The Structure of Georgian London Houses

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ABSTRACT: The influence of the Building Acts, the Great Estates and Pattern Books on the construction of Georgian London houses is considered. The separate structural elements are then assessed – foundations, vaults, external and party walls, internal timber stud walls, the differing types of floors for the various house sizes and types, roofs, staircases and chimneys. These are illustrated by examples encountered during the author's work as a structural engineer in the city.
Particular problems such as snap header facades, eccentric timber stud spine walls, the deflection of long span floors and the vulnerability of end-of-terrace houses to movement are examined in greater detail. Whether and how different elements should and can be strengthened is debated. The ways in which these houses, designed for a different age, have been adapted structurally for modern styles of living is considered.

INTRODUCTION

The reigns of the 4 Georges from 1714 to 1830 correspond to the growth of London from a national capital to the centre of a world-wide empire. It was a time of confidence – victories abroad, increasing prosperity and the triumph of enlightenment in science and art.
The homogenous growth of the western part of London is usually put down to three main factors, the Building Acts, which followed the 1666 fire, the influence of the Great Estates, which had some power to impose uniformity in the areas that they controlled and the numerous architectural Pattern Books that were published in the period. However the over-riding factor was the consensus of architectural taste and the belief in rational planning, including town planning and architectural design, that was typical of the age. The policies of the Great Estates and the existence of the Pattern Books are symptoms of this consensus (Rasmussen 1934 p.178).
The streets were laid out orthogonally and planned to provide for all the needs of the various classes of inhabitants. There is an obvious contrast in Horwood's map of Regency London between the layout of the Great Estates and the medieval streets of the older parts of the city (Margary 1985 pp.12 and 15).

THE BUILDING ACTS

The main London Building Acts were those of 1667, 1707/9 and 1774 (Castelmain 1938 p.111).
The main areas in which the Acts affected construction were:

1. Houses were organised into four main rates (Fig.1) relating to their size (and to the wealth/status of the occupants).
2. Party walls and facade walls had to be brick or stone and their dimensions, thicknesses etc were prescribed (Nicholson 1823 Plate LXXXVII). Parapets were essential for the party walls between adjacent roofs. Resistance to the spread of fire was a major concern.
3. Timber floors of adjacent houses had to have a defined thickness of brickwork between them when they had a bearing onto a party wall. This tended to favour spanning the floor joists parallel to the party walls as they do in the majority of London houses. The joists therefore have their bearings on external walls vulnerable to damp and with openings to be spanned and on a central spine wall usually of timber stud.

THE GREAT ESTATES

The Great Estates dominated the westward expansion of the city. There were many landowners, the largest being the Bedford, Portland, Grosvenor and Portman estates (Summerson 1945 p.166). They controlled development within their areas and to some extent still do. Their contractual arrangements with both the builders and the leaseholders were designed with the long term interests of the estates in mind.

PATTERN BOOKS

The numerous Pattern Books produced in the eighteenth and early nineteenth century were the method of transferring knowledge to clients, architects and builders (Yeomans 2003 p.31). Those different functions were not clear-cut, but the various authors Price, Nicholson, Halfpenny etc catered for somewhat different readerships. The books vary in quality and tend to repeat one another. They can also be misleading, illustrating poor details that were then followed on site. The as-built floors and timber stud walls bear little similarity to some of the pattern book illustrations.

