NICE OFFSHORE - A CASE STUDY IN DISCOTHEQUE NOISE CONTROL

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1. INTRODUCTION

Many discotheques and similar forms of entertainment take place in lightweight buildings where traditional mass controlled noise control is inappropriate. This paper will describe a discotheque problem in which lightweight partition techniques were used as the basis of a scheme that accommodated the architect's aesthetic concepts, met an extremely tight contract timetable and by utilising the residue of an earlier attempt, contained costs at a realistic level. Before and after measurements are given.

2. THE PROJECT

Nice Offshore is located on the corner of rue Alphonse Karr and Avenue Georges Clemenceau, Nice, Cote d'Azure and is targeted at the Mediterranean "offshore" yachting, power boat racing, water skiing and designer deckwear set and chic social scene that goes with it. There is no connection with North Sea oil exploration!

The club is a conversion from the former La Grand Escurial cinema which, although it had been used as a discotheque for some years, still retained all the appearance and trappings of its original purpose. In keeping with the Continental European penchant for economy of space, the building provides nine lock-up shops and its own entrance lobbies to the street frontage with the cinema auditorium behind and a substantial number of apartments on the roof. Fig #3 shows the architect's as-existing survey plan on both floor levels.

Because the noise problem has existed since the first discotheque conversion ten years previously, extensive noise control works, including a floating concrete floor and an isolated ceiling barrier had already been implemented. Notwithstanding the extent, complexity and apparent cost of these works it appeared that none have been effective in resolving the problem so following several years of complaints the Nice authorities were determined that the problem would be solved once and for all and made an effective noise control scheme a condition of planning consent and license.

3. THE PROBLEM

Interviews with residents showed the principal problem to be the constant bass throb of the music and from certain apartments they could identify the particular record being played and hear the DJ's voiceovers. Many were elderly and clearly distressed, many

telling of sleepless nights, and as previous attempts had failed to resolve the problem, were very sceptical that anything would come of this latest endeavour. Some had even resorted to staying with relatives for the weekends.

The problem, unfortunately, is a very common one, for which conventional solutions are not usually effective. The principal difficulty is that for this form of entertainment to be viable, a certain minimum volume level and sound quality is necessary. This can be termed the "adrenalin level" and appears to sit somewhere in the 96dB(A) region, subject to achieving a prerequisite spectral energy distribution, as shown in the upper curve of Fig #1. Note that over the 50Hz - 100Hz octave the energy is some 20dB above the mid-band average, registering 110dB in the 63Hz and 100Hz 1/3rd octave bands as compared to a wide band sound pressure level measurement of only 96dB(A). If this low frequency peak is reduced, then a higher overall volume level will be necessary to achieve a comparable "adrenalin" impact <1>.

The lower curve of Fig #1 shows the residual noise outside a premises. Note that whilst the building facia provides adequate attenuation at mid and high frequencies, this does not hold at LF, leaving that pronounced bass beat clearly audible outside. This is because the Mass Law:-

$$TL = 20 \log (mf) - 47.5$$

where: m = mass density in Kg/sq.m, f = frequency

determines that any partition will provide the lowest TL performance at the lowest frequencies - ie the very area where the highest attenuation is needed. Hence the problem.

4. NOISE TRANSMISSION TESTING

Tests were carried out using an Ivie IE-30A combined SPLM/RTA with its associated IE-17A processor coupled to an HP/Urei 200 XY plotter. A music replay system, incorporating loudspeakers etc found on site from the original disco sound system, was set up to provide the required music spectrum to serve as a test signal. This measured 95dB(A) as shown in the upper curve of Fig #2.

The residual sound was clearly audible in the car park at the rear of the apartment block adjoining Le Grand Escurial and was measured at 72dB(A). Thus, the rear facade was providing only 23dB of sound attenuation in A-weighted terms.

A similar test was carried out in the living room of one of the worst effected apartments at 2nd floor level, shown as the lower curve of Fig #2. Here the music was clearly audible and the bass

beat particularly intrusive. It can be seen that on average, only 45dB of attenuation is being provided by the building over the 50Hz - 100Hz octave. It was observed that the music was still louder in the corridors at 1st, 2nd and 3rd floor levels, where there were no carpets or furnishings to provide absorption and that the handrail to the main staircore was vibrating.

5. SURVEY OF EXISTING NOISE CONTROL MEASURES & BUILDING ELEMENTS

Floating Floor

By breaking out an inspection well it was ascertained that this comprised steel mesh reinforced, site poured concrete, carried by compressed low density fibreglass as a resilient layer, on a PVC sheet DPC, laid over an original concrete floor. There was no evidence of pads or bearings and the perimeter isolation barrier had been bridged in several places due to repairs to the floor screed and alterations over the years.

Isolated Ceiling

This is an extremely complex affair whose conceptual and engineering integrity can only be admired and which must have cost hundreds of thousands of Francs to erect. It essentially comprised a series of steel lateral trusses some 2m below the original fibrous plaster ceiling, spaced between 3.5m and 5m apart, rigidly attached to the structural roof joists by means of steel spars, each with a secondary truss suspended under it by 10mm steel studs carried by proprietary isolators mounted across its upper face. Fig #4 shows the general arrangement.

