Building Research Establishment Report

5M steel-framed houses

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BR 200
ISBN 0 85125 489 6

First published 1991

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SUMMARY

This report records the form of construction of 5M dwellings, identifies positions where deterioration has occurred, and highlights areas where surveyors should pay particular attention when carrying out an inspection.

This report is one of a series produced by BRE giving the results of a survey of the forms of construction and the condition of steel-framed and steel-clad houses (see back cover for list of published titles).

1 BACKGROUND AND IDENTIFICATION

1.1 General

The National Building Agency issued an Appraisal Certificate for the system known as 5M in 1966.

1.2 Background

The 5M system is a lightweight composite steel-and-timber-framed system which was designed by the Ministry of Housing and Local Government Research and Development Group. It followed on from the earlier CLASP (Consortium of Local Authorities Special Programme) system. The 5M design was started in 1961 and the system became available for construction in 1963. Its title is derived from a design planning grid of 1ft 8in* or five times the module of 4in. The system is not a series of type plans but consists of standard components which can be used to produce a wide variety of plans.

About 3500 bungalows, two- and three-storey houses and low-rise flats were constructed with this system between 1963 and 1970.

1.3 The survey

Seven sites, located in England and comprising about 3000 houses and low-rise flats† in total, were visited during this investigation. On each of the sites, BRE examined substantial parts of the framework, and carried out visual checks on as many houses as time allowed.

1.4 Identification

The basic design is of single- or two- or three-storey flat-roofed terraced dwellings with a distinctive continuous fascia at first-floor level and at roof level (Figure 1).

The ground-floor elevations are largely storey-height door and window units, with intermediate panels clad with V-jointed vertical tongued and grooved boarding or exposed aggregate precast concrete panels. The flank-end wall is clad with similar concrete panels or with brickwork. At first-floor level a wide flat plywood or asbestos cement fascia panel encircles the terraced block. The upper-floor elevations are clad with a variety of forms of decorative tile hanging. A matching fascia panel encircles the terraced block at roof level and distinctive vertical timber cover strips mask the joints at corners. The roof is flat with an upstand around the perimeter. The rain-water is drained down internally.

The range of possible designs is wide. Some of the terraces are very long, up to twelve

*As the system was designed using imperial measurements, the original units have been employed throughout this report.
†No flats were examined.

dwellings, and a combination of features such as single-storey extensions, link rooms over external passageways and steps and staggers are used to break up the line. The single-storey extensions form enclosed porches, entrance hall storage areas or integral garages.

Many of these dwellings are currently undergoing upgrading work which, on two schemes seen by BRE, includes a brickwork outer leaf and a pitched roof. Thus the rehabilitated appearance of the structure is very different and will make dwellings of this type difficult to identify in the future.

2 CONSTRUCTION

2.1 General

The following description is typical of a two-storey, two-bedroomed, standard end-of-terrace house. Some of the more distinctive variations in design and layout are discussed in Section 2.11.

2.2 Foundations and substructure

A layer of compacted hardcore spread over the site area as a sub-base is topped with a lightly reinforced in-situ concrete slab about 4in thick. An in-situ concrete kerb upstand about 5in high and 5in wide is formed around the perimeter of the slab and an in-situ concrete or paving slab apron is extended about 18in beyond the face of the kerb upstand to protect the sub-base from the weather (Figure 2). A bitumen damp-proofing membrane is applied over the slab and kerb upstand.

Holding-down bolts or steel locating dowels are either cast into the kerb at stanchion locations during pouring or sockets are formed in the kerb for subsequent grouting in of the bolts and dowels.

2.3 Frame

The frame concept is of vertical steel stanchions connected laterally around the perimeter at first-floor level with plywood box beams capable of spanning up to 10ft and at roof level with identical plywood box beams capable of spanning up to 11ft 8in. In practice, for the two-storey dwellings the greater loads carried by the beams at first-floor level dictate the spacing of the stanchions around the perimeter. Composite flitch beams allow spacings of up to 15ft for internal stanchions.

The framework consists of nine two-storey steel stanchions. Three stanchions about 10ft apart are located in both the front and rear elevations and, together with a matching set of three stanchions across the centre of the dwelling, form a box grid (Figure 3). Stanchions occur within the cavity of the separating wall and are shared with the adjoining property.

