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SOUND INSULATION OF PUGGED FLOORS IN RENOVATED TENEMENT DWELLINGS

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INTRODUCTION

This paper reviews field research on sound insulation of timber joisted separating floors in tenement properties carried out by the Building Acoustics Group of the Glasgow College of Building and Printing on behalf of the Construction Industry Research and Information Association (CIRIA).

BACKGROUND

Traditionally the separating floors in Scottish tenement properties are timber joisted with tongued and grooved flooring and lath and plaster ceilings. Rough boarding at mid depth of joists is sealed with lime plaster and the boards support ash (pugging) deafening, a material which was in plentiful supply during the period of construction of the tenements.

Over the past fifteen years there has been a considerable volume of building work associated with the rehabilitation of such properties. The presence of rot within the separating floor often necessitated either patch or whole floor replacement. In many cases this has resulted in a marked reduction in the airborne and impact sound insulation performance of the floor. This in turn has given rise to complaints from occupants and the adequacy of the deafening has been questioned.

THE RESEARCH OBJECTIVE

Recently [1] several solutions such as top surface treatments or the use of independent ceilings have been validated by field testing and when reasonable workmanship is assured these yield satisfactory results.

Until now no satisfactory solution has been achieved within the original floor zone and this has been identified by CIRIA in collaboration with interested groups in Scotland as an area worthy of field investigation.

To this end a steering group was established (see Acknowledgements) and a test bed tenement was made available by Glasgow District Council. The Building Acoustics Group of the Glasgow College of Building and Printing were asked to undertake field research into the comparative performance of floors with different ceiling constructions incorporating various deafening and resilient layers within the original floor depth.

THE TEST BED

The separating floor between one pair of living rooms of flats on the second and third storeys of the tenement was used for the first three stages of the test programme. These were concerned with finding solutions for situations where the whole floor was to be replaced.

To facilitate the required changes within the floor, the flooring to the upper living room was divided into eight easily handled sections as shown in Fig 1.

SOUND INSULATION OF PUGGED FLOORS IN RENOVATED TENEMENT DWELLINGS

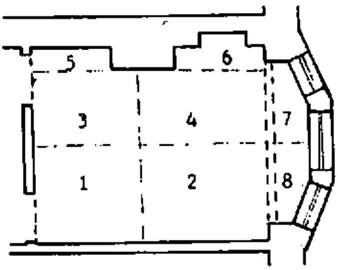

FIG 1

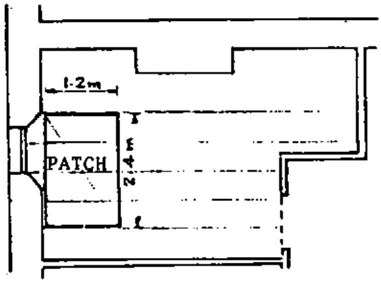

FIG 2

The fourth stage of the test programme sought solutions for patched situations to floors. The tests were carried out on the separating floor between the kitchens of the same pair of flats, the test patch created by cutting an opening 2.4 m by 1.2 m as shown in Fig 2.

THE RESEARCH PROGRAMME

The initial activity centred on establishing a systematic airborne and impact sound insulation testing procedure based on BS 2750 : 1980 followed by an assessment of repeatability of test results.

Thereafter the activity centred on progressive attempts, changing one parameter at a time, to seek a satisfactory solution within the existing floor depth and to obtain comparative performances for a variety of puggings and resilient materials under the following conditions:

Stage 1 lath and plaster ceiling remaining intact
Stage 2 new plasterboard ceiling
Stage 3 new loadbearing ceiling
Stage 4 patch repair within existing floor.

RATING OF PERFORMANCE

Performance assessment was determined in all cases in terms of Aggregate Adverse Deviation (AAD) with reference to Grade 1 curves for both airborne and impact sound and also in terms of weighted standardised airborne level difference (DnT,w) and weighted standardised sound pressure level (L'nT,w) with reference to BS 5821.

