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REFUGEE CAMPS & CAMP PLANNING

Report No. II

Camp Improvements

Refugee Camps and Camp Planning...
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No. II - Camp Improvements. 1974.
30 p. appendix.

1. Refugee housing. 2. Building materials. 3. Plastics in building. I. Title. II. Polyethylene Sheeting in Building.

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October 11, 1974

A.I.D.
Reference Center
Room 1656 NS

Mr. Paul Oecksly
Philippines Desk
Agency for International Development
Department of State
Washington, D.C. 20523

Dear Mr. Oecksly:

When we met last spring, I promised to send you some details on how we handled the use of polyethylene sheeting in India in 1971. I was hoping to send you a copy of the section of our Relief Operations Guidebook which covers the subject very thoroughly, but that work is not yet available for distribution.

Thus, I am enclosing a copy of two reports which are relevant to your request. The first is a copy of Report II of the Refugee Camps and Camp Planning series; page 26 contains data on the use of polyethylene as roofing. The second is a report on the use of films prepared by OXFAM.

I am also enclosing a copy of the report on the Carnegie-Mellon University housing unit.

Sorry for the long delay.

Best regards,

Frederick C. Cuny

Frederick C. Cuny

FCC:jwp

Encls.

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FREDERICK C. CUNY AND ASSOCIATES provide specialized professional services for the preparation of plans and studies related to physical and social problems in urban and area development, public administration, and environmental research and design.

Established 1970.

INTRODUCTION

This report outlines basic camp improvements which should be considered in all camps. The specific improvements outlined, however, are generally more applicable to Phase I and Phase II camps than to Phase III types.

Report II is based upon and is an expansion of a field inspection report prepared by the author for OXFAM - East India (dated 9 July 1971) and was prepared to facilitate OXFAM's assistance to Bengali refugees in the Calcutta, West Bengal District of India.

REFUGEE CAMP IMPROVEMENTS

The problems faced in refugee camps fall into three general categories: overall camp planning/design; sewage and waste disposal; and housing. The overall effort in the physical operations has been very poor in all the refugee operations. The major problem has been the record of recent inability to organise large scale work parties with specialised tasks to carry out necessary operations. The camp commanders must be made to realise that each camp is a complete system and that each operation affects the other. They cannot hope to prevent disease only with medicines; they must also have sanitary conditions which will encourage safety, health, etc. The following recommendations should be effected immediately from the outset of the development of the camps.

A. Planning:

Camps must be planned units and the plans must enable the authorities to administer and control all related activities with maximum flexibility and minimum effort. In effect, a camp is a small city and all the amenities of a city must be installed. These include central activity centres (i.e. hospital, administrative offices, central supply, distribution and storage areas, etc.), proper drainage (to include run-off collectors, local collectors, and major drainage canals), proper waste disposal, lighting, housing cells, circulation systems, and recreation areas.

i. Layout: Due to the limited sophistication of planning techniques, overall camp planning must necessarily utilise a "use area" approach. This entails designation of all land areas as having a particular use and integrating the various uses into an overall system. In most terrains, a grid system of design can be adapted for the use area approach. While the grid provides the least privacy, it facilitates sanitation, drainage, and administration. The grids which delineate the use areas also provide the basis

for the circulation system and drainage system. The central activity centre should be the only unit of the system which does not follow the traditional grid and should have as much open area surrounding it as possible with all approaches well above flood level. (A typical layout is shown on page 4.)

If a permanent, or Phase III, camp is being designed, a more sophisticated design should be used. Several recommended designs are outlined in Report IV of this series.

ii. Circulation: Each camp should develop a circulation system. The system should include vehicular approaches, internal vehicular drives, major walkways connecting the various use areas, and footpaths for local circulation. The entire system should be above the local flood level.

Recommended construction material is brick, bamboo, and whatever wood is available. Drainage ways must be bridged to prevent the standing of water. In some camps, walks can be elevated by using earth extracted from the drainage canals. All walkways should be well lighted. (Typical construction is shown on page 6.)

iii. Lighting: Proper lighting must be installed as soon as possible. While it will assist the people in various ways such as keeping down disturbances, the singular most important aspect is that it will reduce the incidence of night defecation in areas other than the latrines.

iv. Recreational Areas: As the number of refugees increases, they must have a release for tensions that will build up. Thus areas must be designated and preserved for organised recreation. These areas should at least be big enough to play football. They can also be used for other programmes such as camp meetings, etc. The designation and development of these areas should, however, not receive a priority until the monsoon season has passed.

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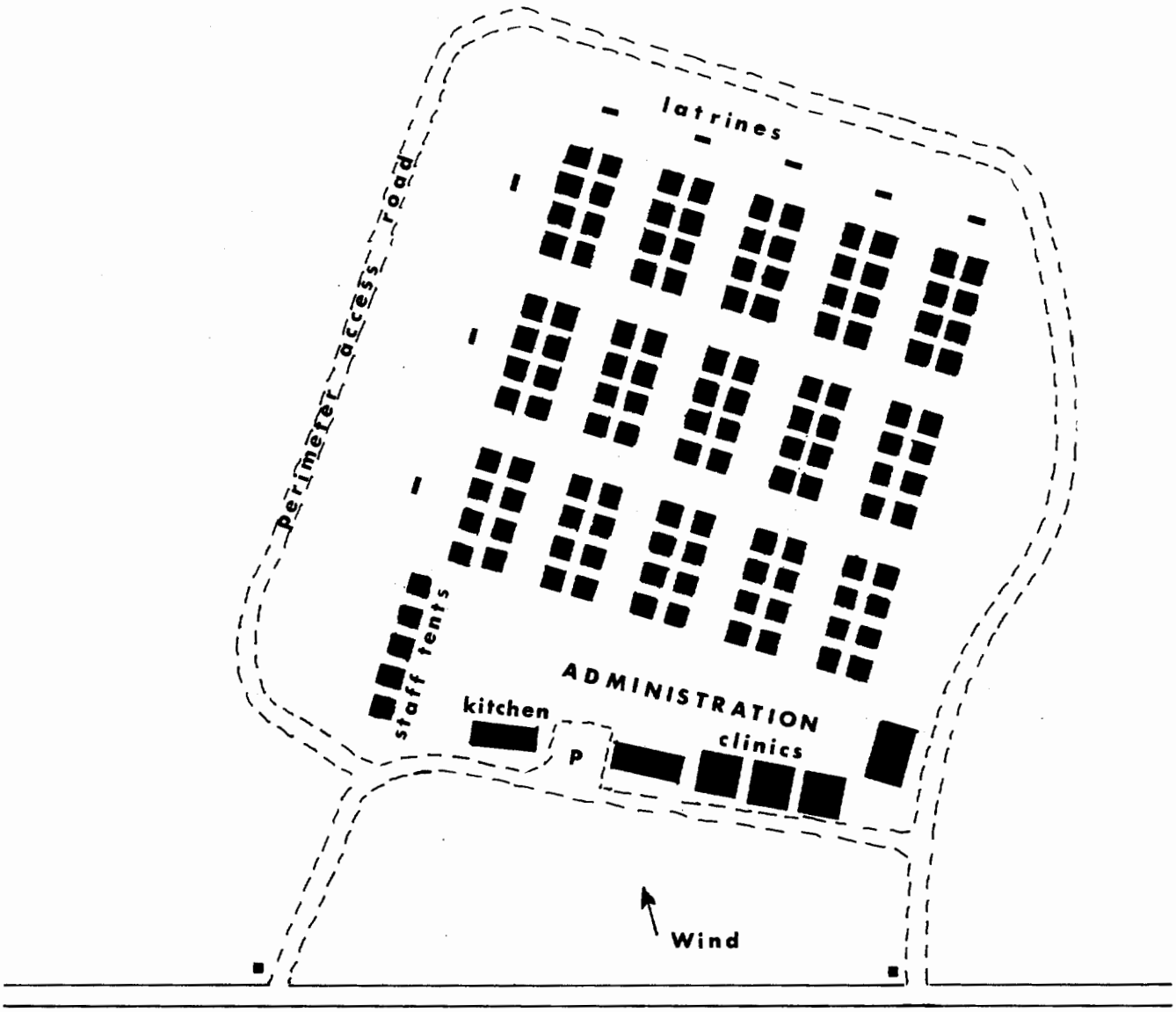
GRID PLAN



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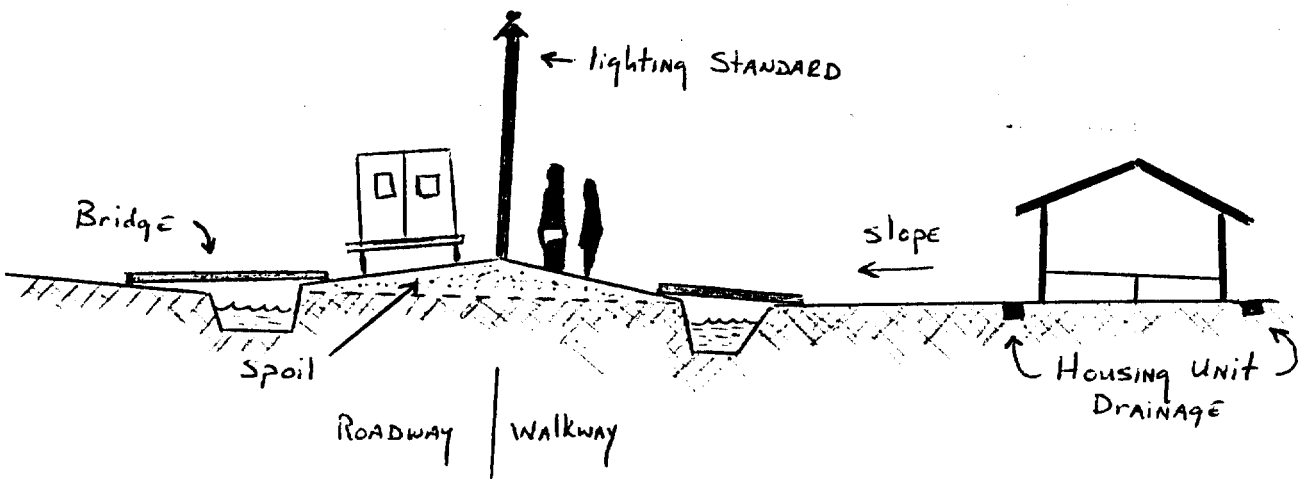
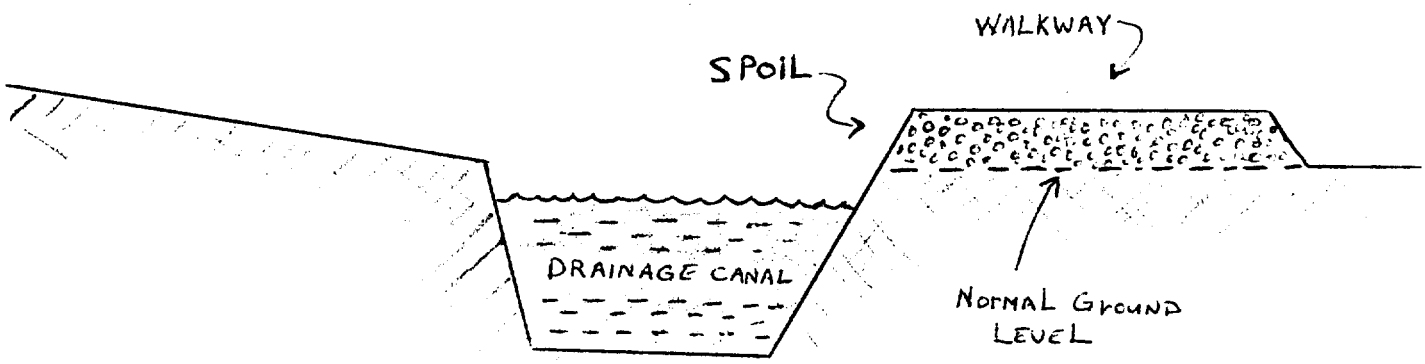
DETAIL 1

ROADWAY/WALKWAY CONSTRUCTION



DETAIL 2

CROSS SECTION OF WALKWAY CONSTRUCTION



v. Central activity centre: All administrative functions of the camps should be placed in a physically central location; as the camps become larger, these centralised posts can be established in sub-areas of the camps. All administrative areas must be above the flood level and well sand-bagged.

vi. Signs: A series of signs should be developed to facilitate the location of activities for both residents and visitors. Signs should be both graphic and colourful, in both the local language and English.

vii. Drainage: In areas subject to heavy rains, proper drainage systems serve dual purposes, the most singularly important being moving water out of the camp. But a second and extremely useful effect is the daily cleansing of the camp site. Therefore, in these areas the most important design/engineering function becomes the development of the drainage system.*

a. The system begins at each building or permanent structure. At the base of each a small localised trench is dug around the structure to collect the run-off and move it away.

b. These trenches, or localised collectors, empty into a lateral which is generally one to two feet wide and which carries the water away from the local areas. These laterals should not be more than one hundred feet long and should generally follow the footpaths of the circulation system.