From the secondary truss is carried a longitudinal superstructure which in turn carries a 2.4m x 1.2m grid of welded T section steel framing, in which is fitted 3 x 13mm full sheets of GRP board, sandwiched together and having a 50mm quilt of low density fibreglass wool laid over. The grid is stopped just short of the perimeter walls and the gap filled with a flexible caulking, thus providing a structurally isolated suspended ceiling system of considerable mass as shown in Fig #5.

This elaborate construction however extended only from the rear of the balcony to the line of the proscenium arch, leaving what was originally the stage area unprotected, it had been penetrated in a number of places and many of the flexible seals were falling out. Also many of the isolation mounts were not aligned with the clearance holes in the lower flange resulting in short circuiting of the isolation mounts via the suspension studs. Further, the GRP panels were sagging due to being supported only by the perimeter lip of the grid with no stiffening to the panel.

Roof Slab

This also formed the floor slab to the 1st apartment level. It was found to be only 15cm thick, comprising steel mesh reinforced site cast concrete, carried by a series of substantial concrete encased lateral RSJs. Thus, with the original fibrous plaster ceiling broken away over fairly large areas, there was only the isolated ceiling and the roof slab separating the discotheque from the apartments above. Using the standard Mass Law formula, the calculated TL figure for this roof is 43dB at 100Hz and 37dB at 50Hz, which agrees with the measured data as earlier discussed and shown in Fig #2.

Side Walls

The outer shell was of site cast concrete with a lining of 50mm low density aerated concrete block over a void which varied between 400 and 600mm. These linings extend upwards to meet the line of the original plaster ceiling and were unfortunately tied back to the outer shell for stability.

Transmission Paths

These were not easy to identify because the rambling nature of the building layout and the absence of any architects drawings. It was possible however to locate particular areas where the sound was louder and using a stethoscope to identify particular walls and columns which are more "live" than others. There was however no evidence of voids, hidden stairwells, disused lift shafts, ventilation ducts or chimneys, although the apartments over the stage end seemed worst affected.

6. THE OPTIONS

This was an obvious candidate for the classic box-within-a-box formula. It would have been a relatively simple matter demolish the isolated ceiling, the remnants of the fibrous plaster ceiling and side wall linings, solidify the dubious floating floor with a further screed and start afresh. Because of the existence of a substantial balcony, the irregular floor levels and triangular floor plan, this would however have been an extremely expensive and complex exercise which would have reduced the licensed capacity of the premises and hence its earning potential and would have delayed the opening until well into the lucrative "season". Also the architect was anxious that at least some of the interior character of the original building be retained and in any event the side wall linings carried huge murals by a local artist of some note, which the Nice authorities wanted preserved, even if these were not actually visible in the refurbished premises. So it was decided that this was not a viable solution.

Accepting that some compromises in the overall noise performance would result, especially at low frequencies, a hybrid scheme was devised whereby as much of the previous noise control works as practicable would be refurbished and re-used and the scheme extended to come as close as we could to the isolated box ideal.

7. DESIGN OVERVIEW

It has long been known that a partition construction of lower mass can often provide better low frequency Transmission Loss performance than a rigid structure. This is because the partition is allowed to behave as a damped resonator, thus absorbing energy as well as providing a barrier. This approach will usually provide far better performance than a Mass Law calculation would suggest as illustrated in Fig #6 <2>. The BBC have used this form of construction in broadcast studios for many years and have achieved startling results with their "Double Camden" screen <3> whilst investigations into the effect of adding a low mass damped lining to a brick wall, carried out by British Gypsum <4> as shown in Fig #7, show a solid 10dB increase in TL.

On the basis of successes in discotheque noise control achieved using this technique elsewhere <5><6> it was decided that a similar approach, adapted to suit the prevailing site conditions, would be adopted. Fig #8 shows the ground floor plan and section through for the finished club.

8. THE BUILDING SHELL & VENTILATION

The first operation was to remove all windows, all ventilation openings and all unnecessary doors and brick up the openings. Next, all the doors to be retained were uprated and provided with noise seals and sound trap lobbies to prevent escape of noise by these routes. This is all standard stuff so I shall not dwell on it here. That meant however that there was then no ventilation to the premises and so mechanical air handling plant had to be provided. This in itself presents a further source of noise so careful siting was necessary, accompanied by the use of noise reducing spiral ducts and louvre silencers at the point of intake and extract.

9. REFURBISHING THE ISOLATED FLOOR & CEILING

The floating floor was repaired and the perimeter gap cleared of rubble, sections of bridging screed removed and the floor made good and extended to include the stage area. Similarly, the isolated ceiling was refurbished by dismantling, checking and re-aligning the isolator units, enlarging the clearance holes so

the suspension studs did not bridge the isolators and again by extending the construction to include the old stage area.