TEST PROCEDURE

The microphone was fixed to a rotating boom and measurements were carried out with a sampling time of 32 seconds. The reverbation time was taken to be the average of nine samples at each one third octave band frequency in the range 100 to 3150 Hz.

Five positions of the footsteps machine were used, the impact level being taken as the average of the five samples.

The positions of sound source, footsteps machine and tripod centre were marked permanently on the floor to standardise test procedures.

VARIABILITY OF RESULTS

In order to assess the variability of the results three tests were carried out the same specification with the lath and plaster ceiling intact and at a later stage six tests were carried out on the same specification with the plaster-board ceiling in position. The results are shown in Table 1.

Specification	BS 2750 AAD Airborne dB	Impact dB	BS 5821 DnT,w Airborne dB	L'nT,w Impact dB
ash deafened floor, lath and plaster ceiling	29.2	29.8	50	58
	28.2	30.6	51	59
	32.6	37.9	51	60
1/1 limestone chip/PFA mix and plasterboard ceiling	91.1	65.7	45	63
	93.2	51.9	45	62
	84.8	54.2	45	62
	85.2	54.6	45	62
	95.0	55.7	44	62
	82.0	55.3	46	62

Table 1

A statistical analysis within ninety five percent confidence limits, of the six results for the 1/1 mix indicated the error in airborne measurements was 6 dB AAD and in impact measurements 5.5 dB AAD. This estimate of variability is of about the same level as found by Fothergill [2] in an earlier study of different operatives carrying out the measurements to an exactly agreed format.

Clearly, from the table above, measurements in terms of DnT,w and L'nT,w are not so sensitive as AAD but the indication is that the measured values are within 1 dB of the mean for both airborne and impact sound.

All the tests carried out during this particular researchprogramme were by the three members of the Building Acoustics Group. It is worth noting that in normal practice, wider variations in airborne and impact AAD are likely due to variations in personnel carrying out such tests together with variations in test methods and equipment.

RESULTS

Some interesting aspects of the tests are highlighted in the graphs which are included in this paper.

Graphs 1 and 2

A variety of deafening materials were tested with the lath and plaster ceiling, being laid to a depth which provided a surface density of 80 kg/m². The spectra for these tests all lie within the windows shown in Graphs 1 and 2. There was little variation in airborne performance but the upper window boundary for impact performance was mainly due to either ash pugging or 10 mm straight limestone ships. The lower window boundary for impact performance was mainly due to pugging consisting of equal parts 6 mm down limestone chips with PFA nodules.

This suggests that pugging consisting of different particle size and shape with fines is more effective than more open textured puggings for impact performance.

Graphs 3 and 4
This shows the airborne and impact test spectra with no pugging or pugging boards within the space between the joists and for three ceiling arrangements:

original lath and plasterboard ceiling	(20 mm)
plasterboard ceiling of three sheets	(9.5 mm; 12.7 mm; 9.5 mm)
plywood (6 mm) and plasterboard loadbearing ceiling	(9.5 mm; 12.7 mm)

The lath and plaster ceiling was by far the most effective for airborne performance but not so effective on impact. The loadbearing ceiling was poorest for both.

Graphs 5 and 6
This shows the airborne and impact test spectra for the three ceiling arrangements with pugging consisting of equal parts 6 mm down limestone chips with PFA nodules laid to a surface density of 80 kg/m^2. The pugging was mid-joist for the lath and plaster and plasterboard ceilings. For the loadbearing ceiling two sets of spectra are shown, one with the pugging mid-joist, the other with the pugging laid directly on the ceiling.

The lath and plaster ceiling gave the best performance and the best of the other arrangements was where the pugging was laid directly on the loadbearing ceiling.

Graphs 7 and 8
This shows the airborne and impact test spectra for the pugging laid directly on the loadbearing ceiling and the comparison with the spectra for the same arrangement with the addition of 150 mm mineral wool quilt on top of the pugging.

