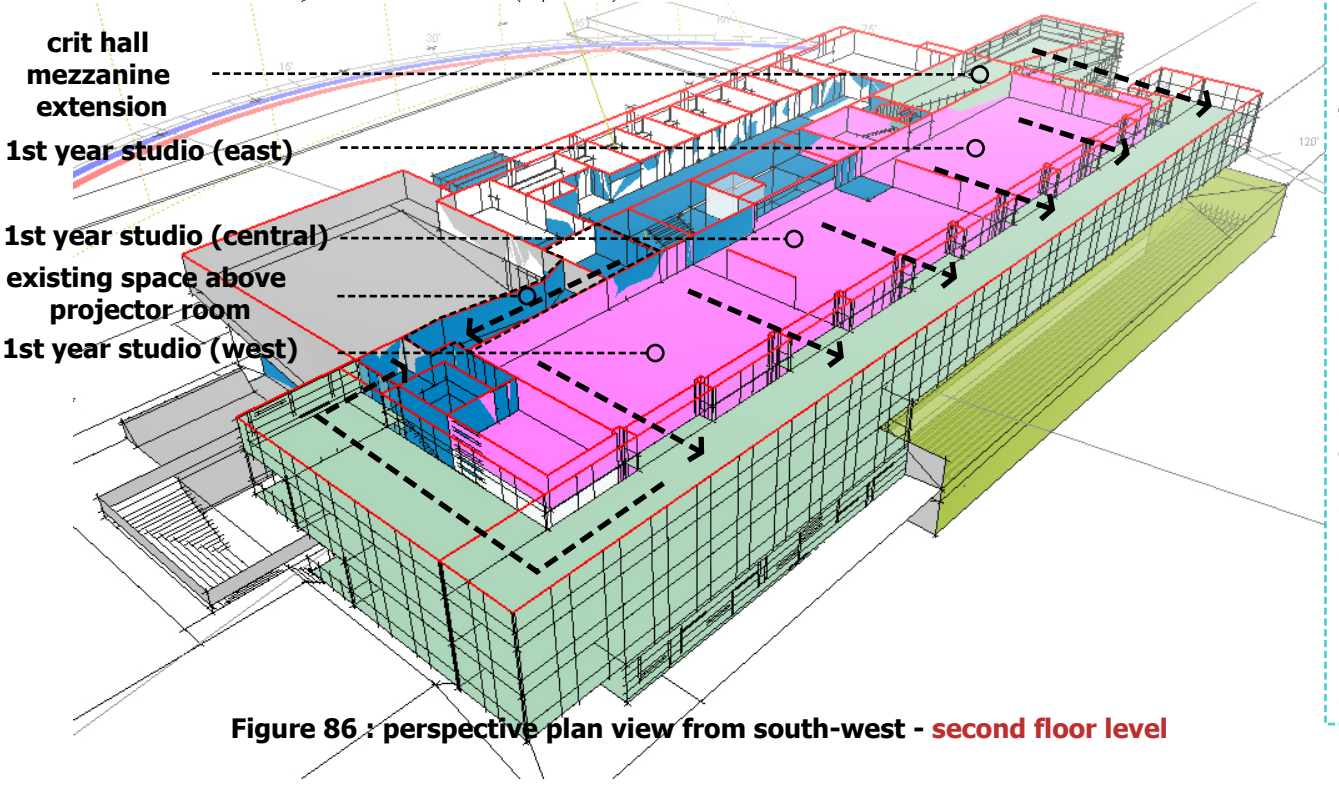


Figure 86 : perspective plan view from south-west - second floor level

FIRST FLOOR LEVEL:

The studio spaces are all extended south through the existing facade. The additional space extends around the western facade and connects back into the building using the existing western fire escape as a point of entry. The extension also draws out to beyond the eastern elevation - overhanging the geothermal ground loop embankment below. The 1st floor footprint is further extended to the east via the existing double volume crit hall - which facilitates a visual connection to the southern additions and lynnwood road beyond it.

SECOND FLOOR LEVEL:

The extension echoes that of the level below, and completes a circulatory loop through the central east-west axis by breaking through a pathway above the existing projector room of lecture hall 3-3 and the store room adjacent to it. The double volume of the crit hall is dissected with the addition of a mezzanine floor and extension, which connects the main passage at 2nd floor level with the new construction - including a new external eastern fire escape.

existing hvac equipment room

existing lecture hall 1-10
(& surrounding locales)

new hvac equipment room

new basement breakthrough
(between gridlines 15-17)

geothermal ground loop embankment

new external circulation path
(along sloped fall to basement level)

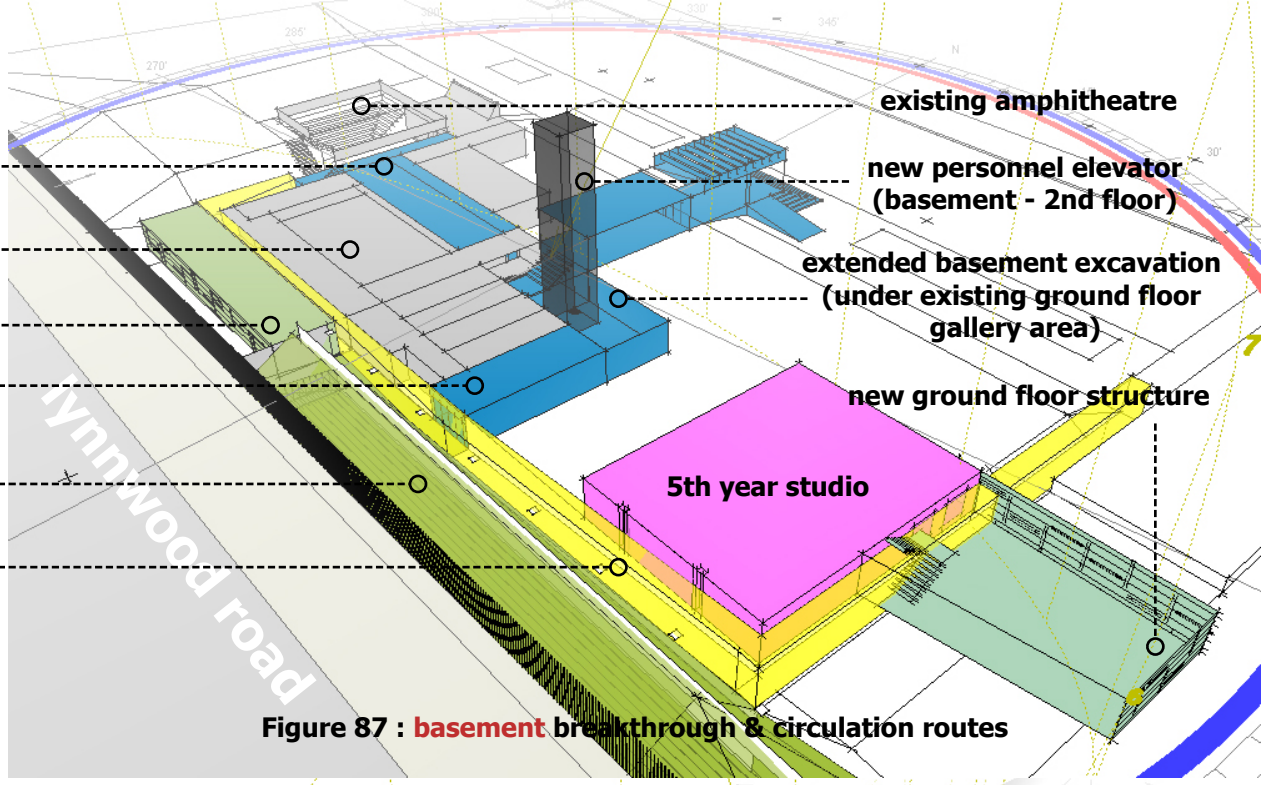


Figure 87 : basement breakthrough & circulation routes

new ground floor structure

new internal circulation path
(connecting the existing west & south)

existing main entrance podium

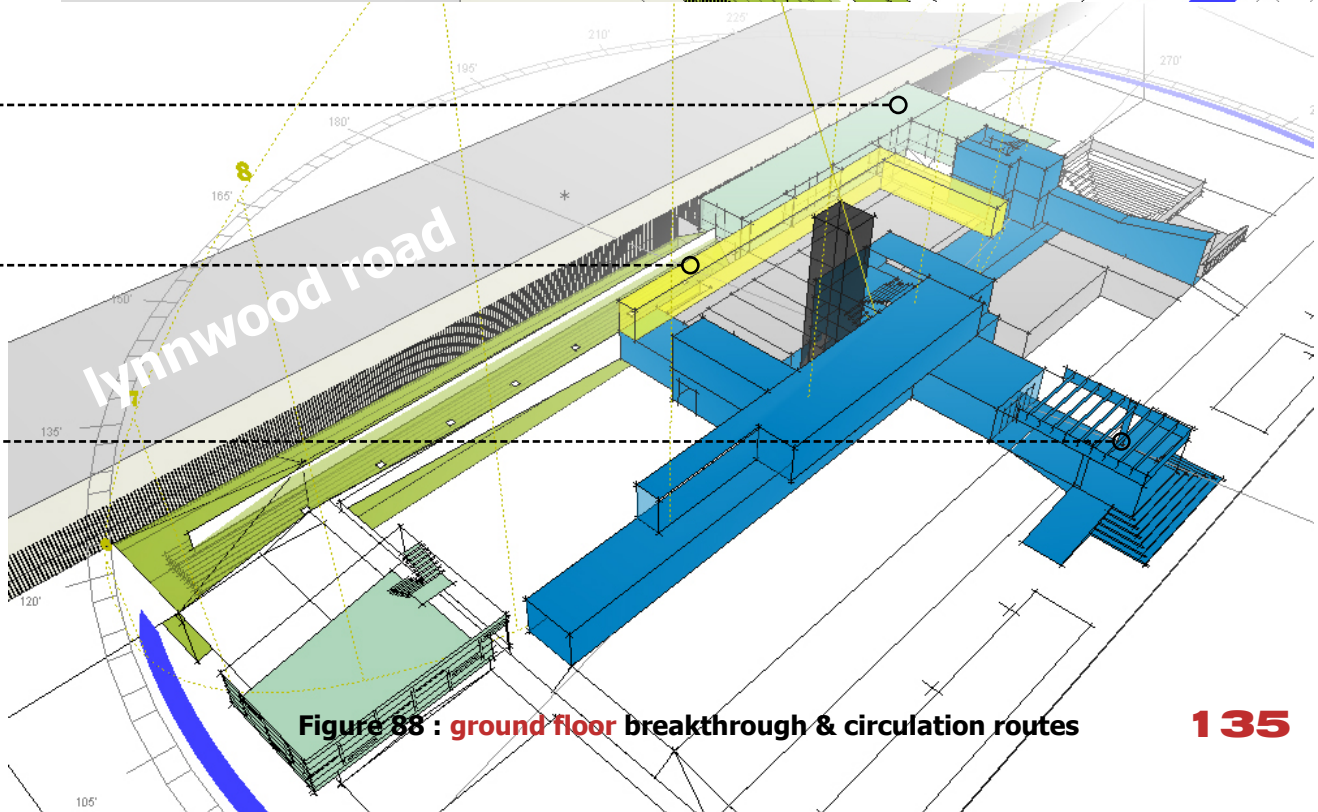


Figure 88 : ground floor breakthrough & circulation routes

new 1st floor south flank

new internal circulation path (connecting east, west & south)

existing 1st floor passage

existing main entrance podium

existing 1st floor east crit hall

new 1st floor extension to east crit hall

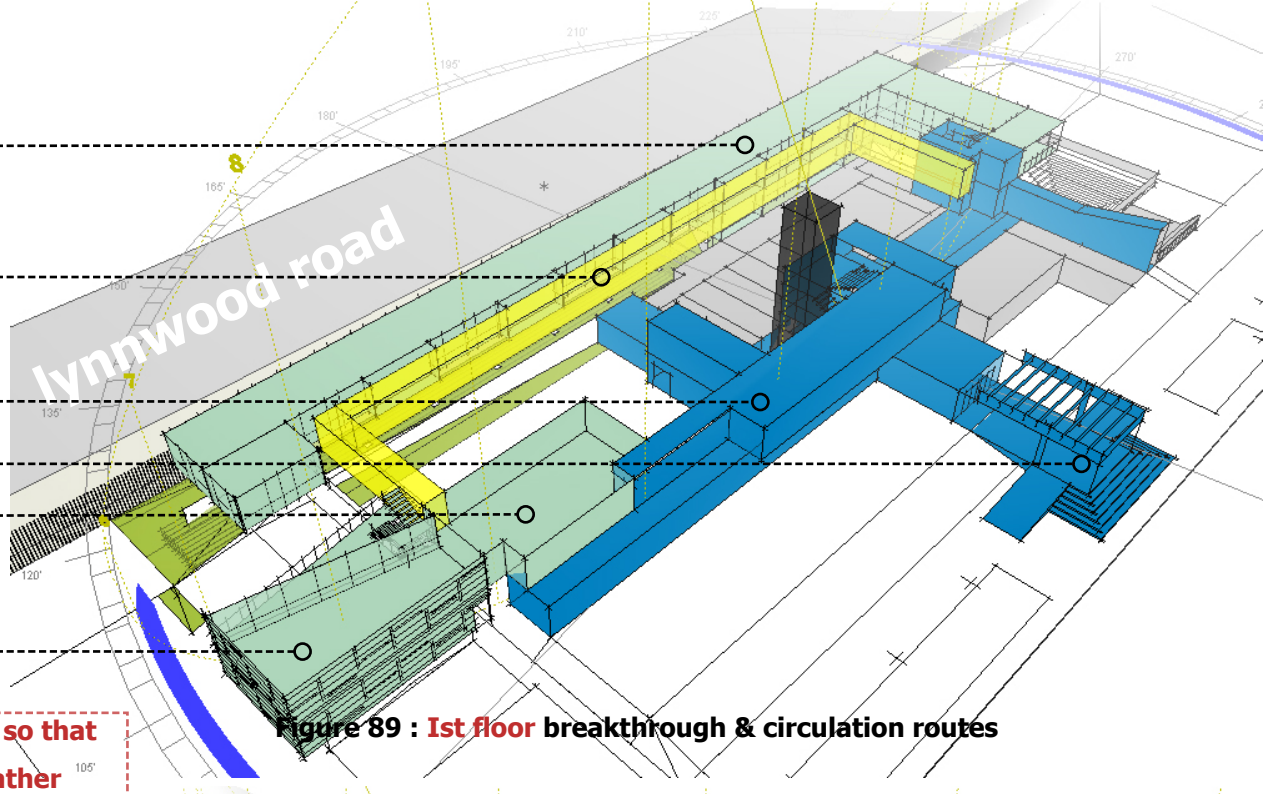


Figure 89 : 1st floor breakthrough & circulation routes

"The height of the building was limited to three stories so that people could use the stairs and meet in the stairwell, rather than being forced to use the elevator..." (Brand. 1994:179)

new mezzanine extension above east crit hall

existing 2nd floor passage

new personnel elevator

existing 2nd floor store room (broken through to passage)

existing volume above lecture hall 3-3 projector room (broken through to store room)

new 2nd floor west flank

existing amphitheatre

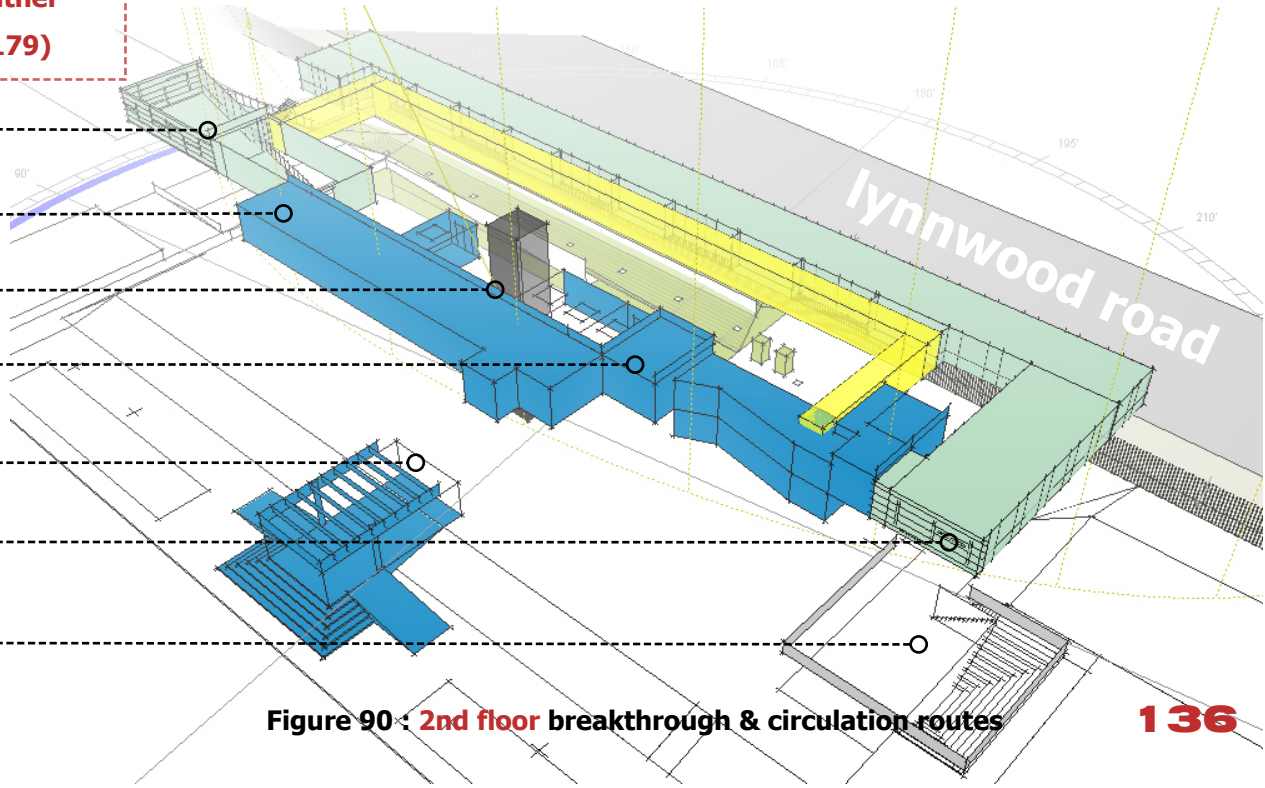
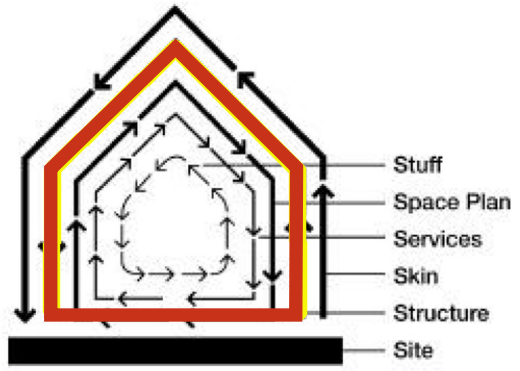


