09 TECHNICAL INVESTIGATION

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Introduction

Research into thermal comfort, light qualities and noise levels of each part of the building is discussed in order to get a better understanding of how the most desirable conditions would be achieved.

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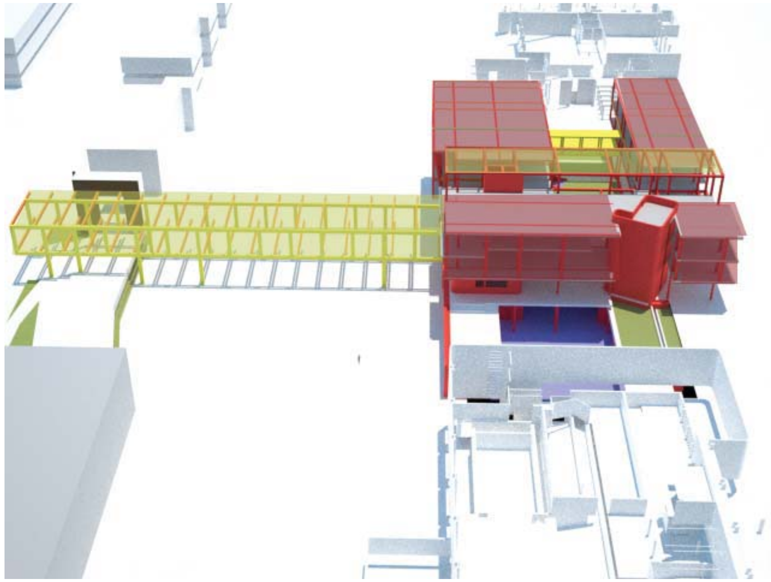

fig. 9.01_Structural model showing the main structural elements

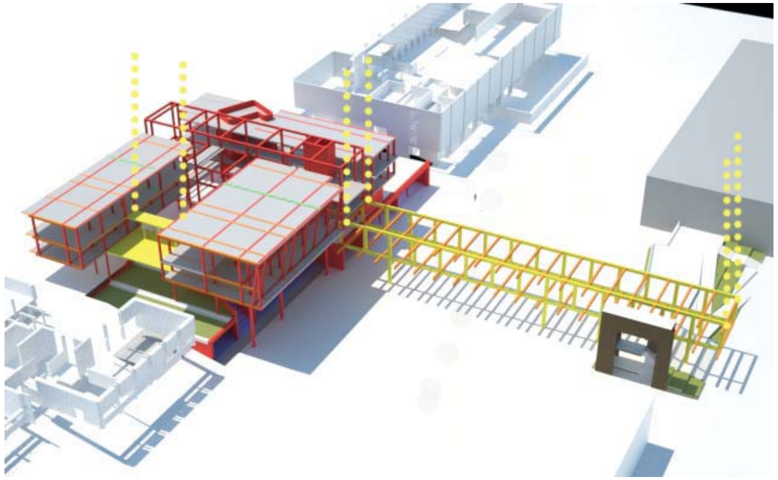

fig.9.02_Vierendeel trusses used on bridge structures in the north - south orientation

main structural components

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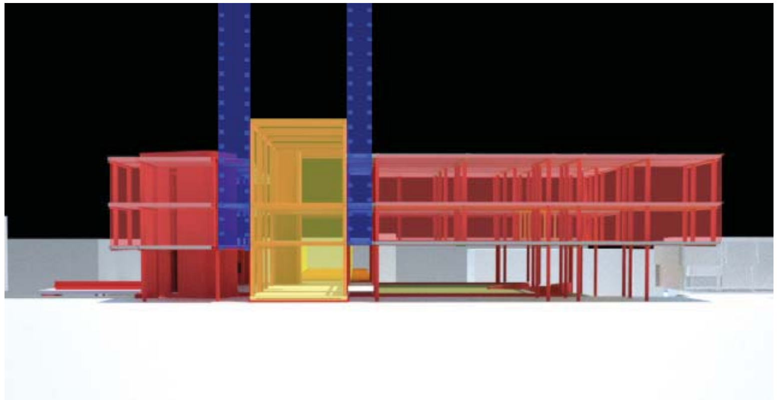

fig. 9.03_Separation of main bridge structure and ancillary accommodation by main circulation routes