There was some improvement in both airborne and impact performance by adding the quilt. In other tests [3,4] when quilt was added there was either no significant improvement in airborne performance or it was a little worse. This arose mainly from the poorer performance with the quilt in position, at the lowest frequencies.

Graphs 9 and 10 (Patch)

These show spectra related to tests on the patched kitchen floor as follows:

a) pretest prior to creating patch;

b) test on floor, after flooring cut, deafening removed from patch, flooring refixed; lath and plaster;

c) test on floor with loadbearing ceiling of timber and plasterboard as previous, no pugging;

d) test on floor with loadbearing ceiling of metal lath and plaster, no pugging.

Again the tests suggest that the lath and plaster ceiling makes a substantial contribution to effective sound insulation. The metal lath was substantially better than timber/plasterboard on airborne performance but not as good on impact performance.

Graphs 11 and 12 (Patch)
These show spectra related to tests on the patched kitchen floor as follows:

tests c) and d) as above
e) as c) with 60 mm whin pugging (80 kg/m²) directly on the ceiling
f) as d) with 60 mm whin pugging directly on the ceiling.

The airborne performance of the pugged metal lath patched ceiling was substantially better than that of the pugged timber/plasterboard ceiling. There was no significant difference in these two arrangements in terms of impact sound.

Specifications which gave satisfactory performance for whole floor solutions, when used as a patch specification within otherwise good floors, did not produce satisfactory overall performance.

SUMMARY

The following points are worth noting from this investigation:

1. Avoid destruction of the lath and plaster ceiling if possible, it is difficult to restore acoustic performance when lath and plaster is partially or completely removed.
2. The surface density of pugging is the important criteria for airborne performance rather than the nature of the material.
3. Mixed particle size and shape including fines leads to better impact performance than more open textured materials.
4. Good performance is obtained by placing the pugging directly on a load-bearing ceiling.
5. Floating the flooring helps impact performance.
6. Adding mineral wool on top of pugging may give a modest improvement in performance.
7. It is difficult to obtain good performance with a patched ceiling.

FURTHER INFORMATION

CIRIA will be publishing a Practice Note for Architects and a Technical Report containing details of all tests early next year. For further information contact The Secretary, CIRIA, 6 Storey's Gate, Westminster, London, SW1P 3AU.

ACKNOWLEDGEMENTS

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Glasgow Institute of Architects

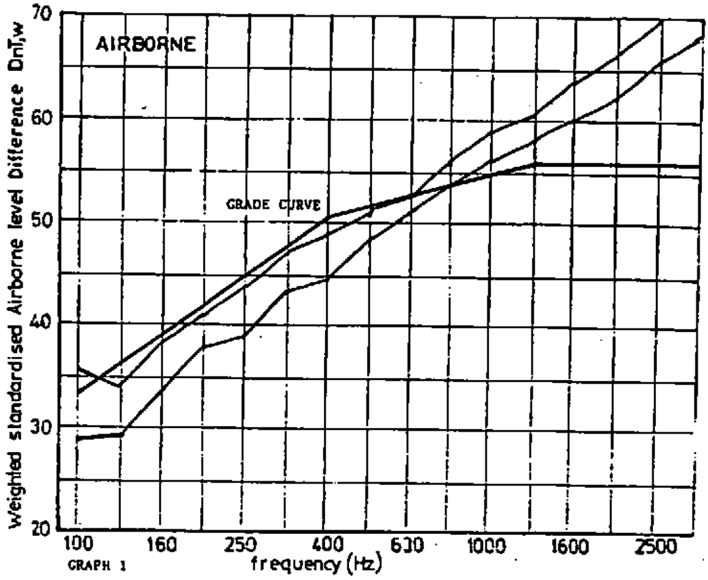
REFERENCES

[1] Sound Insulation of Rehabilitated Tenements, Glasgow. W N Hamilton and R K McLaughlin, Glasgow College of Building and Printing, Proceedings of Institute of Acoustics, York 1985.

