# Case Studies of Change of Use to Dwellings

# Report on Case History Three - A Case History of the Conversion of a Dwelling House/Shop into Flats

## Project Contract Reference: CI 71/6/3 BD 2416

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## Summary

- On 1 July 2003 changes were made to Part E of the Building Regulations which required higher acoustic standards. This applies to new build constructions and buildings converted for residential use, which includes student accommodation, hotels and residential homes. This document is a case history describing the building works to change one particular terraced dwelling house/shop into flats. The aim is to demonstrate the typical changes necessary to satisfy the 2003 requirements. This should help builders wanting to make similar conversions, although exact constructions required will vary from case to case.

## Existing Building

- The frontage of the terrace of houses is shown in Photograph 1.

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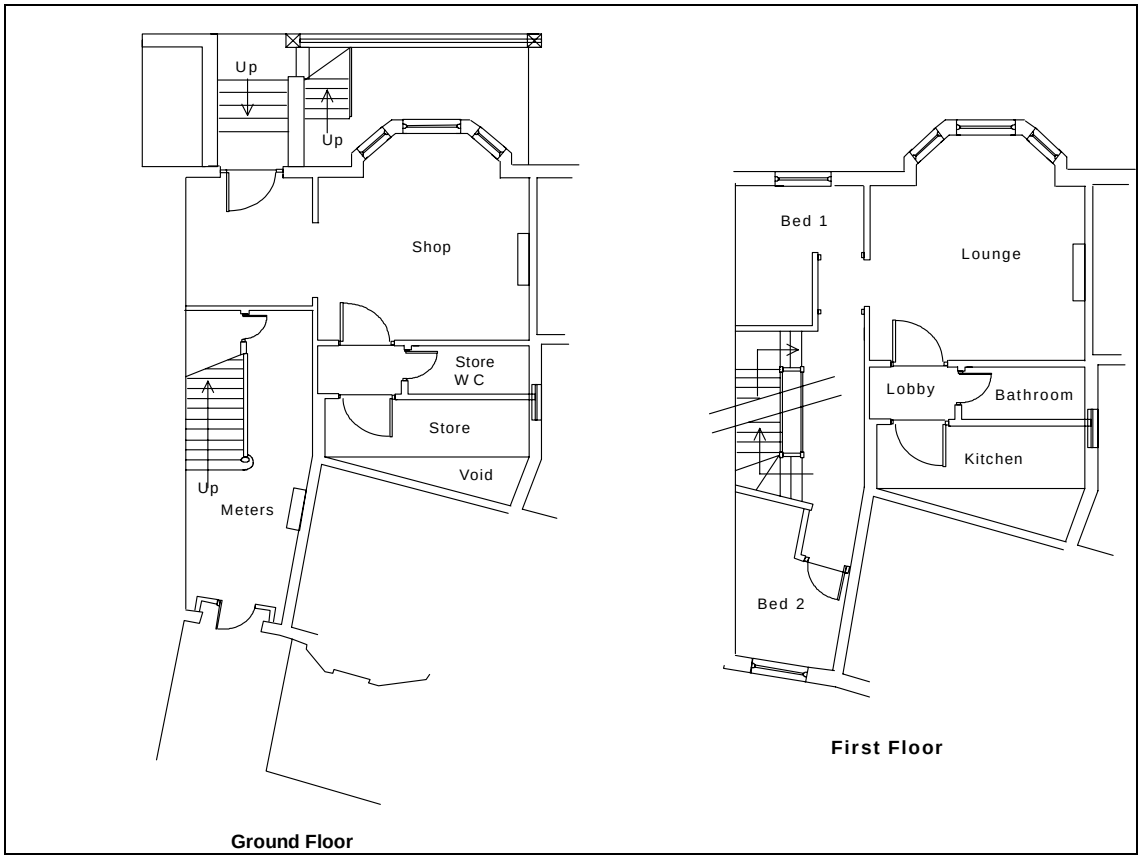
**Photograph 1 – Frontage of Terraced Houses**

- The house had four floors of residential accommodation above a ground floor shop and basement. It has been used recently as a house of multiple occupation. Figure 1 shows typical floor plans of the existing building. The central stairs continued up the building, higher floors having the same layout as the first floor.