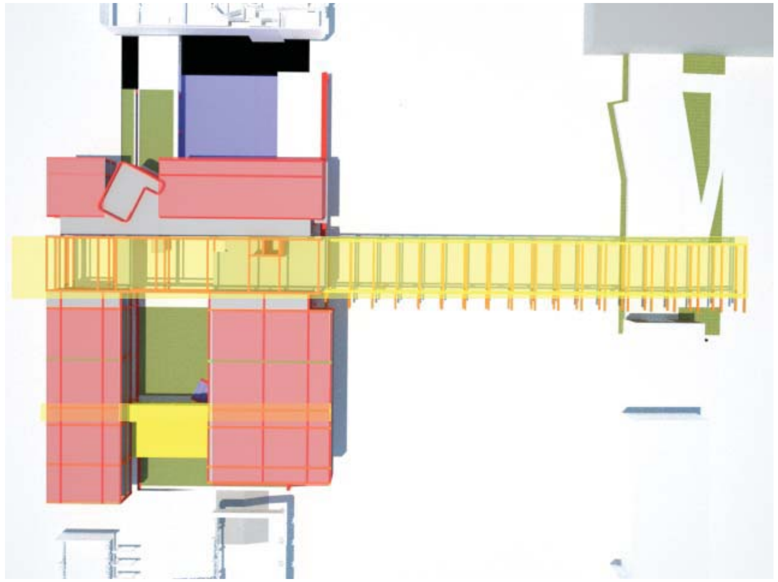

fig. 9.04_Galleries and offices set apart from main bridge structure - main circulation routes separating two typologies

main structural components

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Material study

Material selection is done to reinforce the conceptual ideas involved in the proposed building. The contrast between heavy and light materials are played off against each other in order to illustrate the difference between parts of the building belonging to the ground and those which are conceptually separated from it.

Concrete:
Reinforced concrete is used to emphasize the heavy appearance of stereotomic elements. It is mostly used in the construction of the lower ground floor. As illustrated in the construction details, reinforced concrete retaining walls are used in conjunction with sufficient waterproofing to ensure a damp proof structural member.

The combination of concrete and permanent shuttering are used as supporting structure for the first and second floor raised floors.

Fire resistance
All reinforced concrete supports are required to have a fire rating of at least 120minutes to provide adequate time for occupants to escape without structural failure of the building. All reinforcing steel should have a minimum of 50mm concrete cover.

Reinforcing
Mild steel reinforcing cages can be manufactured off site to speed up construction and to avoid rust collecting on steel surfaces.

Construction
Special care needs to be taken with the inclusion of expansion joints during construction. It is proposed that expansion joints be constructed at 18 - 25m intervals. Expansion joints are located at column and slab junctions where possible to allow for different curing times in constituent structural parts.

Finish
Off shutter finishes are proposed for all concrete construction. Special care needs to be taken to ensure a smooth finish where concrete walls and columns are not covered by acoustic or other finishes.

Glass:
Structural glazing with safety ratings for impact and burglar proofing are used for all glass surfaces which exceed $0.25m^2$. Laminated glass specified to comply with class 2 safety ratings is made up of two layers of 6mm clear float glass with a 0.76mm PVB interleave.

Sizes
Laminated glass is available in maximum sizes of 2400mm x 3200mm. Thicknesses are available in intervals of 2mm up to 10mm.
Vertical structural glazing will be comprised of 2 x 6mm thick clear float glass panes.

Fire resistance
The PVB layer used in the manufacture of laminated glass acts as a bonding material. This provides additional structural strength in case of a fire.

Steel:
Structural steel is used in parts of the building classified as stereotomic. Although steel is not technically a light material it does provide a slender appearance. It allows the use of thin members due to its high tensile strength.

Treatment
All structural steel should be treated with intumescent paint to ensure structural stability in case of a fire.

Expanded aluminium
Although aluminium is not very cost effective, the process of manufacturing expanded metal allows a relatively small piece of material to be ‘stretched’ to cover a large area. There is no material waste as is the case with perforated metal sheets and it is maintenance free.
One of the most important design decisions which led to the selection of expanded aluminium panels was the quality of light achieved inside the building through the filtering of light through the diamond shaped openings. The following section dealing with the double skin facade

Double skin facade

Due to the building's and the especially the bridge's north - south orientation it is important to filter light into spaces on the eastern and western facades of the building. Another concern was that of noise pollution from Lynnwood Road. Although the expanded aluminium mesh provides little sound absorption on its own, in conjunction with the vitrex panels and the air gap inside the double skin facade provides substantial noise reduction.