10. THE SIDE WALLS

Having regard to the exceptionally low mass of the blockwork linings, the presence of the ties and the need to preserve the murals, it was decided to leave these as they stood and simply panel over anew. The new wall linings were constructed in panels between the structural columns, and extending the full length of the building interior on both sides, as seen on the plan drawing of Fig #8. These were built off the floating floor and extended the full height of the room to meet the isolated ceiling, with no ties to the existing blockwork linings. Under the balcony the panels extend from the floating floor to the soffit overhang and continue up from the structural floor of the balcony itself. Although fully sealed all round, the construction was such that each panel was structurally de-coupled from the floor, from the ceiling and from its neighbouring structures, thus enabling it to absorb energy without transmitting the resultant modulation into the building structure.

Each panel comprised a 150 x 75mm studwork frame clad both sides with a GRP board/softboard/GRP board sandwich, thus forming a damped membrane absorber. Care was taken to ensure that all panel joints occurred over studding, staggered between layers and taped to seal. The cavity was filled with 45Kg/cu.m semi-rigid rock fibre slab and a curtain of 36Kg/cu.m wire mesh reinforced rock fibre quilt hung in the void between the new panels and the existing blockwork lining to absorb reverberant energy in the void. The arrangement thus served a triple rolé - it provided an effective noise barrier to the side walls and ceiling void, it preserved the murals, and, as the perimeter gap to the floating floor now ran in the void between the two linings, protected the integrity of the perimeter gap.

11. FLOOR ABSORBERS & FLOATING THE DANCE FLOOR

In order to reduce the apparent height of the interior space the architect wanted to raise the ground floor level. For this purpose the floor was divided into two areas - the dance floor, where stomping feet and the constant thump of the LF loudspeaker cones would give rise to structural vibration, and lounge/bar/circulation areas where the refurbished floating floor would provide sufficient isolation as it stood.

Instead of pouring concrete into timber shuttering to achieve the desired terracing, these were built of timber decking, some of which were polished, others carpeted, thus doubling as low

frequency or broadband absorbers. The dance floor was constructed as a structurally isolated element by excavating through the isolated floor to the original floor screed level and building up using steel mesh reinforced concrete on a plywood raft carried by Tico type CV/LF low-stress architectural bearings to give a calculated 70% isolation down to 13Hz. A 10mm isolation barrier was maintained all round and closed with a non setting mastic caulking. This structurally isolated concrete slug was then topped with solid 75mm thick granite slabs and polished to meet the architects aesthetic requirements. The sheer mass of this construction is such that the additional weight of patrons dancing makes only a small proportional difference and therefore the design was expected to hold whether there are two or two hundred patrons on the dance floor.

12. AESTHETIC CEILING

The architect was not happy about the utility appearance of the isolated ceiling so decided to install a lightweight suspended ceiling underneath. Clearly this would be an added bonus as, provided it was appropriately designed it could provide a high degree of absorption at ceiling level, considerably reduce the RT60 of the interior space and add a few more valuable dBs of TL performance. We went for a 19mm mineral fibre tile system on a 600mm grid using tongue and groove tiles and with a 100mm quilt of 45Kg/cu.m semi-rigid rock fibre slab over, with the outer grid members sealed tight against the perimeter walls with a 12mm thick compression gland all round - and dared any contractor to compromise either ceiling with a services penetration!

13. LIGHTING RIGS & LOUDSPEAKER SYSTEMS

The 2 x 46cm bass cabinets sat neatly on the edge of the floating granite dance floor so that was fine. Originally it was intended that the mid/highs would be pole mounted at a height of about 2.5m over each bass enclosure and facing inwards towards the centre of the dance floor rather than providing general coverage of the entire interior, using a "perimeter fill" system to provide ambience elsewhere. By this means the high SPL music is confined to the dance floor whilst elsewhere patrons are able to converse, order drinks, eat a meal, etc, without having to shout. Also of course, it would reduce the SPL incident upon the building shell. But the sound system contractor was able to persuade the client that full-range systems flown at high level to fill the interior space with sound was a better approach - so we had to make the best of it.

It also emerged, late in the contract period, that the lighting rig would be highly mobile, in several sections, each separately

carried by electric hoists suspended from the roof. Given the vibrational impact of the motors and gearboxes of a dozen or more hoists, coupled with the need to fly the loudspeaker system, it became necessary to surrender the veto over penetration of the double ceiling system. By way of a compromise, a system of vertical steel struts, welded to plates which were rigidly fixed to the soffit slab by gun fired epoxy anchorages, and passing through both ceilings was devised, in which proprietary isolation mounts were installed underneath the ceilings where proper operation could be observed and access for maintenance would be available. The hole in the ceiling was then sealed to the leg of the strut by means of a non-setting mastic caulking. Each isolator was selected for its particular loading, direction of pull, and for the mechanical duty expected of it - but always in such a way that the rubber cushions were under compression instead of tension and so that in the event of failure of a rubber-to-metal bond the system would fail-safe. The sketch of Fig #9 gives the general idea.

14. COMMISSIONING

The project was just completed within the 20 week contract period with the last touch of paint being applied on the morning of the opening day whilst the bars etc were being stocked and staff falling over fitters whilst undergoing training. So we weren't too popular when we wound up the sound system to 105dB(A) pink noise to enable the crossovers, compressors and equalisers to be set up and the noise performance verified!

