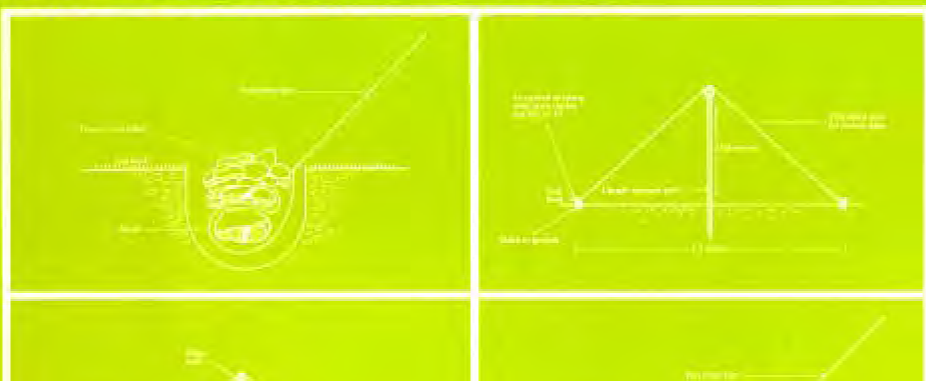
Plastic Sheeting

ITS USE FOR EMERGENCY HOUSING AND OTHER PURPOSES



AN OXFAM TECHNICAL GUIDE

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Metric measurements and their equivalents

1 centimetre	– 10 millimetres	– 0.3937 inches
1 metre	– 100 centimetres	– 3.28 feet

Contents

1. Introduction

Arising from our experience of using considerable quantities of plastic sheeting, a comparatively new material in disaster situations, this technical guide has been prepared to help field staff and others understand the details, advantages and problems of these new sheeting materials.

Polythene sheeting is now readily available in many parts of the world in large quantities and various grades and qualities. This material offers the possibility of building watertight structures at unprecedented low cost.

Polythene sheeting has many uses. It can be used for shelter, storage, tank linings, tarpaulin type covers, groundsheets, food containers, crop protection, inflated air houses, irrigation and soil mulching.

Plastic sheetings are being used in structures with a satisfactory degree of reliability – as is evidenced by the fact that currently in the U.K. there are over 1000 acres of greenhouses, covered with plastic film and a great number of semi-permanent plastic-clad farm buildings used for farm stock, mushroom growing and storage.

Polythene lay-flat tubing (available in widths from 100 mm to 1829 mm in various gauges and in lengths from 50 metres to 150 metres) has outstanding possibilities for water storage – as sand filters for water supplies – or can be used to supply great numbers of individual waterproof covers for personal bedding and belongings.

2.
Types of Plastic Sheeting Available

Most plastic materials such as polythene, poly vinyl chloride (PVC), nylon, terylene, polypropylene, etc., can be made in the form of thin flexible sheeting. Also commercially available are several kinds of flexible sheet reinforced with strands of natural or synthetic fibres to give greater strength. Such reinforcement increases cost and weight per unit area. Reinforced plastic sheeting is normally made in maximum widths up to 1.83 metres and consequently wider sheets have to be fabricated by stitching or heat-sealing.

Most of what follows relates to the use of polythene or, as it should more correctly be called, polyethylene sheeting. However, any of the techniques discussed will work with any flexible plastic sheeting available on site.

3.
General Properties of Polythene Sheeting

Polythene sheeting has many advantages when compared with other flexible materials that can be used as waterproof membranes. The chief advantages are its low cost and weight per unit area. It is available from the manufacturers in standard seamless sheeting up to 8 metres wide in 1000 gauge or 1500 gauge (250 and 375 microns). Its properties are as follows.

a. Resistance to water. It is completely waterproof and with a very low moisture vapour permeability.
b. Chemical resistance. It is unaffected by salts, dung-urine and most agricultural chemicals. Petrol and lubricating oils may cause swelling by absorption and should not be stored in contact with the sheeting.
c. Ageing and weathering. Polythene sheeting cannot mildew or rot in store and it is unaffected by moisture. Clear sheeting deteriorates slowly in sunshine and the progressive loss of strength and flexibility may become apparent after a period of from twelve to fifteen months. Black sheeting, however, is resistant to sunlight and is recommended for most outdoor uses where light transmission is not essential.
d. Thermal properties. The sheeting is flexible down to temperatures well below freezing point. It melts at 115°C (239°F), that is above the boiling point of water, but starts to soften and lose tensile strength at above 80°C (175°F).

Mechanical Properties

As a buried membrane, the main properties required of any plastic material can be listed as follows.

a. Flexibility, for ease of installation and to conform to minor undulations of the excavated base.
b. Toughness, to remain undamaged during the installation process and subsequent 'backfilling' operation.
c. Durability, to retain its physical properties when buried.
d. Resistance to attack by soil fauna.
e. Resistance to extremes of temperature change.

