>>>5.Technical Investigation_

technical investigation

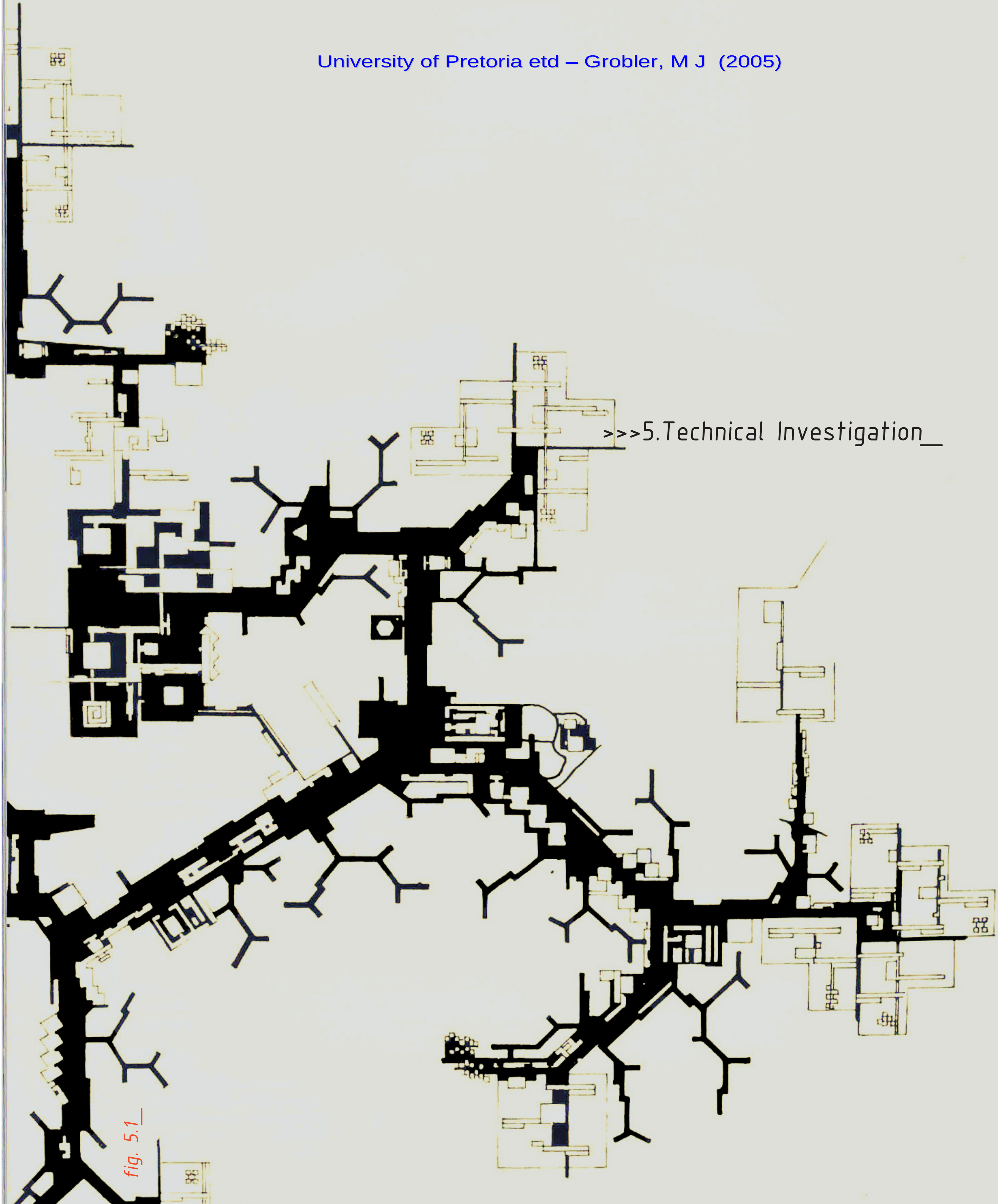


fig. 5.1_

Technical Investigation_

>>5.1 Acoustics_

Precedent_

AGA Hall in the H. P. Berlage's Exchange building in Amsterdam
Designed by Pieter Zannen 1989

This hall has been credited for acoustic excellence. It was studied to recognize the implications of the use of glass in acoustic sensitive spaces. In particular, examples of how to prevent flutter echoes and minimize reverberation is expected.

The Netherlands Philharmonic Orchestra commissioned him to design just a rehearsal hall. The site, within one unmodified hall in the Exchange, was not ideal. The acoustic problems were considerable. The space is also subject to some traffic noise from the nearby road and from sound leakage from the adjoining hall. For adequate sound insulation a heavier roof or suspended ceiling would have been essential. The windows would have required double glazing and every entrance would have needed to be lobbied. Also, vast amounts of acoustic absorption would have been needed to reduce reverberation time. All were architecturally unacceptable. The solution was to build a box within a box.