The double skin also provides the opportunity to hide the building services. Rainwater downpipes and ventilation ducting are housed inside the skin thus eliminating the need for extra space allowance for it inside the building.

The combination of translucent and opaque panels supporting the expanded aluminium mesh allows diffused light to enter the building during the day and gives the building a esoteric glow at night.

The expanded aluminium also reflects light in a haphazard manner thus minimizing glare off the sides of the building.

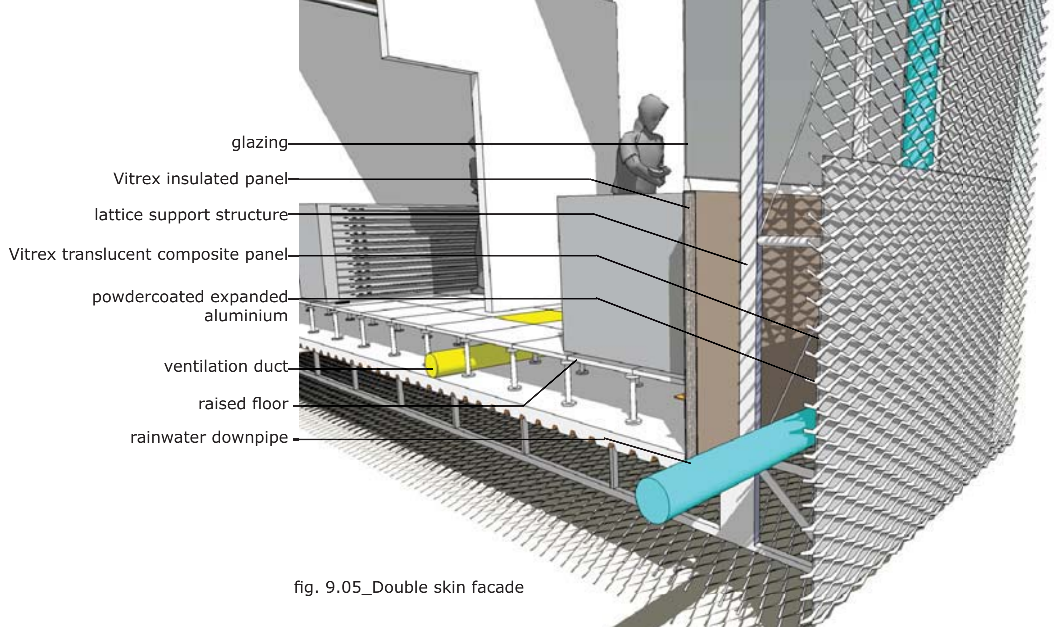
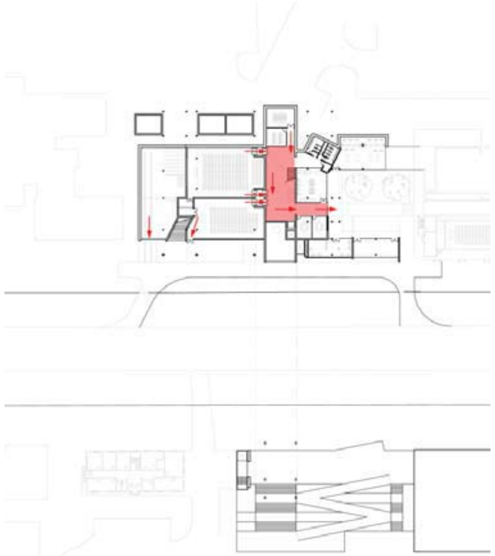
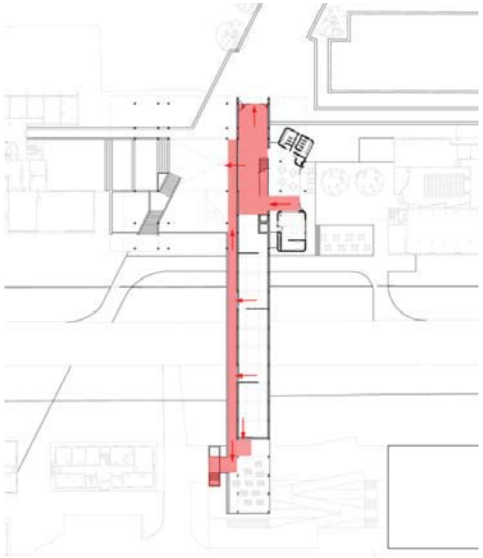


