PROTECTION OF PEOPLE AND PROPERTY IN MOBILE HOMES FROM NATURAL AND NUCLEAR DISASTERS

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INTRODUCTION

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Ecology is becoming more of a household word and measures are being adopted that will lead to a successful war on the misuse of our natural assets. Tremendous damage is wrought by natural disasters such as hurricanes, tornadoes, severe thunderstorms, and flooding. Any preventable loss of life or property due to any such natural disaster is a misuse of our natural assets. In order to help prevent the destruction of our natural assets, government officials at city, county, state and national levels have inaugurated practices that will minimize the effects of such disasters as well as man-made disasters.

In addition to government officials, certain industrial organizations are working hard to minimize loss of life and property due to wind, hurricane, and other types of natural and human related disaster phenomenon. Insurance companies are expending considerable efforts to improve safety. Manufacturing organizations are developing hardware of various types to help thwart the devastating effects of disasters. Some Universities are also playing a significant role in collecting, sifting, and appraising data made available as the result of storm damage. Experimental information obtained through laboratory investigations is being compiled in many universities, private and industrial complexes throughout the country. Then, too, there are certain code organizations such as the Coast Code Administration based in Gulfport, Mississippi that have held conferences. Their main goal is an attempt to get all segments of the economy who have a direct interest in minimization of losses from hurricanes and associated phenomena to openly discuss the problem. It has been recognized at such conferences that a significant gap exists between research being done and the eventual use of such research information. It is to this end that the following Case Study is oriented. It is further noted that although significant research, study of high velocity wind damage, and hurricane phenomena is being performed; this involves many different persons in many different geographical areas of the world. The need to collect this information into a single body of knowledge, to translate that knowledge into terms readily understandable to the people who must use it, is one of the basic purposes of this study.

This particular Case Study discusses in relatively simple terms a number of causes that are responsible for loss of life and property in mobile homes and mobile home parks. Also, a number of protective measures that may readily be employed to insure an effective reduction in bodily injury and property damage are suggested. Basically, these recommendations are two-fold: first, a dual purpose shelter primarily to protect life and secondly, systems primarily to minimize property damage to mobile homes and appurtenances. The dual purpose shelter is intended to provide shelter from natural disasters such as tornadoes, severe winds, hurricanes, and from radio-active fallout. Such a dual purpose shelter can give great peace of mind to members of the mobile home park community as well as serving everyday use as a community center for recreation and social activities. Many mobile home park owners are quite aware of the good will and business advantages such shelters provide. Another major portion of this case study is the presentation of two sample codes to assist in implementing the recommendations on protection of life and property.

Leading atmospheric and oceanographic scientists in our country, on the basis of their wide and deep knowledge in these areas, caution us as citizens to improve our defenses against disastrous storm types. Of course, it is a certainty that meteorology will not alone solve the problems. Architects and engineers must help solve them through constant work and better communication of suggestions. They must present useful ideas that our citizens may assimilate and put to work. For this reason, it is hoped this study may play a small part in the overall effort that must be launched on many fronts in helping to very simply state a few practical approaches to the prevention of damage due to natural and nuclear disasters. The need for code wording in the simplest of terms and the further need for contractors and building inspectors to implement these codes is imperative.

CURRENT FACTS RELATING TO MOBILE HOMES: TODAY AND TOMORROW

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The so-called mobile homes, which in reality are generally transported to a site and remain at that site on the average of ten years, is the oldest form of manufactured housing. This type of home is playing a role of increasing importance in the overall realm of public housing and public housing policy. One of the main reasons for this increasing role of importance is that mobile homes offer a third choice to people who for one reason or another prefer them to single-family dwellings or apartments. Since many are placed on sites and rarely moved, one of the chief problems is that of where to put them. Further, because they are one of the few truly low cost housing solutions of the day, due in part to their industrialized processing, they also will develop in the future to larger modular units and be placed one upon the other or next to each other to form higher density living units not too unlike our townhouse dwelling units of today. Thus, it appears the so-called mobile home will play an even greater role in the future planning of community development.

Usually a mobile home is defined as a transportable structure built on a chassis and designed to be used as a dwelling unit, with or without a permanent foundation, when connected with the required utilities. It differs from the travel trailer in that the latter is smaller, can be towed from site to site, and is operated independently of utility connections. Generally, a mobile home is about 12 feet wide, 60 feet long, and 12 feet high. There are smaller and larger sized mobile homes. There are units consisting of two or more parts that are separately towed and combined horizontally at the site. Until recently, most states prohibited units wider than 12 feet on the highways. However, now at least 14 of the states authorize 14-foot wide homes to be transported, and models of this width are being produced at a faster rate. Most mobile homes of today are too large to be towed by an automobile, and the National Mobile Homes Association recommends a professional moving company be employed for their transportation.

As the size and other amenities of mobile homes increase, the "mobility" feature is increasingly de-emphasized. More correctly, they could be called "manufactured homes". Mobile home manufacturers are increasingly producing mobile modules which can be used to make garden apartments, town houses, or even high-rise apartments. A recent study made by the Electric Heating Association reports a study of 33 mobile home manufacturers and found that 90 percent of them produce modular units.

Old and young, large and small households, high as well as low income individuals and families occupy mobile homes. A close similarity of characteristics between new apartment dwellers and purchasers of mobile homes has been found. This supports the contention that mobile homes compete more strenuously with apartments than with the conventional single-family houses. The increase in mobile home size, comfort and quality has witnessed an increase in the number of people aged 20-34 and 55-74 who find the mobile home appropriate for their lifestyles and incomes. Depending on the number of units and equipment, a mobile home can cost anywhere between $4,000 and about $35,000. The federal government now recognizes mobile homes as housing. HUD's Title 1 mobile home loan insurance went into effect in 1970. Since late 1970, the Veterans Administration has guaranteed loans for mobile homes and owners' lots. Also, federal savings and loan associations are now authorized to lend on mobile homes.

At present there are some five to six million people, out of a total population of slightly more than 200 million, living in mobile homes within our United States. It has been estimated that at least two out of every five families who buy a new home in the year 1971 without federal help will purchase a mobile home. During the year 1970, sales of mobile homes were about 402,000 units. It has been anticipated that close to 450,000 mobile units will be sold in 1971. Further, it has been estimated that roughly 75 percent of all American families would like to own their own homes, while only half can afford to. At any rate, some economists foresee a steady rise in mobile home production over the next few years to the 500,000 and 600,000 range per year.

One of the biggest deterrents in expanded mobile home use appears on the local city and county levels where established zoning laws are often very restrictive. Large companies are beginning to invest in mobile home parks, and the future appears such that current zoning restrictions may break down somewhat as mobile home park developers show that such parks need not be eyesores; but in fact, can be community assets. Dade County, Florida, has a newly adopted mobile home ordinance setting a minimum of 30 acres for any mobile home development, with no more than 7.5 homes allowed per acre. Thus, many of the parks are beginning to take on all of the features of a well-planned housing development of the so-called conventional type complete with landscaping, recreational facilities, shopping areas, community centers, clubhouses, and other attractions. The mobile home park is here to stay.

Now all of this sounds quite promising to various segments of our industrial complex, but at the same time, this presents an ever-increasing problem of safety to inhabitants within these increasingly heavily concentrated mobile home park areas, as well as to the local government officials. Some of our leading atmospheric and oceanographic scientists are becoming increasingly concerned about the buildup of high concentrations of people in mobile homes; not only along the coastal shores of our country, but also in the states subject to higher incidence of high intensity winds. The increasing concentration of mobile homes will not increase the probability of the occurrence of a disaster, but will almost certainly result in much greater loss of life and damage if a disaster strikes an unprotected mobile home park. This is most important in view of the fact that about fifty percent of the mobile homes today are going into parks and subdivisions close to urban areas. The remaining fifty percent go either in a rural area or on a site not occupied by other mobile homes.

One of the nation's chief forecaster of tornadoes states that mobile homes are "sitting ducks" for one of the 700 reported tornadoes, hurricanes, or other high velocity windstorms per year unless their owners take precautions. Almost any time a severe windstorm strikes a mobile home park, or other light residential areas where preparations have been inadequate, there is a scene of utter devastation.

SEVERE STORMS

SEVERE STORMS

Like most human progress, we have learned from past experience with natural disasters such as Hurricane Camille, Hurricane Celia, various tornadoes, and many other storms of similar intensity. We have learned conclusively that a great number of mobile homes have either been completely destroyed or overturned and rendered almost useless. Among the recurring phenomena unveiled with each ensuing storm has been the general tendency for mobile homes to roll over and over on their sides and/or roof. In some instances they have slid off their concrete block supports because these supports have not acted in unison with the superstructure of the mobile home. In other situations, the mobile homes have been blown off their under-frame carriages entirely. This generally happens when the frame has been tied to ground anchors, but the upper portion of the mobile home has not been secured by tie-downs. Another common cause of considerable damage has been one mobile home rolling or being blown into an adjacent mobile home. Sometimes component parts such as shutters will be blown off and take with them a portion of the mobile home metal "skin". This, then, has allowed the wind to get under the remaining parts of the "skin" and eventually blow off the roof and ruin the interior furnishings and fixtures. Further observation shows that components used either on or around the mobile home such as shutters, sign posts, cabanas, storage units, carports, and similar units, if not tied down, usually become flying bits of shrapnel.

Fortunately, various men and groups are beginning to piece together certain facts gathered from storm experiences such as mentioned above. To this information, they are adding other facts gained from research with winds, tests of soils, and development of hardware in order to add protective facets to mobile homes. Also, by improved land use techniques, mobile home parks can be better planned by taking advantage of natural barriers. Orientation of mobile homes on mobile home park sites in a way that the home will present its narrowest side to the probable direction of storm emergence will minimize damage. Further technical studies of wind profiles are lending to increased understanding of the parameters within which man can operate in order to better protect himself and his belongings in mobile homes.

From most of the aforementioned phenomena there has emerged a strong recommendation to use tie-downs. A tie-down is merely a means of securing a strong cable, strap of metal, or other suitable tensile resisting material to an anchor system in the ground. These cables, etc., are run up one side, across the top, and down the opposite side of the mobile home where they are secured on both sides of the home to earth anchors. A series of these units will secure the mobile home in such a manner that severe winds cannot move them far enough to cause structural damage. The entire unit can then act as a whole in resisting the external forces created by the severe winds. The successful and far reaching benefit of tie-downs is increased in terms of minimizing life and property damage. Let it suffice to say there is little question that we need a tie-down anchoring provision in all codes that relate to mobile homes throughout the United States.

Some facts on tornadoes are necessary to understand their effects on mobile homes. Estimates indicate that, out of the more than 700 tornadoes reportedly occurring each year in this country, less than 100 are severe juggernauts, i.e., with winds of 200 miles per hour or more. Tornadoes usually approach from the southwest, with nearly two-thirds of all tornadoes approaching from that direction. Seven-eighths of all tornadoes approach from some westerly direction, namely either from southwest, west or northwest. The direction of approach has great implications for the protection of mobile homes by proper orientation of the homes with respect to the most probable wind direction. However, tornadoes have been known to approach from any direction, stop, change directions, and move in crescent shaped paths. Tornadoes may be stationary or travel with speeds of up to 60 miles per hour while the width of the path of the funnel may vary from about nine feet to over a mile. The length of the path of a tornado may vary from a few feet to nearly 300 miles. In addition to these severe storms, a number of lesser windstorms such as thunderstorms are even more numerous. Experience has shown that a wind of less than 60 miles per hour can topple an unanchored mobile home.

The chart shown in Figure 1 shows the number of tornadoes reported in the United States from the year 1921 thru 1965 in terms of 5 year periods. It further shows the fatalities due to tornado action. Even though the 5 year period from 1961 through 1965 indicated the smallest number of fatalities due to tornadoes, it does show the grim fact that 100 persons a year on the average lose their lives by such phenomena. Additional statistical data from a paper by S. J. Ying and C. C. Chang (1970)* on tornadoes is given in Table 1.

Hurricanes are another serious threat to mobile homes. The U.S. Weather Bureau defines a hurricane to be a tropical storm with winds of more than 74 miles per hour. Hurricanes always approach the United States from over water and strike almost anywhere on the Gulf or Atlantic coasts. Hurricane winds have been measured in excess of 190 miles per hour. In the area of hurricane damage, we find that meteorologic control of the energy or path of such storms is still many years beyond present technology, although several agencies and organizations are actively engaged in research in this area. In spite of reductions in fatalities due to improved warning and evacuation procedures, hurricane produced property damage has been spiraling upward with each succeeding decade, as shown in Figure 2. During the 1960's, such damage averaged in excess of one-half billion dollars. It is readily apparent that with continued development of the coastal areas, utilizing current building policies and procedures, the nation may soon be facing annual losses in excess of one billion dollars. Figure 3 shows the loss in terms of deaths recorded as the result of hurricanes on the basis of 5 year totals from 1900 through 1970. Figure 4 indicates the incidence of tropical storms and hurricane winds that have been recorded along our coastal areas from Texas to Maine. Not much of the coastal region been depicted seems free from such storms and the incidence of such storms appears to be anything but low. Action is immediately required in the use of tie-downs for mobile homes to protect lives and property. A model code developed and implemented, combined with urban planning and administration, fostered by education of builders and the public is a necessity in order to accomplish results.

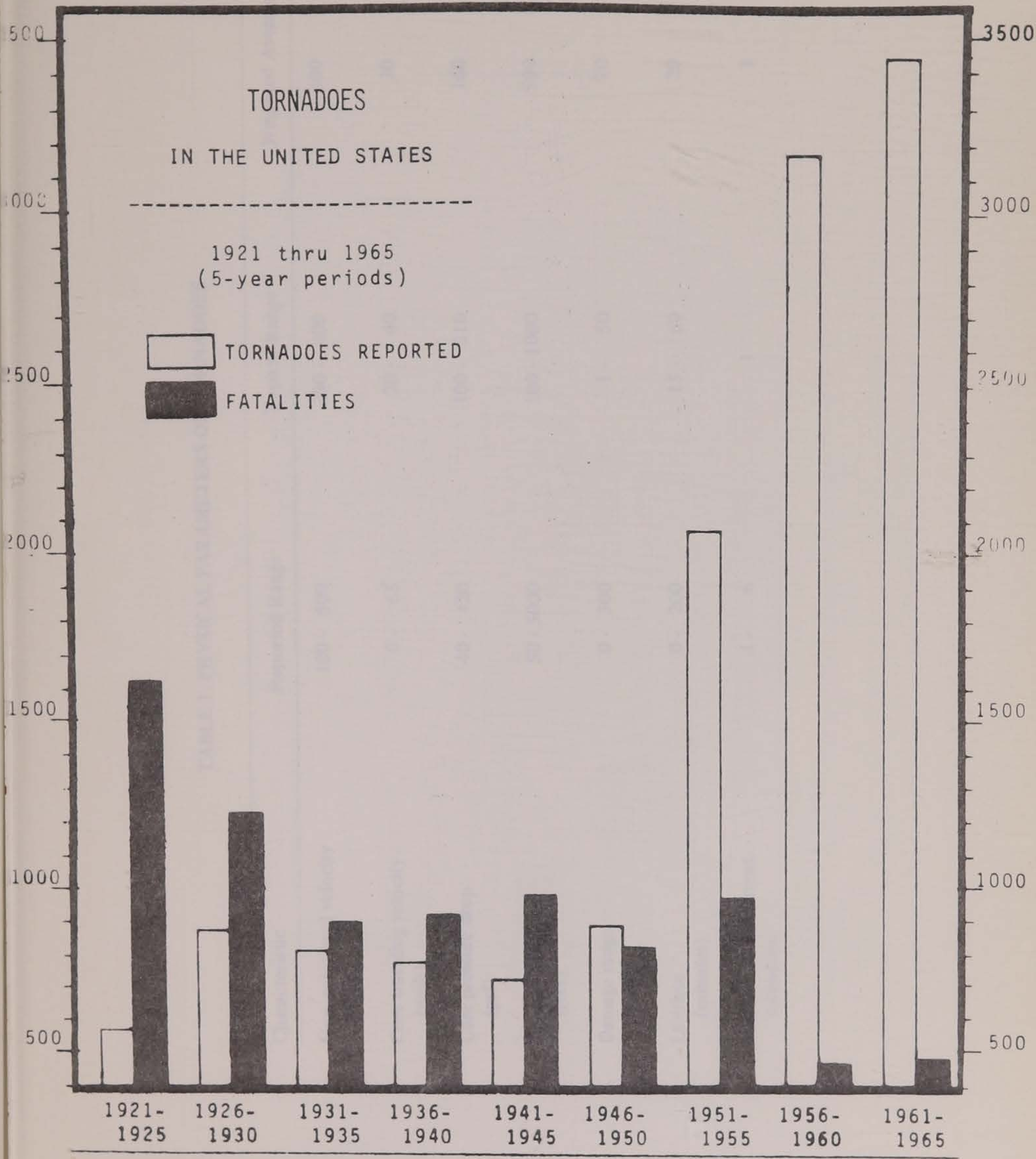
The U.S. Weather Bureau has made extensive statistical studies of wind speeds for many years. Mr. H. C. S. Thom, Chief Climatologist of that organization has compiled a map, Figure 5, which shows contours representing velocities of winds, in miles per hour, at a point measured 30 feet above the ground, and based on a recurrence period of those wind velocities at a time interval of 50 years. This map shows wind velocities of 100 to more than 120 miles per hour for the coastal area subject to hurricanes. More than half of the country has maximum winds of greater than 80 miles per hour and only very few areas have maximum winds of less than 67 miles per hour. It should be remembered that

* References in bibliography by author and date.

winds of 60 miles per hour or less can topple a mobile home. On rare occasions winds can exceed those indicated in Figure 5. Hurricane winds of 190 miles per hour have been measured, while tornado winds in excess of 600 miles per hour have been estimated.

On the basis of these accurate studies, we can see that the 125 mile per hour basis for wind magnitude as it relates to mobile home units should cover the multitude of cases. In addition, Mr. Thom's maps have been adjusted for the shielding of other structures, topography, and similar conditions that have surrounded the placing of his recording instruments. At a larger scale, Figure 5 shows contours representing velocities of winds, at 30 feet above ground, and based on a recurrence period of those velocities at a time interval of 50 years.

Most theories concerning velocities of wind near the ground surface appear to give results that seem too low and, of course, there is room for much disagreement on such criteria. Thus the 30 foot height gives a conservative assumption. Some men have been making studies of so-called wind profiles which tend to clarify wind characteristics in their natural state. Dr. A. G. Davenport from the University of Western Ontario is one of these men. Dr. A. G. Davenport has derived several mathematical expressions which describe the profile of wind as it approaches a building. Dr. Davenport proposed the profile depends upon ground friction and has therefore classified ground friction into three different classes. The first condition is for relatively flat open country such as prairies. This is a condition containing the least amount of friction and is associated with wind coming across a flat field or across a rather smooth surface of water. The second condition is sometimes called a suburban profile and relates to slightly more frictional resistance. It is a profile one would use over rolling land or over low buildings with trees such as one might find in suburban areas. This could include wooded areas where mobile home parks might well be located. The third profile categorized by Dr. Davenport is called the city profile where ground friction is considerably greater because of wind going around and over very tall buildings. One can visualize how terribly complex and variable such studies can be. It also serves to show that more accurate definition of wind behavior is constantly being developed by experts in the field.



TORNADOES
IN THE UNITED STATES
1921 thru 1965
(5-year periods)
TORNADOES REPORTED
FATALITIES
500
1000
1500
2000
2500
3000
3500
1921-1925
1926-1930
1931-1935
1936-1940
1941-1945
1946-1950
1951-1955
1956-1960
1961-1965

Figure 1

TABLE 1. PHYSICAL PARAMETERS OF TORNADOES

Characteristic	Reported Range	Typical Range	Weighted Average
Max. rotational velocity (mph)	100 - 500	200 - 400	300
Core traveling velocity (mph)	0 - 65	20 - 40	30
Core pressure drop (psf)	40 - 420	100 - 210	160
Damage width (feet)	50 - 5000	100 - 1000	500
Damage range (miles)	0 - 300	1 - 50	10
Lifetime (minutes)	0 - 200	15 - 60	20
Number of concurrent tornadoes	1 - 6	1	1

Damage Due
To Hurricanes
In The United States

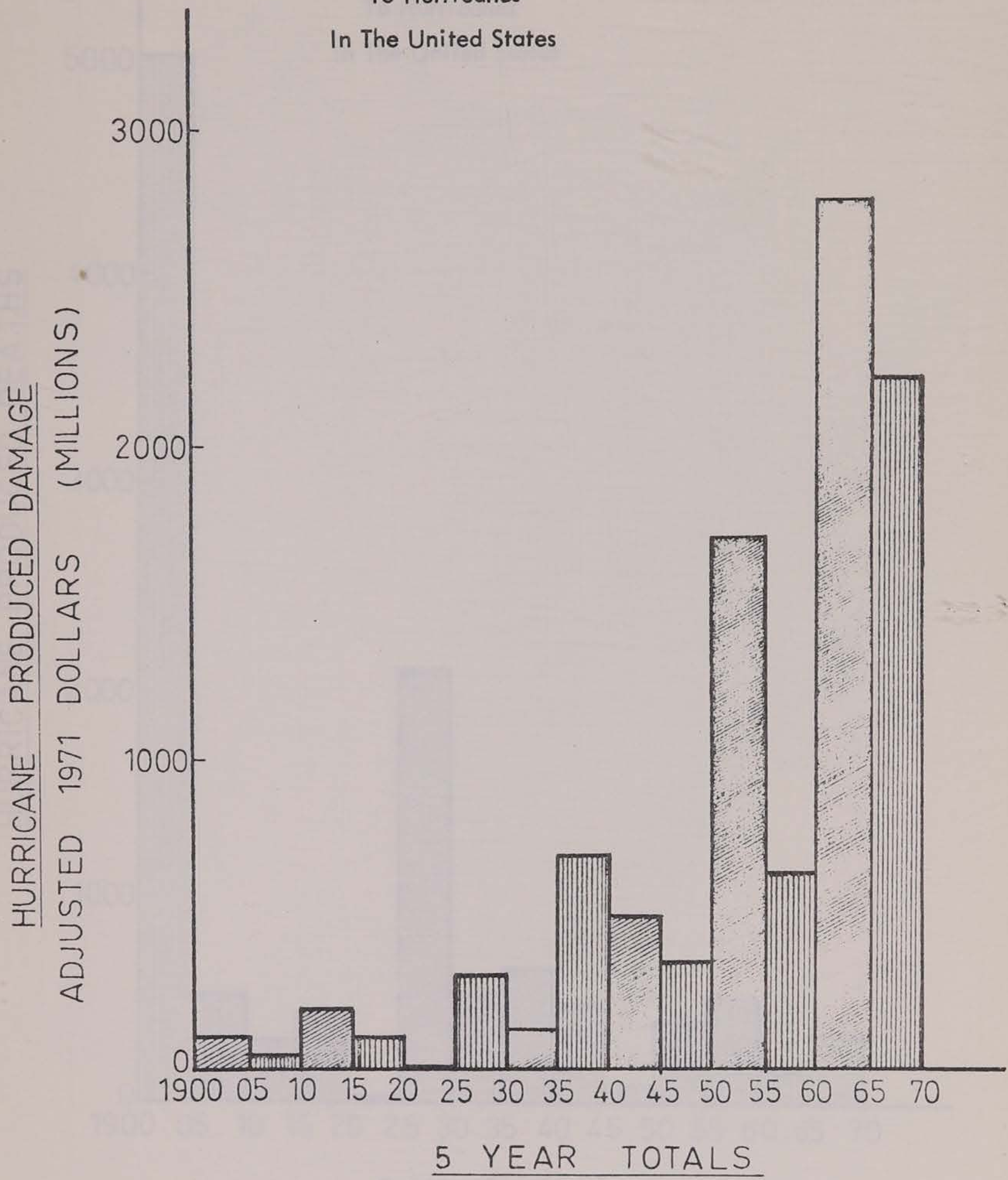


Figure 2

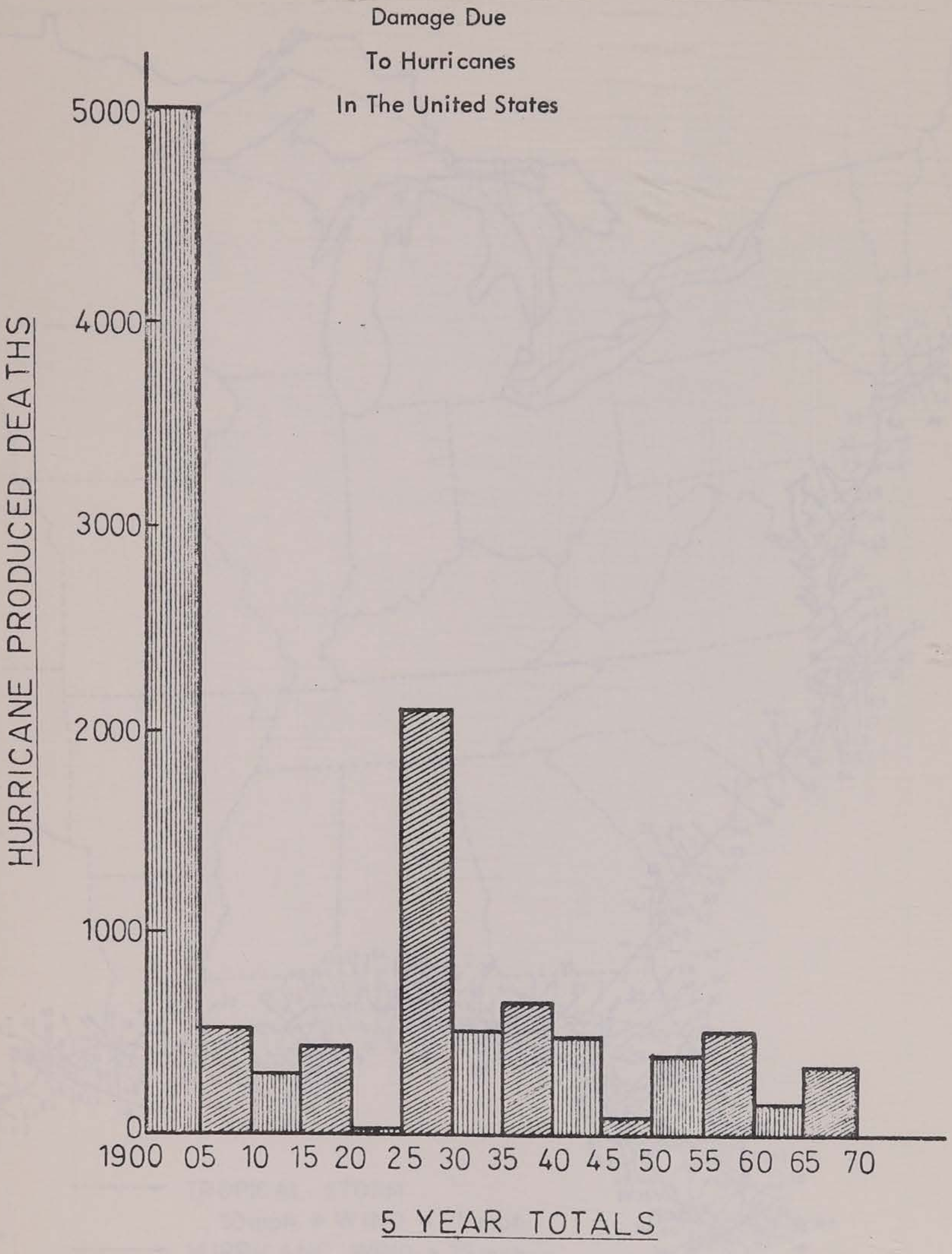

Damage Due
To Hurricanes
In The United States
HURRICANE PRODUCED DEATHS
5000
4000
3000
2000
1000
0
1900
05
10
15
20
25
30
35
40
45
50
55
60
65
70
5 YEAR TOTALS