[2] Recommendations for the Measurement of Sound Insulation Between Dwellings. L C Fothergill, Applied Acoustics, 13 (1980).

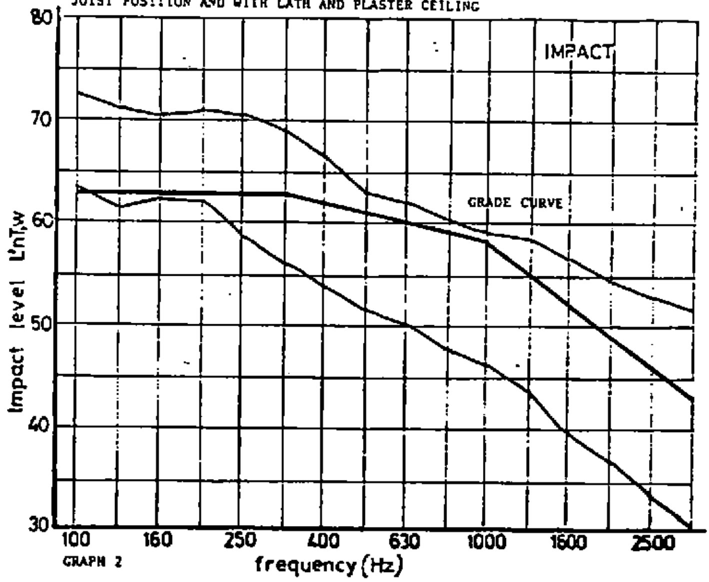
[3] Sound Insulation of Timber Floors in Rehabilitated Scottish Tenements, CIRIA Practice Note (to be published early 1987).

[4] Sound Insulation of Timber Floors in Rehabilitated Scottish Tenements, CIRIA Technical Report (to be published early 1987).

