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THE DESIGN AND CONSTRUCTION OF AN ACOUSTIC TESTING LABORATORY USING LIGHTWEIGHT MATERIALS

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1.INTRODUCTION

Plasterboard based building systems are constantly being developed and improved to the point whereby most systems only have a five year life cycle between first testing and re-testing. Accurate and separate testing for sound insulation is only one criterion which has to be considered when changes are being made to a particular assembly of partition components such as metal studs, types of cavity insulation, board combinations, degree of separation and height requirements.

Included in this re-testing regime, it is necessary to consider the effect on fire resistance, structural strength, cost and ease of assembly. The same factors also effect the design and re-testing of new flooring systems, suspended ceilings and wall linings.

Until 1993, all acoustic testing carried out for Lafarge Plasterboard Ltd was conducted in 'outside' consultants Laboratories namely AIRO [1], Salford University [2], SRL [3], and the BBC Research Centre [4]. Altogether about 300 tests took place, over a four year period. The results of these tests are contained in the "Drywall Manual"[5].

During the test programme it became apparent that gaps existed in our knowledge and understanding as to how and why certain systems gave results which did not match predictions. It was decided that it was necessary to update technical information on a more regular basis as customer needs changed, and in response to competitors efforts aimed at similar objectives. This type of development work needs to be done in a carefully controlled manner with maximum efficiency and convenience. For the results to be meaningful and publishable the testing must be conducted in a NAMAS [6], approved laboratory and this laboratory must be constructed, equipped and staffed so that the testing complies with the appropriate British Standard and with scope for any changes which might take place in ISO and CEN.

2.BACKGROUND

In setting out to design a new acoustic test facility it was necessary to make a study of those Laboratories already in existence, picking out the best features whilst taking care to adhere to the specifications listed in BS2750:Part 1:1980 [7].

The brief was that the suite for testing walls and floors should be separate, that the facility should use materials which were readily available from within the company, that the cost should be kept a minimum and that the testing rooms should be contained within an existing large warehouse, alongside, but separate from, potentially noisy plant used when fire tests are in progress. Vibration isolation was also an important consideration since it would be inconvenient to restrict a forklift truck movement, lorry deliveries and the use of drills and hammer tools during the construction of test specimens in other parts of the building complex.

Whilst it could have been feasible to design the facility entirely from lightweight elements and indeed this was done during the initial state of the feasibility study, the requirements to achieve level differences in excess of 40dB at frequencies below 100Hz made this proposition somewhat risky. The concept which was finally adopted, therefore was that the floors should be concrete, the test apertures should be brick and concrete as appropriate, and that the rest of the structure should be thin gauge steel framing clad with multiple layers of plasterboard

3.STRUCTURAL CONSIDERATIONS

The method which was used for the construction required that the test aperture frames to be of solid brick and concrete 400mm thick in the case of the horizontal suite and 450mm thick in the case of the vertical suite, and that the floor should be 300mm thick concrete with vibration isolation at each intersection. The specification for the walls, roof and doors called for an attenuation of >50dBA from 'inside' to 'outside' using the principle of a room-within-a-room for each chamber. As the walls were to be constructed from essentially non-load bearing metals studs, special structural considerations needed to be employed. To that end it was necessary to retain the services of a consultant structural engineer [8], to design the reinforcement for the concrete elements and to specify the load bearing brick pillars which supported the concrete floor testing aperture at each corner. He also calculated the spanning properties of the roof joists so that the chosen roof structures would adequately carry the weight of multiple layers of plasterboard and the weight of construction workers during building.

4. CONSTRUCTION DETAILS - HORIZONTAL SUITE

The plan and sectional view of the test rooms are shown in Figures 1 & 2. The main features are listed as follows :-

Test Aperture = 3.6m wide x 3.0m high x 600mm deep = 10.8m^2
Source room volume = 76m^3
Receiving Room Volume = 100m^3

The approximate weight of the wall and roof of the chambers is 120kg/m^2

SPECIFICATION

Floor slabs -	300mm dense reinforced concrete
Floor isolation -	100mm Fibreglass Crown Roofboard
Aperture top & bottom lintel -	400mm x 400mm dense reinforced concrete
Aperture support pillars -	400mm x 400mm solid engineering brickwork
Aperture isolation -	50mm thick Hanoband compressible foam rubber
Inner leaf wall frame -	Shaftwall CH metal studding,102mm x 0.9mm
Inner leaf wall lining -	5 layers of 17mm plasterboard, 3 inside, 2 outside
CH stud cavity insulation -	30mm Rocksil AT33
Outer leaf wall frame -	92mm x 0.9mm I metal studs at 600mm centres
Outer leaf wall cavity -	300mm with 30mm Rocksil AT33
Outer frame cladding -	2 layers of 15mm plasterboard
Roof steel joists -	200mm x 63mm x 1.2mm C Section steel joists at 400mm centres
Roof frame lining -	3 layers of 17mm plasterboard, 2 layers 17mm plasterboard
Roof frame cavity insulation -	100mm Rocksil AT33
Outer roof -	Double 102mm E studs at 600mm centres
Outer roof cavity -	125mm with 13mm soft fibreboard
Outer roof frame cladding -	2 layers of 15mm plasterboard
Test aperture shielding -	50mm Fibreglass roof board and 2 layers of 12.5mm plasterboard
Doors, 1 inner and 1 outer -	Solid timber 2100mm x 900mm x 60mm in each chamber on neoprene gaskets