Figure 3

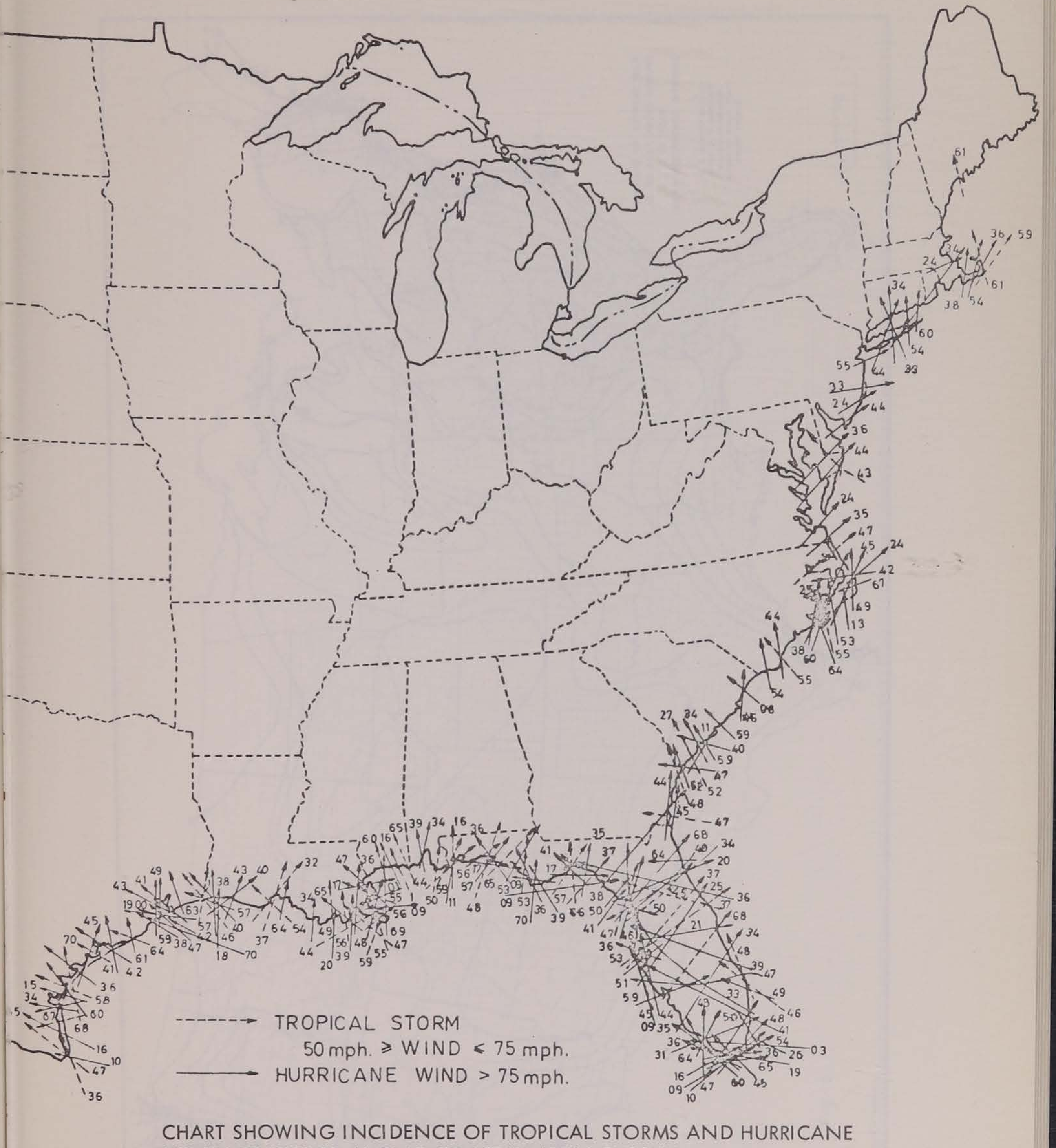


CHART SHOWING INCIDENCE OF TROPICAL STORMS AND HURRICANE WINDS RECORDED ALONG COASTAL AREAS SHOWN.

Figure 4

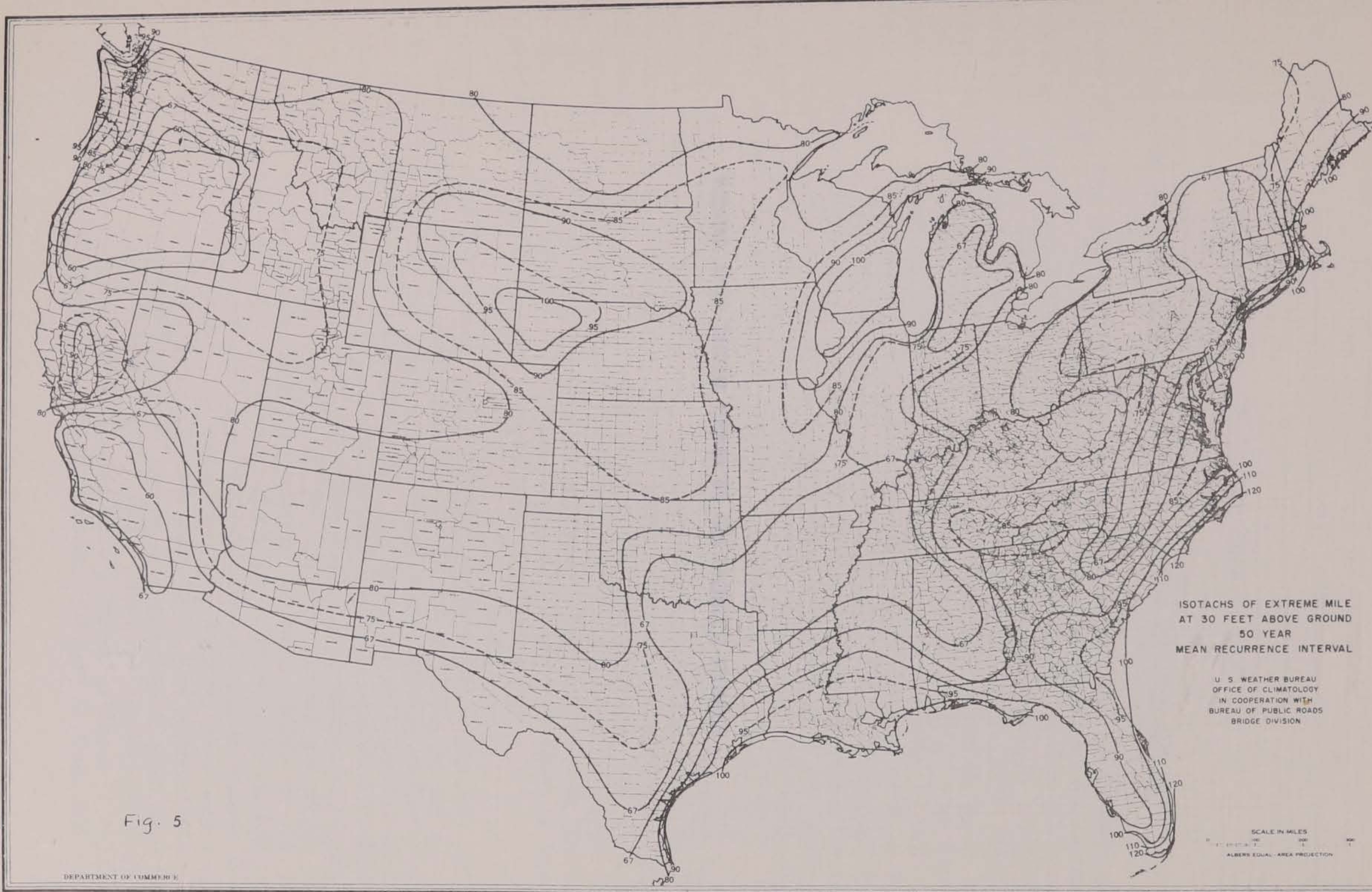

ISOTACHS OF EXTREME MILE
AT 30 FEET ABOVE GROUND
50 YEAR
MEAN RECURRENCE INTERVAL
U. S. WEATHER BUREAU
OFFICE OF CLIMATOLOGY
IN COOPERATION WITH
BUREAU OF PUBLIC ROADS
BRIDGE DIVISION
SCALE IN MILES
ALBERS EQUAL - AREA PROJECTION
DEPARTMENT OF COMMERCE

Fig. 5

WINDS AND THEIR EFFECTS ON MOBILE HOMES

WINDS AND THEIR EFFECTS ON MOBILE HOMES

The mobile home reacts in a special manner when subjected to winds of high intensity because:

(1) It has a unique shape not normally seen in other structures.
(2) It is generally long and narrow.
(3) It is much lighter in weight than conventional homes.
(4) It generally has open space between the ground and the floor framing.

Under the proper anchoring conditions it has been assumed that most mobile homes could resist winds in the 100 to 125 miles per hour category without necessarily disintegrating. Winds of greater magnitude would be in the category of tornado types and consequently, impose considerable damage to the home. Most research on mobile home performance under wind loads has been performed in wind tunnel tests. From past experience and research, equivalent wind pressures normal to the surface of mobile homes will fall somewhere between 20 and 35 pounds per square foot of surface area. Structural engineers have long been placing equivalent wind forces on such structures. If one were to compare the winds of 125 miles per hour with tornado winds estimated at from 400 to 500 miles per hour, we find pressures in the order of 650 pounds per square foot are impinging upon the surface area of mobile homes. This should clearly show why we cannot begin to protect mobile homes, or many other types of homes, from the winds of a tornado funnel. However, we can do much to minimize damage from high winds, such as those from the periphery of a tornado, hurricane or thunderstorm.

Of primary concern is the magnitude of winds that can normally be expected to surge against mobile homes, in a general sense, at geographical locations throughout the United States. Although it is impossible to ascertain exactly what wind velocities may crop up, history shows that winds from 0 to 125 miles an hour will cover the most severe types that normally accompany storms, the funnels of tornadoes excluded. Of course, a few winds may be more severe, but they are the exception rather than the rule. There have been reports of mobile homes being overturned by winds as low as 30 miles an hour and quite generally by winds of about 65 miles an hour.

From most surveys of damage caused by violent windstorms, it has been generally shown that structural failures result from the inability of the home to act as a unit. Basically, buildings securely tied together from ground anchor through roof structure are capable of withstanding considerable punishment. This applies to most conventional homes also where anchors between foundation walls and roof joists or trusses tend to hold roof intact and all members between those two points tend to act together as a unit. The anchor system for mobile homes must go up the wall, over the top and anchor on the opposite side to another ground anchor in order to get unified action. In any violent storm, home structures are subject to extreme lateral forces. These forces are best resisted by unified diaphraghm action of roof, wall, and floor systems acting in concert. Perhaps, an excellent example of a structure not acting in concert between floor, wall, and roof system is a concrete block type building that is unreinforced. The individual blocks with no means of being fastened together fail to perform as a unit. Actual results from damage created by Hurricane Camille showed most mobile homes in unprotected areas were overturned and appeared to be nearly complete losses as shown in Figure 6. Needless to say, no anchoring at all allows for effects as shown in Figure 6. Noticeable in these instances was the absence of rigid attachments between the mobile homes and the ground. Most were resting unanchored on concrete block piers. Where mobile home units were well screened by trees and shrubs, the damage was not extensive. Figure 7 and 8. The anchoring of the bottom frame to the ground secures the frame, but does not necessarily protect the superstructure as shown in Figure 9. The necessity for secure anchorage of concrete block piers to mobile home is demonstrated in actual photo taken after Hurricane Camille, Figure 10. It might be mentioned here that the winds associated with Hurricane Camille were estimated at from 150 to 190 miles per hour. This was one of the most severe storms ever to hit the shores of the United States. Yet some of the mobile homes in protected areas where they were tied down came through with minimum damage. Severe damage due to Camille covered a 40-mile front and a depth inland of 80 miles, which gives some idea of the considerable areas covered by this storm. The promising aspect of all this is that houses and other structures can be made to resist such forces with minimal damage.

The newest of mobile home parks in Gulfport, Mississippi consisted of about 160 mobile homes. At the height of this storm, mobile homes were blowing down the street, rolling into each other, completely breaking apart. This gives a general idea of the scene. Most were newer units, not older than 1968 models. None of these were tied down because there was no requirement to do so. The Foremost Insurance Company insured 90 of these mobile homes which were all total losses. In contrast, some of the older mobile home parks experienced only about 50% damage. It is believed this was due primarily to natural barriers such as trees and shrubbery which protected the units from wind damage. THE FEW MOBILE HOMES THAT WERE TIED DOWN DID NOT MOVE DURING THE STORM. Consequently, they received little damage. Some of the units where tie-downs were attached only to the sub-frame did not hold and were destroyed. Such improper tie-downs allowed units to blow off their frames. The frames held, but the top portions did not. Figure 9. In other words, the floors, walls, and roofs were not acting as a unit. It has been reported that about 67 percent of mobile home owners in the Gulfport area planned some preventive measures to safeguard their homes against future storms as the result of Hurricane Camille.

The first effect of a tornado to be felt is the tangential or peripheral winds. If the building withstands this, then the pressure is suddenly reduced. The pressure near a tornado is much lower than the ambient pressure in the dwelling. Even a pressure differential of 1 pound per square inch atmospheric means 144 pounds per square foot. On an entire mobile home wall of 60 feet by 10 feet, we would have a total pressure difference of 600 x 144 = 86,400 pounds normal to the surface. This explosive type of force from inside to outside due to the tornadoes' vacuum would stress the mobile home considerably. This would occur during a short span of time. Obviously, in addition to proper anchorage, there is a need to vent buildings during the presence of tornadoes. In a general sense, about 1 square foot of window or door venting for each 10 square feet of floor area will greatly relieve the pressures on the walls of the mobile home.

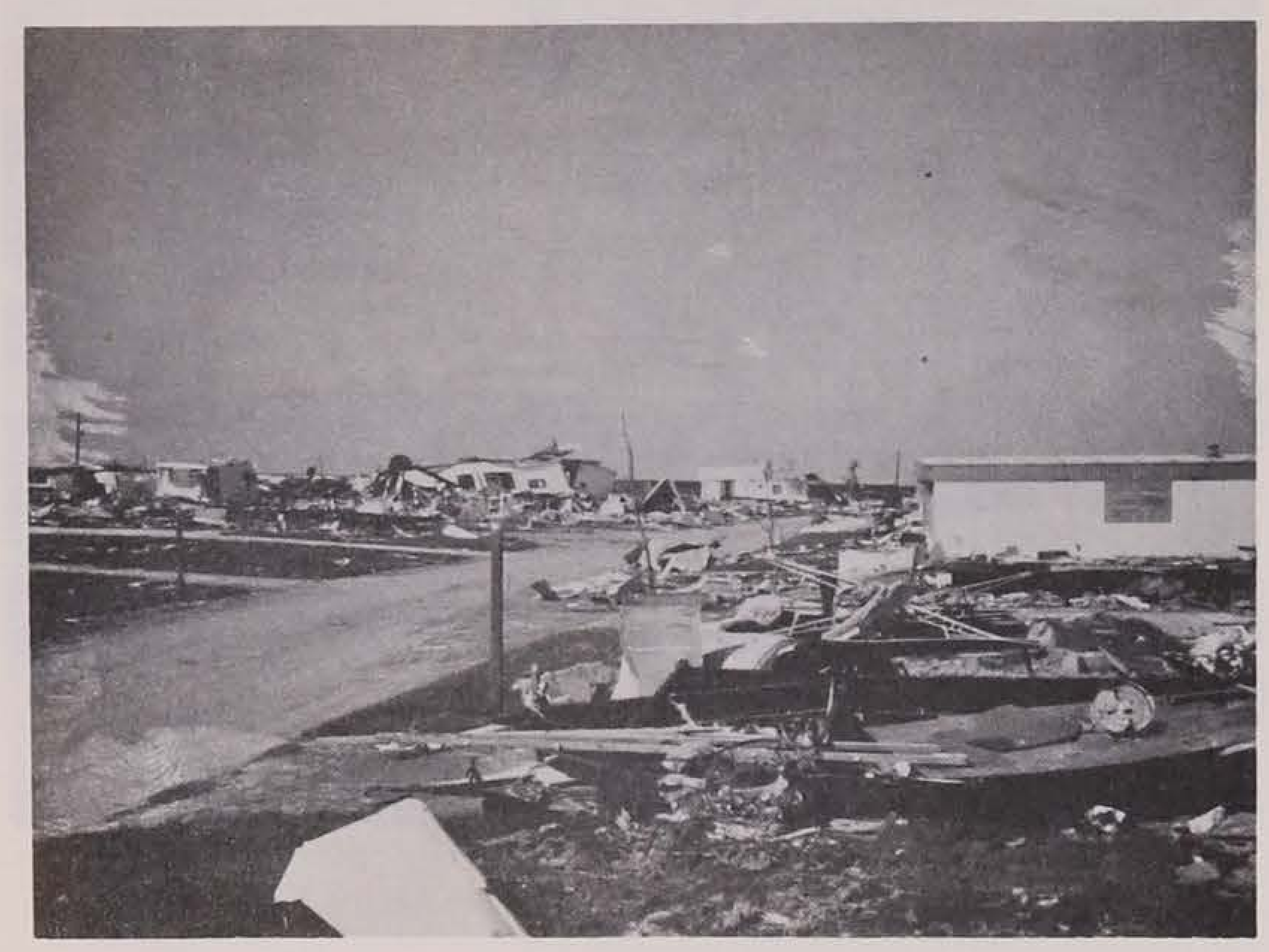


Figure 6 Scene after Hurricane Camille showing effects of storm on mobile homes in unprotected areas.

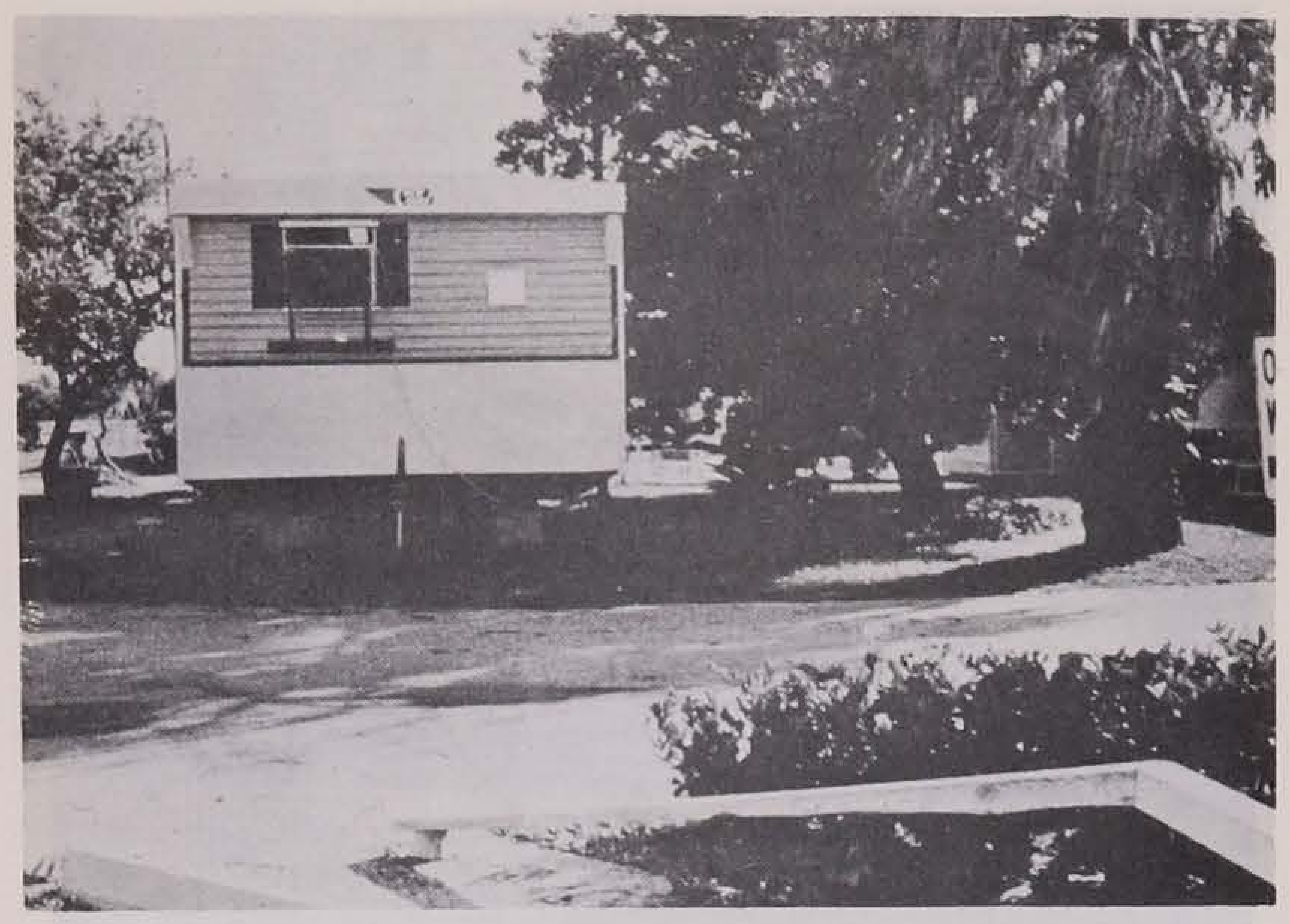


Figure 7. Mobile home intact after Hurricane Camille as direct result of being shielded by trees and adjacent planting.

Figure 8. Mobile homes shown intact after Hurricane Camille. Notice tree to right is stripped of leaves and trees to left are leaning considerably due to hurricane force winds. Proof that trees can and do shield mobile homes adequately.

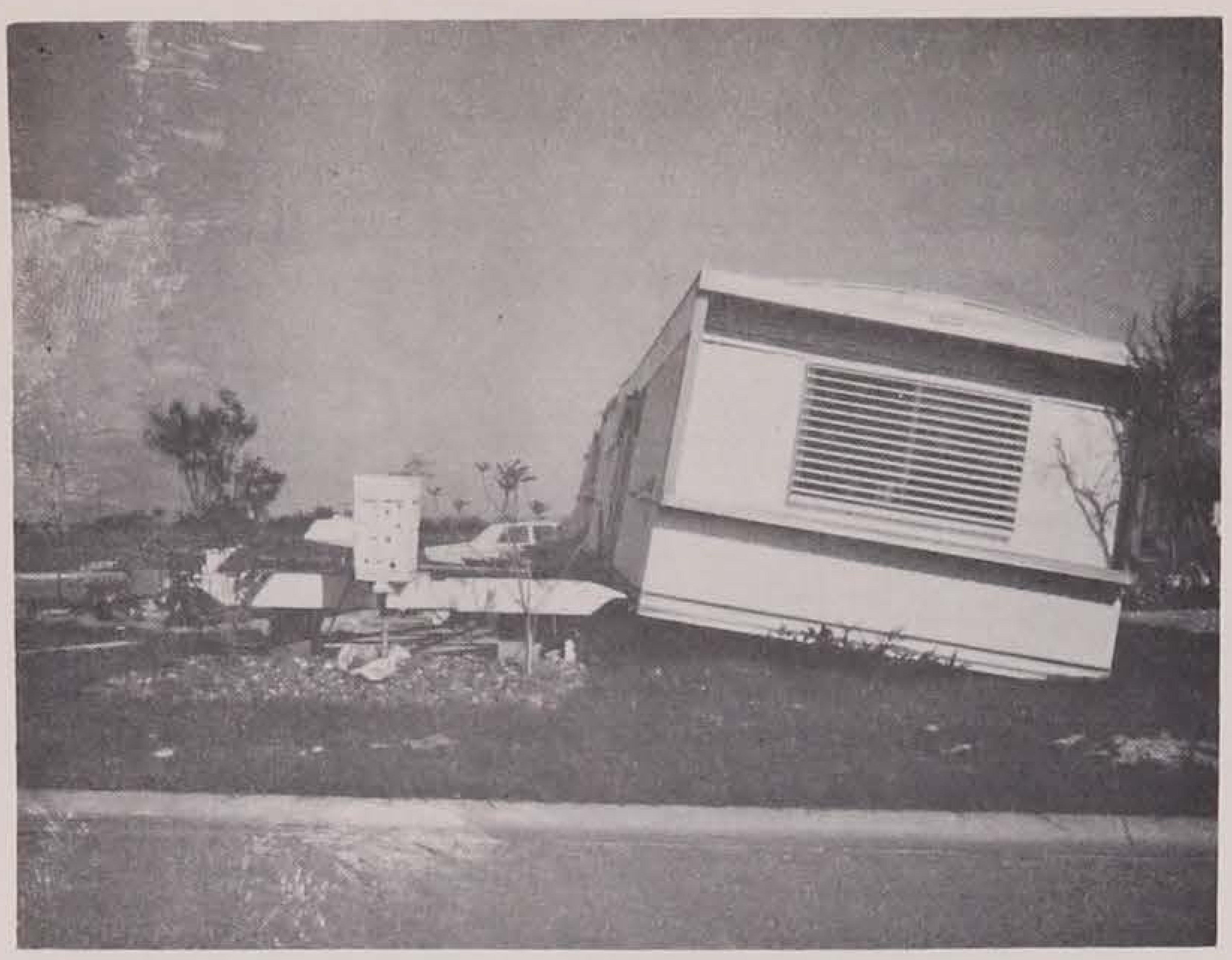


Figure 9. Although lower frame of mobile home was anchored, winds from Hurricane Camille blew upper superstructure of home off of frame. Entire home must be tied down to be effective.