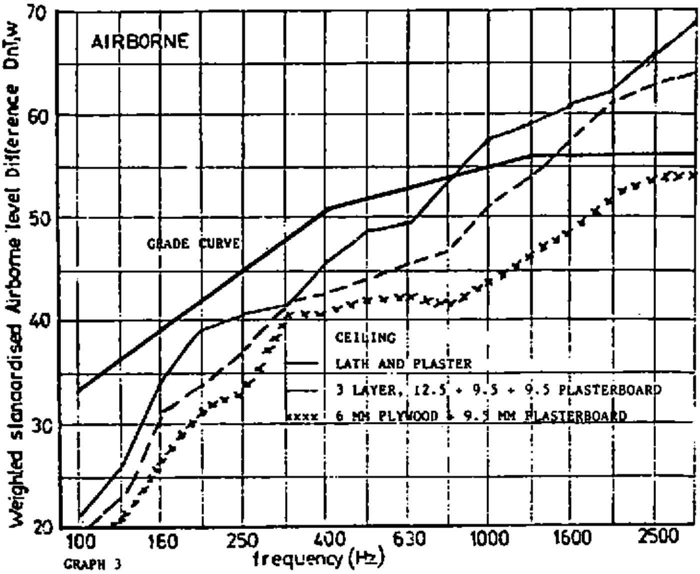


GRAPH 1

'PERFORMANCE WINDOWS' FOR DIFFERENT TYPES OF DEAFENING MATERIALS AT MID-JOIST POSITION AND WITH LATH AND PLASTER CEILING

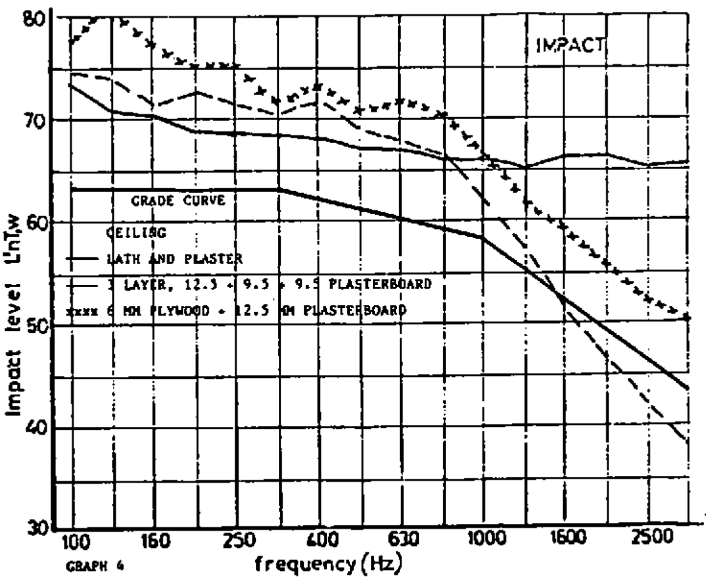


GRAPH 2

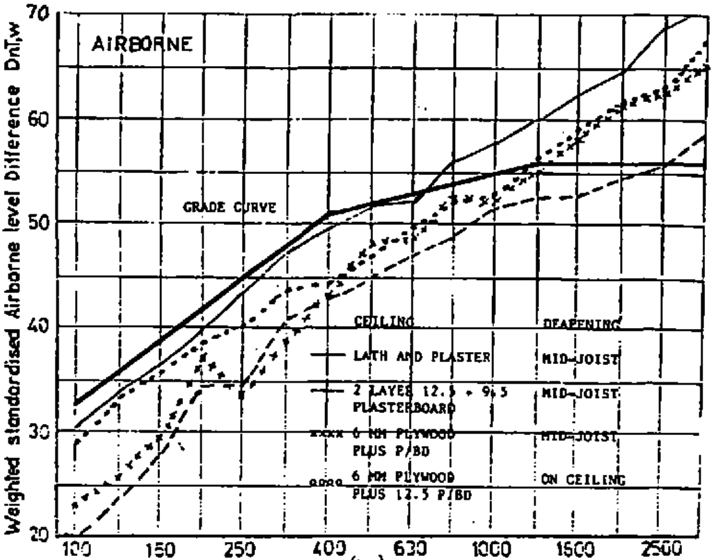


GRAPH 3