## Figure 1 – Existing Ground and First Floor Plans

- The house construction comprised:
  - Solid brick external walls (340mm and 225mm) rendered on the outside and with sash windows.
  - A part flat, part pitched tiled roof with parapet wall. The top storey built into the roof with dormer widows.
  - Solid brick party walls, 225mm thick plus plaster finish.
  - Internal brick walls, generally 110mm thick plus plaster finish.
  - Brick fireplace and chimneybreast on one party wall.
  - Some studwork internal partitions and wall linings faced with plasterboard on plaster on lath.
  - Timber joist floor with floorboards or chipboard deck and plasterboard ceilings.
  - Between the ground floor shop and first floor accommodation, there was a floated chipboard deck on top of older floor boarding.
  - An internal staircase gave access to the first floor and above from the rear entrance.
  - The ground floor and basement shop had direct access from the front of the building.

## *Measured Sound Insulation before Conversion*

- Sound insulation tests were done on four existing floors and one staircase wall.
- Tests were done in accordance with BS EN ISO 140-4:1998. The results are tabulated below.

| **Source Room** | **Receiving Room** | **Element Tested** | **$D_{nT,w} + C_{tr}$ dB** | **$L'_{nT,w}$** |
|---|---|---|---|---|
| 1F Lounge | Ground floor Shop | Timber Floor | 43 | 62 |
| 2F Lounge | 1F Lounge | Timber Floor | 38 | 67 |
| 3F Bedroom | 2F Bedroom | Timber Floor | 39 | 73 |
| 3F Bedroom | 2F Kitchen | Timber Floor | 38 | 72 |
| Staircase | 3F Bedroom | Brick Wall/Lobbied Door | 37 | - |

## *Outline of Proposed Development*

- The building has been redeveloped as five flats. The ground floor and basement shop has become a two storey flat with its own entrance in the front façade. Each of the other four floors comprises one flat with a common staircase and entrance hall with access from the street at the back of the terrace.
- The layouts of the first floor flat, which is typical, and the ground floor are shown in Figure 2.
- Floorboards were made good, mineral wool quilt fixed between joists and joints sealed. The chipboard floating floor on the first floor had been damaged and was removed.
- Existing ceilings were upgraded and an additional plasterboard mf ceiling suspended below using proprietary acoustic hangers.
- The existing separating walls were 225mm solid brick with plaster finish and were expected to meet the performance standard without upgrading.
- Internal brick walls were kept.
- Internal stud walls and linings were all removed and replaced with new.
- Some doorways were filled in and other openings created in internal walls.
- Fireplaces were removed and chimney-breasts closed off.


**Figure 2 - Layout of the Ground and First Floor Flat**

# Design

## *Separating Floor Construction*

- The existing floors did not give adequate sound insulation. Between the ground and first floor one test did just meet the sound insulation requirement for conversions, but the floating floor there was damaged and had to be removed.
- A suspended ceiling system was used. This improved the airborne and impact sound transmission. The construction is shown in Figure 3.
  - The existing ceiling was kept but upgraded where necessary to 20 kg/m$^2$ with fire rated plasterboard and plaster skim finish.
  - A new additional ceiling of 12.5mm + 15mm fire rated plasterboard (9.5 + 11.5 kg/m$^2$) with plaster skim finish was suspended 150mm below the existing ceiling. It was fixed to an MF grid supported from the existing joists via acoustic hangers.
- The existing floorboards and chipboard were removed and 100mm of mineral wool quilt fixed between the 195mm deep joists.
- Refurbished or new floorboards were replaced and joints sealed with mastic.