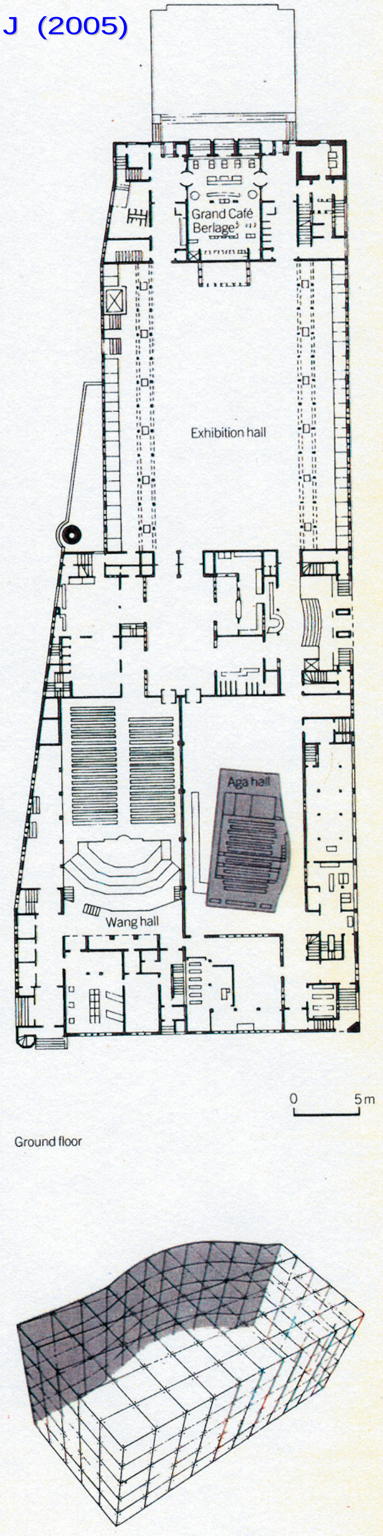


fig. 5.2_ Position of hall within the Berlage's Exchange building

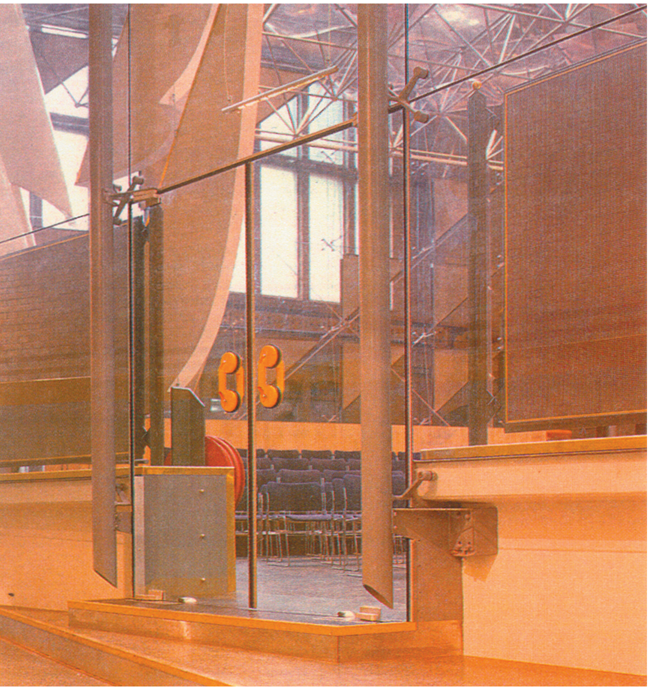


fig. 5.3_ Door with similar acoustic performance to the wall

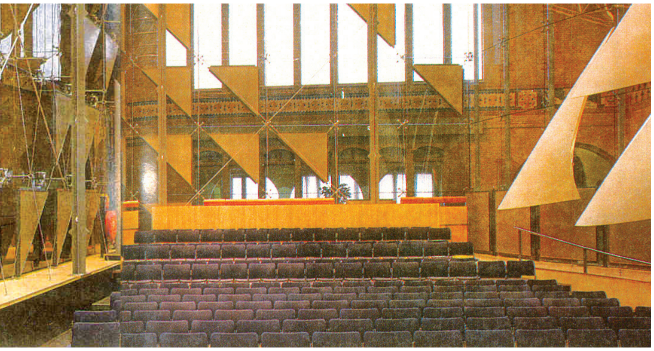


fig. 5.4_ The hall in concert layout

-So as not to destroy the architecture of the space, the walls of the inner box had to be glass. The charm of the Berlage interior would be visible from the inner box and its interior could be seen from elsewhere in the original space. While this is aesthetically logical, the acoustical problem appeared to be without precedent [Lewers, 1990:51].

There are few acoustic problems associated with the glass walls. The sound insulation of the single layer of 8 mm toughened glass already chosen is about 25dB. Single glass doors offer comparable sound insulation. This glass partition reduces the background noise level from 48dBAin the outer volume to an acceptable level in the inner box. This level of sound insulation is also enough to ensure that the offices surrounding the hall are not subject to disturbing noise levels from orchestral rehearsals. Excessive reverberation reduces clarity. Musical detail is then harder to discern. Chamber music suits halls with a shorter reverberation time than is normal for conventional concert auditoriums; it is a form of music written to be performed in smallish rooms with an audience of only a few dozen people [Lewers, 1990:51]. Reverberation time is directly proportional

technical investigation

to volume and inversely proportional to the amount of acoustic absorption in the room [Van Zyl, 2004]. For reasons other than the acoustic, there was a limit of 2000m^3 for the volume of the inner box, one-fifth of the volume of the original space. Thus, the reverberation time of this box is naturally less than the seven seconds of the original. In the finished box the reverberation time is 1:6seconds in its rehearsal format and 1.3 seconds in concert format with an audience present.

Resonance and diffusion__

Flat surfaces within concert halls can detract from ideal listening, conditions due to too little diffuse sound. Sound reflecting between flat surfaces may lead to resonance and flutter echoes. An orthogonal space accentuates these problems. If the surfaces are wide apart, an impulsive noise bouncing between them may sound like a series of echoes. If the surfaces are closer, the echoes coalesce into a metallic ringing sound. These flutter echoes can be very disturbing both for performers and listeners and should be prevented. The designers reduced the number of parallel walls. Seen from the inside of the box, a convex shape would have reduced seating space but not focused sound. 'The concave surface could have caused its own acoustic problems by focusing sound.

Diffusing 'sails' on the concave wall obstruct any possible focusing – they present a hard convex surface to the room and have a sound absorbing rear surface. The plastic domes cover 30per cent of the ceiling and face low frequency absorbing material. A uniform reverberation time over the middle frequency range is maintained by the acoustic absorption in these elements [Lewers, 1990:52].

The use of glass in speech-orientated halls should be restricted as it increases unwanted reverberation times. It is however possible to use segments of glass provided that the absorption of the hall is increased and the volume limited. To avoid flutter echoes, parallel glass surfaces should be avoided. The initial octagonal shape for a ground level conference hall should be reconsidered.