The stanchions are 2¾in square steel tubes with vertical slots at the base to allow any internal condensation to drain away. Shaped steel base plates for corner or intermediate locations are welded to the bottom of the stanchions for bolting down to the concrete kerb. Holding-down bolts are not required at all stanchions; some are located over a steel dowel projecting from the concrete kerb. Steel support brackets and lugs (Figures 2 and 4) are welded to the sides of the stanchions at first-floor and roof levels as fixings for the plywood box perimeter beams and internal flitch beams.

Preformed asbestos cement coverings or flat asbestos cement strips are wired around the stanchions for fire protection.

Around the external perimeter, plywood box beams are bolted between the stanchions at first-floor and roof level. Composite flitch beams span from the separating wall to the flank-end wall between the central stanchions, and floor joist section timber beams are bolted on either side of the stanchions along the separating wall (Figure 4). The plywood box beams are about 16in deep and 4in thick with rebated composite ends of solid timber and plywood. The flitch beams are about 8in deep by 3½in wide made up of 1½in thick timber sections bolted on either side of a 5/16in thick steel plate. The floor joist beams are of standard timber section 8in deep by 2⅛in wide.

2.4 External walls

On the ground floor the external walls are storey-height door and window units with intermediate panels clad with vertical V-jointed tongued and grooved boarding. The boarding is nailed to 1½in × 1⅛in timber cross battens fixed through a building paper membrane to fabricated timber sub-frames made up of 3½in × 1½in studding (Figure 2). The door and window units and sub-frames are fitted between the stanchions and nailed into fixing plugs set into the concrete of the kerb and into the plywood box perimeter beams. The internal lining is of ½in thick foil-backed plasterboard. A paper-wrapped mineral fibre blanket about 1in thick is packed between the timber studs of the sub-frames.

The flank-end wall is clad with storey-height, precast reinforced concrete panels with an exposed aggregate surface. The concrete panels are nailed through projecting nibs formed at the top and bottom of the panel into a timber sub-frame made up of 3½in × 1½in timber studding fitted between the stanchions. Vertical joints between adjacent panels are sealed with rubber gaskets.

At first-floor level plywood fascia panels mask the perimeter beams and a timber sill section at the bottom of the fascia weathers the joint over the lower cladding.

At the first floor of the front, rear and flank-end walls, timber sub-frames are fitted between the stanchions and nailed into the plywood box perimeter beams at the top and bottom. The sub-frames are faced externally with flat asbestos cement sheeting, a building paper membrane, horizontal tiling battens and tile hanging (Figure 2). The internal lining is of ½in thick foil-backed plasterboard. A paper-wrapped mineral fibre blanket about 1in thick is packed between the timber studs of the sub-frames.

The corners of the flank-end walls are masked with vertical timber cover pieces.

At roof level plywood fascia panels similar to those at first-floor level mask the perimeter beams, and a timber sill section weathers the joint over the lower claddings.

2.5 Separating wall

The separating wall is of cavity construction with two leaves of laminated plasterboard panels separated by a cavity about 7in wide containing the steel stanchions. The storey-height plasterboard panels are about 1½in thick and are fixed to rebated timber sole and head plates (Figure 4).

A strip of flat asbestos sheet material is fixed across the cavity at first-floor and at roof level as a fire stop and strips of the same material are fixed to the sides of the floor and roof beams along the line of the separating wall.

Mineral fibre blankets are suspended within the cavity at each storey as additional sound insulation.

2.6 Partitions

The partitions throughout are prefabricated panels, made up of 3in × 1½in timber studding faced on both sides with ½in thick plasterboard.

2.7 Floors

2.7.1 Ground floor

The ground floor is of solid concrete construction topped with a sand and cement screed and finished with thermoplastic tiles.

2.7.2 First floor

The first floor has 8in × 2$^{1}/_{8}$in timber floor joists spaced at 20in centres spanning from the front elevation to the rear elevation. The joists are pre-cut to length and supported on galvanised steel joist hangers pre-fixed to the perimeter beams and flitch beams. The floor is of 4$^{1}/_{2}$in × $^{3}/_{4}$in nominal tongued and grooved boarding.

2.8 Ceilings

The ceilings are of $^{1}/_{2}$in thick foil-backed plasterboard nailed to the underside of the floor and roof joists.