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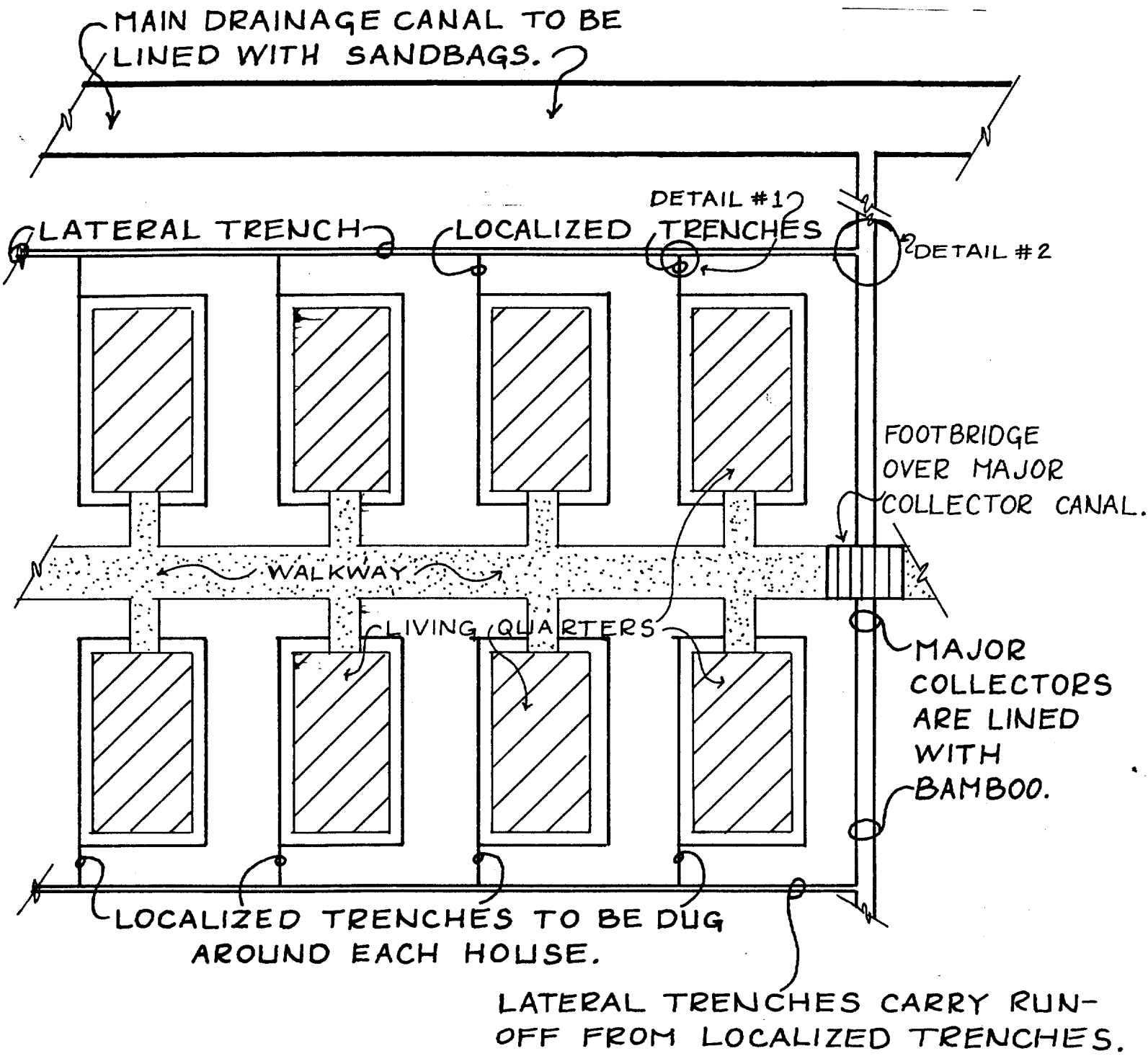
* See schematic of drainage system, Detail 3, page 7.

DETAIL 3

DRAINAGE SCHEMATIC



NOTE: NOT TO SCALE

c. Laterals empty into major collectors which are placed approximately 200 - 500 feet apart and which follow the major walkways and vehicular approaches. In the smaller camps, only one or two major collectors are necessary. Laterals are usually 2 and a half to three and a half feet wide.

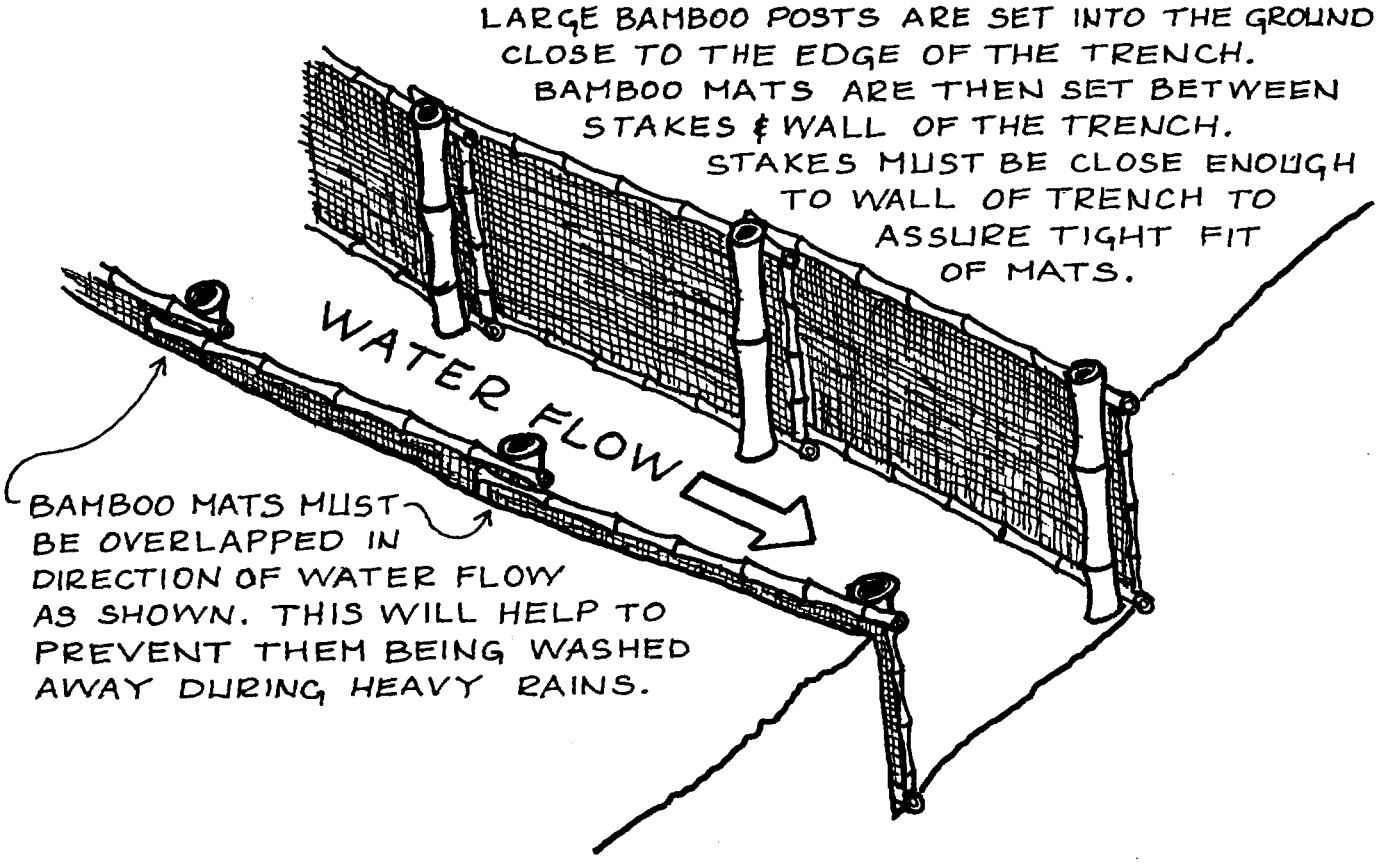
d. As the water reaches the lowest point in the camp or general area, it enters a drainage canal and is taken out of the camp. If possible, a single drainage canal is used to empty the entire camp and it is constructed well beyond the camp boundary to a nearby stream, lake or river a minimum of three hundred metres away. A series of straining gates should be deployed at the point where the drainage canal leaves the camp site to prevent solid waste from flowing into the adjoining countryside.

All the parts of the drainage system should be lined either with sandbags or whatever local materials are available. Bamboo matting, tree bark, plywood, plastic sheeting, etc., may be used. (See Detail 4, page9). The major intersections of the system must have the opposing side wall supported to prevent washing away during heavy drainage flow periods. Brick material is very good for this purpose. (See Details 5 and 6, page 10). Backup gates should be installed throughout the system to aid in controlling flooding and to assist in repair and cleaning the system. (See Detail 7, page 11).

Depending on the local soils, maintenance of the drainage system will be a full-time job and should have the continuous supervision of the camp engineer. In dry periods, standing