On these counts 1000 gauge or 1500 gauge polythene sheeting compares favourably with any other plastic material.

Polythene is an inert material – it will not rot even if buried in fertile soil and is not readily attacked by rodents or insects (although termites have been known to eat it). Polythene film will not deteriorate during storage although clear films must be stored in shade.

Thicknesses

Polythene films can be made in thicknesses ranging from 12 microns (50 gauge) to 375 microns (1500 gauge). Cost per unit area is proportional to thickness.

For emergency housing purposes films thinner than 500 gauge would be unsuitable and it is recommended that 1000 or 1500 gauge should be used. It is light in weight – approximately 4 sq. metres of 1000 gauge sheeting weighs 1 kg.

Polythene is available from U.K., Continental and American manufacturers in seamless widths of up to 8 metres in 1000 gauge and in seamless widths of 11 metres in 500 gauge. For ease of transport this wide sheeting is normally folded twice at the factory so that it can be rolled on to a cardboard core. Thus, 8 metre wide seamless sheeting is rolled on a 2 metre long core.

Polythene films are marginally stronger in the *machine* direction (along the length of the film) than in the transverse direction.

Unreinforced polythene film of 1000 gauge is tough and adequate to withstand wind stresses if correctly fixed to structures. (Most of the greenhouse acreage already mentioned is covered with film of 500 gauge. The 50 kg. sacks used to transport fertilisers and other chemicals are usually made from 800 gauge sheeting and some farmers use cut-open plastic sacks for simple farm buildings such as calf housing.)

It is the cheapest flexible plastic material; for example, a roll of 1000 gauge sheeting 8 metres x 35 metres would cost the U.K. farmer about £40 – £50 in 1980. For the same sum he would obtain twice the area of 500 gauge film.

Colours

The two most important types are *natural* (clear or translucent) and *black-pigmented.* Black films contain about 2% of very finely divided carbon black (lamp-black).

Sunshine Degradation or Weakening

Clear plastic sheeting deteriorates fairly quickly in strong sunlight and black sheeting is best used under these conditions.

Well-made *black* polythene films are extremely resistant to sunshine degradation.

Farm buildings covered with 1000 gauge black polythene sheeting have been in continuous use in the U.K. since the middle 1960s, with no apparent weakening of the film cover.

All transparent plastic films are slowly weakened on continuous exposure to sunshine. The durability of clear films intended for use outside can be considerably increased by adding chemicals called 'ultra-violet-light absorbers' during manufacture. Such 'ultra-violet-light inhibited' films currently commercially available last for at least two years when continuously exposed to sunshine on greenhouse structures in the U.K. and it would be reasonable to expect at least a one-year life from them even in countries like India. Ultra-violet-light inhibited films often have a slight yellow or green colour which is due to the nature of the absorbing chemical used.

Living conditions in an emergency shelter covered with white film might be more agreeable than in structures clad with clear or black film; day temperatures would certainly be more equable as emergency housing shelters clad with clear plastic film will tend to be hot when the sun shines and cold at night. When the temperature inside the shelter is greater than outside, moisture and condensation may form on the inner surface. (If this is a great nuisance the amount of condensation forming can be reduced by using a polythene film 'carpet' on the floor of the shelter). This prevents the soil giving off more moisture thereby increasing the humidity. This situation only applies where soil moistures are high.

An interesting and important observation from Oxfam field operations in Bangladesh is that in locations with long sunshine periods, at high temperatures the degradation of reinforced plastic sheeting is markedly accelerated when such sheetings are directly exposed to sunlight. The reinforcing material whether this be metal wire, nylon or some plastic substance, causes 'hot spots' within the sheeting and these temperature differentials cause local damage – brittleness or laminating which lowers the structural strength of the sheeting material. Therefore it is not recommended to use reinforced plastic sheeting for roofing or similar purposes where it is directly exposed to strong sunlight.

To a lesser degree this same 'hot spot' problem arises where polythene film is stressed over any structure which will absorb and hold heat such as metal tubing. Film in contact with this hot structure will weaken more quickly for any given amount of ultra violet light radiation than film at air temperature.

Two ways of providing the required protection are,

a) by using a black polythene adhesive tape on the outside of the polythene cover, so that it protects the sheet itself from sunshine in this critical area (black polythene film is almost completely resistant to ultra violet light degradation), and
b) by painting the film with aluminium or bitumastic paint above those points where it is in contact with the structure.

4.
Use and Fixing of Plastic Films on Structures

Any plastic structure intended for emergency housing must

a) offer shelter from the weather,
b) be stable in wind, and
c) not be unbearably hot in daytime.