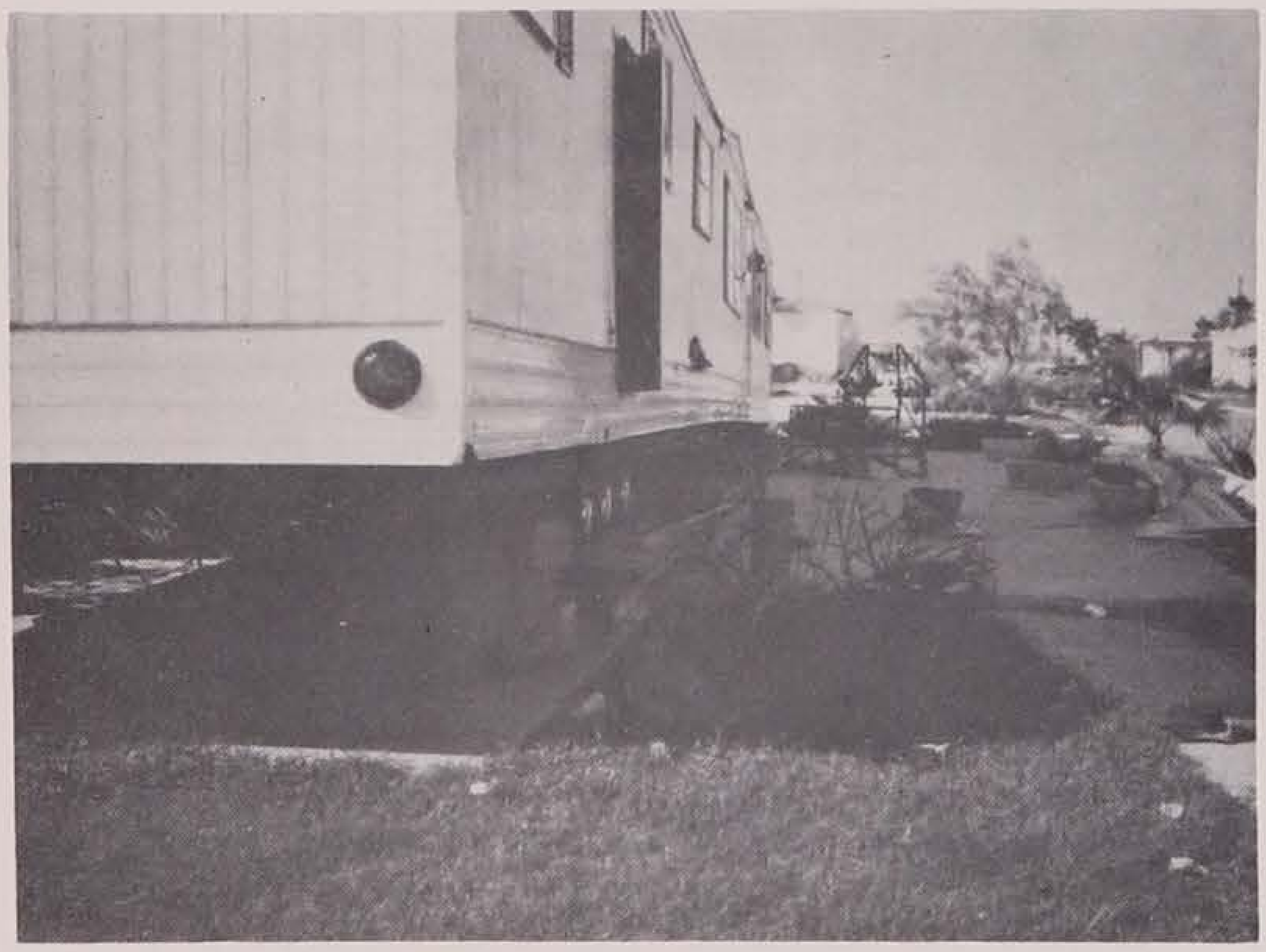


Figure 10. Even with secure anchor system to hold concrete pier supports down, the wind forces of Hurricane Camille moved the concrete block supports around with considerable ease. This type of support must be extremely secure.

ORIENTATION AND LANDSCAPING
OF
MOBILE HOME COURTS

ORIENTATION AND LANDSCAPING OF MOBILE HOME COURTS

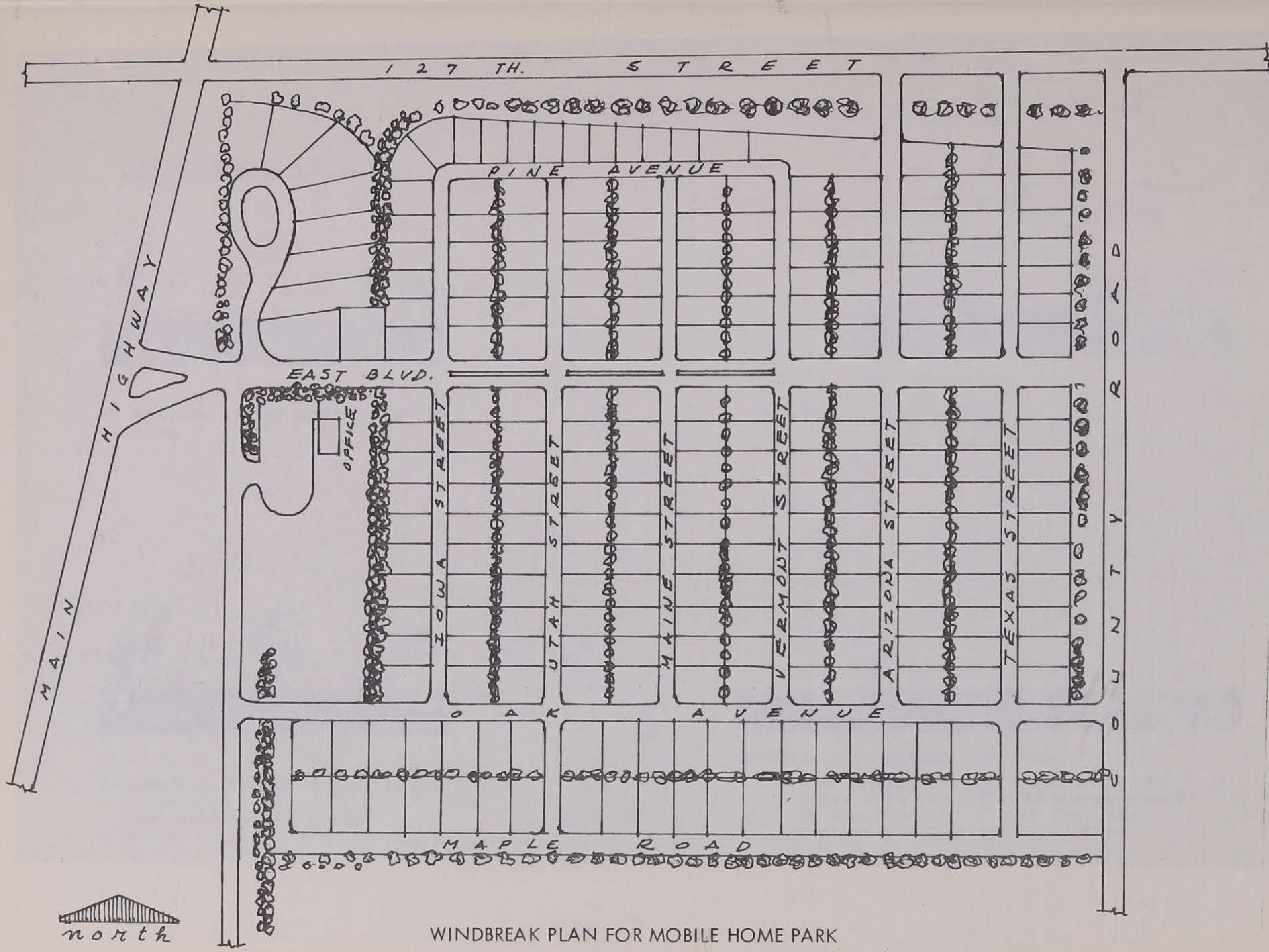
Although many mobile home courts are well conceived and planned, tremendous numbers of them just seem to "grow like topsy". They develop in size without any well defined set of established planning criteria. They especially lack planning criteria which could make them safer against the effects of high velocity winds. For example, it is not generally known that a few insurance companies give reductions of about 10% in premium payments if the mobile home court has well planned street layouts, provision for offstreet parking, minimum lawn areas, and regulated property line setbacks. Some insurance companies even require that supporting piers of mobile homes be set on concrete slabs or well tamped crushed rock extending under the entire mobile home. The main purpose of these and other features is to minimize uneven pier settling due to applied pressures from severe winds, prevent easy toppling of the homes, and make them weather resistant. A proper consideration of these facts and others can go a long way in creating safer conditions surrounding mobile home court occupants.

One of the most effective means of reducing wind velocities and preventing snow from drifting on areas around mobile homes in mobile home parks is to design windbreaks. These windbreaks also beautify the mobile home court. They will reduce weathering of the mobile homes, reduce building maintenance costs, and even cut fuel bills for the heating of mobile homes. They further provide means of shelter for songbirds, and other wildlife during the winter months in many of the more frigid areas. When considering a windbreak, it is important to keep in mind that it will be a permanent part of the mobile home court landscape. The only requisite is that of giving a little careful thought and planning preceding the actual planting of trees and shrubs.

In much of our country, the land is relatively level to gently rolling terrain with few trees to block the prevailing winter winds. Since many of these winds come from the west, or at least a westerly direction, a windbreak should be located on the west sides of the mobile home court. A few trees planted on the north side will also be effective in breaking the force of winds. Figure 11 shows a suggested plan for windbreak protection of the mobile home court. Figure 12 shows, in a diagrammatic way, how windbreaks and low profile can reduce effect of winds on the mobile home.

Slope and drainage of land, as well as the arrangement of buildings (mobile homes), must be considered when planning a workable windbreak. Planting the barrier too close to the mobile home clusters can promote air stagnation in the summer months. It can also create unwanted snow drifts in the winter months. Conversely, planting trees and shrubs too far away tends to provide too little protection. What is the proper distance to plant these barriers of wind? A general rule of thumb is to locate the windbreak at least 100 to 150 feet from the area to be protected. Trees planted more than 300 to 350 feet from the area to be protected actually provide very little protection.

Naturally, there are situations and circumstances when these parameters might not work in an effective manner. For example, should the land slope steeply away from the mobile home court, (i.e., should the mobile home court be located on a rather steeply inclined hill sloping to the west or north), it may be necessary to plant the barrier of trees and shrubs closer than 100 feet from the mobile homes to be protected. There is no

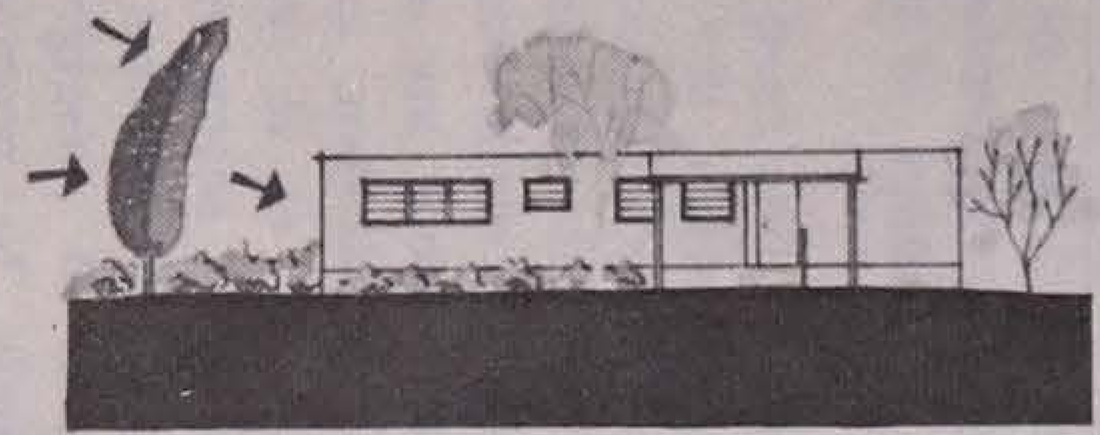


WINDBREAK PLAN FOR MOBILE HOME PARK

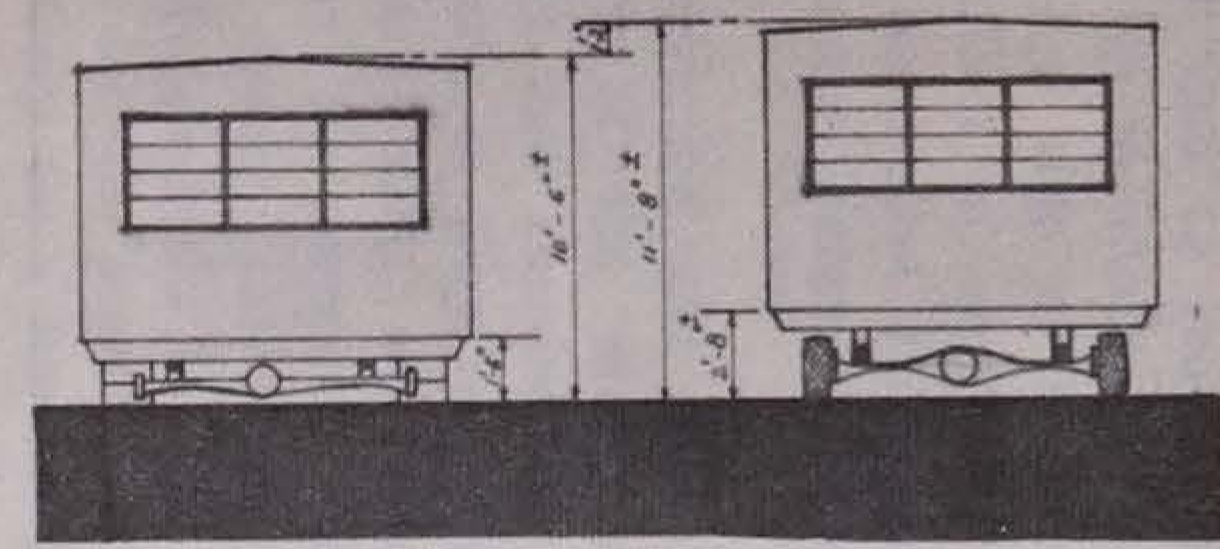
1" - 200'

Figure 11

WINDBREAKS

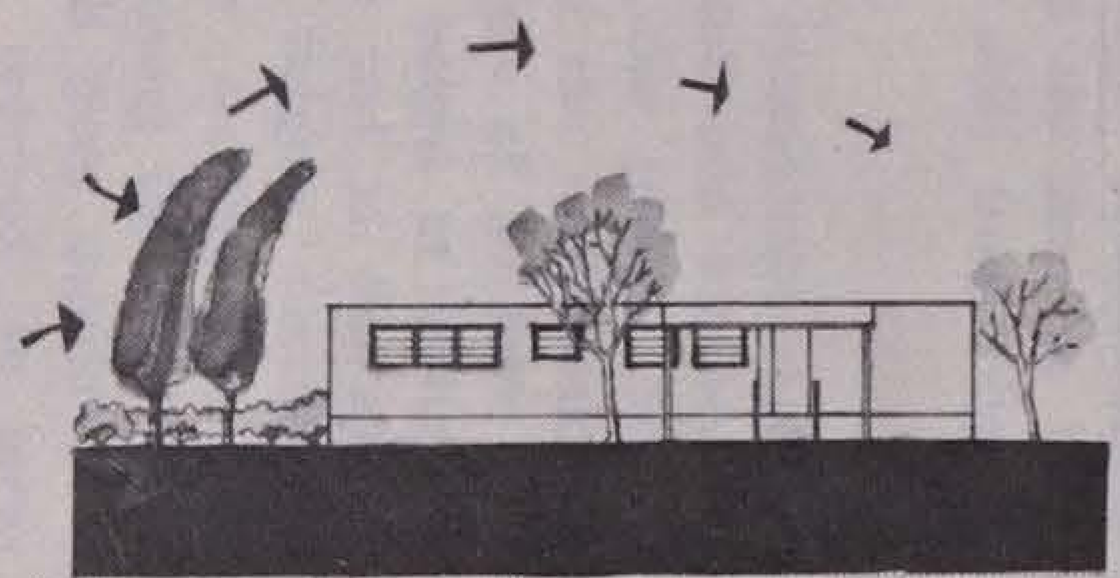


one row of trees protect a mobile home

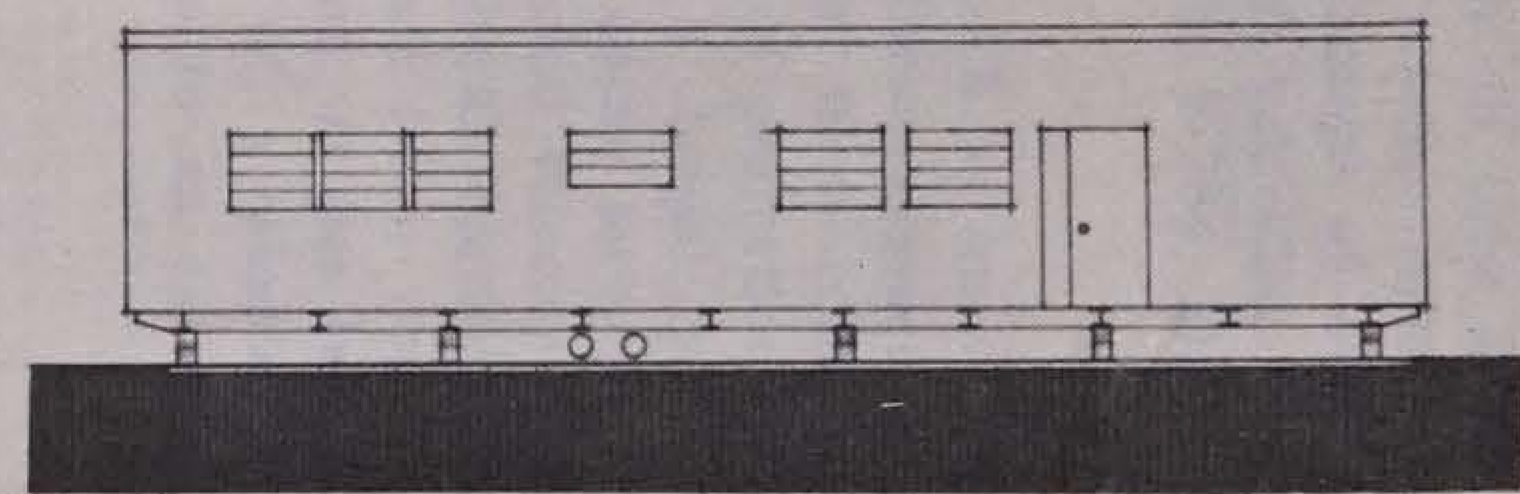


LOW PROFILE

remove wheels
set frame low on piers
skirts that allow some air passage



double row of planting deflects more wind
low plantings help also.
secure carports, awnings, loose components



SOUND BLOCKING SUPPORTS

Pier footing = 16"x16"x4" min. concrete
Piers to be 8"x8"x16" solid concrete blocks
10' max. spacing ; 5' max from end
2 piers on each frame member

Figure 12

real reason why windbreaks need be restricted to straight rows if their placement protects the mobile homes from prevailing westerly winds. As an example, a windbreak that is 30 feet tall will tend to reduce winds up to 50 percent of their original velocities at leeward distances of up to about 240 feet. Figure 13 shows relative zones of reduced wind velocity on the leeward side of a planted barrier as a percentage of open field velocity. Table 2 shows the effect of windbreaks on open field wind velocities, as taken from Iowa State University Cooperative Extension Service Bulletin No. F-284, March 1966, as prepared by James Gottsacker, extension forester.

Wind reduction and protection from elements such as snow will depend upon certain characteristics of the windbreak. Notable among these characteristics is height, density, width, length and continuity of the barrier. Each of these component characteristics have important parts to play regarding extent and degree of protection provided. For the average mobile home court, windbreaks should provide a height sufficient to reduce wind approximately 50 percent of its velocity over the entire area. It should be composed of enough low density shrubbery to not only reduce wind velocity at low levels but to force snow to drift close in to the windbreak. The windbreak barrier must also be of sufficient length in order to protect most areas of the mobile home court as winds tend to shift from a westerly to a northerly or southerly direction. It has been mentioned the distance that wind protection extends on the leeward side of a windbreak is proportional to its height. The most protective leeward zone will relate to an extended distance of from six to eight times the windbreak's height.

Density of a windbreak will influence the wind velocity. An extremely dense barrier will reduce windspeeds close to the barrier itself. A medium dense barrier will reduce wind velocity a greater distance to the leeward of the barrier. It has been found that a moderately dense barrier, between 75 to 85 percent density, will be the most effective type for mobile home courts that occupy a relatively large leeward area with respect to the barrier. See Figures 14 and 15 showing diagrammatically the path of wind flow related to extremely dense and moderately dense windbreaks respectively.

Narrow type windbreaks of the 80 percent density type are generally as effective as wider barriers. It would be well to remember when planning windbreaks that single rows of one species have relatively small effect due to the fact that gaps between single row trees seriously reduce efficiency of the windbreak. Length considerations suggest the windbreak would do well to extend about 100 feet beyond the area to be protected. Such practice would provide added protection when the winds shift from one direction to another such as west to north or south.