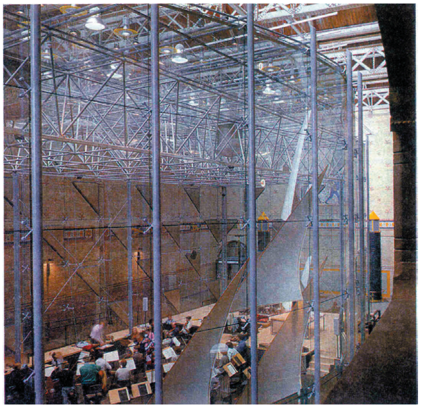


fig. 5.5__

Curved wall of the glass box

*Noise Control*_

The most important kind of external noise affecting this building is transport noise from road traffic. This noise is estimated at 75-80 dB during rush hour. As long as it is relatively constant and immediate noise is eliminated, distant road and city noise can actually work to your advantage, as it now acts as ambient noise. As noise is defined as the difference between the measured sound and the ambient noise, an increase in ambient noise will reduce the impact of the blast of sound considered as noise. Pedestrian noise and street activity is the other concern. This is estimated at 65-70 dB. The diverse functions of the centre requires diverse sound considerations:

- *In conference centers and auditoria noise should not exceed 30 dB.*
- *Exhibition gallery, 35-38 dB*
- *Office, 50dB*

The whole structure can protect more noise sensitive spaces on the side remote from the traffic. This is mainly why a hotel is sited between Schoeman Street and the Conference Centre, also because a hotel favors a location with an important address. Noise considerations for the hotel are less vital than in the conference rooms. The fact that the hotel will have to be sealed from the outside regardless, for the sake of air conditioning, makes this the clear position for it.

Noise control already starts on the outside of the building where grass and vegetation will absorb sound pressure waves. Vertical planters, incorporated into gabion structures will also absorb noise. The gabion walls will screen of direct sound pressure waves, causing them to travel further. Traveling through more air, they will be less pronounced.

From here sound will be restricted to the outside by sound insulation. The best insulator of sound is mass. A 110mm plastered brick wall reduces noise by 48 dB and a 220mm plastered brick wall by 54dB [Van Zyl, 2004]. The next step is a cavity wall filled with glass wool. This would be too extravagant for the noise reduction level that is to be achieved.

By buffering sound sensitive spaces with translation rooms, storerooms, foyers and the ventilation stack, huge cavity walls are actually created. The enclosed air in these spaces will absorb all noise emerging through the outer skin. This is an extremely cost efficient way of isolating noise, as minimal specialized

technical investigation

acoustic materials and building methods is required.

Glass. A normal openable window can only achieve 10dB reduction in noise. To increase reduction, the frame should be able to seal tightly. Aluminum frames work the best because of their small tolerances. A good steel profile would also be adequate. The glass used floats in neoprene packing manufactured by Sonlor. These rubber strips have a closed cell structure. A thick 10mm strip will be used because of the deformations in the steel profile and the expansiveness of some glass elements. Laminated safety glass, consisting of 3mm and 5mm thick segments is used. The glass has a 30-33 dB reduction. [Van Zyl, 2004].

The use of a double-glazing frame proved to be too expensive. Where double-glazing is used, two singular frames are situated alongside each other with a 50mm air gap. This method can achieve a 45-50 dB reduction [Van Zyl, 2004] and is more economical. The thickness of the two glass planes is different. This is to prevent resonance of the glass. Certain sound pressure waves will cause a glass panel to resonate at its natural frequency, making its sound reduction redundant. The second panel now has a different thickness and natural frequency, discontinuing this phenomenon. By placing each frame on its own side of a cavity wall, even more reduction is possible. The wall cavity is filled with glass wool to absorb more sound. The glass cavity should have a few small holes to prevent the build up of moisture. This method has been used in the translation rooms and machine rooms.

The reduction sound through doors is problematic. Doors deform over time, causing it not to seal properly. Acoustic doors are highly specialized elements that need to be hand made. A door with a limited lifespan achieving 40 dB reductions is priced at R18 000 [Van Zyl, 2004]. The employment of spaces acting as plenums, make the use of low-priced doors viable. Double doors can achieve larger noise reductions economically. The foyer between the doors should be lined with sound absorbing material.

A foyer serving conference halls and auditoria creates a plenum that prohibits sound from intruding or escaping from the halls. These foyers incorporate absorption to eliminate noise. Foyers are so designed that they can be leaved open. The difference in pressure between *the foyer and atrium spaces prevents sound to infiltrate due to the effect of impedance.*

Sound is transmitted from one room to an adjacent room via many paths. Where the separating wall has a sound reduction index of 35 dB or less, most of the sound is transmitted through the wall. If, however, we try to improve the insulation by using a heavier wall, the flanking paths, or indirect transmission routes, become more important. In fact, it is difficult to achieve better than 60 dB sound level differences without special measures, such as carefully designed structural discontinuities, to reduce the flanking transmission. [Adler, 1999:40/4] By creating a 'box within a box' these dangers are ruled out.

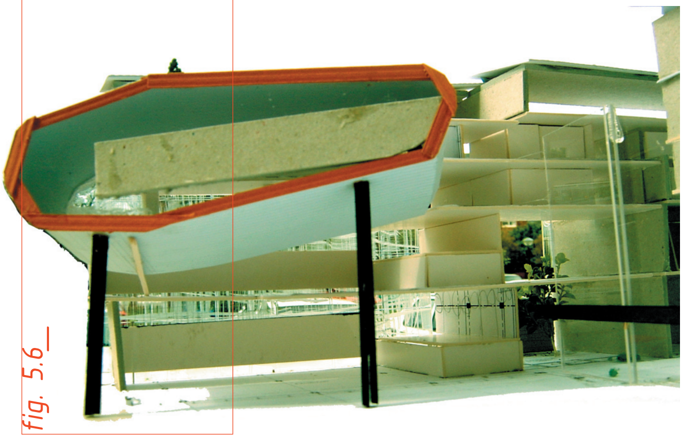


*fig. 5.6_*

*>>3. Auditorium Acoustics_*

_Form

Spatial layouts and sight lines dictated the form. Very large auditoria are difficult to fill with sound. Most of the direct sound will never reach the remoter parts, and the large surface area produces a corresponding absorption resulting in a weak level of reverberant sound. It follows then that the greater the volume of the hall, the less background noise can be endured.

technical investigation

Unconventional shapes introduce the risk of incorporating intolerable defects, which prove impracticable to correct. Consequently the forms of the halls is either rectangular or fan shaped.