Figure 90 : 2nd floor breakthrough & circulation routes



retrofit : structure

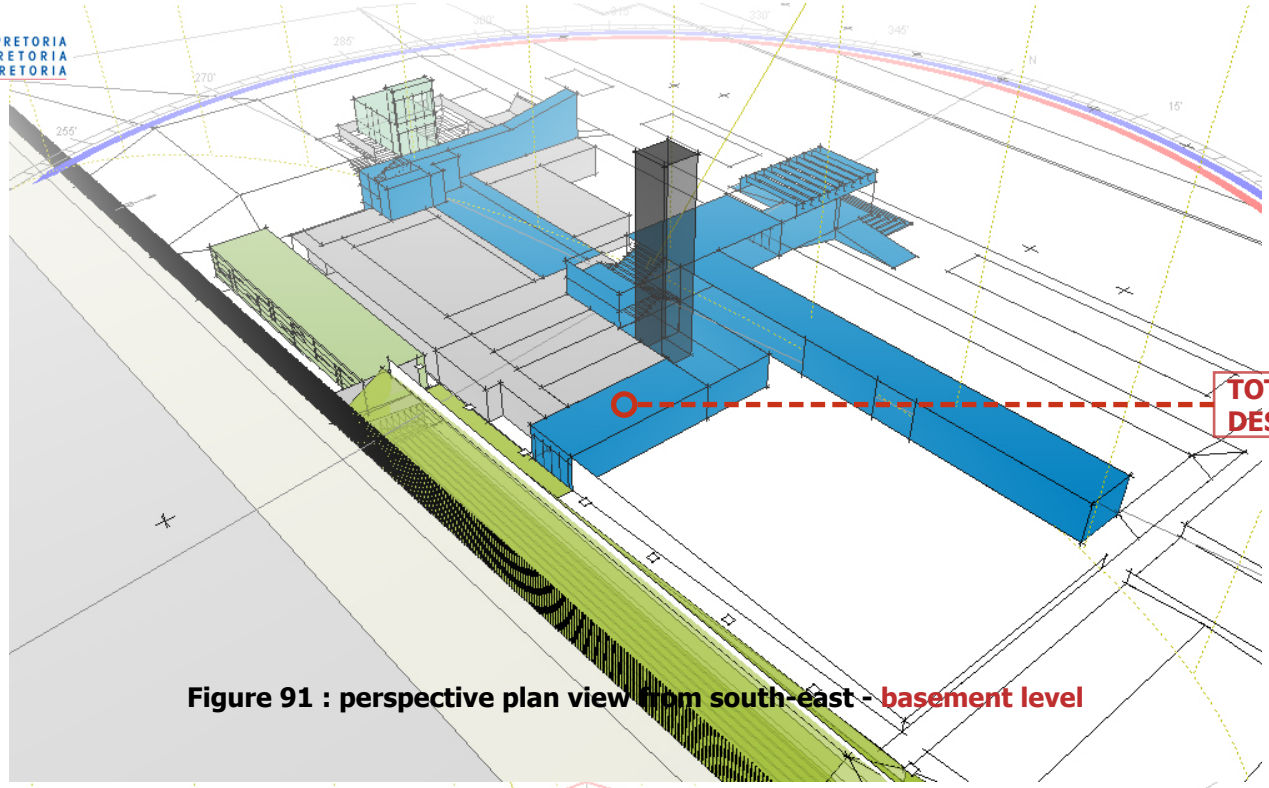


Figure 91 : perspective plan view from south-east - basement level

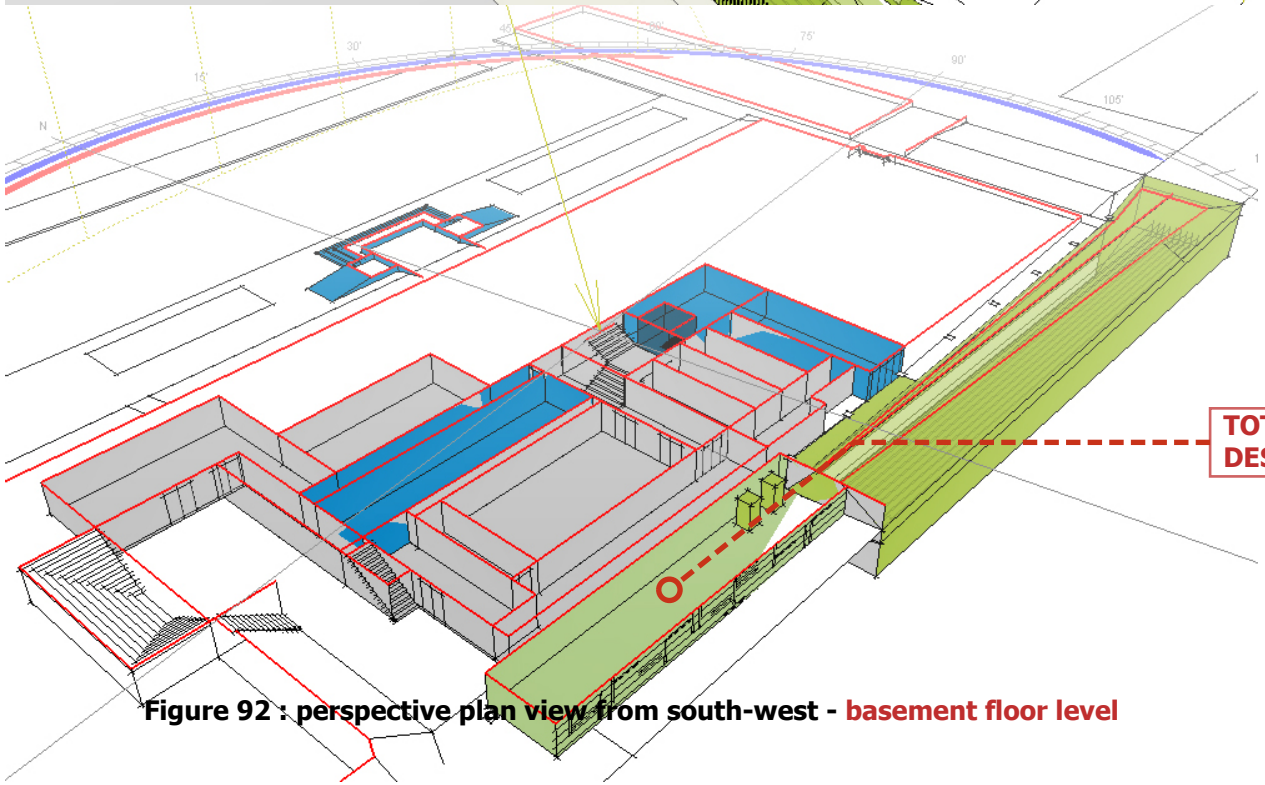


Figure 92 : perspective plan view from south-west - basement floor level

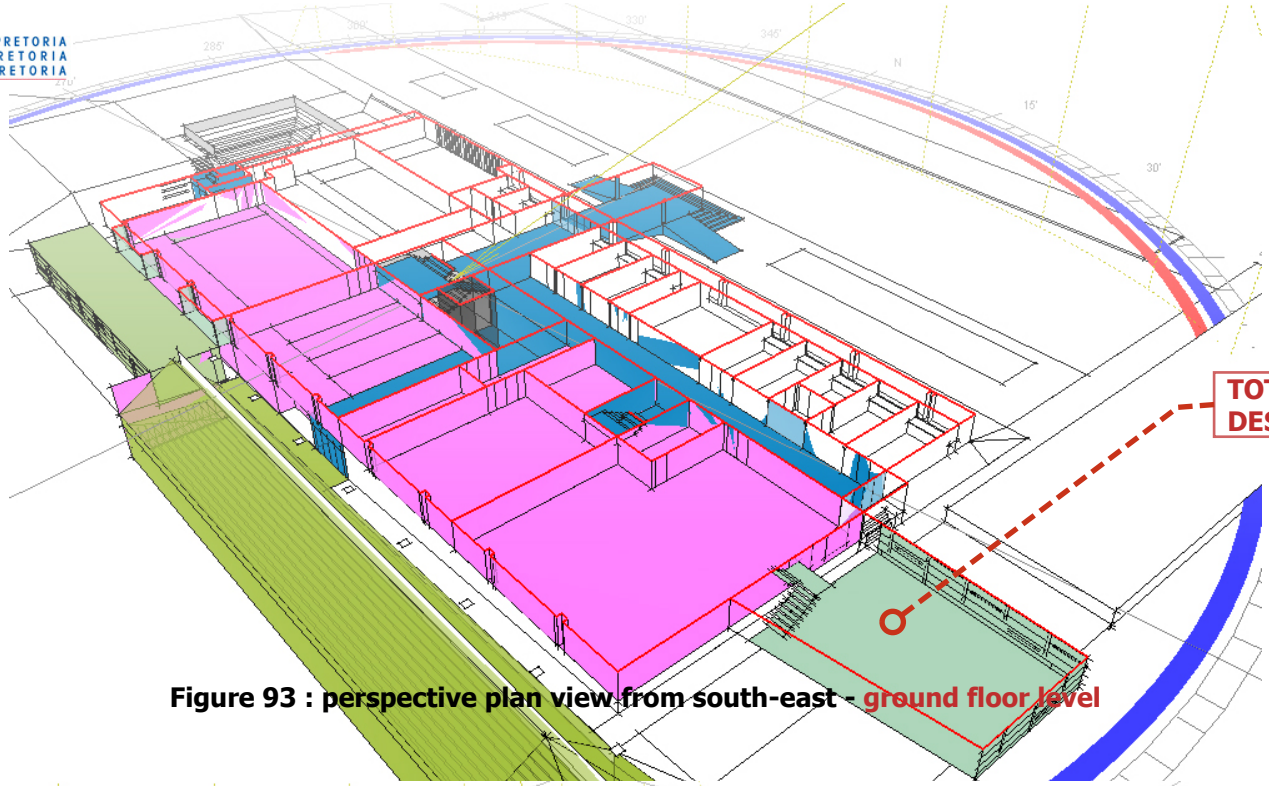


Figure 93 : perspective plan view from south-east - ground floor level

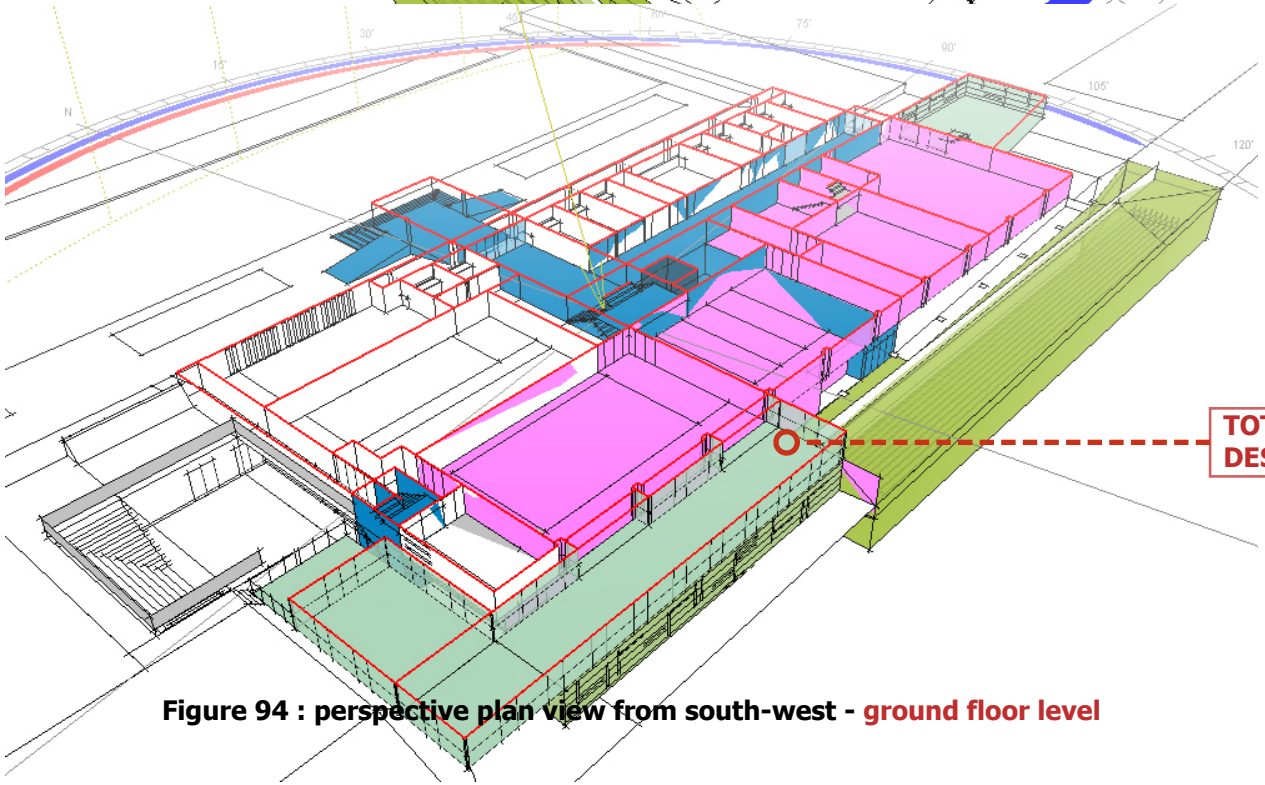


Figure 94 : perspective plan view from south-west - ground floor level

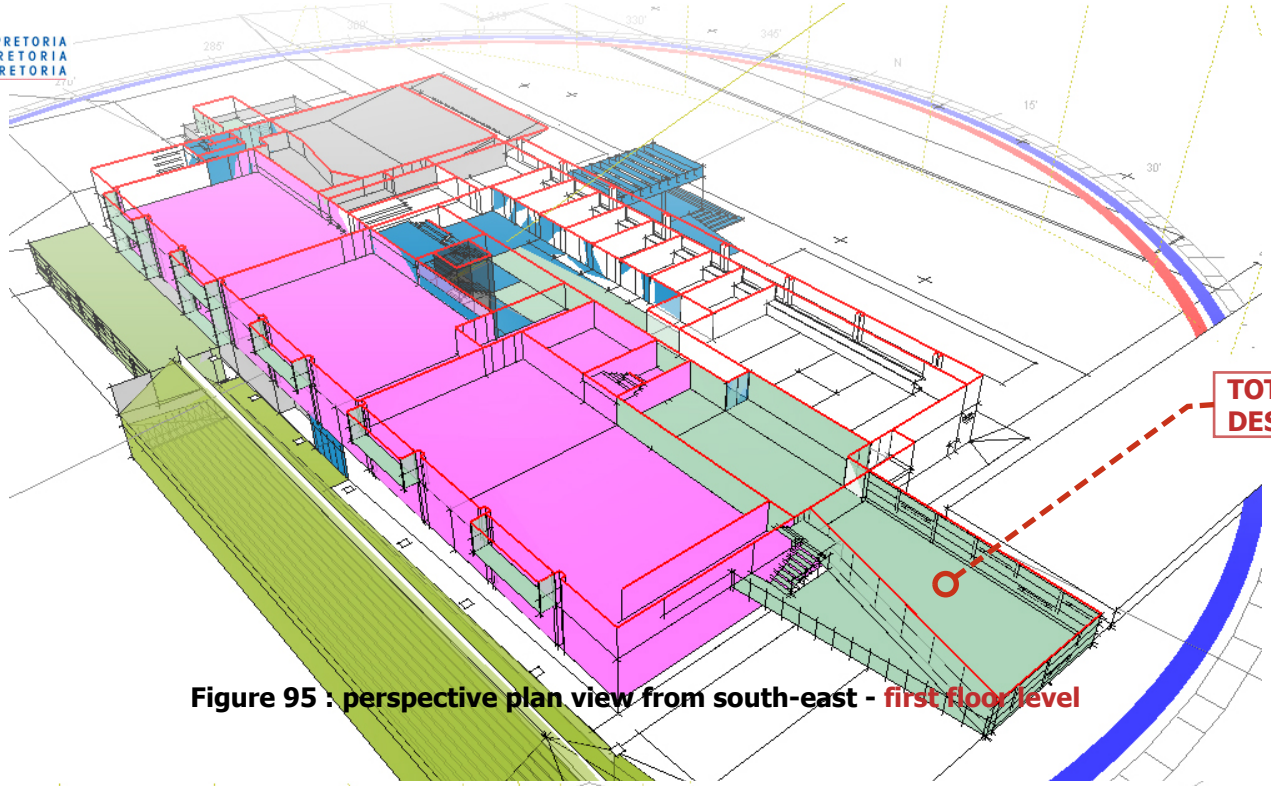


Figure 95 : perspective plan view from south-east - first floor level

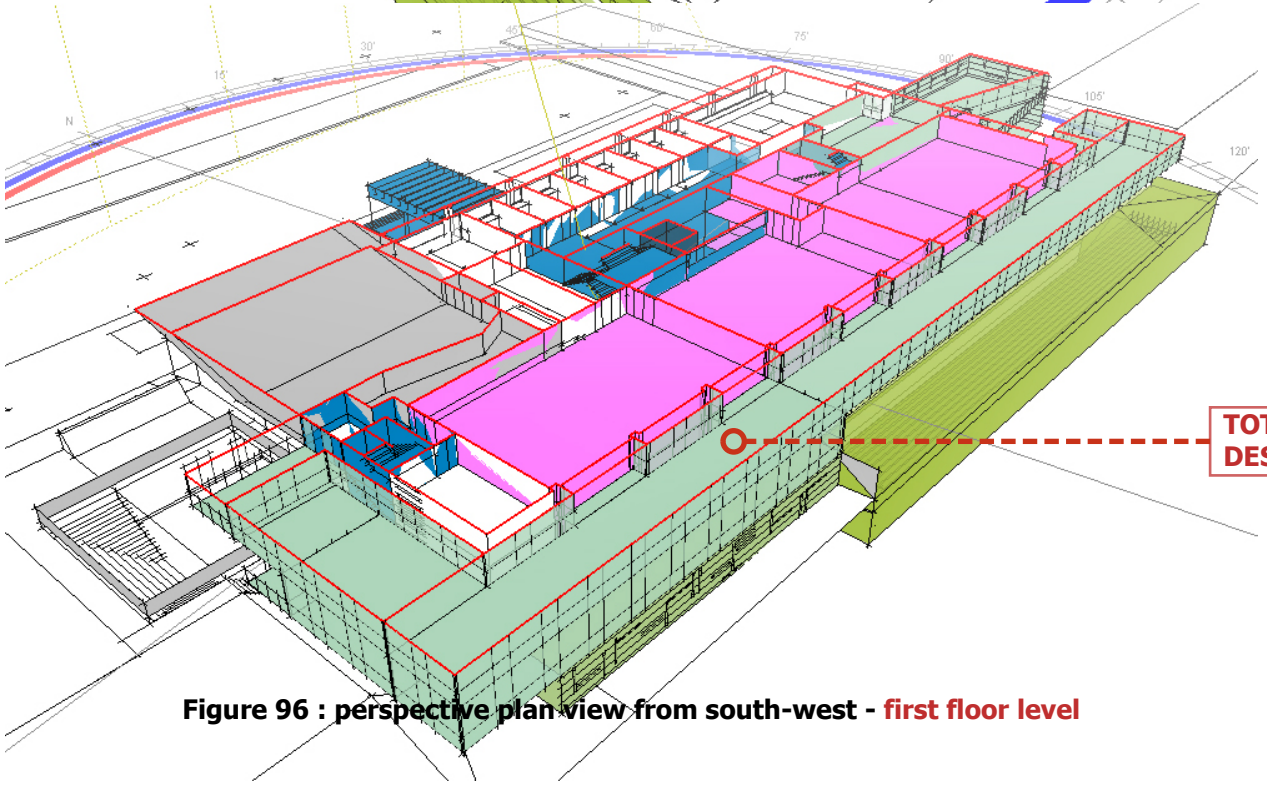


Figure 96 : perspective plan view from south-west - first floor level

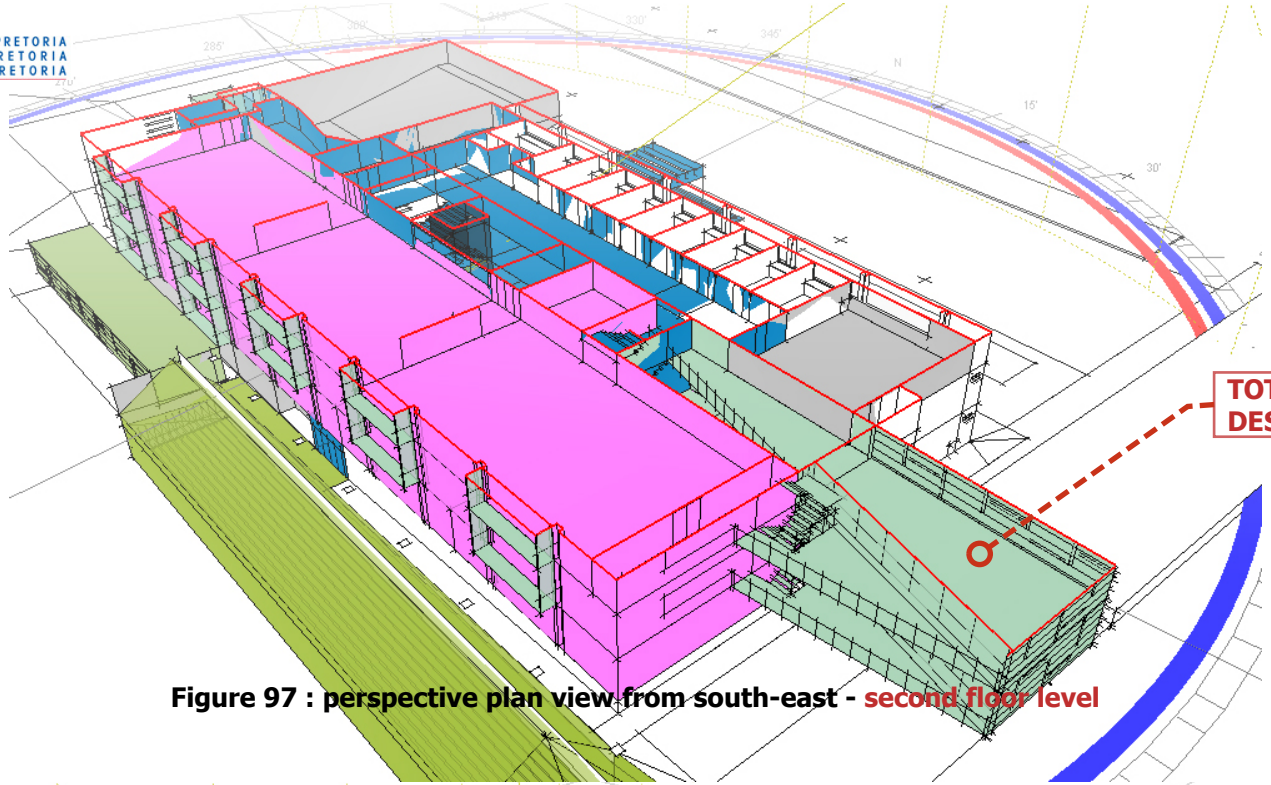


Figure 97 : perspective plan view from south-east - second floor level

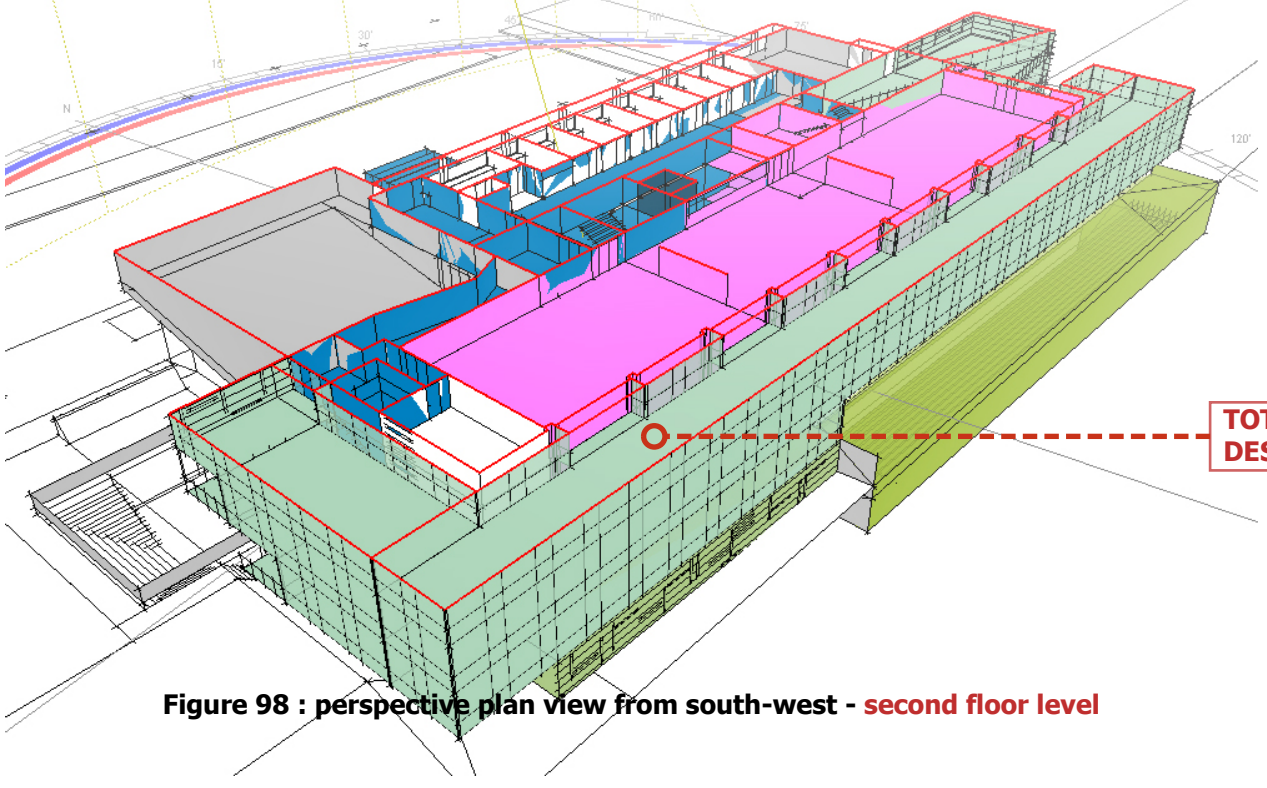


Figure 98 : perspective plan view from south-west - second floor level

SPATIAL QUOTAS:

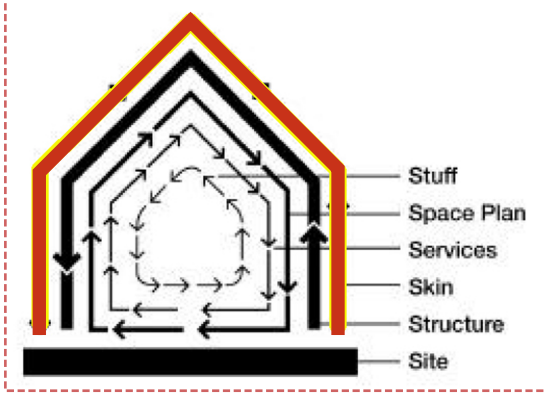
ADDITIONAL	STUDIO/LAB SPACE	EXHIBITION SPACE (formal)
Basement	0m²	284m²
Ground floor	768m²	0m²
1st floor	1024m²	150m²
2nd floor	1024m²	190m²

RESULTANT	STUDIO/LAB SPACE	EXHIBITION SPACE (formal)	EXHIBITION SPACE (informal)
Basement	0m²	284m²	190m² (amphitheatre + store room)
Ground floor	1428m²	172m²	60m² (passage ways)
1st floor	1724m²	300m²	110m² (passage ways)
2nd floor	1724m²	190m²	800m² (1st year studio + passage)

The 3D printing lab would be run by the 5th year students - whose studio is adjacent to the new facility. The lab itself, is therefore seen as supplementary 5th year studio space and allocated accordingly.