2.9 Roof

The flat roof is constructed in the same way as the first floor with identical joists and flitch beams. The box plywood perimeter beams form an upstand around the perimeter of the block of dwellings (Figure 2) and the rain-water is drained down internally. The roof decking is of $^{3}/_{8}$in thick plywood covered with a $^{3}/_{4}$in thick layer of asphalt which is dressed up the inner face and over the top of the plywood box perimeter beams finishing at an aluminium trim. A paper-wrapped mineral fibre insulation blanket is laid between the joists in the roof void.

2.10 Corrosion protection

The stanchions are protected by a treatment of phosphoric acid followed by stove enamelling with two coats of red oxide/zinc chromate paint.

2.11 Variations

The following does not claim to be a comprehensive list of all the variations to the system, but records all of those noted by BRE both on site and in the available literature.

2.11.1 Foundations

Precast concrete sections of kerb upstand bedded and tied into the continuous ground-floor slab and apron extension.

Terraces built down sloping sites with traditional concrete strip footings and brickwork substructures to support the ground-floor slab.

2.11.2 Frame

A basic nine-stanchion box grid with additional single-storey stanchions. The design has a wider frontage and greater depth and incorporates an entrance hall and garage extension and an extension to the living-room (Figure 5(a)).

A basic nine-stanchion box grid with additional two-storey stanchions. The design has an extra bedroom built over a through passageway and linked to an adjacent block (Figure 5(b)).

2.11.3 External walls

The ground floor of the flank-end wall clad with an outer leaf of brickwork tied back to the timber sub-frames with galvanised frame ties.

Ribbed asbestos sheet material fascia panels.

Bitumen-impregnated fibre board sheeting used behind the tile hanging of the front, rear and flank-end walls.

Flank-end corners with the concrete panels or brickwork cladding returned around the ground-floor corners and special angled corner tiles at first-floor level.

2.11.4 Separating wall
Cavity construction, formed of two leaves of 3in blockwork separated by a 3in cavity. Wall surfaces finished with a sand and cement render and a skim coat of plaster.

2.11.5 Floors
7/8in thick chipboard sheeting as a floor finish.

2.11.6 Ceilings
Asbestos cement sheet lining to the underside of link rooms over the external through passageways.

3 PERFORMANCE IN USE

3.1 General

In general the steel stanchions are in good condition. However, the protective coatings to the steelwork are deteriorating and instances of superficial corrosion have been noted particularly at stanchion bases.

The specification for external panels clad with timber boarding calls for a building paper membrane behind the cladding (Reference 1); in one instance polyethylene sheeting has been used in this location.

Most of the problems occurring in the dwellings are associated with the roofs and claddings.

3.2 Foundations and substructure

(a) Carbonation of the concrete of the kerb upstand leading to corrosion of the steel reinforcement and spalling of the concrete.

(b) Damp penetration of the concrete kerb.

3.3 Frame

(a) Protective coatings deteriorating, particularly at the lower part of the stanchions, and superficial corrosion evident.

(b) At some stanchions excessive numbers of steel shim levelling pieces packed between the concrete kerb and the stanchion base. These steel packing pieces beginning to corrode.

3.4 External walls

(a) Carbonation of the concrete in the cladding panels leading to corrosion of the reinforcement and spalling of the surfaces. Horizontal cracks across the concrete cladding panels.

(b) Broken and missing tiles in the tile hanging.

(c) Wet rot in the plywood box beams and plywood fascia panels at roof level due to rain penetration (Figure 6).

(d) Deterioration of the external paintwork leading to wet rot in the timber joinery units, particularly at the lower joints in the opening windows and at timber sills and in the lower areas of timber claddings.

(e) Mineral fibre insulating blankets detached from their fixings and sagging to the bottom of the cavities (Figure 7).

(f) Severe mould growth on internal wall faces due largely to rain penetration in unoccupied dwellings and to a lesser extent to condensation in occupied dwellings.

3.5 Floors

(a) First-floor joists with wide gaps between the end of the joist and the joist hangers (Figure 8).

(b) Large notches cut in the tops of the floor joists and composite flitch beams for central heating pipes.

3.6 Roof

The roofs do not always slope towards the drainage outlet, creating areas of ponding. The asphalt roof covering is deteriorating and cracking allowing water to penetrate to the plywood decking and to the rooms below. Cracks along the top of the perimeter beams at the joint between the asphalt and the aluminium flashing are common and allow water to penetrate to the plywood box perimeter beams (Figure 9).