Conference rooms and auditoria will mainly be designed to accommodate speech and have clarity as a key requirement. The shape should ensure that the audience receives strong sound reflections immediately after the direct sound. The first part of the ceiling or walls should be reflective, to enhance and project the voice of the speaker. Surfaces directly above and adjacent the speaker should be made absorbing or be so angled as to propel the sound forward. If this is not done, a stationary wave of sound forms between surfaces, which can be extremely disconcerting for any speaker. This is avoided by introducing a suspended, curving ceiling element that project the waves to the audience. The ceiling also disguise projectors and contain lighting and ventilation ducts.

Initially a dome shaped ceiling was envisaged. This caused extreme acoustical problems in that the dome would focus sound on selective areas and prevent it from reaching others. This was also the case with an initial conference area that was circular in plan. The circular segment of the fan shaped auditoriums does not produce this problem, as they are highly absorbing. The shape of absorbing surfaces is irrelevant, as they cannot reflect the sound in any way. Shape is only relevant to surfaces that reflect.

The height of the halls should not exceed 8m. This will cause too long a delay in the reflection from the ceiling. By using a projecting element above the speaker, the space can have a greater vertical dimension. Great vertical dimensions are considered for occupant comfort, sight lines and passive climate control.

The smaller the volume of the hall, the higher the level of the background noise can be. This is why the sizes of conference rooms were kept modest. The smaller conference rooms can now have greater interaction with the partially enclosed outside spaces. Surfaces that are opened to the outside will be discussed further under absorption.

Musical events will be limited to the main hall

_Reflection

Sound Propagation in an Auditorium_

Direct sound will decrease by 6 dB for each doubling of distance propagated. Our auditory system will determine the direction of a sound source from the direct sounds reaching the ear. The source is perceived to be in the direction from which the first sound arrives provided that (1) successive sounds arrive within about 35 milliseconds, (2) the successive sounds have spectra and time envelopes reasonably similar to the first sound, and (3) the successive sounds are not too much louder than the first [BSI, 2003: 16]. This is required for speech in the auditoriums and conference halls. Shortly after the arrival of the direct sound, a series of semi-distinct reflections from various reflecting surfaces (walls and ceiling) will reach the listener. These early reflections typically will occur within about 50 milliseconds and are not heard as separate from the direct sounds. Rather, they tend to reinforce the direct sound. The reflections, which reach the listener after the early reflections, are typically of lower amplitude and very closely spaced in time. These reflections merge into what is called the reverberant sound or late reflections. If the source emits a continuous sound, the reverberant sound builds up until it reaches an equilibrium level. When the sound stops, the sound level decreases at more or less a constant rate, until it reaches inaudibility. For impulsive sounds, the reverberant sound begins to decay immediately [BSI, 2003:19]. During a continuous sound, the reverberant sound level is reached when the rate at which energy is supplied by the source is equal to the rate at which sound is absorbed by the room and its contents. The reverberation time is defined as the time taken for an interrupted sound to fall in level by 60 dB. The reverberation time and its variation with frequency is probably the most significant measurable factor determining the acoustical character of a room. In a bare room, where all surfaces absorb the same fraction of the sound that reaches them, the theoretical reverberation time is proportional to the ratio of volume to surface area. It can be calculated from Sabine's formula:

__Absorption

Absorption is crucial to prevent the upsurge of reverberation. Together with late reflections, these sounds are not perceived as part of the direct sound from the source and are consequently no more than disturbing noise. This is especially the case in speech-orientated halls. Late reflections occur from surfaces furthest from the source like the back walls and ceilings. To absorb sound, the pressure waves needs to set the material particles in motion, causing it to be transformed into heat. For this thick, open cell structured fibers are required. Soft plastic foams perform the best but has a limited lifespan and release toxic fumes during fires. Glass wool and mineral wool is used as they perform the best, measured against life-cycle cost. These materials can withstand temperatures in excess of 1200 degrees [Van Zyl, 2004]. These materials only start absorbing at 25mm thickness. 100mm thicknesses are required to absorb lower frequencies. High frequencies are easy to absorb and the contributions of carpets, air and the audience are already significant. Air contributes a substantial amount to the absorption of high frequency sound.

Low frequencies require more mass to absorb and have a cost implication. By introducing a 50mm air gap, only 50mm thick glass wool board can absorb almost the same as a 100mm thick one, reducing costs significantly. A permeable material, such as perforated board or spaced wooden slats, protects this board. This covering should allow for 15-25% permeability [Van Zyl, 2004]. The mounting fixture is be constructed of metal, wood or other non-porous material with a surface density of at least 20 kg m2, and enclose an air space The joint between the fixture and the room surface is sealed to prevent air leaks between the enclosed space and the outside.