Choice between black and clear film as a covering will depend on

a) availability,
b) expected life of the shelter, and
c) prevailing climatic condition.

In Bangladesh and in India plastic sheeting has been used in conjunction with bamboo mattings in a very successful way. Several thousand houses have been built using plastic sheeting as a waterproof and windproof membrane sandwiched between an inner and outer bamboo woven mat (Figure 1).

In using sheeting alone for long term occupancy it should not be difficult to devise structures which make use of black sheeting for the roofs (for durability) and clear film for part of the walls for light admittance.

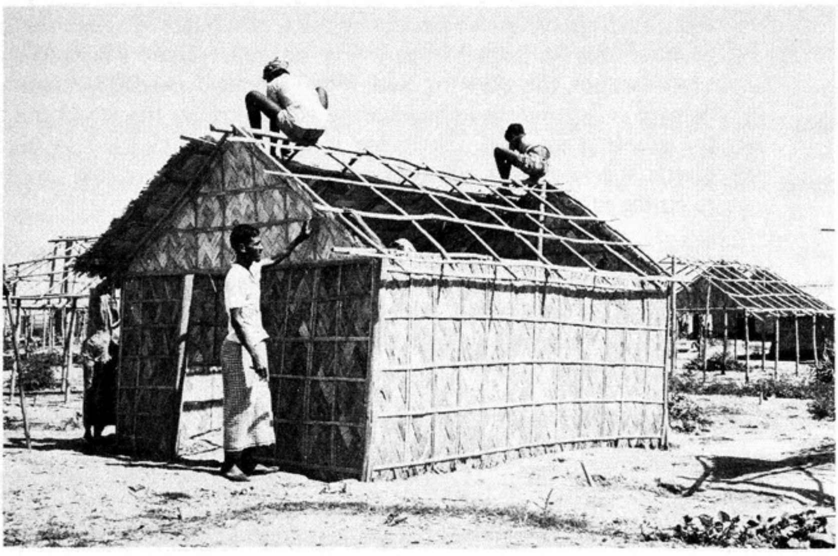


Figure 1. Plastic and Bamboo Matting House – Bangladesh

General Points

Black films expand when the sun shines and contract at night. The actual expansion factor is 1½% per 38°C (100°F) temperature change. Thus a black plastic skin fitted to a structure when the sun is shining will become drum-tight after nightfall. Clear films do not absorb heat energy from the sun and stay at ambient temperature; consequently the expansion/contraction rate can generally be ignored.

If the temperature within any plastic-clad structure becomes too high in sunshine it can be reduced by spraying the outer surface with aluminium or light-coloured paint. Even a suspension of powdered limestone in water or thin mud slurry might give temporary protection in extreme circumstances. Some paints do not adhere very well to polythene surfaces, and may need to be replaced after a period of time.

The thermal insulation properties ('U' factor) of polythene films are poor. However, well-insulated buildings can be made by using two sheets of plastic between which is sandwiched an insulating material. In the U.K. some very satisfactory mushroom-growing houses have been made in this way, using fibreglass or mineral wool as an insulant. In Italy, farm buildings have been made in the same manner, using two layers of plastic with straw as an insulant. Any lightweight, dry material which contains a lot of air spaces would be suitable. If an organic material like straw or hay is so used it would be desirable to pre-treat it with an insecticide.

The fire hazards to the occupants of a structure covered with a single skin of polythene are minimal; the film melts at temperatures in excess of 100°C (212°F).

However, this is not true where two layers of plastic are used with a straw or hay inner filling. Clearly the risk of ignition from cooking, oil, lighting, or cigarettes is much higher. It is essential that the fire risks and danger are appreciated by the users of the structures.

Fixing film to structures and possible types of structure

The circumstances in which any emergency and locally available structural materials are used will obviously vary greatly. It would therefore be impertinent to be dogmatic in these notes which are intended for general guidance only.

There are two problems in supported polythene structures, namely,

a) erection of the framework, and
b) securing the plastic to it.

An ideal shape of a structure to be covered with plastic film is semi-cylindrical. If the width of such a structure is not too great it can easily and cheaply be covered with a single sheet of wide, seamless polythene.

We can learn something from the cross-section of the most popular type of plastic greenhouse (tunnel greenhouse) in use in the U.K. at the present time. This is illustrated in Figures 2 and 3.