Using a 2-way radio link these adjustments were carried out to provide a best compromise between sound quality within the club and audibility in the apartments. Upon completion music was no longer permeating the corridors and stairwells, the structural walls were no longer "live", the stair handrail was no longer vibrating to the bass beat and it was no longer possible to hear the music or DJ voiceovers as such. There was however a residual dull thud of the bass beat still present in the most sensitive parts of the building.

Fig #2 shows the noise transmission plot as originally recorded at the start of the project and Fig #10 on completion. In both cases the upper curve represents the spectral energy distribution inside the club and the lower the residual noise at the worst affected apartment. The figures in the TL table show the sound attenuation between the two points of measurement, being the simple difference between the two curves. Fig #10 also shows the background noise level at the point of measurement without the music playing, thus providing a with music vs without music comparison. It can be seen that only at the low frequency bands does the music penetrate the background noise floor.

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A comparison between the low frequency data from the two TL tables gives the following:-

Frequency Band	Original TL	New TL	Improvement
50Hz	36dB	56dB	20dB
63Hz	43dB	63dB	20dB
80Hz	48dB	68dB	20dB
100Hz	48dB	63dB	15dB
125Hz	45dB	63dB	18dB

Whilst a significant improvement had undoubtedly been achieved it was the view of the author that once the euphoria had died down and Discothèque Nice Offshore settled down to its regular trading pattern, the residual low frequency throb would give rise to further complaints. Certainly, in the UK, an average increase of 8dB above background between 50Hz and 125Hz would not be accepted by the authorities inside a dwelling.

As far as the motorised lighting rigs were concerned, there was no audible transmission inside the apartments, either whilst running, starting, or when stopped abruptly thus jolting the suspension isolators almost to the deflection limits.

Nice Offshore opened literally, with a roar. But it was the roar of power boat engines off the Baie des Anges as the proprietors – Whitegate Leisure SA – pulled off a coup de théâtre by sponsoring the Nice Offshore international power boat race on the very day of the opening of the new club! So after Champagne had been duly sprayed over the hulls of the winning craft the magnificent machines were trailered off to rue Alphonse Karr to be displayed outside the main entrance doors to the club, where the boat crews and race officials, along with civic dignitaries and invited illuminati of the international discotheque scene received red carpet treatment and were regaled in Champagne into the early hours of Sunday morning. That is unquestionably the way to do it, yet the residents in the apartments slept through it all, quite unperturbed. Some would not accept that the sound system was operating close to its maximum volume level whilst others could not believe such an improvement was possible.

15. DEFECTS SURVEY

Notwithstanding the high standard of workmanship and attention to detail on the part of the main contractor, because of site conditions and other pressures, there were a number of matters which had not been addressed in strict accordance with the design guidance provided and which would probably have resulted in a total solution to the problem. These included some poorly patched

over openings in the isolated ceiling, the addition of secondary fixings to the ceiling which partly bridged the isolation scheme but which were required by the Nice fire authorities, an increase of 6dB above the design criterion in loudspeaker SPL due to their increased distance from the dance floor, and the failure by the sound system contractor to provide the frequency selective limiting system specified.

It was recommended that the obvious defects be rectified as part of the usual "contract snagging list", that the fire authorities be persuaded to allow removal of the so-called safety harnesses and that the frequency selective compressor/limiter concept be implemented as originally specified. Should complaints continue, or should the club wish to operate at a higher SPL, the long term solution would be to replace the existing Klevulor M.85012/13 isolators with Dunlop Metalastic Equi-Frequency mounts type 17/1463. These have the same fixing centers but employ an annular rubber isolation cushion, whereas the existing French isolator uses a moulded plastic compound which had become brittle with age and many had cracked or collapsed. So notwithstanding the gratifying performance of the scheme as it stands, there remains scope to address the small residual LF problem at relatively small cost.

16. CONCLUSION

Lightweight partition constructions and damped membrane absorbers have been employed by the author as a means of controlling low frequency noise propagation for many years, often in the face of scepticism from professional colleagues. Following a series of highly successful smaller scale applications, the principle was first employed on a major UK discotheque noise control scheme as long ago as 1983 in the City of Norwich (5) and again in 1986 at Romford Hollywood - a £4m green field development just north of London set in the midst of a residential area, at a time when UK authorities were flexing their muscles on environmental issues <6>. The scheme fully complied with the local authority conditions of license, enabling a relatively inexpensive steel framed, lightweight clad building to be erected without the bass beat or DJ voiceovers permeating the neighbourhood. Nice Offshore represents a more advanced application of the same principles in a high budget, high profile international venue, and again, it has been shown to be effective as a solution to this emerging international problem.

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References:-

<1> Dibble K, "The BEDA Discotheque Survey Project", Proc. IoA, Vol 10, Part 7, pp 275 thru 285, 1988.

<2> Hirschorn M, "Noise Control Reference Handbook", Industrial Acoustics Company, NY, pp D2/D3, 1982.