fig. 9.05_Double skin facade

fig. 9.06_Expanded aluminium *(www.gsdmaterials.com)*

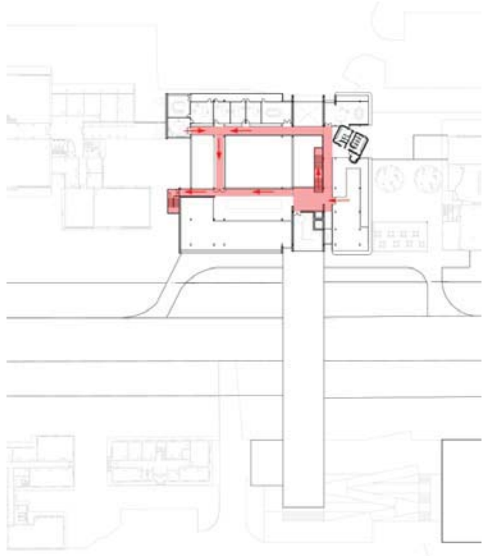


lower ground floor layout



ground floor layout

first floor layout



second floor layout

fig. 9.07_Fire routes

Emergency routes

All accommodated spaces are situated to ensure that travel distances to the nearest emergency door do not exceed 45m. The width of emergency exit are in excess of 800mm. Both the classroom and auditorium are provided with 2 exit doors. All walls, ceilings and floors enclosing emergency routes have fire resistance of not less than 120 minutes. All emergency routes are sufficiently illuminated and demarcated in accordance with regulations stipulated in part TT29 of the SABS 0400. All ventilation and service shafts are constructed as to not promote the spread of combustible materials and gases between spaces. No firemen’s lift is necessary due to the total building height not exceeding 30meters. Figure 9.07 indicates the emergency routes in the proposed building.

Occupancies and structural stability

According to the SABS 0400 the table below provides occupancies in the proposed building and the time structural components need to be stable in case of a fire.

Occupancy	Class of occupancy	3 – 10 storey building	Basement
Places of instruction	A3	90mins	120mins
Exhibition hall	C1	120mins	
Museum	C2	90mins	
Plant room	D4		120mins
Offices	G1	60mins	
Moderate risk storage	J2		180mins
Low risk storage	J3	90mins	120mins
Parking garage	J4	60mins	120mins

Table 9.08

All structural steel components shall be treated with an intumescent paint application to have a fire resistance of not less than 120minutes.

Auditoriums and lecture theatres:

The proposed lecture theater and classroom shall comply with SABS 0400 part TT50.

Portable extinguishers:

Occupancy	Class of occupancy	Number of portable extinguishers
Places of instruction	A3	1 per 200m²
Exhibition hall	C1	1 per 200m²
Museum	C2	1 per 200m²
Plant room	D4	1 per 400m²
Offices	G1	1 per 200m²
Moderate risk storage	J2	1 per 100m²
Low risk storage	J3	1 per 100m²
Parking garage	J4	1 per 400m²

Table 9.09

fig. 9.10

Inert gas fire extinguishing system

Composition

The inert gas is made up of natural gases that exist in our atmosphere. Inert gas is not harmful when inhaled and people trapped in an area where the gas is present will be able to escape without suffocating.

The gas consists of the following elements: Nitrogen, Helium, Neon, Argon and carbon dioxide as a secondary agent.

Objectives of system

The main purpose of the gas is to reduce oxygen levels in the air to a level which will not sustain a fire rated in the classes A, B or C.[1] Oxygen levels are reduced to a level which can still sustain human life at a low level of activity.

1 Fire classifications: Class A – Surface fires or deep seated fires, Class B – Flammable liquids, Class C, Electrical equipment fires.

Disadvantages of inert gas system

Although the system is excellent in replacing its predecessor Halon, it has some disadvantages. High pressure operation causes regular maintenance checks. The area protected by the system must to some extent be contained in a room with minimal openings at the time of discharge. The system does not protect the building structure so all structural components need to be protected separately. The high pressure release during discharge might cause small items to be blown around the room.