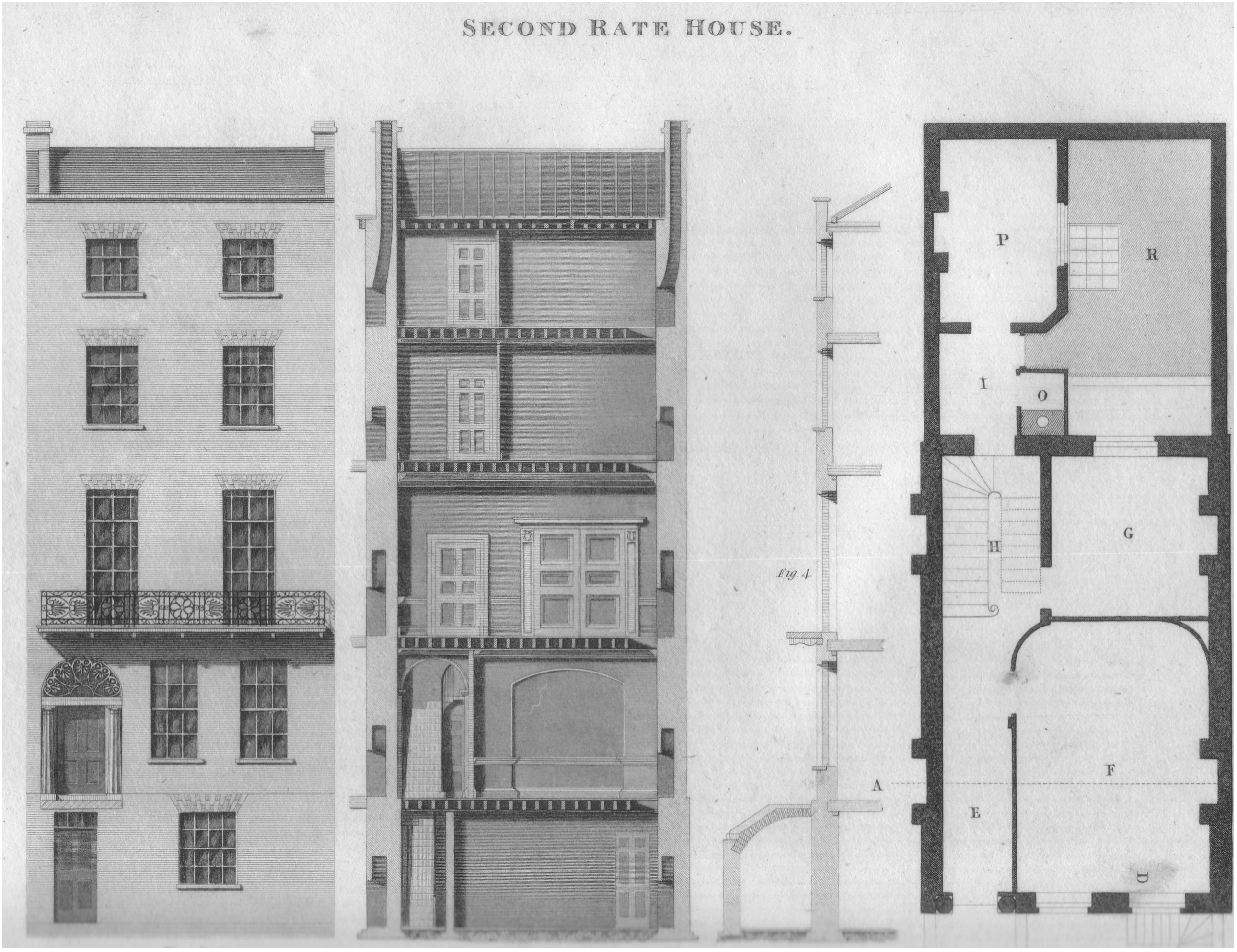


Figure 1: Second Rate House; (Nicholson 1823, Plate III).

FOUNDATIONS

The subsoil in central London is generally ballast, a mixture of sand and gravel deposited in the geologically recent past by the river Thames. Outside the city centre the subsoil is clay, which is a much worse foundation material with a lower allowable bearing pressure and prone to movement with changes in water content.

The foundations of the walls of all the various rates of houses consisted of corbelled footings on the subsoil. Almost all the houses had basements. The footings, particularly those of fourth rate houses, are often minimal, but fortunately on the firm ballast at least this has not led to subsequent problems.

The pattern books advocate the use of inverted arch foundations (also Pasley 1826 p.22) and one finds built examples of this technique (Fig.2). The modern engineer needs to consider the possible harmful effect of removing the panels under basement windows, particularly on clay, since this will cause increased local bearing pressure.

VAULTS

At the front of the houses there were vaults under the pavement, their usual purpose being to store coal delivered down vertically through a coal-hole. These vaults have tended to suffer as water has got into the brickwork causing them to deteriorate due to freeze/thaw action. Decayed vaults can collapse if, for example, a lorry mounts the pavement and imposes a substantial load on the arch. It is difficult to convert the vaults into habitable space.