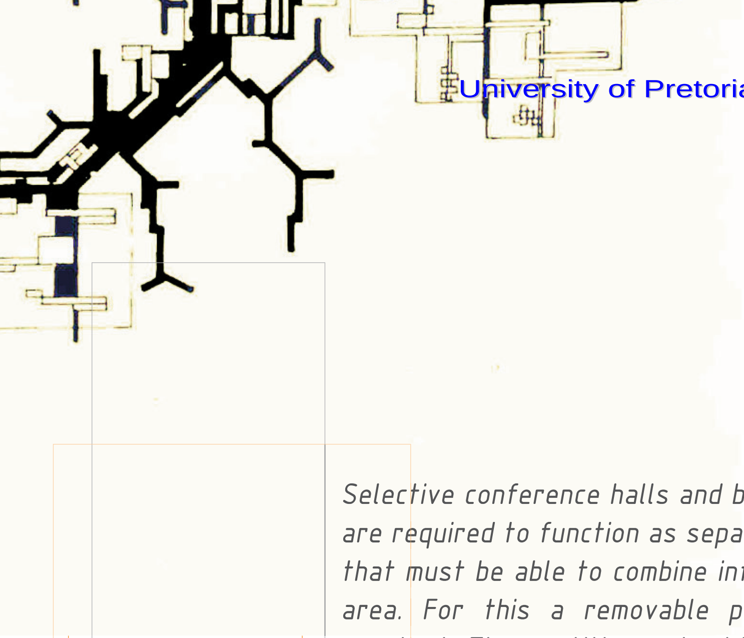
The best absorption is achieved by an opening to the outside, where nothing can reflect the sound back inside. The problem is that noise will infiltrate. The noise can however be overpowered by electronic amplifying, but may become a new source of noise for other halls and auditoria. In the smaller halls and boardrooms, this is not a problem. Here more background noise can be tolerated and they are opened up towards semi-enclosed exterior spaces.

__Diffusers

Diffusion of sound is not preferred for speech and diffusers used in the conference halls and auditoria, are reflecting panels that are angled at minimum 4 degrees [Van Zyl, 2004], only to prevent stationary waves from forming. These stationary waves are perceived as flutter echoes.

For musical performances many prefer early sound reflections arriving at the listener from a lateral direction. [Adler, D. 1999:40/2] To prevent stationary waves, and to diffuse sound, there are angled partitions that can be retracted into the ceiling void. Diffusing elements should be sheets with low sound absorption and with a mass per unit area of about 5 kg/m2. Diffusers of different sizes, ranging from approximately 0,8 m^2 to 3 m^2 in area (for one side) are recommended. [BSI, 2003:18]. The sheets are slightly curved and is oriented at random and positioned throughout the room.

__Sliding Screens



Technical investigation
Technical investigation

Selective conference halls and boardrooms are required to function as separate areas that must be able to combine into a larger area. For this a removable partition is required. The partitions should be sound absorbent and must not allow sound to permeate to the adjacent hall. An acoustic sliding screen is used that can be stacked away, combining the two spaces. The panels consist of two absorbing layers with an air cavity and have a stop that drop out, into the floor to completely seal the space.

_Using sound amplifying.

The main hall will rely heavily on electronic sound amplifying, mainly because of its huge size and multiple uses. In conference and auditoria, normal speech is preferred, but presenters will have the opportunity to use electronic sound reinforcing. The use of electronic equipment is necessary for translation purposes, which will occur often seeing that South Africa entertains 11 official languages. For this purpose translation rooms are much bigger than recommended.

For acoustic excellence, a hall should be as dead as possible when using sound amplifying [Van Zyl, 2004]. This translates into large, highly absorbing panels and minimum reverberation. A misconception is that by increasing the amplification of sound, the reverberation noise will be drowned out. This is not the case and will only result in even stronger reverberation and a louder noise. A hall that works well for speech and drama will consequently also serve well for the use of electronic sound amplifying [Van Zyl, 2004].

Offices_

Part of the office functions as open. Partitions double as sound absorbing pin-up boards to prevent sound from one cubicle to be audible to the rest of the office. This alone is not effective and consequently the ceiling is made highly absorbent. Background noise from outside is permitted to a certain extend to elevate ambient noise in order to mask one person's voice from its neighbour. All these measures will not eliminate sound proliferation, but will deform voices to incomprehensible murmurs [Van Zyl, 2004].

To isolate sound in closed offices, a cavity is introduced into the dry walling. Each panel is framed in an independent structure to eliminate flanking. Dry walling extends through the ceiling all the way to the slab. Mineral wool is laid inside and, together with the air gap, the whole ceiling now acts as a plenum, preventing sound to spread.

Residential units__

Acoustic considerations concerning the residential units were limited to noise control. By positioning them on the top floors, the units are removed from the noise on the street. They are also set back to the middle of the floor to remove them from the line of sight of noise. In general these methods would suffice in controlling street noise, but as these units are intended for an affluent market segment, more precautions were taken. All units entertain vast spanning glass facades. Double glazing was ruled out due to cost implications. The sound insulation was rather incorporated into the shading device. This resulted in a manageable device that can be closed to enclose an air cavity. This cavity not only acts as thermal insulation, but as sound insulation as well. Care was taken to eliminate the possibility of flanking by incorporating neoprene joints to stiff members protruding through the cavity. Rubber seals at edges ensure a fully enclosed cavity and limits sound proliferation transmitted by resonance of the outer sheet.

technical investigation

>>5.2 Climate control_

An openable ventilation stack is situated on the northern façade. The stack acts as a buffer for noise. It consists of a glass façade, and a concrete wall, which is painted black to promote heat gain. This system acts as a trombe wall, allowing the built up heat to dispense at night. When the stack is in the open position, the hot air escapes from the top, sucking in cooler air through the spaces. In the closed position heat is allowed to build up and dispense to the adjacent spaces. When necessary, this is assisted by mechanical fans. An investigation of the thermal levels, which can be achieved with this system, discovered that it is not adequate in peak summer conditions. A HVAC system will assist in peak conditions. All these systems will be operated through a Building Automated System [BAS]. Energy for the opening and closing of stacks will be attained from solar panels. According to an Internet weather report, the BAS will allow heat to be flushed out at night.

