As Safe as Houses

Contents: A survey of the structure of a building, followed by data analysis, information and questions.

Time: 2 to 4 periods. The time required will depend on whether Parts 1 and 4 are done in school or for homework.

Intended use: GCSE Science courses. Links with the study of materials in physics and chemistry. Links with technology.

Aims:

- To complement work on the properties and uses of materials
- To create interest in the basic methods of house construction and how these are related to local resources and traditions
- To provide opportunities for making observations and interpreting data.

Requirements: Students' worksheets No.1006.

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This unit is in four parts. It is differentiated and teachers can select those parts which are appropriate for their students.

Part 1 Survey of a building
This has been written so that it can either be done at home or as a school-based activity. Students are encouraged to use diagrams to illustrate their notes.

Part 2 A closer look at materials for building

Part 3 Materials for window frames
These two parts are more challenging and require students to interpret numerical data.

Part 4 Houses around the world
This part includes reading and questions to set the topic of building homes in a wider context.

Part 1 Survey of a building

The advantages of loft insulation and double glazing are well documented. However, 15 per cent of heat is lost through the ground floors by conduction. Most British homes do not have floor insulation.

Students may introduce the subject of condensation, which tends to occur in rooms where the humidity is high or on poorly insulated surfaces where ventilation is inadequate.

A damp-proof course (DPC) prevents rising damp from the ground. A DPC must be included wherever the cavity is bridged, for example, around windows and doors.

Students may be interested in an explanation of damp penetration. Moisture will penetrate brickwork by capillary action. Solid walls are prone to damp and the outsides are often rendered to make them waterproof. The cavity in modern wall construction not only improves thermal insulation but also stops damp penetrating to the inner wall. Cavity fill insulation occasionally introduces problems of damp because it bridges the cavity.

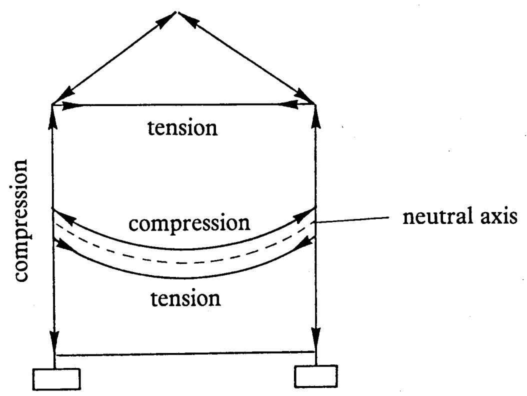
Flashing, usually made of lead, prevents damp penetration where a roof adjoins a wall or other vertical surface.

The Building Regulations are very specific about structural fire precautions in the construction of hearths and fireplaces and the installation of boilers and flues to reduce fire hazards. Terraced houses and flats must have a fireproof wall between them. A door from a house to a garage must be fire-resisting and self-closing. Local bye-laws may have extra requirements.

The designs for staircases must conform to Building Regulations and there must be a handrail. Balustrades must be of a safe height. There have been bad accidents through people crashing into patio doors, few of which are fitted with safety glass (though this is becoming more common).

Part 2 A closer look at materials for building

The directions of the *internal* forces in the structure are shown in the diagram.



Part 3 Materials for window frames

More energy escapes through aluminium and steel frames than from timber or UPVC. Some makes of aluminium frames now have a thermal barrier. UPVC has a much higher expansivity than the other materials and initially there were problems with windows sticking.

Part 4 Houses around the world

The unit is designed to provide a simple background in building methods by comparing British homes with those in other developed countries.

On the continent of Europe there are many firms who supply factory-made homes for a client's site and a few in England (for example, Guildway) who do so. In Britain, many small builders tend to use traditional wet construction and some of the larger firms, such as Barratts, use timber-frame above the level of the DPC. The economics of large-scale production favour timber frame, where much of the work is standardized and can be carried out independent of weather conditions. There is also the advantage that timber-frame houses are immediately dry whereas traditional buildings take weeks or months to dry out.

Timber-frame construction is used in many countries — USA, Canada, Sweden, etc. British builders and homeowners have experienced some problems, largely due to inexperience. Timber-frame houses are normally very well insulated. They have low thermal inertia, and so require less energy to heat them and warm up quickly once the heating has been switched on.