Damp-proofing by rendering is vulnerable to movement of the masonry; a cavity drain system may conceal the future deterioration of the hidden wall behind. A final, if negative, way of dealing with the problem is to abandon the vaults and backfill them with concrete.

It is not unusual to discover disused vaults particularly under the mews buildings behind larger houses. The mews were at ground level, to suit the horses and carriages for which they were designed. They were therefore higher than the basement of the main house and it was possible to build vaults beneath them. These vaults can be a hazard if undiscovered during alterations.

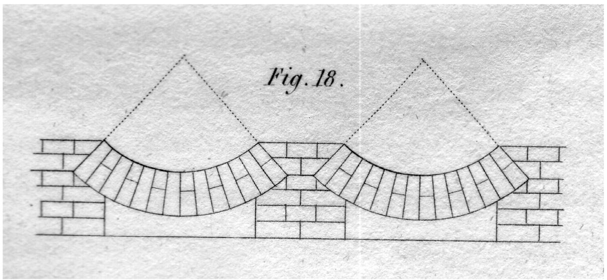


Figure 2: Inverted Arch Foundation. Nicholson 1823 Plate LXXXV (left). Albert Street Example (right).

BRICK WALLS

The brick walls were built with London stocks, made in the brick fields using the clay and brickearth (clay with sand) that surrounded the city (Ayres 1998 p.101). The walls are often not well tied together due to the use of different bricks and bricklayers to build different parts of the building.

The front facades were built using the better bricks and bricklayers. The outer skin was often not well bonded to the backing since it was cheaper to snap some of the headers of the more attractive and expensive bricks. Consequently there can be few full headers tying the wall together. The facades have a tendency to delaminate, which can be seen in bulging, sometimes most apparent at the window reveals. Stainless steel rods set in epoxy resin can be used to tie the wall back together, invisible if inserted from the inside.

The facades were not always built concurrently with the party walls so the connection between the two can be problematic, movement and cracking can occur. A common repair is to tie the facades to the party walls. This can be done with L-shaped concrete “elbows” (CIRIA 1986 p.36). However since that can be a damaging process, the alternative of drilling and setting in resin stainless steel rods through the facade (concealed in the bed joints) into the party wall may be preferable. It is generally beneficial to tie the walls together and to tie them to the floors.

Bonding timbers were built into the external walls until the mid-19th century and as the timbers become damp and rot the facades develop bulges due to the eccentricity of load on the outer part of the wall (Hurst 2006 p.1633).

Since the floors span front-to-back, the end-of-terrace walls have little lateral restraint and can become unstable. The terrace as a whole expands and contracts and there tends to be a ratchetting effect as cracks occur and fill with debris. The upper parts of the terrace, being more exposed and having less restraint, expand more and the end walls of the terrace lean out towards the top. This has been called the bookend effect (Richardson and Messenger 2000 p.19). The layout of the end-of-terrace house has an influence. If the stair is against the end-of-terrace wall the restraint may be reduced. If the chimneys are on the wall they can stiffen the wall. Ties have often been put in with plates on the outside. They can be ineffective if they are not well anchored internally.

The chimneys on end-of-terrace walls are prone to sulphate reaction between the flue gases and the moisture available on the outside of the wall. The consequent expansion of the mortar causes the wall to bulge and the chimney to lean, generally inwards since there is more moisture available on the outer face to fuel the sulphate reaction. End of terrace houses are also more prone to foundation problems since there is the possibility of unplanned excavation against the wall and, where the subsoil is clay, the shrinkage effect of nearby trees. Opinions differ on the bookend effect and methods of repair but the structural problems associated with end-of-terrace houses are undoubted.

TIMBER STUD WALLS

The internal walls of London Houses above ground floor level are generally built in timber stud. Sometimes there is brick infill. The central timber stud wall parallel to the facades is usually known as the spine wall and carries the load of the upper floors and roof. Often it has larger openings at first floor level due to the desire for a large piano nobile. Quite often the spine wall is not vertically in line between floors, particularly between ground and first floor. The bending in the floor joists due to the eccentric line load can be considerable with consequent deflection.