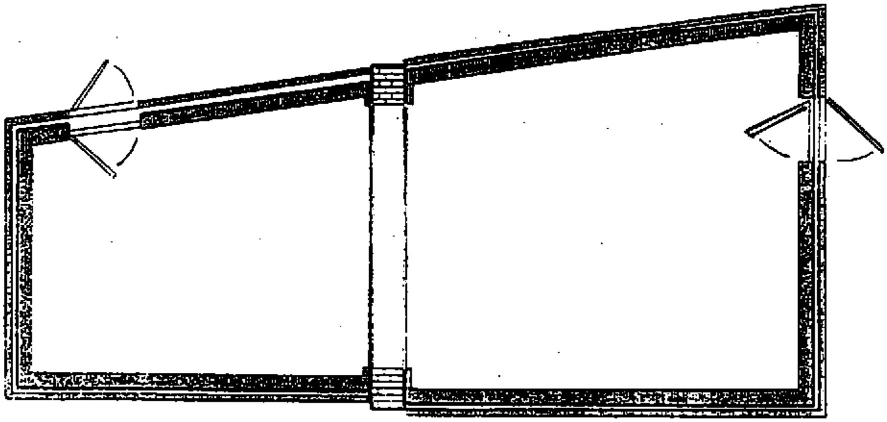

FIGURE 1: PLAN OF HORIZONTAL TRANSMISSION SUITE.

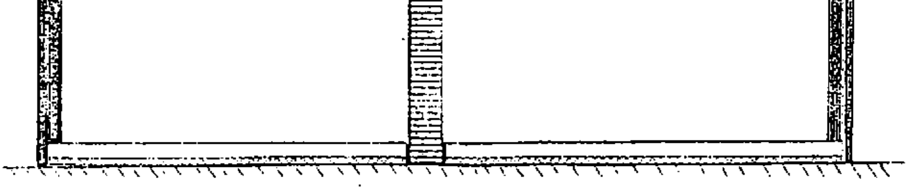

FIGURE 2: SECTION THROUGH HORIZONTAL TRANSMISSION SUITE.

5.CONSTRUCTION DETAILS - VERTICAL SUITE

The plan and sectional view of the test rooms are shown in Figures 3 & 4. The main features are listed as follows:-

Test aperture in upper room = 4.3m x 3.6m x 450mm deep = 15.5m^2
Test ceiling in lower room = 4.0m x 3.3m = 14.2m^2
Upper room volume = 88m^3
Lower room volume = 79m^3

The approximate weight of the walls and roof of the upper room is 94kg/m^2

SPECIFICATION

The main specification for the wall frames, cladding layers, insulation, roof frame and vibration isolation is the same as the horizontal suite. The door leafs were of the same construction but with double width doors in the lower room. The other differences are listed below :-

Test aperture floor -	450mm thick dense reinforced concrete
Aperture support piers -	1200mm x 1200mm x 225mm engineering brickwork
Upper room wall frame -	Inner leaf 60mm x 40mm x 0.7mm I studs at 600mm centres
Upper room inner lining -	2 layers 12.5mm plasterboard
Upper room cladding -	Outer leaf, 2 layers of 15mm plasterboard on inside, 2 layers of 17mm outside
Upper room ceiling -	2 layers of 12.5mm plasterboard on resilient bars

6.LOADING PLATFORM AND CONTROL ROOM

It was necessary to construct a platform alongside the vertical transmission suite so that construction materials could be safely man-handled into the upper transmission room. This platform and the stairs leading up to it are constructed using the same type of framework and floor joists as the transmission rooms. The platform upper surface is 22mm chipboard flooring - area 4m x 4m. The control room is located under the platform.

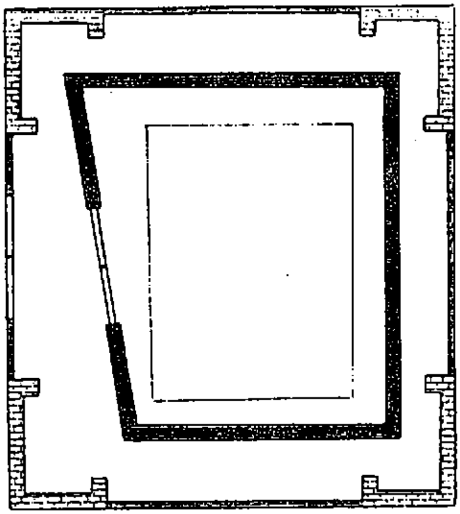

FIGURE 3: PLAN OF LOWER ROOM IN THE VERTICAL TRANSMISSION SUITE.