Timber-frame construction is not new to Britain. It was introduced by the Saxons who employed boat-building techniques to construct strong frames which were filled in with wattle and daub or brick. Modern timber-frame buildings have an internal timber frame, the external face is merely a cladding (for example, brick, timber, aluminium panels, etc.). The inside is dry-lined with plasterboard.

Further resources

Everett, Alan, *Materials*. Mitchell's Building Series. Batsford, rev. edn, 1986.
Thomas, Jill, *Home Insulation.* Aura Books for Texas Homecare, 1985. Available from Texas Homecare stores. This is simply written and well illustrated.

Acknowledgements Figures 3, 5, 6, 7, 8 and 9 supplied by Anabel Curry.

AS SAFE AS HOUSES

Part 1 Survey of a building

Find out as much as possible about the structure of a building you live or work in. You may find it easier to report on your findings with the help of a number of labelled diagrams.

Points to look for

1 Is the building detached or linked to other buildings? Does it have one storey, or several storeys? Is it a permanent or a temporary structure?

2 When was it built?

3 What are the outside walls made of (for example, brick, stone, timber, etc.)?

4 Is there a cavity in the walls or are they solid? If there is a cavity, does it contain extra insulation?

5 Is the roof/loft of the building insulated? If so, what is the thickness (in millimetres) of the insulation?

6 What are the window frames made of?

7 Does the building have double glazing? If so, is it useful? Give reasons for your answer.

8 What are the floors at ground level made of (for example, wood, concrete)?

9 Are the ground floors insulated to stop energy loss downwards?

10 Are the floors strong enough to support a heavy load such as a piano or a heavy piece of equipment?

11 Does the building have a damp-proof course? What is its purpose?

12 Does the building have flashings where a small roof (for example, of a porch or bay window) joins the walls or where a chimney stack joins the roof? What is the purpose of flashings?

13 Fire can be a fatal hazard. Large buildings have fire doors which must be kept closed. Some have smoke detectors and sprinkler systems.
(a) What safety features are designed into the building to prevent fire, or stop it spreading?
(b) What precautions can be taken against fire by the people who use the building?
(c) How can fire be prevented from spreading from one building to another?

14 Many accidents happen in buildings.
(a) What accidents have there been recently in the building you are surveying?
(b) Are there any special risks for young children or elderly people in your building?
(c) Would your building be suitable for a person in a wheelchair?

15 How might your building be changed to make it safer and more convenient for the people who live or work in it?

Part 2 A closer look at materials for building

The choice of building material depends in part on whether it needs to be 'strong'. In fact, there are several ways of looking at the strength of a material.

In buildings, the walls are being squashed by the weight of the roof. They are *in compression.*

The roof ties are *in tension* to hold the roof together.

Putting furniture on the floors makes them bend. We say that the floor joists are subject to a *bending moment.*

Materials like brick and concrete are strong in compression but weak in tension. Timber is more versatile because it is strong in tension *and* in compression.

Table 1 on page 3 shows the strengths of typical building materials. Remember that there are many types of brick, concrete and timber. The figures given are for materials in common use.

The table also shows the density of the materials. The denser the material, the heavier will be a beam or a wall made of it.

Thermal conductivity shows how fast energy can be conducted through the material if it is colder on one side than on the other.