Figure 2. Cross Section of Plastic Greenhouse

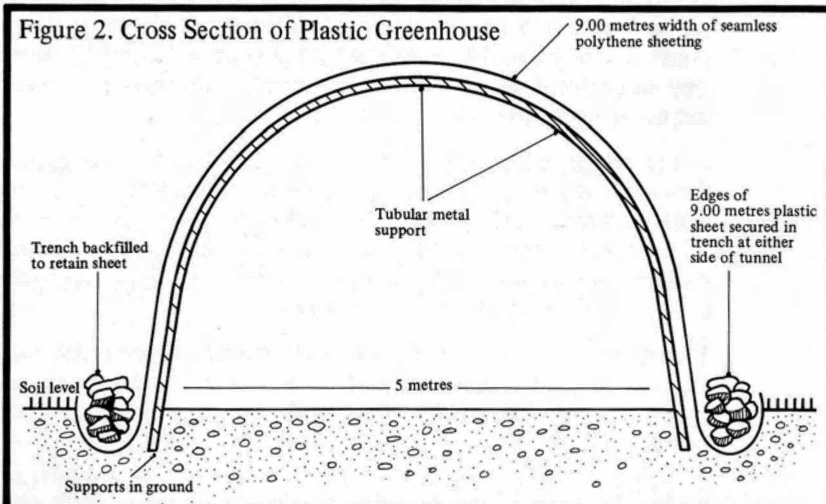
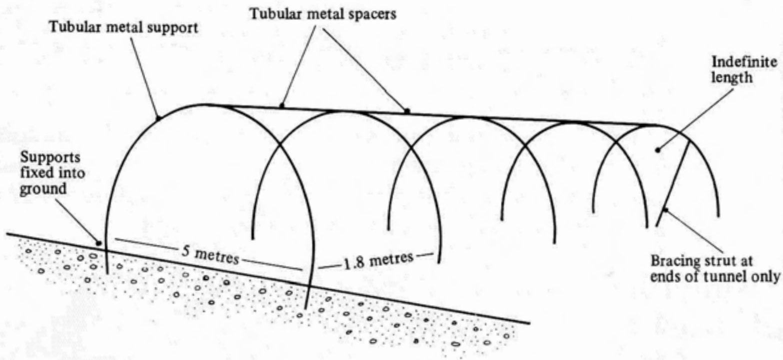


Figure 3. Framework for Plastic Greenhouse



It is appreciated that 25mm steel tubing, suitably curved, will probably not be available quickly in a disaster area, but some of the ideas of this proven structure can be adopted. PVC rigid tube has been used with great success in Bulgaria. PVC tube arches smoothly, returns to its original straight, is easy to transport, is lightweight and is low cost. But it is important to note that,

a) the fixing of the film is achieved simply by burying the edges of the plastic; and, no other fixing is involved other than to the end hoops of the structure.

b) because the plastic is stretched tautly and uniformly over a curved surface no stress points exist and no 'flapping' of the film should occur in wind.

A very simple emergency shelter could be achieved by using a 7.3 metre seamless sheet stretched over a ridge bar running parallel to and 2.00 metres above the soil surface. If 60cm of each edge of the sheet is buried, the cross-section of this simple shelter will be as shown in Figures 4 and 5.

Figure 4. Cross Section of Simple Plastic Covered Shelter

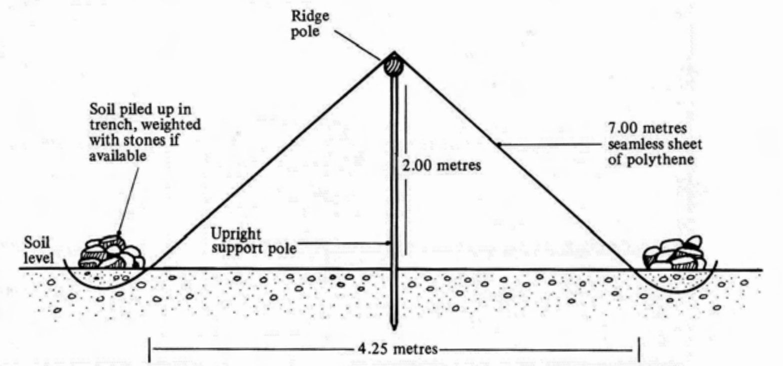
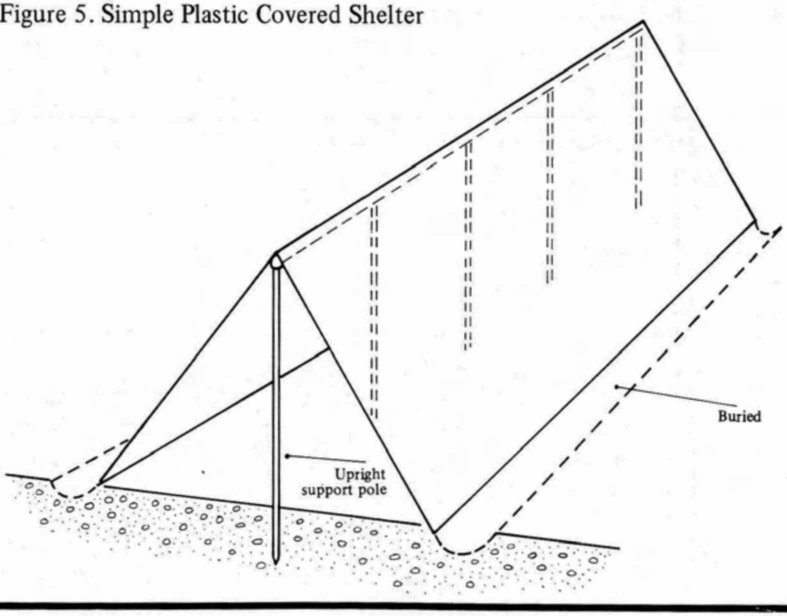