EFFECT OF DIFFERENT TYPES OF CEILING WITH NO DEAFENING

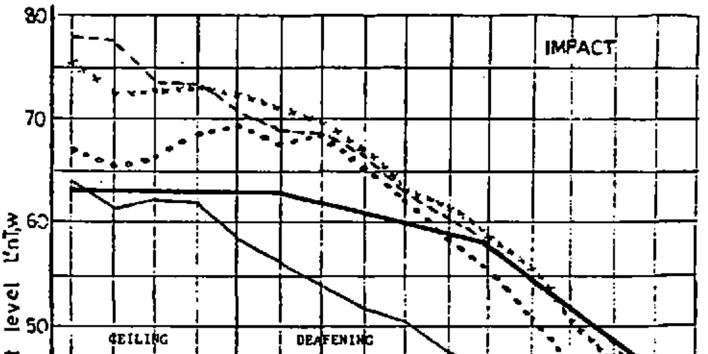


GRAPH 4

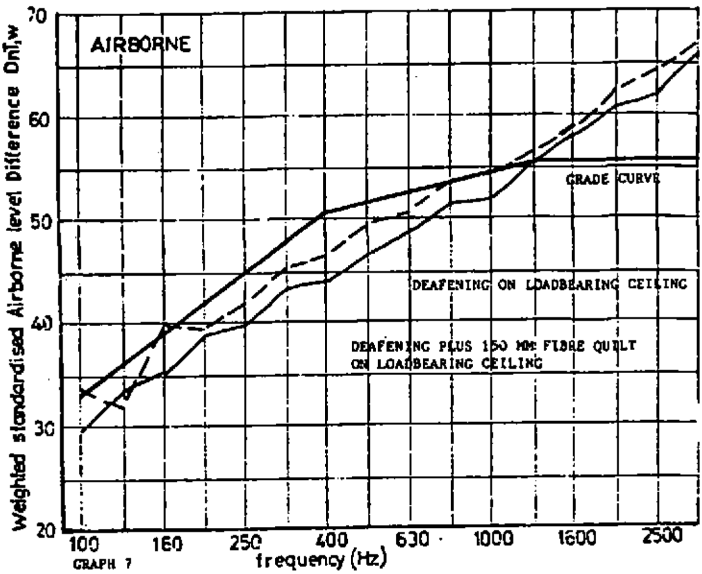


GRAPH 5

EFFECT OF DEAFEINING WITH DIFFERENT TYPES OF CEILINGS

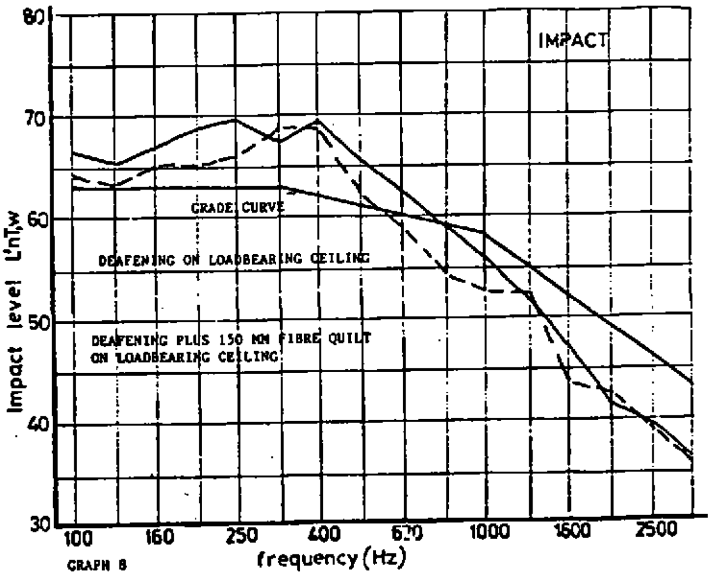


GRAPH 6

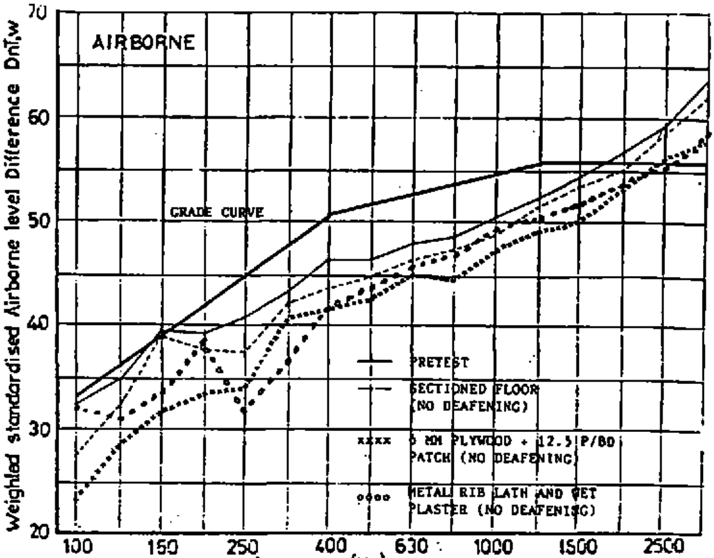


GRAPH 7