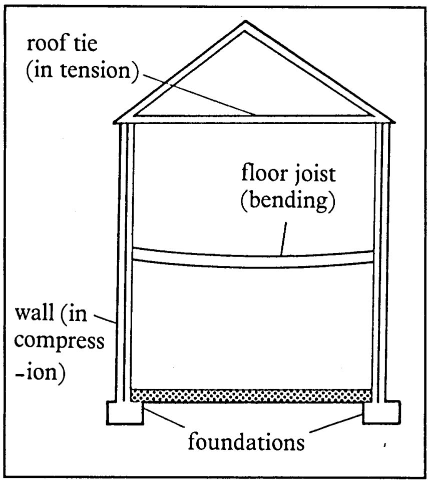


Figure 1

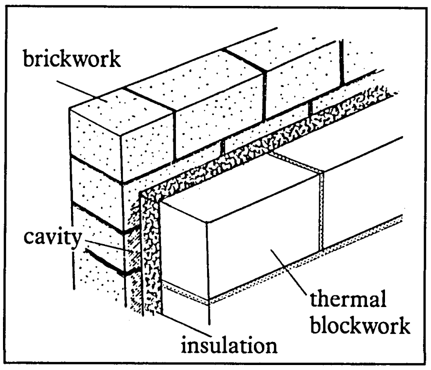


Figure 2 A modern brick cavity wall

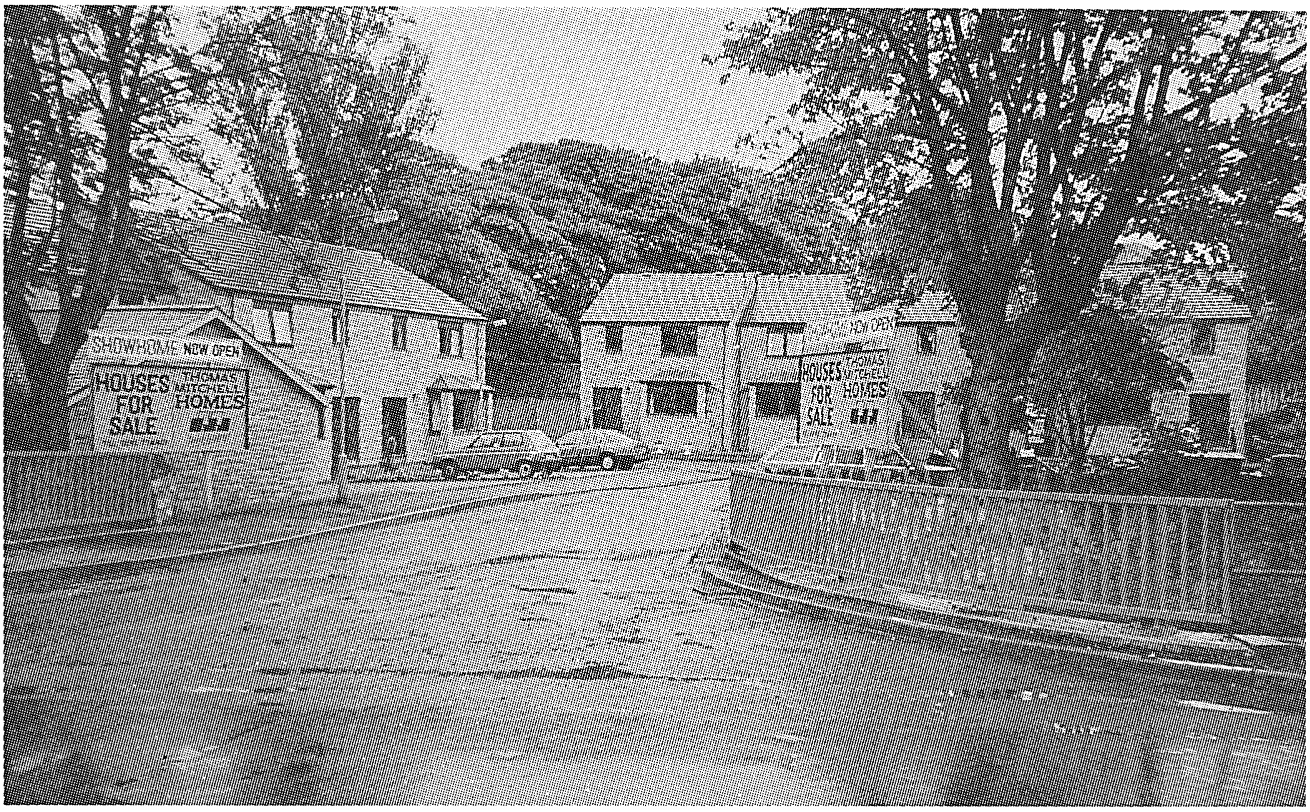


Figure 3 These stone houses are built with a timber frame. The outer walls are made of simulated stone