Figure 5. Simple Plastic Covered Shelter

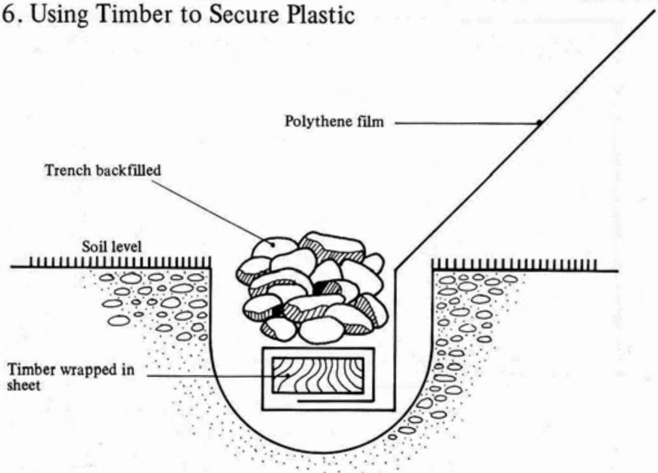


The stability of this structure will depend on

a) the rigidity of the ridge, and
b) the security of its fixing at soil level.

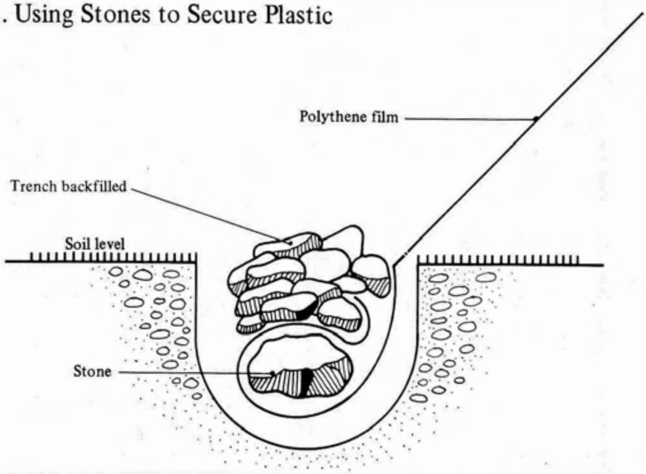
If the soil will not 'grip' the plastic adequately greater purchase can be obtained by rolling the edge of the plastic around a piece of timber before burying it, as shown in Figure 6.

Figure 6. Using Timber to Secure Plastic



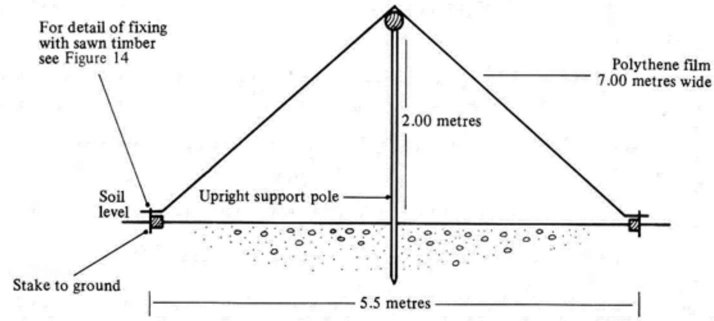
If no timber is available individual stones ideally 100mm – 200mm in diameter can be used, in which case the film should be folded over them as shown in Figure 7.

Figure 7. Using Stones to Secure Plastic



If sawn timber is available the fixing method illustrated in Figure 14 can be adopted and the simple triangular structure illustrated can be increased in width to about 5.5 metres as shown in Figure 8.