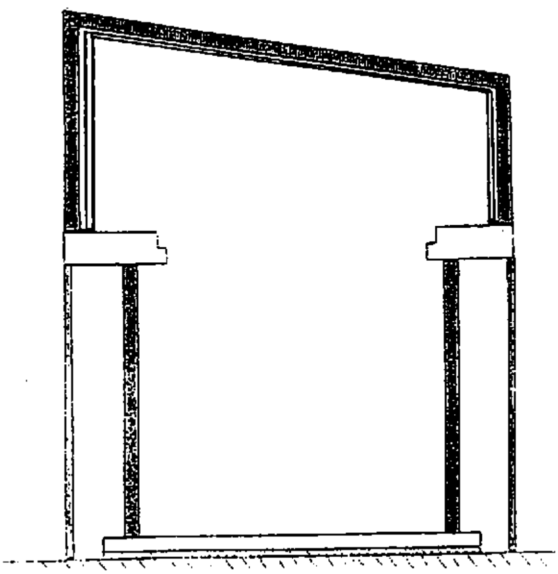

FIGURE 4: VERTICAL SECTION THROUGH THE FLOOR TRANSMISSION SUITE.

ACOUSTIC LABORATORY FROM LIGHTWEIGHT MATERIALS

7.INSTRUMENTATION

The equipment used for the testing comprises a Norsonics 830 Dual Channel Analyzer, Dodecahedron loudspeakers, rotating booms with 1/2" B & K condenser microphones and a Norsonics 211 tapping machine. The measuring technique closely follows the requirements in accordance with BS2750:Parts 3 & 6:1980 [9]. Additional 1/3 octave frequencies 50Hz, 63Hz, 80Hz, 4KHz, 5KHz are also included in the spectrum so that the test result can be expressed more fully. Otherwise the read-out is plotted graphically as in BS5821:1984 [10], and given a single number rating Rw, Lnw, or STC [American] or Rrose [French].

8.NAMAS ACCREDITATION & COMMISSIONING

The new test facility had been fully commissioned and is now in regular daily use for development work and commercial testing. In order to prove the maximum capability and assess flanking limits, a double frame cinema type partition was installed in the horizontal suite. Similarly, a triple layer separating floor was installed in the vertical suite. The results are shown in table 1. NAMAS Accreditation was achieved on the 3rd November 1993.

9.ACKNOWLEDGMENTS

The author wishes to thank Lafarge Plasterboard Ltd, for giving permission to disclose the information contained in this paper. The facility was largely constructed by the staff of the Development Department and was very much of a team effort. Dr.J.S.George, our Technical Director provided an invaluable contribution in terms of the original design brief, and help and support throughout the project. Mr P.E.Jones MIOA, assisted with the commissioning. Some of the insulation materials were supplied by Pilkington Insulation Ltd, St.Helens. The structural metal components, known as SPAR BEAMS were supplied by Midland Industrial Holdings Ltd.

Table 1. Maximum sound insulation achievable from a double frame cinema partition, and a multiple layer timber joist floor.

FREQUENCY Hz 1/3 OCTAVES	R-SOUND REDUCTIONS INDEX dB		Ln-NORMALISED IMPACT SOUND LEVEL - FLOOR
	WALL	FLOOR	
50	29	39	60
63	37	37	58
80	39	41	55
100	47	45	53
125	53	49	46
160	56	54	40
200	57	57	33
250	59	64	20
315	62	65	14
400	65	67	9
500	66	71	7
630	68	71	7
800	73	75	7
1000	78	77	6
1250	82	79	9
1600	86	78	15
2000	87	75	18
2500	88	77	12
3150	88	79	10
4000	88	75	8
5000	88	75	8
	Rw=69dB	Rw=71dB	Lnw 34dB

10.REFERENCES

[1] Acoustical Investigation & Research Organisation.,
Duxons Turn, Maylands Avenue, Hemel Hempstead, U.K.

[2] Sound Research Laboratories Ltd.,
Holbrook Hall, Little Waldingfield, Sudbury, Suffolk, U.K.

[3] University of Salford, Department of Applied Acoustics.,
Salford, U.K

[4] Research Department, Engineering Division.,
British Broadcasting Corporation, Kingswood Warren,
Tadworth, Surrey, U.K.

[5] The Drywall Manual: 1994 Edition. Available from Lafarge Plasterboard Ltd,
Wray Coppice, Oaks Road, Wray Common, Reigate Surrey.

[6] NAMAS Executive, National Physical Laboratory.,
Teddington, Middlesex, U.K
- Lafarge Drywall Test Centre, Rainham Testing Laboratary No: 1095.

[7] BS2750:PART 1:1980 Method of Measurement of Sound insulation in
buildings and building elements
- Recommendations for laboratories (also ISO 140/1-1978)

[8] W.W.Chan. 48 Wembley Park Drive, Wembley, Middlesex, U.K - Drawings
Letters & Private communications.

[9] BS2750:PART 3:1980 Laboratory measurement of airborne sound
insulation of building elements. (also ISO 140/111-1978)

[10] BS2750:PART 6:1980 Laboratory measurement of impact sound
insulation of floors. (also ISO 140/V1-1978)