The resultant spatial quotas have been added to the existing space plan in an open format which does not specifically demarcate areas for the various tertiary levels within the Department. If the new studio space were to be allocated according to proximity - the following approximate assignments would result:

2015 (projected - excluding research)	population increase	available workspace increase
1st Year - 140 within 1724m² = 12.30m² / head	30%	146%
2nd year - 130 within 1164m² = 8.95m² / head	30%	165%
3rd year - 100 within 1028m² = 10.28m² / head	30%	157%
4th year - 80 within 560m² = 7.00m² / head	30%	115%
5th year - 60 within 400m² = 6.70m² / head	30%	54%



retrofit : skin

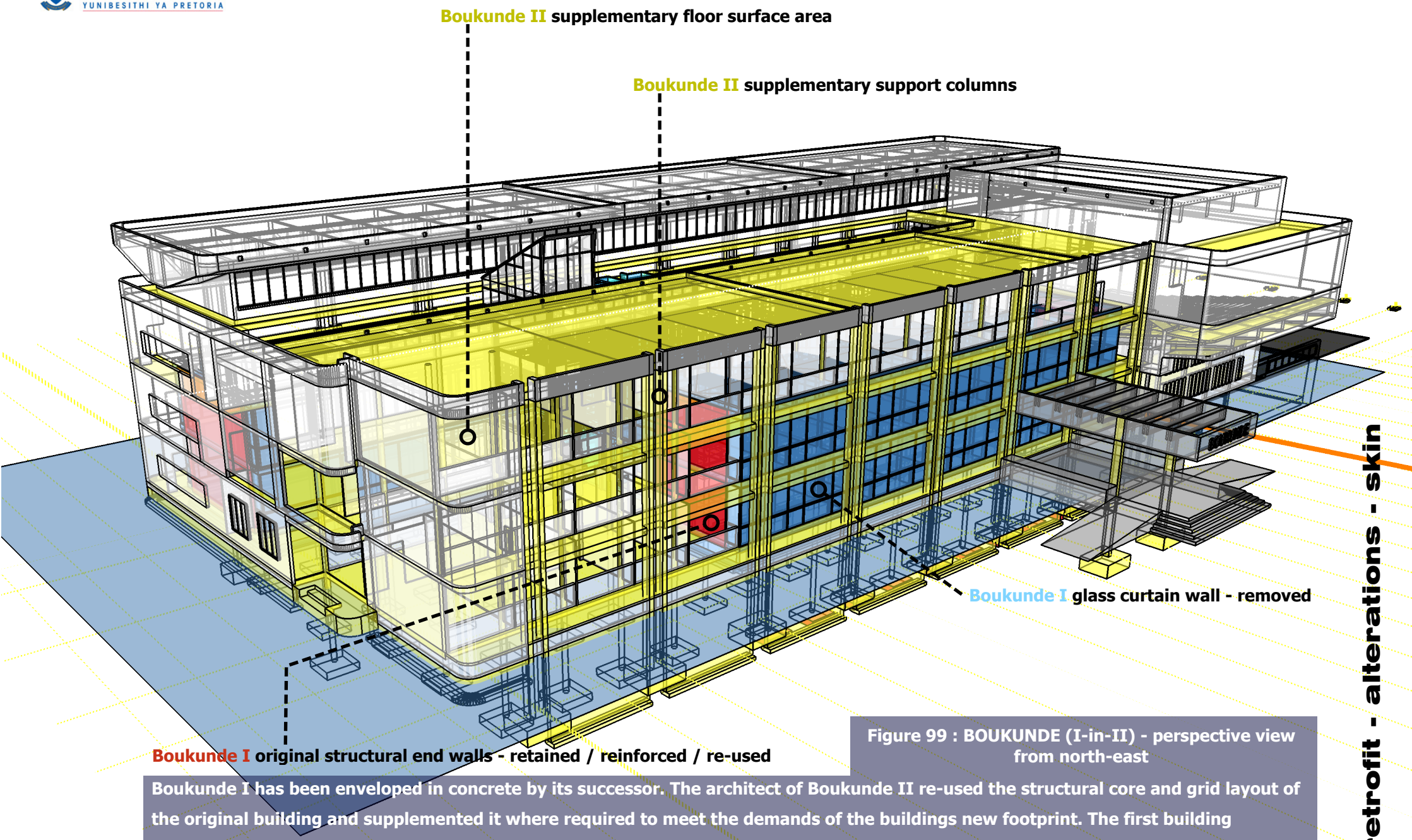


Figure 99 : BOUKUNDE (I-in-II) - perspective view from north-east

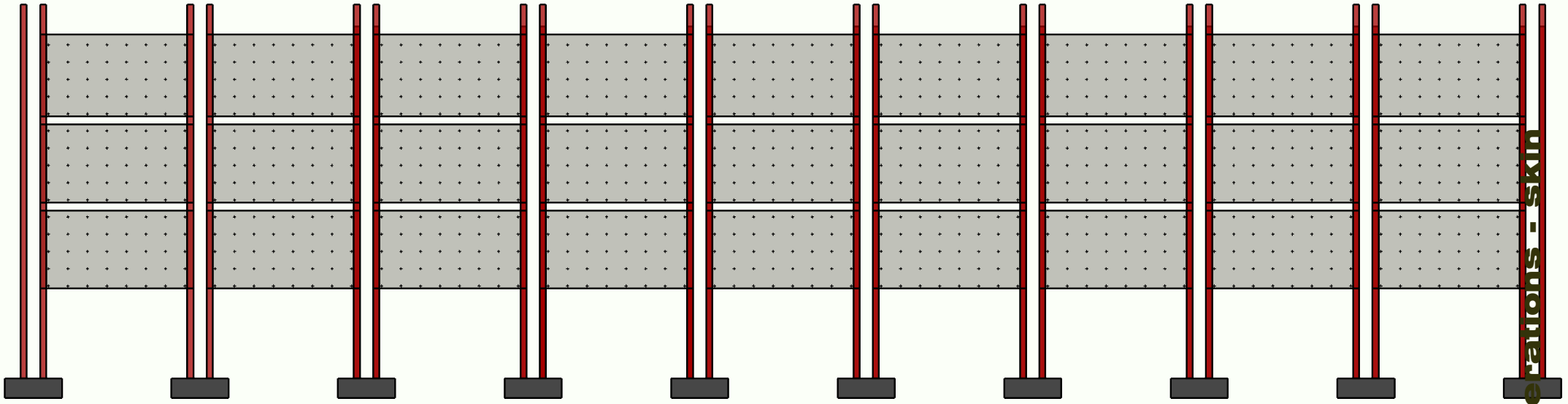
Boukunde I has been enveloped in concrete by its successor. The architect of Boukunde II re-used the structural core and grid layout of the original building and supplemented it where required to meet the demands of the buildings new footprint. The first building presumably informed certain aspects of the design, and an effective concrete shield was drawn up around what once stood. The proposal for Boukunde III now seeks to resurrect certain aspects of the original built form which could benefit the current condition.

"Concrete is treated like nuclear power: we try not to think about decommissioning." (Brand. 1994:126)

27 x 7" (178mm) thick concrete panels will be removed from between the southern facade columns.

Panel Surface area:
5520mm x 3048mm = 16.82m^2 each

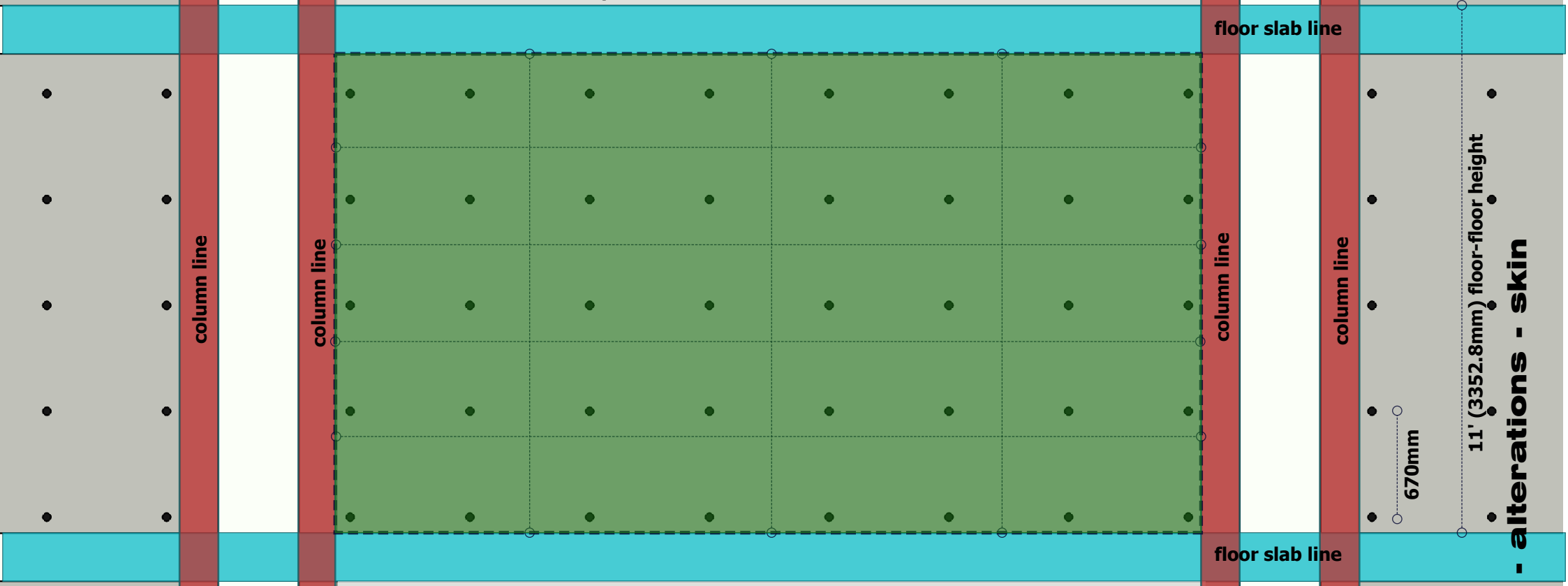
Panel Mass = approx. 6880kgs each (based upon a bulk density of 2300kg/m^3 for in-situ concrete)



During construction almost 186 tonnes of concrete will be cut from the buildings southern facade & brought to ground level. The method being proposed for effecting these incisions is thermolancing - as opposed to mechanical cutting (using a combination of circular saws & percussion drills). The process of using heat energy to cut through concrete instead of brute force and abrasion-based techniques would be less disruptive to functional continuity within the building due to less noise & vibration produced.

Regardless of the cutting method used - the intention would be to reduce the production of rubble waste and dissect the panels into uniform concrete 'sub-panels' to be redeployed as building block units. This 'disassembly' of the facade - as opposed to destruction - would also reduce the carbon footprint of the building works as approx. 186 tonnes of rubble would not have to be trucked away from site.

The entire building facade is punctuated with 60mm diameter shutter holes which are spaced at approx. 760mm horizontal centres & 670mm vertical centres. Each panel would be divided into sections generally in accordance with this shutter hole 'grid'. Accordingly, 20 sub-panels of approx. dimensions - 580mm x 1350mm x 178mm thick would be rendered from each facade panel.



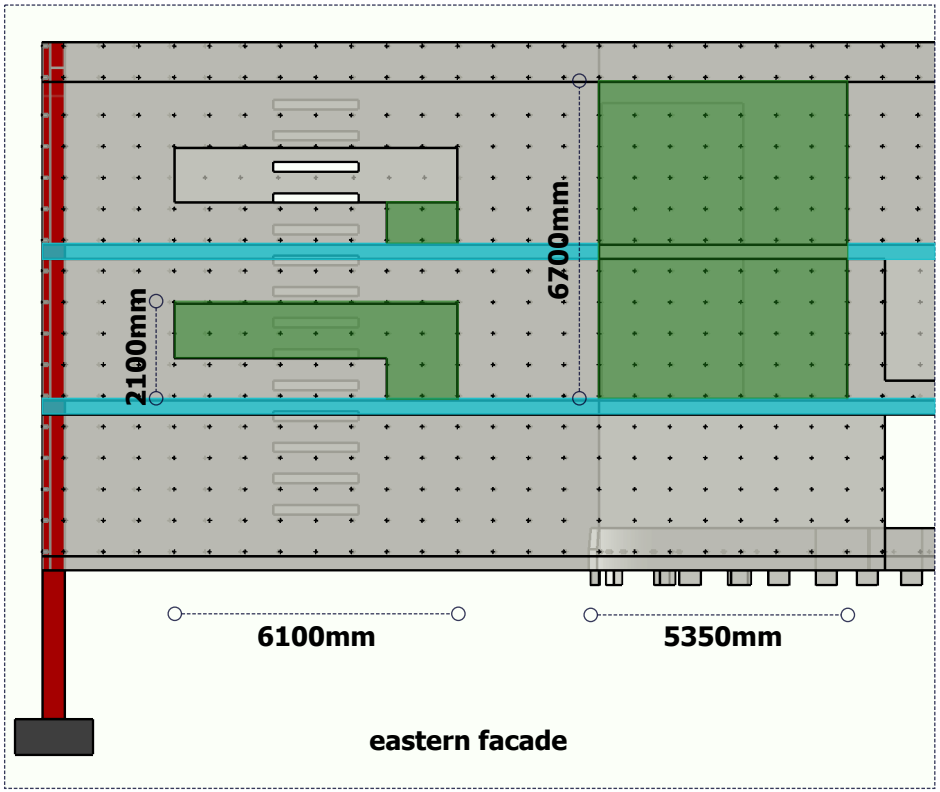
Each sub-panel has a mass of approx. 320kgs.

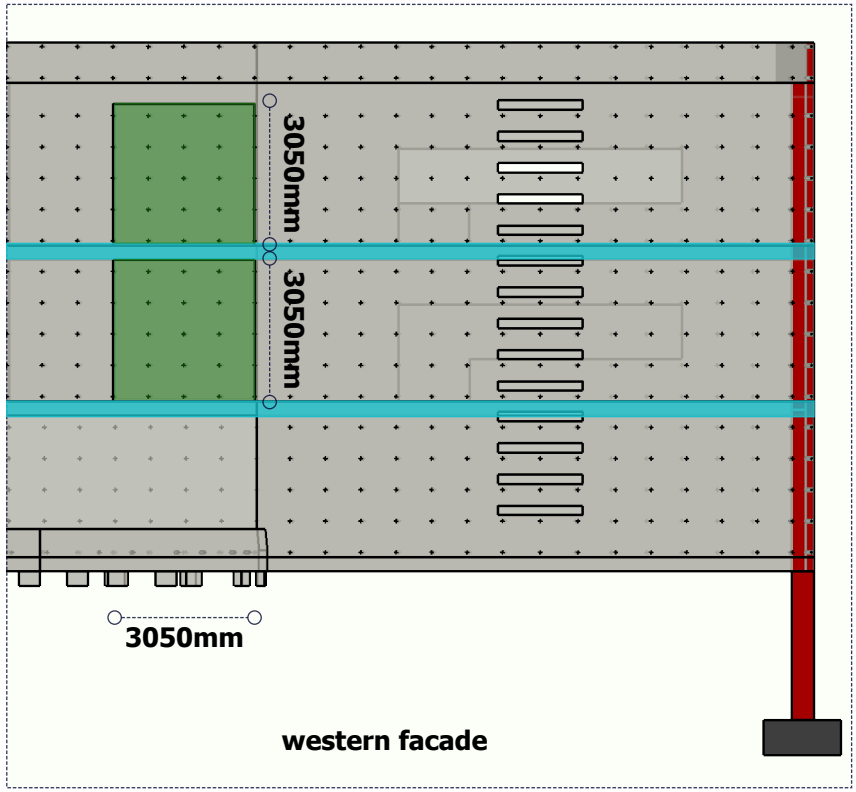
"Concrete is second only to water as the worlds most heavily consumed substance." (Brand. 1994:125)

(192mm) thick concrete panels will be removed from the eastern- & western facades.

Panel Surface area:
East = 45.87m² / West = 18.61m²

Panel Mass:
East = approx. 18 780kgs / West = approx. 7 620kgs





The new building works would produce approx. 518.62m² of concrete 'facade' that would be re-used as building block units. The designated unit dimensions of approx. 1350mm x 580mm x (178/152mm) thick could vary without affecting the their application, and 30mm variance in block measurements has been factored in for their use in this scheme.

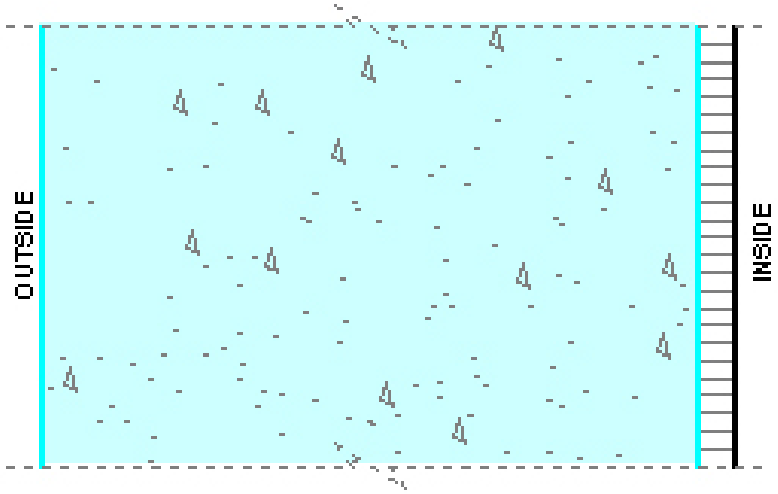


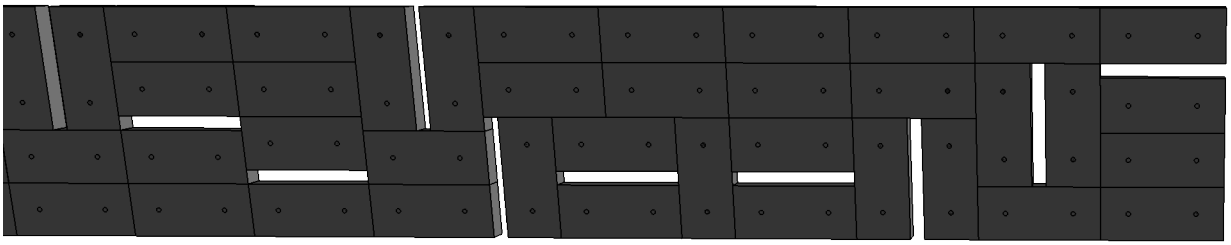
Figure 100 : Detail Section - Boukunde II wall panel

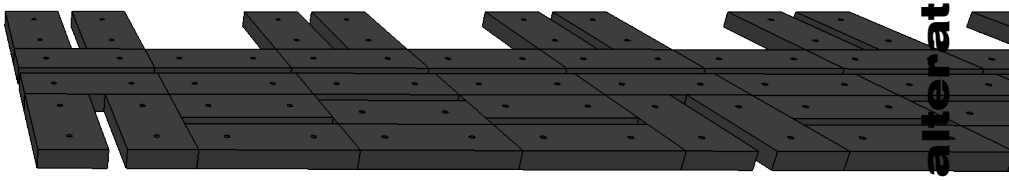
The wall panels are all of the same general construction, with walls to the south being 1" thicker than those on the 3 remaining facades.

EXISTING WALL PANEL:
- 10mm thick cement plaster
- 6/7" (152/178mm) thick mesh reinforced in-situ concrete wall panel

152mm thick:
U-value : 2.90 (W/m².K)
Thermal Decrement : 0.69
Thermal Lag : approx. 4 hours

178mm thick:
U-value : 2.68 (W/m².K)
Thermal Decrement : 0.60
Thermal Lag : approx. 5 hours





The re-deployment of the concrete panels will be in accordance with their inherent thermal capacity and the areas of the new construction that would benefit most from these qualities. Thus, the thicker panels with a greater capacity to exclude unwanted heat in summer, and to reduce the extent of this penetrative heat - will be used on the north-, east- & western facades. The remaining panels will be used on the southern facade (basement level), and as landscaping / retaining / ballast structures.

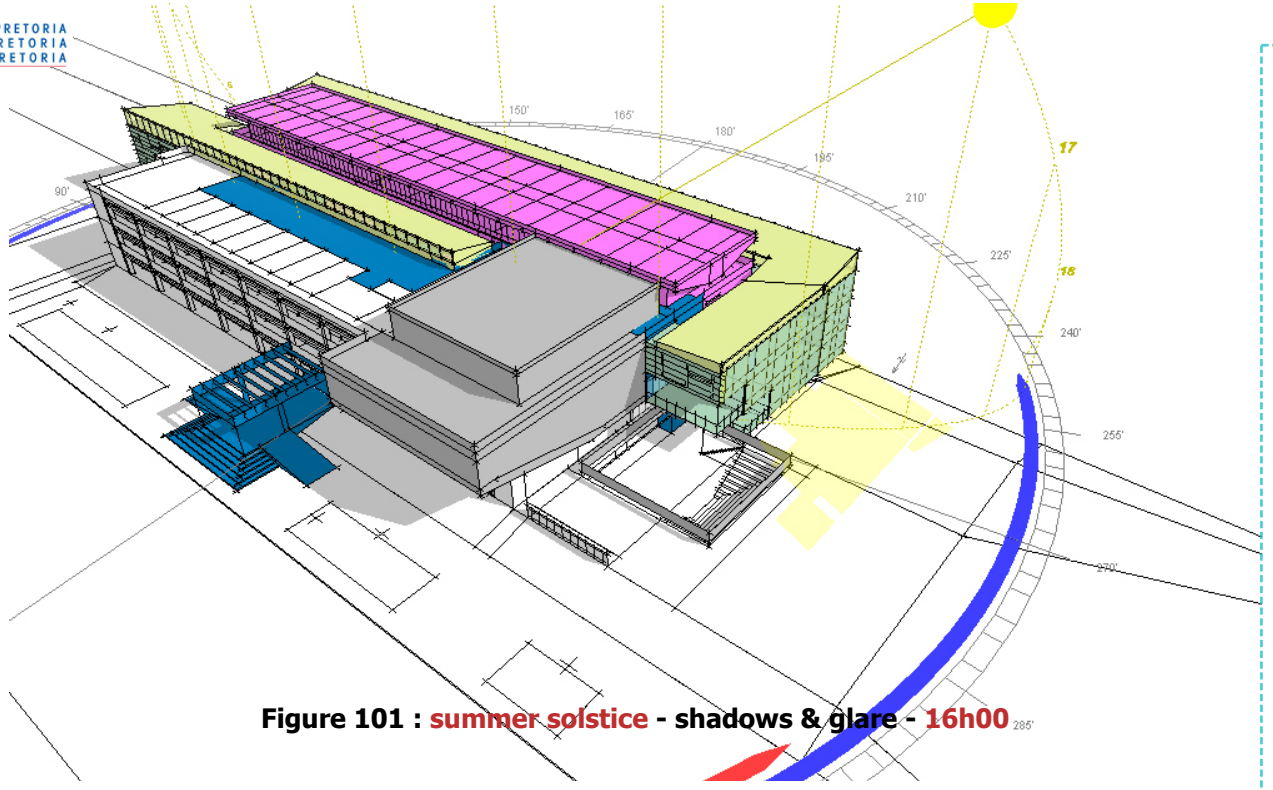


Figure 101 : summer solstice - shadows & glare - 16h00

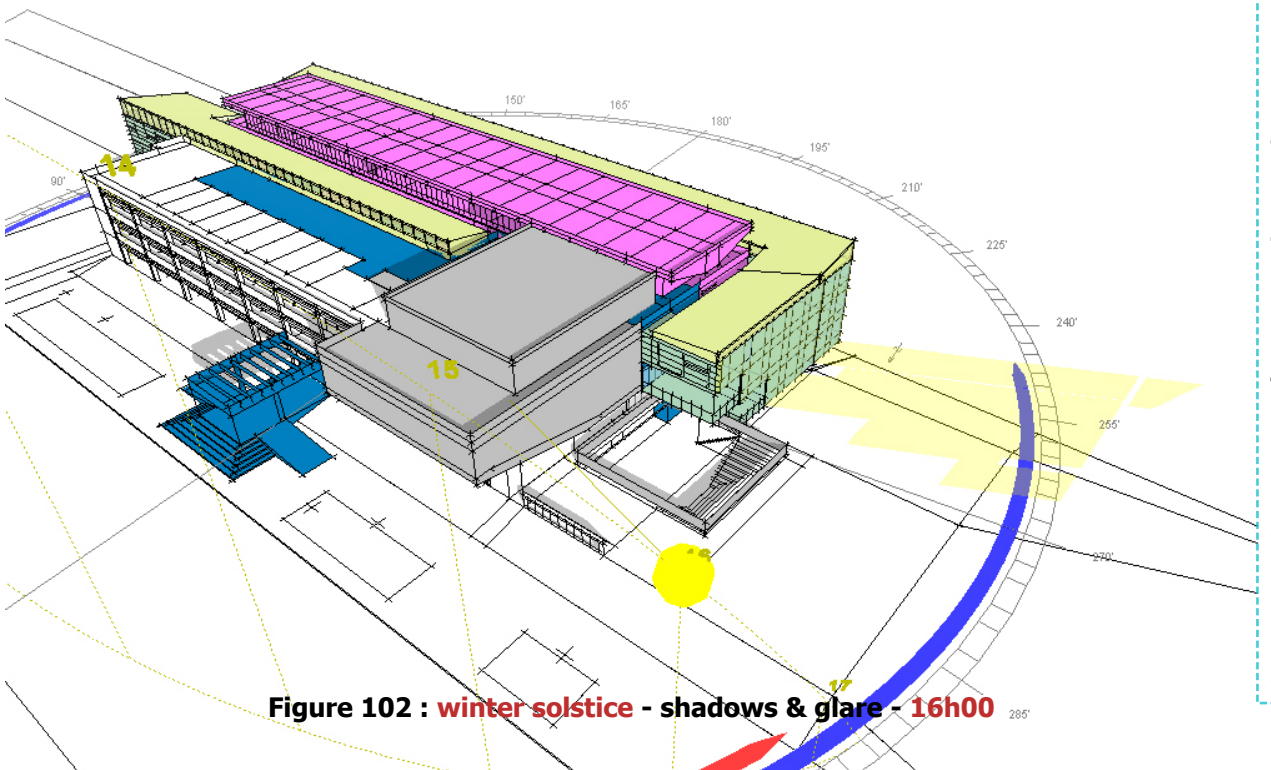


Figure 102 : winter solstice - shadows & glare - 16h00

One of the salient goals of the Boukunde III proposal is to achieve a significant improvement in natural light disbursement throughout the building. The execution of this ideal comes primarily via the southern flank, which is broken through and extended, resulting in a translucent elevation facing Lynnwood road.