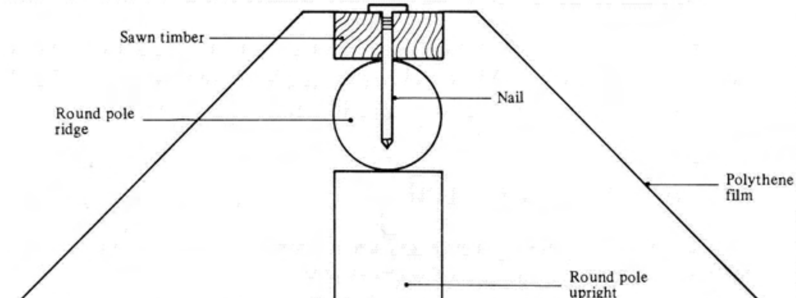
Figure 8. Plastic Tent Using Sawn Timber to Secure Plastic



Unreasonable stresses to the film could occur to such simple triangular structures in high wind unless it could be located in a naturally sheltered site. Strands of wire, rope or polypropylene baler twine could be stretched tautly between the ridge and the timber rail at ground level, on each side of the plastic, in order to give greater stability. If locally available, pig wire netting or hexagonal mesh chicken wire can be used to 'sandwich' the film. The wind energy is then absorbed by the reinforcements and not by the film.

Round-pole timber (as cut from growing trees) can be used for the ridge and upright supporting members but, if available, a strip of sawn timber on top of the ridge will reduce local stressing due to the irregularities of the round-pole timber, as shown in Figure 9. Obviously sharp edges or rubbing points must be avoided.

Figure 9. Detail of Apex of Ridge



Wherever possible it is better to secure sheeting along a whole edge rather than to allow the strain to be taken at eyelets or individual (relatively small) fixing points. However, 1000 gauge polythene film is tough enough for actual eyelets to be fixed around the edges of a sheet and such an eyeletted sheet can be used as a substitute for canvas tarpaulin. Eyelets should be placed at intervals no greater than 45.75cm around the edges.

Eyelets are in two pieces (eyelet and 'B' ring). Eyelets are fixed through sheeting material by a simple mandrel and die. It is strongly recommended that the turnover ring type be used rather than the plain ring which can cut the sheeting.

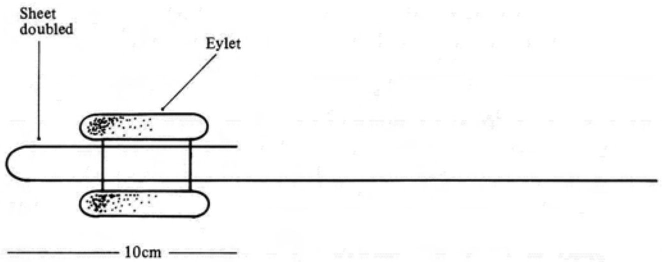
No. 23B	sail eyelet takes approximately 8mm diameter rope
No. 24B	sail eyelet takes approximately 10mm diameter rope
No. 23	eyelets cost £8.00 per 1000 (1980 prices)
No. 24	eyelets cost £10.00 per 1000 (1980 prices)

A simple mandrel and die for fixing eyelets costs £12.00

A hand loaded eyelet fixing machine costs £70.00

Sheet materials should be double thickness, if possible, at eyeletting points. This is achieved by folding material back from the edge, say 10cm, as shown in Figure 10.

Figure 10. Eyeletting

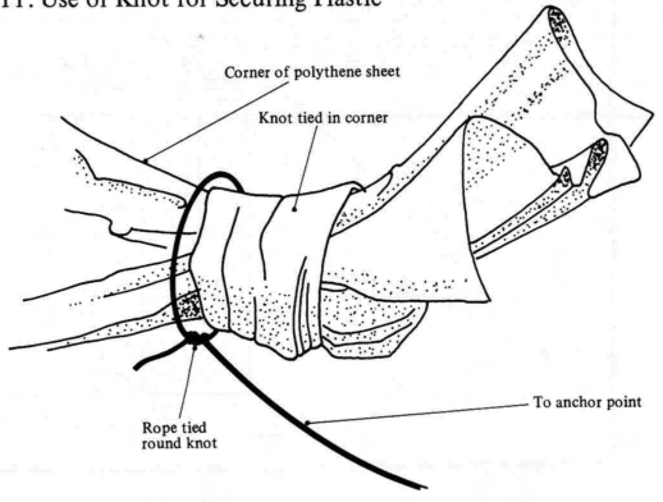


For additional strength when eyeletting sheeting, adhesive reinforcing patches can be fixed. Sellotape eyelet reinforcement patches 9002 cost £15.00 approximately per 1000 patches (1980).

Other film-fixing methods

If no other fixing methods are available, sheeting can be secured by tying a knot in the corner of a sheet (like tying a knot in a handkerchief) and, if necessary, tying a rope around the knot, as shown in Figure 11.