DETAIL 4

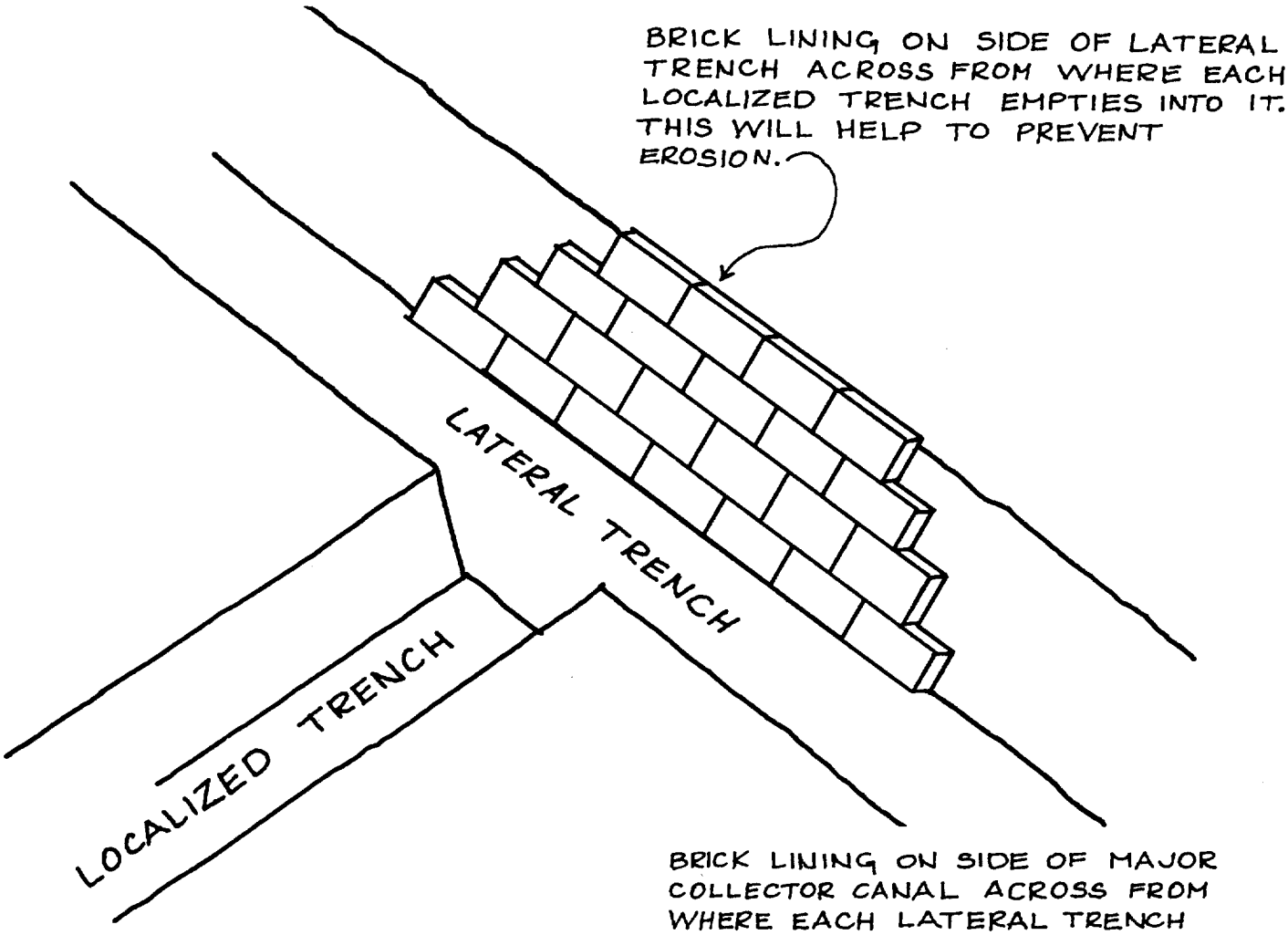
DRAINAGE LINING

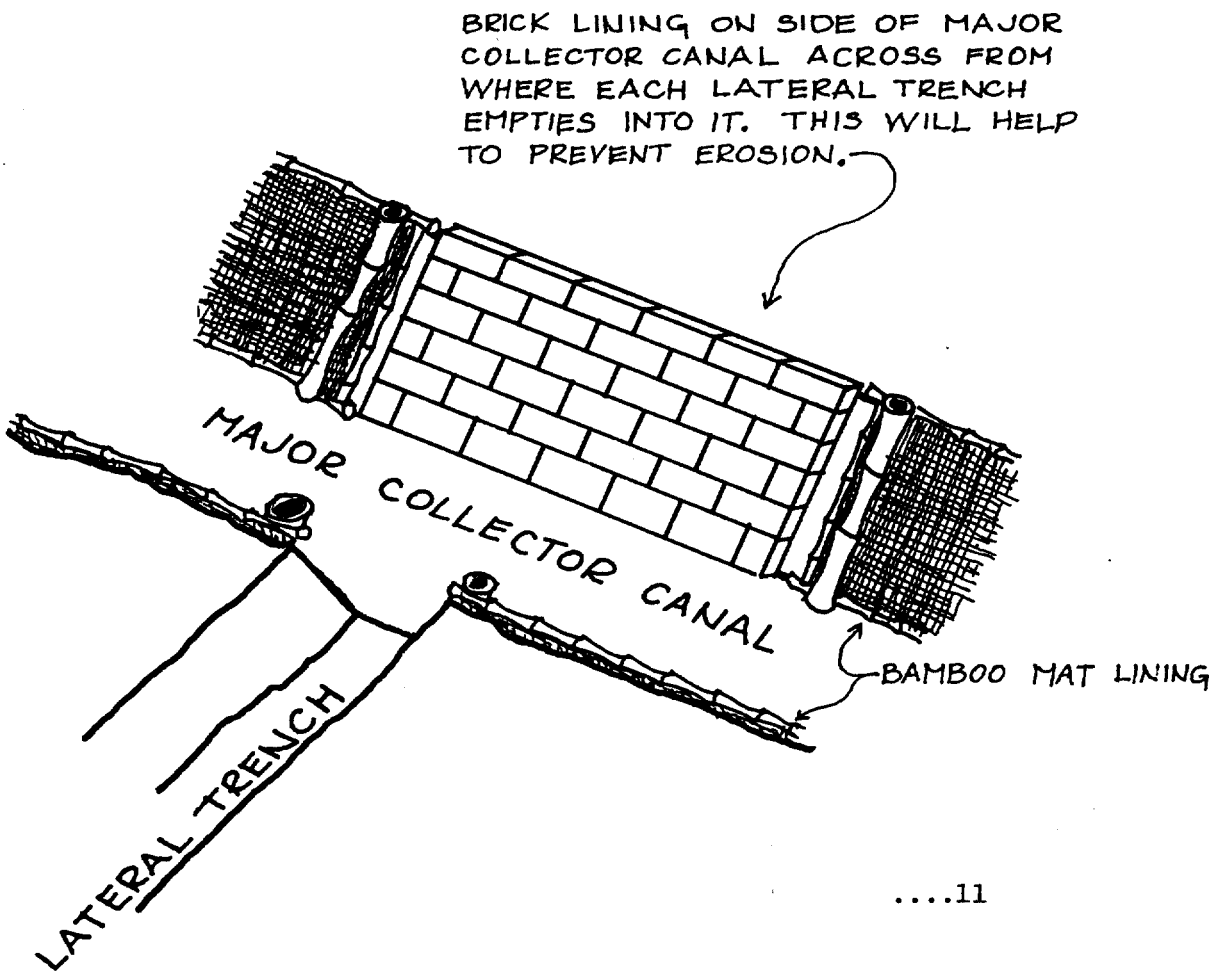


DETAIL OF MAJOR COLLECTOR TRENCH SHOWING LINING WITH BAMBOO MATS.

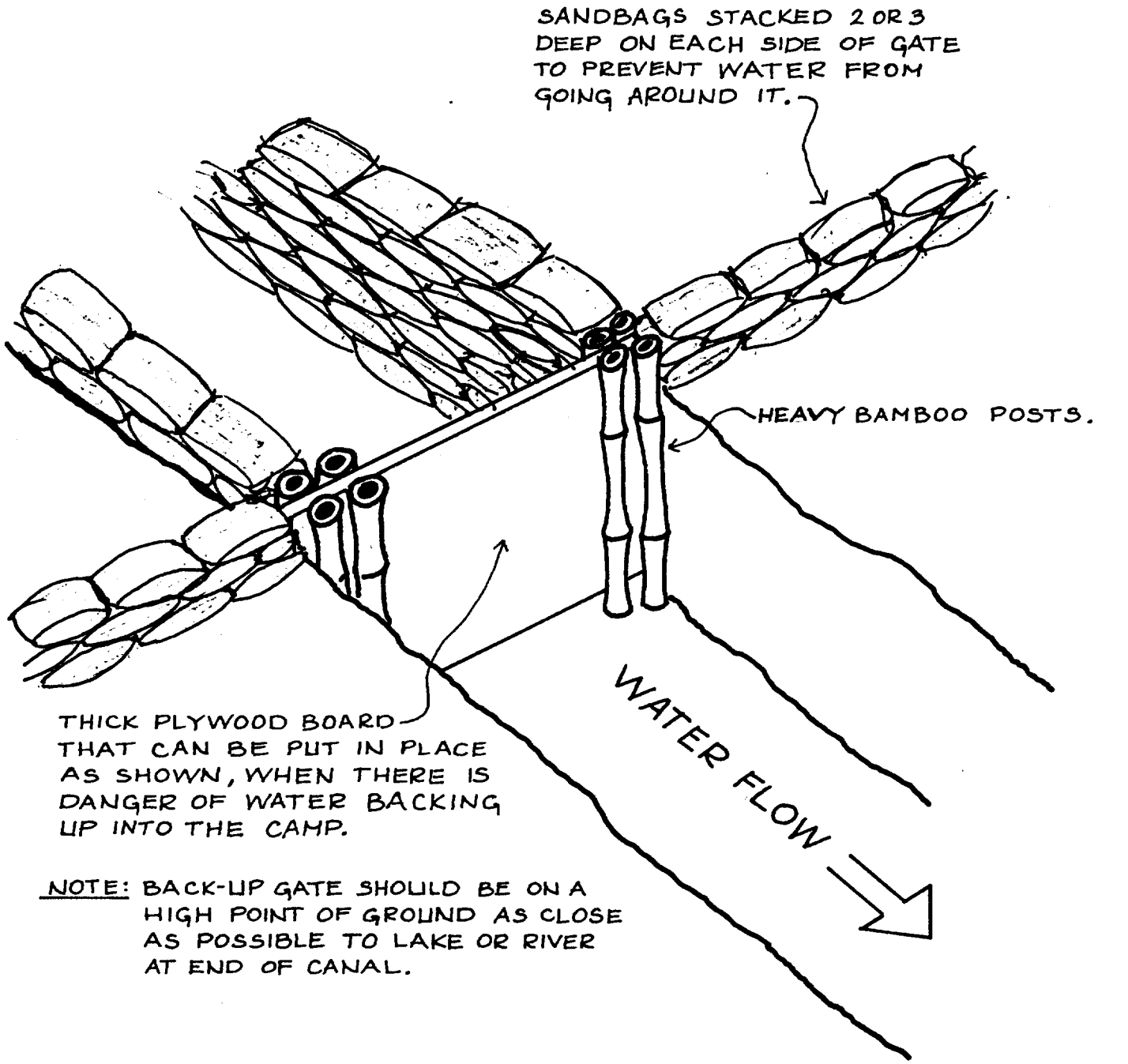
NOTE: NOT TO SCALE

DETAIL 5


BRICK LINING ON SIDE OF LATERAL TRENCH ACROSS FROM WHERE EACH LOCALIZED TRENCH EMPTIES INTO IT. THIS WILL HELP TO PREVENT EROSION.
LATERAL TRENCH
LOCALIZED TRENCH


BRICK LINING ON SIDE OF MAJOR COLLECTOR CANAL ACROSS FROM WHERE EACH LATERAL TRENCH EMPTIES INTO IT. THIS WILL HELP TO PREVENT EROSION.
MAJOR COLLECTOR CANAL
BAMBOO MAT LINING
LATERAL TRENCH

DETAIL 7



NOTE: BACK-UP GATE SHOULD BE ON A HIGH POINT OF GROUND AS CLOSE AS POSSIBLE TO LAKE OR RIVER AT END OF CANAL.

NOTE: NOT TO SCALE

DETAIL OF MAIN DRAINAGE CANAL SHOWING BACK-UP GATE & LINING OF CANAL WITH SAND-BAGS.

water must be pushed out of the pools, the silt removed and the lining repaired.

The system discussed herein is not a sophisticated system; in fact, it is similar in principle to the irrigation techniques employed universally. A force of 50 men per 1000 adult refugees can adequately build the system in most soils and 50 men per 2500 refugees can adequately maintain it.

B. Sewage and Waste Disposal:

Of primary importance, the problem of human wastes must be tackled with much greater effort than is usually expended. At this time, several new methods have been developed to handle human wastes, such as polythene septic tanks, porta cans, chemical latrines, etc. However, until they become available, primary reliance will continue to be standard earthen latrines, and each camp must continually build new latrines and keep the ones they already have clean. The sanitary team must hourly clean them out.

Sewage: The problems of the latrines fall into four categories: location, approaches, cleanliness and disposal. It should be remembered that the latrine regimen instilled in the refugees can have a long-range effect.

i. Location: The location of the latrines is usually dictated by circumstance. As much as possible, they should be below the prevailing wind, near the housing areas, away from the hospital, kitchen and contaminatables, and close to a surface water supply (for washing down).

ii. Approaches: The approaches to the latrine must be designed and maintained to encourage people to use the latrines at all times - night and day. Walkways must be constructed which are solid, dry and not slippery and which are well lighted at night (if electrical power is not available,

then lanterns or candles placed in tin cans should be used). Recent experience in Bengal indicates that bright lighting along the way to the latrines almost eliminated the amount of feces left near the latrines at night.

iii. Cleanliness: A work team must wash the latrines down at least every hour day and night and spread bleach or sanitation chemicals to reduce odours. Latrines which utilise concrete floors or squatting pans are useless unless they are washed out after each use.

iv. Construction of Latrines: The following general rules apply to the construction of all types of latrines:

a. To make sure that food and water will be protected from contamination, latrines should be built at least 100 yards from the unit mess and the nearest water source. Also, the latrine should not be dug below the water level in the ground nor in a place where it may drain into a water source. Usually, latrines are built at least 30 yards from the end of the unit area but within a reasonable distance for easy access. At night, if the military situation permits, they should be well lighted. If lights cannot be used, a piece of cord or tape may be fastened to trees or stakes to serve as a guide to the latrine.

b. A canvas or brush screen should be placed around each latrine, or the latrine may be enclosed within a tent. In cold climates this shelter should be heated. The screen or the tent should have a drainage ditch dug around its edges to prevent water from flowing over the ground into the latrine. For fly control, these shelters should be sprayed twice weekly with an approved insecticide.

c. On the outside of each latrine enclosure a simple hand-washing device should be installed. This device should always be kept filled with water and should be easy to operate.

d. Latrines should be policed every day. Certain unit personnel should be assigned the responsibility of ensuring that the latrines are being properly maintained.

e. When a latrine has been filled to within one foot of the surface, or when it is to be abandoned, it should be closed in the following manner: the contents of the pit, the side walls, and the ground surface to a distance of two feet from the side walls should be sprayed with a DDT residual solution or other insecticide. Then the pit should be filled to the ground surface with successive, 3-inch layers of earth. Each layer is packed down and its surface is sprayed with insecticide before the next layer is added. Then the latrine pit is mounded over with at least one foot of dirt. The purpose of this method of closing is to prevent any immature fly that may hatch in the closed latrine from getting out. The location of the latrine should then be plainly indicated with a sign which is marked LATRINE CLOSED and is dated.

Appendix I provides examples of some common latrines.

Solid Waste: Solid wastes must be collected and disposed of daily. Vehicles such as carts or wheelbarrows should be provided for this task. Disposal can take two forms - burial or burning.

i. Burial: This method is the most preferable in dry areas if the disinfectants can be secured. Pits are dug, the waste is sprayed with disinfectant and then covered with earth. This method can be useful for filling in low-lying areas and if disinfected properly will have no adverse effects.

The dirt cover must be a minimum of one foot thick, however, and garbage should be packed down in a series of layers as it is placed in the pit for disposal. The waste must be buried below the highest natural topographic peak in the land surface. During the monsoon season, burial operations must, of necessity, be in scattered locations and in deep pits (a minimum of four feet deep) and must be covered daily. If the area is subject to flooding, burial techniques should not be used. A pit 4' x 4' x 4' serves 100 people for one day; thus it can be readily seen that for large camps, burial is least preferable due to space requirements.

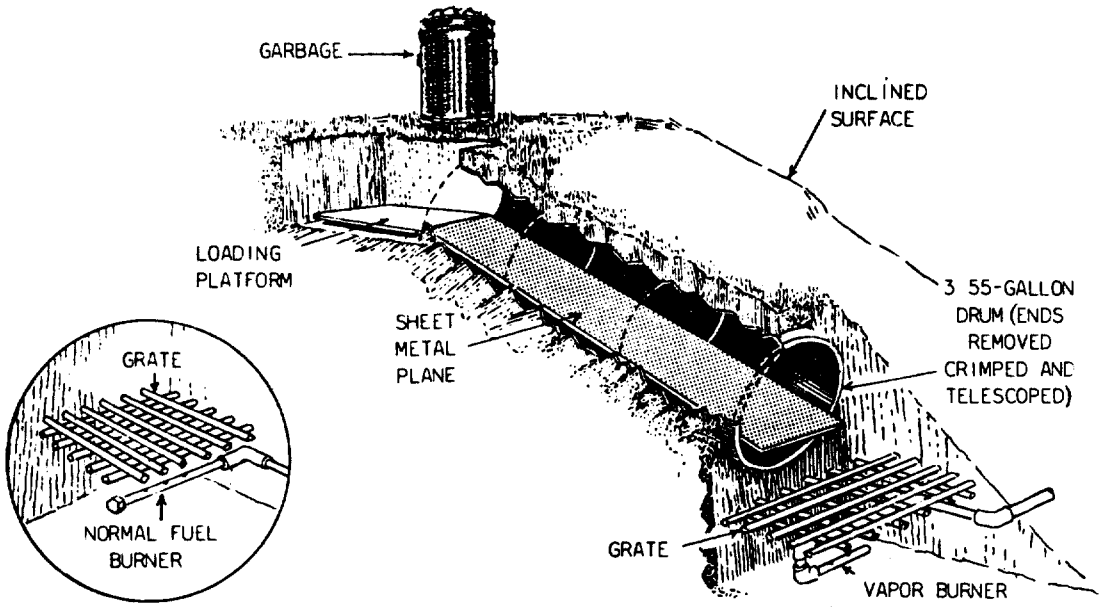
ii. Burning: When burning wastes, a permanent site should be selected as far as reasonably possible from the camp and below the prevailing wind. Decontamination prior to burning is not necessary, but chemical waste fuels (e.g., gasoline) should be used to ensure an even, intense burn. Each day ashes should receive a thin layer of dirt to keep them from blowing.