Table 1

Material	*Strength in compression (MN/m^2)*	*Strength in tension and bending (MN/m^2)*	*Density (kg/m^3)*	*Thermal conductivity ($W/m\,^\circ C$)*
Bricks (for loadbearing walls)	7-70	depends on the joints	1800	1.0
Low density concrete blocks (for inner walls)	4-8	depends on the joints	500-1000	0.4
Plain concrete	20-35	cracks unless reinforced	2400	1.5
Softwood (spruce, parallel to the grain)	5	7	400	0.12
Hardwood (oak, parallel to the grain)	15	21	720	0.16
Mild steel	250	2501	7700	60

Look at the information in the table and then answer questions 1 to 7. You are only asked to compare one material with another so you do not need to worry about the units.

Questions

1 *Why are walls usually made of bricks or concrete blocks?*

2 *Why does the tensile strength of brick walls depend on the joints?*

3 *Why are floor joists and roof trusses in houses made of timber?*

4 *Why is steel used as the framework for many big buildings?*

5 *How can plain concrete be made stronger in tension?*

6 *Is timber suitable or unsuitable for walls?*

7 *Explain how building houses with timber instead of with brick and concrete might help to conserve fossil fuels.*

Part 3 Materials for window frames

Table 2 shows figures for the thermal conductivity of materials used to make window frames. The values compare how much energy can escape through different materials when it is cold outside.

The rate of loss of energy is bigger if there is a big temperature difference between the inside and the outside. The rate is slower if the material is thicker.

Glass and brickwork are included for comparison.

Use this information and anything else you may know about these materials to answer the questions 8 to 12.

Table 2

Material	*Thermal conductivity (W/m°C)*	*Comment*
Aluminium	200	Strong, does not need painting
Steel	60	Very strong, but needs painting to stop it rusting
Timber (hardwood)	0.16	Strong, needs a little varnish
Timber (softwood)	0.12	Needs paint or preservative
UPVC (plastic)	0.15	White, needs no painting, does not rot.
Glass	1.0	
Brickwork	1.0	

Questions

8 *Which material would allow least energy to escape through the frame?*

9 *Some buildings have window frames made of steel. Steel window frames tend to suffer from condensation in winter. Why?*

10 *New houses in Britain often have aluminium window frames and patio doors. What do you think might be the advantages and disadvantages of aluminium window frames?*

11 *UPVC is a stiff white plastic. It has been used to make window frames in Germany for the past thirty years. It has only recently been used in Britain. What advantages does it seem to have over the other materials? Can you think of any disadvantages?*

12 *Many houses, both old and new, have wooden window frames.*

(a) Explain why wood is a particularly suitable material.

(b) What are the disadvantages of wood compared with aluminium and UPVC?

Part 4 Houses around the world

Polar bears live in cold climates, hippopotamuses in hot. Yet by building houses, humans have extended their habitat from the tropics to the tundra.