<3> Randall K E, Meares D J & Rose K A, "Sound Insulation of Partitions in Broadcasting Studio Centres", British Broadcasting Corporation Research Department, 1986 October, London.

<4> Jones P E (British Gypsum Research & Development) "Improving the Situation of Inadequate Noise Insulation between Houses", Noise & Vibration Control Worldwide, 1981 November, pp 335 thru 337.

<5> Dibble K, "Environmental Control of Entertainment Sound - Some Guidelines & Case Studies", Proc. IoA, Vol 7, Part 6, pp 299 thru 306, 1985.

<6> Dibble K & Burgin M, "Hollywood Nightclub, Romford - A Case Study in Entertainment Noise Control", Proc. IoA, Vol 9, Part 6, pp 1 thru 12, 1987.

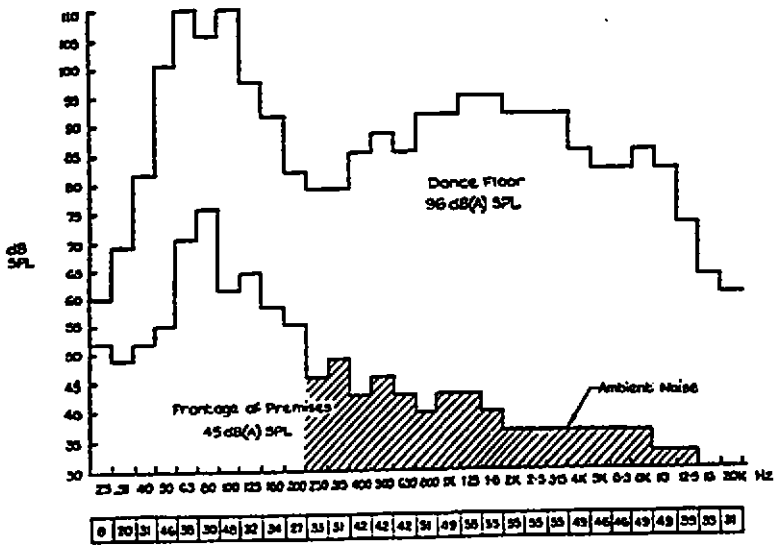

Fig.1 Typical Discotheque Noise Spectra Inside & Outside Premises

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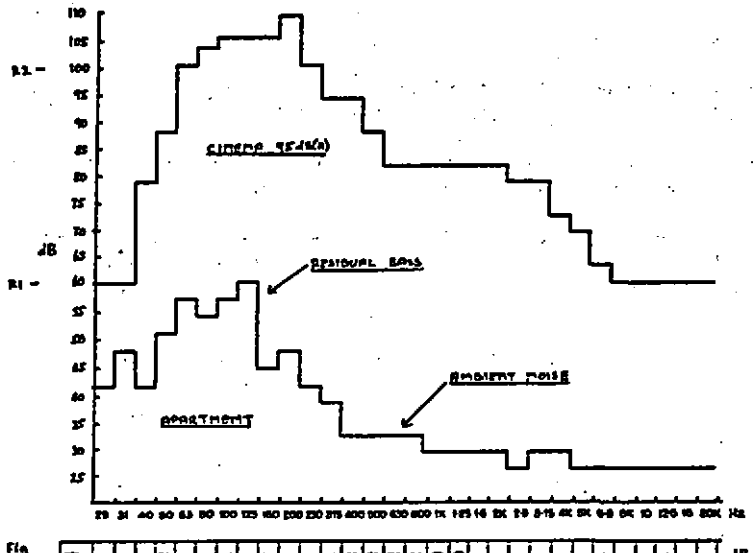