Garbage is often burned in open incinerators. Excellent types of open incinerators may be constructed from materials which are readily available in any camp area. Since incinerators will not handle wet garbage, it is necessary to separate the liquid from the solid portion. This is done by straining the garbage with a coarse strainer such as an old bucket, salvaged can, or 55-gallon drum in which holes have been punched in the bottom. The solids remaining in the strainer are incinerated, and the liquids are poured through a grease trap into a soakage pit or trench. Field incinerators should be located at least 50 yards downwind from the camp to prevent their being an odour nuisance.

The inclined plane incinerator (Detail 8) will dispose of the garbage of an entire camp, evacuation hospital, or other unit of similar size. Its effectiveness in combustion

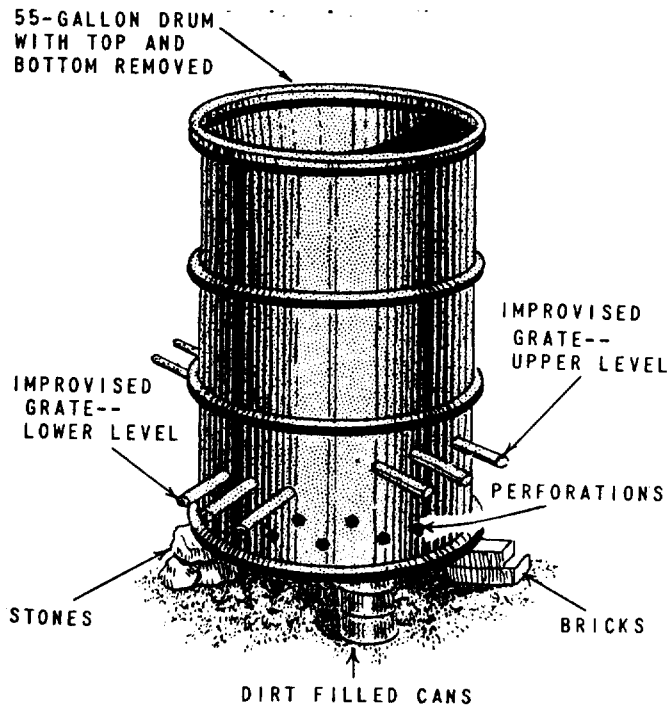
DETAIL 8

INCLINED PLANE INCINERATOR



DETAIL 9

BARREL INCINERATOR



and the fact that it is somewhat protected from rain or wind make it an excellent improvised device. Time and skill, however, are required in building it. A sheet metal plane is inserted through telescoped 55-gallon drums from which the ends have been removed. The metal plane should extend approximately 2 feet beyond the upper end of the telescoped drums to serve as a loading or stoking platform. The telescoped drums are positioned on an inclined surface. A grate is placed at the lower end of the telescoped drums, and a wood or fuel oil fire is provided under the grate. After the incinerator becomes hot, drained garbage is placed on the stoking platform. As the garbage becomes dry, it is pushed through the telescoped drums in small amounts to burn. Final burning takes place on the grate. If time does not permit the construction of the inclined place incinerator, it can be simplified as follows: dig a fire pit at the bottom of an incline, line it with rocks, and place a grate over it. Place three telescoped drums in a shallow trench up to the incline, letting the lower end of the telescoped drums extend somewhat over the fire pit so the flame will be drawn up the drums. The sheet metal plane, if available, should be used, as it permits more thorough drying of the garbage.

A simple barrel incinerator can be made from a 55-gallon drum by cutting out both ends, punching many holes near the bottom, and inserting grates inside the barrel several inches above the holes. The barrel is supported several inches above the ground on stones, bricks, or dirt-filled cans, thus allowing space to build a fire under the barrel. The rubbish is put into the barrel on the top grate.

Examples of the above incinerators can be seen in Details 8 and 9, page 16.

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Liquid Waste: In the field, wash, bath, and liquid kitchen wastes are disposed of in the soil usually by means of either soakage pits or soakage trenches. In order for the soil to absorb these liquids, the grease and soap, as well as any solid particles, must first be removed from them. For this reason, a grease trap is made a part of each soakage pit or trench to be used for the disposal of wash and liquid kitchen wastes. In places where heavy clay soil prevents the use of soakage pits or trenches, evaporation beds may be used if the climate is hot and dry.

i. Soakage Pits: In a temporary camp, a soakage pit 4 feet square and 4 feet deep normally will be adequate to dispose of liquid kitchen waste for 200 persons. If the people are to remain in the camp for 2 weeks, two pits should be constructed for disposal of liquid kitchen waste; each pit should be used on alternate days, thus lessening the possibility of clogging. Each device provided for washing and bathing must also have a soakage pit under it. These soakage pits are constructed in the same way as a urinal soakage pit (see Appendix I) except that the urinal pipes are omitted. A grease trap is provided for each pit, except those under showers. The area under field showers, as well as under drinking devices, should be excavated a few inches and then filled with small, smooth stones to keep the water from standing. Should a soakage pit become clogged, it is closed, and a new one is constructed. A soakage pit is closed by covering it with 1 foot of compacted earth and marked PIT CLOSED __(date)_____.

ii. Soakage trenches: If the ground water level or a rock formation exists close to the surface, soakage trenches instead of pits should be used. A soakage trench consists of a pit, 2 feet square and 1 foot deep, with a trench extending outward from each of its sides for a distance of 6 or more feet.

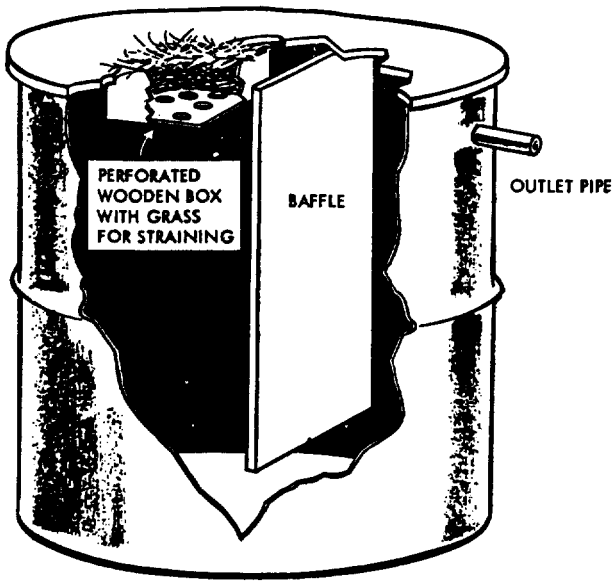
The trenches are 1 foot wide and vary in depth from 1 foot at the central pit to 1 ½ feet at the outer ends. The pit and trenches are filled with the same material used in a soakage pit. Two such units should be built to dispose of liquid kitchen waste for every 200 persons, and each unit should be used on alternate days. One unit should be built for each washing device provided. A grease trap is provided for each soakage trench. A soakage trench is closed by covering it with 1 foot of compacted earth and marked PIT CLOSED (date) .

iii. Grease Traps:

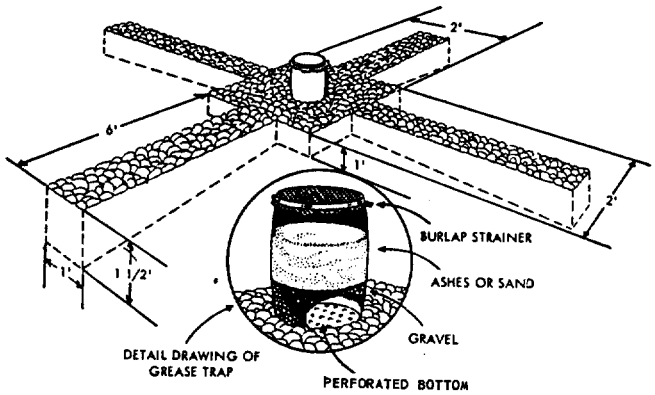
a. Baffle Grease Trap: A baffle grease trap may be made from a drum (Detail 10). The drum is divided vertically into an entrance chamber and an exit chamber by attaching a wooden baffle. The baffle should be placed so that the entrance chamber will be approximately twice the size of the exit chamber. The baffle should hang to a point within 1 inch of the bottom. A strainer which may be made from a small perforated box filled with straw, hay, or burlap is inserted into the lid above the entrance chamber. A pipe is inserted into the exit chamber about 3 to 6 inches below the top as an outlet to the soakage pit. This baffle grease trap is usually placed on the ground at the side of the soakage pit with the outlet pipe extending 1 foot beneath the surface at the center of the pit. If a grease trap is not water-tight, it must be placed partially under the ground.

Before the grease trap is used, the chambers are filled with cool water. The waste liquid is poured through the strainer which retains any solids. As the warm liquid strikes the cool water, the grease rises to the surface of the entrance chamber and the liquid

DETAIL 10
BAFFLE GREASE TRAP



DETAIL 11
SOAKAGE PIT



runs under the baffle, filling the exit chamber. When the liquid reaches the outlet pipe near the top of the exit chamber, it runs through this pipe into the soakage pit. Unless the grease trap is of sufficient capacity, the warm greasy liquid poured into the trap will heat the cool water in the trap, thus allowing the grease to remain uncongealed and to pass through the trap. The efficiency of this grease trap can be increased by constructing it with multiple baffles. Also, a series of traps may be used.

The baffle grease trap must be properly maintained to prevent clogging of the soakage pit. The grease retained in the trap should be skimmed from the surface of the water daily or as often as required and either buried or burned. The entire trap should be emptied and thoroughly scrubbed with hot, soapy water as often as necessary.

b. Barrel Filter Grease Trap: The barrel filter grease trap may be made from a 30- to 50-gallon barrel or drum which has the top removed and a number of large holes bored into the bottom (Detail 11). Eight inches of gravel or small stones are placed in the bottom and covered with 12 to 18 inches of ashes or sand. A piece of burlap is fastened to the top of the barrel to serve as a coarse filter. The trap may be placed directly on the soakage pit, or it may be placed on a platform with a trough leading to the pit.

Every 2 days the grease trap should be emptied, washed, and refilled as described above. The material removed should be buried. The burlap filter should be either washed or replaced every day.

A pail strainer may be used instead of the burlap filter. It is made by boring holes in the bottom of

an old metal pail or can and filling it with grass or straw. This strainer will remove coarse particles of food and a small part of the grease. It is placed on top of the barrel grease trap.

iv. Evaporation Beds: In places where clay soil prevents the use of standard soakage pits, evaporation beds (Detail 12) may be used if the climate is hot and dry.

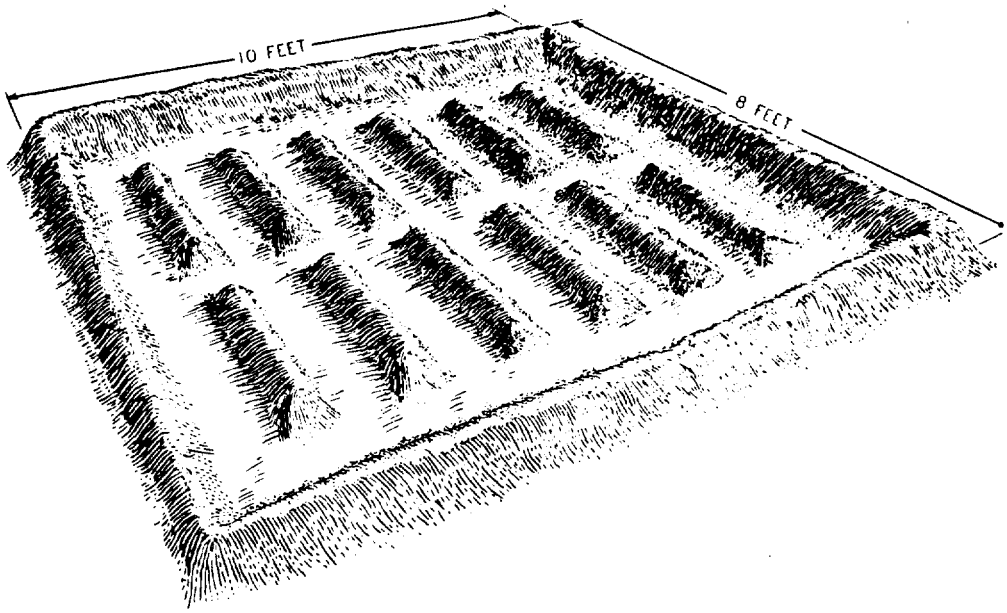
a. Sufficient beds, 8 by 10 feet, are constructed to allow 3 square feet of surface area per person per day for kitchen waste and 2 square feet per person per day for wash and bath wastes. The beds are spaced so that the wastes can be distributed to any one of the beds. In the construction of a bed, the top soil is first scraped to the edges, thus forming a small dike around it; then the earth within the bed is spaded to a depth of 10 to 15 inches and raked into a series of rows, making the ridges approximately 6 inches above the depressions. These rows may be formed either lengthwise or crosswise as deemed desirable for best distribution of water.

b. In operation, one bed is flooded during the day with liquid waste to the top of the ridges, which is equivalent to an average depth of 3 inches over the bed; then the liquid waste is allowed to evaporate and percolate. After 3 or 4 days this bed is usually sufficiently dry for respading and re-forming. The other beds are flooded on successive days, and the same sequence of events is followed.

c. Careful attention must be given to proper rotation, maintenance, and dosage of evaporation beds. It is also essential that the kitchen waste be run through an efficient grease trap before it is allowed to enter the evaporation beds. If these beds are used properly,

DETAIL 12

EVAPORATION BED



they create no insect hazard and only a slight odor. Other modifications of waste disposal methods are possible and should be used when they are more adaptable to the particular situation.