From the viewpoint of a modern engineer the most interesting element is the timber walls built in the form of trusses. Where openings were required the spine walls were detailed as trusses to carry the floors above (Fig.3). The forms of these trusses show the level of understanding of truss action at the time. Designs for various types of truss were given in the pattern books.

Figure 3: Trussed Timber Wall. Nicholson 1823 Plate XXIII (left). Park Square West Example (right).

Trussed timber stud spine walls are particularly vulnerable to irregular alterations. Builders and occupiers have not realised that the truss is destroyed by cutting its members even locally. There can be an erroneous belief that a timber wall is not a loadbearing member and a lack of understanding of its function spanning across a room below. It is common to find the centre of the house sagging relative to the surrounding masonry walls. This can be due to these misguided alterations but there is also the effect of shrinkage of the tall timber structure as the temperature of the house has increased with central heating.

FLOORS

For suspended floors timber was the only available material. For floors of normal spans in houses of second, third and fourth rates timber joists were laid with 12 inches between each joist. On the larger houses the spans became too great for common joists and large baulks of timber (girders) were put across (Fig.4).

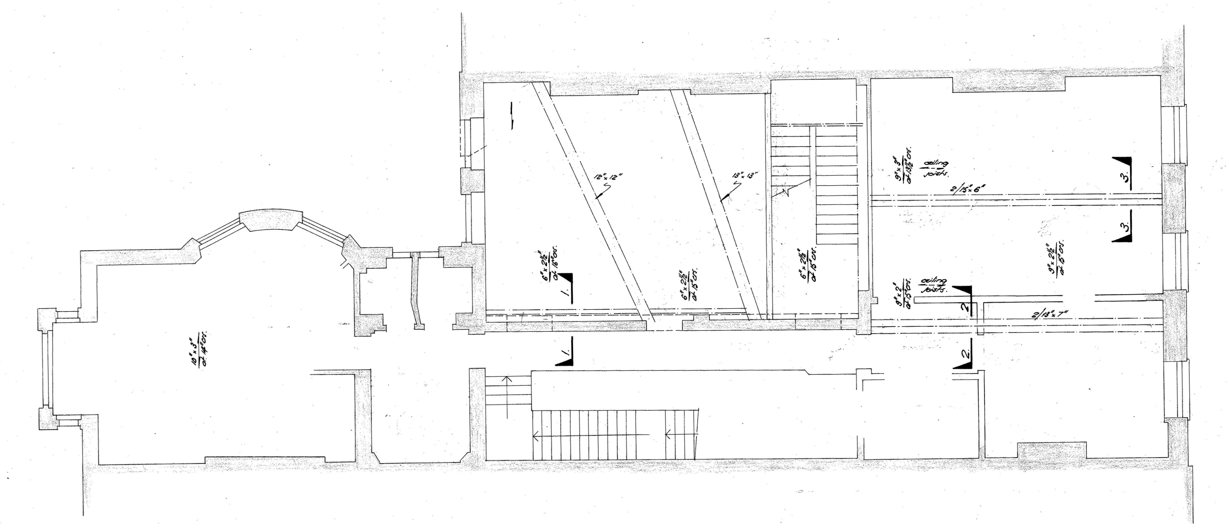


Figure 4: Second Floor 29 Portland Place showing timber girders.

These floors had separate small floor and ceiling joists connected to binding joists spanning between and connected to the timber girders (Yeomans 1991 p.47). On larger spans these girders often show quite considerable deflections under load and cannot be justified to modern deflection criteria. They have often been weakened originally by the mortise joints of the binding joists and later by notches for services when subsequent builders discovered that the girder fills the full height of the floor and cannot be avoided.
Enthusiastic engineers try to strengthen and stiffen the girders but it is not a straightforward exercise. Cutting slots for flitch plates into the hard timber is difficult. Residual stresses can be released causing warping. Substantial connections are required to transfer the forces into and then out of the flitch plate. Since the larger houses, where these floors are found, are often now used as offices it is sensible to consider the actual loading which is likely to be applied rather than a modern statutory loading (English Heritage 1994). The engineer can sometimes persuade his clients to forego elaborate and possibly ineffective strengthening schemes on this basis.