Fig 9

TL	-	-	-	56	53	48	48	45	50	53	52	51	54	50	50	51	52	-	-	-	-	-	-	-	-	-	-	-	dB

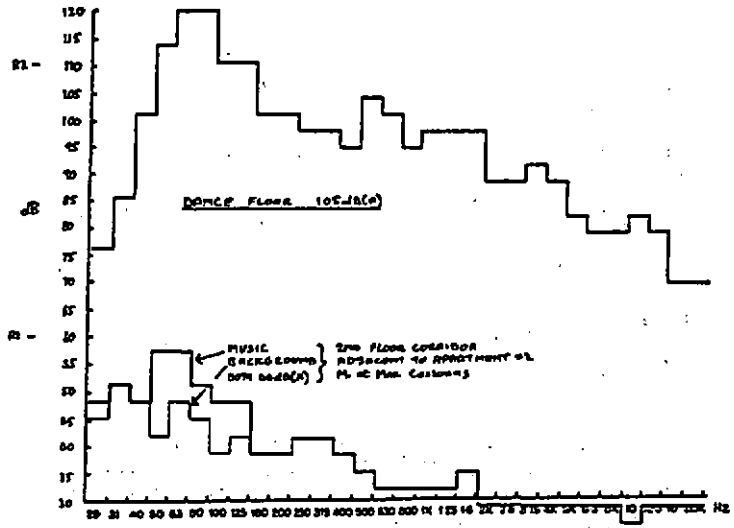

Fig 10

TL	58	53	53	48	45	50	53	45	44	44	54	52	52	57	50	53	45	45	-	-	-	-	-	-	-	-	-	-	-

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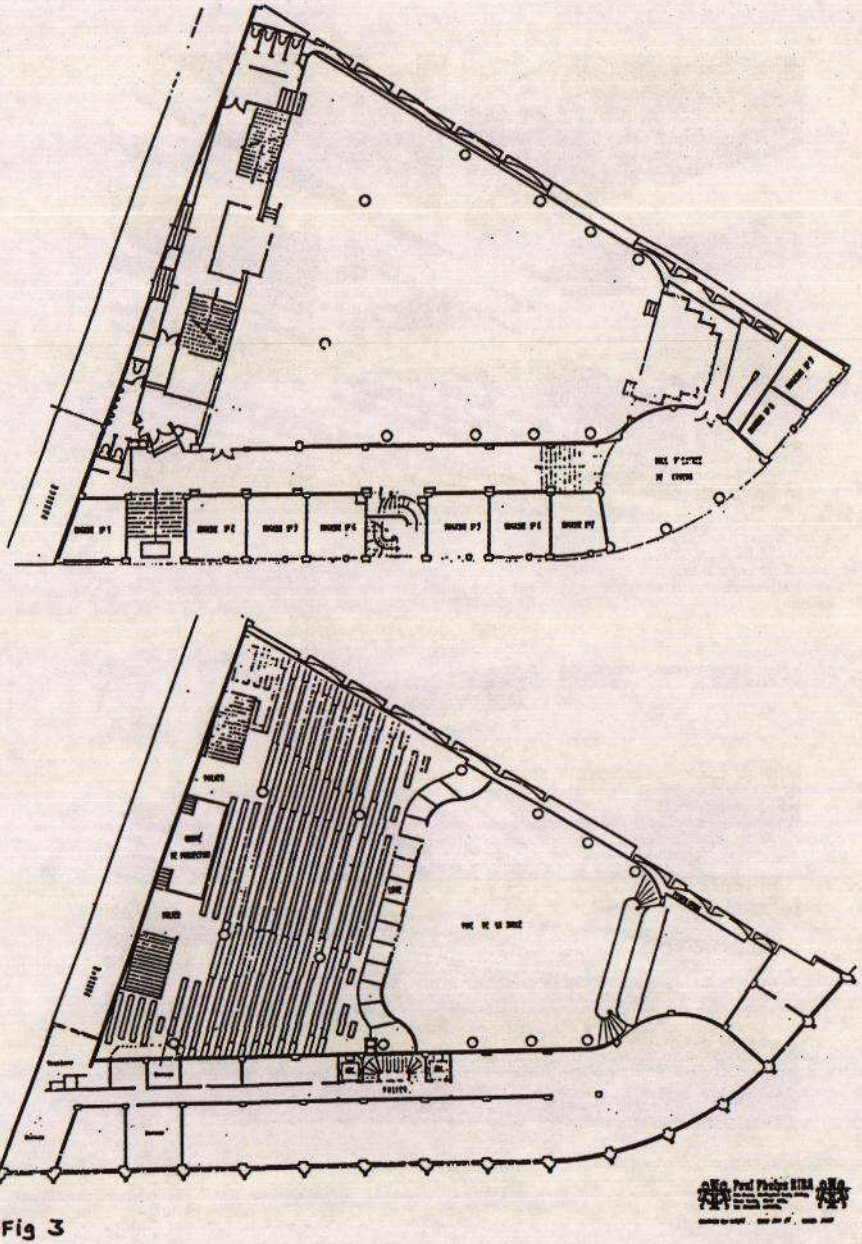