Species of trees and shrubs are deserving of considerable attention. The choice of trees for windbreaks will normally depend upon the soil and locality in which they are to be planted. It is generally wise to plant more than one species. Should one species die or be damaged by insects or disease, the effectiveness of the windbreak would not be totally lost. Trees are defined herein as those reaching a height of 30 feet or more at maturity. Small trees and shrubs are those less than 30 feet in height at maturity. It is more effective to plant small trees and shrubs in the outer rows and at the end positions of windbreaks. Their prime task is to provide density at low heights. Center rows of trees should be primarily of evergreens because they hold their needles year round and are constantly efficient at all seasons. Of course, those areas having tight soil and poor drainage are not suitable for evergreens. In these areas broadleaved trees should be planted. If this type is planted, a minimum of about four rows are required. In areas where soil is highly

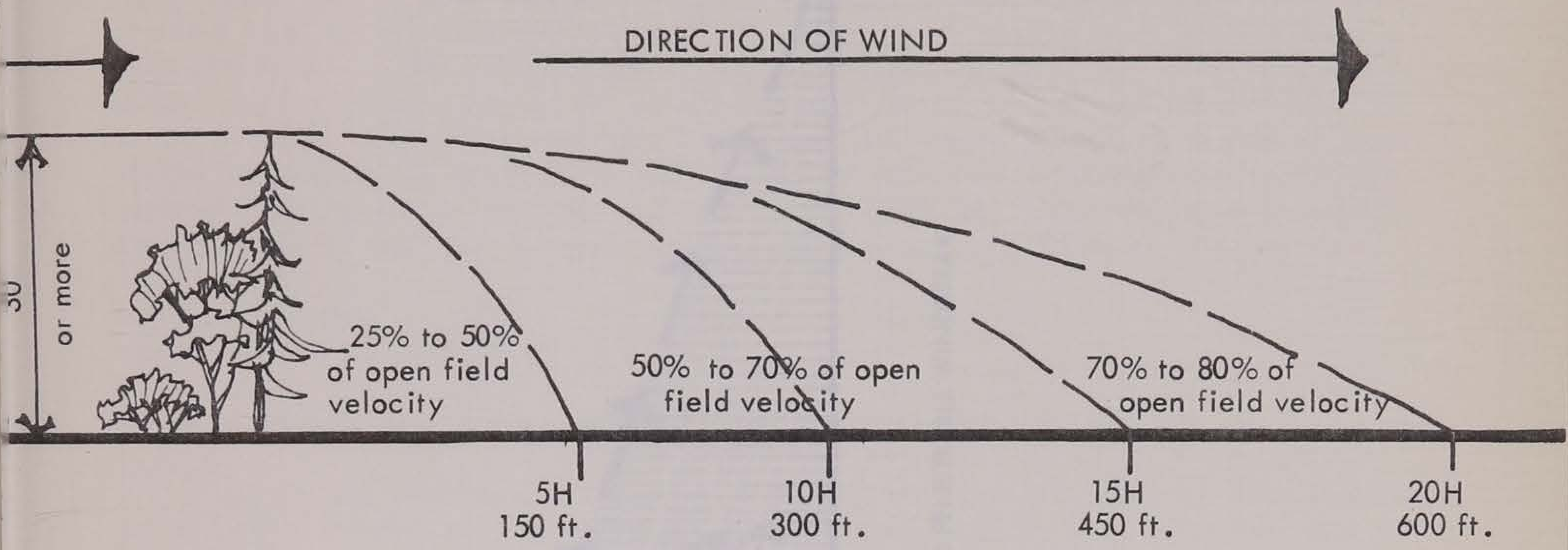


FIGURE 13 REDUCED WIND VELOCITIES TO LEEWARD OF WINDBREAK BARRIER

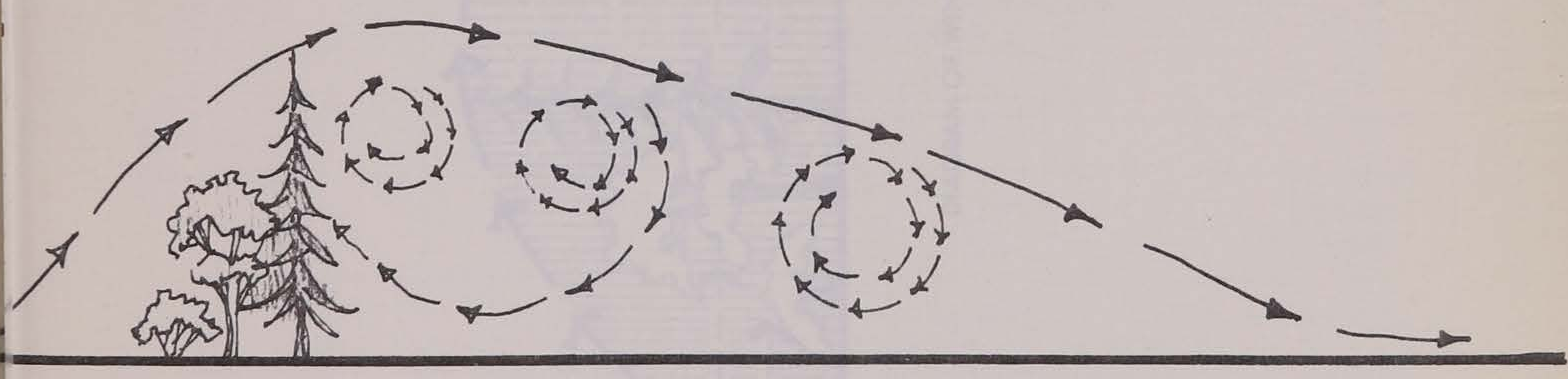


FIGURE 14 FLOW OF WIND OVER DENSE WINDBREAK BARRIER SHOWING INTENSE TURBULENCE CREATED BY SLOW PRESSURE (SUCTION)

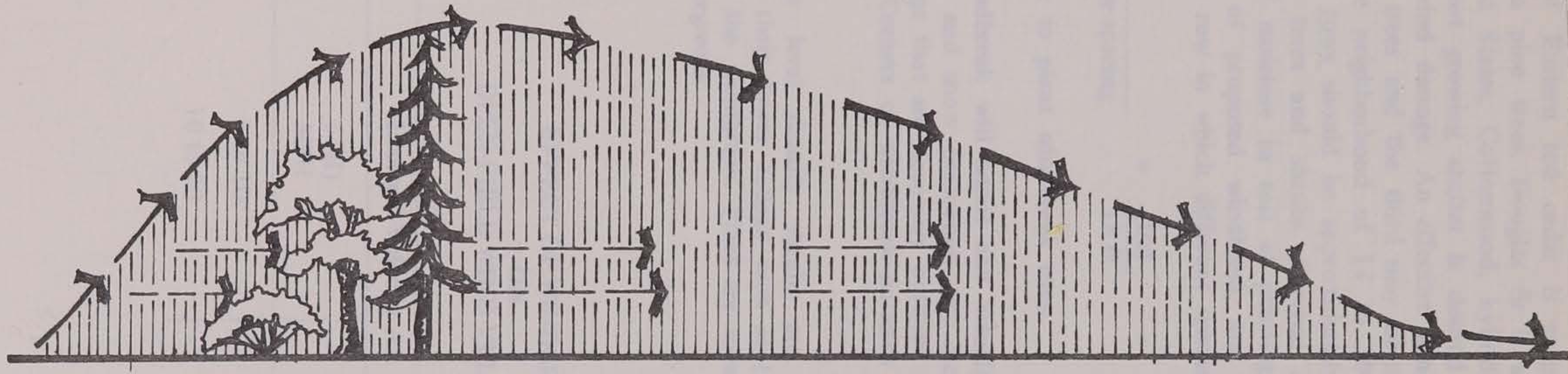


DIAGRAM OF WIND FLOW OVER A MEDIUM DENSE AND PENETRABLE WINDBREAK

FIGURE 15

calcareous, the use of Eastern red cedar is suggested. Needle blight disease confronts Austrian and Ponderosa pine trees. Douglas fir is a good choice and is native to a large area of western United States. Cottonwood, hybrid poplar, and soft maple can be used where temporary or fast growing shelter is desired in areas of poor drainage. They are highly susceptible to wind damage. An effective windbreak must have at least 3 rows. Two of these must be tall trees and the third may be shrubs or smaller trees. Spacing between rows should be in the neighborhood of 14 to 20 feet for trees and 4 to 10 feet for shrubs. Spacing within rows should be approximately 12 to 18 feet for tall trees and 12 to 16 feet for small trees and shrubs. Survival and initial growth of windbreak trees depend on amount of moisture in soil at planting time. To determine number of trees required, take length of proposed windbreak and divide by within-row spacing between trees. Do this for each row in which different spacings are used. Example:

$$\frac{\text{length of windbreak}}{\text{recommended within row spacing}} = \frac{360}{18\text{ ft.}} = 20 \text{ trees}$$

Spring is the best time to plant windbreak trees.

A gap in the windbreak will admit and actually accelerate the speed of wind. Besides the reduction in wind and snow protection, the increased velocity wind speed will tend to harm nearby trees. Gaps that are necessary between windbreak trees for access roads should be angled or curved. Corners of windbreak patterns should be rounded and reinforced with extra shrubs.

Examples of low level density shrubs are (honeysuckle, ninebark, dogwood) or evergreens that retain their lower foliage such as (spruce, firs, eastern red cedar) at ends and on both sides of the windbreak. Pines are some of the tallest of trees and are among the fastest growing evergreens.

TABLE 2

EFFECT OF WINDBREAK
ON
OPEN-FIELD WIND VELOCITIES

Open-Field Wind Velocity	Leeward Velocity At:		
	5 (H) MPH	10 (H) MPH	15 (H) MPH
20	5 to 10	10 to 14	14 to 16
40	10 to 20	20 to 28	28 to 32

ANALYSIS OF WIND FORCES

ANALYSIS OF WIND FORCES

A knowledge of the magnitude of forces acting upon a mobile home is necessary to determine proper tie-down and anchor systems. Previous sections have given information and data or tie-down forces for one special case. Below a formula valid for a large number of cases will be developed.

The free body diagram of Figure 31a shows and defines the forces acting upon a mobile home, while Figure 32a shows the dimensions of the mobile home. It has been assumed that rotation about point 0 (toppling) impends. The source of the Forces F_t, F_s, F_f, and W are obvious. The drag force F_d is due to resistance of the home to flow of the air around it. The lift force is due to the pressure differential between the top and bottom surfaces of the mobile home. Even with no skirt enclosing the area under the mobile home, the velocity near the top surface will be significantly greater than the velocity near the bottom surface. Bernoulli's equation indicates that the higher the velocity, the lower the pressure, and thus a lift force will be produced. An airplane wing will produce similar drag and lift forces. Both the drag and lift forces tend to rotate the mobile home while the weight and tie-down force tend to prevent rotation.

The magnitudes of the forces must now be computed. Assume that the wind velocity is perpendicular to the longitudinal axis and that upstream the flow is one dimensional. Further assume then, in flowing over the mobile home, negligible energy is lost and the flow is steady state. Further, it will be assumed the mobile home has a skirt so that the air pressure on the bottom surface will be the stagnation pressure. See the work edited by R. D. Marshall and H. C. S. Thom (1970) for studies of cases (not mobile homes) where some of the above assumptions are not satisfied. Bernoulli's equation can be written,

$$\frac{V_1^2}{2} + \frac{p_1}{\rho} + gz_1 = \frac{V_2^2}{2} + \frac{p_2}{\rho} + gz_2 \qquad (1)$$

where z_1, z_2 are elevations and all other terms are defined with Figure 31. Point 2 in defined on Figure 32b and point 1 has the same elevation as point 2, but is sufficiently far upstream so that the flow is undisturbed. In this case $z_2 - z_1 = 0$ and since point 2 is a stagnation point $V_2 = 0$. Thus from (1),

$$\Delta p = p_2 - p_1 = ½ \rho V_1^2 \qquad (2)$$

For convenience, the subscript on V_1, will be dropped. This result gives the theoretical pressure acting on the windward side of the mobile home. Using standard practice, multiplicative coefficients will be added to take into account non-ideal conditions. Thus, introducing coefficients into (2)

$$p_{ave} = ½ C_{de} V^2 \qquad (3a)$$

$$p_{max} = ½ C_g C_{de} V^2 \qquad (3b)$$

where C_d is the drag coefficient and C_g is the gust coefficient. The gust coefficient corrects for sudden increase of pressure due to gusting of the wind. The drag force will then be the pressure times the area over which it acts. Thus, $F_d = p_{max} \times (hL)$ or

$$F_d = ½ C_g C_{de} V^2 hL \qquad (4)$$

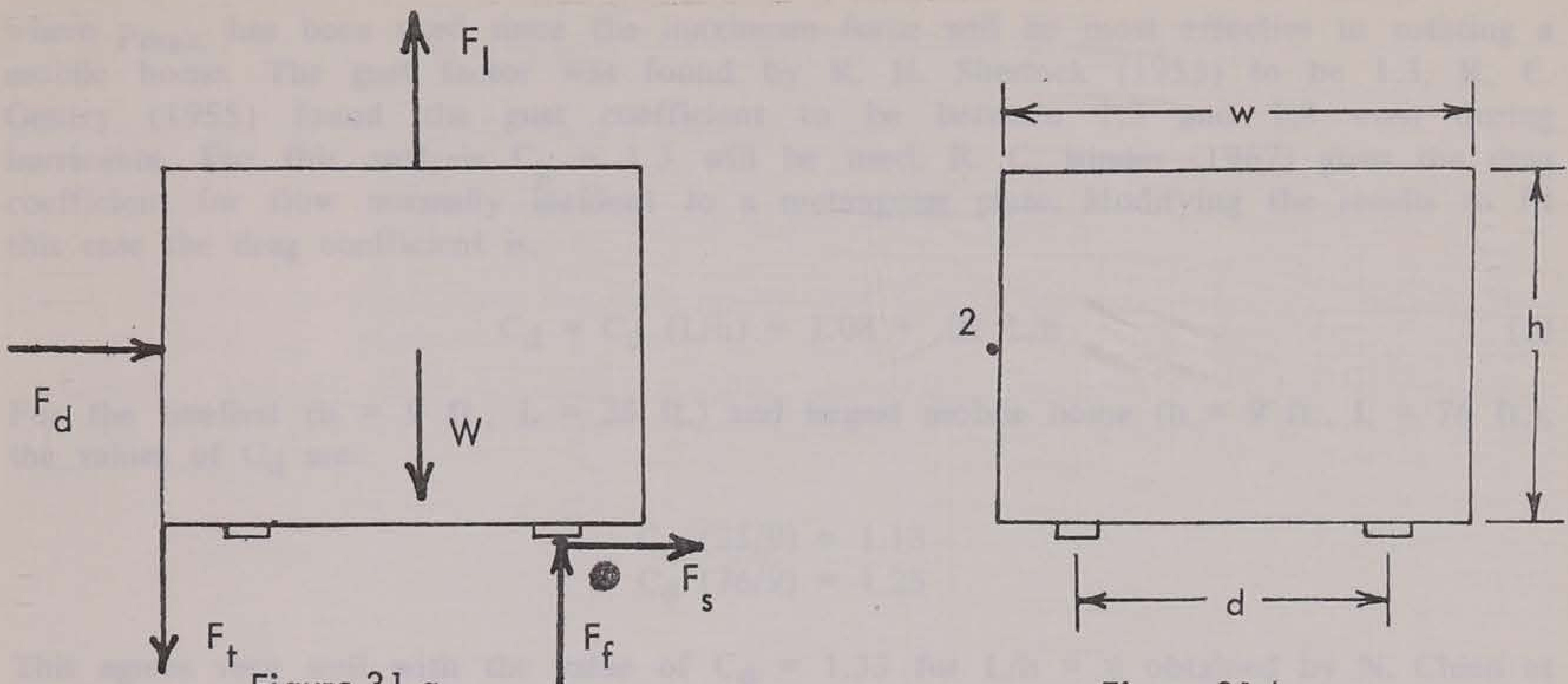


Figure 31 a Figure 31 b

F_d = Transverse drag force
F_l = Lift force
F_t = Tie-down force
F_f = Vertical reaction of foundation
F_s = Horizontal reaction of foundation
F_c = Longitudinal drag force
W = Weight
L = Length
p = Pressure
V = Velocity
ρ = Mass density = 0.00238 slug/ft^3
z = Elevation
g = Gravitational constant
h = Height
w = Width
d = Frame spacing

Free Body Diagram and Definition of Terms

where p_{max} has been used since the maximum force will be most effective in rotating a mobile home. The gust factor was found by R. H. Sherlock (1953) to be 1.3, R. C. Gentry (1955) found the gust coefficient to be between 1.3 and 1.4 even during hurricanes. For this analysis C_g = 1.3 will be used. R. C. Binder (1967) gives the drag coefficient for flow normally incident to a rectangular plate. Modifying the results to fit this case the drag coefficient is,

$$C_d = C_d\,(L/h) = 1.08 + .02\ L/h \tag{5}$$

For the smallest (h = 9 ft., L = 25 ft.) and largest mobile home (h = 9 ft., L = 76 ft.), the values of C_d are:

$$C_d\,(25/9) = 1.13$$
$$C_d\,(76/9) = 1.25$$

This agrees very well with the value of C_d = 1.33 for L/h = 4 obtained by N. Chien et al. (1951). The values from (5) give values that almost exactly agree with values obtained by R. B. Harris (1962) on wind tunnel test of mobile homes without skirts. Based upon tests of a single model, R. B. Harris (1962) found the worst case C_d = 1.31 for a mobile home without skirts. Following standard practice in fluid mechanics the coefficients C_g and C_d are assumed to be independent of wind velocity.

Next, the lift force must be determined. The lift is similar to (4) and is the product of pressure times area over which it acts. Thus,

$$F_l = \tfrac{1}{2} C_g C_l\ V^2 wL \tag{6}$$

as before, C_g is the gust coefficient and C_l is the lift coefficient. As before, the gust coefficient will be taken to be C_g = 1.3. The lift coefficient for a wind velocity perpendicular to the longitudinal axis was found by R. B. Harris (1962) to be C_l = 0.78, while the worst case value was found to be C_l = 0.89. Again these values are assumed to be independent of V, w, l.

The next problem is to locate the center of pressure. The usual procedure which will be followed here, is to assume the center of pressure at the geometrical center. Wind tunnel tests by N. Chien et al. (1951) indicate that this assumption is valid for the vertical surfaces as long as the wind velocity is not normal, then the center of pressure can be as much as 15% of the height below or 10% of the height above the geometrical center, but this can be either up-wind or down-wind. Thus, for this analysis, it will be assumed that mass center will be at the geometrical center.

Applying the equations of equilibrium to the free body diagram of Fig. 31a,

$$\overset{\curvearrowleft}{+} \qquad \Sigma M_o = 0$$

$$F_t\left(\frac{d}{2} + \frac{w}{2}\right) + W\frac{d}{2} - F_d\left(\frac{h}{2}\right) - F_l\left(\frac{d}{2}\right) = 0$$

or

$$F_t = F_d\left(\frac{h}{d + w}\right) + F_l\left(\frac{d}{d + w}\right) - W\left(\frac{d}{d + w}\right)$$

Substituting the results of (4) and (6), the tie-down force becomes,

$$F_t = [\frac{1}{2}C_{ge}V^2 (C_dh^2 + C_lwd) L - Wd] \frac{1}{d + w}$$

This result can be put into a more convenient form

$$f_l = F_l/L = [\frac{1}{2}C_{ge}V^2 (C_dh^2 + C_lwd)] \frac{1}{d + w} \quad (7)$$

where f_l is the tie-down force per unit length and W/L is the weight per unit length. Note that f_l must be positive. If f_l from (7) is negative, then the wind forces are not sufficiently large to cause impending rotation (toppling). For units in (7) to be consistent, V must be in feet per second (fps). For convenience a brief tabulation of values of pV^2 appears below.

V (mph)	V (fps)	pV^2 (psf)
70	103	25.1
80	117	32.8
90	132	41.5
100	147	51.2
110	167	62.0
120	176	73.8

Equation (7) can be used to compute more accurate values of the tie-down force per unit length than the values given in section on "Soil Anchors". This is due, at least in part, to the fact that (7) allows the actual dimensions and weights to be used, while tabulation in previous section was for a specific case.

Values of F_d and the corresponding longitudinal force F_c are important in designing foundations. From (4)

$$F_c = \frac{1}{2}C_gC_{ce}V^2wh \quad (8)$$

where C_c is the longitudinal drag coefficient. In the worst case, where the wind velocity is neither perpendicular nor parallel to the longitudinal axis, R. B. Harris (1962) found C_c = 1.20, again assumed to be independent of V, w, l.

In order to use (7), values for the coefficients must be chosen. At this point, two sets of values will be recommended. To determine the actual value of f_l for the wind velocity perpendicular to the mobile home, use

$$C_g = 1.3$$
$$C_d = 1.08 + .02L/h \quad (9)$$
$$C_l = 0.78$$

For design purposes where the wind velocity may not be perpendicular to the longitudinal axis, as the worst case, use

$$C_g = 1.3$$
$$C_d = 1.31$$
$$C_l = 0.89$$
$$C_c = 1.20$$

In order to obtain some numerical results, a particular size mobile home will be assumed. This size is probably the most common being sold today.

L	=	60 feet
w	=	12 feet
d	=	9.5 feet
h	=	9 feet
W	=	14,000 lbs.

For all computations, the values given above and in (10) will be used. The frame spacing of 9.5 feet appears to be standard for 12 foot wide mobile homes with the frame outside the wheels, while the standard spacing appears to be 6.6 feet when the frame is inside of the wheels. The pressure acting upon the windward surface of a mobile home as a function of velocity is given in Figure 32. Such data is useful.

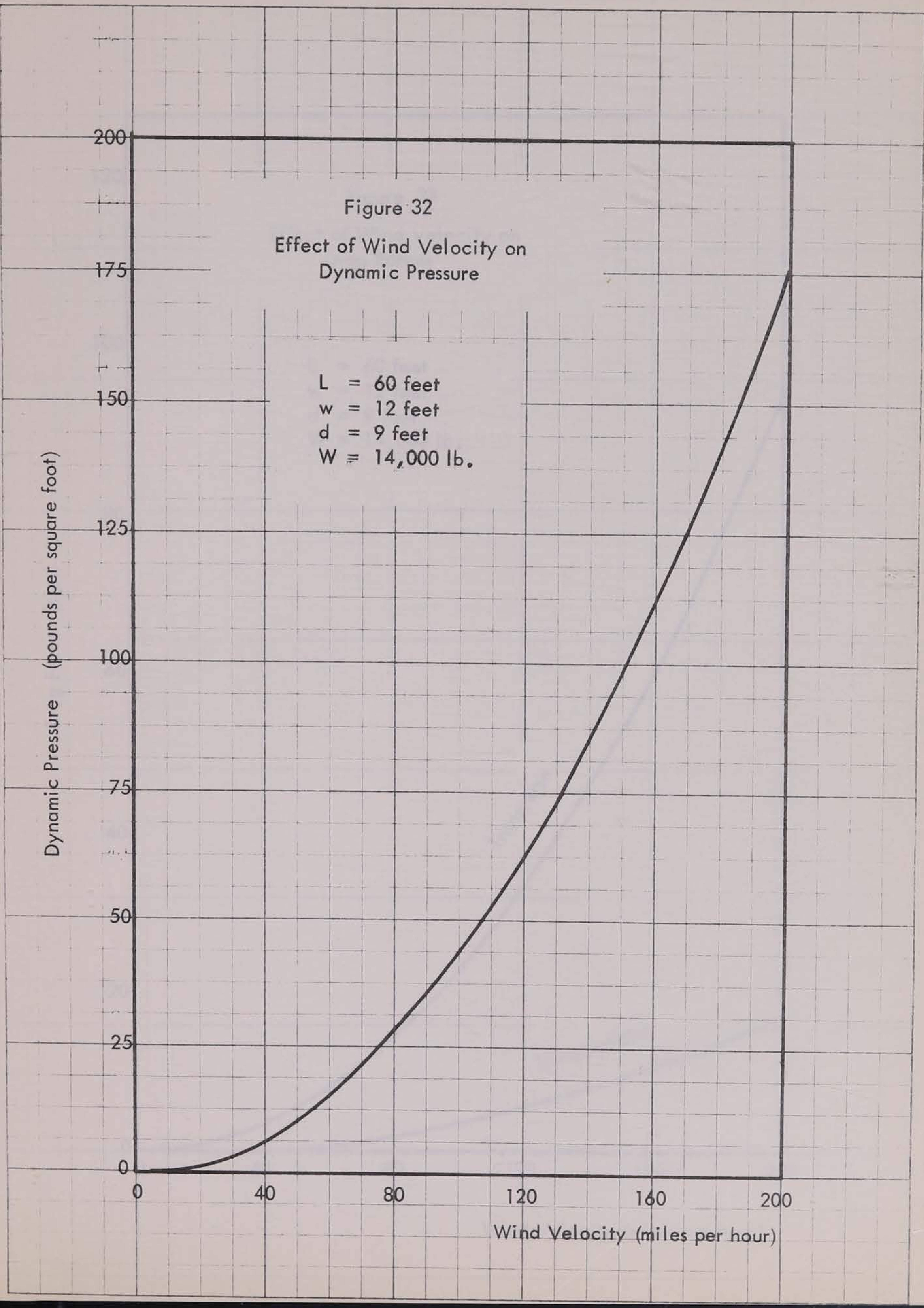


Figure 32
Effect of Wind Velocity on Dynamic Pressure
L = 60 feet
w = 12 feet
d = 9 feet
W = 14,000 lb.
200
175
150
125
100
75
50
25
0
Dynamic Pressure (pounds per square foot)
0
40
80
120
160
200
Wind Velocity (miles per hour)

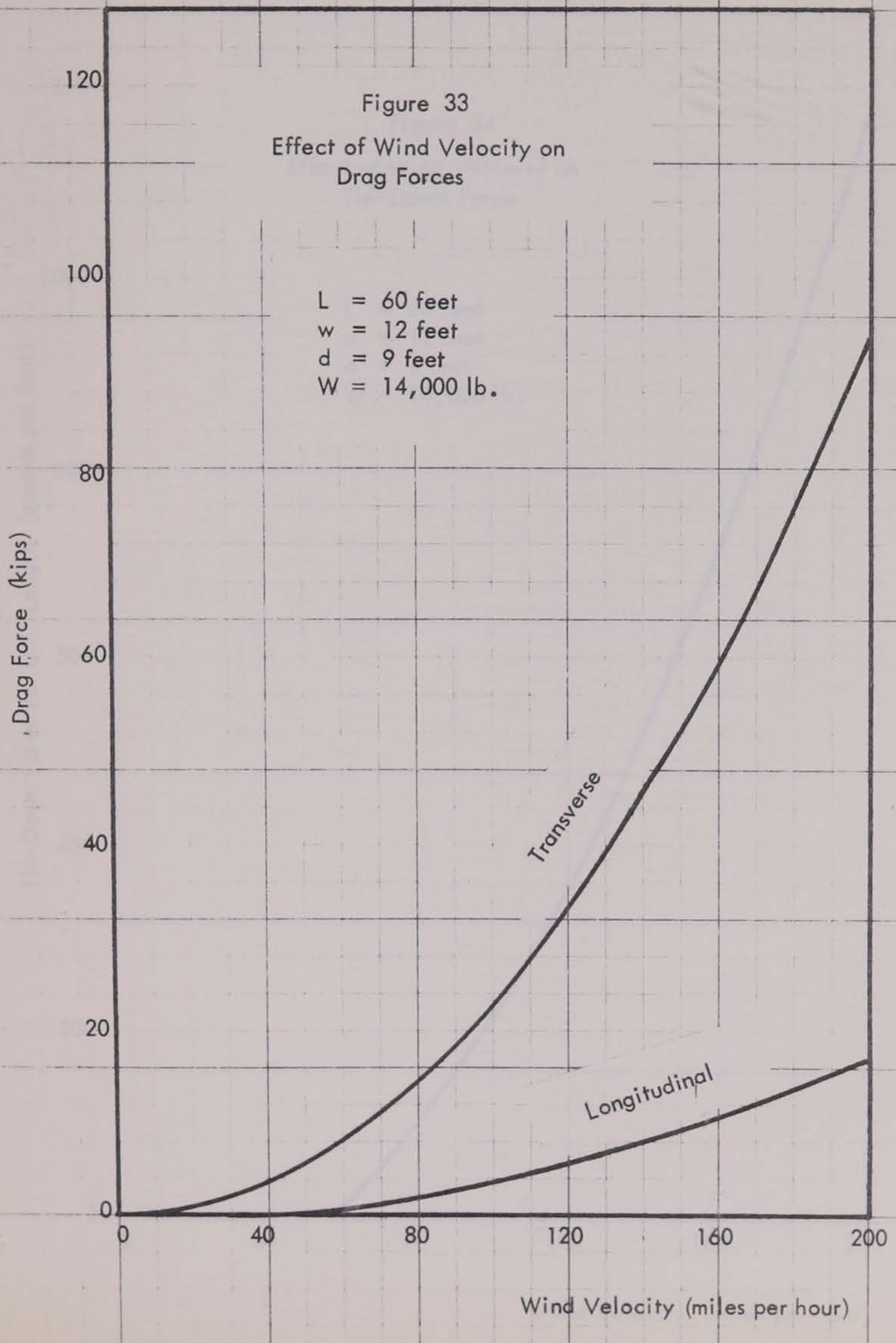


Figure 33
Effect of Wind Velocity on
Drag Forces
L = 60 feet
w = 12 feet
d = 9 feet
W = 14,000 lb.
Transverse
Longitudinal
Drag Force (kips)
0
20
40
60
80
100
120
0
40
80
120
160
200
Wind Velocity (miles per hour)