In addition to the inert gas system used in art storage, restoration and galleries, handheld extinguishers and a fire hose reels will be provided in areas as indicated on the fire protection layout plans. All gypsum dry walling should have a fire rating of at least one hour.

Installation and operation

All piping must run no closer than 200mm from electrical conduits. All parts of the system must be painted in accordance to the regulations specified by the SABS 0140-3.

Piping shall consist of seamless carbon steel pipes, tested at 120Bar for 4 hours. The system should be under enough pressure to discharge at least 95% of its content within the first 40 seconds of activation.

Maximum hanger spans for piping shall be as follows:

Pipe diameter	Maximum span
< 25mm	1500mm
<40mm	2500mm
<65mm	3000mm
>65mm	3500mm

Cylinder storage

Cylinders should not be stacked more than three levels unless access from both sides are provided. Cylinders should be housed in a designated room to allow access only to fire personnel. If this is not possible dedicated steel enclosures should be constructed to house the cylinders.

Smoke and heat detectors shall be provided in each space and be in compliance with requirements for the specific accommodation.

Doors and door equipment

Any doors enclosing a space protected by inert gas systems shall have automatic closers which will activated before the gas is discharged. Escape doors shall be fitted with alarms and all doors shall be fitted with approved locks.

Breathing apparatus

All areas protected by inert gas fire protection systems shall be supplied with breathing apparatus which will allow occupants at least ten minutes of continuous use. These will be installed at every exit door.

Maintenance

Maintenance shall be carried out in accordance with specific requirements as supplied by manufacturer.

Water supply to additional fire protection

A fire hydrant which is accessible from Lynnwood Road should be supplied in addition to the inert gas and portable fire protection systems. The supply of water to the hydrant will be discussed later in the document.

Alternative fire protection system: Water mist fire protection system

This system consist of a high pressure water storage unit which, on activation, releases a fine mist spray which acts in much the same way as the conventional water sprinkler systems currently used. The advantage of this system over conventional systems is that it releases only 35% of the volume of water compared to the conventional system. This makes it suitable for galleries where works of art are exhibited. Most of the water discharged by the high pressure nozzles evaporates on contact with higher temperatures which decreases the total amount of water left on surfaces after discharge.

Some of the disadvantages of the system are the high cost of installation and operation. This is mostly due to water storage tanks having to be kept under high pressure at all times and the limited number of manufacturers of the constituent parts of the system.

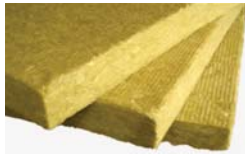
This system was successfully installed at the National Gallery of Art in Washington D.C. but due to considerable costs involved in installation and operation, was not selected for this project.

fig. 9.11_Inert gas nozzle *(www.wormaldfire.co.uk)*

fig. 9.12_Inert gas storage units (www.wormaldfire.co.uk)

Acoustics

Sound is measured in decibels (dBA) and an increase of 10dBA gives an approximate doubling in loudness and although the measurement in decibels might be the same in two instances the perceived sound disturbance might differ because of the difference in frequency. It is therefore important to measure acoustic performance of enclosures in terms of the whole range of frequencies audible to the human ear.



Porous sound absorber

Panel sound absorber

fig. 9.13 *(www.engineeringtoolbox.com)*

acoustic control

Sound absorption materials

Sound absorption materials can be classified into three categories:

1. Porous materials – absorb sound over the whole frequency range and the efficiency depends on the thickness of the element
2. Panel absorbers – absorbs sound over a narrow frequency range and the effectiveness depends on the weight and airspace depth of the panel. It is very useful in low frequency absorption i.e. road noise interferences.
3. Cavity resonators can be "tuned" to give selective absorption over a small frequency range. Cavity resonators can be made up of a combination of category 1 and 2 to give good sound absorption and reflection. The following table shows the maximum intrusive noise levels allowing reliable conversation:

Type of space and task	Noise level (dB)
Auditoriums requiring very good listening conditions	20 – 30
Small auditorium, lecture room and conference room	30 – 35
Small office, classroom and media centre and studio	40 – 45
Large office, restaurant	45 – 50
Workshop, machine room	50 - 55

Table 9.14

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Noise levels calculated at position of proposed building:

Vehicles per hour average - 1800
Speed of vehicles perpendicular to vantage point - 55km/h
Distance from centre of road - 25metres
Height of observer - 4metres above road level
View angle - 127degrees
Distance to closest intersection in road - 170metres

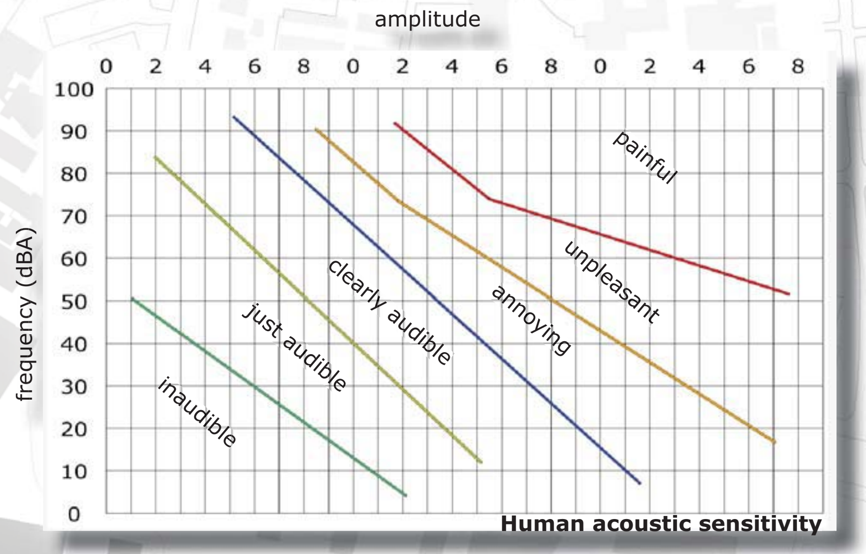

fig. 9.16

Noise concentrating on site due to traffic

fig. 9.15

Drainage, water supply and stormwater drainage

Normal supply and supply for fire protection

Potable water supply should be linked to the existing supply grid of the University of Pretoria's main campus. A fire hydrant should be supplied and be accessible from Lynnwood Road. The fire protection supply should be on a dedicated water supply system and not linked to the normal water supply network.

In addition to potable water supply to kitchens, ablution facilities and workshops, a 25mm diameter cold water supply pipe should be provided to serve the air conditioning units inside the plant room.

Hot water should only be supplied to the kitchen, workshop and printing studio.

Cold water conservancy tanks should be provided for buildings which exceed two storeys in height. These can be used to supplement normal water supply or supply for fire protection.

Stormwater drainage

Guides for the sizing of downpipes and gutters are provided SABS 0400 part RR3.1. The relevant data in Table 9.17 has been reproduced for use in the proposed building.

Rainwater downpipes shall have a cross section of no less than 100mm² for every 1m² of roof plan area which it serves. And at no time be less than 4400mm²

All stormwater runoff should be piped and linked to the existing stormwater system which links up with the main stormwater channels in Lynnwood Road.

Gutter and downpipe calculations

Rainfall region	Internal cross sectional area of valley or gutter per m² of roof plan area served
Summer rainfall region	140mm²

Table 9.17

stormwater disposal

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Storm water storage tanks

Volume of storage tanks (proposed)	$304m^3$
Volume of storage tanks (proposed)	304000litres
Total roof catchment area	$1632m^2$
Precipitation per day (maximum average)	14mm
Roof area X precipitation	$22.848m^3$
Volume of storm water/day	22848litres
Volume of grey water used in sanitary appliances per day	262litres
Total rainwater available for irrigation per day	22586litres

Table 9.18

Grey-water use in proposed building per day

	WC's	Urinals
Male	1litre/50students	1litre/50students
Female	1litre/30students	n/a

Number of students in building (approximated maximum)	
Male	300
Female	300

Water usage per day		
	WC	Urinals
Male	6litres/wc	6litres/urinal
Female	10litres/wc	n/a
Number of sanitary appliances		
Male	8+1 disabled	8
Female	16	n/a
Male	54litres/day	48litres/day
Female	160litres/day	n/a

