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THE DEVELOPMENT OF A SOUND ABSORBING FLOORING SYSTEM

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INTRODUCTION

The introduction of Approved Document E into the Building Regulations in 1985 ensured that the 150mm thick hollow concrete pre-cast floor slab of 220 kg/m^3 density would remain as one of the most commonly used structural floor specifications for many years to come.

The use of this type of slab in combination with the timber raft floor has brought about a number of problems concerning sound insulation, in particular impact sound insulation. This paper describes the nature of these problems and outlines the development of a new design of floating raft construction for laying on top of concrete slab or timber joist structural floors. The specification comprises of chipboard flooring laid upon a timber batten to which a lamination of polyethylene and polyether foams are bonded to the underside. The specification differs from existing design by virtue of the fact that a lamination of polyether and polyethylene foam has been used instead of the more conventional single material layers. The open cell structure of the polyether foam provides sound absorption in the cavity which is not present in the case of closed cell polyethylene or polyurethane foams. Under dynamic loading e.g. footsteps, the deflection provided by the use of the new system results in a superior performance in terms of impact sound reduction compared with polyethylene or polyurethane foams.

RESILIENT BATTENS VS. QUILT

The results of measurements in the field have indicated that the use of a 25mm thick mineral wool quilt (density 36 kg/m^3) as resilient layer is necessary in order to achieve a pass result, L'_{nTw} = 61 dB; AAD = 23 dB (Scotland) in terms of impact sound reduction.

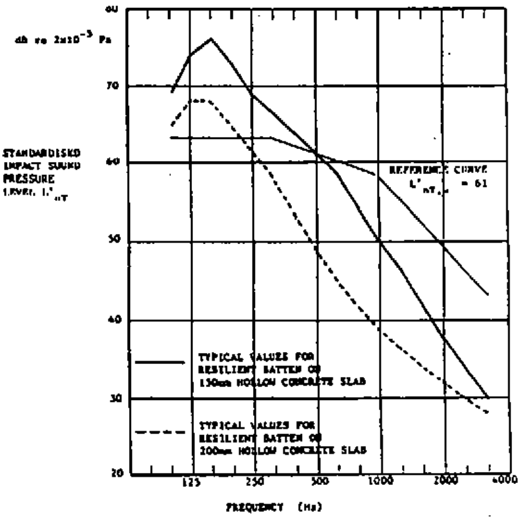
Many developers have expressed a desire to replace the quilt, as resilient layer, with integral flooring battens incorporating resilient foam strips. The principal reasons given for wishing to replace the quilt include:-

(a) Question of long term dynamic behaviour.
(b) Loss of resilience following contact with water.
(c) Unpleasant to handle.

Proprietary flooring systems in use today include integral battens with Polyethylene, Polyurethane and Polyvinylchloride foam strips.

FIELD RESULTS

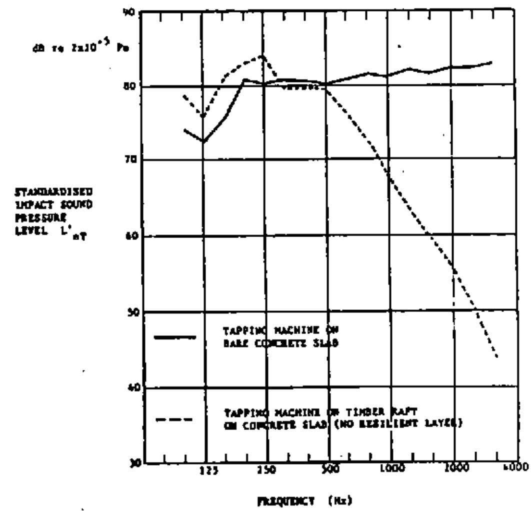
Field results involving the use of resilient battens on 150mm thick concrete slabs have generally indicated a failure in terms of the regulations with typical results showing an $L'_{nT,w}$ = 61 - 64 dB; or AAD = 30 - 50 dB.



Only when the slab is upgraded to 200mm thickness, or when a 50mm thick screed is added is one likely to achieve a pass result of typically $L'_{nT,w}$ = 57 - 60 dB or AAD = 0 - 20 dB.