C. Housing:

Housing problems that usually arise are related to the problem of numbers of refugees as well as construction. The following is a discussion of construction and construction techniques, not design. Some recommended designs can be found in Report V of this series.

i. Roof Construction:

a. Thatch: In most areas there are usually sufficient indigenous materials for construction of adequate roofing material if proper design techniques are used. The thatch roof leaks only because it is being placed on the roofs improperly, i.e., layed out rather than woven. Until other material becomes available in quantity, the engineering team must force the people to utilise the bamboo and straw in the proper manner (if basket weavers are available within the camp, they should be placed in charge of weaving mats to be used as roofing material).

b. Tarpaulins: Tarps are generally good but have definite limitations. They are subject to shrinkage and rot. Both these conditions can be significantly slowed, however, by spraying them with a fabric preservant, specifically a product called "Scotch-Guard" manufactured by the 3M Company in the United States and Great Britain. Tarps are only as good as the means in which they are secured to the housing frame. Nylon cord should be used where possible.

c. Fibreglass roofing: The most durable material currently available, it should be used on the high activity

buildings initially, and then used for housing as much as possible. The supports for the material must be stronger and more secure than the frames used for holding the tarps and thatch due to the increase of weight and the increased wind resistance. On non-peaked roofs (lean-tos) the low end should be placed into the wind for maximum support and best cooling effect. Another means of cooling the fibreglass is to paint the top surface with a white paint.

d. Polythene Sheets, or synthetic rubber stripping: A good all-round construction material, polythene (or polyethylene) is easy to ship and store and is becoming widespread in use. As a roofing material, it is best used as an interim material or a supplement to existing roofs (to cover thatch, for example). Due to its susceptability to wind damage and tearing, when used on the outer surface of a structure it should be attached to a frame (see Detail 13, page 26). In humid tropical areas, use of polythene over thatch often causes rot and deterioration of the thatch and can cause a health hazard in living or medical structures.

ii. Flooring:

a. Floors must be designed and built to assist the drainage in the immediate area. The centre line of the floor should be a peak to enable any water which enters the structure to flow outside.

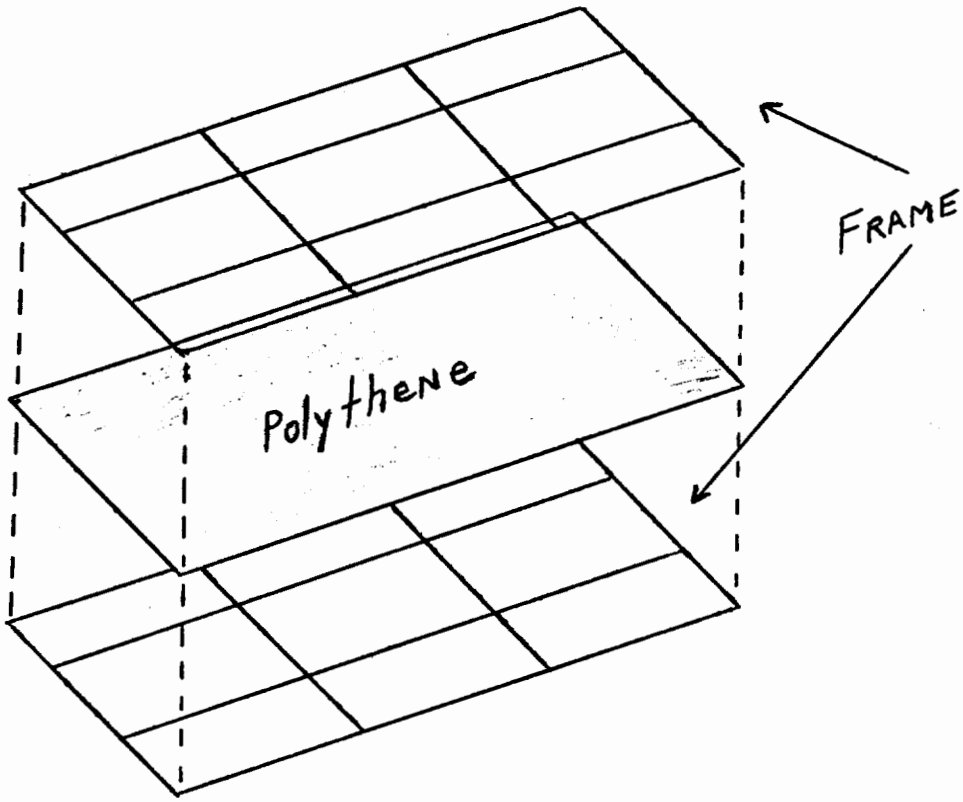
b. Floors should be constructed of solid materials, preferably brick, and should be covered with either mud mortar or straw to enable cleaning activities on the floor.

c. Floors must be built above the local flood level (see page 27). If the availability of construction materials is limited, dikes and small levees must be built at the edges of the building beneath the roofline and should be

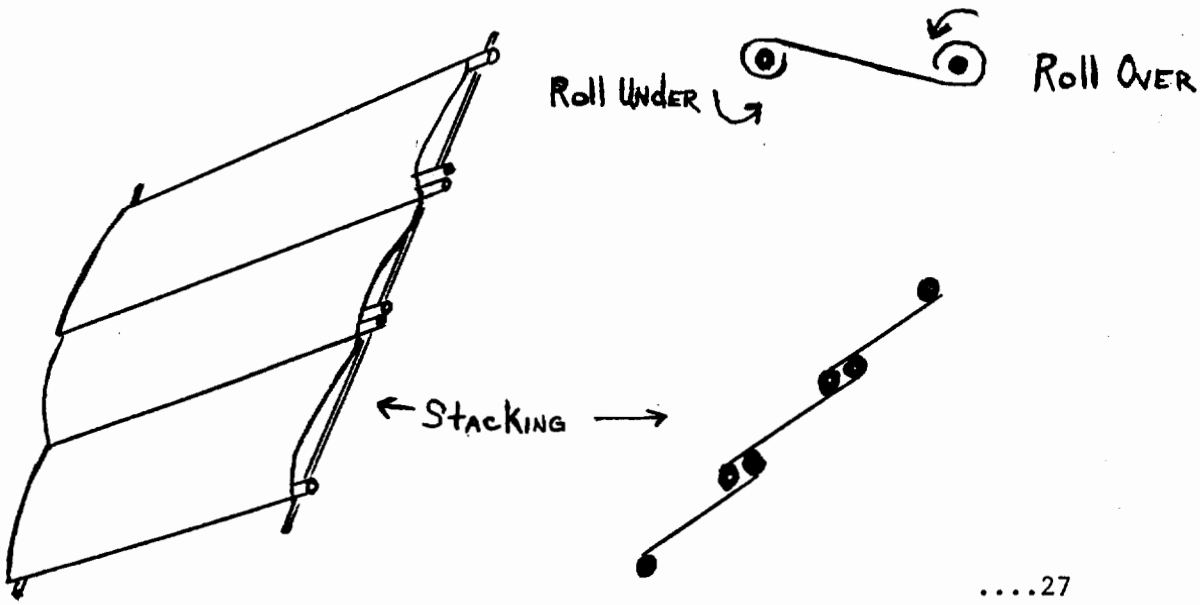
DETAIL 13

POLYTHENE FRAMES

Press Frame

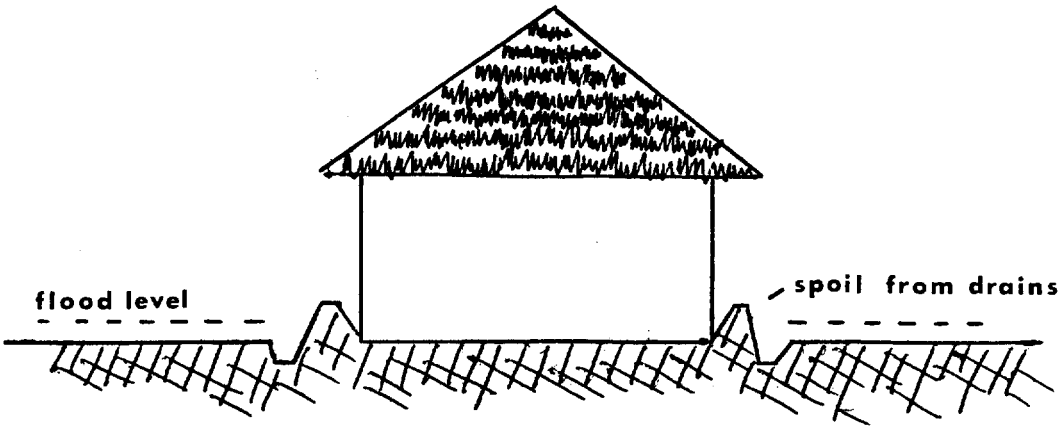


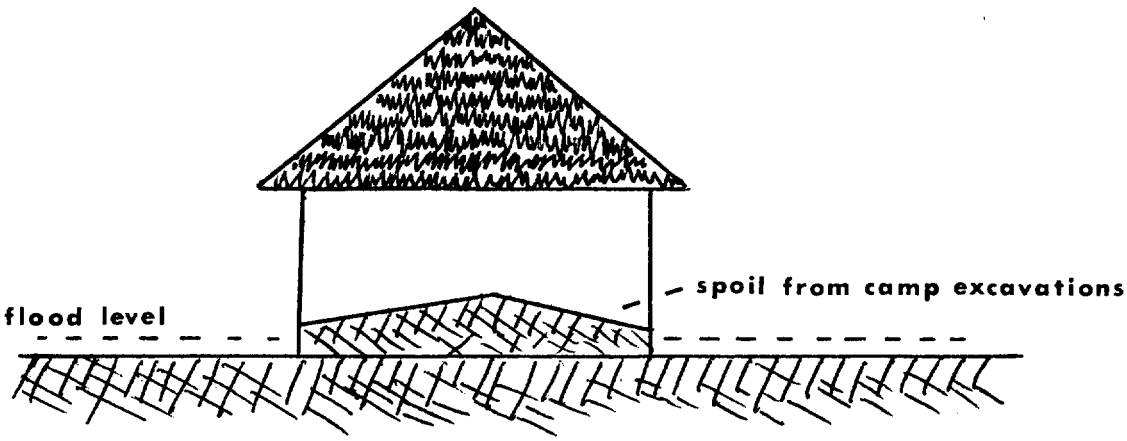
Tension Frame

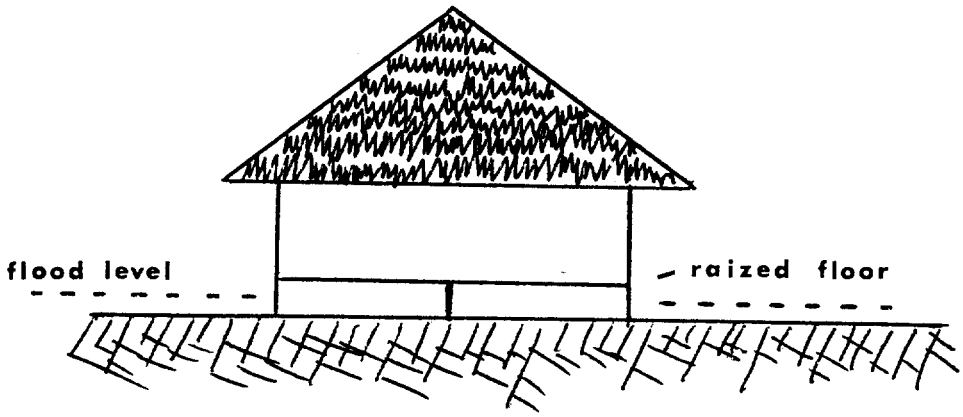


DETAIL 14

PROTECTION FROM FLOODING







of sufficient strength to keep out any localised flood waters. Bricks are the best material for this type of construction. (If brick material is not available, bricks may be constructed by placing mud and straw in layers and compressing it between blocks or pieces of wood and heated by smoke fires in any dry enclosed room. This type of brick will work in temporary situations and should last approximately 10 days before deteriorating, much longer if the brick can be fired or dried for a long period.)

SUMMARY OF PLANNING RECOMMENDATIONS

A refugee camp must be designed from the beginning with a well-defined, orderly and symmetrical camp plan. Sanitation should have the top priority in the approach to each task. In the planning and administration of a camp, the following items should be carried out:

--- Establish water points for drinking and for washing; dig latrines immediately, and mark them plainly; locate the kitchens on the side of camp away from the latrines and close to the water wells; dig a garbage pit.

--- Establish a communications and administrative centre during the early stages of development. Develop and mark access roads and the camp road network.

--- Lay out and build camps and facilities around a sanitation plan. Make sanitation facilities convenient to all refugees and staff.

--- Control the water supply. Purify drinking water by accepted techniques. Establish and plainly mark separate water points for washing, cooking, and human consumption. Locate washing points downstream from points used for human consumption. (See Appendix II)

--- Give particular care to location, maintenance, and cleanliness of latrines. Follow prescribed designs in construction. Flyproof every

latrine. Locate latrines conveniently to shelter areas but away from the kitchens, dispensary, and water supply. Never locate a latrine uphill on a drainage line leading down toward a water source. When a latrine is taken out of use, it must be filled and covered, and then marked with a sign, LATRINE CLOSED (date) .