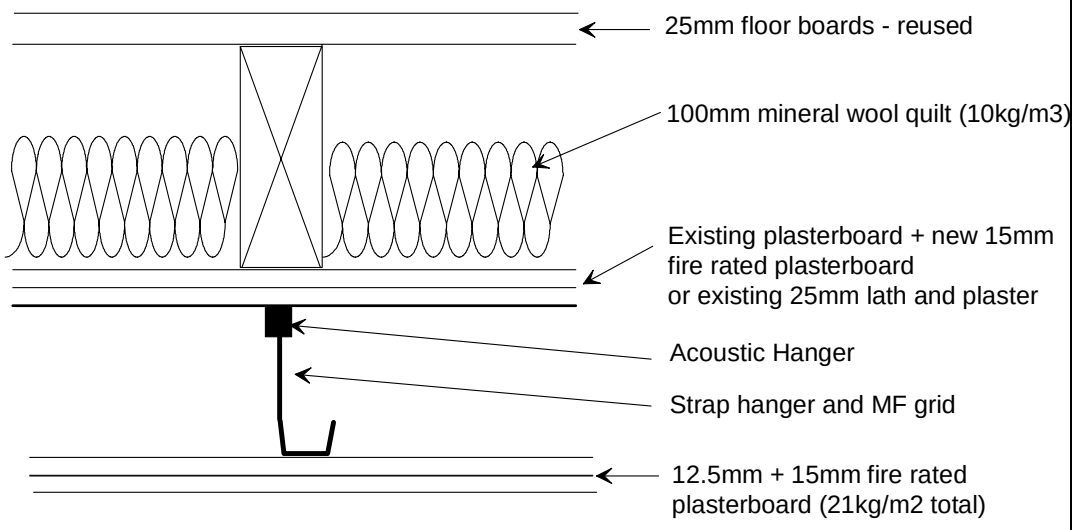



**Figure 3 - Section through Separating Floor**

## *Separating Walls*

- Existing separating walls between this property and adjacent buildings in the terrace were kept unaltered. These were a minimum of 225mm solid brick plus plaster finish. Any unsound plaster was hacked off and replaced. It was considered that sound travelling down these walls between flats would be adequately attenuated.

## *Internal Walls*

- Many of the internal walls were removed and replaced with plasterboard on timber studwork. The construction, shown in Figure 4, comprised 75 x 50mm timber studs at 600mm centres with 12.5mm dense plasterboard (10 kg/m$^2$) each side and 80mm mineral wool quilt (10 kg/m$^3$) in the cavity. This construction had an $R_w$ of 41dB and meets the requirements in the Regulations for new internal walls around bedrooms and rooms containing a water closet.

- Where an existing wall is retained the requirement for a 40dB $R_w$ rating does not apply. However, the 225mm brick wall that was kept between the lounge and bathroom would meet the sound insulation rating.

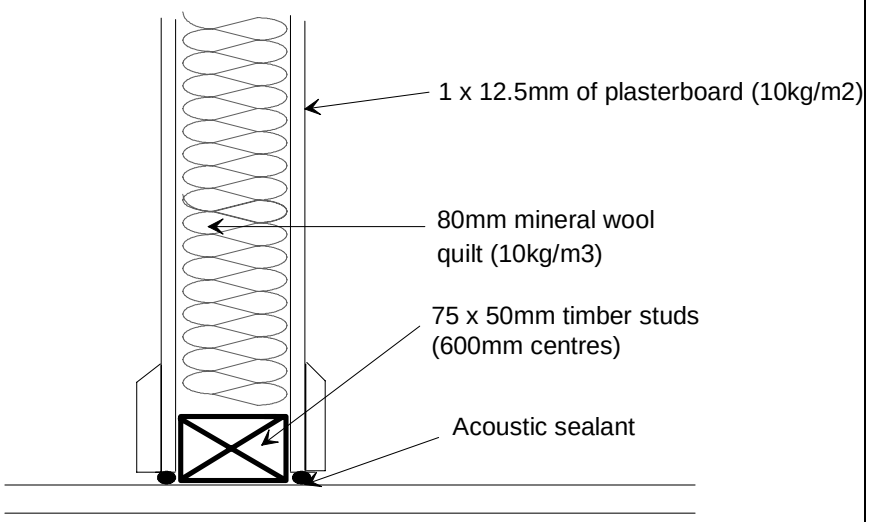



**Figure 4 - New Internal Wall**

### *External Walls*

- The external walls were 225mm and 340mm thick. These are heavy and it was not considered necessary to do anything further to reduce flanking sound transmission up and down them. The walls were lined inside the rooms with plasterboard faced 60mm thermal insulating board. To minimise flanking sound transmission, it would be more effective to use thermal board comprising plasterboard laminated with mineral wool, rather than with foamed plastic.
- It is important to check the weight of the inner leaf of external walls or other walls that are continuous between floor levels. Particularly with timber separating floors, lightweight blockwork will carry excessive flanking sound between flats and a plasterboard lining spaced well away from the wall is necessary.
- When the floorboards were replaced the junction between boards and inner leaf of external wall was sealed with acoustic sealant. Similar sealing was applied where the new suspended ceiling met the external wall lining and where ceiling and floors met the separating walls.
- A section of this junction is shown on Figure 5.