Based upon the surface finish of the material being proposed to render this translucence - there will be a light reflective component that will affect the pedestrian & vehicular traffic passing by the buildings south facade. Given the law of reflection - angle of incidence = angle of reflection - the figures indicate the potential hazardous glare that could result off the western facade in the mid- to late afternoon during winter.

This would be indicative of specular reflection - typically from a hard polished surface such as plate glass. If one were to replicate the envelope of Boukunde I in the new facade proposals, then this form of reflected glare would have to be accounted for.

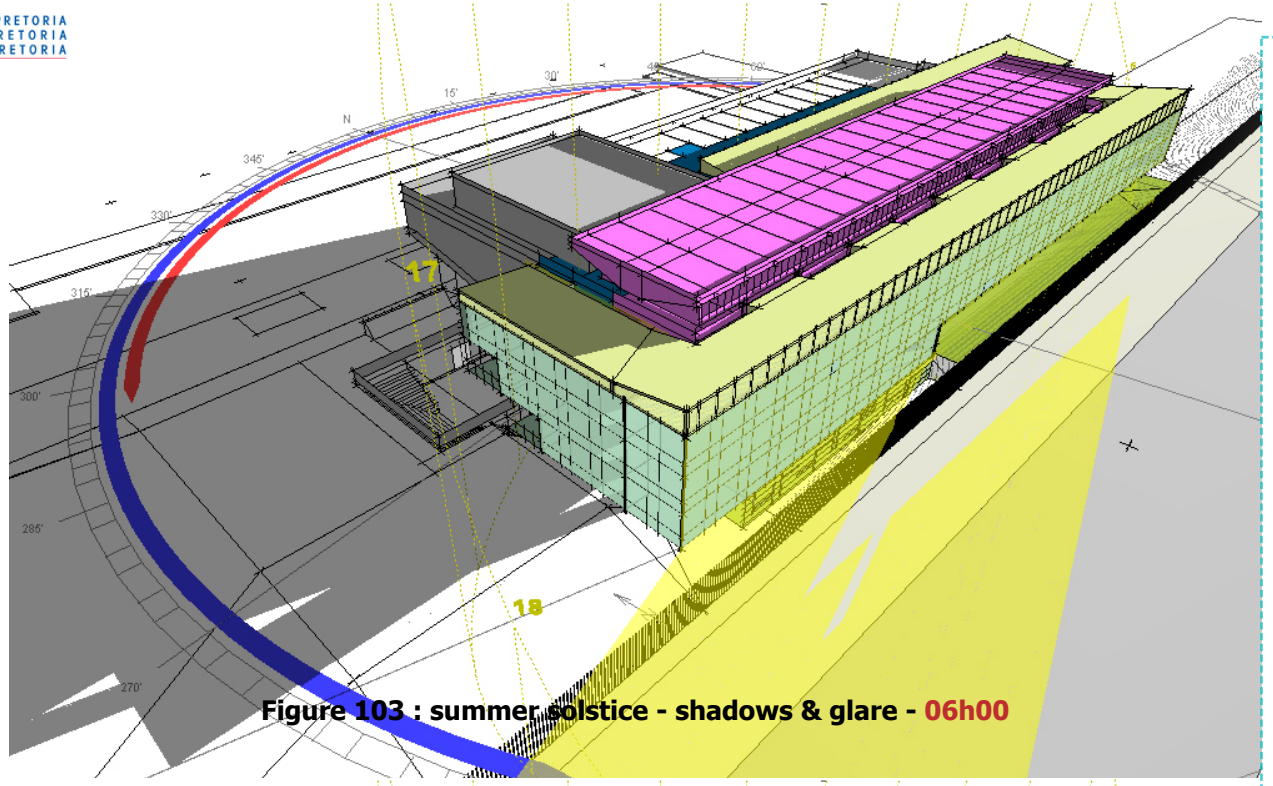


Figure 103 : summer solstice - shadows & glare - 06h00



Figure 104 : summer solstice - shadows & glare - 18h00

The reflective glare off the southern facade alone would only be a factor during the summer months - peaking at the solstice. The solar altitude during early morning- & late afternoon hours would result in an incident angle sufficient to produce glare off the glazed facade.

Due to the fact that Lynnwood road traffic flow is bi-directional and fairly evenly weighted in terms of directional volumes throughout the day - a glare attenuation strategy will have to accommodate both easterly- & westerly traffic flow, and do so at all times that there is a risk of reflected glare.

If the skin of Boukunde I is to be 'resurrected' for the new building - it will have to be evaluated for it's prospects in terms of over-exposure, as was indicative of the building in the 1960's. There will be a significant measure of overshadowing from the existing building, but not much from other elements in the immediate vicinity.

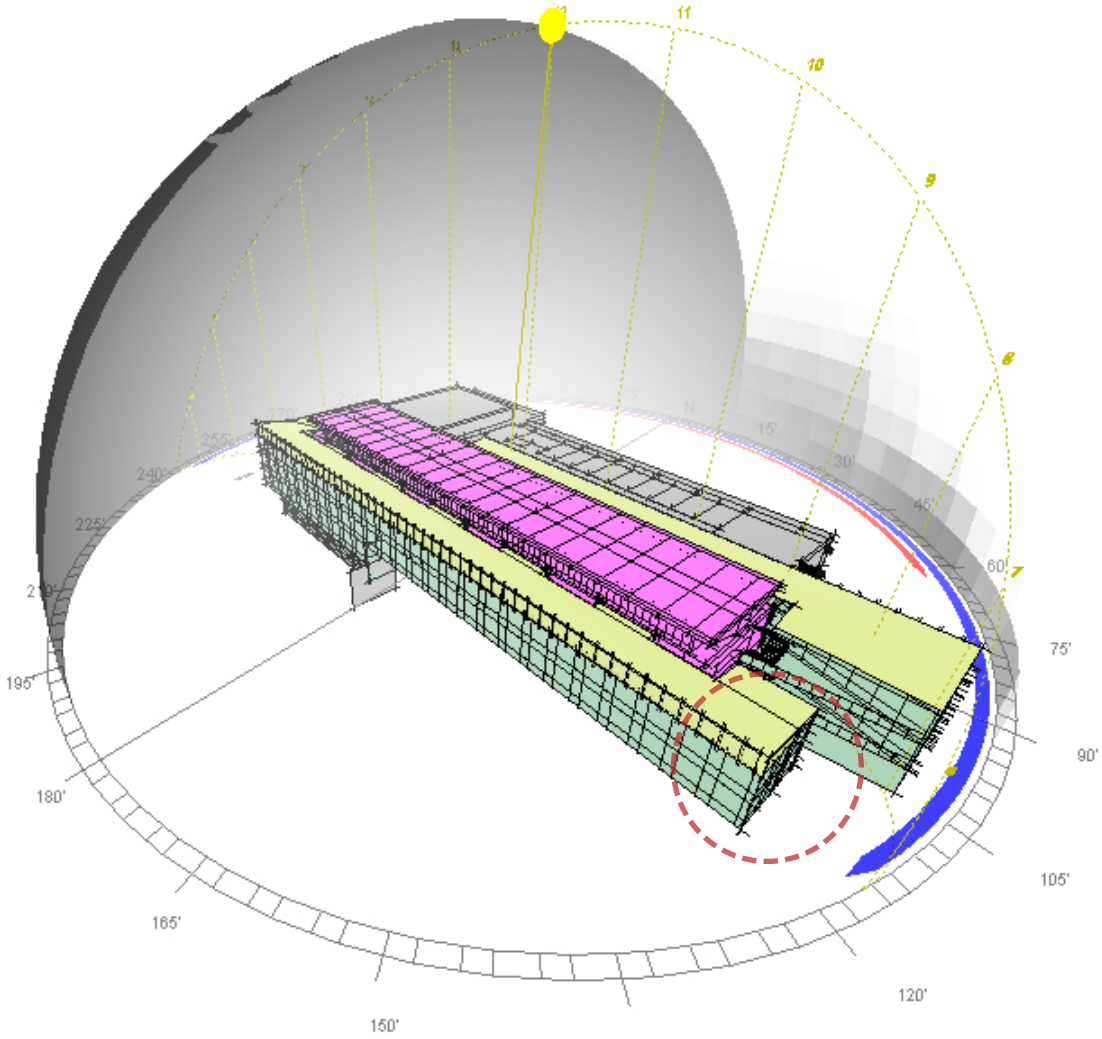


Figure 105 : overshadowing profile - new east facade

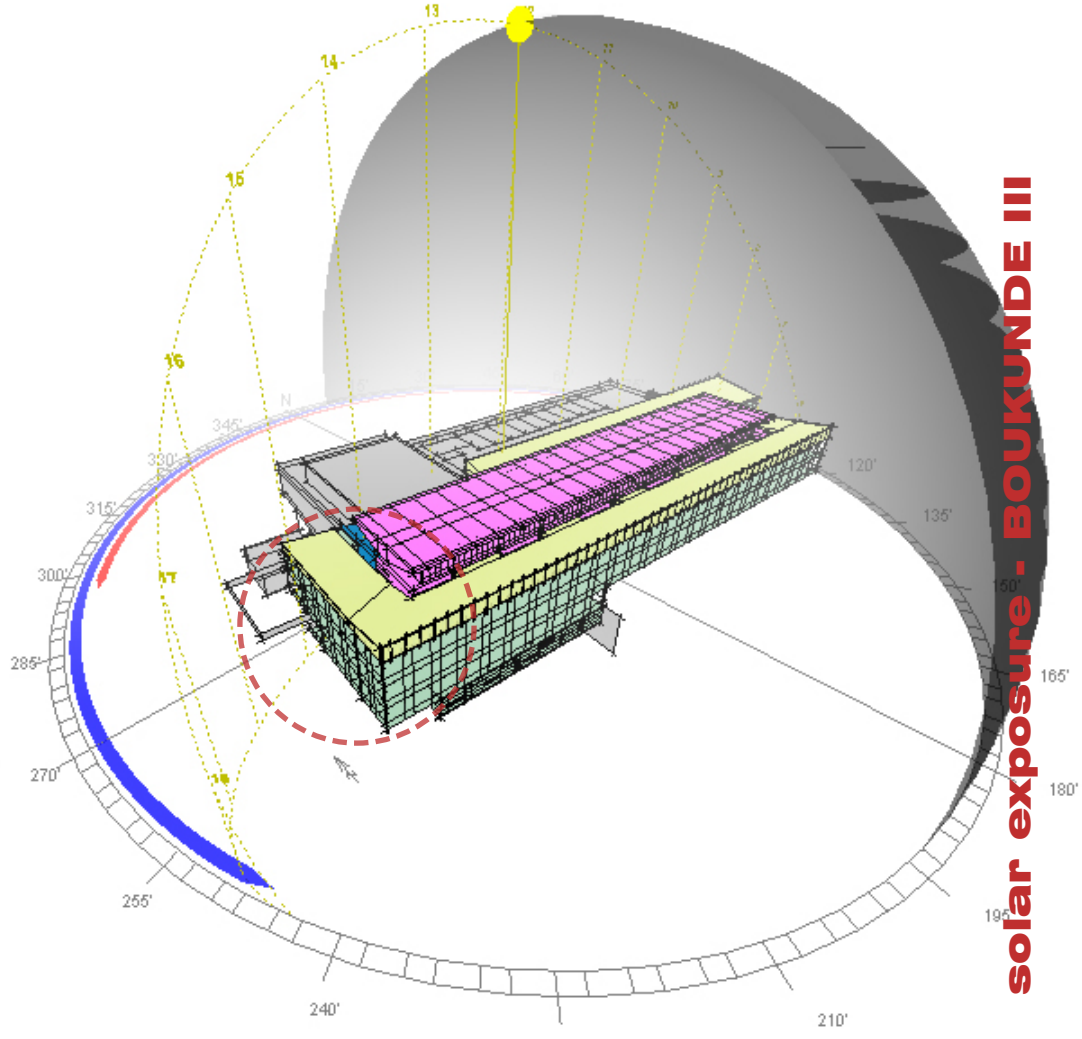


Figure 106 : overshadowing profile - new west facade

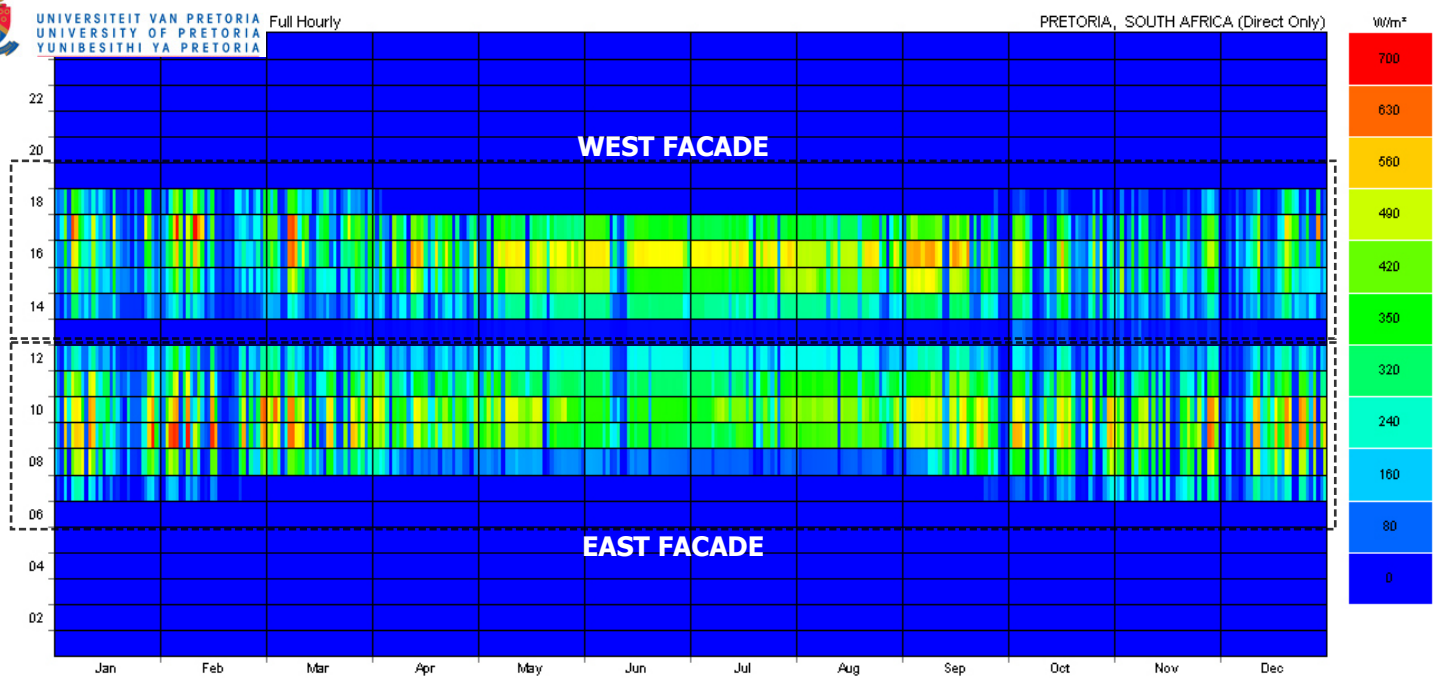


Table 33 : Incident Solar Radiation (annual) - Boukunde III facade - EAST & WEST

TOTAL MONTHLY SOLAR EXPOSURE - direct / no reflection
PRETORIA, SOUTH AFRICA

	EAST FACADE (Exposed Area: 51.00 m2)								WEST FACADE (Exposed Area: 203.70 m2)							
	AVAIL	AVG	INCIDENT		ABSORBED		TRANSMITTED		AVG	INCIDENT		ABSORBED		TRANSMITTED		
MONTH	Wh/m2	SHADE	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	SHADE	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	
Jan	119043	43%	41938	2138859	3483	177639	31348	1598755	57%	25145	5122074	2123	432381	18436	3755429	
Feb	107949	43%	37351	1904921	3111	158646	27996	1427816	57%	24208	4931222	2040	415537	17717	3608896	
Mar	138774	48%	46441	2368492	3878	197771	34901	1779937	52%	31808	6479247	2707	551428	23519	4790814	
Apr	140162	56%	40116	2045921	3330	169839	29972	1528550	50%	27352	5571564	2299	468289	19964	4066665	
May	185742	56%	44495	2269234	3653	186315	32879	1676836	50%	38456	7833486	3224	656783	27997	5703052	
Jun	183244	59%	36015	1836779	2913	148539	26213	1336850	50%	39909	8129522	3337	679806	28976	5902396	
Jul	193465	57%	40895	2085664	3346	170630	30111	1535674	50%	42593	8676285	3545	722056	30771	6268125	
Aug	186277	56%	43750	2231233	3600	183623	32404	1652606	50%	38535	7849580	3199	651618	27767	5656139	
Sep	163402	51%	47033	2398662	3926	200205	35330	1801842	51%	36234	7380964	3065	624418	26626	5423783	
Oct	134069	49%	44950	2292445	3755	191501	33794	1723509	51%	25986	5293371	2132	434281	18498	3767980	
Nov	109570	49%	39292	2003903	3301	168358	29710	1515219	51%	19885	4050537	1635	332986	14184	2889325	
Dec	119249	45%	43724	2229912	3654	186336	32883	1677020	55%	20980	4273670	1760	358603	15287	3113948	
TOTALS	1780946		506000	25806024	41949	2139402	377542	19254618		371092	75591520	31066	6328186	269743	54946552	

The graphs facilitate a comparison between the eastern & western facade proposals in terms of the amount of solar radiation incident upon them during the course of the year. Both facades will experience a more consistent exposure during winter months, and a greater magnitude - albeit less consistently - in summer.

The magnitude of variation and respective location different will determine whether a significantly varied approach is applied in ultimately resolving the 2 elevations.

From the detailed breakdown of exposure values it can be seen that the eastern facade will experience greater incidence of solar radiation per m^2 than the west due to its longer period of exposure, however the greater surface area of the western facade results in a far larger total transmitted load being brought into the open, contiguous volumes of the new construction.

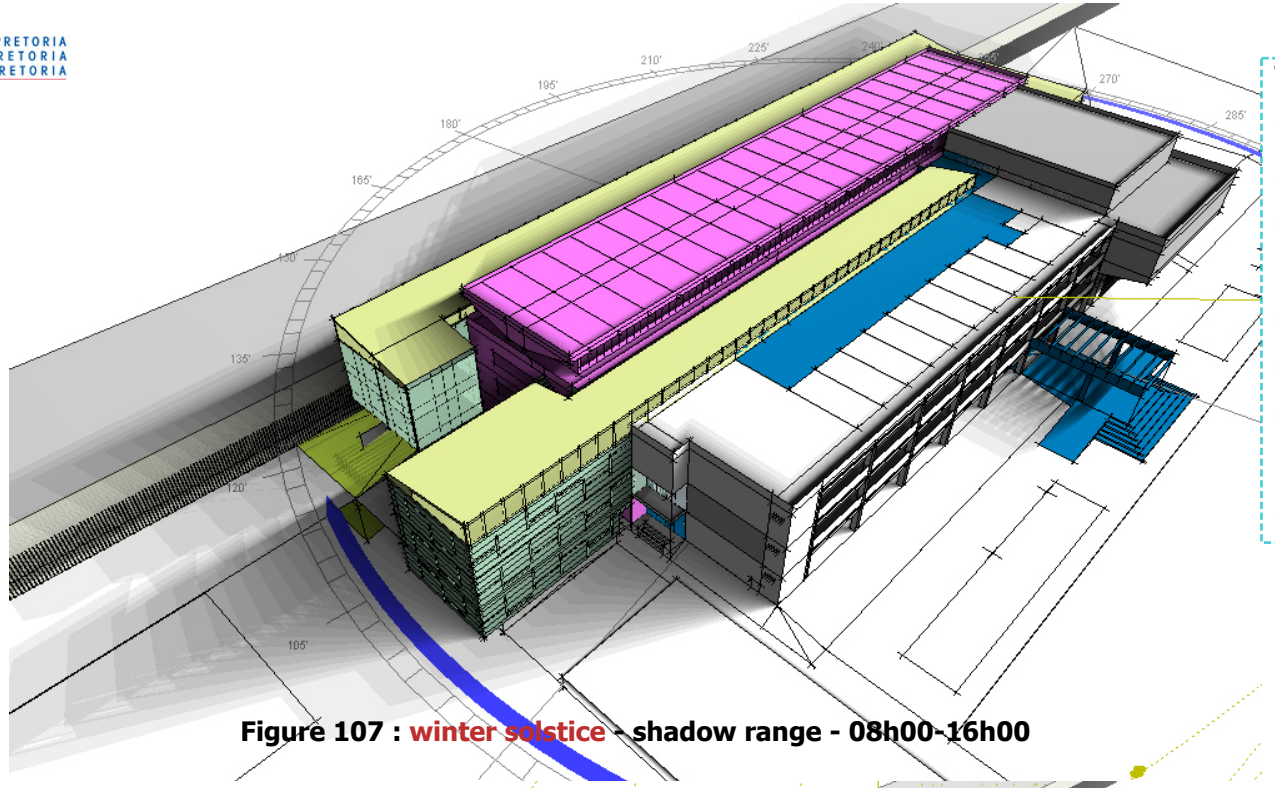


Figure 107 : winter solstice - shadow range - 08h00-16h00

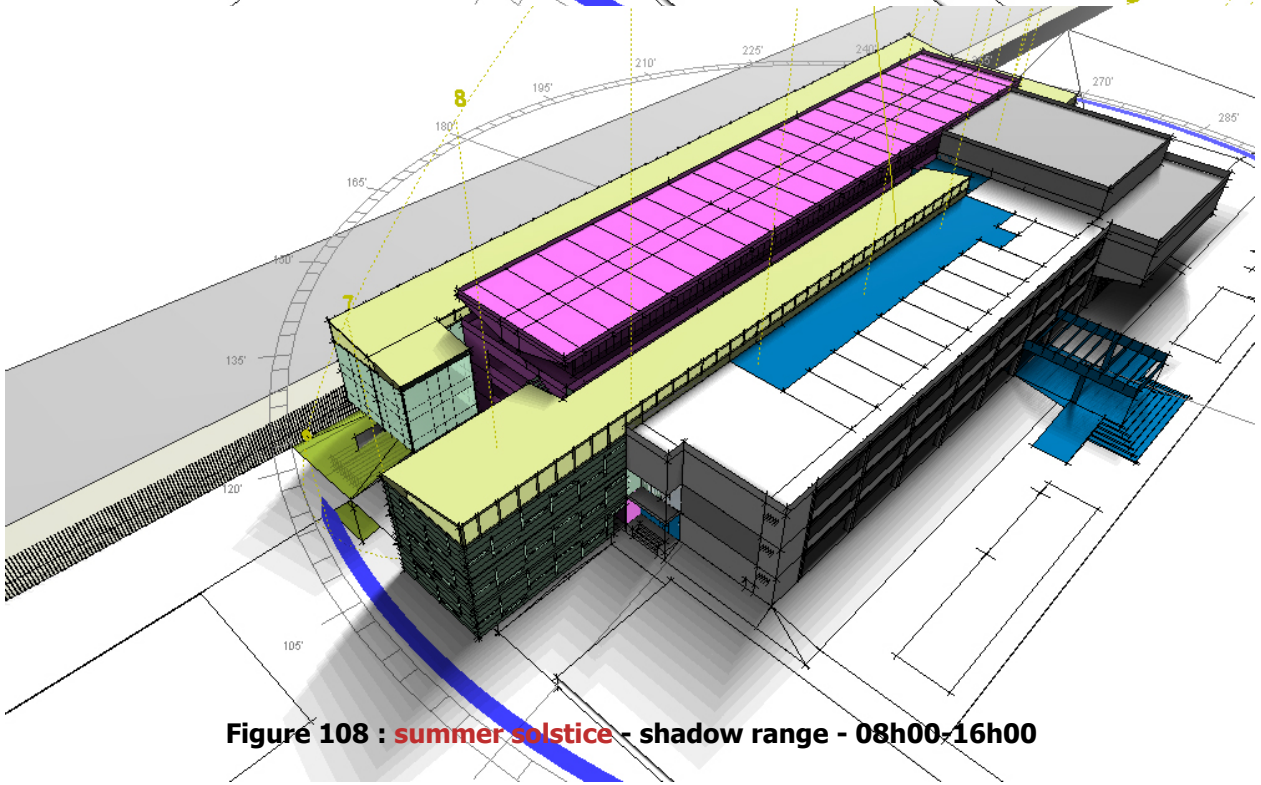


Figure 108 : summer solstice - shadow range - 08h00-16h00

The figures illustrate the extent of diurnal overshadowing that will be applicable during the longest- and shortest days of the year. This protection of the new exposed skin elements will be supplemented by new screening elements, as well as pre-existing natural features of the site. (*see technical annexure for development & incorporation)