--- Sanitary conditions in the kitchen are as important as in the latrines. The kitchen, garbage pits, and if possible, the godown must be flyproof. Garbage must be kept covered and must be removed to garbage pits at least once daily. Empty food containers should either be burned or buried to prevent flies from swarming. For each kitchen a grease trap should be built for the disposal of waste grease and greasy water. Most important, the kitchen area must include facilities so that all kitchen gear (plus all pots and food containers) can be thoroughly washed down in boiling soapy water and then rinsed twice in boiling clear water.

--- Wage ceaseless war on insects and pests. The simplest way to control flies is to cut off their nourishment by screening latrines, kitchens and garbage pits. This keeps flies away from food and thus from poisoning the refugees. Watch for young flies, particularly inside a screened structure. The presence of young flies means that flies are breeding nearby, usually inside.

--- Drainage of standing water, coupled with oiling of stagnant pools and swampy areas, kills mosquito larvae as they breed. The clearing of tall grass, brush, and undergrowth helps to reduce the danger from mites. Human cleanliness and rodent control stop lice. All insect control problems can be reduced in the camps if periodic dusting or spraying with insecticides is carried out.

--- Be prepared for emergencies. Never neglect security; establish a camp guard; promulgate a fire bill; know your sources of outside help; keep your fuel dump secure against fire and theft; establish liaison with your neighbors.

Notes prepared for circulation to Oxfam field staff

CONTENTS

1. INTRODUCTION

2. TYPES OF SHEETINGS

3. PROPERTIES - THICKNESSES - COLOURS

4. USE AND FIXINGS

5. MANUFACTURERS DETAILS

1. Introduction

A recent report on an Oxfam project stated 'while very large quantities of polythene sheeting were sent in by Oxfam, very little guidance was given as to how it was intended to be used'. The report also highlighted the difficulties of fixing plastic to structures and hazards to plastic buildings in wind.

This report was in fact about emergency shelters in the Bengal refugee camps.

This paper has therefore been prepared to help field staff and others understand the advantages and problems of these new sheeting materials.

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 etc.

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.

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 about 300 acres of greenhouses covered with plastic film and a great number of semi-permanent plastic-clad farm buildings used for farm stock and storage purposes.

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 six feet 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 tech-

niques discussed will work with any flexible plastic sheeting available on site.

3. General Properties of polythene film

Thicknesses

Polythene films can be made in thicknesses from .0005" (50 gauge) to 0.015" (1500 gauge). Cost per unit area is proportional to thickness. Metric equivalent of these gauges is:

.0005"	-	50 gauge	-	12 microns
.015"	-	1500 gauge	-	375 microns

American terminology for thickness is 'mils' which is confusing since the term refers to 'thousandths of an inch'. In American parlance a '10 mil' film refers to 1000 gauge or 0.01".

For emergency housing purposes films thinner than 500 gauge (0.005") (5 mil) would be unsuitable.

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

Polythene is available from U.K., Continental and American manufacturers in seamless widths of up to 24ft. in 1000 gauge (0.01"), and in seamless widths of 36ft. in 500 gauge (0.005"). 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 24ft. wide seamless sheeting is rolled on a 6ft. long core.

It is light in weight - approximately 20 sq.ft. of 1000 gauge sheeting weighs 1 lb.

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 - e.g. one-half as thick as 1000 gauge. The hundredweight sacks used to transport fertilizers and other chemicals are usually made from 800 gauge (0.008") 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 24' x 100' would cost the U.K. farmer about £20-£25, approximately 1p per sq.ft. For the same sum he would obtain twice the area of 500 gauge film.

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

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, 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 since the middle 1960s, with no apparent weakening of the film cover.

If clear films are required then types are available which will last for a year in any climate.

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.

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.

Ultra-violet-light inhibited films often have a slight yellow or green colour - this is due to the nature of the absorbing chemical used.

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 condition only applies where soil moistures are high.

4. Use and Fixings of Plastic Films on Structures

Any plastic structure intended for emergency housing must:

1) Offer shelter from the weather

2) Be stable in wind

3) Not be unbearably hot in daytime

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

1) Availability

2) Expected life of the shelter

3) Prevailing climatic condition

For long-term occupancy it would not be difficult to devise structures which make use of black film for the roof (for durability) and clear film for part of the walls (light admittance).

Black films expand when the sun shines and contract at night. Actual expansion factor is 1½% per 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 - the expansion/contraction rate can generally be ignored.

If temperatures within any plastic-clad structure become too high in sunshine they can be reduced by spraying the outer surface with aluminium or light-coloured paint. Some paints do not 'key' very well to polythene surfaces, and may need to be replaced after a period of time.

The thermal insulation properties ('H' 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 light-weight dry material which contains a lot of air spaces would be suitable. If an organic material like straw and hay is so used it would be desirable to pre-treat it with an insecticide.

Fixing film to structures and possible types of structure

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

There are two problems in supported polythene structures

1) Erection of the framework

2) Securing the plastic to it

The ideal shape of a structure to be covered with plastic film is semi-cylindrical and if the width of such a structure is not too wide 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 England at the present time, which is illustrated in Sketches 1 and 2.

It is appreciated that 1" steel tubing, suitable 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 - lightweight and low cost.

Note that

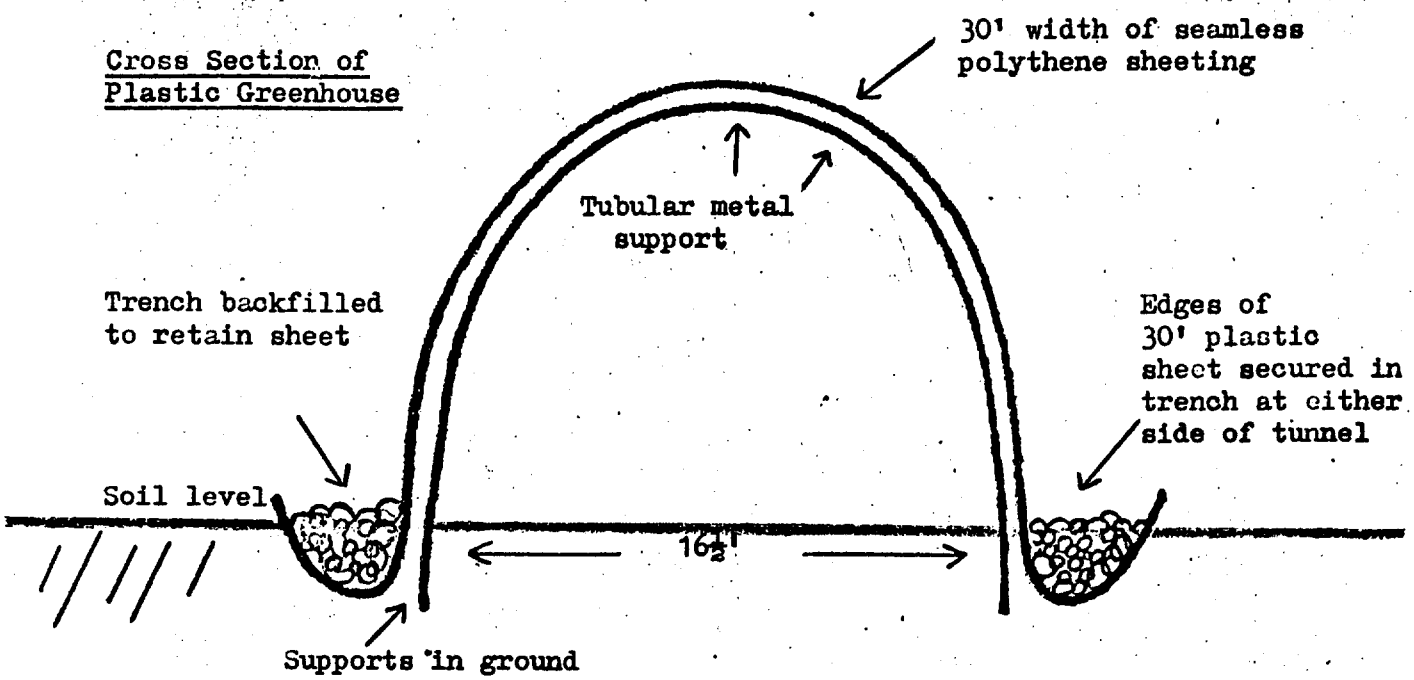
a) The fixing of the film is achieved simply by burying the edges of the plastic. No other fixing is involved other than to the end hoops of the structure.

b) Because the plastic is stretched tautly and uniformly over the curved

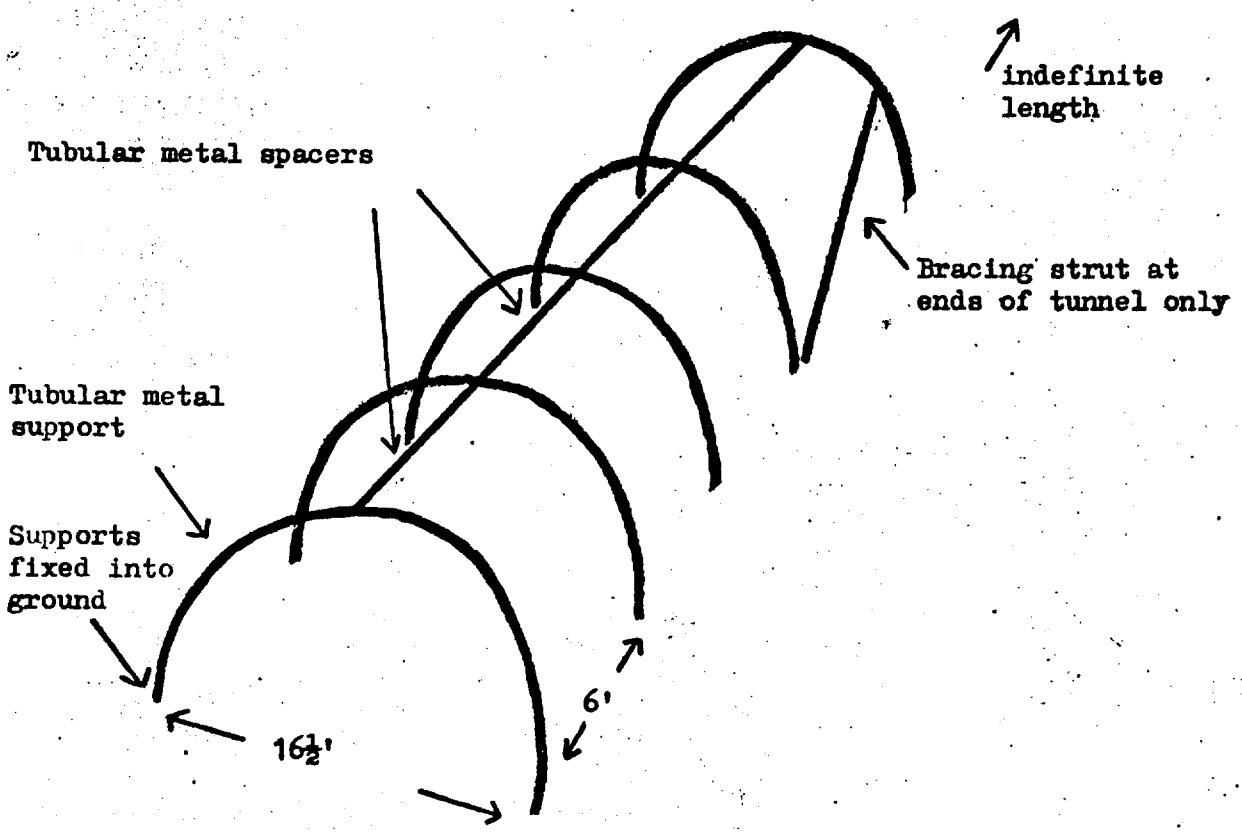
surface no stress points exist and no 'flapping' of the film can occur in wind.