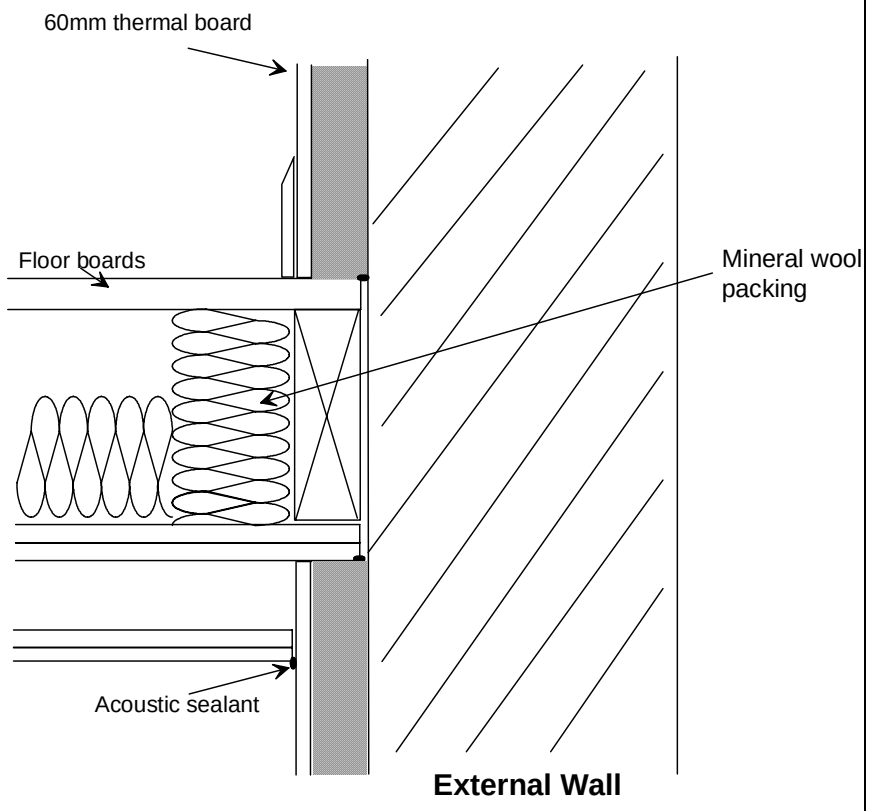



**Figure 5 - Section through Separating Floor/External Wall Junction**

### *Separating Walls between Flats and Common Areas*

- The walls separating flats and the common staircase and entrance hallway are retained brick walls or in one location new 100mm dense blockwork. Most of the brickwork walls around the staircase are only half brick, nominally 110mm plus plaster. These would not give adequate sound insulation between the flats and the staircase.
- The staircase walls might also be expected to carry sound vertically between flats bypassing the separating floors.
- These walls were upgraded by installing an independent plasterboard wall lining on their roomside.
- The lining comprised 2 layers of 12.5mm standard plasterboard (2 x 8 kg/$m^2$) fixed to 75 x 50mm timber stud framework. The timber studs were spaced 50mm from the wall and 80mm of mineral fibre quilt hung between them. The construction is shown in Figure 6.