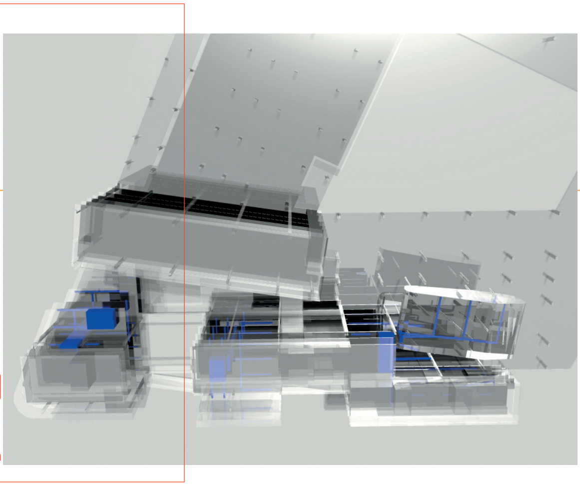


*fig. 5.7_*

Plant rooms and air ducts of the HVAC system

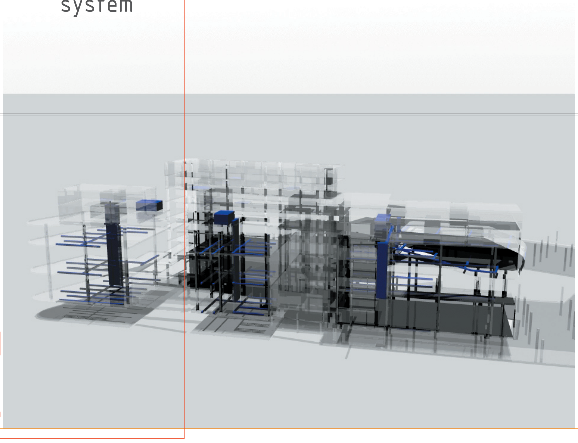


*fig. 5.8_*

The atrium will rely solely on passive ventilation for climate control. Hot air is allowed escape through the roof. Heat gain through northern glass curtain walls heats up the atrium in winter. A split console unit will be used in the cafeteria. Conference rooms will have separate split console units so that future tenants may be billed separately. This also allows for greater future flexibility, smaller duct spaces and individual control. Ducts run in the floor and air is released through operable vents in the floor. Only the bottom part of the space is required to fall within the thermal comfort zone. Hot air is allowed to accumulate at the top. The BAS will calculate the most efficient source for the intake of air, depending on outside conditions, or whether to recycle the air. Hot air is available from the stack. Machine rooms are located near every hall to reduce duct spaces. The main hall will have a large machine room in the basement.

Residential units will rely on passive climate control. A ventilated roof will prohibit heat gain through the roof and ensure insulation in winter. Western walls are designed to absorb heat and release it at night. North and south facades are both of glass. This allows for heat gain in winter and excellent cross ventilation in summer. An exterior shading device that can enclose a sealed air cavity is used to block noise. It also serves as insulation to keep in heat. Units also have interior louvers.

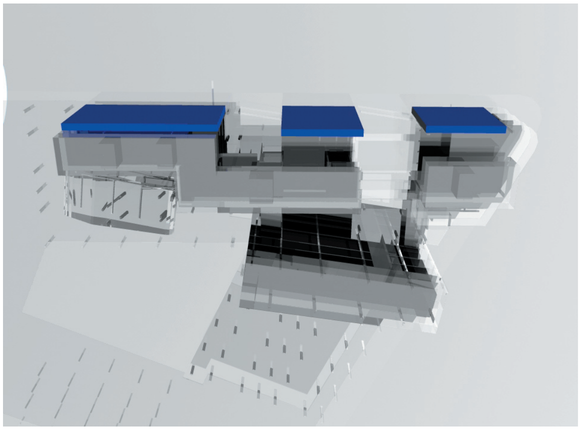


fig. 5.9_

Ventilation stacks and trombe walls

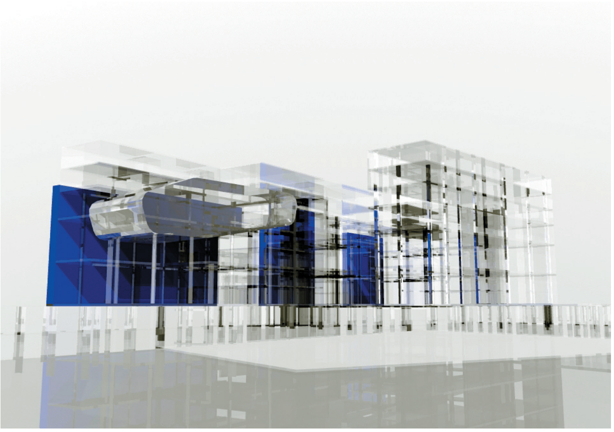


fig. 5.10_

>>5.3 Fire management_

The building is designed to comply with the SABS fire regulations. This is the main reason it has a concrete structure. Larger conference halls and auditoria are sited at ground level. Because they seat more than fifty people, two or more exits should be provided. The halls on upper levels seats less than 50 people and therefore one exit suffice, eliminating the need for expensive additional staircases. No person is more than 45m away from an exit. A sprinkler system serves all spaces. Glass wool and mineral wool is the chosen as materials for acoustical treatment, for reasons which include their fire resistance.