Sketch 1

Cross Section of Plastic Greenhouse



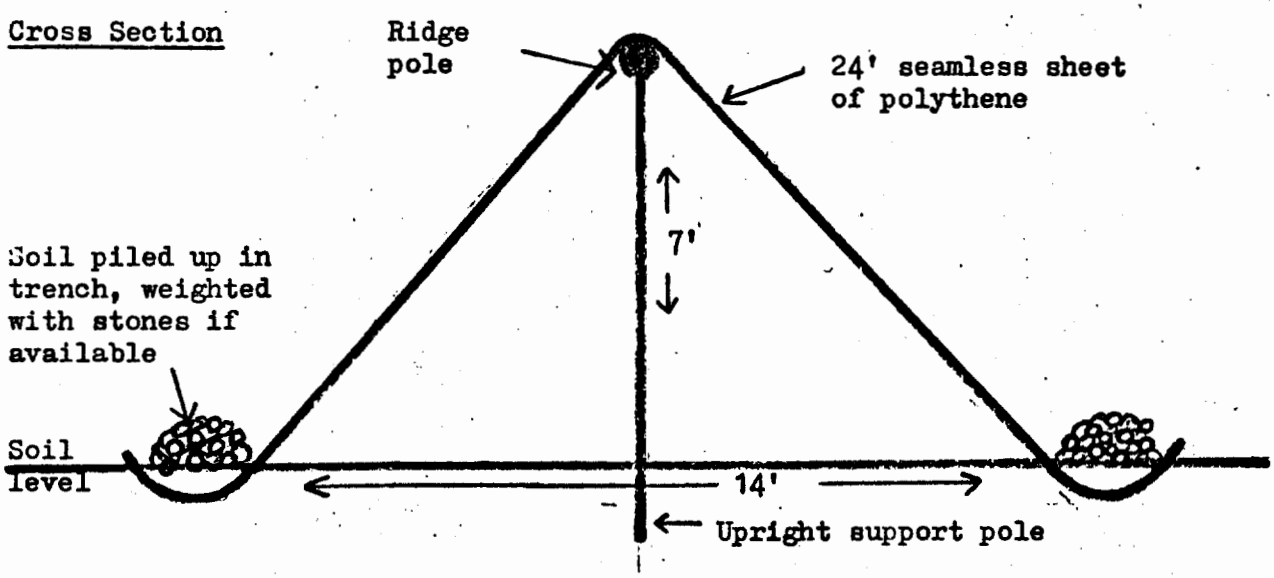
Sketch 2



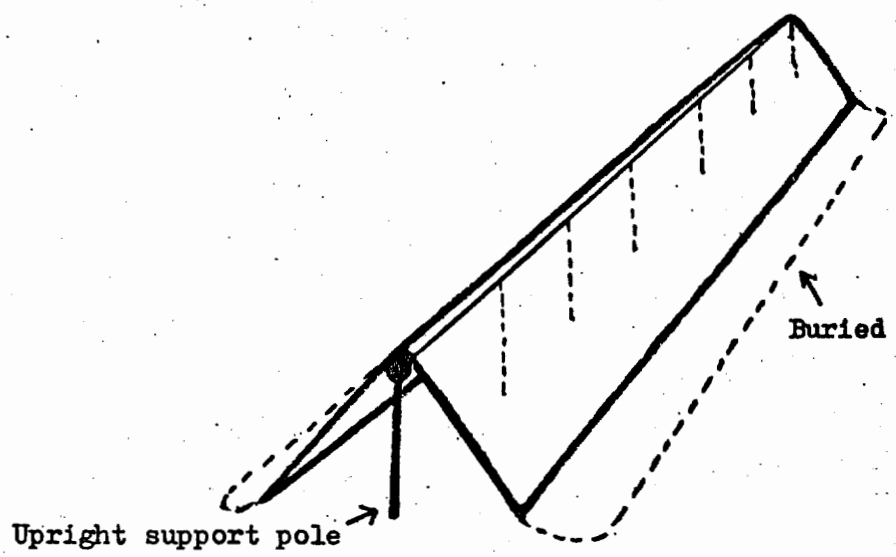
A very simple emergency shelter could be achieved by using a 24ft. seamless sheet stretched over a ridge bar running parallel to and 7ft. above the soil surface. If two feet of each edge of the sheet is buried the cross-section of this simple shelter is as shown in Sketches 3 and 4.

Sketch 3

Cross Section



Sketch 4



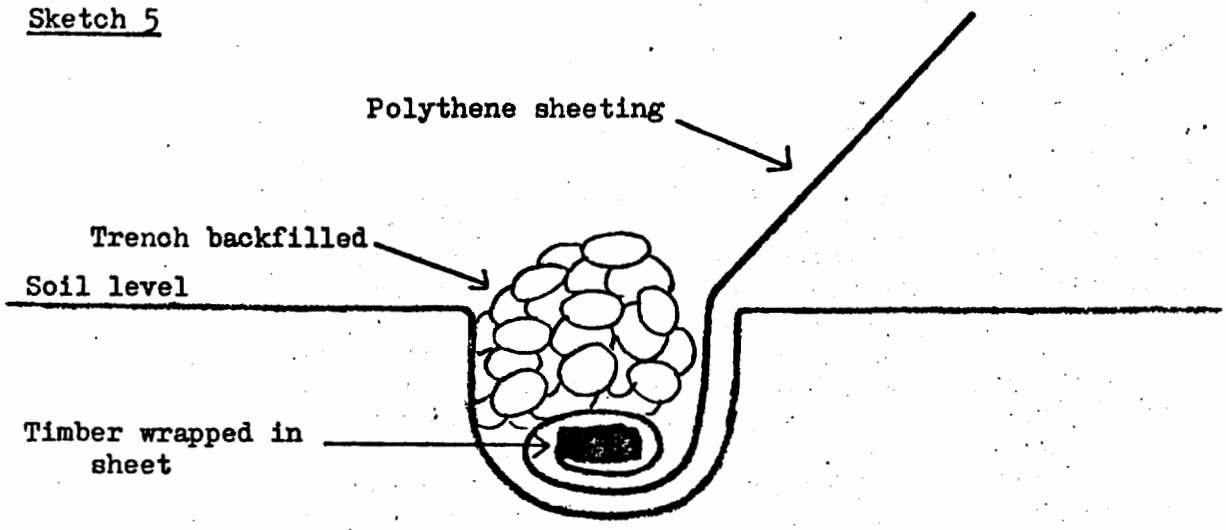
The stability of this structure will depend on

1) Rigidity of ridge

2) Security of fixing at soil level

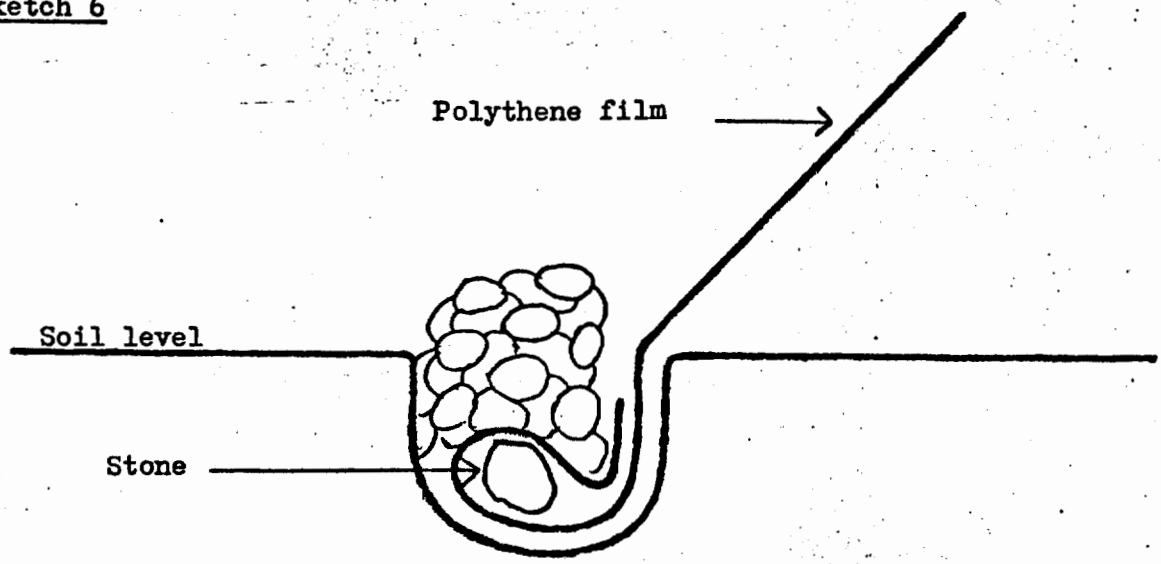
If the soil will not 'grip' the plastic adequately, greater purchase can be obtained by rolling the edge of the plastic around a piece of timber before burying it, as shown in Sketch 5.

Sketch 5



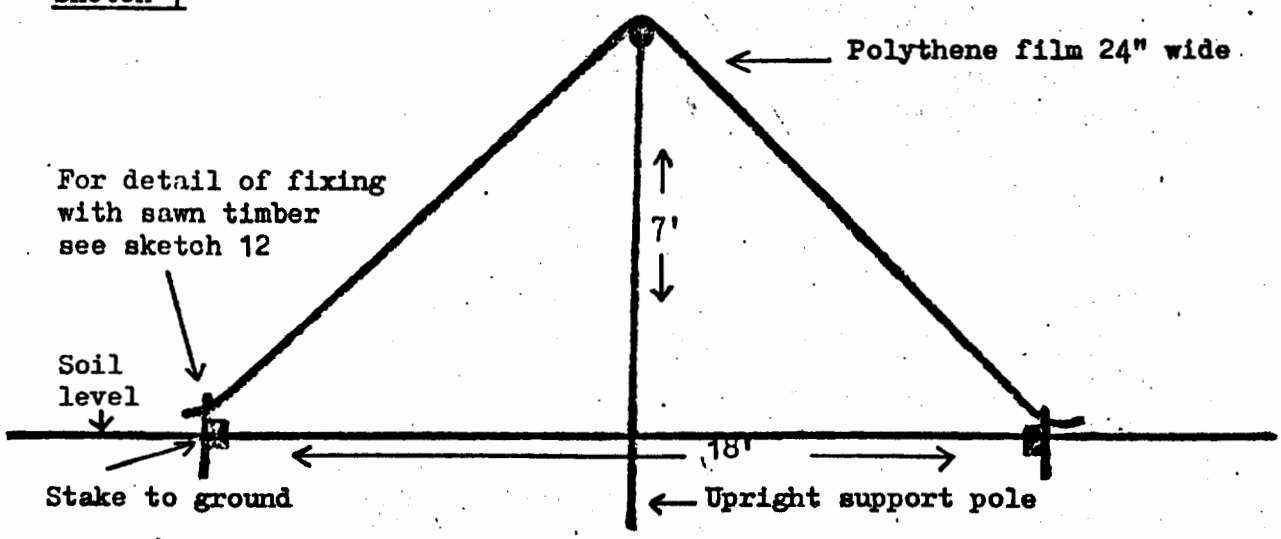
If no timber is available individual stones ideally 5"-8" in diameter can be used, in which case fold the film over them as shown in Sketch 6.

Sketch 6



If sawn timber is available the fixing method illustrated in Sketch 12 can be adopted and the simple triangular structure illustrated can be increased in width to about 18ft. as shown in Sketch 7.

Sketch 7

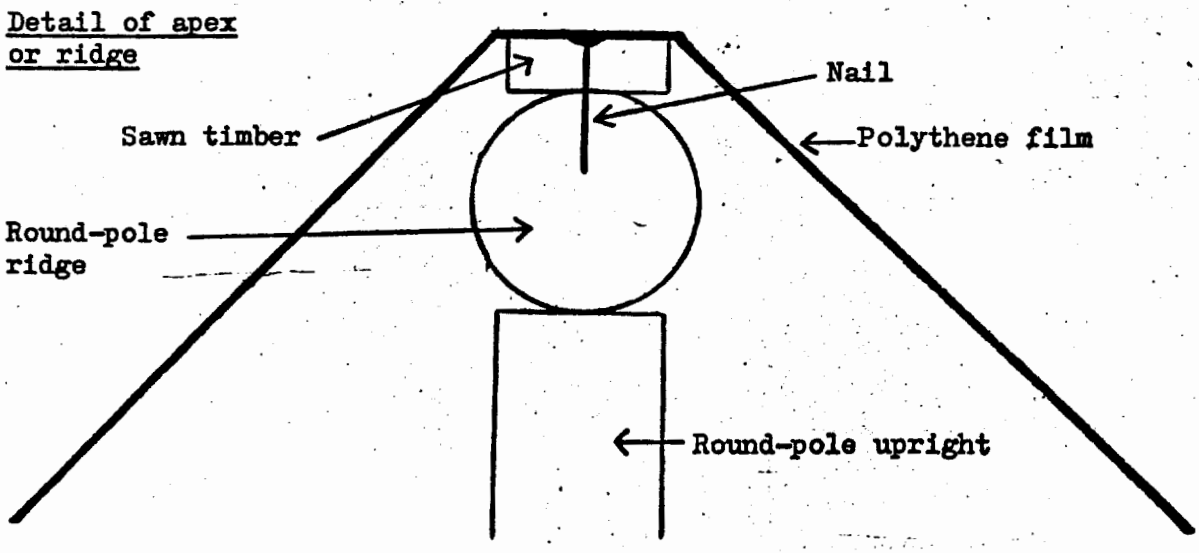


Unreasonable stresses to the film could occur to such simple triangular structures in high wind unless it could be located in a naturally sheltered site. Strands of wire, rope or polypropylene baler twine could be stretched tautly between ridge and timber rail at ground level, on each side of the plastic,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

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 Sketch 8. Obviously sharp edges or rubbing points must be avoided.

Sketch 8

Detail of apex or ridge



Other film-fixing methods

Wherever possible it is better to secure sheeting along a whole edge rather than that strain should 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 18" around the edges. Eyeletting details are as follows.

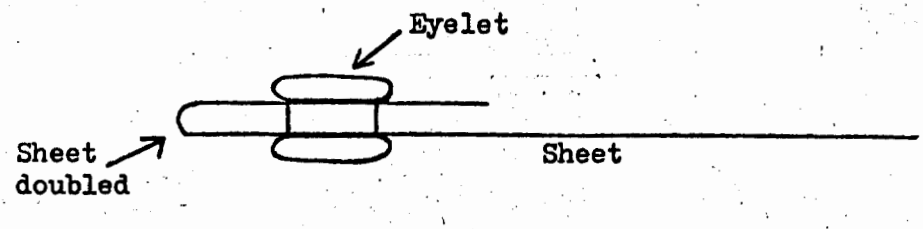
Eyelets are in two pieces (eyelet and 'B' ring). Eyelets are fixed through sheeting material by a simple mandr el and die.

No. 23 sail eyelet takes 5/16" diameter rope
No. 24 sail eyelet takes 3/8" diameter rope

No. 23 eyelets cost £1.50 per 1000
No. 24 eyelets cost £2.304 per 1000

Simple mandrel and die for fixing eyelets cost £2.00.