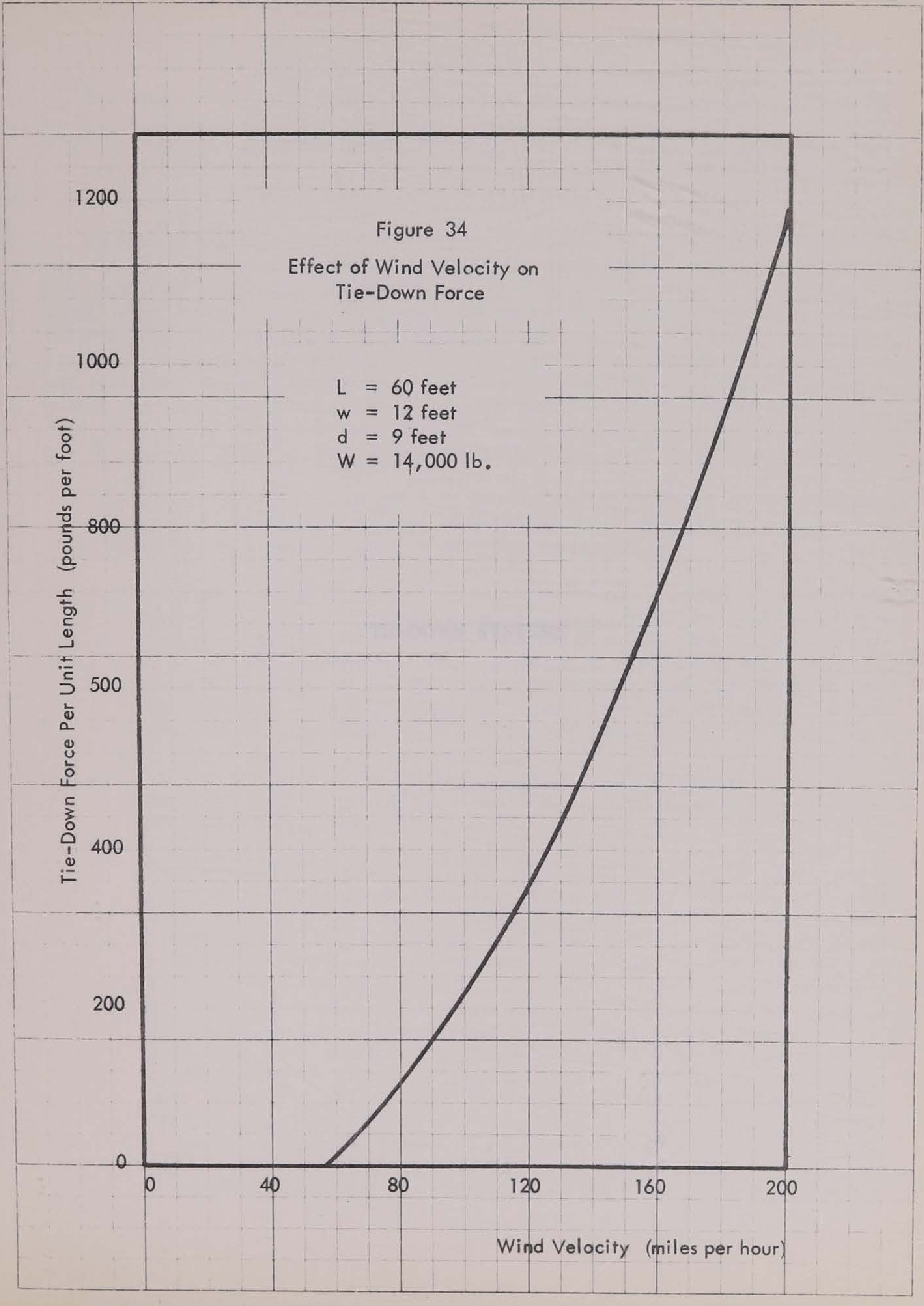


Figure 34
Effect of Wind Velocity on
Tie-Down Force
L = 60 feet
w = 12 feet
d = 9 feet
W = 14,000 lb.
Tie-Down Force Per Unit Length (pounds per foot)
1200
1000
800
500
400
200
0
0
40
80
120
160
200
Wind Velocity (miles per hour)

TIE-DOWN SYSTEMS

TIE-DOWN SYSTEMS

The salient parts of a mobile home include supporting piers on which the mobile home rests in equilibrium, the undercarriage frame, usually made of steel, on which the floor rests. In addition to the above, the walls rest on the frame and the roof in turn rests on the walls. The frame, floor, walls, and roof are each a basic frame that is fastened together in such a manner so as to create a box-like unit.

Peculiar to this lightweight type home is its inability to maintain equilibrium when subjected to the build-up of pressures against the outside surfaces caused by reasonably high velocity winds. Further, the pressures set in action by the winds blowing against the mobile home initiates internal stresses in the various frame components just mentioned. Unfortunately, when the stresses are set in action within wall and roof frameworks, there is a tremendous possibility for warping and racking of these components. The mobile home unit demands a situation wherein all of these framing components work together in unison. It is in this sense that the tie-down is most effective. The term "tie-down" is intended to mean a system of component parts acting in concert for the express purpose of insuring that all parts of the mobile home react as a total unit against externally applied forces.

The tie-down insures that all structural parts of the mobile home act as a complete unit. In doing this, the tie-down prevents undue stresses from developing on any given part of the home. The basic parts of the tie-down system are as follows:

1. The Earth Anchor which provides the primary anchor capabilities. One of the more effective types of anchors is the earth auger. See Figure 16-A. This anchor is placed a minimum of 4 feet deep into the earth. The lower end has an auger of 6" or 8" diameter. The shaft is to be of 5/8 inch diameter steel and terminates in a loop at the end exposed above the ground. See Figure 16-A. In some instances, a Tensioning Head is fixed to the exposed end of the earth anchor and is an approved type of fastener. See Figure 16-B.

2. A second basic part of the tie-down system is the Turnbuckle which is shown in Figure 16-C. This is used to place tensioning in the entire system and should be made of drop-forged steel.

3. Attached to the turnbuckle is a Cable which is to be secured by a minimum of 3 steel clamps in the manner shown by Figure 16-C. The Cable runs up one side of the mobile home, through a bracket placed atop the home at the intersection of walls and roof. See Figure 17-A. This bracket has as its principle purpose the distribution of compressive stresses over a larger area of the mobile home framework. The compressive stresses are caused, of course, by the tensioning of the cables. The brackets are to be of steel 1/8" thick and of 2"-0" length. A "W" shaped bracket with outer legs of 2" dimension and inner legs of 3" dimension is quite effective. See Figure 17-A. If steel brackets are used over aluminum siding, they should be separated from the aluminum by a neoprene or rubber gasket in order to prevent electrolysis. Any other gasket material which would serve the same purpose, of course, would be acceptable. Brackets are held in place by compression stresses caused through tensioning the cable. The Cable runs up through the brackets, across the top of the mobile home, down through the opposite bracket, down the opposite side of the home, and is then secured to

another earth anchor to complete the unit.

Steel Cable has been mentioned as one material for use in tie-downs. When used it shall be 3/8" diameter or larger steel cable 7 x 7 - 7 strands of 7 wires each. Aircraft cable of 1/4" diameter or larger, 7 x 19 - 7 strands of 19 wires each is also recommended. Steel strapping made of high tensile galvanized or zinc coated steel is also recommended. The size of strapping should be a minimum of 0.185 sq. in. Some factory installed steel strap ties of the above mentioned type have been used on new mobile homes. In this manner, the ties become a more integral part of the mobile home framework and at the same time, become concealed within the walls. This makes for an aesthetic appearance of the entire mobile home unit. The zinc-coated (galvanized) steel straps shall conform to ASTM A446-69, standard specification for zinc-coated (galvanized) steel sheets of structural quality, and shall have a cross-sectional area of not less than 0.185 square inches. Also recommended is corrosion-resisting chromium-nickel steel. AISI Types 201, 202, 301, 302, 304, and 316 straps having a cross-sectional area of not less than 0.185 square inches. The tensioning devices of single head type, see Figure 16-B, must be made of one continuous piece of 1/4" x 1 1/2" or larger formed steel. Tension bolts must be a minimum of 5/8" diameter and must be zinc coated. If tie-down cable is used, it must be tensioned and fastened to the earth anchor with 1/2" or larger galvanized, drop forged eyes. Turnbuckles with hooked ends are not approved. However, turnbuckles with "U" jaws or closed eyes can be used. All cable ends shall be secured with at least three "U" bolt type galvanized cable clamps sized to fit the wire rope diameter used. In the event straps are used, they may be fastened around the frame with aluminum strap buckles or 2 galvanized 1 1/2" strap clamps.

Because the mobile home will, at times, have a tendency to move parallel to the long axis, as well as laterally, it is good practice to install short cables that are attached to the frame which supports the home. These tie-down cables are best installed to the frame at each corner of the mobile home. See Figure 23-B. The cable may be fastened to the frame with 1 1/2" drop-forged, closed eye, bolt, bolted through a hole drilled in the frame. Use a washer to help reinforce around each hole. The corner earth anchor eyelets can serve as the anchoring medium for these shorter type cables as well as for the corner tie system. See Figure 16-C.

Although not strictly a part of the tie-down system, but strategically important in its overall functioning, is the pier support system which supports the mobile home. The piers should be positioned in the same location as the tie-downs over the coach. Several methods of support are recommended, but the most common is the use of concrete blocks placed over a footing of concrete, see Figures 16-D and 17-B. The cores of the concrete block are placed in a vertical position and preferably filled with masonry cement or concrete. The insertion of a single vertical No. 4 steel bar in the central core and continuing down into the concrete footing below, gives an extremely secure type of pier. The footing size may be a minimum of 16" x 16" x 4" if the soil is extremely solid and of high load bearing capabilities. If the soil is soft and of poor load bearing quality, a larger (2'-0" x 2'-0" x 4") footing should be used. Footing depth should be 4" and 6-6/10-10 wire mesh reinforcing steel should be used in the footing. See Figures 17-B and 17-C.

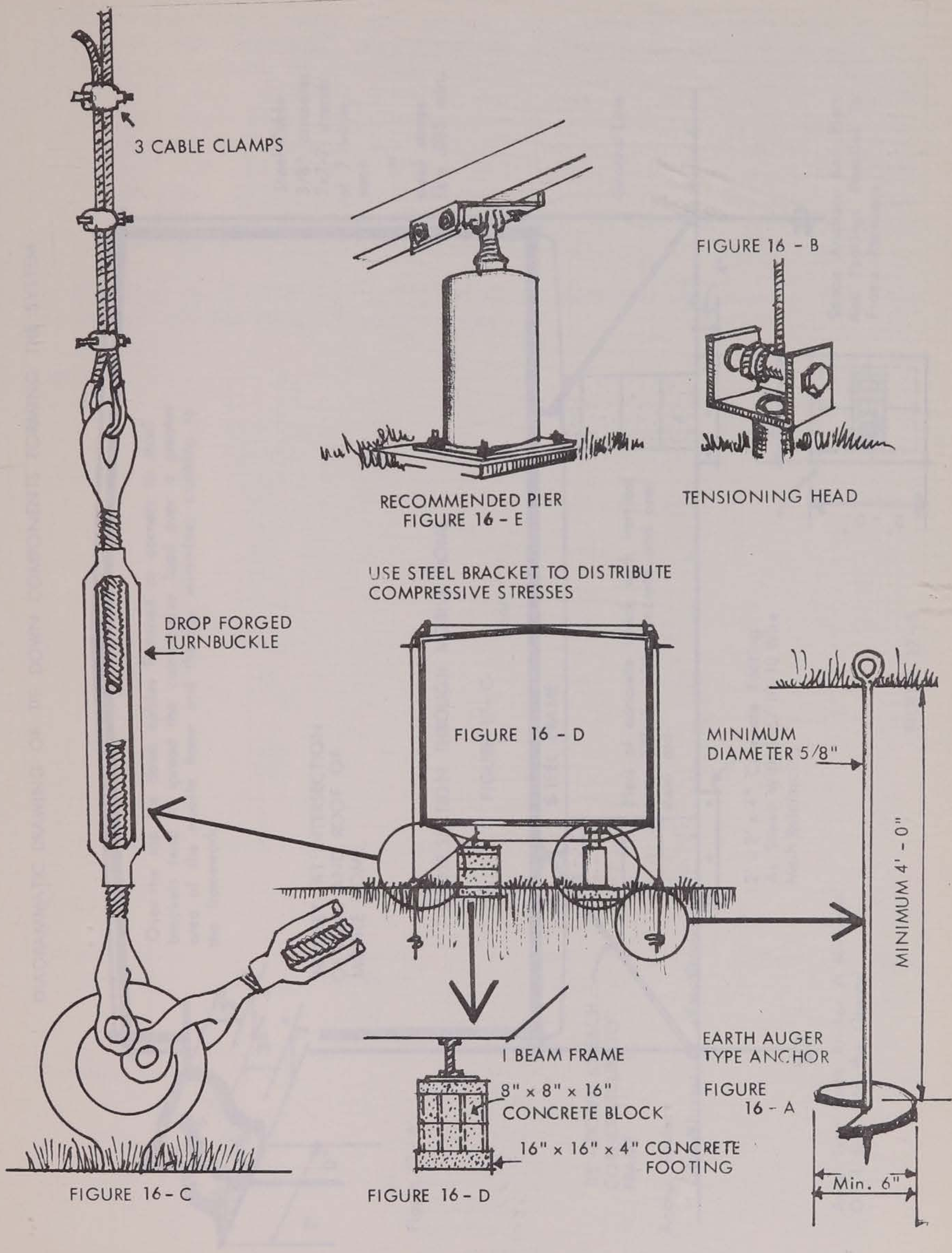


FIGURE 16 - B

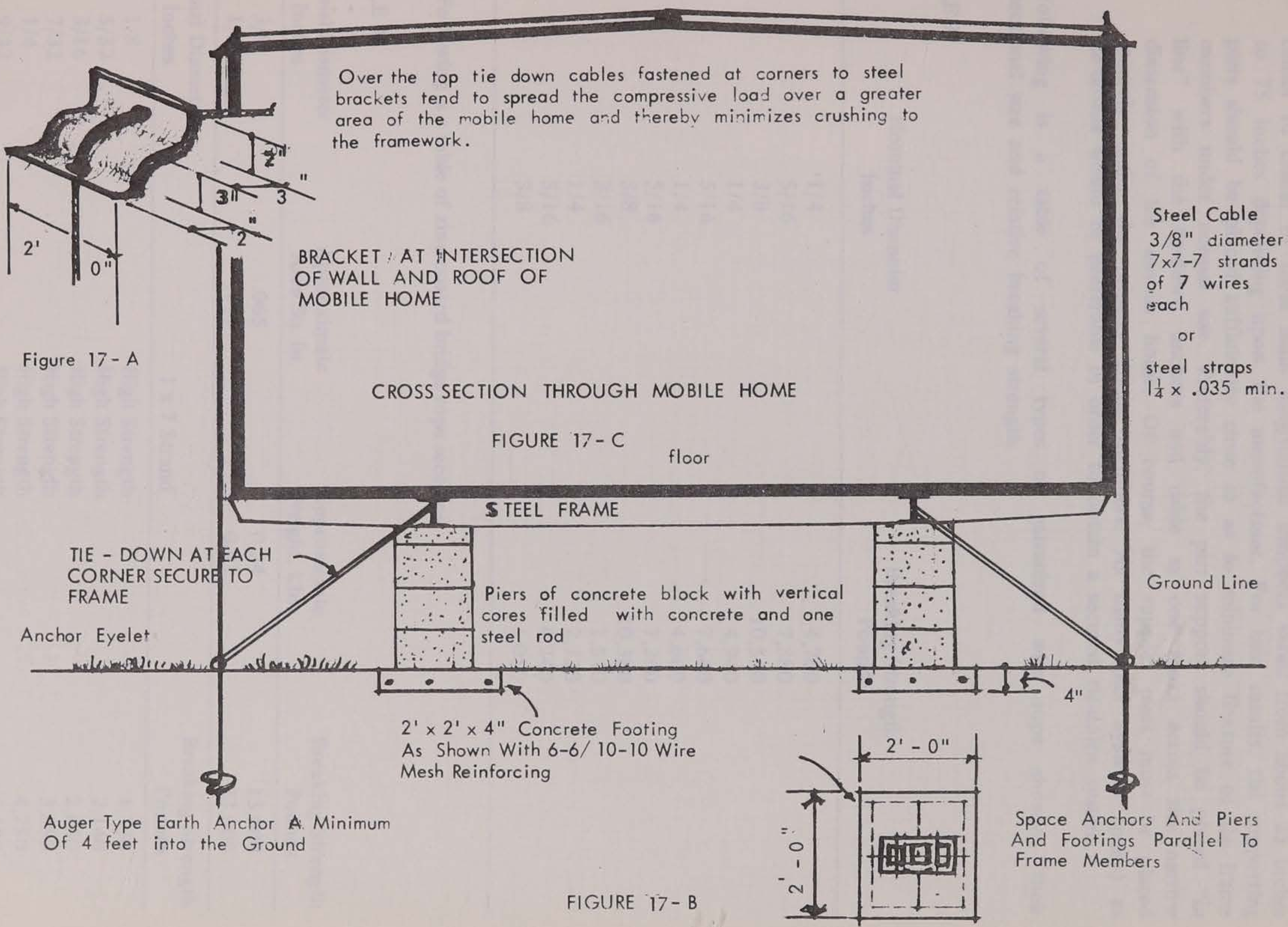
RECOMMENDED PIER FIGURE 16 - E

FIGURE 16 - A

FIGURE 16 - C

FIGURE 16 - D

DIAGRAMMATIC DRAWING OF TIE DOWN COMPONENTS FORMING THE SYSTEM



In supporting a mobile home on piers, the common practice is to block it under the main longitudinal members of the under-support-frame. The distance from center to center of these main longitudinal members varies from about 25 inches to 75 inches depending upon the manufacturer. For best results, the supporting piers should be placed sufficiently close so as to minimize flexture of the frame members under normal use. Preferably, the pier support should be placed "in line" with the tie-down anchors and cable as one looks across the narrow dimension of the mobile home. Of course, the support piers must be placed securely under the primary frame members. As many pier systems (pairs) as tie-downs would be preferable in order to obtain a secured tie-down system.

Following is a table of several types of galvanized wire rope showing their cross-sectional size and relative breaking strength.

TABLE 3.

Nominal Diameter Inches	Breaking Strength Pounds
1/4	4,760
5/16	7,380
3/8	10,540
1/4	4,940
5/16	7,660
1/4	4,660
5/16	7,260
3/8	10,380
3/16	1,540
1/4	2,720
5/16	4,240
3/8	6,080

Following is a table of zinc-coated bridge rope sections.

TABLE 4.

Nominal Diameter Inches	Approximate Area Sq. In.	Approximate Weight, Lbs.	Breaking Strength Pounds
3/8	.065	0.24	13,000
1/2	.119	0.42	23,000

Nominal Diameter Inches	1 x 7 Strand	Breaking Strength Pounds
1/8	High Strength	1,330
5/32	High Strength	2,140
3/16	High Strength	2,850
7/32	High Strength	3,850
1/4	High Strength	4,750
9/32	High Strength	6,400

It is apparent after reading the above tables to see that a variety of cables are available on the market and the necessary cross-section area for tie-down purposes is relatively small.

"Over the Roof-Ties"

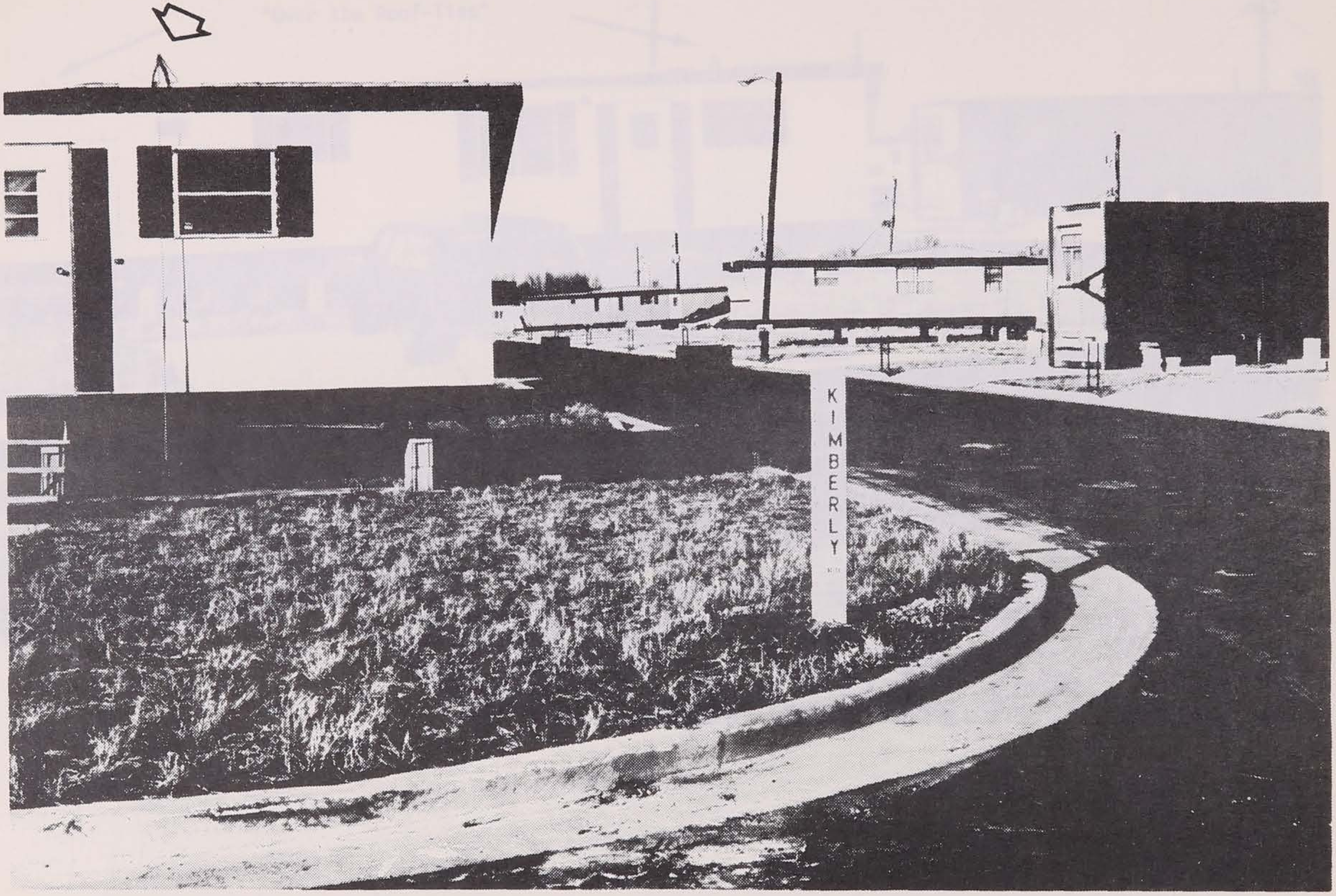


Figure 19

Figure 20

Soil Type	Wind Velocity m.p.h.	Pull On Anchors Lbs. Per Lineal Ft. of Home	Type AA Anchor Spacing Ft.	Type A Anchor Spacing Ft.	Load Per Anchor Type A Lbs.	Load Per Anchor Type AA Lbs.	Cable Size Type AA In.	Cable Size Type A In.
Stiff Clay,	20	0	---	---	---	---	3/8	3/8
	30	2	---	---	---	---	3/8	3/8
Dense Rocky Sand	40	14	---	---	---	---	3/8	3/8
	50	35	---	---	---	---	3/8	3/8
	60	65	---	---	---	---	3/8	3/8
	70	105	---	40	---	4,200	3/8	3/8
	80	150	35	28 1/2	3,675	2,993	3/8	3/8
	90	200	26 1/2	21 1/2	5,300	4,300	3/8	3/8
	100	260	20	16 1/2	5,200	4,290	3/8	3/8
	110	320	16 1/2	13 1/2	5,280	4,320	3/8	3/8
	120	390	13 1/2	11	5,265	4,290	3/8	3/8
	130	460	11 1/2	9 1/4	5,290	4,255	3/8	3/8
Medium Soft Clay,	20	0	---	---	---	---	3/8	3/8
	30	2	---	---	---	---	3/8	3/8
Well Graded Sand and	40	14	---	---	---	---	3/8	3/8
	50	35	---	---	---	---	3/8	3/8
Gravel. Wet Plastic	60	65	---	35	---	2,275	3/8	3/8
	70	105	32	22	3,360	2,310	3/8	3/8
Soils	80	150	---	15	3,300	2,250	3/8	3/8
	90	200	---	11 1/2	3,300	2,300	3/8	3/8
	100	260	---	8 3/4	3,250	2,275	3/8	3/8
	110	320	---	7	3,200	2,240	3/8	3/8
	120	390	8	5 3/4	3,315	3,253	3/8	3/8
	130	460	5	5	3,220	2,300	3/8	3/8
Firm Clay, Compact	20	0	---	---	---	---	3/8	3/8
	30	2	---	---	---	---	3/8	3/8
Clayey Sand. Usually	40	14	---	---	---	---	3/8	3/8
	50	35	---	---	---	---	3/8	3/8
Moist. Most Soils In	60	65	---	---	---	---	3/8	3/8
	70	105	40	31	4,200	3,255	3/8	3/8
Well Drained Areas	80	150	28	22	4,200	3,300	3/8	3/8
	90	200	22	16 1/2	4,400	3,300	3/8	3/8
	100	260	16 1/2	13	4,290	3,380	3/8	3/8
	110	320	13	10	4,160	3,200	3/8	3/8
	120	390	11	9	4,290	3,510	3/8	3/8
	130	460	9 1/4	6 1/4	4,255	2,875	3/8	3/8

SOIL ANCHORS

SOIL ANCHORS

A rather exhaustive and very excellent set of recommendations for anchor spacing related to various types of soil and to varying velocities of wind intensity has been prepared by R. B. Harris (1962). Some of the following requirements are the result of that study.