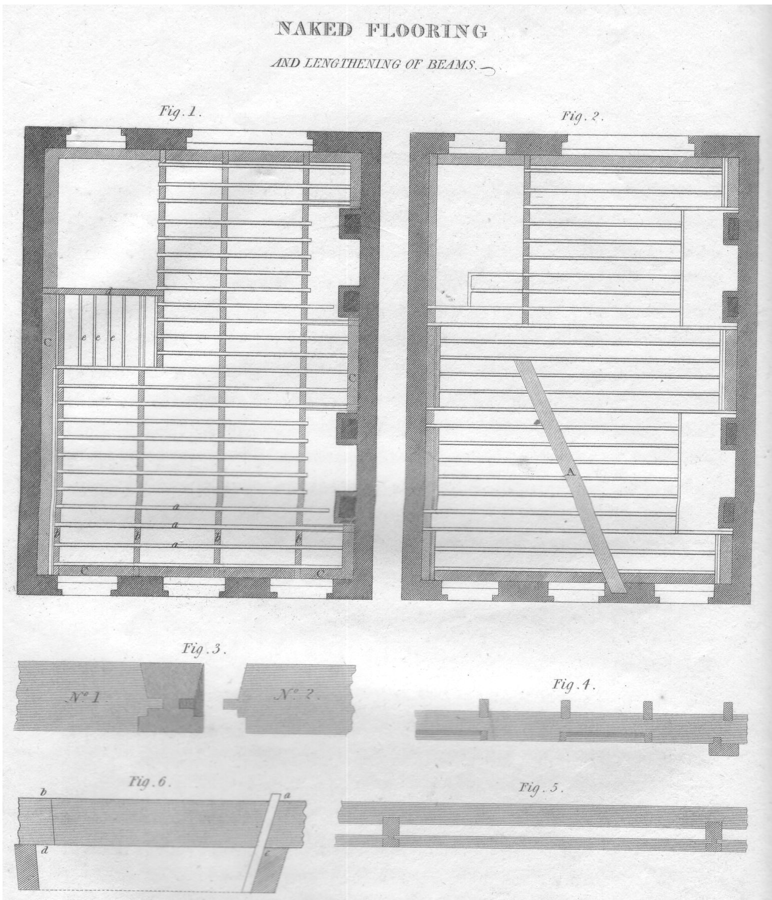
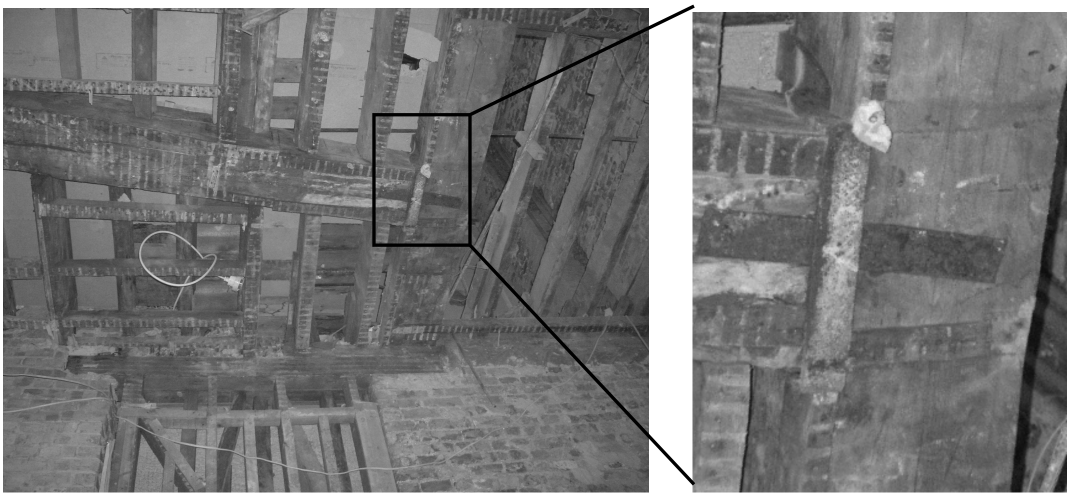


Figure 5: Nicholson 1823 Plate X. Few built examples resemble these closely.

Figure 6: Floor Kent Terrace – a rare example following Nicholson (Fig.5 left).