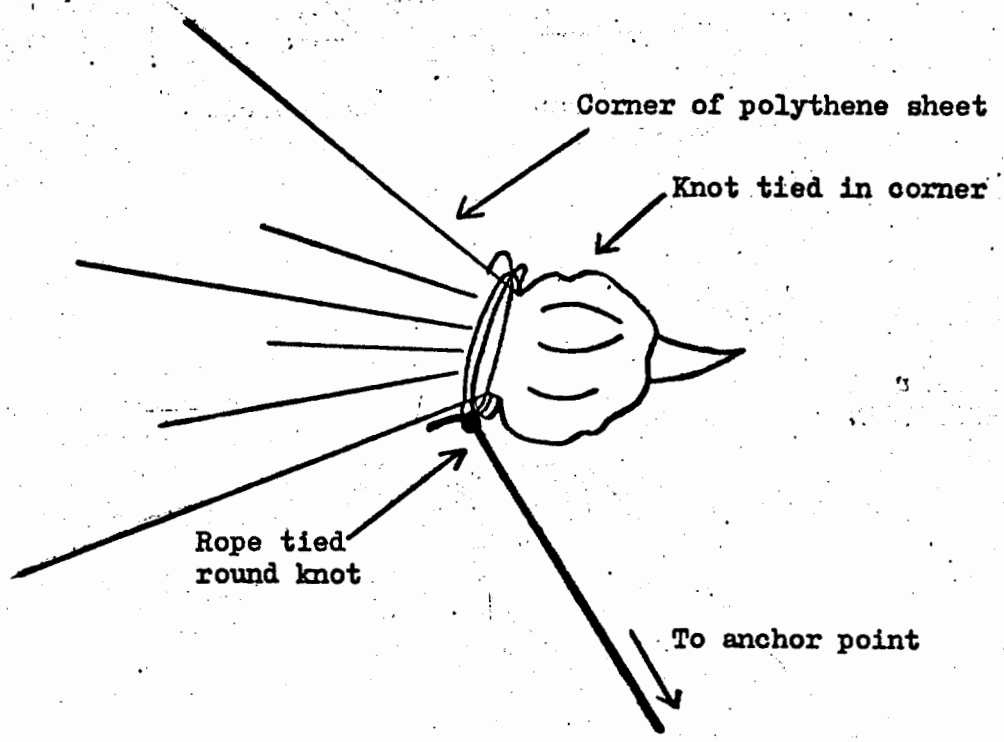
Sheet materials should be double thickness if possible at eyeletting points. This is achieved by folding material back from edge, say 4".



For additional strength when eyeletting sheeting, adhesive reinforcing patches can be fixed. Sellotape eyelet reinforcement patches 9002 cost £7.85 per 1000 patches. Samples are shown in this booklet.

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 a rope can be tied round the knot, as shown in Sketch 9.

Sketch 9



Several devices for securing ropes to polythene sheeting are available. (See Appendix sheet)

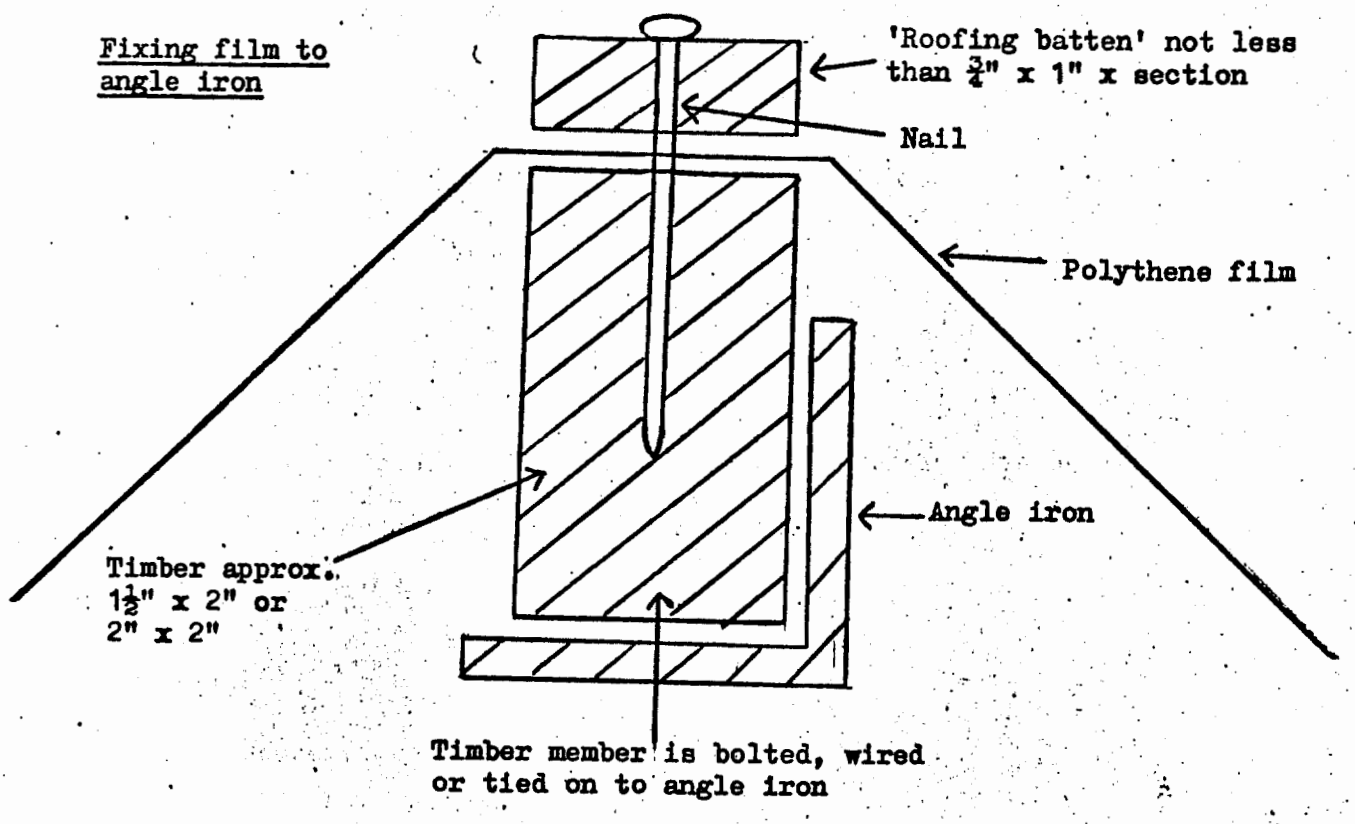
Fixing film to metal structures

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 Sketches 10 and 11. It is assumed that sawn timber is available.

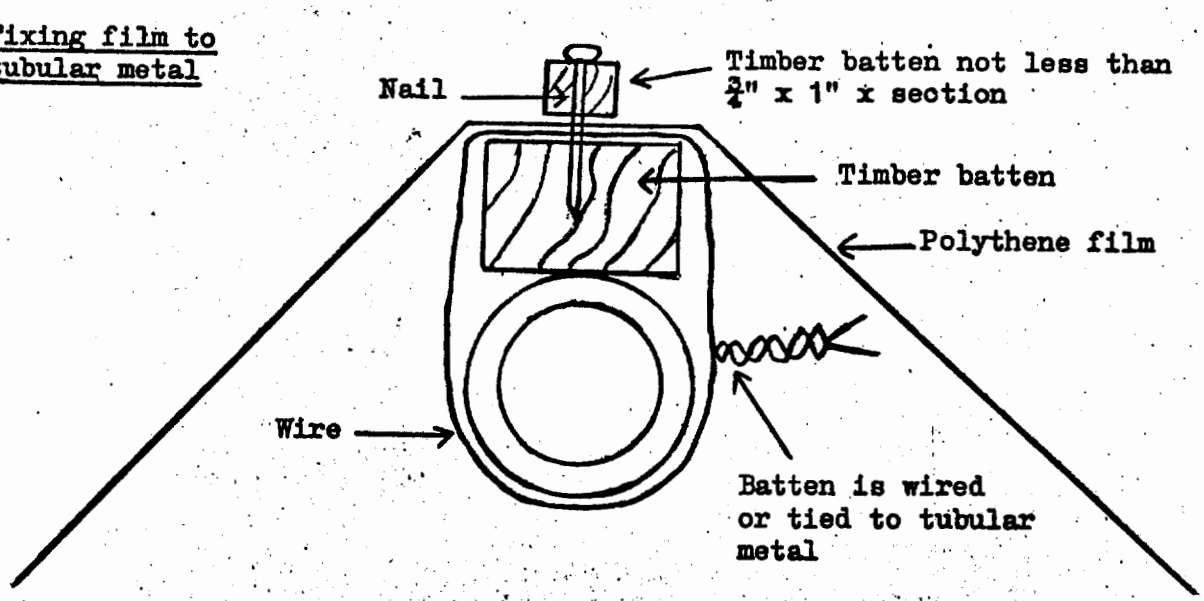
Sketch 10

Fixing film to angle iron



Sketch 11

Fixing film to tubular metal

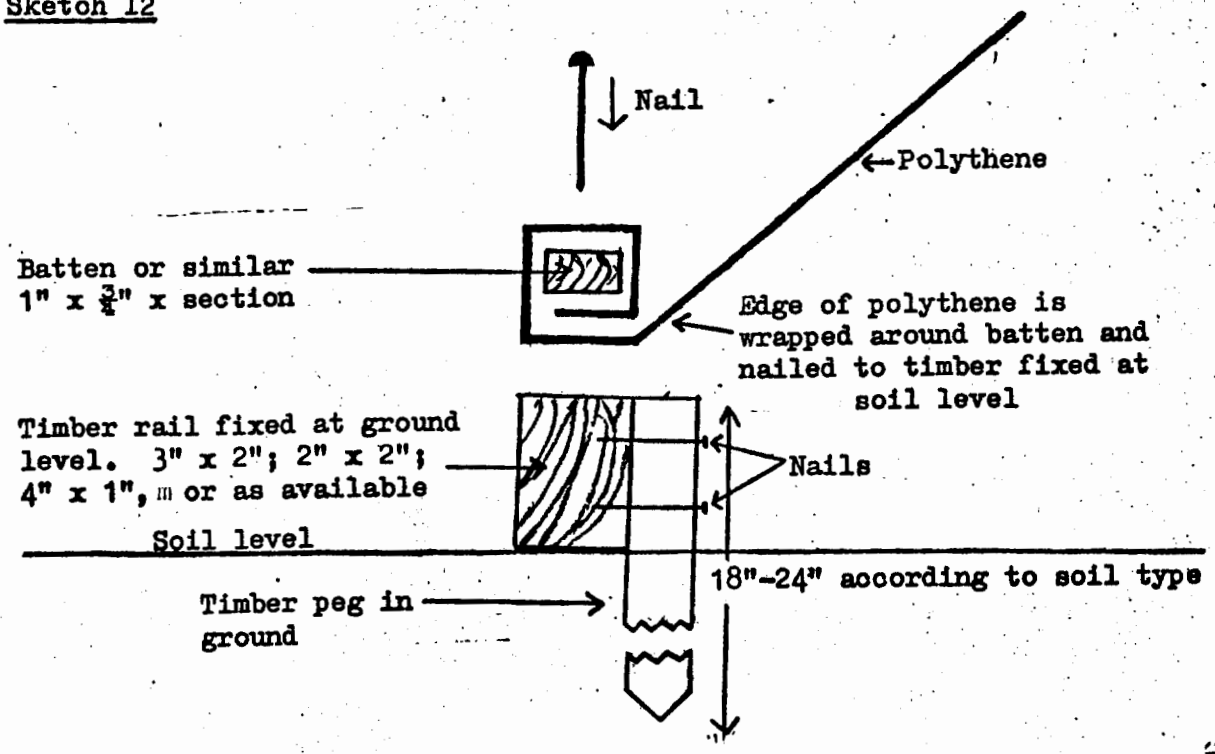


10

Fixing film at soil level (with sawn timber)

If timber is available the method illustrated in Sketch 12 is a reasonably foolproof method of fixing sheeting at ground level.

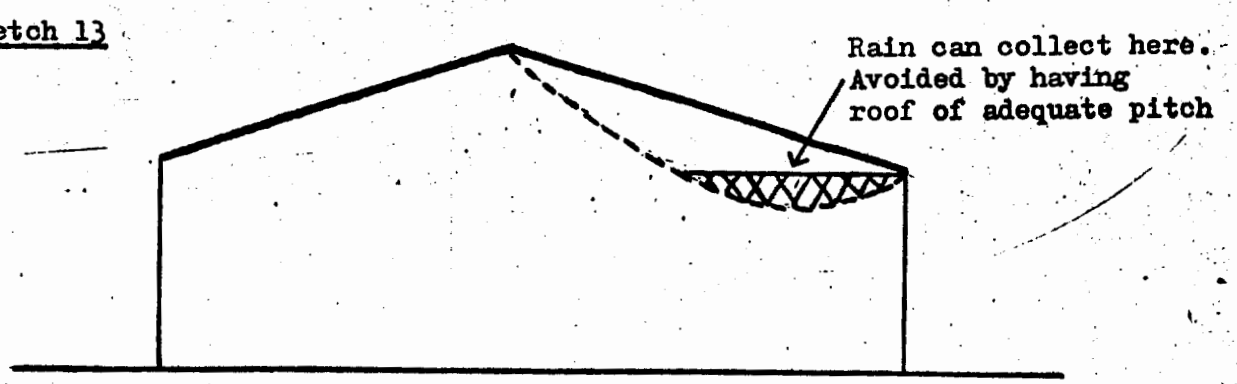
Sketch 12



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 Sketch 13) can cause unreasonable stresses on films and structure.

Sketch 13



Fire hazards to a structure covered with a single skin are minimal but the film melts at temperatures in excess of 100°C (212°F).

Fire hazards of an insulated, i.e. two layers of plastic sandwiching an insulant could be considerable depending on the materials used.

Air Housing Air inflated film is virtually unbeatable for speedy cover of large areas. Material needs are a sheet of film, a spade to bury it round the edge, a fan, generator and supply of fuel. Double airlock is required for entrance point.