4 GUIDE TO INSPECTION

A BRE report (Reference 2) describes in general terms the methods of inspection and assessment of the steel content of steel-framed and steel-clad houses; it identifies general locations where steel is vulnerable to corrosion and gives outline advice on the rate at which unprotected steel might corrode in the future. Advice on the likely integrity and durability of protection systems is also given.

The present report describes deterioration and faults that have been reported to or identified by BRE which are specific to the 5M steel-framed house. Section 3 lists the principal defects as:

Carbonation of the concrete to the kerb upstand and precast concrete cladding panels leading to corrosion of the steel reinforcement and spalling of the concrete faces. Horizontal cracks across the concrete cladding panels (3.2(a) and 3.4(a)).

Damp penetration of the concrete kerb upstand (3.2(b)).

Deterioration of the protective coatings to the steelwork and superficial corrosion at the base of stanchions. Excessive numbers of steel shim packing pieces (3.3(a) and (b)).

Broken and missing tiles from the tile hanging (3.4(b)).

Wet rot in the plywood box perimeter beams, door and window joinery units and lower areas of timber claddings (3.4(c) and (d)).

Ineffective insulation and mould growth (3.4(e) and (f)).

Poorly fitting floor joists and large notches cut into the joists (3.5(a) and (b)).

Cracks in the asphalt roof covering, allowing water to penetrate through to the structure. Poor drainage of the roof creating ponding (3.6).

These do not constitute a comprehensive list of possible defects. Equally not all the above defects will necessarily be present in one property. Nonetheless this list serves to highlight features which should be subjected to close examination as part of any overall inspection procedure for 5M houses.

It is emphasised that if significant corrosion of the steelwork has occurred, the extent of deterioration may be masked by the corrosion product itself. In such cases it is difficult, if not impossible, to determine the condition of the steelwork solely by visual means. This limits the effective application of purely visual inspection techniques, including the use of optical probes. If corrosion is seen to exist, the component should be exposed in order to enable the extent of deterioration to be determined by removal of the corrosion product.

5 GENERAL COMMENT ON CONDITION

The observations in this report result from examination of 5M houses in England. Some of the houses were in their original condition, others were in the process of being refurbished.

The steel stanchions are generally in good condition. However the protective coatings are deteriorating and superficial corrosion is evident at the stanchion bases. Corrosion is occurring to the reinforcement in the kerb upstand and cladding panels largely due to carbonation of the concrete.

Rain penetration through cracks in the asphalt roof covering has led to wet rot in the plywood box perimeter beams.

6 ACKNOWLEDGEMENTS

This report was prepared by E Grant, based on site studies and other work carried out by E Grant, K C Harling and A J Stevens.

The ready co-operation of the local authorities who made properties available for inspection is much appreciated.

7 REFERENCES

1 **Ministry of Housing and Local Government.** 5M System Specification Notes and Component Drawings. London, MHLG, 1965.

2 **Harrison H W.** *Steel-framed and steel-clad houses: inspection and assessment.* Building Research Establishment Report. Garston, BRE, 1987.