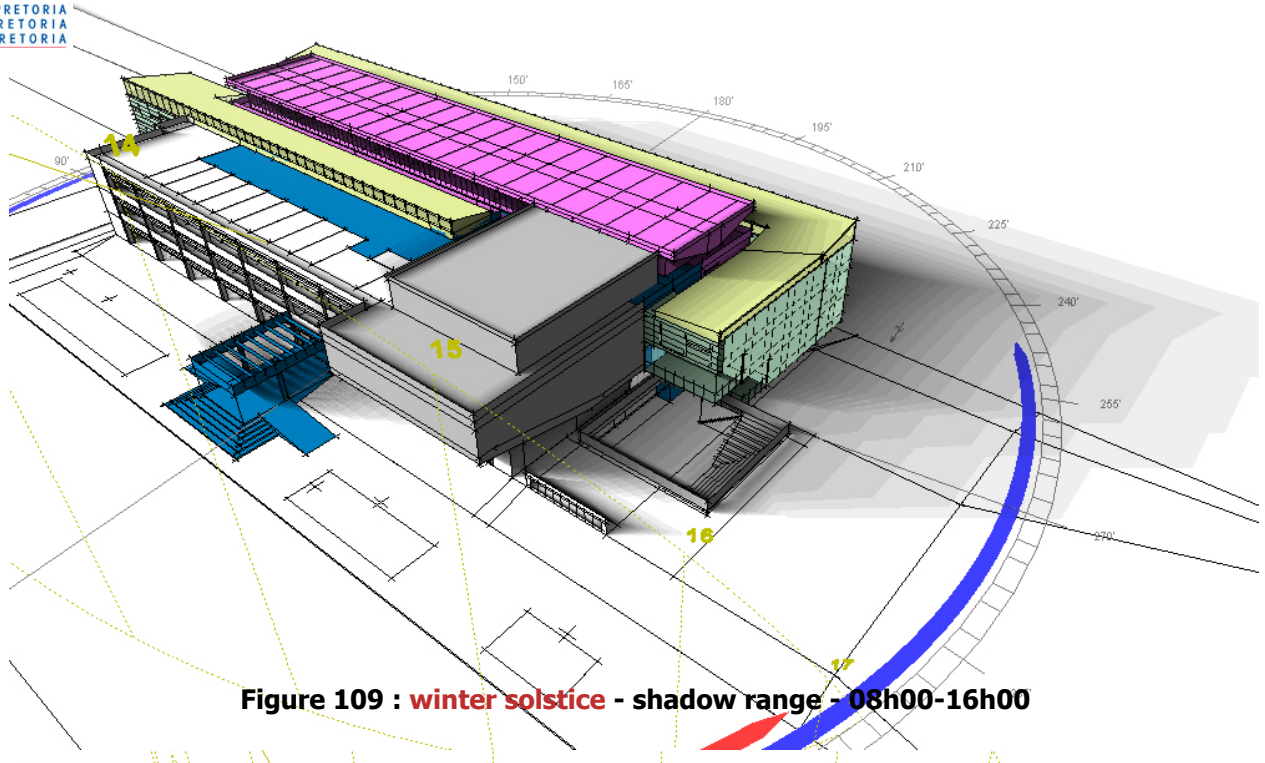


Figure 109 : winter solstice - shadow range - 08h00-16h00

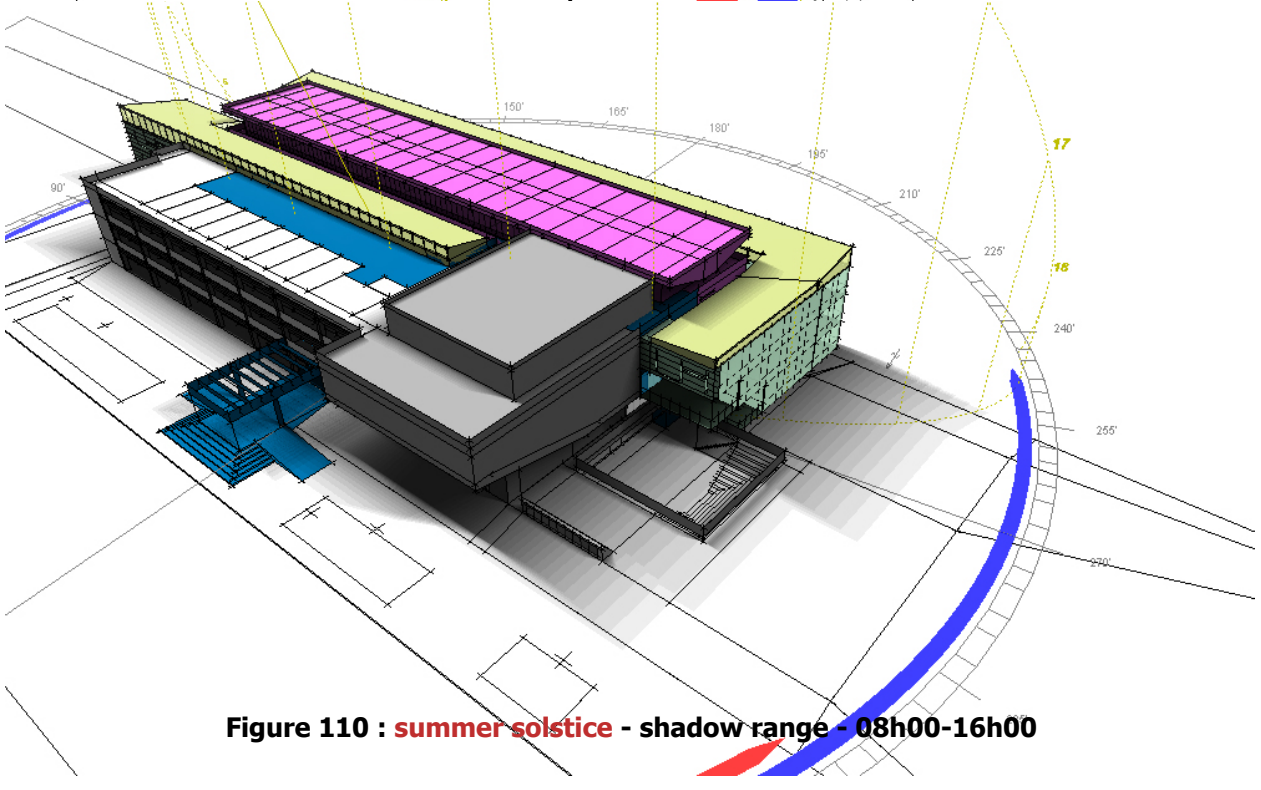


Figure 110 : summer solstice - shadow range - 08h00-16h00

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references

ADLER, D. (ed). 1999. Metric Handbook: Planning and Data (2nd Edition) - Part 1 - Drawing Utilities. Architectural Press.

ADLER, D. (ed). 1999. Metric Handbook: Planning and Data (2nd Edition) - Part 11 - Offices. Architectural Press.

ADLER, D. (ed). 1999. Metric Handbook: Planning and Data (2nd Edition) - Part 29 - Higher Education. Architectural Press.

BLAIK, O. 2007. Campuses in Cities: Places between engagement and retreat . The Chronicle of Higher Education: Campus Architecture. 53 (25) May B25

BOND, P. 2006. Global warming and the Privatised atmosphere . Proceedings: Goedgedacht Forum for Social Reflection dialogue of 8 April 2006: Climate change. Available from: www.project90x2030.org.za [accessed on 20th April 2008]

BRAND, S. 1994. How buildings learn: What happens after theyre built . Penguin Books.

BURBERRY, P. 1983. Practical Thermal Design in Buildings . Batsford Academic.

CONSTANDIUS, E. 2006. OBE: The only way forward for design education? Proceedings: Design Educators Forum of South Africa (DEFSA) Conference.
Available from: www.defsa.org.za [accessed on 14th August 2007]

CREAMER, T. 2008. Climate Change. Engineering News: News & Insight. 27 (28) July 9

ELFLAND, C. & KANTER, M. & KENNEY, D. 2006. The Good, the Bad, and the Future in Campus Design. The Chronicle of Higher Education: Campus Architecture. 52 (34) Page B28

FREELAND, R. 2006. Universities and Cities Need to Rethink Their Relationships . The Chronicle of Higher Education: The Chronicle Review. 51 (36) April B20

GRAY, B. 2006. Learners as Agents: design as a learning vehicle . Proceedings: Design Educators Forum of South Africa (DEFSA) Conference. Available from: www.defsa.org.za [accessed on 14th August 2007]

GREENBERG, A. 2007. Colleges have lost interest in designing campuses with meaning . The Chronicle of Higher Education: Campus Architecture. 53 (25) May B21

HAGHPARAST, F. & MARSH, A. 2004. The Application of computer-optimised solutions to tightly defined design problems . Proceedings: Passive and Low Energy Architecture (PLEA) Conference. 19-22 September 2004. Eindhoven, Netherlands. Available from: www.plea-arch.net [accessed on 6th February 2008]

HALSBAND, F. 2006. Living and Learning: the campus redefined . The Chronicle of Higher Education: Campus Architecture. 52 (34) Page B25

HOLM, D. 2000. Manual for Research and Postgraduate Study: Masters degree and PhD . School for the Built Environment. University of Pretoria. Pretoria.

KIBERT, C. 2000. Deconstruction as an essential component of sustainable construction . Proceedings: Strategies for a Sustainable Built Environment. 23-25 August 2000 Pretoria. Available from: www.sustainablesettlement.co.za [accessed on 10th April 2007]

KIBERT, C., SENZIMIR, J. & GUY, B. 2000. Construction Ecology: Natural systems models for the built environment . Proceedings: Strategies for a Sustainable Built Environment. 23-25 August 2000 Pretoria. Available from: www.sustainablesettlement.co.za [accessed on 10th April 2007]

SAMSON, D. 2006. What the Bilbao effect can do to- and for a Campus . The Chronicle of Higher Education: Campus Architecture. 52 (34) Page B17

SCHOLES, B. 2006. Climate change . Proceedings: Goedgedacht Forum for Social Reflection dialogue of 8 April 2006: Climate change. Available from: www.project90x2030.org.za [accessed on 20th April 2008]

SMITH, A. 2008. Funding Excellence: Britain's universities are trying to build new financial muscle to compete for talented staff and students . Time Magazine: Life. July 14, 2008

SUTHERLAND, N. 1986. South Africa: An aerial close up. Johannesburg: Central News Agency Ltd.

THOMPSON, J. WILLIAM & SORVIG, K. 2000. Sustainable Landscape Construction: A guide to green building outdoors. Island Press.

VAN HEERDEN, B. 2000. Architecture of the Apocalypse: The business of architecture and the myth of sustainable design and building . Proceedings: Strategies for a Sustainable Built Environment. 23-25 August 2000 Pretoria. Available from: www.sustainablesettlement.co.za [accessed on 10th April 2007]

SOUTH AFRICAN WEATHER SERVICE. 2007. Climate data for Pretoria region 1961 - 1990. Available from: www.weathersa.co.za [accessed on 14th July 2007]

INTERNATIONAL EDUCATION ASSOCIATION OF SOUTH AFRICA. 2007. Available from: www.studysa.co.za [accessed on 10th May 2007]

HEALTHY BUILDINGS INTERNATIONAL. Optimising Indoor Air Quality via Thermal Displacement Air-Conditioning and Computer Modelling (CFD). Available from: www.hbi.com.au [accessed on 23 July 2008]

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appendices

50 LUX
Car Parks
Main Entrances and exits
Store rooms
Outdoor platforms
Stables
Hotel bedrooms
Garages
100 LUX
Corridors and passageways
Stairs and escalators
Entrance gates
Changing rooms
Rest rooms
Raw material stores
Machine rooms
Loading bays
Foyers
Domestic living rooms
200 LUX
Lifts and lift lobbies
Waiting rooms
Medical stores
Machine assembly rooms
Finished goods stores
Vaults and strong-rooms
Print rooms
Shopping centre circulation areas
Airport lounges
Museum areas (general)
School assembly halls
Lecture theatres
Gymnasiums
Sports spectator areas

400 LUX
Enquiry desks and counters
Food preparation areas
Consulting and treatment rooms
General clerical offices
Library reading tables
Assembly hall platforms
Classroom white-boards
Laboratories
Hospital dispensing rooms
Workshop benches
600 LUX
Engine testing rooms
Cutting and assembly rooms
Inspection and product testing benches
Computer rooms
Drawing board task lighting
Food sales counters
Cashier counters
Supermarkets
School art rooms
Vision testing rooms
Sewing rooms
900 LUX
Electronics assembly areas
Instrumentation workbenches
Supermarket displays
1200+ LUX
Sorting and grading areas
Clothing inspection areas
Hand engraving workbenches
Jewellery workbenches
Boxing rings

Table 34 : Recommended minimum illuminance levels (source : Square One Research - Ecotect)

Single Leaf Construction	U	Y	Lag	Decr	Abs
1mm Framed Galvanised Iron	5.66	5.2	0	1	0.3
75mm Concrete Panel Precast	4.28	4.9	1.9	0.91	0.62
75mm Panel + 13mm Dense Plaster	3.88	4.78	2	0.89	0.62
75mm Panel + 10mm Gyprock	3.65	4.72	2	0.88	0.62
110mm Brick Single	3.3	4.2	3	0.87	0.7
110mm Brick + 13mm Dense Plaster	2.7	4.1	3	0.84	0.7
110mm Brick + 10mm Gyprock	2.6	4	3	0.83	0.7
150mm Aerated Concrete Block	1.28	2.28	7.1	0.54	0.6
150mm Aerated + 13mm Dense Plaster	1	2	7	0.51	0.6
150mm Aerated + 10mm Gyprock	0.95	2	7	0.5	0.6
150mm Concrete Dense Cast In-situ	3.48	5.2	4	0.7	0.6
150mm In-situ + 13mm Dense Plaster	3	5.05	4.1	0.68	0.6
150mm In-situ + 10mm Gyprock	2.96	5	4.1	0.67	0.6
200mm Concrete Blockwork	2.1	2.6	6.5	0.36	0.6
200mm Blockwork + 13mm Dense Plaster	1.8	2.48	6.8	0.35	0.6
200mm Blockwork + 10mm Gyprock	1.7	2.47	6.8	0.35	0.6
230mm Brick Header	2.3	4.7	6.1	0.54	0.7
220mm Brick + 13mm Dense Plaster	2.1	4.5	6.5	0.49	0.7
230mm Brick + 10mm Gyprock	1.9	4.5	6.5	0.47	0.7
250mm Concrete Dense Cast In-situ	2.84	5.2	5.8	0.52	0.65
250mm In-situ + 13mm Dense Plaster	2.66	5	6	0.5	0.65
Cavity Construction	**U**	**Y**	**Lag**	**Decr**	**Abs**
2 x 1mm Galv. Iron + 100mm Gap	2.86	2.34	0.3	1	0.3
2 x 1mm Galv. Iron + Gap + 50mm Insulation	0.63	0.9	0.7	0.99	0.3
270mm BkVeneer + 50mm Insulation	0.51	0.9	4.3	0.69	0.7
270mm BkVeneer + Foil + 50mm Insulation	0.34	0.9	4.3	0.69	0.7
270mm BkVeneer + Foil + 100mm Insulation	0.29	0.41	4.3	0.68	0.7
270mm Cavity Brick	1.88	4.4	7.7	0.44	0.7
270mm Cavity + 13mm Dense Plaster	1.72	4.22	7.8	0.41	0.7
270mm Cavity + 10mm Gyprock	1.58	4	7.8	0.4	0.7
270mm Cavity + 50mm Insul. + 10mm Gyprock	0.47	4.7	9.2	0.32	0.7

Roof Construction	U	Y	Lag	Decr	Abs
1mm Angled Metal Decking	7.14	7.1	0	1	0.5
1mm Metal + Attic + Gyprockk	2.54	2.6	0.3	1	0.5
1mm Metal + Attic + 50mm Insulation + Gyprockk	0.55	1	0.7	0.95	0.5
Gyprockk	0.44	0.88	0.9	0.9	0.5
10mm Angled Clay Tiles	3.1	3.1	0.2	1	0.6
10mm Tiles + Attic + Gyprockk	2.6	2.64	0.5	1	0.6
10mm Tiles + Foil + Attic + Gyprockk	1.82	2	0.5	0.95	0.6
10mm Tiles + Attic + 50mm Insulation + Gyprockk	0.61	1	1.5	0.91	0.6
Gyprockk	0.35	0.88	1.8	0.88	0.6
19mm Asphalt + 150mm Concrete Slab	2.8	5.9	8	0.4	0.9
25mm Pebbles + Asphalt + 150mm Slab	2.5	4.35	7	0.34	0.7
19mm Asphalt + 150mm Aerated Concrete Slab	0.88	2.3	7	0.58	0.9
25mm Pebbles + Asphalt + 150mm Aerated Slab	0.66	4.21	6.2	0.31	0.7
Floor Construction	**U**	**Y**	**Lag**	**Decr**	**Abs**
Suspended Timber Floor	2.16	2	0.7	0.99	--
Suspended Timber Floor + Carpet Thin	1.43	1.5	0.8	0.94	--
Suspended Timber Floor + Carpet Thick	1.24	1.3	0.8	0.93	--
100mm Concrete Slab Suspended	2.56	4.2	4	0.7	--
100mm Concrete Slab on Ground + 4 Exp. Edges	1.1	6	4	0.32	--
100mm Concrete Slab on Ground + 2 Exp. Edges	1.07	6	4	0.32	--
100mm Concrete Slab on Ground + Carpet Thin	0.92	6	4.2	0.31	--
100mm Concrete Slab on Ground + Carpet Thick	0.9	6	4.2	0.31	--
150mm CSOG + 4 Exp. Edges	0.88	6	4.6	0.3	--
150mm CSOG + 2 Exp. Edges	0.45	6	4.6	0.3	--
150mm CSOG + Carpet Thin	0.72	6	4.6	0.28	--
150mm CSOG + Carpet Thick	0.71	6	4.6	0.28	--
150mm CSOG + 25mm Insul. + 4 Exp. Edges	0.21	6	4.6	0.18	--
150mm CSOG + 25mm Insul. + 2 Exp. Edges	0.2	6	4.6	0.18	--

GARMENT DESCRIPTION		CLO	m^2K/W
Underwear, pants	Pantyhose	0.02	0.003
	Panties	0.03	0.005
	Briefs	0.04	0.006
	Pants 1/2 long legs, wool	0.06	0.009
	Pants long legs	0.1	0.016
Underwear, shirts	Bra	0.01	0.002
	Shirt sleeveless	0.06	0.009
	T-shirt	0.09	0.014
	Shirt with long sleeves	0.12	0.019
	Half-slip, nylon	0.14	0.022
Shirts	Tube top	0.06	0.009
	Short sleeve	0.09	0.029
	Light blouse, long sleeves	0.15	0.023
	Light shirt, long sleeves	0.20	0.031
	Normal, long sleeves	0.25	0.039
	Flannel shirt, long sleeves	0.30	0.047
	Long sleeves, turtleneck blouse	0.34	0.053
Trousers	Shorts	0.06	0.009
	Walking shorts	0.11	0.017
	Light trousers	0.20	0.031
	Normal trousers	0.25	0.039
	Flannel trousers	0.28	0.043
	Overalls	0.28	0.043
Coveralls	Daily wear, belted	0.49	0.076
	Work	0.50	0.078
Highly-insulating coveralls	Multi-component, filling	1.03	0.160
	Fibre-pelt	1.13	0.175
Sweaters	Sleeveless vest	0.12	0.019
	Thin sweater	0.20	0.031
	Long sleeves, turtleneck (thin)	0.26	0.040
	Thick sweater	0.35	0.054
	Long sleeves, turtleneck (thick)	0.37	0.057
Sundries	Socks	0.02	0.003
	Shoes (thin soled)	0.02	0.003
	Slippers, quilted fleece	0.03	0.005
	Shoes (thick soled)	0.04	0.006
	Thick, ankle socks	0.05	0.008
	Boots 0.1 0.016 Gloves	0.05	0.008
	Thick, long socks	0.10	0.016
Skirts, dresses	Light skirt, 15 cm. above knee	0.01	0.016
	Light skirt, 15 cm. below knee	0.18	0.028
	Heavy skirt, knee-length	0.25	0.039
	Light dress, sleeveless	0.25	0.039
	Winter dress, long sleeves	0.40	0.062
Sleepwear	Undershorts	0.10	0.016
	Thin strap, short gown	0.15	0.023
	Long sleeve, long gown	0.30	0.047
	Hospital gown	0.31	0.048
	Long sleeve, long pyjamas	0.50	0.078
	Body sleep with feet	0.72	0.112
Robes	Long sleeve, wrap, short	0.41	0.064
	Long sleeve, wrap, long	0.53	0.082
	Wooden or metal	0.00	0.000
	Fabric-covered, cushioned, swivel	0.10	0.016
	Armchair	0.20	0.032

Table 37 : Typical CLO values for garments (www.squ1.org)



Figure 111 : Barbie & Ken's Malibu Vacation fashions

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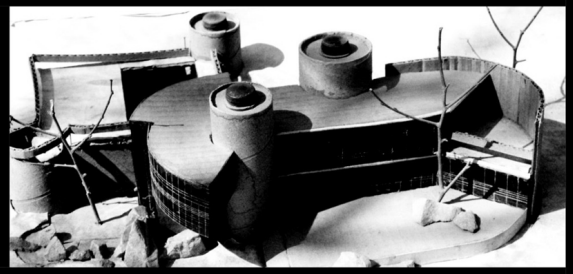
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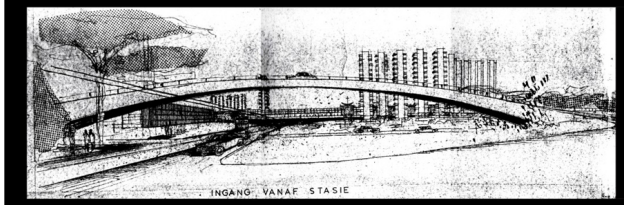
My sincere thanks to Mr. Daniel De Beer for making time available to talk to me about his building.

I regret not having the opportunity to visit again to discuss the result of this study ...and to somehow repay him for the insight that he offered me.

His passing is a loss to both his family and the profession...