The anchoring requirements for mobile homes are generally stated in terms of pounds of anchorage capability per foot of length along the sides of the mobile home. With this as a basis, one can readily determine what spacing is required for anchors which must resist the pull of cables extending over and holding the mobile home in place. Following is a compilation of anchorage pull in terms of the wind velocity causing that pull by blowing against the wall of a mobile home.

Wind Velocity	Pounds Per Lineal Foot of Home
20 miles per hour	0
30 miles per hour	2
40 miles per hour	14
50 miles per hour	35
60 miles per hour	65
70 miles per hour	105
80 miles per hour	150
90 miles per hour	200
100 miles per hour	260
110 miles per hour	320
120 miles per hour	390
130 miles per hour	460

For the above magnitudes of pull on the anchors there is a relationship as to the resisting capacity of various type soils in which the earth anchors are embedded. In a general sense the Stiff Clay, Dense Rocky Sand soils are most resistant to pull. They are followed next in line by the Firm Clay and Compact Clayey Sands. These in turn are followed by the Medium Soft Clays and Well-graded Sand and Gravel (wet plastic soils) and lastly the Very Soft Clay, Loose Sand, and Fine Gravel with little clay in the soil.

The following example assumes a wind velocity of one hundred twenty miles per hour. From the previous table of values we can see a requirement of 390 pounds per foot resistance is required of the anchor system for the 120 mile per hour wind velocity. The following spacings for anchors are recommended for the various types of soils listed. These values are based on the use of Screw Auger Type Anchors of 6 inch minimum diameter or 8 inch diameter Screw Auger Type Anchors set a minimum depth of four feet (4 ft.) in the ground. This also applies to a 10 inch Arrowhead Type Anchor. The values of anchor spacing are based on average strengths of the soil type listed.

SOIL	ANCHOR SPACING	LOAD PER ANCHOR
Stiff Clay, Dense Rocky Sand	11½ Feet	4255 lbs.
Firm Clay, Compact Clayey Sand	11 Feet	3510 lbs.
Medium Soft Clay, Well-graded Sand and Gravel	8 Feet	3253 lbs.

From the above information it must be emphasized that the number of tie-downs required is directly dependent upon the holding power of the soil. If you have sandy soil, you need more tie-downs than if you have stiff clay soil. In fact, you need about twice as many anchors and tie-downs for a loose sandy soil as you need for a firm compact clay.

It must also be mentioned that selection of cable size is important. For example, we would not want to place a 4,700 pound load on a cable that has a safe tensile rating of 1,950 pounds.

With the preceding information, let us now work a problem or two that determines the number of tie-downs needed for a mobile home under varied conditions of wind velocity, soil type, and mobile home size. Let us assume we have a 60 foot long mobile home that is to be tied down in soil that is of the stiff clay, dense rocky sand type. The mobile home is to be located along a coastal region where hurricanes are likely to pass and that historical records show winds of 100 miles an hour occur every few years. From Table 5 we find that a wind velocity of 100 miles per hour can build up pressures on the mobile home to the magnitude of 260 pounds per lineal foot of mobile home. If we consider a Type A-A anchor (8" diameter auger), the anchor spacing could be 20 feet on center. The allowable load on each anchor under these conditions would approximate 4,290 pounds if we were using the Type A-A anchor. Assuming we place a set of ties one foot in from each end of the mobile home, there is a remaining distance of 58 lineal feet in which we can space the tie-downs. This would require 2 more tie-downs within the 58 feet, thus dividing the 58 feet into 3 parts of approximately 19'-4". See Figure 22-A. Although this works quite well insofar as soil conditions are concerned, the one remaining variable is the strength of the mobile home framework. Some men knowledgeable in the use of tie-downs as they relate to the stress potential of the mobile home frames suggest the tie-downs be spaced no more than 15 feet on centers. In this particular case, following such procedure would require 3 intervening tie-downs making a total of 5 required on a 14'-6" spacing. See Figure 22-B. It is hereby recommended that the 15 foot maximum spacing be adhered to where soil type, wind velocity, and anchor-type suggest a wider spacing. By following this procedure, a minimum amount of "racking damage" should be experienced in the framework.

It is interesting to note here that if a Type A anchor was used in lieu of a Type A-A anchor, the same velocity and soil conditions would require a 16 1/2 foot spacing and would require the same total number of tie-downs, i.e., 5 total.

If we were to use the same velocity conditions, the same length mobile home, but place the earth anchors in wet plastic soil that was medium soft clay or a well graded sand and gravel, a Type A anchor spacing of 8'-9" would be required for tie-downs. A total load per anchor under these conditions would be 3,250 pounds. At such a spacing (8-3/4 ft.), we would place a tie-down one foot in from each end plus adding 6 tie-downs. We thereby, create seven intervening spaces between the two end tie-downs of approximately 8'-4". The total number of tie-downs would be 8 in this instance. See Figure 23-A. Thus, the difference in soil from the first example illustrated would create the need for 3 additional tie-downs.

Among the most important criteria needed to successfully complete a viable tie-down system is the proper spacing of tie-downs on a mobile home. Related directly to this phenomena is the type and quality of soil into which the earth augers or other type earth anchors must be embedded. One may say in a general sense that spacing of tie-down units should never exceed 15 feet. However, the following tables for various types of soil will give a good idea of the variation in spacing encountered by using two different types of earth anchors. Type A-A and Type A. The Type A-A earth anchor is an earth auger with 8" minimum diameter auger and a minimum 5/8" diameter rod. A Type A earth anchor has a 6" minimum diameter auger with a minimum 5/8" diameter rod. Both types must have a minimum depth of 4 feet. The tables also relate to the wind velocity in miles per hour, the resultant pull on the earth anchors as a result of the wind velocity. The pull is in terms of pounds per lineal foot of mobile home length which is a rather convenient relationship. The anchor spacing is then given in terms of feet and the resulting total load per anchor type is shown. The 3/8" steel cable is sufficiently proper in all instances presented.

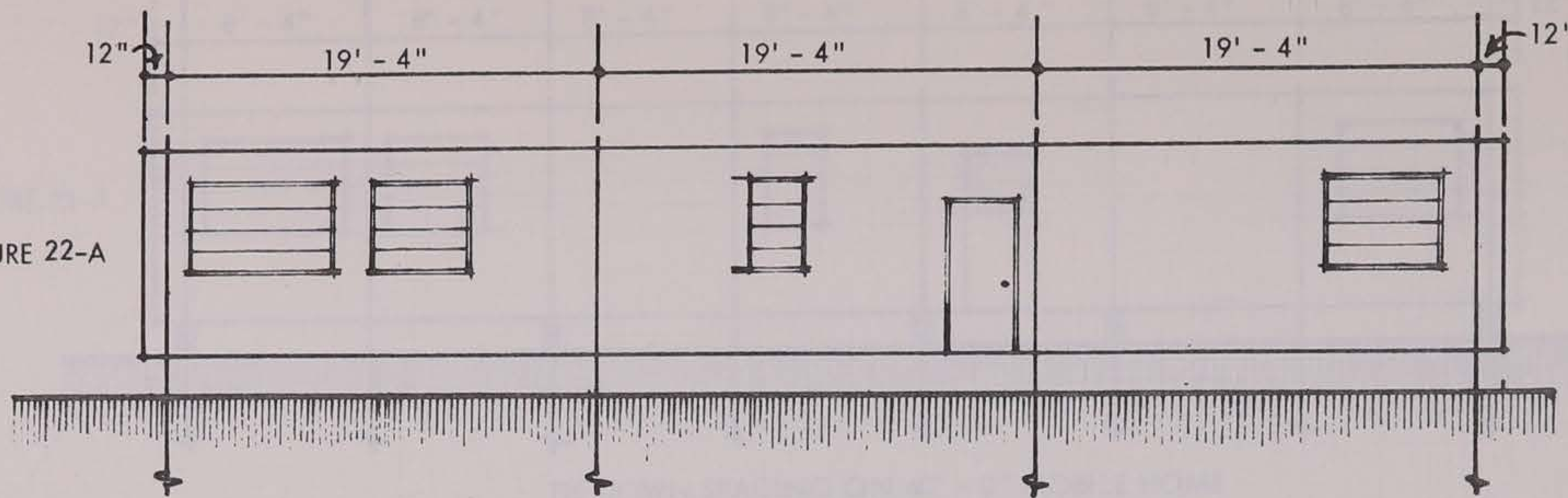
Tie-down systems are available from commercial sources. Among these sources are the Mobile Home Mooring, Incorporated, 195 South Pauline, Memphis, Tennessee 38104. They may also be obtained from the Minute Man Anchor Company of East Flat Rock, North Carolina.

The Mobile Home Information Service, Room 1204, 745 Fifth Avenue, New York, New York 10022 may also be of service in giving you information on other known manufacturers.

Figure 18 shows a commercially available tie-down set. Various components such as earth anchors, cables, clamps, turnbuckles, steel brackets can be obtained from various tradesmen. It is most convenient to purchase the sets already complete.

Figure 19 shows over-the-roof tie-down in place, as does Figure 20.

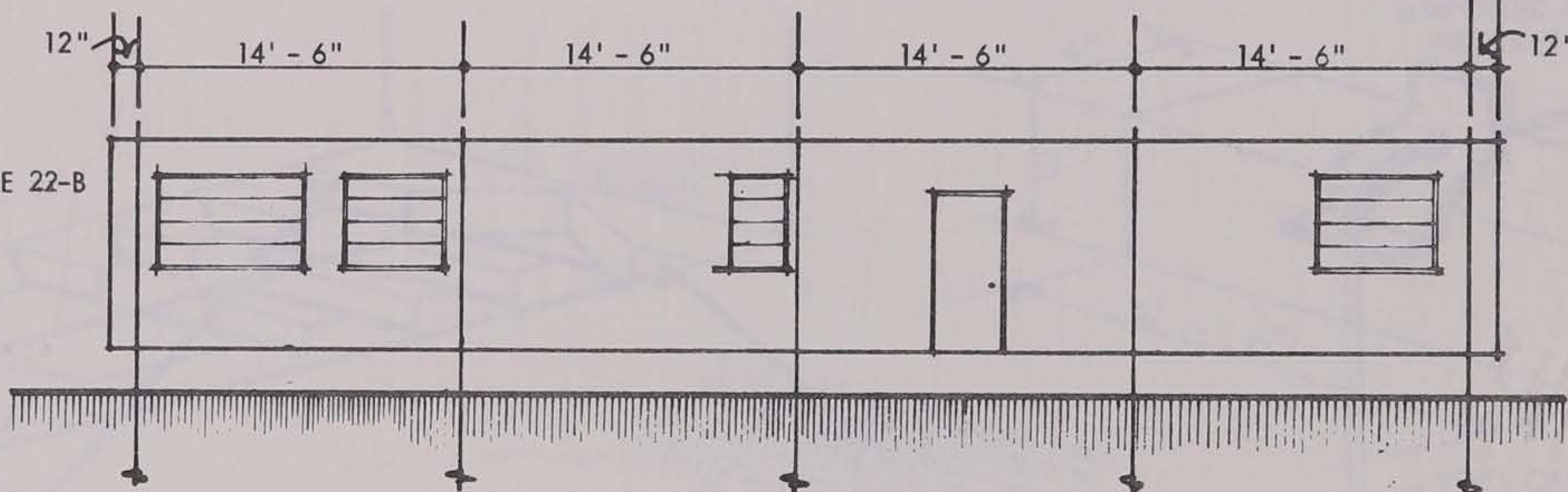
FIGURE 22-A



TIE DOWN SPACING ON 60' - 0" MOBILE HOME USING TYPE A - A ANCHORS IN STIFF CLAY RESISTING PRESSURES CAUSED BY 100 MILES PER HOUR WINDS. TOTAL LOAD 4,290 LBS PER ANCHOR.

TYPE A-A ANCHOR

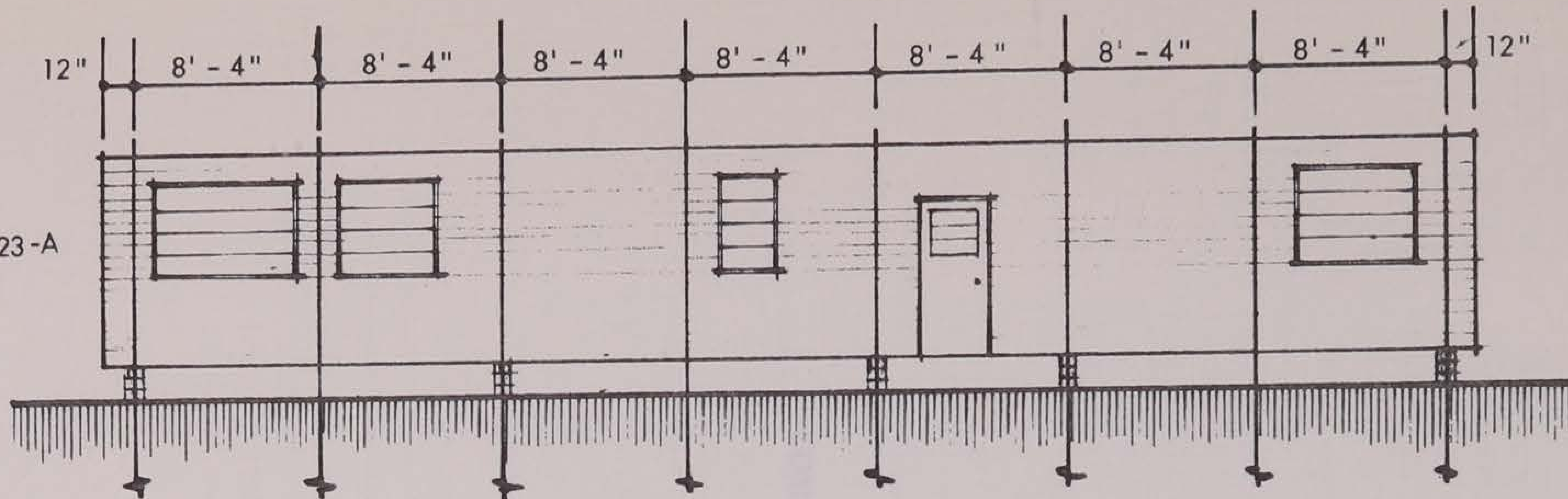
FIGURE 22-B



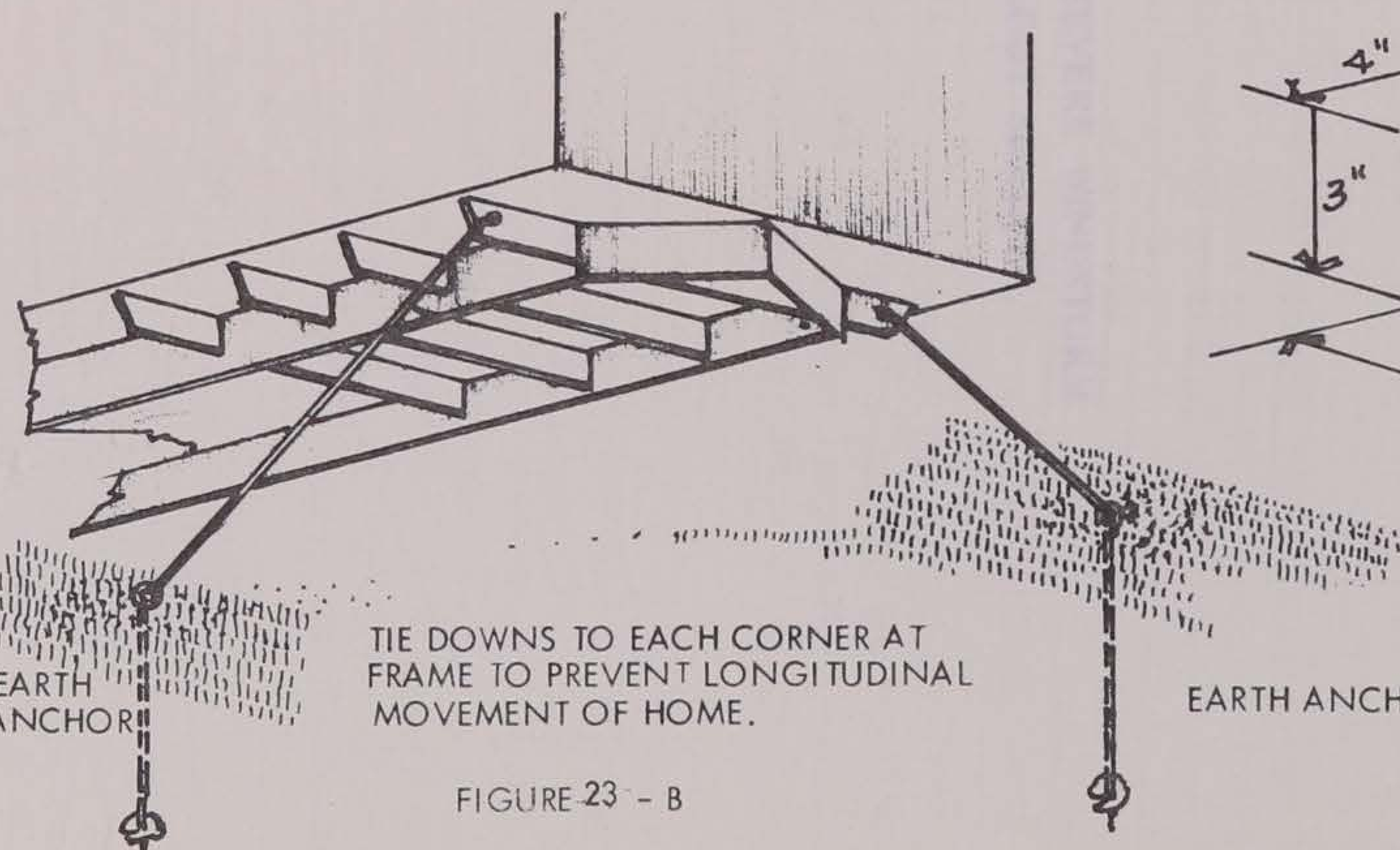
TIE DOWN SPACING ON 60' - 0" MOBILE HOME USING TYPE A - A ANCHORS IN STIFF CLAY SOIL BUT SPACED ON THE BASIS OF NOT EXCEEDING 100 MILE PER HOUR WINDS. RECOMMENDED PROCEDURE TOTAL PRESSURE 3,770 LBS PER ANCHOR.

TYPE A ANCHOR

FIGURE 23-A



TIE DOWN SPACING ON 60' - 0" MOBILE HOME USING TYPE A ANCHORS IN WET PLASTIC CLAY RESISTING 100 MILE PER HOUR WINDS. TOTAL LOAD PER ANCHOR 3,250 POUNDS. RECOMMENDED AS SHOWN ABOVE.



TIE DOWNS TO EACH CORNER AT FRAME TO PREVENT LONGITUDINAL MOVEMENT OF HOME.

FIGURE 23 - B

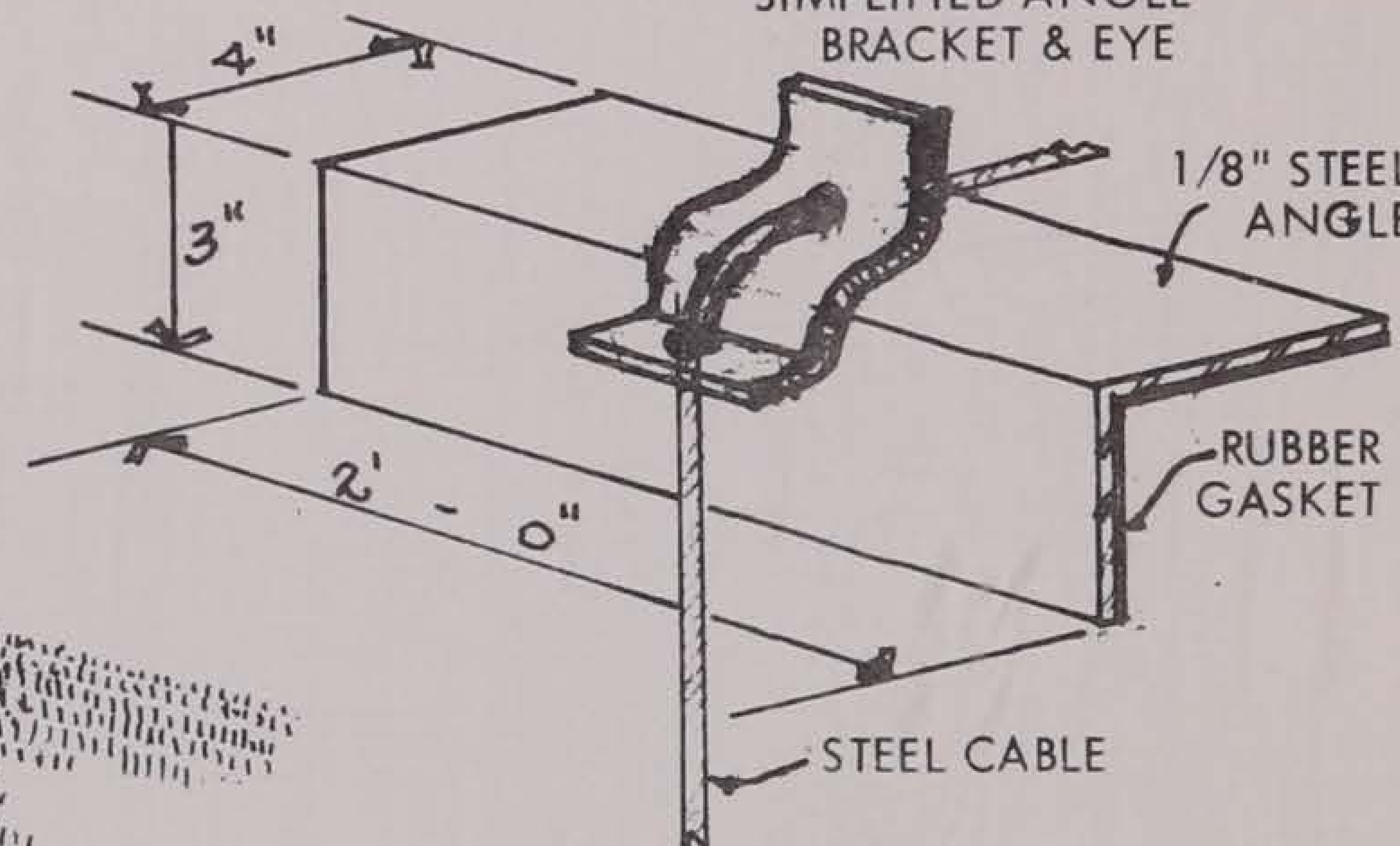


FIGURE 23-C

COMBINATION SEVERE WINDSTORM AND FALLOUT SHELTER

COMBINATION SEVERE WINDSTORM AND FALLOUT SHELTER

In the face of severe windstorms and nuclear hazards, citizens of unprotected mobile home residency are relatively defenseless. For this reason, it is felt one of the most effective means of offering protection for lives is the so-called "permanent type shelters", centrally located in the mobile home park. The shelter should be designed to withstand the worst possible storms. To the mobile home park with its relatively high concentration of population, a fine answer to the problem is a dual or triple purpose community building and shelter. The owners of such establishments are most emphatic in their belief that such a solution is a proper approach to the problem. This community shelter in their neighborhoods would prevent the traffic snarls, logistics problems, and inconveniences attendant to large scale evacuation. In the case of hurricanes, the National Hurricane Center in Miami, Florida could give about a 15-hour warning time. Any increase in warning time will not be significantly increased during the next decade because the state of the art is quite well advanced at present. In the case of tornadoes, the warning time would be even shorter and evacuation would be impossible. Thus, without a community shelter, people would be unprotected from tornadoes.

For a number of years now, the Department of Defense has been promoting the building and use of fallout shelters to protect our population against the effects of nuclear weapons. Fortunately, in many instances, the concentration of mass thickness in a shelter against high velocity windstorms will prove equally effective as a shelter against gamma radiation. Experience with radiation shelters has shown that about 10 square feet of area per person is necessary in order for basic survival to take place in a fallout shelter. This would also require a minimum of 65 cubic feet of space per individual shelteree. Most of these Department of Defense recommendations relate to a time stay inside the shelter of approximately fourteen days. After this time, it is felt the radioactive fallout would "decay" to the point where individuals might come out of the shelter for short periods of time until the decay process had run its course and persons could survive quite well outside once more. Of course, the shelter would be used for a much shorter time when protection from a severe windstorm is desired.