EFFECT OF FIBRE QUILT ON TOP OF DEAFENING

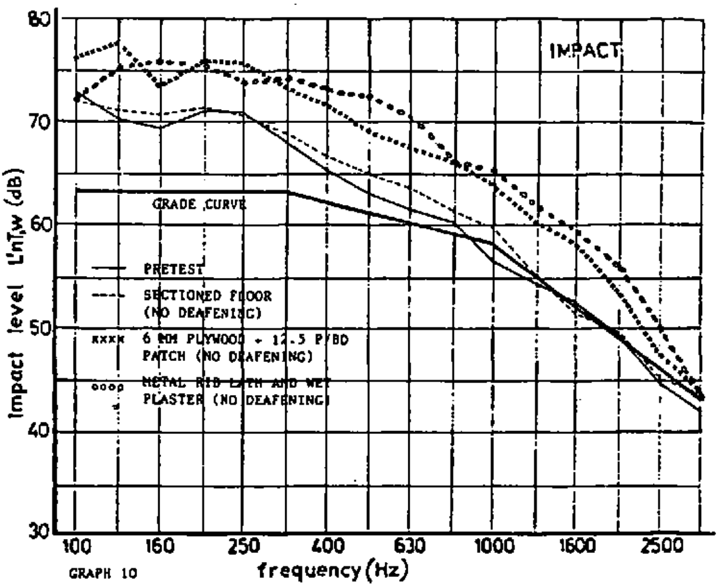


GRAPH 8

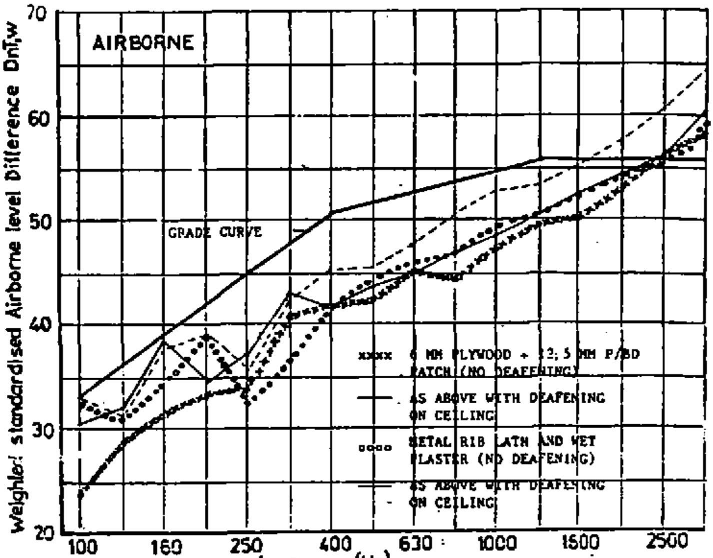


GRADE 9

EFFECT OF DIFFERENT CEILINGS ON PATCHED FLOORS

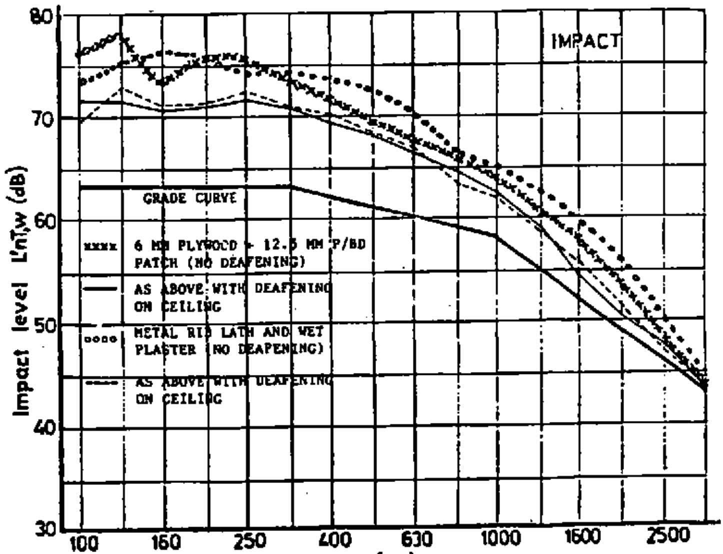


GRAPH 10



GRAPH 11

EFFECT OF DEAFENING ON CEILING PATCH



GRAPH 12