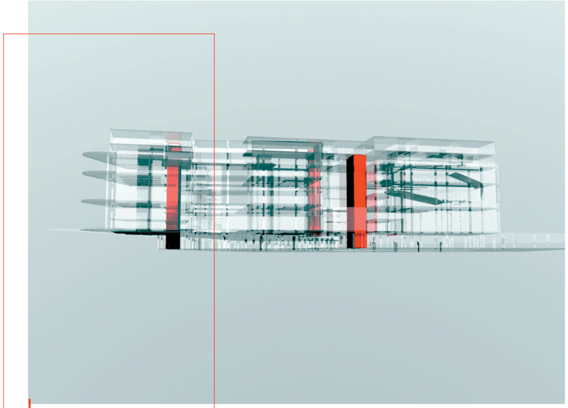


fig. 5.11_ Fire escape stairs. Northern elevation

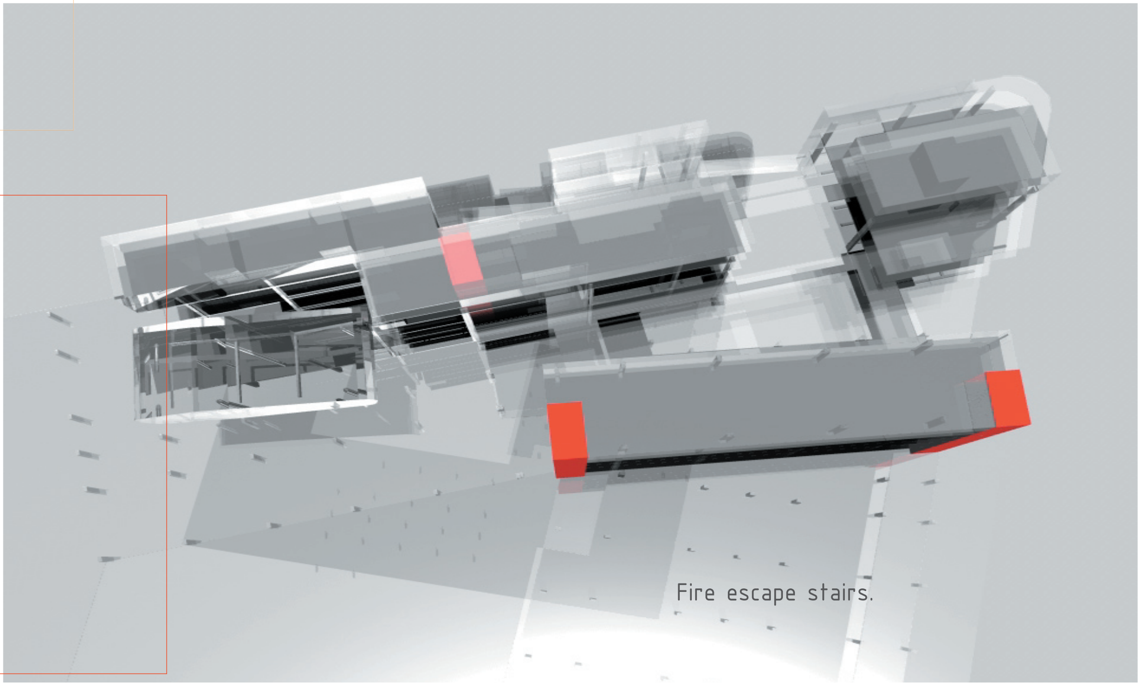


fig. 5.12_ Fire escape stairs.

>>5.4 Water system_

Grey water will be filtered and cleaned and then stored. A solar powered pump will circulate the water to be used for flushing toilets, washing and irrigation. Municipal water will supplement the grey flushing system in the dry season. The sewerage will form part of the municipal system. Rainwater will be harvested, UV-filtered and stored and then used for irrigation, evaporative cooling and circulation of the grey water.

>>5.5 Solar energy_

Solar energy will be used for opening and closing the ventilation stack, as well as operating the water system. The solar panels used will be the copper-indium-gallium-diselenide-diulfide (CIGSS)-solar panels, recently developed by professor Vivian Alberts and manufactured locally. It is six times cheaper to manufacture than the normal silicone panels and is more efficient in transforming the energy into electricity. Where a normal 50W panel is normally imported for R3000, a CIGSS panel will cost R500. Solar panels doubles as shading devices.

Dit lyk dalk vir gewone mense na Grieks, maar die inligting op die skerm agter prof. Vivian Alberts, 'n fisikus van die RAU, kan sorg dat honderde elektrisiteitslose Suid-Afrikaners in plattelandse gebiede binnekort ook die luukse van elektrisiteit ervaar. **Foto: LISA SKINNER**

Goedkoop sonpanele dalk oplossing vir armes

'n Suid-Afrikaanse navorser se baanbrekerswerk met sonpanele bring nuwe hoop vir duisende mense sonder elektrisiteit, omdat dié panele nou goedkoper én vir die eerste keer plaaslik vervaardig kan word.

Prof. Vivian Alberts van die departement fisika aan die RAU het 'n koste-doeltreffende sonpaneel ontwikkel wat van koper-indium-gallium-diselenied-disulfied (CIGSS) gemaak word. Die aanvooraanleg by RAU waar dié sonpanele vervaardig gaan word, is gister deur mnr. Mosibudi Mangena, minister van wetenskap en tegnologie, by RAU bekend gestel.

By dié aanleg sal sonpanele vir die eerste keer kommersieel in Afrika vervaardig word.

Die CIGSS-sonpaneel is goedkoper om te vervaardig as bestaande silikon-sonpanele en is boonop baie doeltreffender om sonenergie in elektrisiteit om te skakel.

Mangena het gesê die departement van minerale en energie het onlangs waarskuwings uitgestuur dat Suid-Afrika moontlik reeds teen 2006 nie meer in die plaaslike vraag na elektrisiteit sal kan voorsien nie.

"Om dié rede is projekte soos dié, wat na alternatiewe energiebronne kyk, baie belangrik vir ekonomiese groei op die kontinent. Dié projek gee voorts nie net aandag aan hoe energie op 'n volhoubare en bekostigbare manier aan arm gemeenskappe verskaf kan word nie, maar maak ons ook opgewonde oor die groot potensiaal wat dit het om die globale kwessie rondom hernieubare en omgewingsvriendelike energievorme te help oplos."

Volgens Alberts het die nuwe tegnologie nie vroeër in Suid-Afrika bestaan nie en moes 50W-sonpanele teen 'n koste van tussen R2 500 en R3 000 stuk ingevoer word. Dit sal sowat R500 kos om 'n soortgelyke CIGSS-sonpaneel te vervaardig.