Fig 3

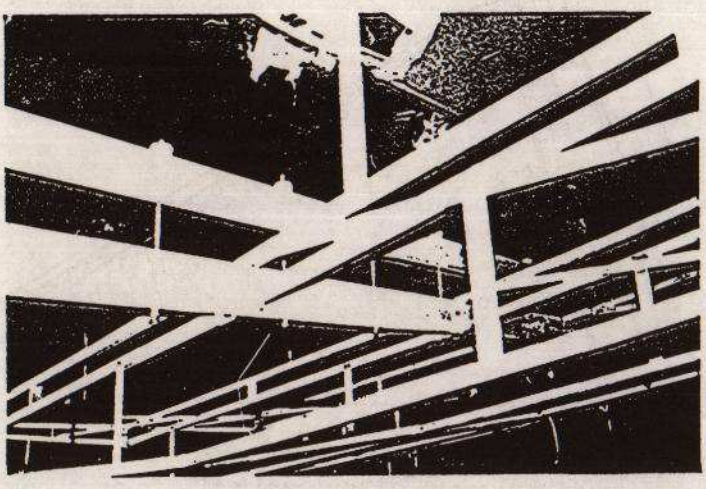

Fig 4

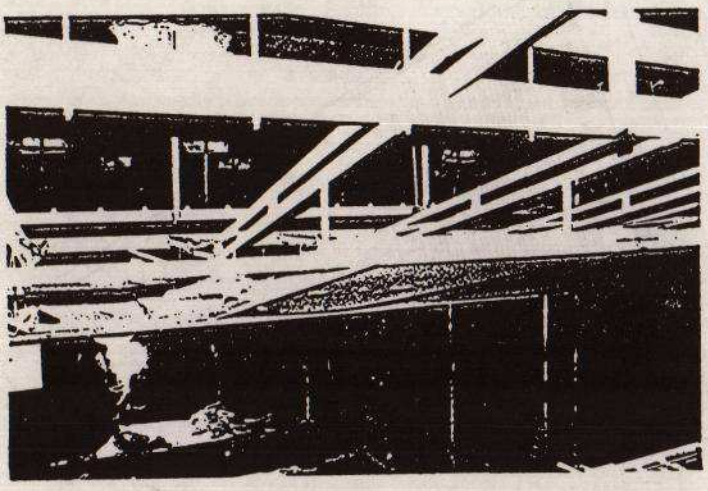

Fig 5

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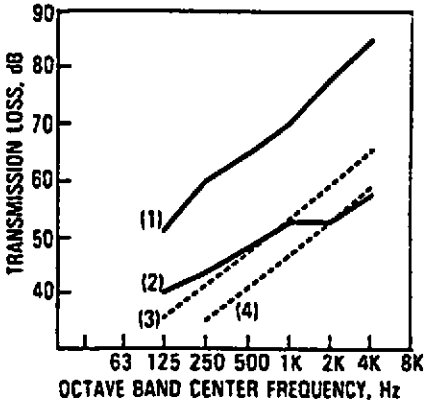
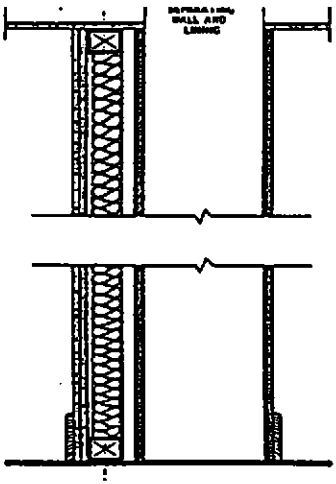
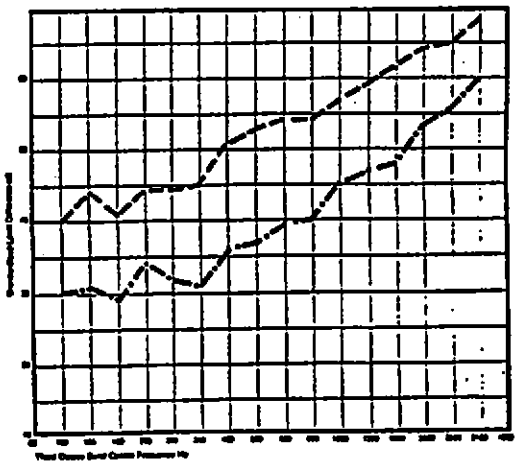
Comparisons between Measured and (NI Mass Law) Calculated TL



1. MEASURED DATA TWO IAC 4 IN. (102 mm) PANELS SEPARATED BY 4 IN. (102 mm) AIRSPACE. TOTAL WEIGHT 20 LB/FT² (98 kg/m²).
2. MEASURED DATA SINGLE IAC PANEL 10 LB/FT² (49 kg/m²) 4 IN. (102 mm) THICK.
3. MASS LAW PREDICTION FOR 20 LB/FT² (98 kg/m²)PANEL.
4. MASS LAW PREDICTION FOR 10 LB/FT² (49 kg/m²) PANEL.

Fig 6





Improvements in sound insulation due to the independent timber frame method of remedial treatment.