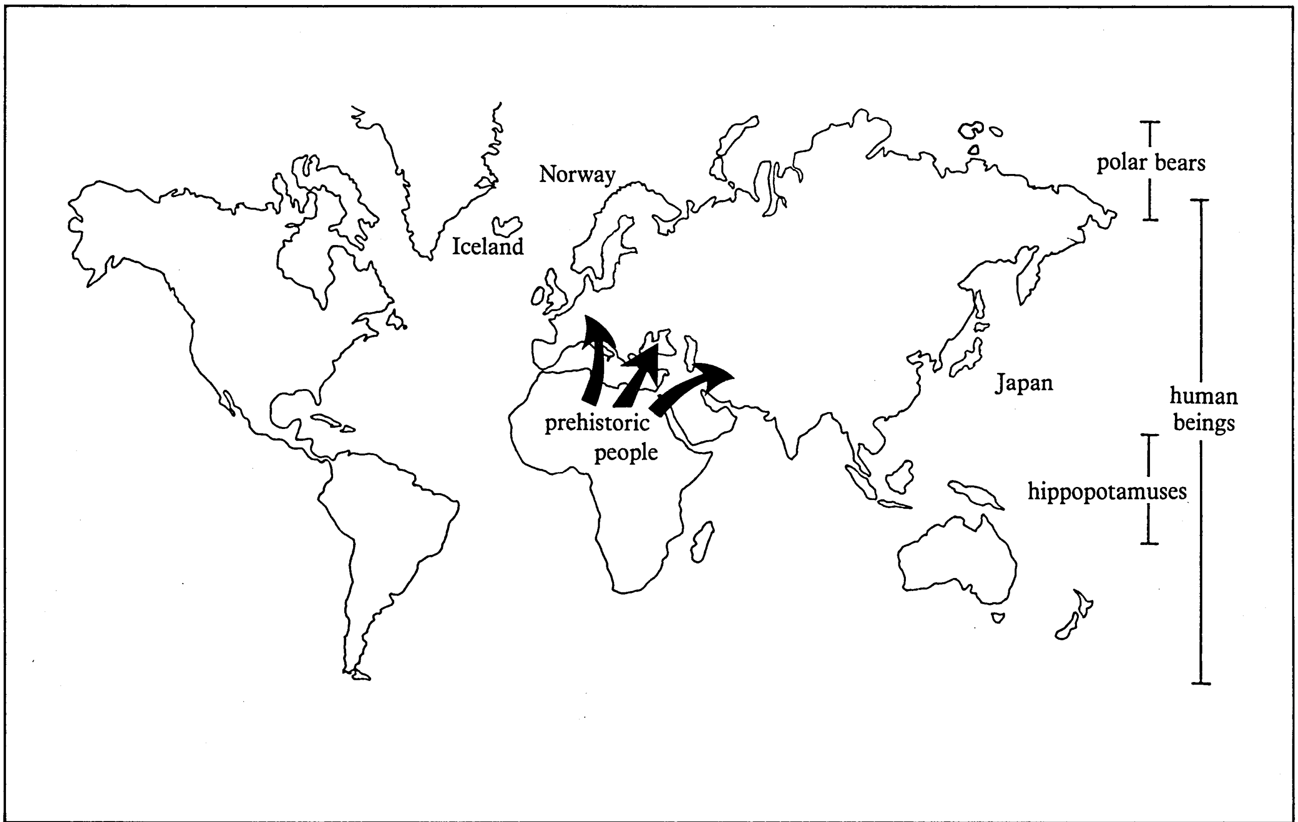


Figure 4

The last ice age finished about 10 000 years ago and the glaciers retreated. Archaeologists believe that the prehistoric people then moved out of Africa into the cooler climates of Europe, North America and Asia.

Human beings were ill-adapted to their new environment with their bare skin. They had to find food and firewood to survive. They also had to build shelters to protect themselves from the wild animals and chilly weather.

The wild animals may have disappeared but the need for warmth and shelter remains. People throughout the world today are highly skilled at building homes to suit their needs.

Now answer question 13.

Question

13 Why do human beings need warmth and shelter in a cold habitat, but polar bears do not?

Japanese houses

Japanese homes are timber-frame structures which have to withstand frequent earth tremors. They have high ceilings to allow air to circulate during the hot and humid summers. Many Japanese houses have no form of heating.

Answer question 14.