A particularly weak point in the floor occurs when one girder is supported by another since the timber-to-timber jointing techniques were unable to transmit large shears. The builders showed an awareness of this when they used iron hangers to reinforce the joint (Figs 7 and 8).



Figures 7 and 8: Iron Hanger Reinforcing Joint between Timber Girders 92 New Cavendish Street.

STAIRS

The lower flights of the stairs of the larger houses were generally stone cantilevers (Fig.7). The walls surrounding these stairs were brick up to the top level of the stone stair, which was housed into them.

Much has been written about the possible modes of structural behaviour of this type of stair. The lower treads/risers provide support so that the pure cantilever is apparent rather than real (Price and Rogers 2005 p.29). The most problematic elements can be the stone landing slabs where there is little possibility of anything but cantilever action.

Figure 9: Cantilever Stone Stair 29 Portland Place.

Timber stairs in the fourth rate houses become almost an element of joinery since the timber partition that surrounds them does not have substantial studs and consists mainly of boarding.

ROOFS

The standard roof for the lower rate houses has a parapet at the front and central valley beams with a sloping gutter between them draining the roof to the rear, the beams supported at mid-span on the central timber spine partition. The use of Welsh slate after 1760 allowed roof pitches to be quite shallow. The valley gutter beams are vulnerable if the gutter leaks. The rafters and ceiling joists are often very light and poorly supported at their party wall ends. The gutter beams are under-size by modern standards.

The roofs of the larger houses have various forms depending on the plan of the houses, often with king and queen post trusses (Fig.8). Sometimes the shape of the roof meant that hidden gutters within the roof space were needed, for example to drain the front parapet gutter.

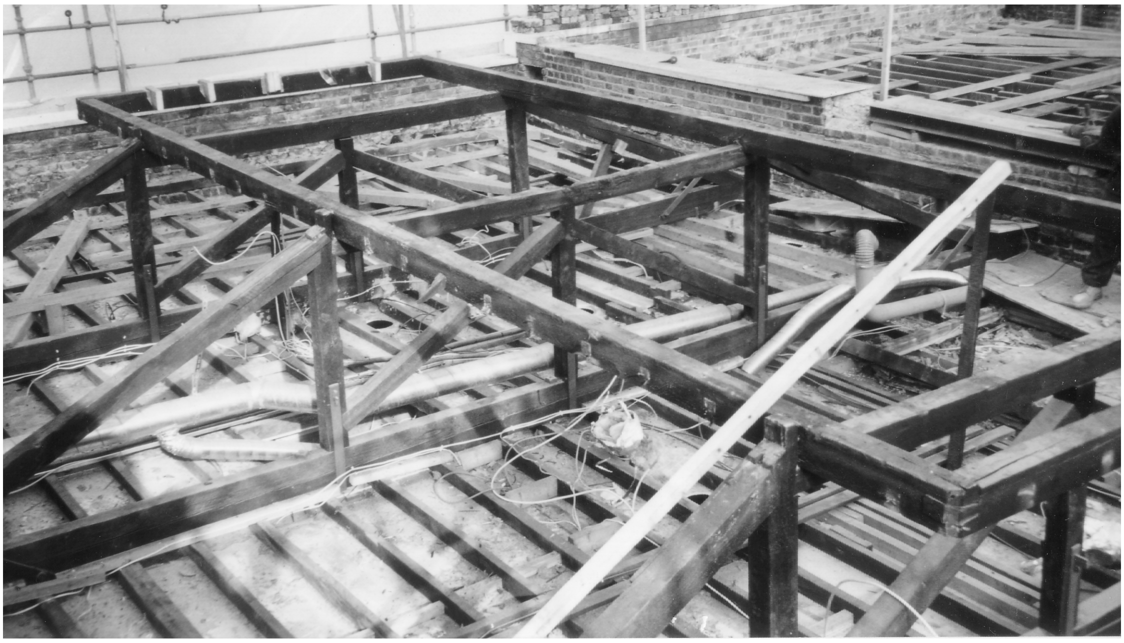


Figure 10: Queen Post Roof Trusses Seymour Street.

Although the Industrial Revolution was taking place during the Georgian period it had little effect on house-building technology. The use of iron was confined to straps and ties used locally in floors, roof trusses and trussed timber stud walls.