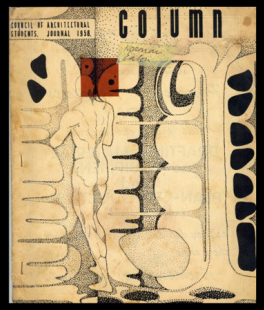


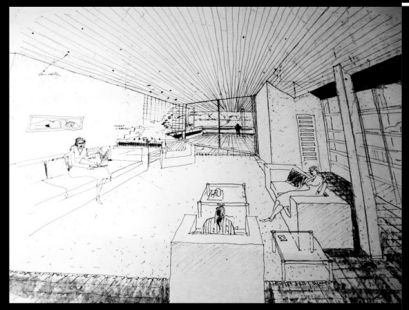


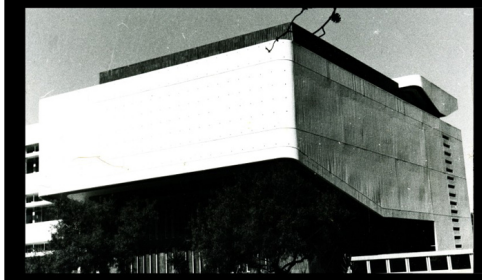


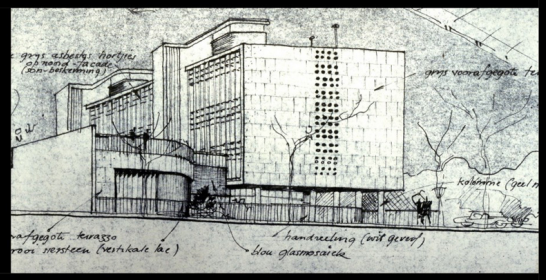


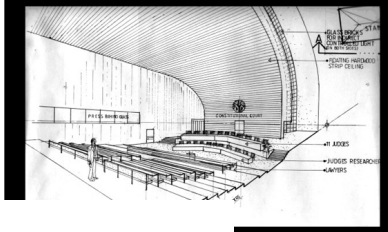




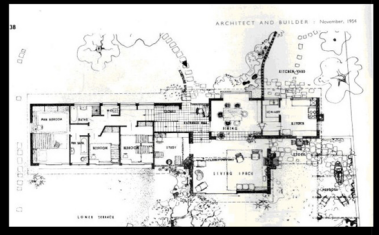












as ek die begeerte mog waag,sou ek dit graag so wou he,
dat die engel wat my kom haal huistoe, my daar bring met
die verslag : “ek het hom by sy werk gekry”

cj langenhoven





danie de beer

07/12/1927-16/10/2008

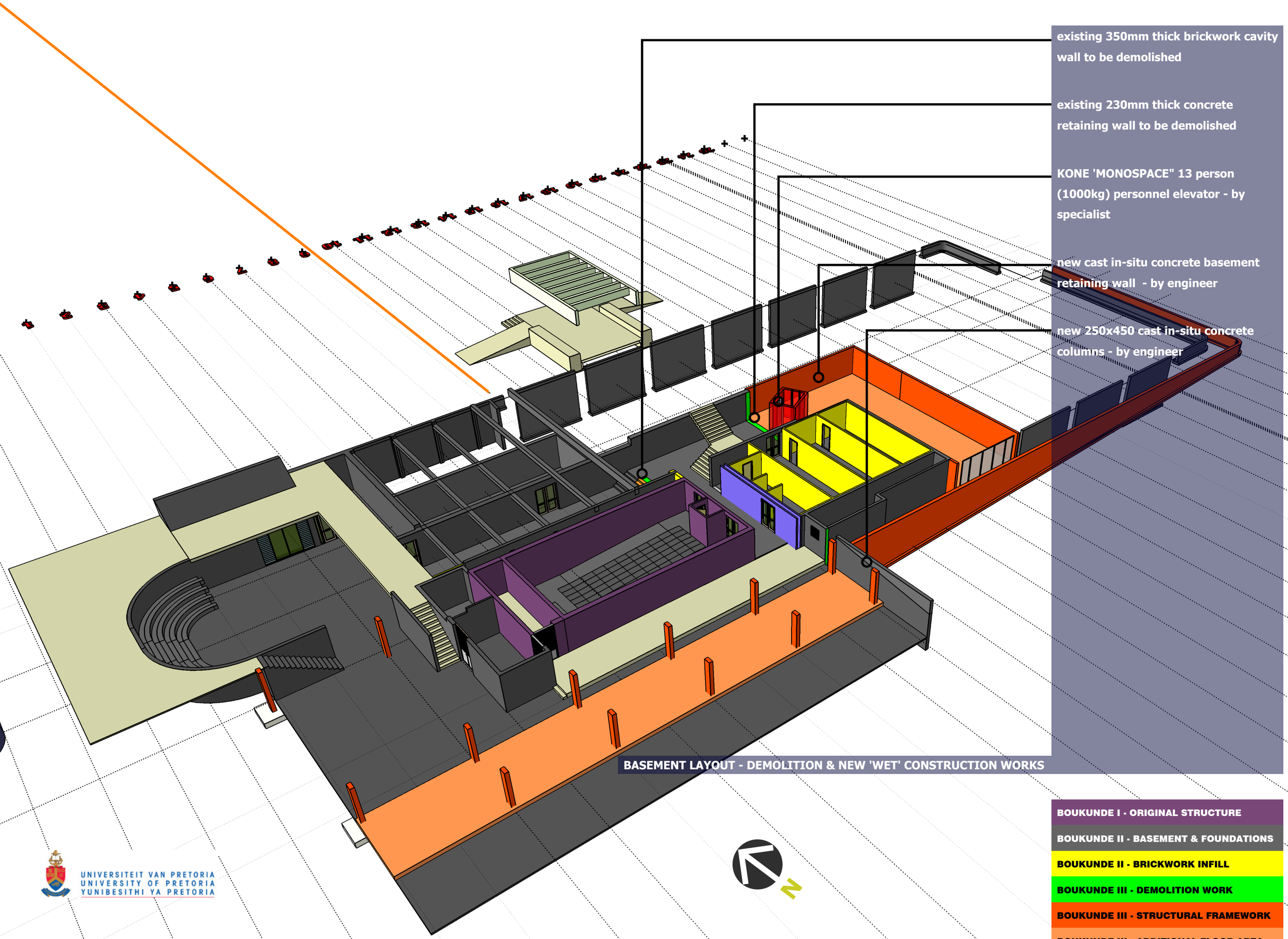
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(image source : the De Beer family)

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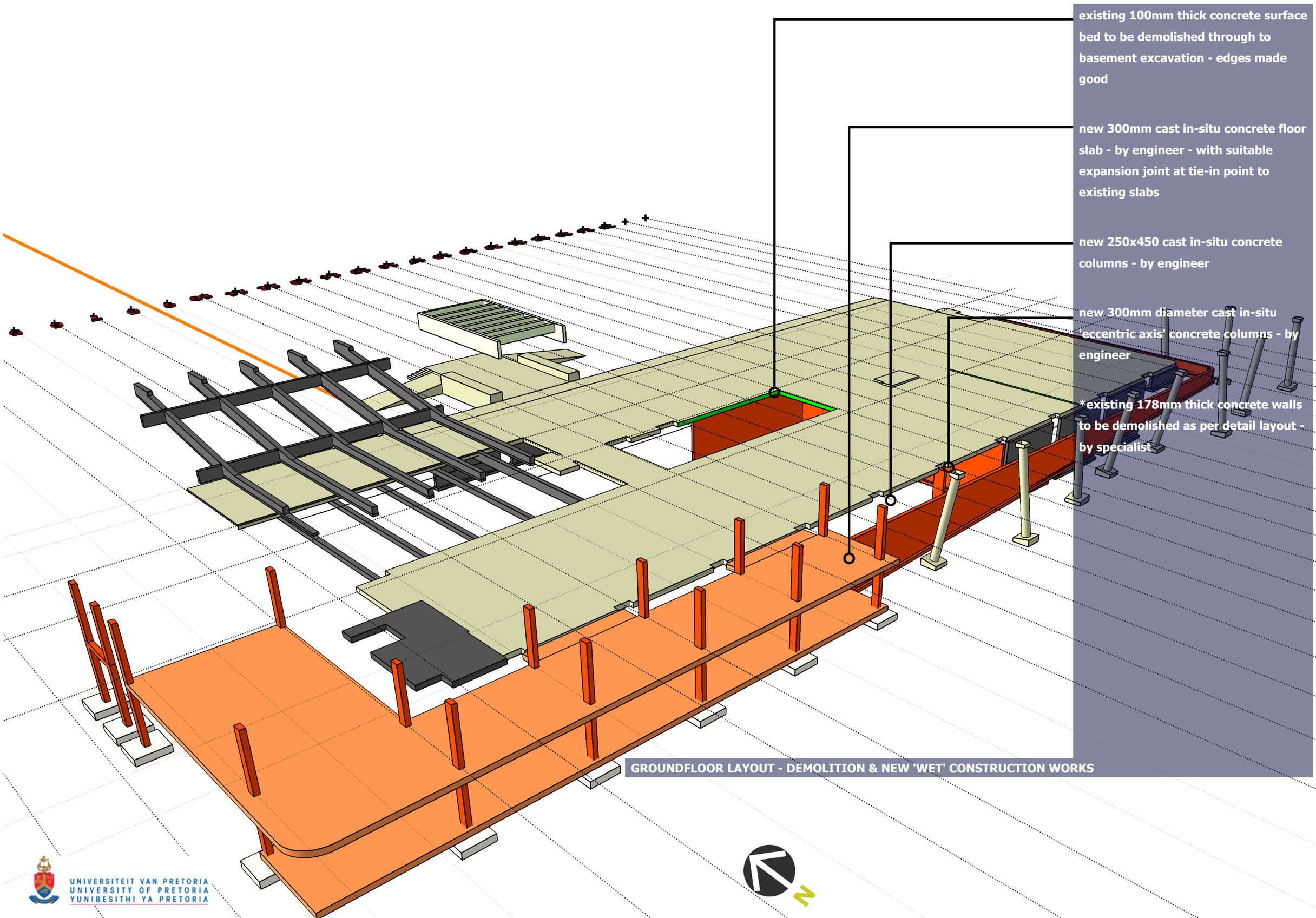
technical annexure

011.0



BASEMENT LAYOUT - DEMOLITION & NEW 'WET' CONSTRUCTION WORKS

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existing 100mm thick concrete surface bed to be demolished through to basement excavation - edges made good

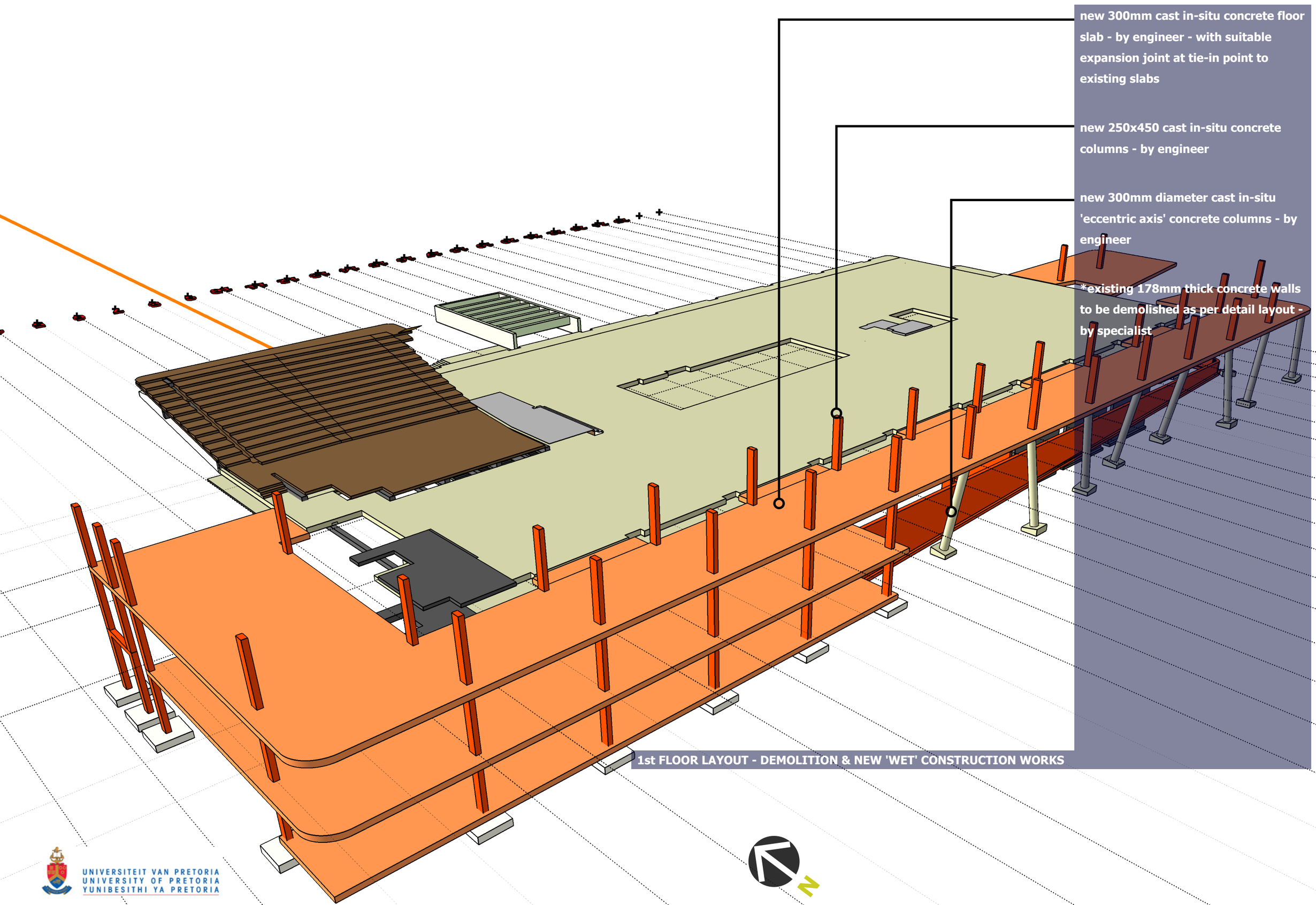
new 300mm cast in-situ concrete floor slab - by engineer - with suitable expansion joint at tie-in point to existing slabs

new 250x450 cast in-situ concrete columns - by engineer

new 300mm diameter cast in-situ 'eccentric axis' concrete columns - by engineer

*existing 178mm thick concrete walls to be demolished as per detail layout - by specialist

GROUNDFLOOR LAYOUT - DEMOLITION & NEW 'WET' CONSTRUCTION WORKS



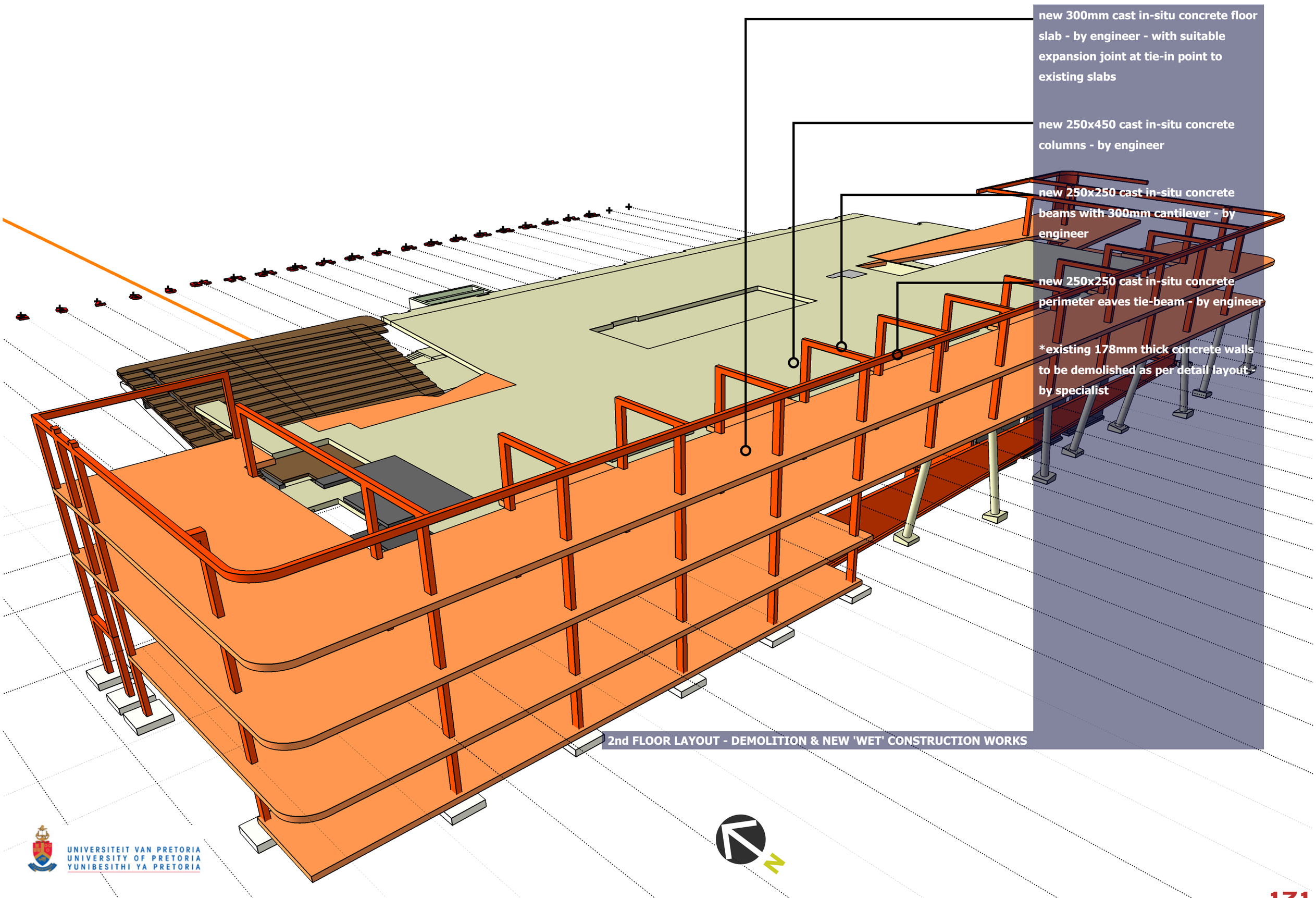
new 300mm cast in-situ concrete floor slab - by engineer - with suitable expansion joint at tie-in point to existing slabs

new 250x450 cast in-situ concrete columns - by engineer

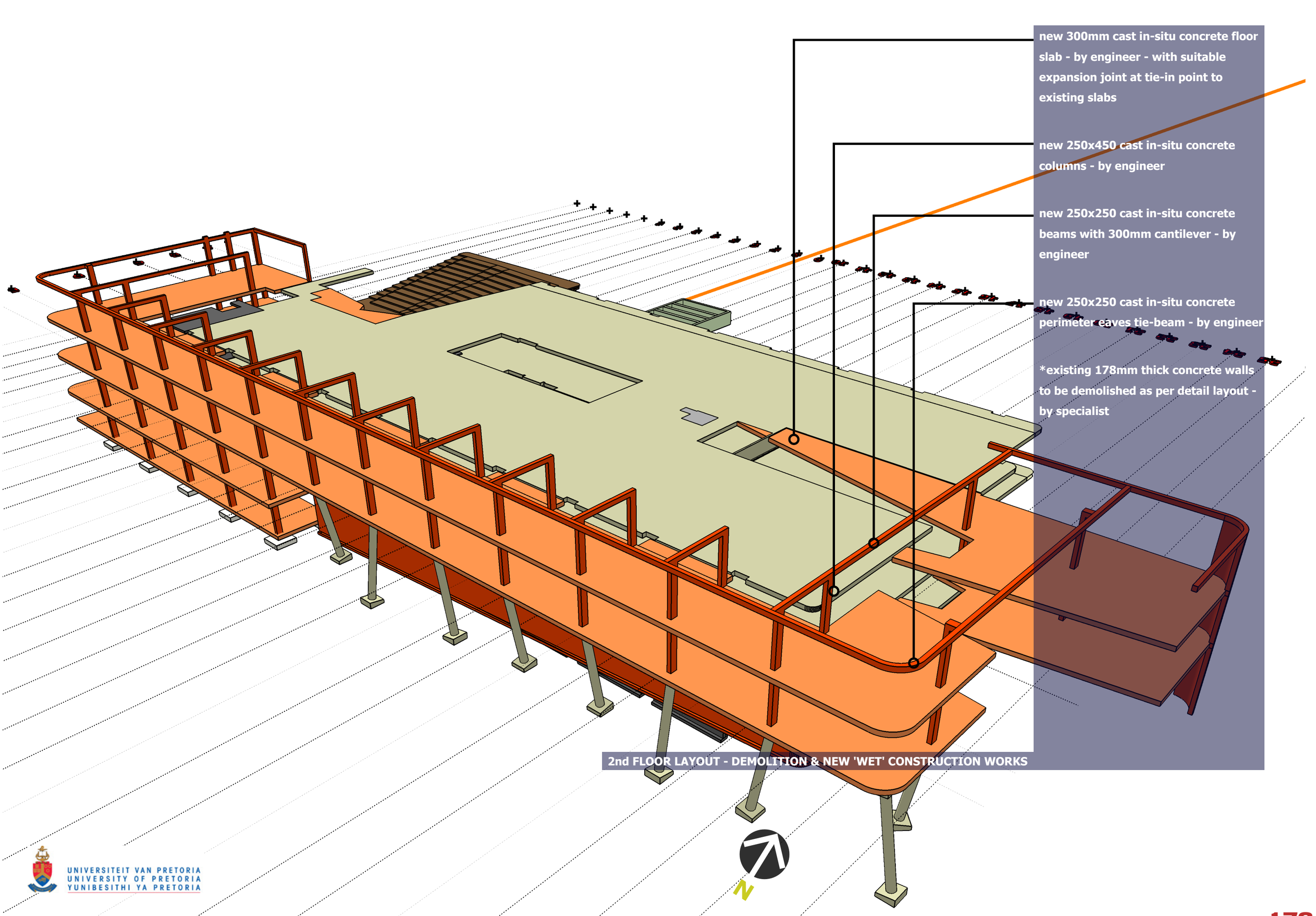
new 300mm diameter cast in-situ 'eccentric axis' concrete columns - by engineer

*existing 178mm thick concrete walls to be demolished as per detail layout - by specialist

1st FLOOR LAYOUT - DEMOLITION & NEW 'WET' CONSTRUCTION WORKS

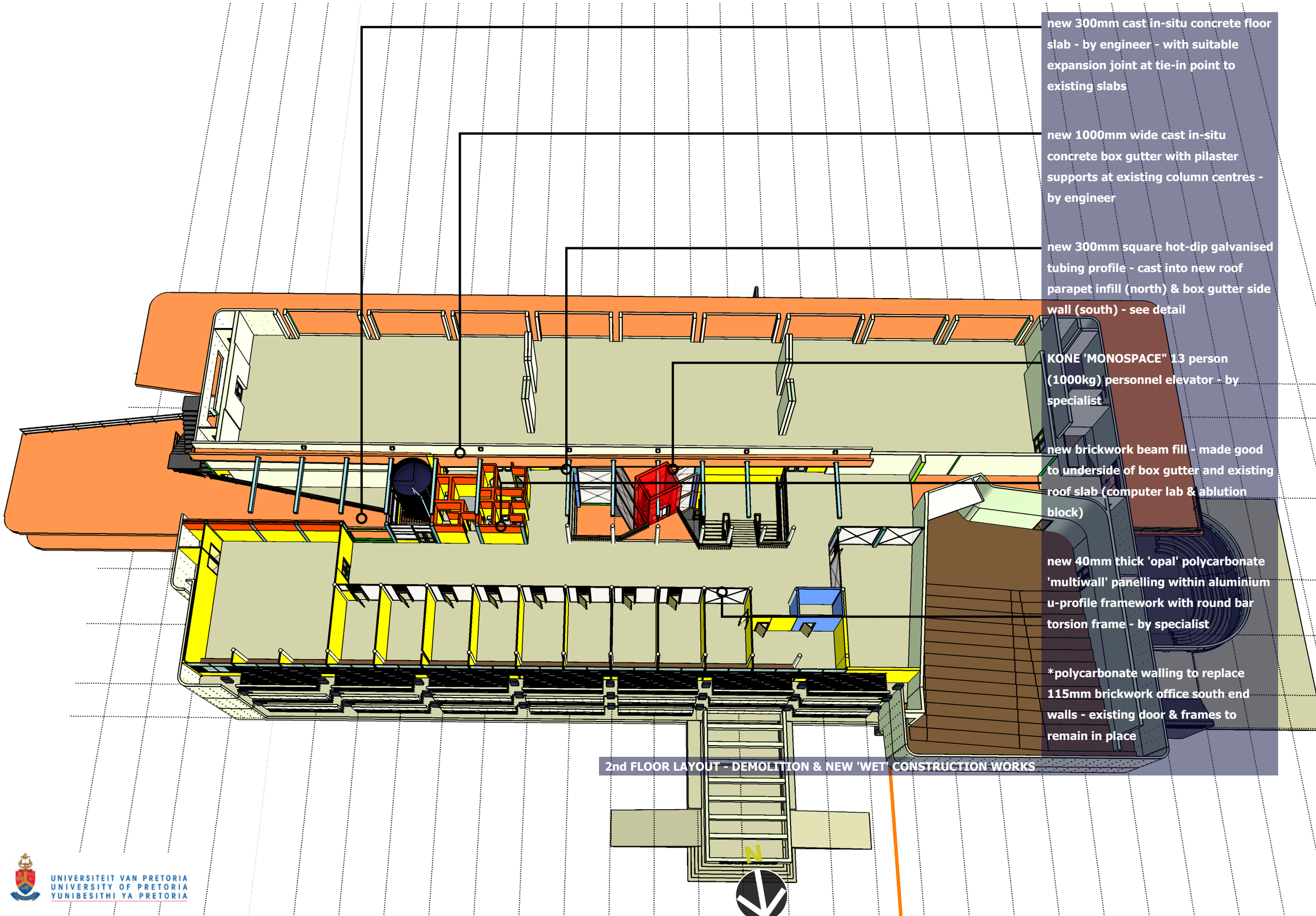


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2nd FLOOR LAYOUT - DEMOLITION & NEW 'WET' CONSTRUCTION WORKS

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new 300mm cast in-situ concrete floor slab - by engineer - with suitable expansion joint at tie-in point to existing slabs

new 1000mm wide cast in-situ concrete box gutter with pilaster supports at existing column centres - by engineer

new 300mm square hot-dip galvanised tubing profile - cast into new roof parapet infill (north) & box gutter side wall (south) - see detail