Total usage per day	**262litres/day**

Table 9.19

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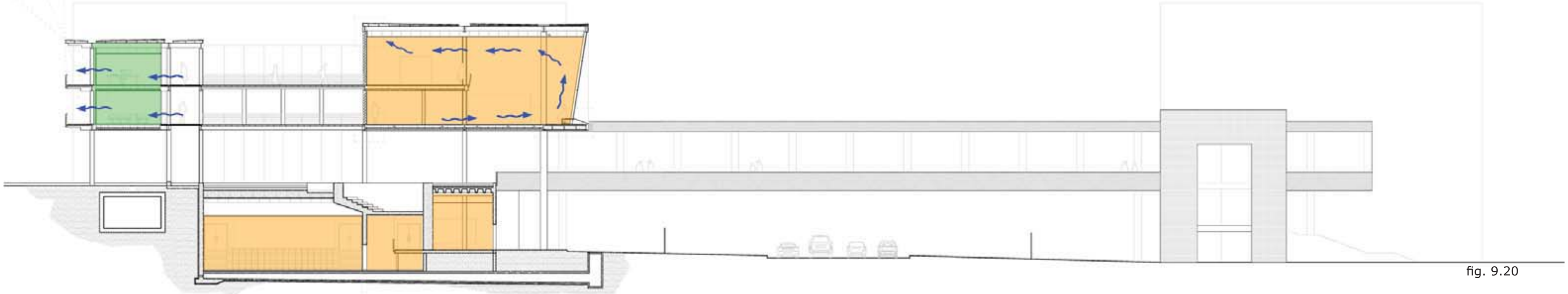

fig. 9.20

galleries, lecture theatres and classrooms to be air conditioned with humidity control in galleries art storage and restoration spaces

natural cross ventilation in offices and crit rooms on northern side of proposed building

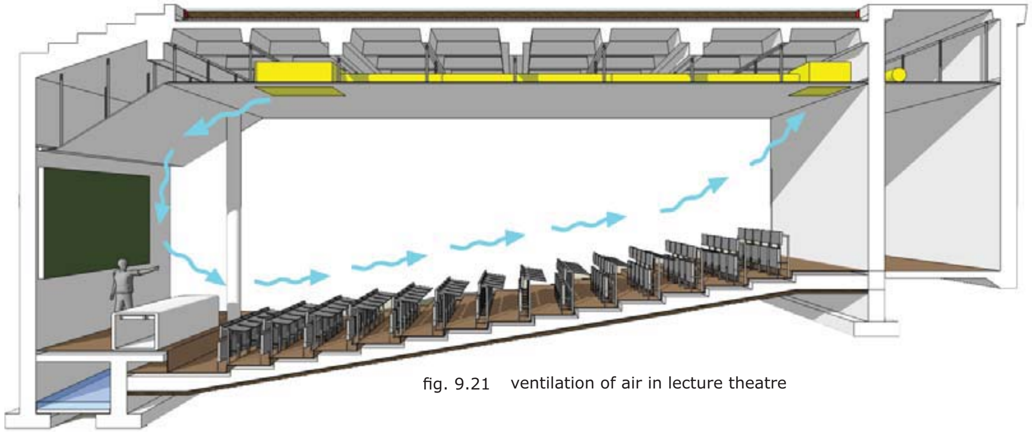

fig. 9.21 ventilation of air in lecture theatre

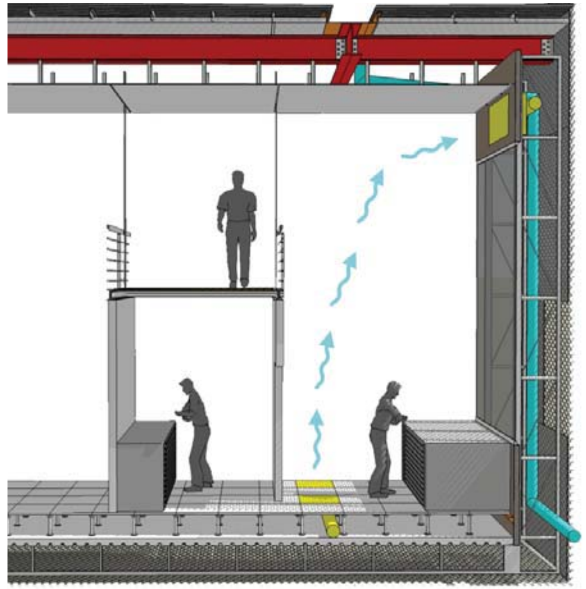

fig. 9.22 mechanical ventilation in workshop allows dusty air to be drawn into ducting inside the double skin facade

ventilation