Alberts se deurbraak lê nie net in die materiaal wat hy gebruik nie. Hy het die tegnologie wat in die vervaardiging van sonpanele gebruik word só verbeter dat sonenergie amper net so goedkoop word as die energie uit fossielbrandstowwe soos steenkool, olie en gas. – **Annie Olivier**

fig. 5.13_

Technical investigation

>>5.6 Structure_

The main structure consists of concrete columns and slabs. This allows for greater flexibility in future. Although certain columns are subjected to greater forces where some beams have greater spans, they all have the same dimensions. These columns will have more steel reinforcing. This allows for the same shuttering to be used, streamlining the construction process. Steel trusses support ventilated, sheet metal roofs. Circular, hollow section steel columns support the protruding atrium, which incorporates water drainage to storage tanks. The auditorium has a steel frame with metal cladding supported to a secondary frame. The floor, walls and roof are all part of the same folded plane.

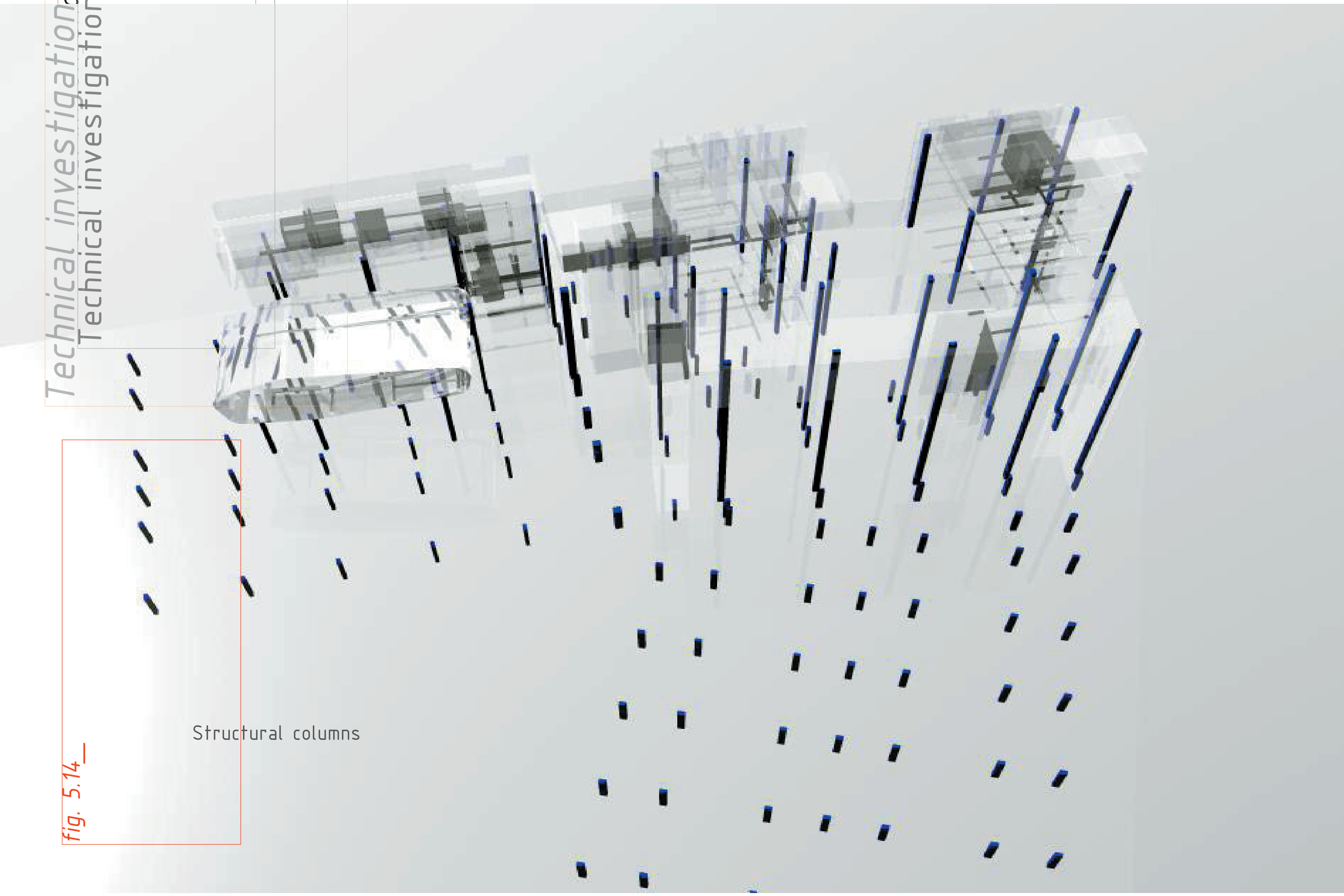


fig. 5.14_

Structural columns

technical investigation

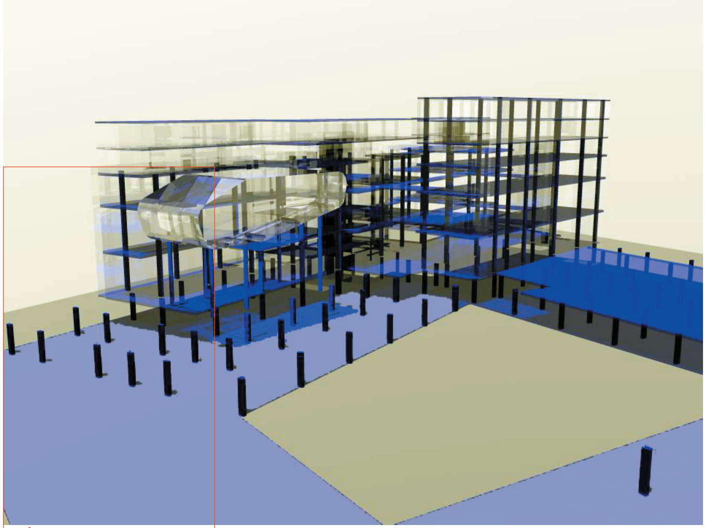


fig. 5.15_ Concrete column and slab structure