Fig 7

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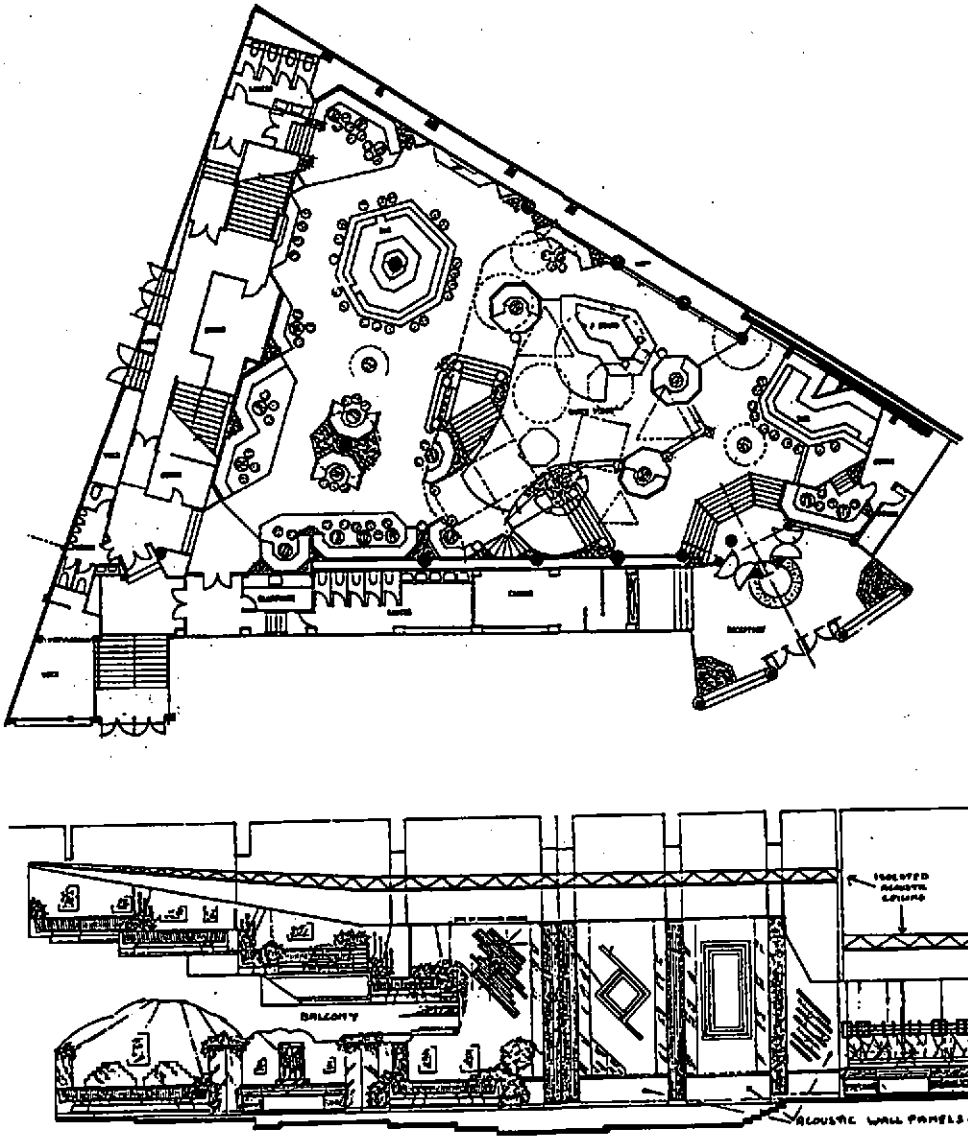
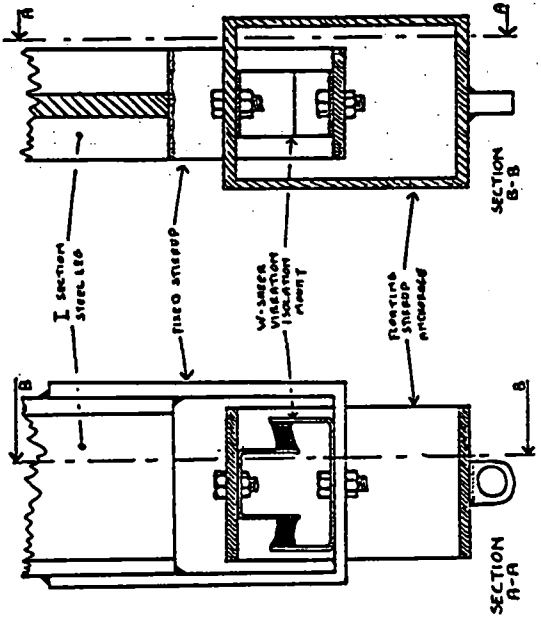


Fig 8

NICE OFFSHORE – A CASE STUDY IN DISCOTHEQUE NOISE CONTROL



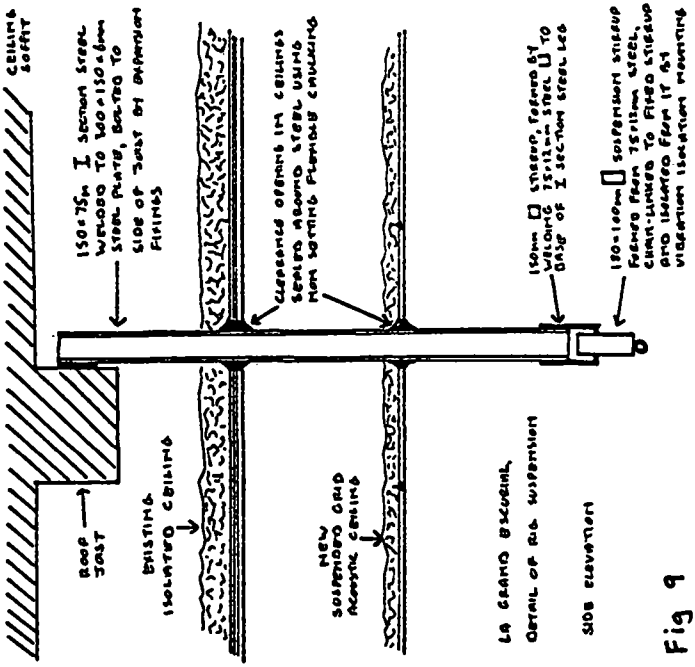


Fig 9