Figure 11. Use of Knot for Securing Plastic



Several devices for securing ropes to polythene sheeting are available (see Section 5).

Fixing film to metal structures

As already mentioned, an ideal fixing method is to use wide seamless sheeting the edges of which are secured by burying in trenches, outside the metal hoops forming a tunnel.

If the design of a structure requires that film should be fixed to metal angle-iron, or tubular steel, two reliable fixing methods are illustrated in Figures 12 and 13. It is assumed that sawn timber is available.

Figure 12. Fixing Film to Tubular Metal

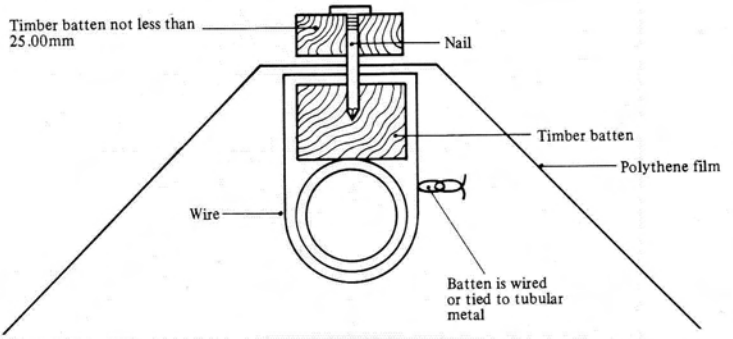
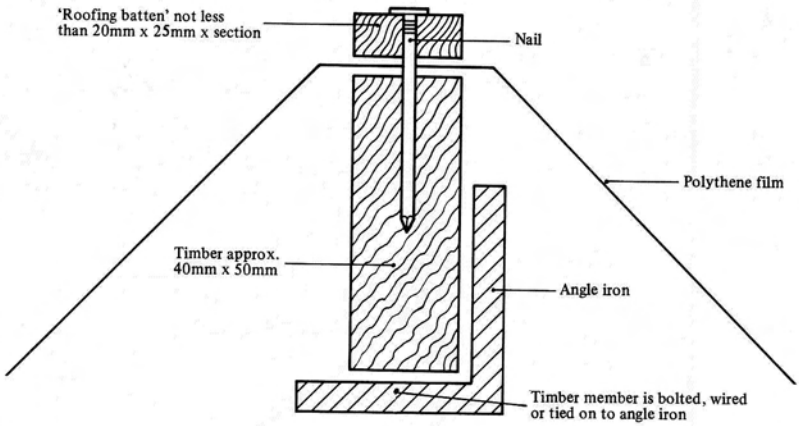


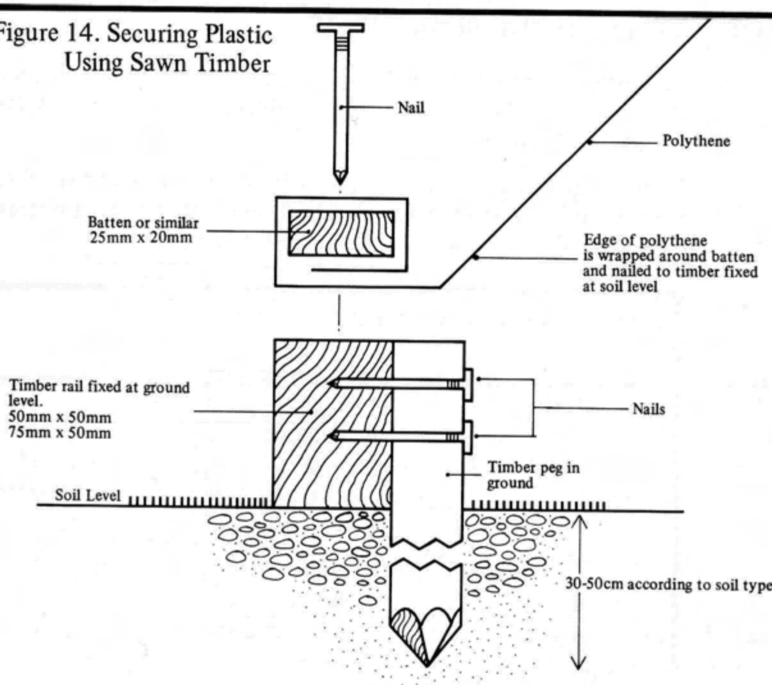
Figure 13. Fixing Film to Angle Iron



Fixing film at soil level (with sawn timber)

If timber is available, the method illustrated in Figure 14 is a reasonably fool-proof method of fixing sheeting at ground level.