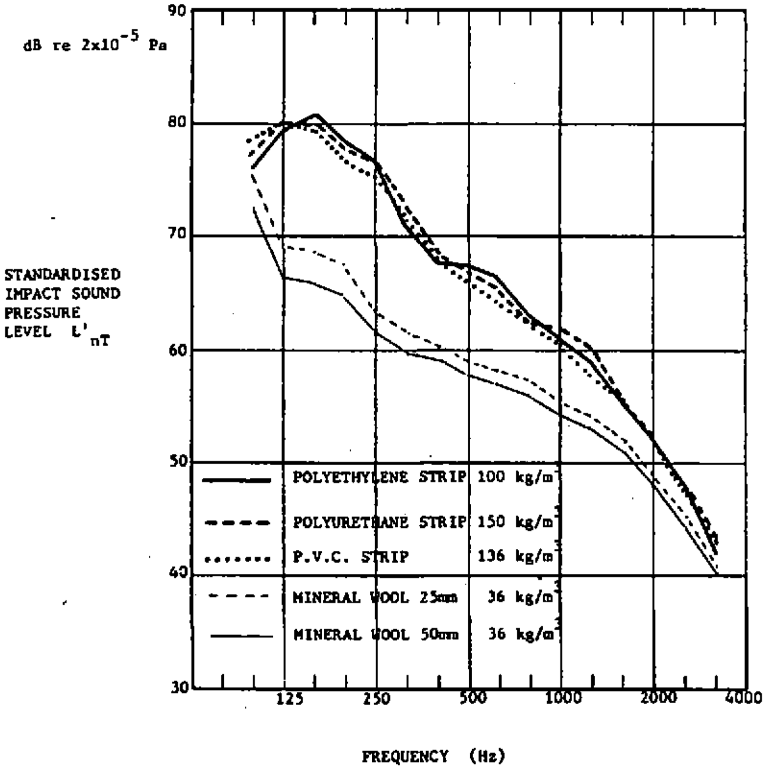
EXPERIMENTAL PROGRAMME

A programme of tests has been carried out in the laboratory using a 150mm thick concrete floor slab as the basic structural element.



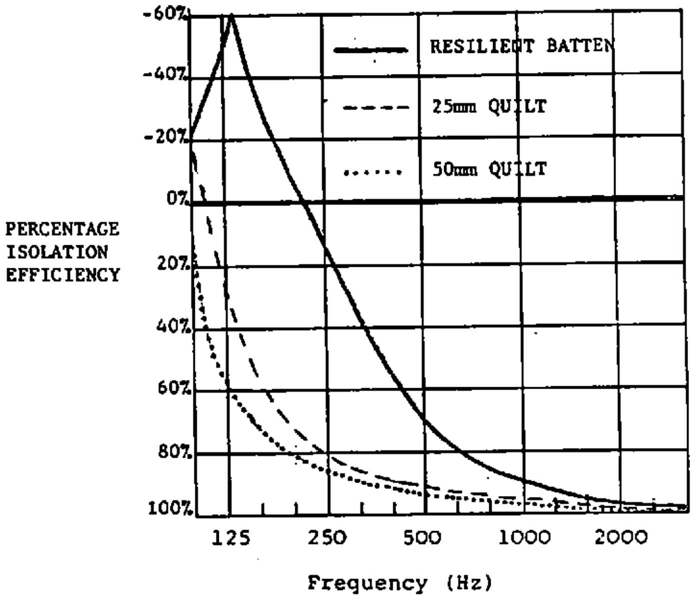
The effect upon impact sound reduction of adding a timber raft floor is shown above. Resonant behaviour of the timber floor accounts for the deterioration in the sound reduction properties of the floor below 250 Hz, whereas the benefit of the air space is clearly demonstrated, above 630 Hz.

The relative performance of three flooring systems involving different types of resilient battens are shown below.



Two additional results showing the use of 25mm and 50mm thick mineral wool quilts (36 kg/m^3) under raft construction without the resilient strips, are also shown.

The dynamical behaviour of the resilient layers is more appropriately indicated in the graph overleaf which shows the relative isolation efficiencies of three of the systems.