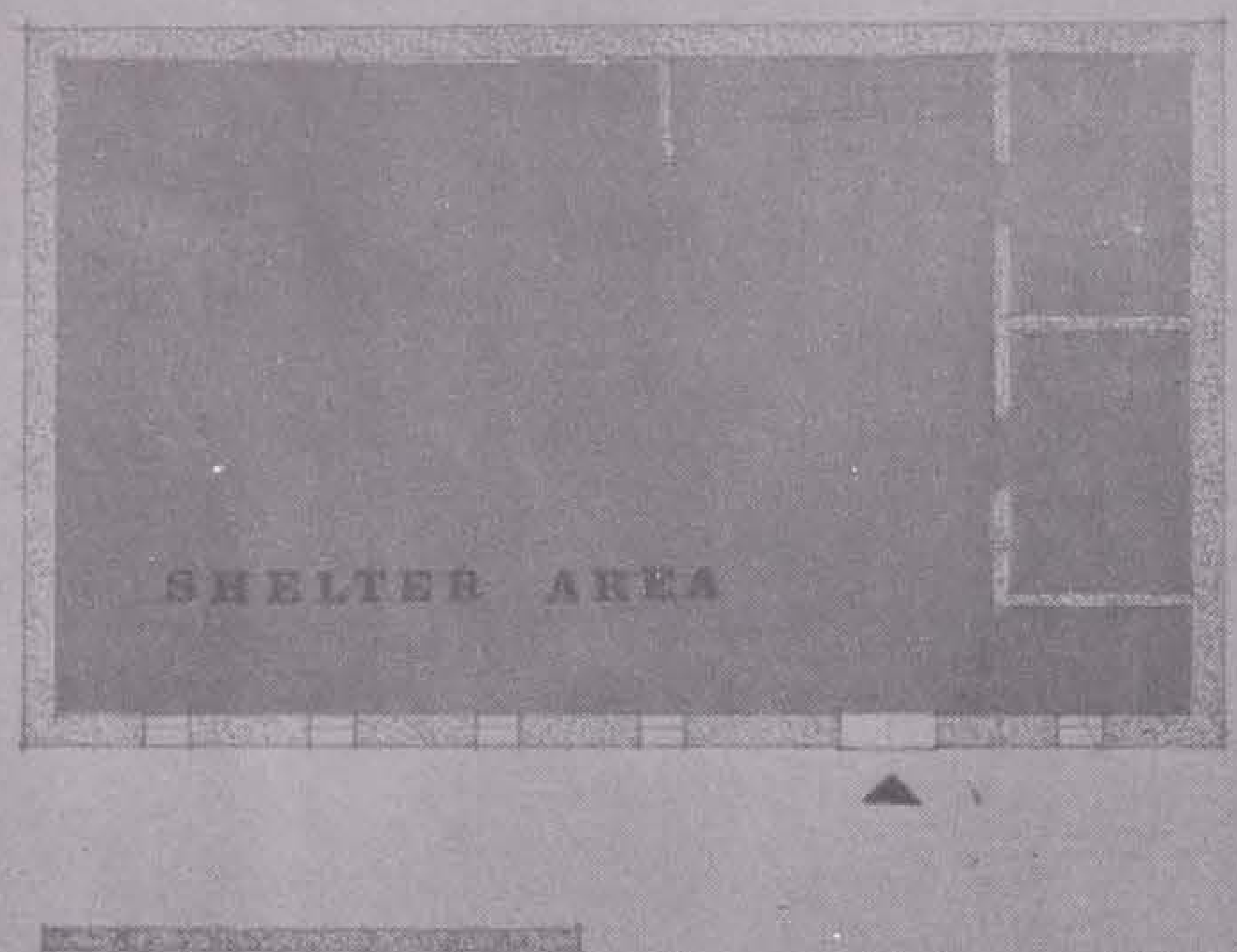
The primary shielding requirements for such shelters means in a simple sense that relatively heavy masses of material in the building work to separate the persons inside from the radioactive particles on the outside. This had demanded somewhat heavy walls, a few heavy partitions inside the building, a minimum of window area that allows radiation to enter the sheltered area, window sills of three feet or higher, the use of adjacent barriers such as other buildings nearby, sloping ground that runs downhill from around the shelter, and various other shielding characteristics. Fortunately, the type of construction discussed above for radiation shielding will usually be effective in protecting people from severe windstorms.

Let us take, for example, the type of shelter that might work for citizens of a mobile home park community. First of all, it should be centrally located within the park allowing easy access by all citizens. The following is an example of the Lazy R Mobile Home Park where the operators, Mr. and Mrs. Glen Holt were interested in getting a dual or triple use from the shelter space. They had a hill located near the center of the mobile home park and this hill, on the downward side, faced north and looked upon a goodly portion of the park. They felt it might be a fine spot to erect a shelter and possibly later a house for his family. The idea was presented to them by Civil Defense officials to consider a shelter in the basement area for use against both high winds and fallout. It was pointed out to them that current practices in the realm of reinforced and prestressed concrete materials would allow the economical purchase of four foot wide reinforced prestressed concrete slabs. These could be ordered exactly the width of the basement. See Figure 25. In this case, the width of the basement was about 24 feet long. The thickness of the slab would be 10 inches, with a 2 inch concrete topping for a smooth floor for the future residence. It was further shown that these precast-prestressed concrete units had hollow cores. These cores could be used for running electrical wire conduit, water pipe, and even could be used as heating ducts if main trunk supply duct were attached in a direct manner. This phenomenon opened up a new trend of thought and with the aid of Civil Defense expertise, they finally decided to go on with the project. First, they would construct the basement shelter using it as a recreation room, social hall, and wind and fallout shelter in time of emergency. They would cover the Shelter with the aforementioned concrete precast, prestressed units. They have this completed at present. See Figure 24-A. When their decision warrants, they can come in and erect a residence over the shelter and even make the residence larger by having no basement under the dining room and kitchen to the south. The residence is shown by Figures 24-B and 26 as one possible solution. Also included in the shelter is a separate shower, lavatory, and water closet for men and women. They installed a small kitchenette for the preparation of food. Other elements include a furnace and a water heater. The shelter includes 836 square feet of space. This gives tornado shelter to the 125 residents and would accommodate 75 persons against radioactive fallout. The windows of the shelter were narrow with sills not lower than 3 feet above the finished shelter floor. There was one door installed on the same side as the windows. The other three sides were set into the side of the hill and offered excellent protection because of this arrangement. The walls were made of 12" reinforced concrete, although they might have been a bit thinner because of the protection offered by their being depressed in the ground. Shielding the windows, in the event of wind-blown debris or radioactive fallout, is a reinforced concrete support in the form of a wall about 10 feet long and placed out in front of the window wall approximately 8 feet. This serves the function of supporting an outdoor deck which will lead off of the living room when the residence is constructed. A contemporary residence concept to set above the shelter is shown in Figures 24, 25 and 26, and includes a spacious living room with fireplace, a dining room open to lovely landscaping on the south. Adjacent to the dining room is a kitchen. Leading off a central hall area just inside the front entry is a rather short stair leading to a master bedroom and a children's bedroom. These, in turn, are very close to a functional bathroom. Off the east part of the dining room and still under cover of the residence roof is a stair leading down to the shelter. The thick floor design in addition to giving fine shelter, also had wonderful properties for shutting out the noise that might be generated from the recreation-shelter area below. It has been reported that within the year it has operated, the shelter-recreation room has been used over a dozen times during severe windstorms. The mobile home owners and residents are extremely pleased with its performances and the peace of mind it brings to the people. The Protection Factor of this shelter is well above the 40 required by the Department of Defense for minimum protection against radioactive fallout.

Not related to the above situation, but well conceived and relating to the surrounding mobile home park is an excellent shelter situated in Cloverleaf Mobile Home Park at St. Cloud, Minnesota, Figures 27 and 28. It is a combination Storm Shelter, Fallout Shelter, and Recreation Center. Other shelters of a similar type are being constructed in a few progressive mobile home parks today. There is an urgent need for their adoption in all mobile home parks throughout the country.

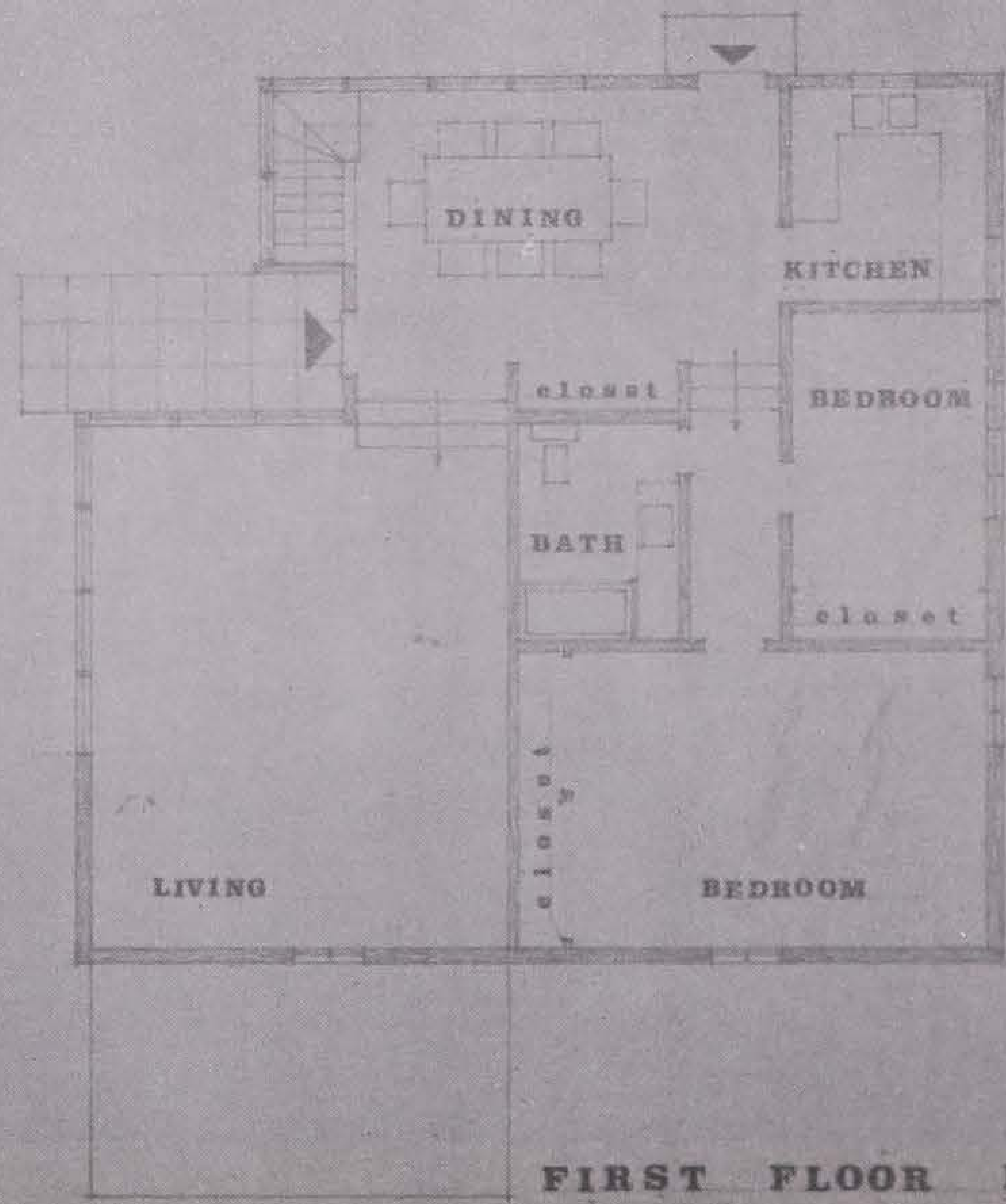
SHELTER AND RESIDENCE

Located in a central part of this Mobile Home Park is an excellent triple purpose shelter. It is the owners basement social hall, severe wind, and fallout shelter. All citizens use it. Built of 12" reinforced concrete walls, its ceiling is of 10" cored slabs and 2" poured slab. It boasts a kitchen, 2 baths, and mechanical room. Mobile home citizens gain safety during natural dis-aster. Other typical functions like beauty and barber salons, laundromat; offer alternate possibilities.



BASEMENT PLAN

Figure 24-A



FIRST FLOOR PLAN

Figure 24-B

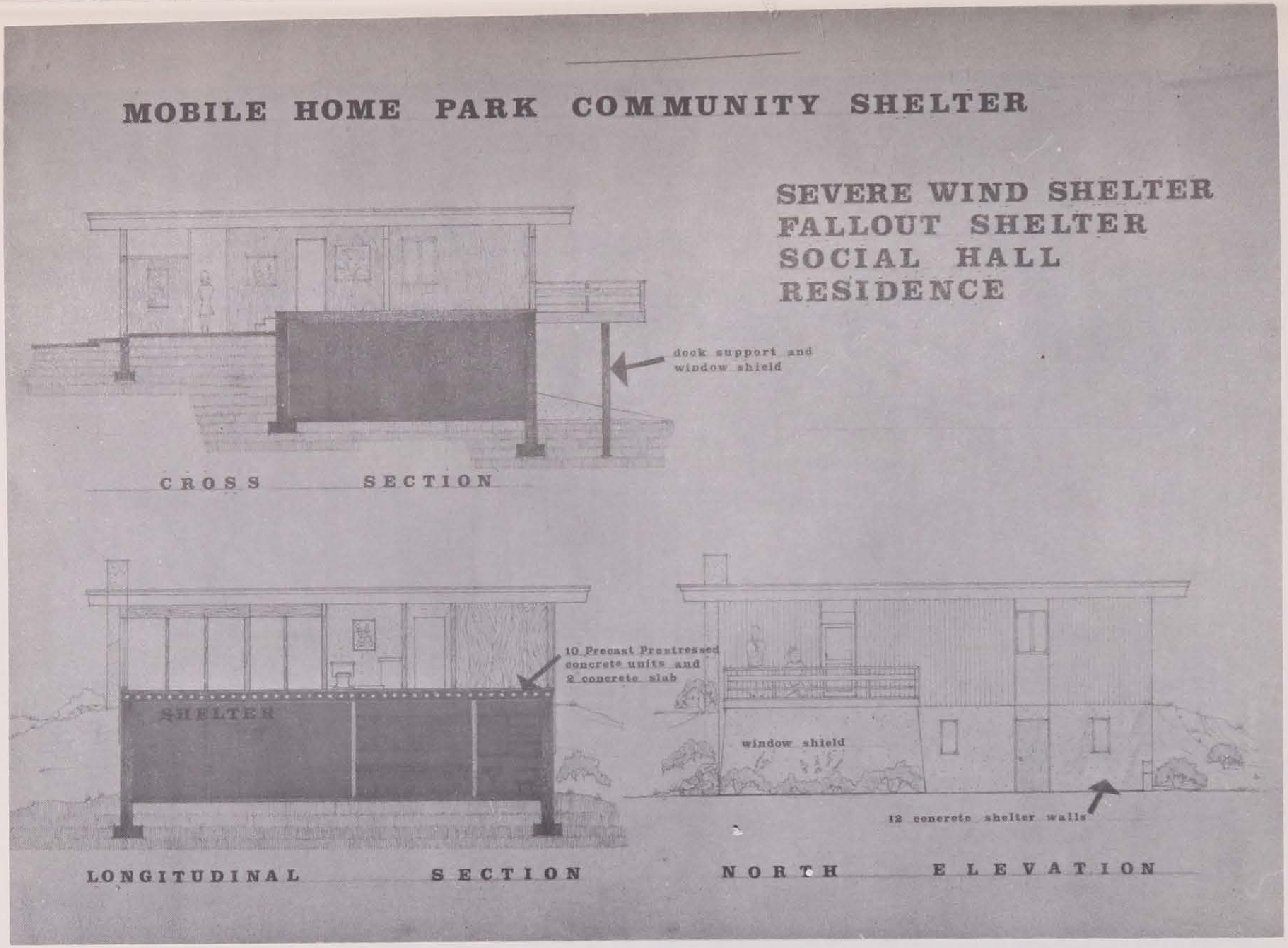

MOBILE HOME PARK COMMUNITY SHELTER
SEVERE WIND SHELTER
FALLOUT SHELTER
SOCIAL HALL
RESIDENCE
deck support and
window shield
CROSS SECTION
10 Precast Prestressed
concrete units and
2 concrete slab
SHELTER
window shield
12 concrete shelter walls
LONGITUDINAL SECTION
NORTH ELEVATION

Figure 25

SHELTER AGAINST RADIOACTIVE FALLOUT AND HIGH WINDS IS LOCATED IN BASEMENT OF MOBILE HOME OWNERS RESIDENCE, WHICH IS CENTRALLY LOCATED IN HIS MOBILE HOME PARK.

CONSTRUCTION FEATURES:

- 12" thick reinforced concrete basement walls
- 10" thick Precast Prestressed concrete floor units hoisted into place plus 2" concrete topping
- shelter set into side of hill
- balcony support shields windows
- 1/2" painted steel window shutter shields

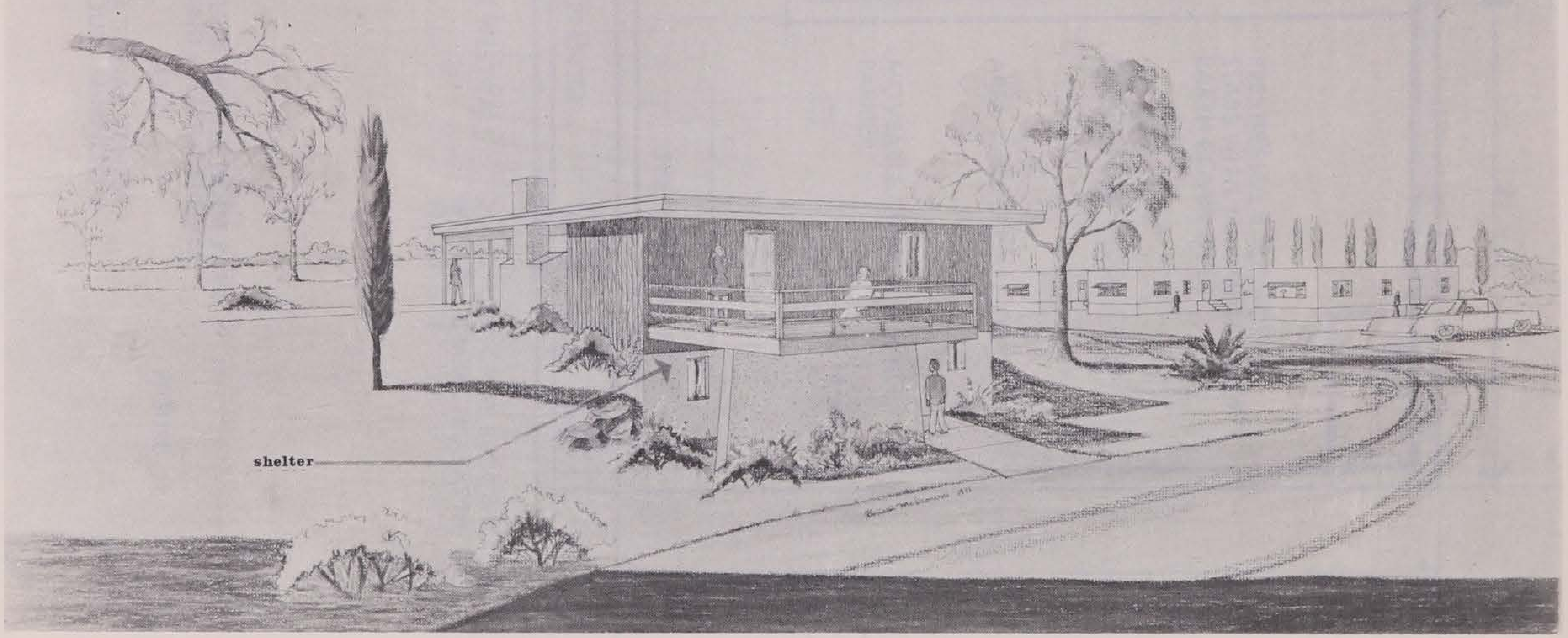
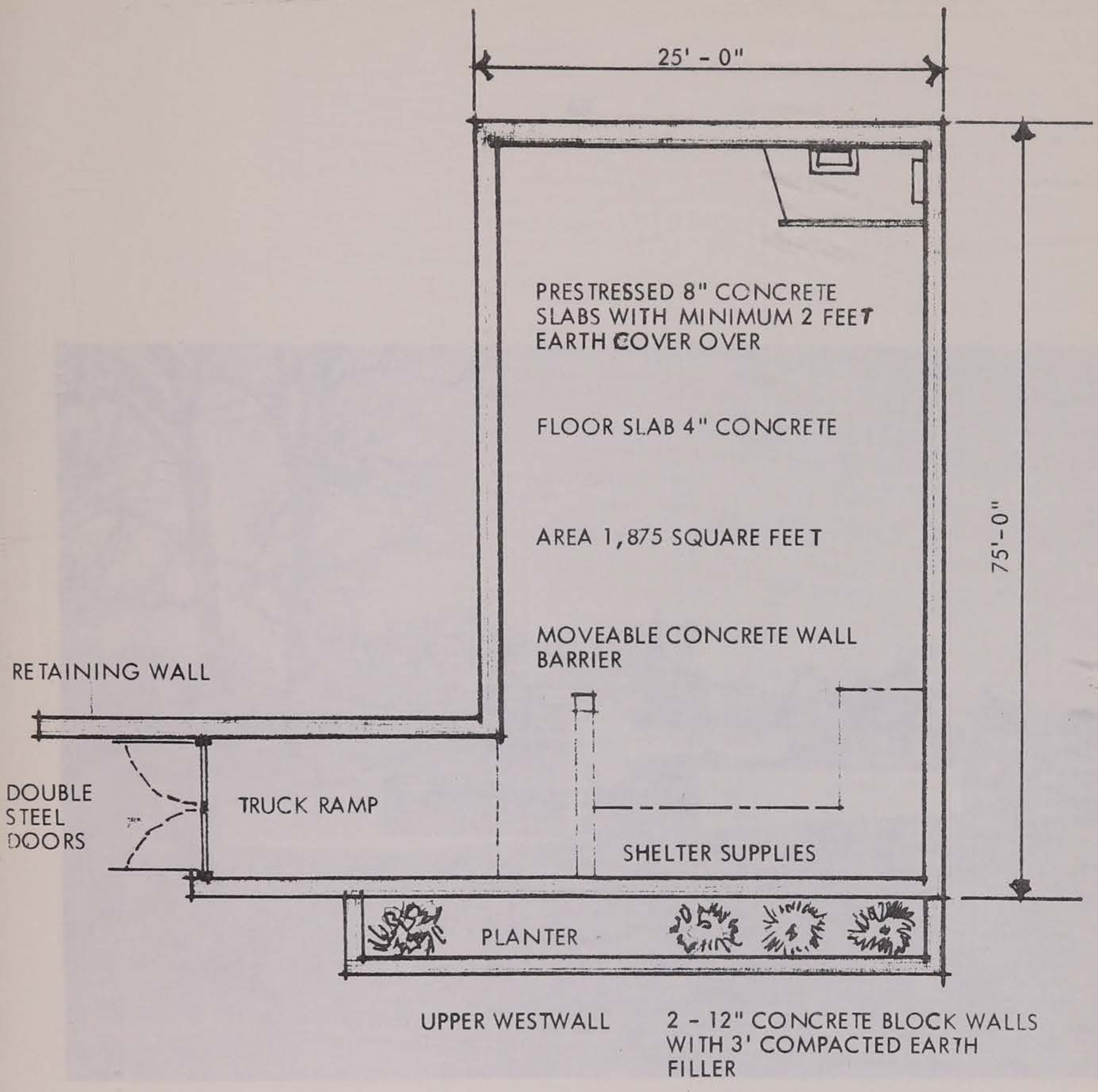


Figure 26



CLOVER LEAF MOBILE HOME PARK
STORM AND FALLOUT SHELTER
AND
RECREATIONAL CENTER
ST. CLOUD, MINNESOTA

FIGURE 27

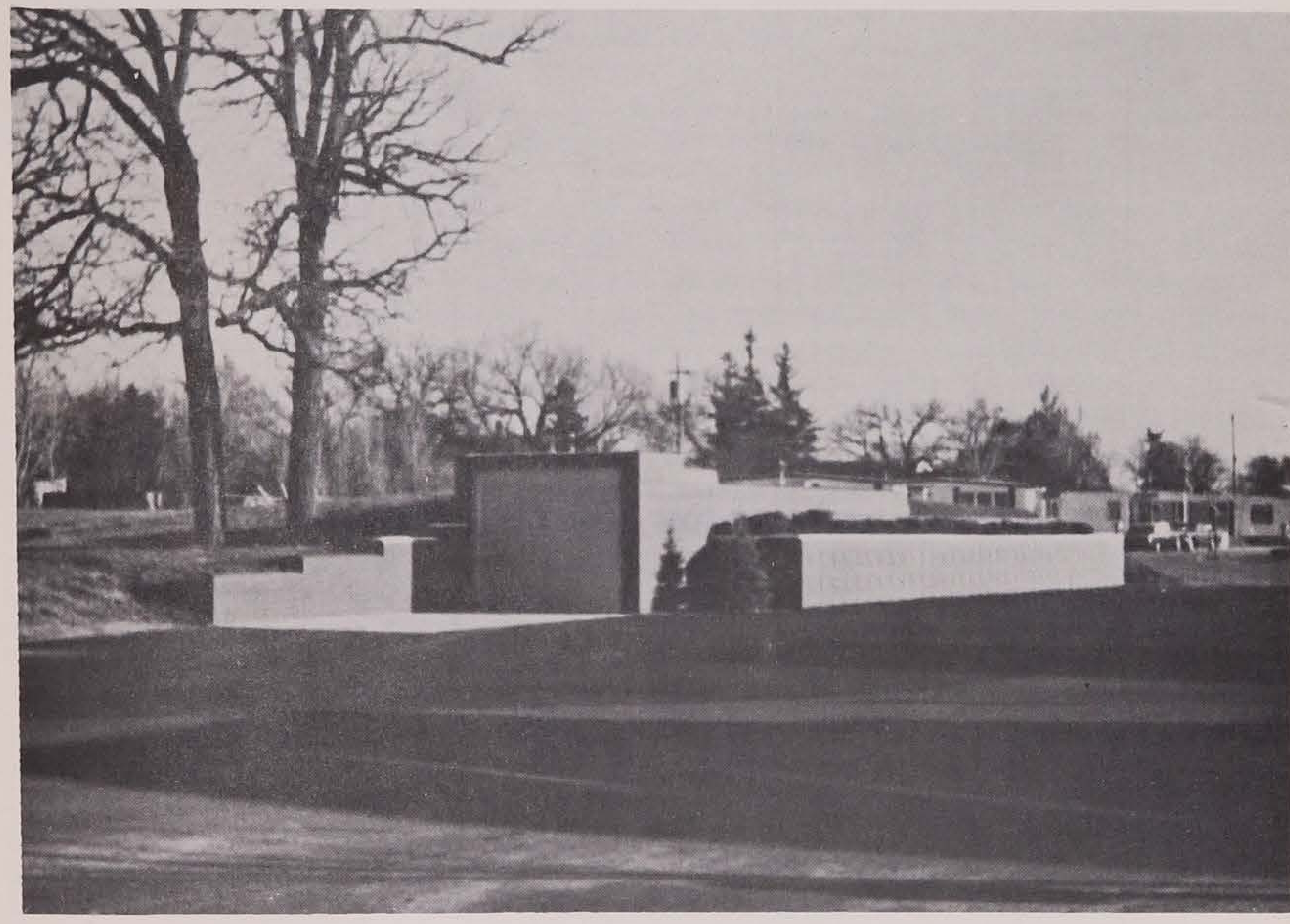


Figure 28

EXPEDIENT SHELTER IN MOBILE HOME COURTS

EXPEDIENT SHELTER IN MOBILE HOME COURTS

With the number of persons living in mobile homes increasing with great rapidity, it is worth consideration to dwell on a few approaches that might be taken to provide expedient shelter in these homes.