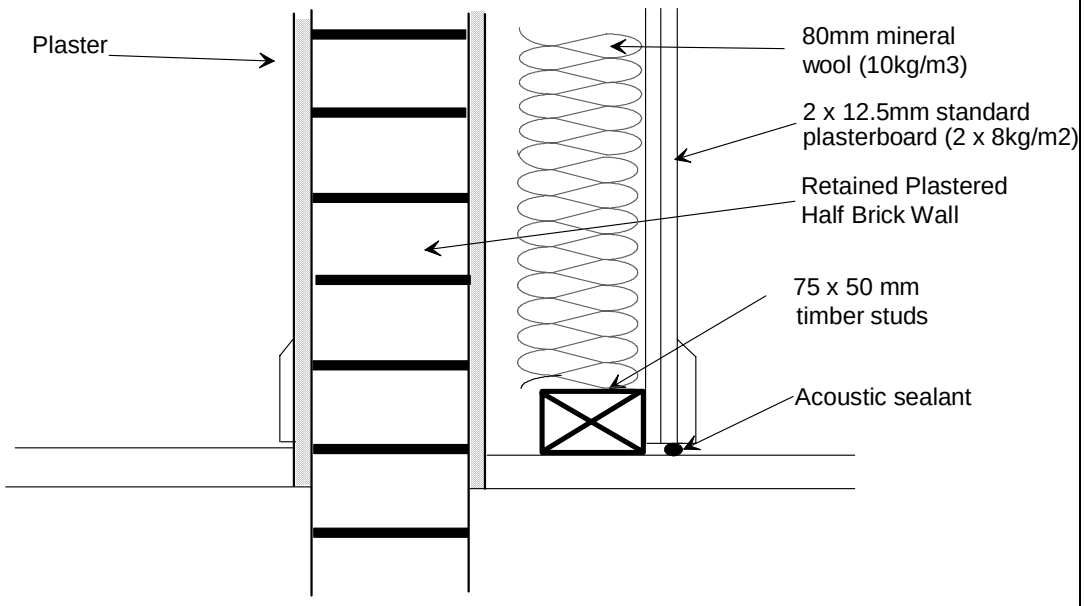



**Figure 6 - Lining to Upgrade Retained Brick Wall between Flats and Common Areas**

### *Doors*

- The guidance in Approved Document E is that doors to common areas should have a mass of at least 25 kg/m$^2$ and have good perimeter sealing all round. Solid timber doors were used. Entrances to apartments had a small lobbied hallway that protected the other rooms from noise intrusion.
- The two storey flat has a door from the kitchen out into the common hallway. The door was provided with acoustic seals.

### *Internal Floors*

- There are internal floors between the ground floor and basement level of the two storey dwelling. If they had been new they would have had to have the sound insulation rating (40dB $R_w$). However, the existing floors were kept so no upgrading was required.

### *Common Areas*

- Under the Regulations (Requirement E3), sound absorbing finishes must be installed in the common areas, in this building the hallway and staircase leading to the first floor flats and above. The guidance in Section 7 of Approved Document E describes how to calculate the area of such finishes required. One option for the hallways is to install one area of Class C (or better) sound absorbing finish equal to the floor (or ceiling) area. 'Class C' is a rating based on the sound absorption coefficients of the finish measured in a laboratory.
- A suspended mineral fibre tile ceiling was used throughout the hallway to meet this requirement.
- For staircases the area calculation is different. It is the combined area of stair-treads, upper surfaces of intermediate landings and landings (excluding the lowest floor) and the ceiling area of the top floor. In this case adequate absorption was achieved by carpet throughout the staircase which was rated Class D and a suspended mineral fibre tile ceiling to the ceiling over the top floor which was Class C. This gave an adequate area of absorbing finish.

### *Services*

- Ventilation fans were installed in or ducted directly to external walls and did not affect the sound insulation.

- Most soil vent pipes followed the existing route outside of the building. One soil vent pipe was taken between floors inside the building together with water pipes.
- The pipes that penetrated separating floors were boxed in the corner of the room to prevent them degrading sound insulation. The two sided enclosure ran between floor and the upper (not suspended) ceiling level. It comprised two layers of 12.5mm plasterboard (2 x 8 kg/$m^2$) on timber grounds. The enclosure was divided inside into separate compartments for the SVP and the water pipes. The pipes were wrapped with 25mm of mineral wool quilt (10 kg/$m^3$).
- The penetration within the depth of the separating floor was also treated with an intumescent collar and mineral fibre packing to provide adequate fire resistance. This also helped the sound insulation.
- The gas riser had the same enclosure construction but without the mineral wool wrapping which is not allowable under fire safety Regulations. The enclosure was also vented to outside at top and bottom at each floor level.

### *Thermal Requirements*

- The four new construction details, Figures 3 to Figure 6, were reviewed in light of the Building Regulations Part L1 and Part F.
- The improvements to the separating floors and walls (Figures 3, 4 & 6) will not affect the performance from a heat loss point of view. The insulation of external wall (Figure 5) may not meet the thermal insulation requirements unless the thickness of the thermal insulating board is 60 mm with the 225mm thickness solid brick wall.
- More details on the insulating material were required. The system was using Gyproc ThermaLine SUPER board. Data taken from the Gyproc White Book technical data series allows the U- values to be calculated. The external wall needs to reach a U- value of 0.35 W/$m^2$ K to meet the minimum standards in Part L1 (2002), the following list gives the 4 combinations of U- values for the wall.