Question

14 Why do you think that a timber-frame house might be better at surviving earth tremors than other types of building?

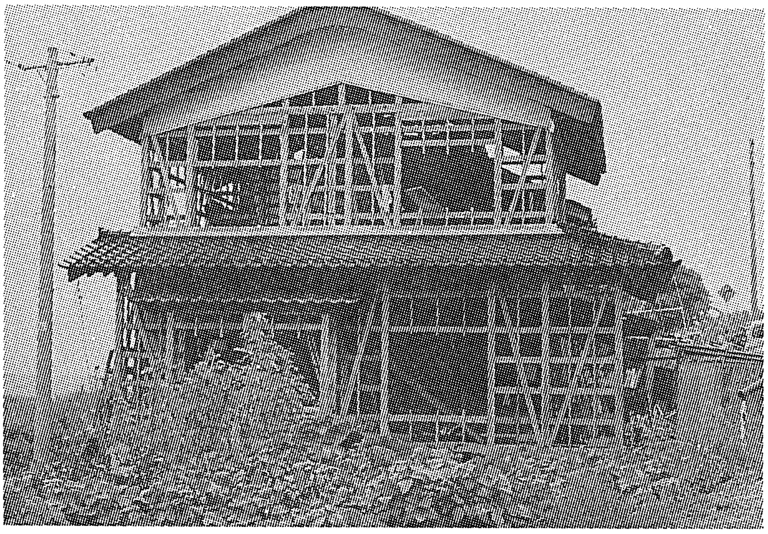


Figure 5 A Japanese house being built

Icelandic houses

All timber has to be imported into Iceland and so Icelanders build with as little timber as possible.

This suburban house in the capital city of Reykjavik is made of concrete (Figure 6). The roof is made from sheets of corrugated iron. The roof is light so it needs little timber to support it. The iron is painted red to make it look better.

Questions

15 (a) What are the advantages of making roofs out of corrugated iron in Iceland?

(b) What do you think the disadvantages might be?

16 What is a geothermal well?

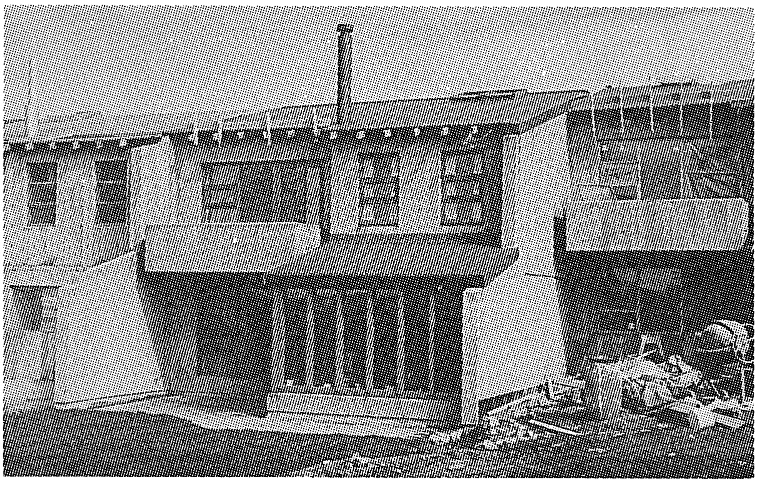


Figure 6 An Icelandic house

Houses in Reykjavik have no boilers or fireplaces. They have central heating supplied with hot water piped from geothermal wells or springs.

Answer questions 15 and 16.

Norwegian houses

Norway is a cold country but it has many large forests. People use timber-frame construction on top of concrete basements. The outside walls are made of timber. The wood is painted with a coloured preservative.

Norwegian homes are very well insulated (large windows have triple glazing). Electricity is quite cheap because there is plenty of hydroelectric power. Most Norwegians have a fireplace for burning logs in the living room but otherwise they heat their homes with electric radiators.

Timber is an excellent building material. It is light and strong as well as being a good insulator.

Answer question 17.

Question

17 Why do you think that Norwegians insulate their houses to a higher standard than we do in Britain?

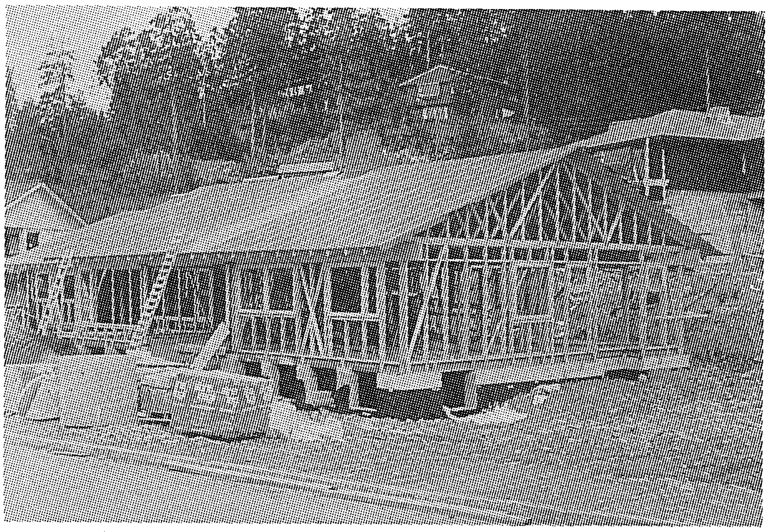


Figure 7 A Norwegian house under construction

British houses

Most houses in Britain are built of brick or from local stone.