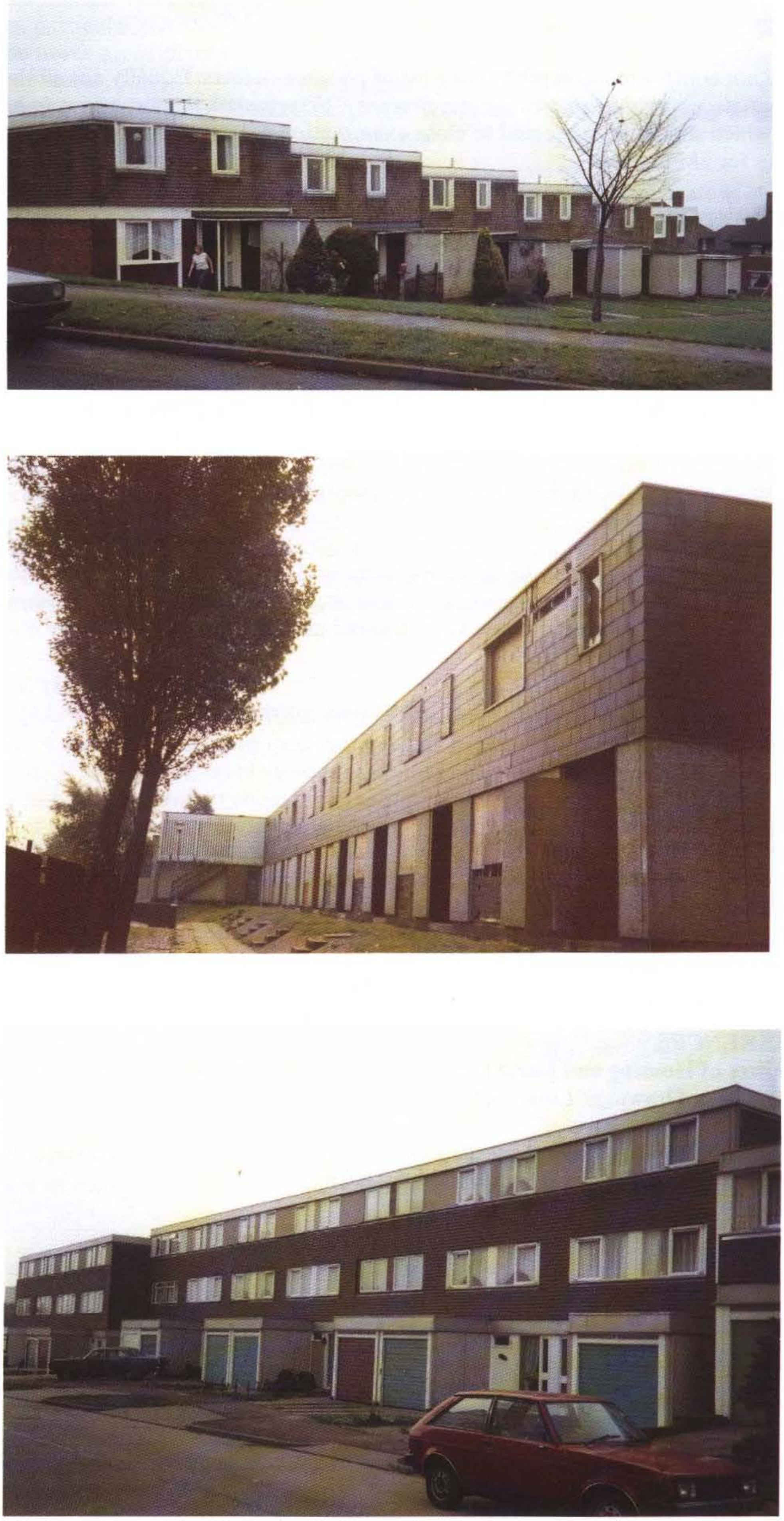


Figure 1 Typical 5M houses

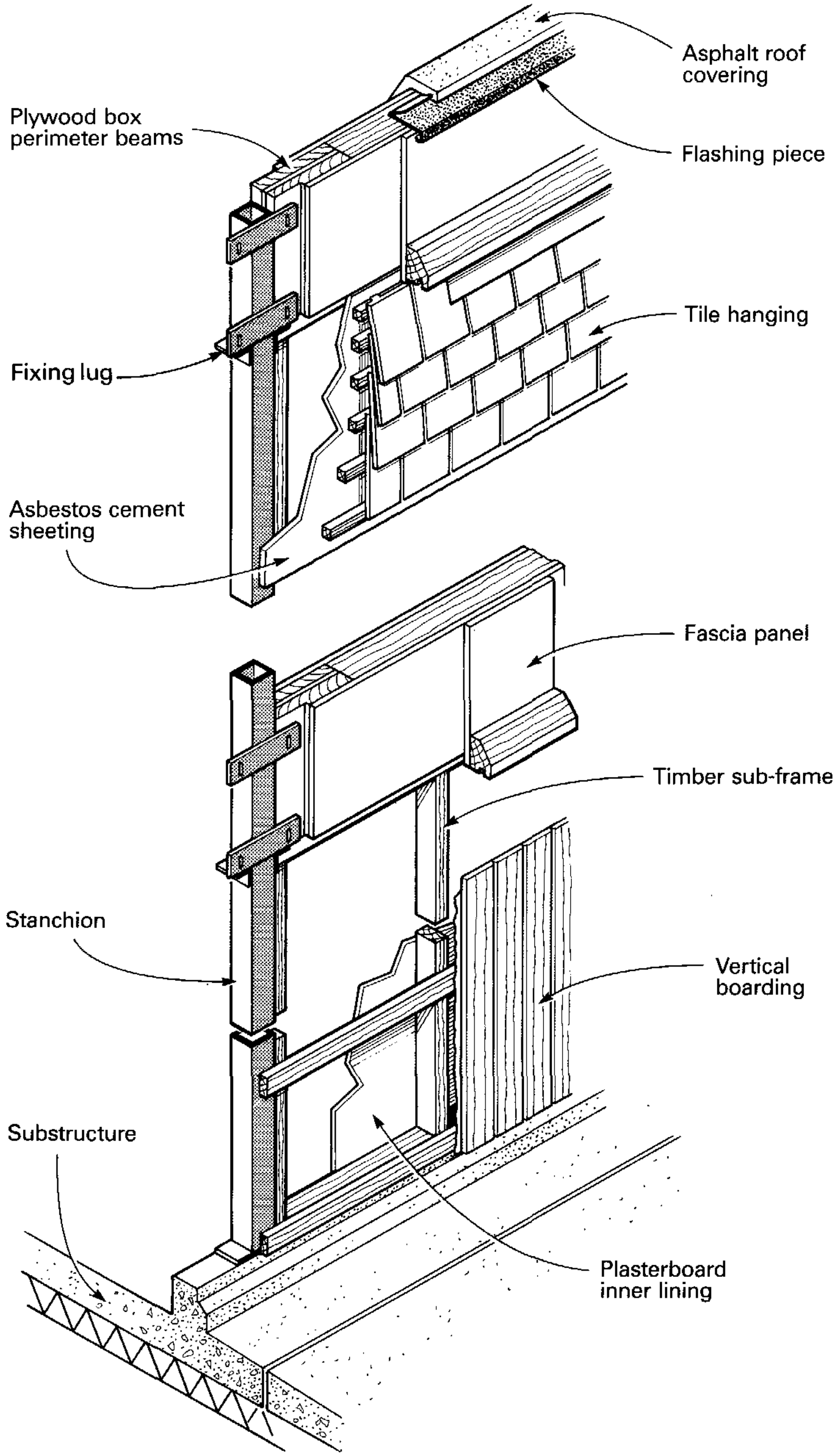