  340 mm solid brickwork with 50 mm ThermaLine = 0.348 W/$m^2$ K

  340 mm solid brickwork with 60 mm ThermaLine = 0.293 W/$m^2$ K

  225 mm solid brickwork with 50 mm ThermaLine = 0.367 W/$m^2$ K

  225 mm solid brickwork with 60 mm ThermaLine = 0.3407W/$m^2$ K

- The U-values were calculated using the following inside and external surface resistances for a wall with horizontal heat flow taken from BS EN ISO 6946. ($R_{se}$ of 0.04 $m^2$K/W and $R_{si}$ of 0.13 $m^2$K/W)
- The 225mm solid brickwork external wall must therefore use a 60 mm ThermaLine SUPER board to meet the Part L1 requirements.
- There is also a thermal bridge where the internal floor junction abuts the solid external wall. This was improved with extra mineral wool packing. An alternative would have been rigid phenolic foam against the timber joist, but the mineral wool is probably better from the acoustic point of view.
- The insulation of the walls for acoustic reasons helps with the conservation of fuel and power by improving the thermal performance of the building envelope. The overall air infiltration within the flats will be reduced because of the acoustic sealing and will make an improvement in internal comfort conditions. None of the improvements interfere with the purpose made ventilation paths and therefore do not affect Part F of the Building Regulations.

## Pre Completion Testing

- Pre completion testing must be done on at least one in every ten units completed including the first ones, to show that the specified levels of airborne and impact sound insulation have been achieved.
- Before the building was handed over and occupied a set of sound insulation tests were done between two pairs of rooms. Note that if different separating floor constructions had been used at different levels, a set of tests would have been required for each type of construction.

- Access could not be obtained to the largely unoccupied properties on either side, so the separating walls could not be tested. As the existing separating walls were 225mm solid brick with plastic finish, they were expected to meet the performance standard without upgrading. If the separating walls had been of a lighter construction, upgrading would have been necessary, probably by installing wall linings. This treatment would be required, even if the separating walls could not be tested because there was no access.
- Tests were done in accordance with BS EN ISO 140-4, 1998 and BS EN ISO 140-7, 1998.
- Airborne and impact sound insulation of separating floors were measured between lounges and between a bedroom and kitchen. Carpets had been fitted so these were taken up about 75 percent for the tests. To comply with the Regulations, impact tests cannot be done with carpet or other soft covering fitted except for heavy concrete floors ($\geq$ 365 kg/m$^2$) where it is a fixed part of the construction.
- The results are tabulated below.

| **Source Room** | **Receiving Room** | **Element Tested** | **$D_{nT,w} + C_{tr}$** **dB** | **Limit** dB - min |
|---|---|---|---|---|
| 1st Floor Lounge | Ground floor Lounge | Separating Floor | 54 | 43 |
| 1st Floor Bedroom | Ground Floor Kitchen | Separating Floor | 51 | 43 |
| Staircase | 1st Floor Bedroom | Separating Wall to Common Areas | 47 | 43 |
| | | | $L'_{nT,w}$ - dB | dB - max |
| 1st Floor Lounge | Ground Floor Lounge | Separating Floor | 50 | 64 |
| 1st Floor Bedroom | Ground Floor Kitchen | Separating Floor | 58 | 64 |

### *The Measured Sound Insulation Met the Requirements of the New Regulations*

- The airborne sound insulation of floors is well above the limit for conversions. It is important to note that this good performance relied on the flanking sound being well controlled. Half brick walls (110mm) that were continuous between floors were independently lined. Also all gaps between floorboards were sealed.
- The impact sound insulation was within the limit. It was significantly better between lounges than bedroom to kitchen. There was no apparent reason for this, although the fact that the kitchen is larger than the bedroom does explain 2dB of the difference.
- This shows that builders must allow a good margin in the design of separating floors for adequate sound insulation.
- The sound insulation between stairwell and flats would not be tested to show Building Regulations compliance because the accuracy of such measurements is less than those taken between rooms. However, for research purposes, a test was done between the stairwell and first floor bedroom. This showed that independently lining the half brick wall and having lobbied entrances achieved the sound insulation required in the design.

## Costs

- The cost of the constructions has been estimated. This includes those constructions affected by the requirements of Part E, that is separating floors, new internal walls and linings, pipework enclosure and sound absorption in the hallway. It does not include doors, surface finishes, floor coverings (carpet), fittings and fixtures.
- The cost is the total cost of installing these items including a proportion of site facilities overheads and profit but excluding VAT. It has been calculated for the first floor flat, which is typical, but excluding the separate utility room. The total area costed is 47m$^2$.

- The rounded total is £6400 for the typical flat plus £35/$m^2$ for absorptive treatment to the hallway. The main items are

| | |
|---|---|
| Separating Floor | £5000 |
| Internal Wall | £400 |
| Internal Wall Linings | £850 |
| Boxing of SVP/Water Pipes | £160 |

- These costs are for all the works as described, not the additional cost of complying with the latest revision of Part E.