KONE 'MONOSPACE" 13 person (1000kg) personnel elevator - by specialist

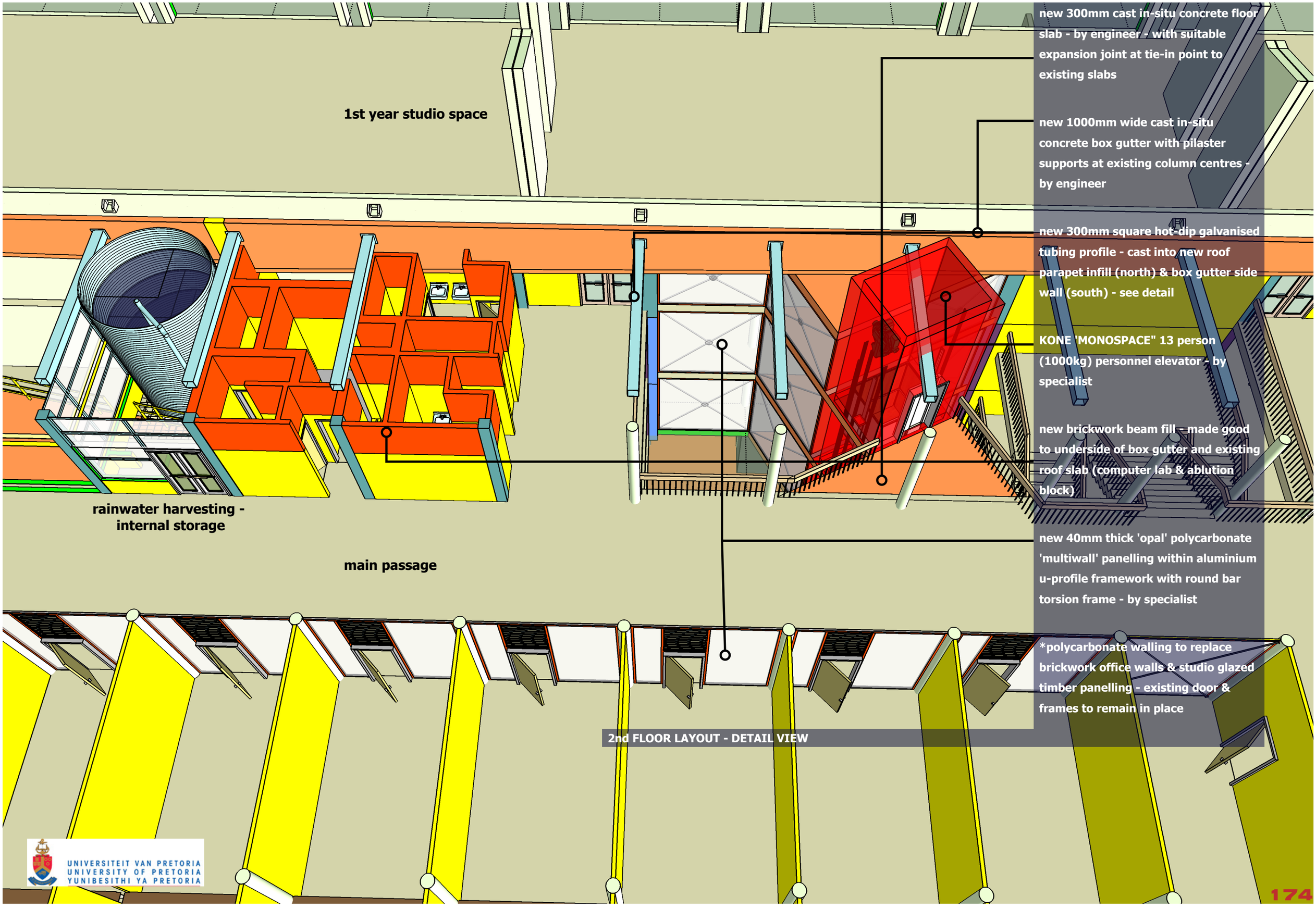
new brickwork beam fill - made good to underside of box gutter and existing roof slab (computer lab & ablution block)

new 40mm thick 'opal' polycarbonate 'multiwall' panelling within aluminium u-profile framework with round bar torsion frame - by specialist

*polycarbonate walling to replace 115mm brickwork office south end walls - existing door & frames to remain in place

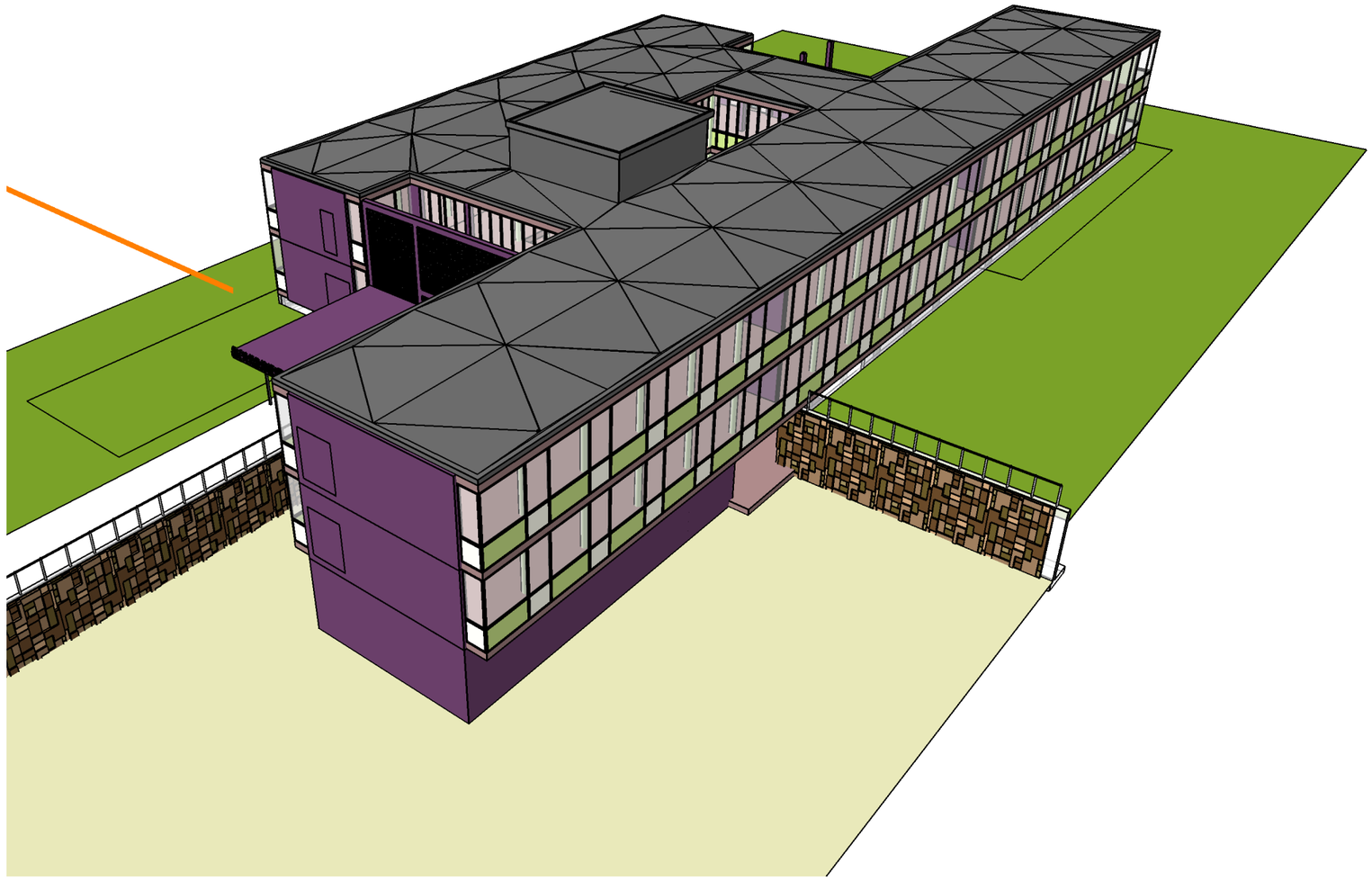
2nd FLOOR LAYOUT - DEMOLITION & NEW 'WET' CONSTRUCTION WORKS

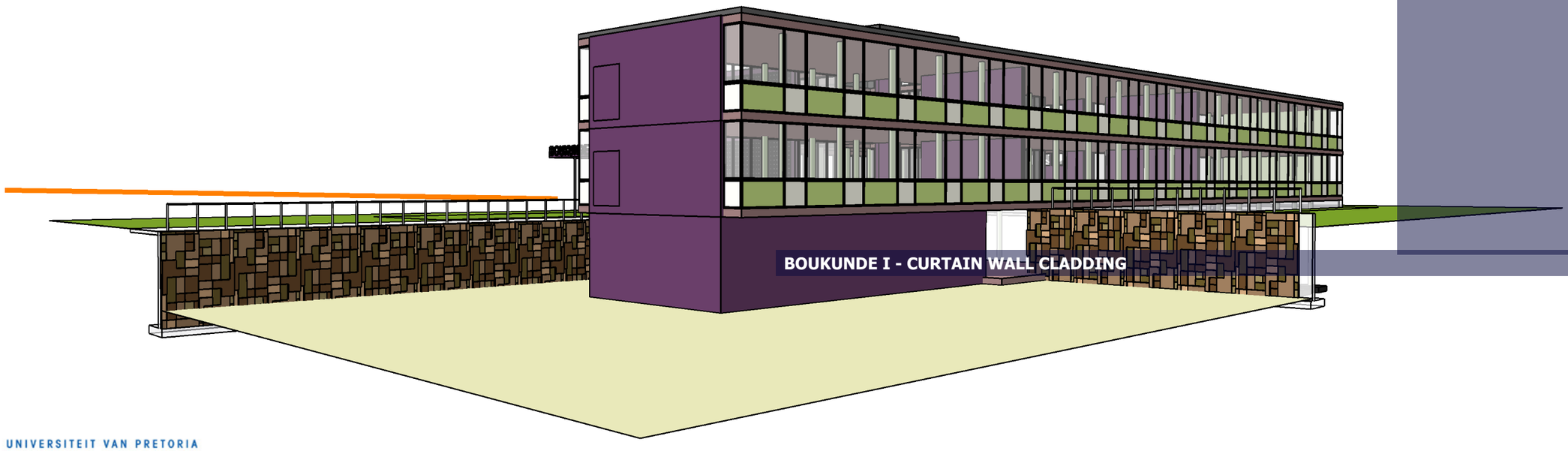
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2nd FLOOR LAYOUT - DETAIL VIEW

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The curtain wall cladding of Boukunde I is 'resurrected' within the proposal for the new building.

The previous version had facade panels with increments set into the column centres - being 3251mm.

Boukunde III will be set out using the existing column grid and thus, will employ the commensurate glazing panel divisions.

The western facade (and entrance) of Boukunde I was protected by a vertical screen comprising 'Briti' terracotta grille blocks. Its primary function would have been to prevent late afternoon glare & gains, as the open gap between the screen & building would still have allowed a significant percentage of the afternoon sun through.

BOUKUNDE I - CURTAIN WALL CLADDING

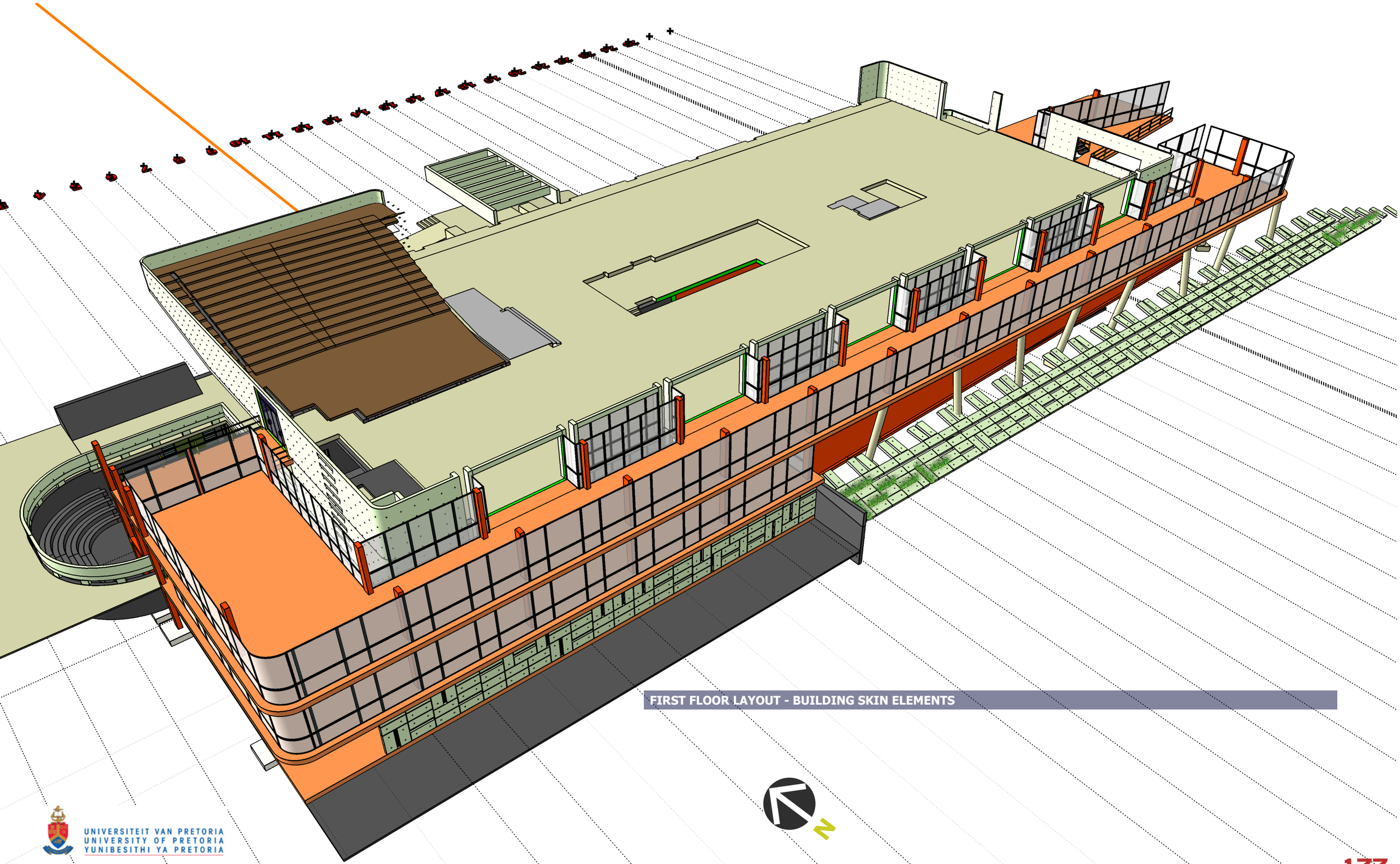
'recovered' concrete panels from building facade - re-used as building blocks with air inlet grilles set into block spacing (format for new hvac plant room application)

flat glass curtain wall - by specialist

curved polycarbonate curtain wall corner sections - ex 4.5mm flat opal PC sheeting set into natural anodised aluminium glazing framework with 50x50mm square steel tubing mullions at either end of framework

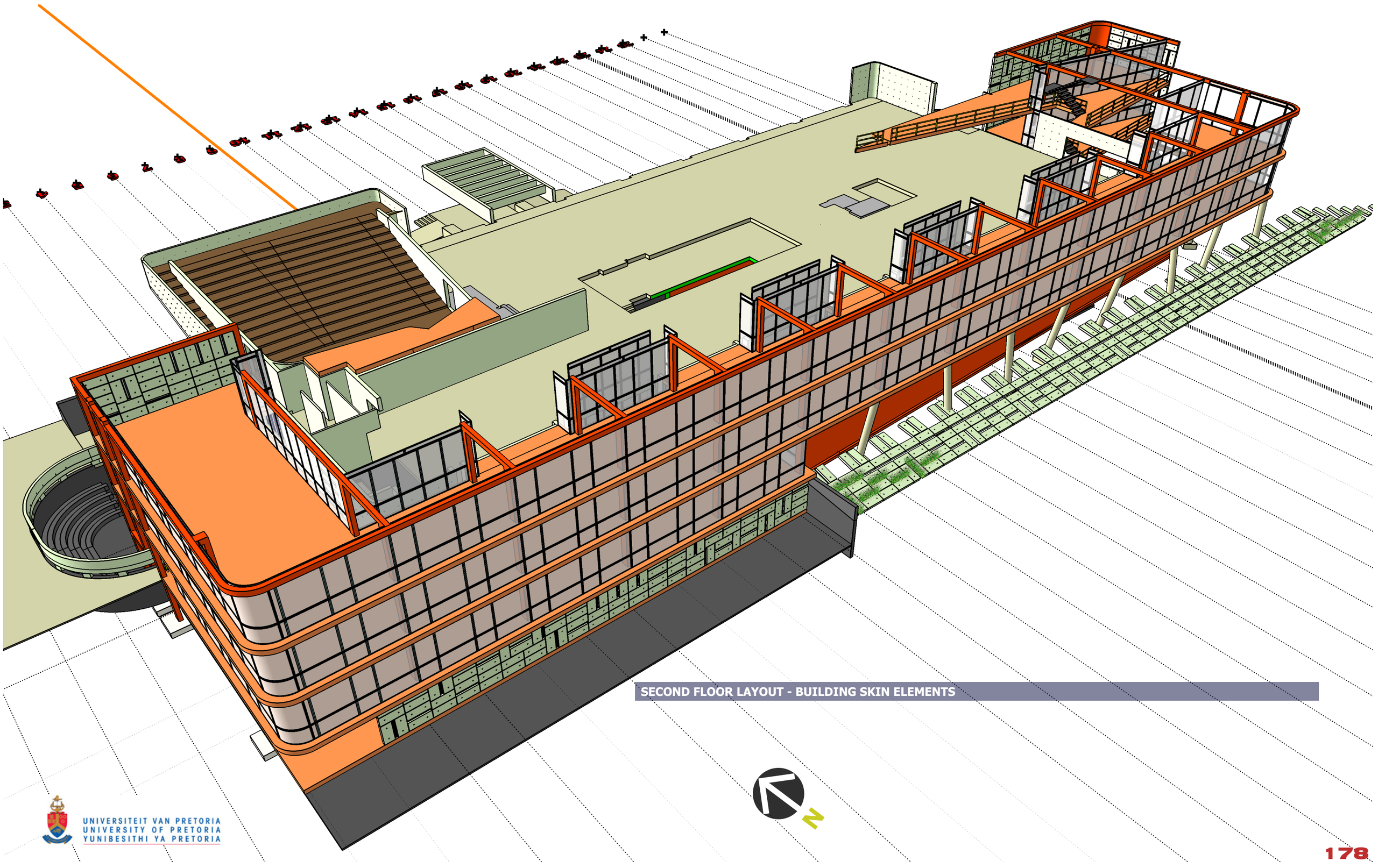
'recovered' concrete panels from building facade - re-used as landscaping retaining blocks with groundcover planting set into block spacing (format for new geothermal embankment application)

GROUND FLOOR LAYOUT - BUILDING SKIN ELEMENTS



FIRST FLOOR LAYOUT - BUILDING SKIN ELEMENTS

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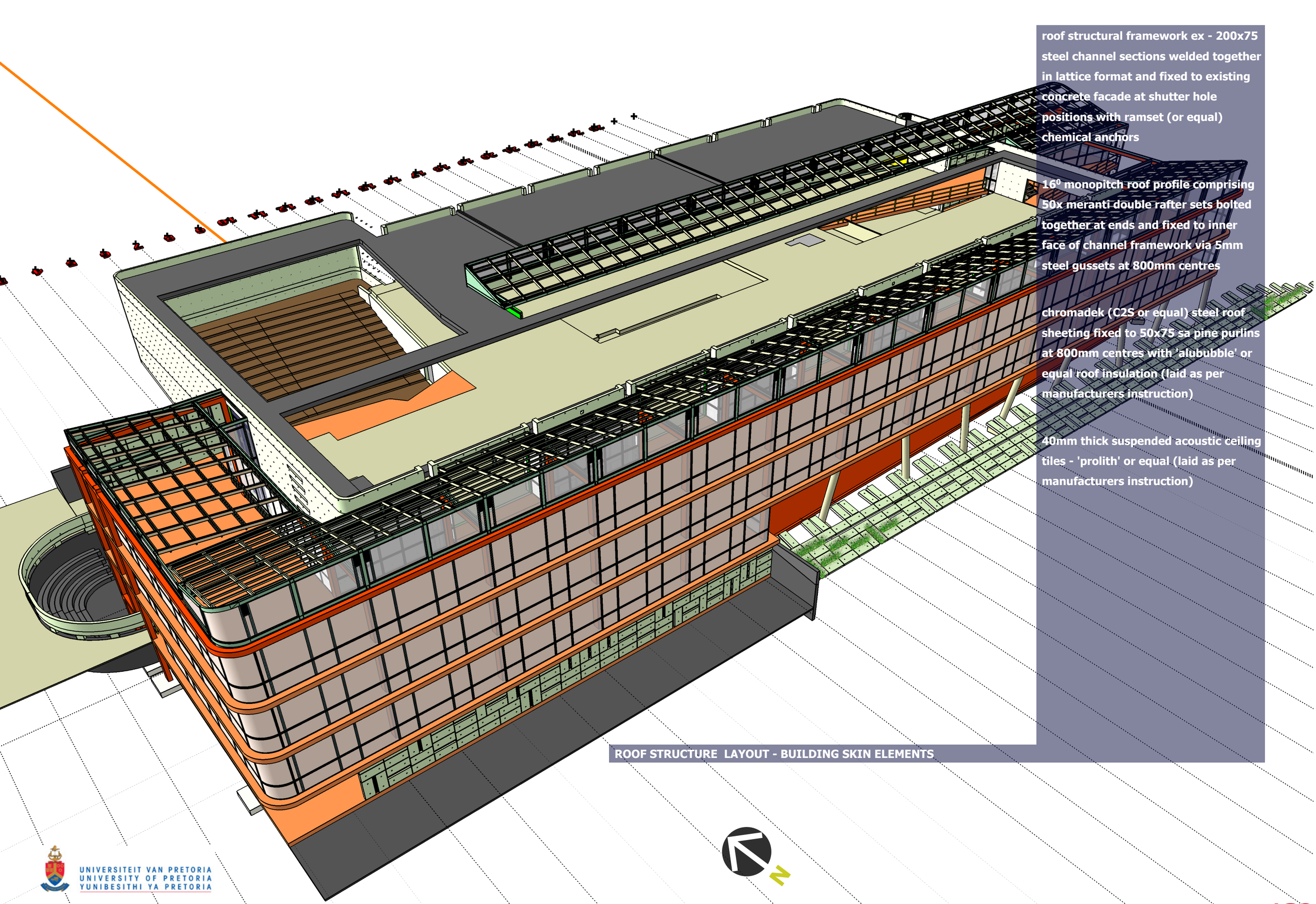
SECOND FLOOR LAYOUT - BUILDING SKIN ELEMENTS

fat glass curtain wall - by specialist

curved polycarbonate curtain wall corner sections - ex 4.5mm flat opal PC sheeting set into natural anodised aluminium glazing framework with 50x50mm square steel tubing mullions at either end of framework