CHIMNEYS

London was, until the Clean Air Acts of the 1950s, a city of coal fires and chimneys. One way of understanding the original configuration of a house, if it has been extensively altered, is to consider its chimneys and the original routes of the flues. Many party walls consist almost entirely of flues, making it difficult to bear new steel beams on them.

MODERN ADAPTATION

The first point when considering structural modification of a Georgian house is the need for planning permission and listed building consent. The listing of a building is not confined to its facades and no alteration can be contemplated that does not have the agreement of the planners and English Heritage.

Georgian houses have been through many economic cycles and the Blitz so it is becoming uncommon to find one that has not had some previous alteration. Georgian houses are adaptable. Their straightforward simplicity makes them reasonably easy for the structural engineer to “read”.

In the later part of the 20^{th} century the gentrification of London has led to the re-conversion of many of the smaller Georgian houses to single family occupancy. The preferred layout now calls for larger spaces at lower ground/basement level for kitchen/living/eating with access to the garden. The structural engineer is asked to remove the spine wall and parts of the back wall to achieve this and he responds with steel “picture” frames carrying the comparatively lightweight central upper parts of the building without adding load to the party walls with their many flues.

The Party Wall Act controls the rights and responsibilities of building owners with respect to their party walls. In general it is advantageous to maintain existing load paths and not add load to party walls, not least in order to avoid lengthy negotiations.

Removing these spine walls (often masonry in the lower ground floor) and replacing them with steel frames reduces the longitudinal stability of the whole terrace. The frames can be designed with moment connections to resist lateral load but these are not going to have the stiffness of the masonry walls they replace. As more and

more houses have their spine walls removed the lateral stability of the whole terrace becomes questionable. It is sometimes difficult to persuade house owners that the stability of the terrace is important when dealing with an alteration to their house.
The headroom in the lower ground/basement floors was often low originally, with foundations only just below the floor. The larger room created by removing the spine wall calls for increased headroom. However it is difficult to gain significant height without having to underpin the surrounding wall foundations.
Another common alteration is the insertion of bathrooms in the central area of the upper floors. Apart from the difficulty of running services in the timber floors this often involves alterations to the timber spine wall, building new stud partitions on timber floors and fixing brittle finishes to timber structures that are prone to movement due to deflection and shrinkage. The timber joists may need doubling-up with a staggered double plywood deck to limit movement.
The final alteration when trying to add area to the house is to replace the valley gutter roof with a mansard storey. This disturbs the original elevation but in many parts of London is so common that it has become the rule rather than the exception. The houses were originally built with narrow street frontages for cost reasons and therefore were comparatively tall with a large proportion of stair to overall area. Adding another storey exaggerates this effect. It also raises questions in the engineer's mind concerning the fragility of the original structure when adding, for example, a sixth storey to a five storey two hundred year old building. The question of disproportionate collapse needs to be considered but it is difficult to do much more than tying the building together better horizontally. The continuous vertical ties that would be required in a modern building are, in practice, impossible to retrofit.
The additional structure needed to add the mansard can be quite minimal since the party walls and chimneys for a central valley roof are already quite high. New timber floors can span between steel beams bearing onto the party walls, avoiding flues, provided that the increase in load on those walls can be justified.

CONCLUSION

The Georgian houses of London have served the city well. There has not been a major fire. Their behaviour in the Blitz was helped by their brick walls and parapets. They have proved adaptable, changing from desirable residence to tenement and back to desirable residence.
They could not, however, escape some of their inherent design faults. Hidden gutters have inevitably led to problems. Long terraces have been susceptible to movement. Floors and trussed timber walls have sagged. Bond timbers have decayed causing brick walls to bow. The short-cuts taken by builders have revealed themselves as time has passed. Walls with snap headers have delaminated. Irregular alterations by subsequent owners and builders have taken their toll. Timber joists have been notched and notched again.
The remarkable consensus of architectural taste for about 150 years was broken by the Gothic revival. The Victorian view of the Georgian terrace was that it was monotonous and soulless. Pugin's Contrasts took this criticism to the extreme. But Georgian London survived reasonably intact until 1945. With post-war rebuilding, height restrictions were relaxed and the introduction of piled foundations provided structural engineers with the freedom to design tall buildings.

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