Older houses have solid walls and were originally heated by a fireplace in every room. Cavity walls were introduced in the late 1920s.

Today, many homes are built with central heating and older houses have been modernized by removing fireplaces and installing radiators or electric storage heaters.

Energy for heating is expensive. If a house is well insulated, it saves money on fuel bills and helps to prevent condensation on walls and windows. Yet many older homes are still not insulated at all because people cannot afford the cost or do not appreciate the benefits.

Answer question 18.

Question

18 People who cannot afford the cost of insulation have to spend more money on heating their homes. Wasting heat is wasting a non-renewable fossil fuel. Does it matter? Who should be responsible for insulating houses — individual families or the community at large?

When the oil crisis of the 1970s caused the cost of fuels to rise rapidly, it had two effects on British house design:

- The Government introduced stricter building regulations to save energy. New houses now have to have much higher standards of insulation.
- The price of traditional building materials, such as bricks and cement, rose with the increasing cost of fuel. Wages rose too. Brick laying and plastering are skilled jobs and building brick houses required much expensive labour. Timber-frame construction became an economic alternative. Parts could be factory-made and houses speedily erected on a prepared site.

The houses being built today may look very similar to those of the past, but their structure is different and their standard of insulation much higher. New 'brick' houses have only the outer wall of brick and the inner one of insulating blockwork. 'Timber-frame' houses may be brick on the outside too, but an internal timber frame carries the load of the building.

Answer questions 19 and 20.

Questions

19 What are the advantages of factory-made houses?

20 Timber-frame construction was first introduced to Britain by the Saxons. How does the traditional method of construction differ from the modern one?

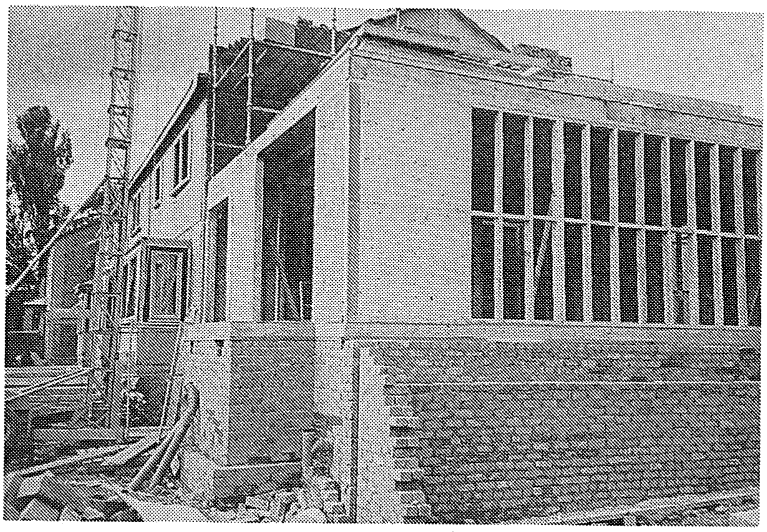


Figure 8 Modern timber-frame construction

Figure 9 Traditional timber-frame construction

As safe as houses?

When someone builds a house, there are many checks to ensure that its structure is safe. The local authority must see that the plans conform to the Building Regulations. A building inspector must visit the site at each stage of construction to check that the work has been done properly.

Sometimes people want to alter the structure of a house, perhaps by removing a wall or adding a window. This cannot be done before it has been approved by the local authority. The local authority checks the plans and makes sure that they do not break any bye-laws. The officers of the authority will give advice if necessary. This is the way that the community ensures that our homes are structurally safe.

Answer question 21.

Question

21 Find the notice of planning applications in your local paper.

(a) What sort of planning applications do people in your neighbourhood make? Give several examples.

(b) Why does the Chief Planning Officer publish a list of planning applications?