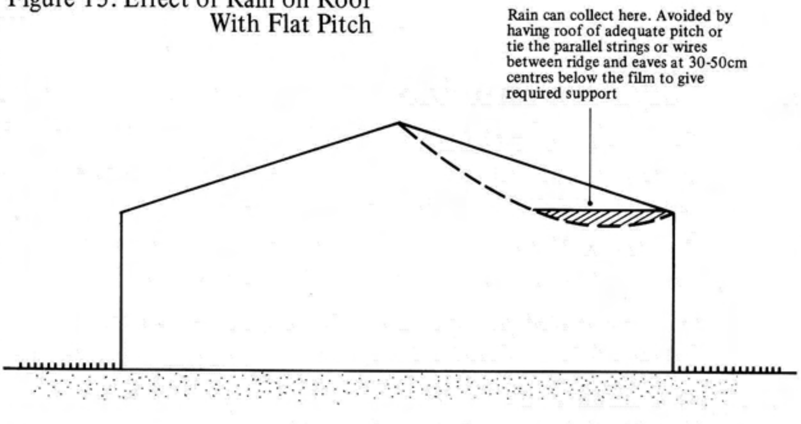
Figure 14. Securing Plastic Using Sawn Timber



Some other considerations

Make sure that the roof pitch of any structure is steep enough to shed water. If a roof is too flat, rain lodging on the roof (as illustrated by the dotted line in Figure 15) can cause unreasonable stresses on films and structure.

Figure 15. Effect of Rain on Roof With Flat Pitch



5.

Details of Literature and Manufacturers

Use of Polythene Sheeting

Film Plastic Tunnels. Leaflet No. 17.
Contains the published findings of a great deal of research in the use of polythene sheeting in horticulture.

Film Plastic Multispan Tunnels. Leaflet No. 20.
Contains descriptions of prototypes designed and erected.

Cropping in Walk-in Film Plastic Tunnels. Leaflet No. 21.
Contains details of crop trials carried out with vegetables and flowers.

All available from:
Ministry of Agriculture, Fisheries and Food,
Lee Valley Experimental Horticulture Station,
Ware Road,
Hoddesdon,
Hertfordshire,
England.

Suppliers of Polythene Sheeting

1. **Imperial Chemical Industries Ltd.,**
Plastics Division,
P.O. Box No. 6.,
Bessemer Road,
Welwyn Garden City,
Hertfordshire AL7 14D,
England.

ICI publish the following pamphlets:

Water Storage
Polythene Films for Horticulture
Agricultural Polythene Sheeting
Polythene Sheeting on the Farm
'Polythro' (Tarpaulins)
Heavy Duty Polythene Sacks
Moist Green Storage Sacks

2. **Ethylene Products,**
Maerdy Industrial Estate,

Rhymney,
Gwent,
Wales.

3. **British Cellophane Ltd.,**
Bridgewater,
Somerset,
England.

Suppliers of Polythene Lay Flat Tubing (Tarpaulin — Polythene Bags — Polythene Sheeting)

Turner Whitehead Industries Ltd.,
65-71, Bermondery Street,
London SE1 3HP,
England.

Makers and Suppliers of Eyelets and Eyeletting Machines

Geo. Tucker Eyelet Co.,
62 Horn Lane,
Acton,
London W3 6MT,
England.

Makers of Adhesive Tapes for Polythene Sheeting

Sellotape Products Ltd.,
54, High Street,
Edgeware,
Middlesex,
England.

APPENDIX I Useful data for water storage

1 gallon of water	=	10 lb
1 cubic foot of water	=	6.25 gallons
1 cubic metre	=	1000 litres = 220 gallons
1 gallon	=	4.546 litres
1 litre of water	=	1 kilogram
1 cubic metre of water	=	1000 kilograms
1 cubic yard of water	=	764.6 kilograms
1 cubic yard	=	0.7646 cubic metres
1 cubic metre	=	1.308 cubic yards
1 sq. metre	=	1.196 sq. yards
1 hectare	=	2.47 acres

APPENDIX II Precipitation data

1 mm of water	=	10,000 litres of water/hectare
1 inch of water	=	22,610 gallons/acre
1 inch of water	=	4½ gallons/sq. yard
1 acre – inch	=	22,610 gallons
1 acre – foot	=	271,320 gallons
1 mm of water	=	1 litre of water/sq. metre
1 acre – 100 mm	=	405 cubic metres = 89,000 gallons
1 hectare – 100 mm	=	1000 cubic metres – 220,000 gallons
1 hectare – inch	=	254 cubic metres – 55,880 gallons

Oxfam has accumulated considerable experience in the use of quantities of plastic sheeting, a relatively new material, in disaster situations. This technical guide has been prepared to help field personnel in particular to understand the detail, advantages and problems of these sheeting materials.

60p

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