Figure 2 Typical section through the external wall

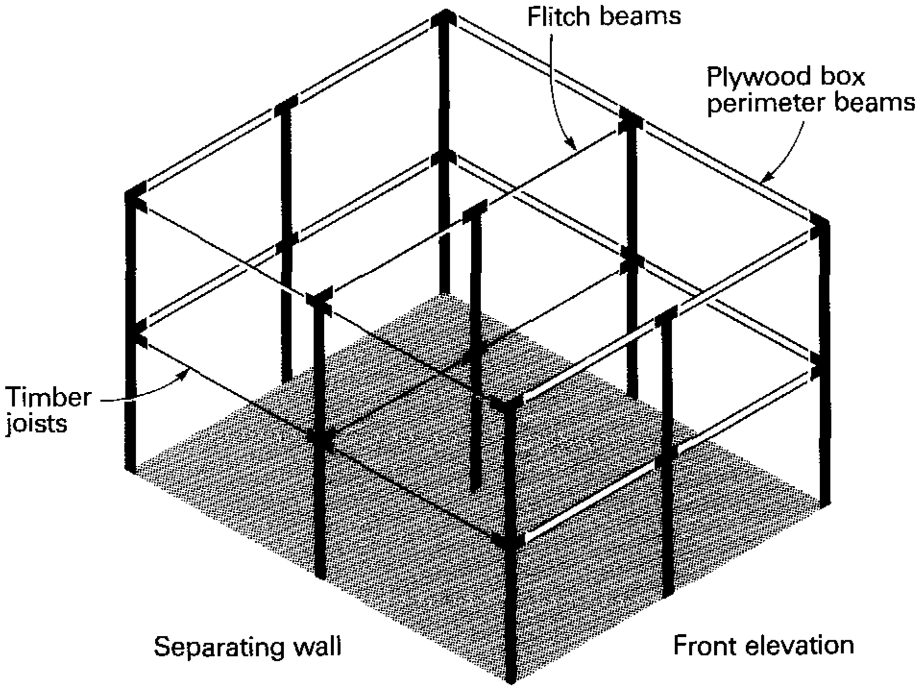


Figure 3 Diagram of typical frame layout