VIBRATION ISOLATION

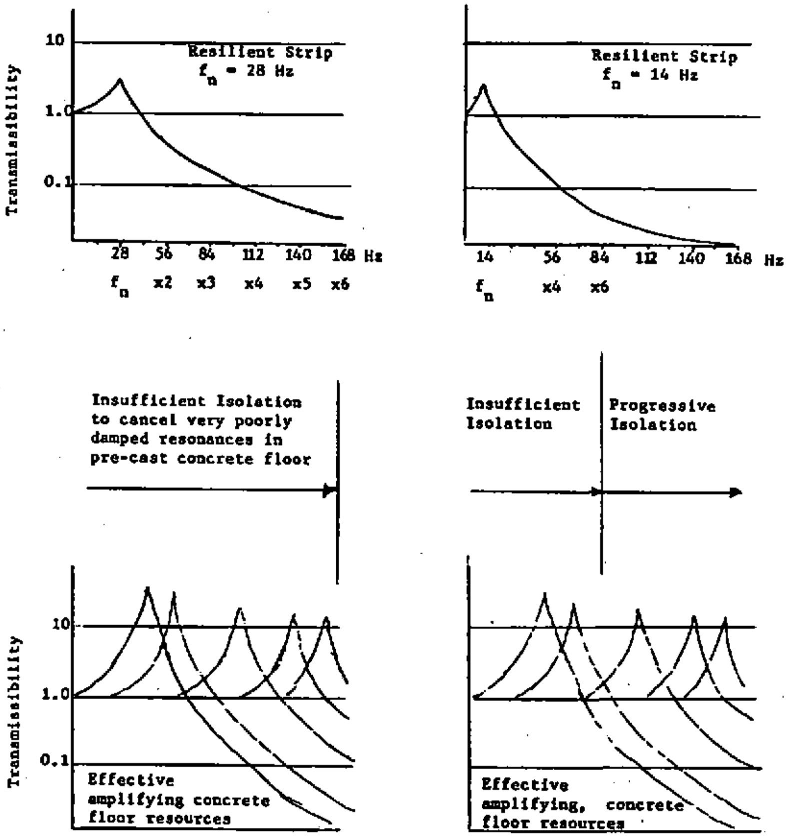
The relative static deflections of the five resilient layers under the self load of the battens and 18mm thick chipboard floor and the imposed load of the tapping machine are given below:-

Resilient layer	Thickness	Density	Static Defln.	f_n
Polyethylene	9mm	100 kg/m^3	0.3 mm	28.6 Hz *
Polyurethane	8mm	150 kg/m^3	0.35mm	26.5 Hz *
Polyvinylchloride	9mm	136 kg/m^3	0.39mm	25.1 Hz *
Mineral Wool Quilt	25mm	36 kg/m^3	1.21mm	14.3 Hz
Mineral Wool Quilt	50mm	36 kg/m^3	2.29mm	10.4 Hz

* These values may be up to 20% too low since the dynamic stiffness of a polymer is greater than its static value and is also a function of frequency.

The poor vibration isolation provided by the plastic foams between 100 - 160 Hz is due to the low ratio of forcing frequency/natural frequency of the resilient layer.

Whilst a ratio of between 3 - 5 would be perfectly adequate for many situations, pre-stressed, cast concrete floors are very poorly damped with amplifying resonances of up to x 20 acting against the vibration isolation efficiency of the resilient layer.



To ensure complete isolation a natural frequency of approximately 10 Hz is required although satisfactory isolation (i.e. sufficient to give a pass result in terms of the Building Regulations) may be achieved by an f_n of 15 Hz, equivalent to a static deflection of 1.1mm under self load.

POLYESTER RESILIENT STRIP

In order to achieve a satisfactory isolation using an integral resilient floor system without a quilt, a foam plastic strip with static deflection, under self load, of not less than 1.1mm is required.

A number of plastic foams were considered from which a polyester foam with an open cell design was ultimately chosen for its acoustic as well as its dynamic properties.

Tests were conducted on two thicknesses of the polyester foam, 12.5mm and 25mm thick. The results were as follows:-

Resilient Strip	$L'_{nT,w}$	AAD
25mm thick Polyester	60 dB	18.3 dB
12.5mm thick Polyester	61	26.2

Although the optimum thickness lay somewhere between 12.5mm and 25mm, it was decided, for practical reasons rather than simple dynamical considerations, to laminate a 6mm polyethylene layer to the underside of the polyester foam. This provided the soft polyester foam with greater protection from tear; a major problem with soft resilient materials on building sites.

The laminated polyester/polyethylene batten has been tested and gives an $L'_{nT,w}$ = 60 dB; AAD = 21.7 dB.

The use of open cell polyester has, however, provided a useful means of damping the sub-panel resonances which are particularly strong between 100 - 200 Hz. When tested on a 150mm thick pre-cast concrete floor with a plasterboard ceiling on 15mm branders, a D_{nTw} of 52 dB, AAD of 18.0 dB was obtained compared with D_{nTw} = 51 dB, AAD = 29.7 dB on the same floor with polyethylene battens. The influence of the open cell layer as an absorbent rather than simply as an isolation strip was verified by lining the sides of the battens with 4mm thick hardboard, thus covering the resilient strip. The D_{nTw} dropped to 51 dB and the AAD to 27.4 dB.

SUMMARY

An integral resilient batten which provides a performance similar to timber battens on mineral wool quilt has been developed by studying the dynamical behaviour of the resilient layer.

A flooring system has been developed which when used in conjunction with a 150mm pre-stressed hollow concrete floor slab of 220 kg/m^3 density will give a pass result in terms of airborne and impact sound insulation requirements of the Building Regulations.