2nd floor clerestory band comprising 4.5mm opal polycarbonate sheeting set into natural anodised aluminium glazing framework with adjustable air inlet grilles at 6500mm centres

SECOND FLOOR LAYOUT - BUILDING SKIN ELEMENTS



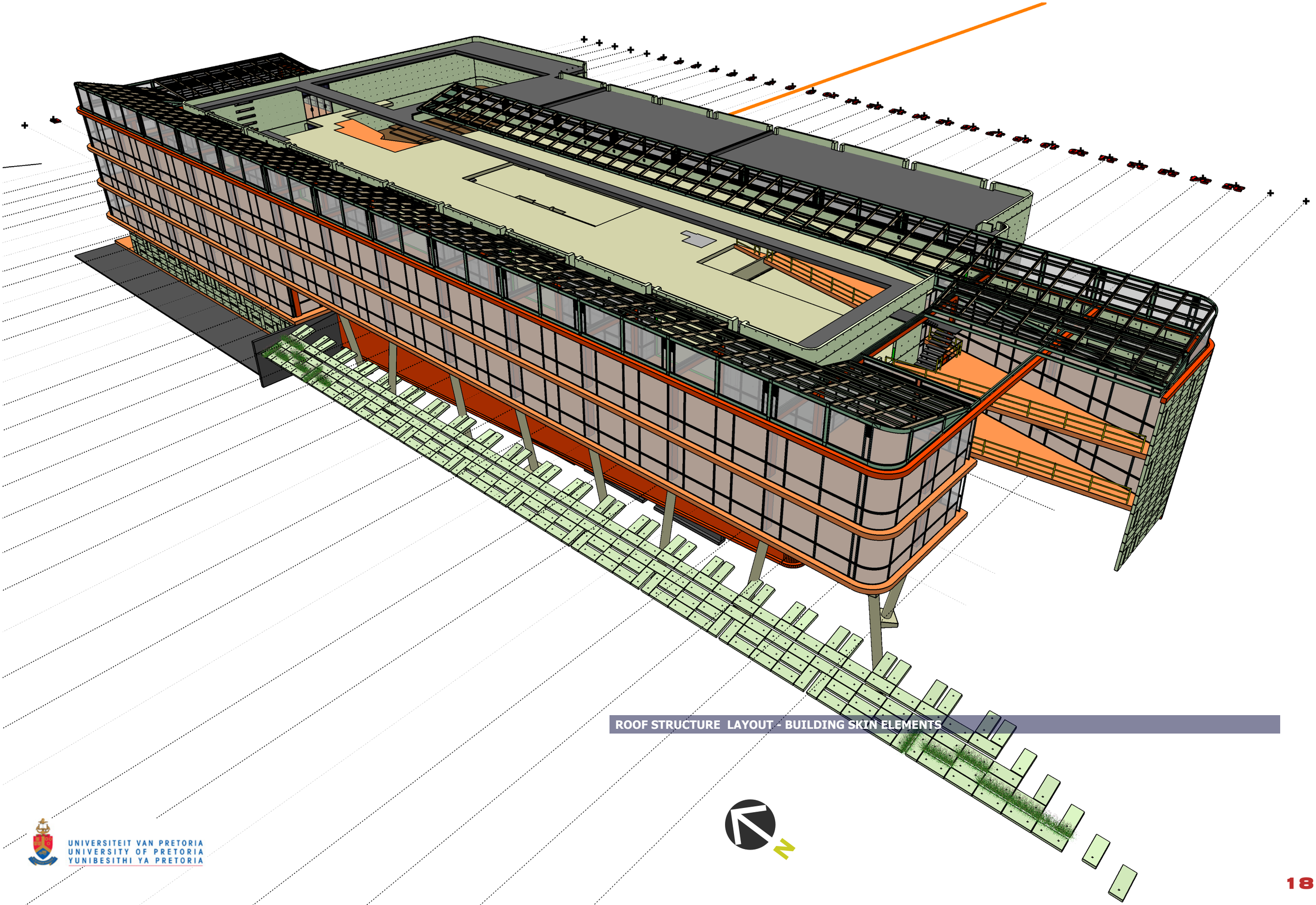
roof structural framework ex - 200x75 steel channel sections welded together in lattice format and fixed to existing concrete facade at shutter hole positions with ramset (or equal) chemical anchors

16^0 monopitch roof profile comprising 50x meranti double rafter sets bolted together at ends and fixed to inner face of channel framework via 5mm steel gussets at 800mm centres

chromadek (C2S or equal) steel roof sheeting fixed to 50x75 sa pine purlins at 800mm centres with 'alububble' or equal roof insulation (laid as per manufacturers instruction)

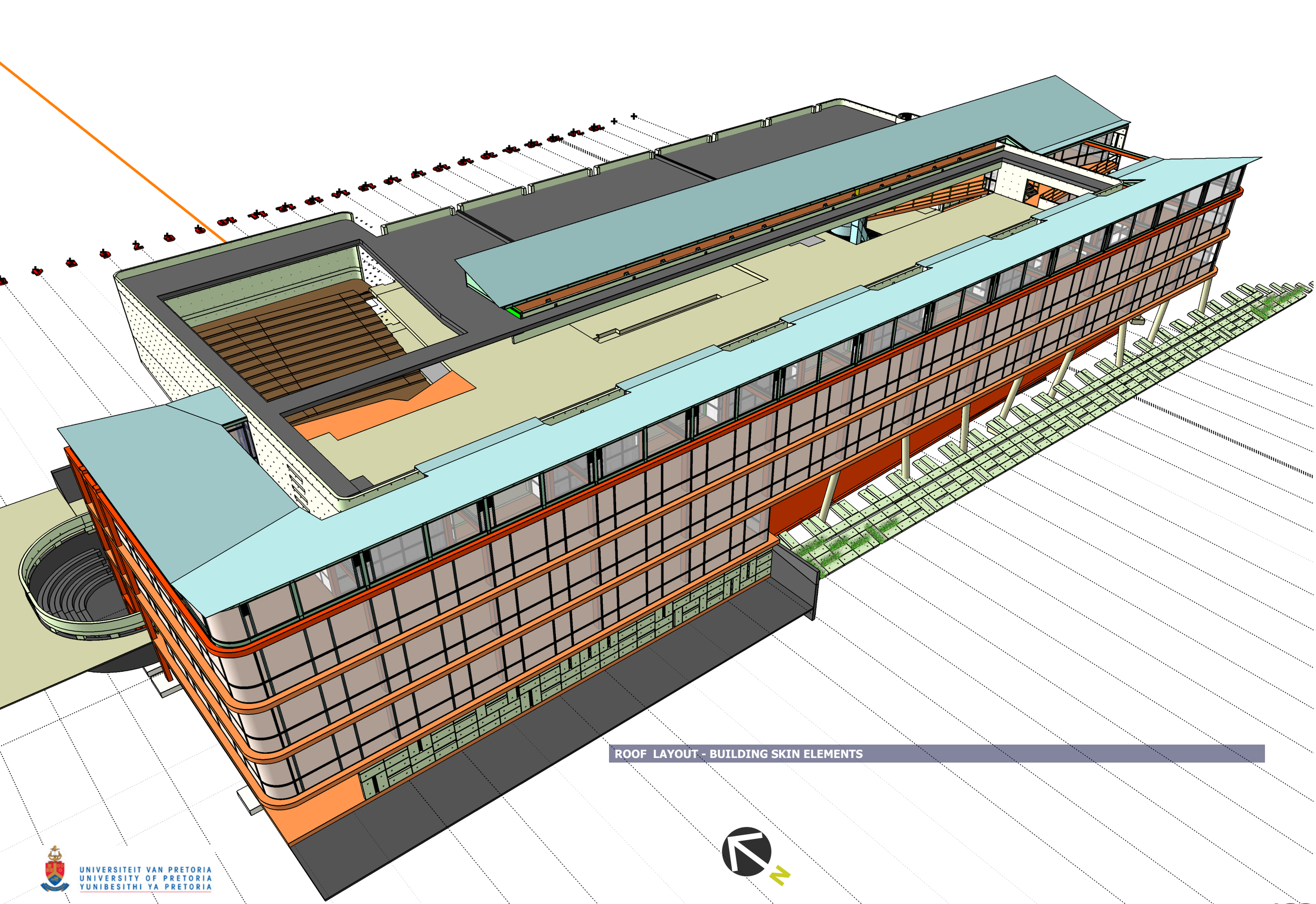
40mm thick suspended acoustic ceiling tiles - 'prolith' or equal (laid as per manufacturers instruction)

ROOF STRUCTURE LAYOUT - BUILDING SKIN ELEMENTS



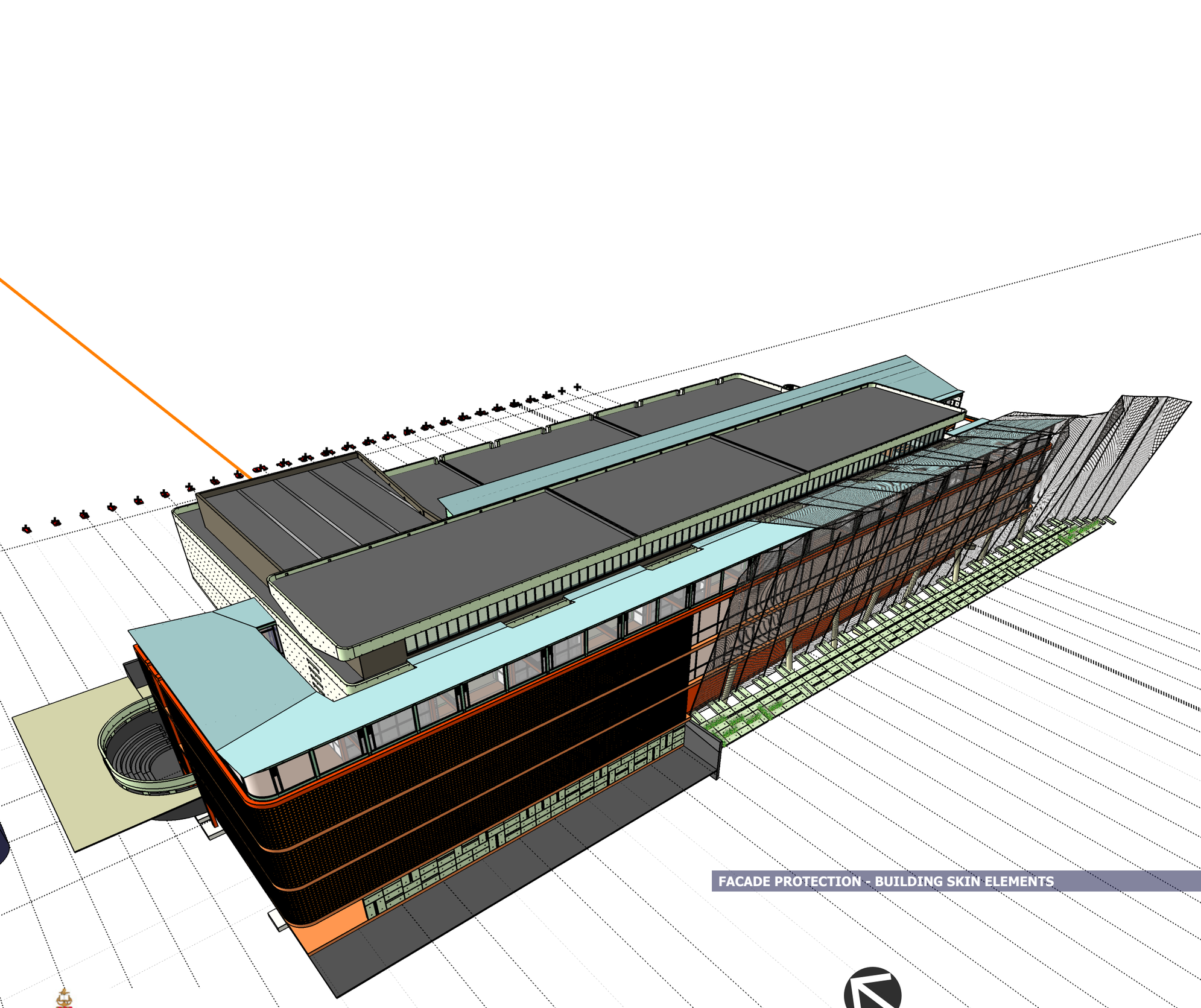
ROOF STRUCTURE LAYOUT - BUILDING SKIN ELEMENTS

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ROOF LAYOUT - BUILDING SKIN ELEMENTS

ROOF LAYOUT - BUILDING SKIN ELEMENTS



The Boukunde III proposal utilises the singular facade protection element from the first building.

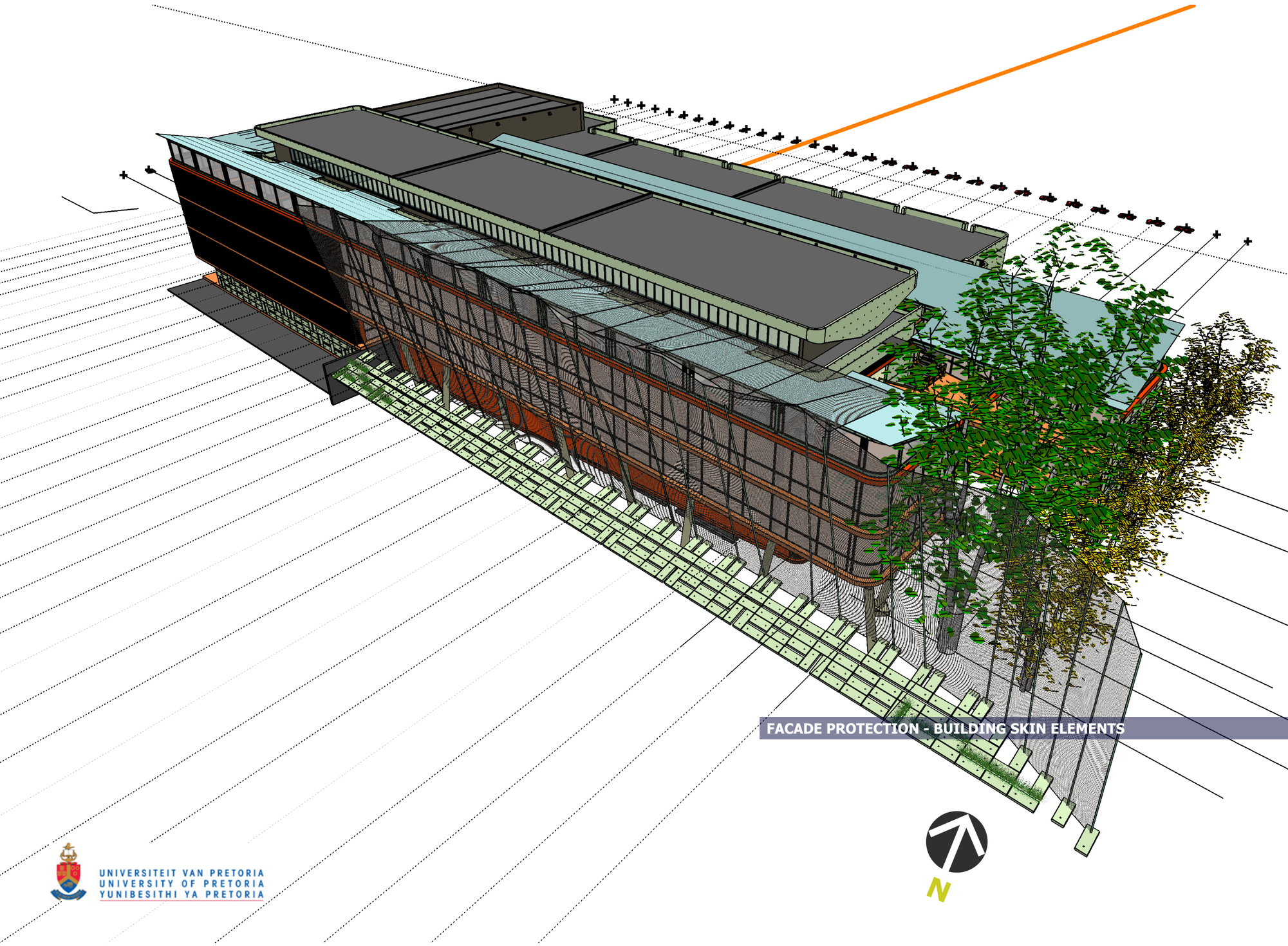
The 'Briti' terracotta grille blocks are not available in exactly the same profile as they were in 1960, but they are raised from past nonetheless - to be used (as they were in 1960) to protect the western facade.

They wrap themselves around the curved corner of the building to extend along the southern flank - terminating at the facades point of base level interchange.

The facade is further protected from above, by a 'free-form' tubular framework with wire mesh covering. This 'translucent' screen extends up from ballast base plates formed by the 384kg 'recovered' concrete blocks that retain the geothermal embankment slope.

The wire mesh screen is translucent to perpendicular view (from Lynnwood road - to Lynnwood road), but throws a shadow vertically from the face as the view through it's apertures becomes restricted.

FACADE PROTECTION - BUILDING SKIN ELEMENTS



The eastern end of the new construction has been left exposed in terms of protective building elements.

Cover will be provided by significant tree growth in the immediate vicinity, with the southern flank purposefully nestling itself in amongst the grouping.

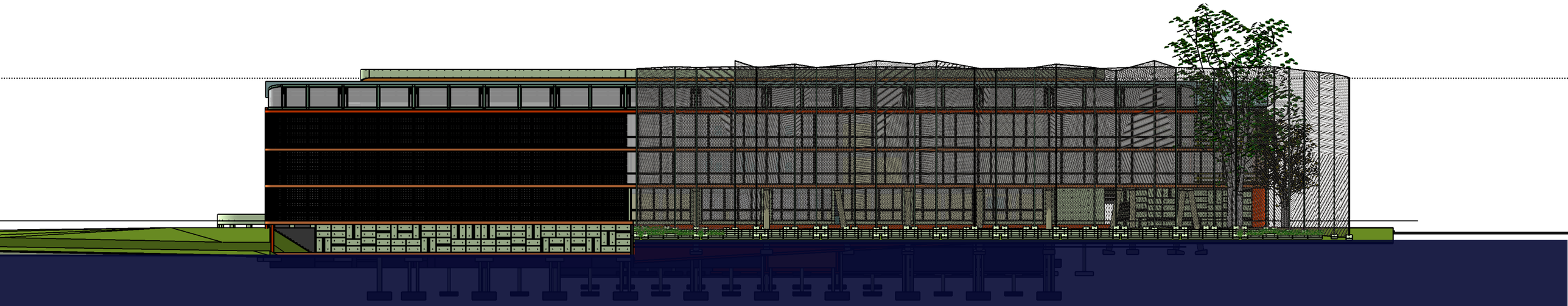
The 'wing' which opposes it, will gain from the area remaining as natural as possible - offering relief during end-year critiques taking place in the exhibition spaces that it houses.

This northern outcrop of the building extension will be protected on it's 2 exposed sides (north & east) bu concrete elevations comprising 'recovered' Boukunde II facade blocks.

FACADE PROTECTION - BUILDING SKIN ELEMENTS

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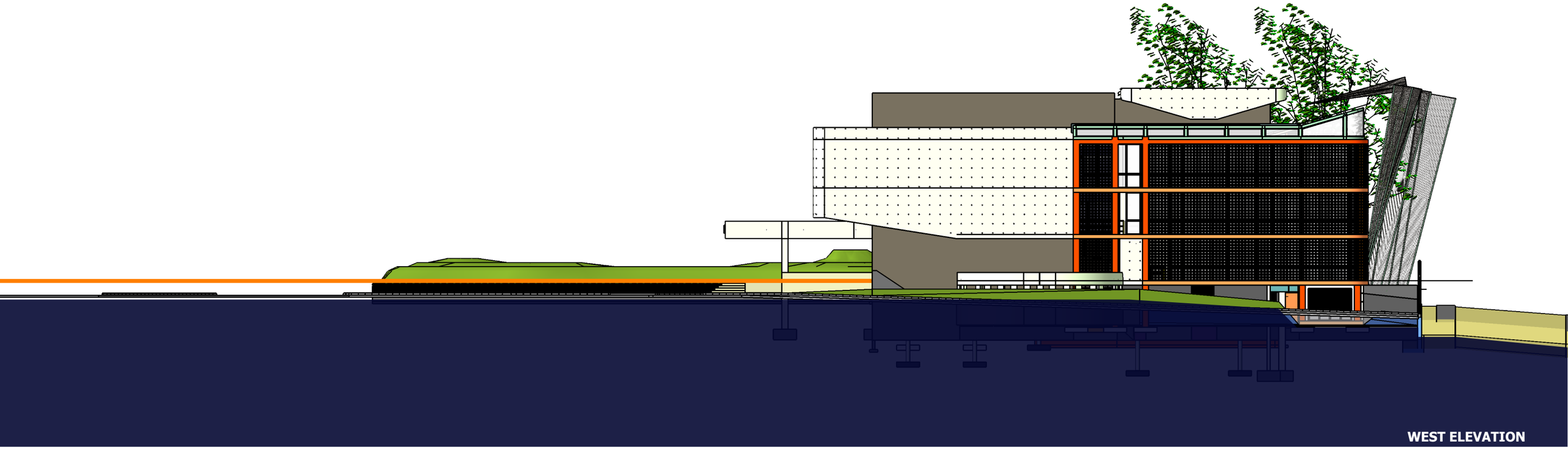


SOUTH ELEVATION

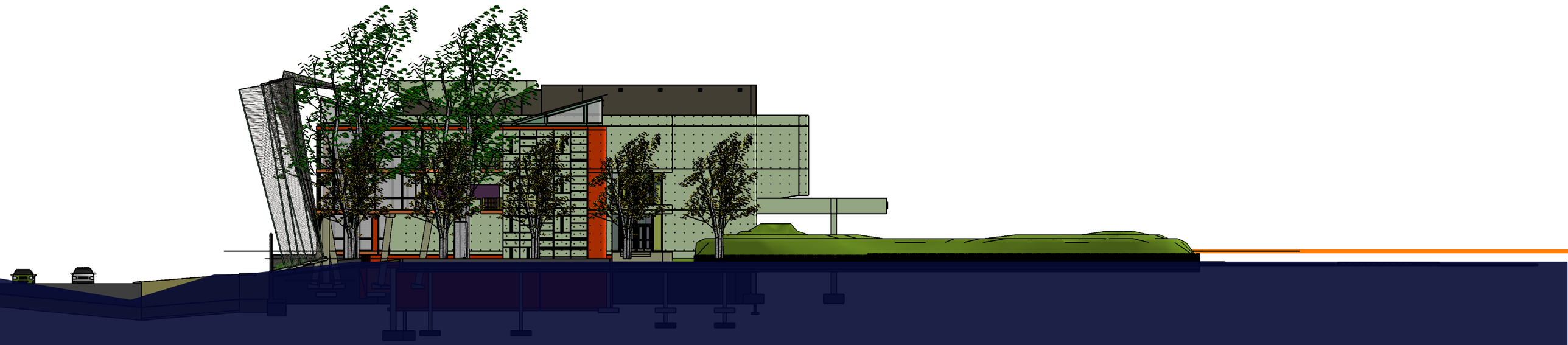
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NORTH ELEVATION



WEST ELEVATION



EAST ELEVATION