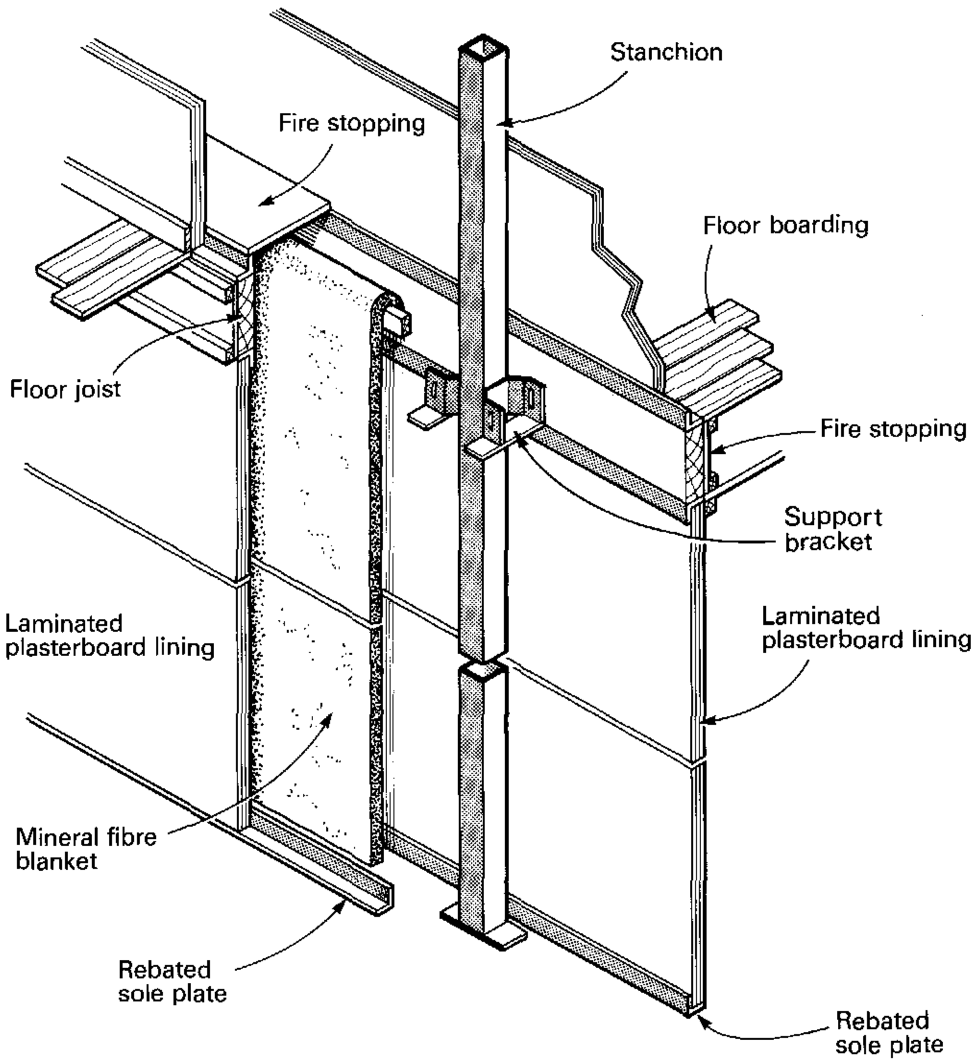
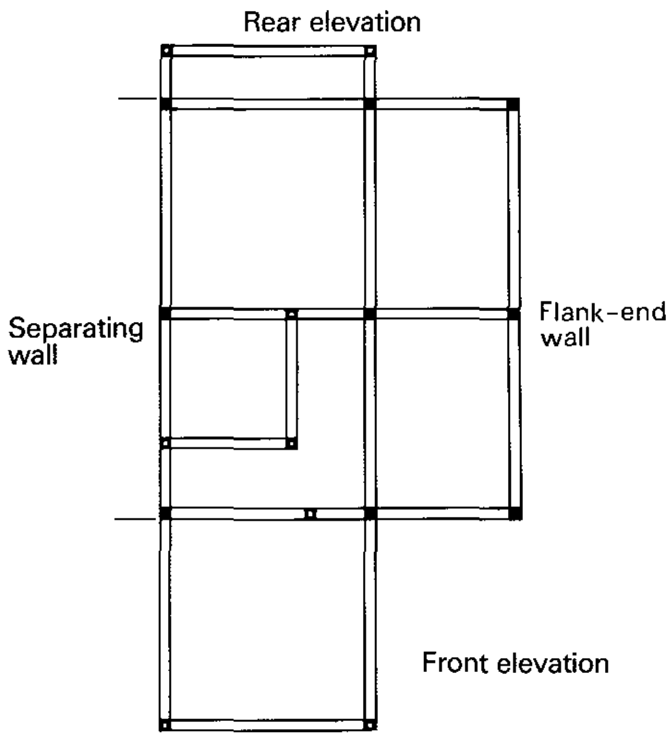
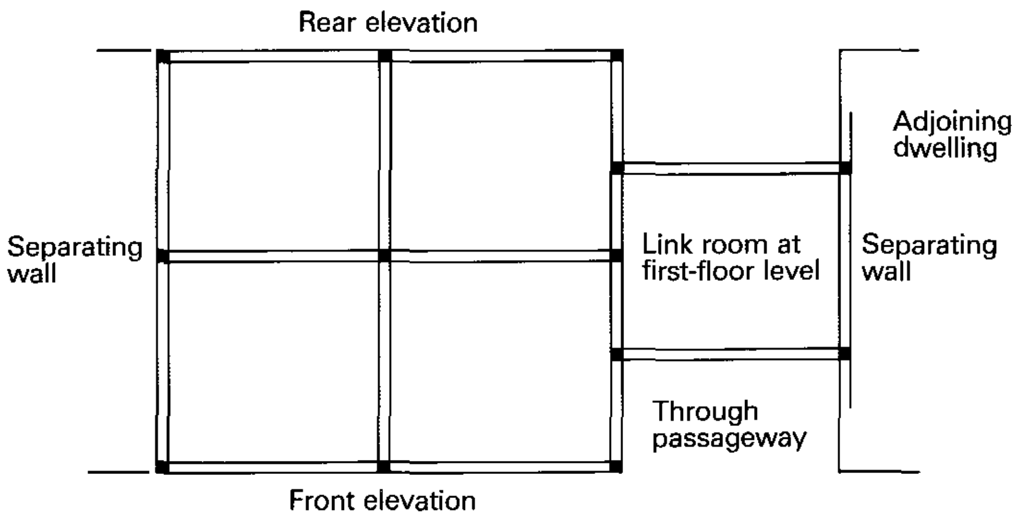


Figure 4 Typical section through the separating wall



(a) Stanchion layout for a three-bedroomed dwelling with an integral garage and extended living-room



(b) Stanchion layout for a four-bedroomed dwelling with a link room over a through passageway

Figure 5 Plans of variations in stanchion locations

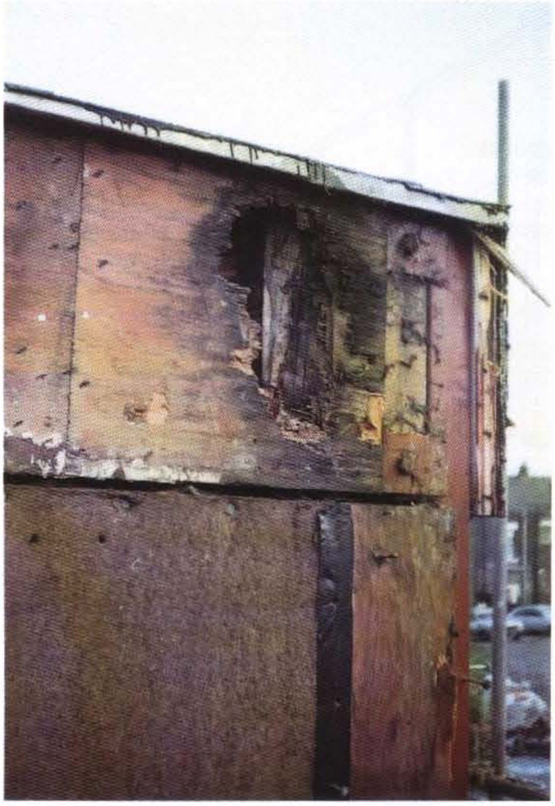


Figure 6 Wet rot in the plywood box beams

Figure 7 Detached mineral fibre insulating blankets

Figure 8 Wide gaps between the ends of joists and joist hangers

Figure 9 Crack between the asphalt roof cover and aluminium flashing