Most estimates for the year 1972 claim that one out of every five new homes built in the United States will be a mobile home. In rural areas, the bulk of all new housing is in mobile homes. It is fair to say that many of these mobile homes will be located within mobile home parks and courts. It is also fair to say that most of these mobile home parks and courts will not have fallout shelters of a heavy, rugged, and permanent nature. It is important that these citizens at least be aware of a variety of ways within their means in which they might construct so-called "expedient shelters" in case of emergency. This type of emergency would relate specifically to fallout shelter against the effects of radioactive fallout. It does not relate to natural disaster caused by high velocity winds.

It has been estimated that about half of all mobile homes sold will be placed on rural or small-town lots. Between one quarter and one half of the new mobile homes will go into mobile home parks. From such estimates, it can be readily seen how important the need for expedient shelter information becomes for these persons. These new mobile home parks are a far cry from the unsightly clusters of house trailers which are still evident on the outskirts of many cities. These new mobile home parks are more like small subdivisions, complete with landscaping. They are becoming a big business. These parks are primarily of two kinds. One type tends to locate in rural or resort areas and feature community centers, swimming pools, tennis courts, golf courses, and similar assets. The older persons tend to prefer this type of location. The second type is located quite close to urban areas. It has a minimum of facilities and its occupants prefer close proximity to work. They also prefer the relatively low cost and are interested primarily in economical shelter.

It is felt a mobile home occupant, in case of extreme emergency for survival, could prepare an adequate shelter by accomplishing the following procedures. These are suggested on the basis of having most of the necessary materials readily on hand. 1. The owner could build a skirt around the lower portion of the mobile home, if he does not already have one in place. 2. He could then use this skirt as a retaining wall and shovel dirt against the skirt. This, in essence, would be an earth berm capable of attenuating gamma radiation on a direct line at ground level through the space under the mobile home. See Figures 29 & 30. The third step would be to place a layer of visqueen type plastic or other thin membrane on the floor of the mobile home and shovel a rather uniform thickness of sand or soil onto the floor of the home. This soil layer should be a minimum of 8" in thickness. See Figure 30.

If one were to consider the size of a mobile home similar to that given on page 66 with a length of 60 feet and a width of 12 feet, we could proceed as follows: if the soil weight were on the average of ten pounds per square foot per inch of thickness, we would have a weight of 80 pounds per square foot with 8 inches of soil thickness. We could assume the mass thickness of the roof would be approximately 5 pounds per square foot. The floor mass thickness would be in the realm of 10 pounds per square foot. If we assumed the ground contribution of gamma radiation were negligible, the resulting Protection Factor would be approximately 40 at the bottom edge of the mobile home

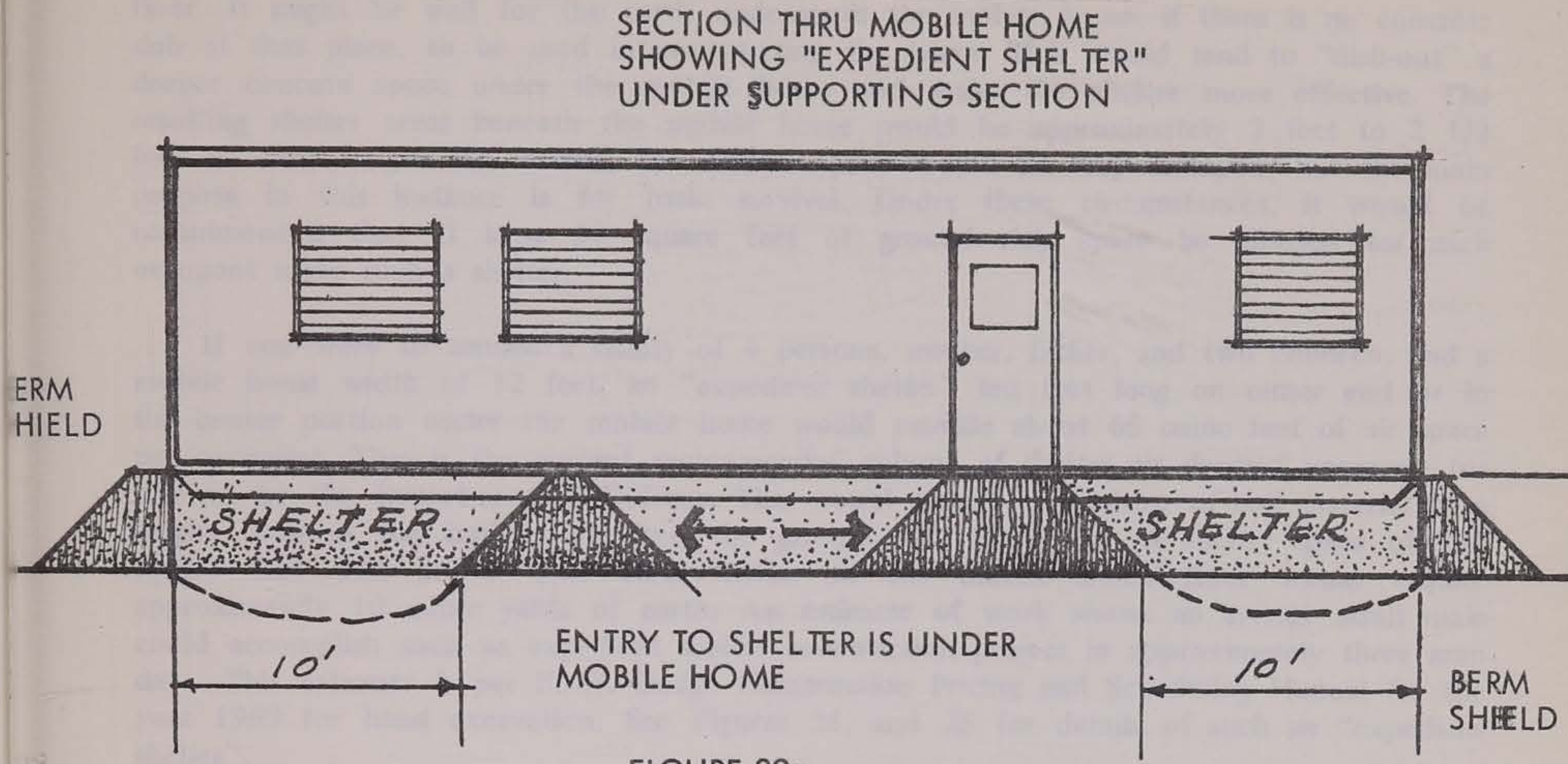
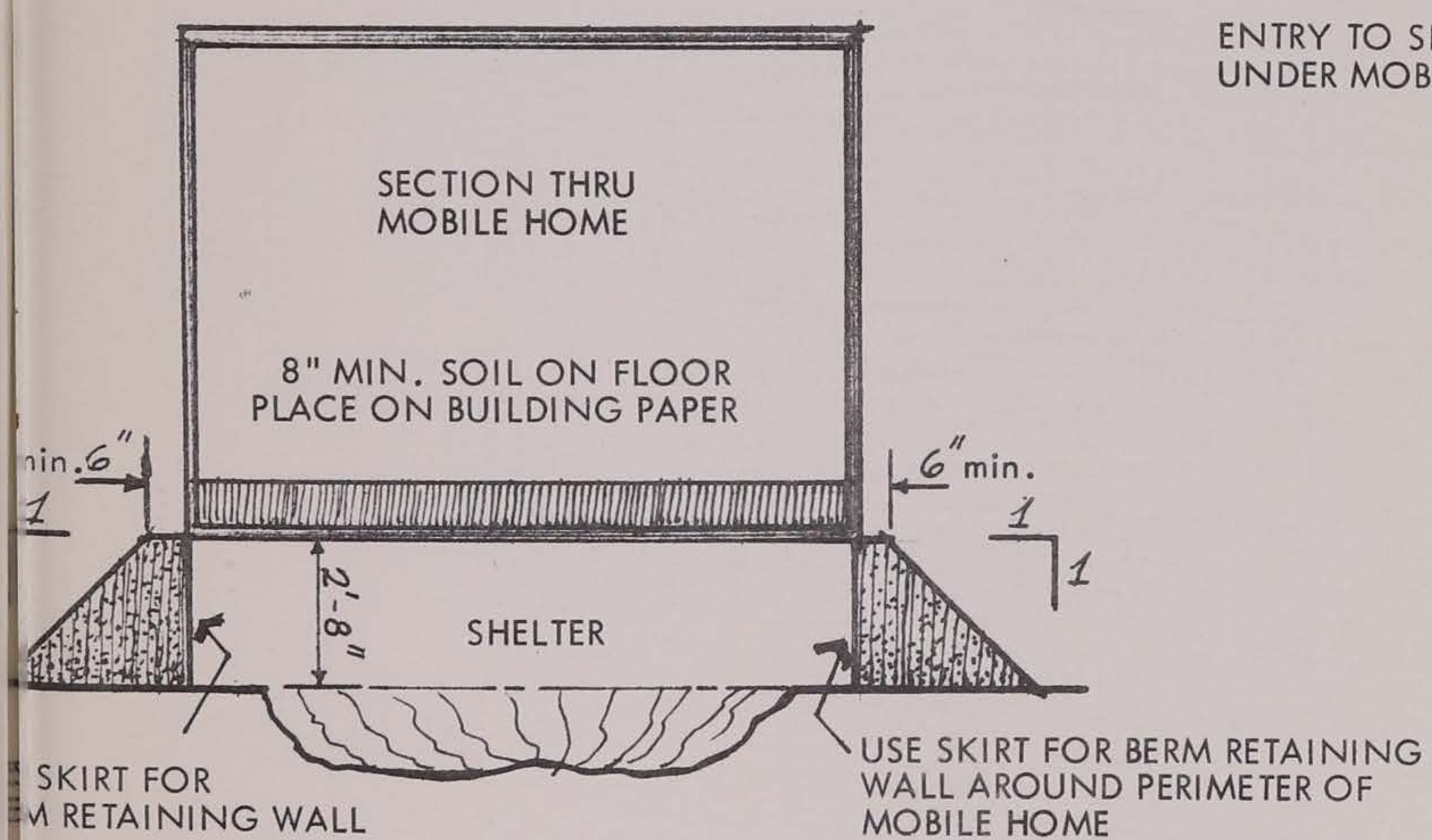


FIGURE 29



EXPEDIENT FALLOUT SHELTER DETAILS

FIGURE 30

floor. It might be well for the earth underneath the mobile home, if there is no concrete slab at that place, to be used in constructing the berm. This would tend to "dish-out" a deeper concave space under the mobile home and make the shelter more effective. The resulting shelter areas beneath the mobile home would be approximately 2 feet to 2 1/2 feet in clear height. Of course, the shelter space would be very cramped, but the main purpose in this instance is for basic survival. Under these circumstances, it would be recommended that at least 30 square feet of ground slab space be allotted for each occupant using such a shelter.

If one were to assume a family of 4 persons, mother, father, and two children, and a mobile home width of 12 feet, an "expedient shelter" ten feet long on either end or in the center portion under the mobile home would provide about 65 cubic feet of air space per occupant. This is the current recommended volume of shelter air deemed necessary for survival by the Department of Defense. This would require a windrow of soil material of a height between the trailer floor and the ground. See Figure 29. A shelter space of 120 square feet and an 8 inch earth cover on the mobile home floor would require approximately 10 cubic yards of earth. An estimate of work shows an average adult male could accomplish such an expedient shelter construction project in approximately three man days. This estimate is per F. W. Dodge Construction Pricing and Scheduling Manual for the year 1969 for hand excavation. See Figures 24, and 25 for details of such an "expedient shelter".

RECOMMENDATIONS

RECOMMENDATIONS

As a result of this Case Study, the following recommendations are presented in the belief that many lives will be saved and many dollars of property damage will be prevented if they are followed by mobile home owners and mobile home park owners.

1. It is recommended that mobile homes be anchored with suitable tie-down systems.

2. Piers supporting the mobile home frame should be of concrete block with cores vertical and reinforcing rod, 1/2" diameter, running from footing of concrete up through center core of block. Core should then be filled with concrete or masonry cement. This will give a stable type pier.

3. Concrete footing should support piers. If 4" minimum thickness of footing is used, it is recommended that 6-6/10-10 steel wire mesh be used in footing as reinforcing. Extend one rod up through center cores of concrete block that will rest on footings.

4. Shimming between pier and steel frame should be of treated wood or steel sheets. Shim very tightly to prevent rocking of mobile home under action of severe winds.

5. Use auger type ground anchors and imbed in earth a minimum of 4 feet. Various soils present various pullout resistances. See table in this study for proper spacing of tie-down units.

6. Ties passing over the mobile home may be steel strapping that is galvanized or zinc coated of a size 0.185 sq. in. Steel cable may be used and shall be either 3/8" diameter cable 7 x 7 - 7 strands of 7 wires each of 1/4" diameter or larger aircraft cable 7 x 19 - 7 strands of 19 wires each. Ties passing over coach should pass over metal brackets each of 2 foot length and a minimum of 3 inches bearing width to transfer loads from cables to mobile home frame in an evenly distributed manner.

7. Longitudinal movement should be resisted by a tie-down cable to the frame at each corner of the mobile home. (See Figure 23-B) The corner earth anchor eyelets can serve as the anchoring for these shorter type cables.

8. If skirts are used around periphery of mobile home at ground level, they should be of a free standing type and not fixed to the coach. Preferably they should allow air to pass through them with relative ease.

All mobile homes shall be anchored and tied down in a manner equivalent to or better than the following on or before this date, as follows:

MINIMUM ANCHORAGE REQUIREMENTS FOR HURRICANE OR SEVERE WIND

<u>NUMBER OF TIES.</u>

A. Up to 30' mobile home length - 3 frame ties per side
B. 30' to 40' mobile home length - 3 frame ties per side
C. 40' to 50' mobile home length - 4 frame ties per side

D. 50' to 60' mobile home length - 5 frame ties per side
E. 60' to 70' mobile home length - 6 frame ties per side
F. 70' over mobile home length - 7 frame ties per side
G. Also separate tie from each corner of ground anchor to frame in order to resist longitudinal movement of home

ANCHORS. Soil test to assure that following will withstand 3750 pounds of pull per 10 feet of mobile home length.

A. Auger of dead man, 6" in diameter—Arrowhead anchor 8" in diameter.
B. Auger or Arrowhead depth to be 4 feet and a Dead Man Anchor to be 5 feet in depth. All augers must be screwed into the earth a full 4 foot depth.
C. Anchor rod to be 5/8 inch diameter with welded eye at the top. It must be hooked into concrete when used in dead man anchors.
D. Anchors to slabs must equal above in pull resistance.

CONNECTORS.

A. Galvanized or stainless steel cable—3/8" (7 x 7 - 7 wires each,) or;
B. Galvanized aircraft cable 1/4" (7x 19 - 7 strands of 19 wires each)
C. Steel strap 1 1/4" x .035" galvanized, with tensioning device.
D. Cable ends secured by 3 "U" bolt clamps.
E. Steel rods 5/8" with ends welded closed to form an eye.
F. Turnbuckles 5/8" drop forged—closed eyes. Other tensioning devices of similar strength approved.

PIERS AND FOOTINGS.

A. Spaced at 10' intervals on both frame rails with end ones no further than 5' from end of mobile home.
B. Footings of solid concrete 24" x 24" x 4" or 16" x 16" x 4".
C. Piers of standard 8" x 16" concrete block either solid or middle core with reinforcing rod anchored to footing and filled with concrete or masonry cement, fully.
D. Wood blocks used for leveling not to exceed maximum thickness of 4 inches.
E. Other equivalent piers accepted. An adjustable screw-anchor type column fastened to frame rail and to concrete pad is also recommended.

PATIO AWNINGS AND CABANA ROOFS.

A. Two rows of vertical support bars—spacing 12 feet. Second row to be down middle or at mobile home edge, anchored to concrete floor or equivalent footings.
B. Other structures on lot must be secured.
C. Tip-out rooms to be held by over the home tie at outer edge.
D. Clerestory roof requires over the home tie at end of each raised section.

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RECOMMENDED MODEL CODES

Two model codes are presented. Model Code No. 1, patterned after American Insurance Association Code, is in considerably more detail. It is intended to serve those officials who wish to concern themselves with specification information on the Mobile Homes as well as the Tie-Down considerations.

Model Code No. 2 is patterned after the Corpus Christi, Texas Code and is intended to relate more specifically to Tie-Down requirements only.

Both Model Codes are presented with the idea in mind that officials should study them and encourage the adoption of similar codes in their areas. Corpus Christi, Texas is one city that has already acted in this regard.

Recommended Model Code No. 1

This suggested Ordinance is intended for adoption in those areas subject to severe wind conditions in the order of hurricane intensity or 75 mile per hour to 125 mile per hour magnitude. This would include Gulf Coast, Atlantic Coast, and Mid-West States subject to such high velocity winds. It is not intended to protect against winds of tornado velocities which need special consideration. However, significant protection against the peripheral winds of tornadoes can be effected through adherance to this Ordinance.

The information contained in this publication was obtained from sources believed to be reliable. There is no intent to make any guarantees of results and no liability is assumed in connection with either the information herein contained, or the suggestions herein made. Moreover, it cannot be assumed that every pertinent precaution or procedure is contained herein; or that abnormal or unusual circumstances may not warrant or require further or additional precautions or procedures.

AN ORDINANCE PROVIDING FOR SAFETY, HEALTH, AND PUBLIC WELFARE IN MOBILE HOMES LOCATED IN AREAS SUBJECT TO SEVERE WIND CONDITIONS THROUGH STRUCTURAL STRENGTH AND ANCHORAGE AND PROTECTION TO LIFE AND PROPERTY FROM FIRE AND HAZARDS INCIDENT TO DESIGN, CONSTRUCTION, AND INSTALLATION OF APPLIANCES AND SYSTEMS

SECTION 1. PERMITS.

No mobile home, as defined in Section 3 of this Ordinance, shall be located or occupied except by permit from ______________________________

____

The permit shall be valid for one year from date of issue and shall be revocable for cause. Application for permit shall be submitted in a form prescribed by ______________

____

The application shall contain the full names and addresses of the applicant and of the owner and, if the owner is a corporate body, of its responsible officer. The application shall also state the manufacturer and model of the unit, its design live loads, and location in the parking facility. No permit shall be issued until provisions of this Ordinance have been complied with and approval has been obtained from the ______________

____

Note: The blanks should be completed by inserting the name of the department, division, or bureau of the local government.

SECTION 2. APPLICATION OF ORDINANCE.

The provisions of this Ordinance apply to structural strength and anchorage, equipment and systems, use, occupancy, and maintenance of mobile homes and of their appurtenances, such as patio roofs, awnings, shutters, located within the municipality. Compliance with the following sections is not intended for existing mobile homes:

Section 5 (c)	Design Loads
Section 5 (d)	Rigidity
Section 8	Roof Covering
Section 9	Light and Ventilation
Section 10	Exits
Section 16	Plumbing

SECTION 3. DEFINITIONS.

(a) Approved, as applied to a material, mode of construction, equipment, device, occupancy, or use, means approved by the enforcing official in accordance with the provisions of this Ordinance, or by other authority designated by law to give approval on the matter in question.

(b) Court means an open, uncovered, unoccupied space on the same site with the mobile home.

(c) Existing mobile home means a mobile home that was positioned on supports on a parcel of ground in accordance with zoning and other municipal ordinances prior to the effective date of this Ordinance.

(d) Habitable room means a room or enclosed floor space arranged for living, eating, food preparation, or sleeping purposes, not including bathrooms, water closet compartments, laundries, pantries, foyers, hallways and other accessory floor areas.

(e) Mobile home means a vehicular, portable unit built on a chassis and designed to be used without a permanent foundation as a dwelling unit when connected to utilities. The phase "without a permanent foundation" indicates that the support system is constructed with the intent that the mobile home placed thereon will be moved from time to time at the convenience of the owner.

(f) Public Place means a thoroughfare more than 21 feet in width which is dedicated to a governmental body maintaining accessibility to fire department vehicles and other public services.

(g) Publicway means a thoroughfare on privately owned, privately maintained property but designated for public use and which by agreement is kept accessible at all times to the fire department and other public services.

SECTION 4. INSPECTIONS.

(a) Inspection required by the provisions of this Ordinance shall be made by the enforcing official or his duly appointed assistant. The enforcing official may accept reports of inspectors of recognized inspection services, after investigation of their qualifications and reliability. No permit required by any provision of this Ordinance shall be issued on the basis of such reports unless the reports are in writing and certified to by a responsible officer of such service.

(b) The enforcing official shall make a reinspection of electrical wiring systems, electrical supply and grounding facilities, heat producing appliances and systems, roof jacks, vents, gas piping systems, liquid fuel piping systems, and anchorage systems whenever deemed necessary in the interest of public safety.

(c) If an electrical wiring system, electrical supply and grounding facility, heat producing appliance, roof jack, vent, gas piping system, liquid fuel piping system, or anchorage system is found to be defective or unsafe, the enforcing official shall revoke the permit, or, depending upon the degree of the hazard, may permit occupancy for a reasonable length of time to allow for removal of the hazard and for corrective action. If any defective system, appliance, roof jack, or vent is not repaired, replaced, corrected or installed to conform to this Ordinance within a reasonable length of time, as fixed by written order of the enforcing official, the mobile home may not be occupied until made to conform to this Ordinance.

SECTION 5. STRUCTURAL REQUIREMENTS.

(a) Workmanship in the fabrication, preparation, and installation of units, materials, appliances, devices, or systems shall conform to generally accepted good practice, and shall be reasonably safe to persons and property. Specific provisions of this Ordinance shall not be deemed to suspend any requirements of good practice and safety to persons and property but shall be regarded as supplementing or emphasizing them, and shall be controlling.

(b) In case there is a reason to question the safety of a floor, roof, wall, or other structural part of a mobile home before a permit has been issued, the enforcing official may require load tests or other suitable tests to determine the acceptability of the unit or of the structural component. Such tests shall be made with the superimposed load equal to not less than twice the design live load, and within 24 hours after the load is removed, the assembly shall recover at least three quarters of the maximum deflection.

(c) Design loads.

(1) Floor assemblies shall be designed and constructed to support a live load of 40 pounds per square foot of area uniformly distributed with any deflection of structural members not to exceed 1/360 of the span. In addition, but not simultaneously, roof assemblies shall be able to support a concentrated load of 200 pounds placed upon a 2-inch diameter disk at the most critical location with a deflection not to exceed 1/240 of the span of any structural member or of 1/12 of an inch of the roof sheathing between ribs. Roof assemblies shall be capable of withstanding an impact load, on the outer surface, of a 10 inch diameter sandbag weighing 60 pounds which when dropped 3 feet results in no breaking through of the roof sheathing.

(2) Overhanging eaves, awnings, or similar projections attached beyond the exterior walls of mobile homes shall be designed and constructed for a live load of 70 pounds per square foot uniformly distributed, acting upward normal to the sheathing or deck surface with a deflection of structural members not to exceed 1/180 of the span. In addition, but not simultaneously, the sheathing and its structural members shall be able to support a concentrated load of 200 pounds placed upon a 2-inch diameter disk at the most critical location with a deflection not to exceed 1/180 of the span of any structural member or of 1/4 of an inch of any sheathing between ribs. The sheathing, structural members, and the complete projection shall be capable of withstanding an impact load, on the upper surface, of a 10-inch diameter sandbag weighing 60 pounds, which when dropped 3 feet results in no breaking through of the sheathing or failure of the structural members. Structural members shall be designed and constructed to transfer the uplift load to the walls and to the tie-down connections with any deflection not to exceed 1/180 of the span.

(3) Exterior walls shall be designed and constructed for a wind load of 35 pounds per square foot uniformly distributed acting inward or outward transversely to the wall surface with a deflection of structural members not to exceed 1/240 of their length. In addition, but not simultaneously, exterior wall assemblies shall be able to withstand a concentrated load of 40 pounds on a 2-inch diameter disk on either surface where greatest deflection or identation, or both, will occur with a deflection of the sheathing not to exceed 1/120 of the length of any structural member or of 1/8 of an inch of the exterior sheathing or 1/10 of an inch of the interior surface. Wall-assemblies shall be capable of withstanding an impact load of a 10-inch diameter sandbag weighing 60 pounds which when dropped 1 1/2 feet on either surface at the weakest point of assembly results in no residual deflection of the material between ribs.

(4) Windows and doors, including the glazing and frames, shall be designed, constructed, and installed to withstand, when closed, a wind load of 35 pounds per square foot uniformly distributed, acting inward or outward normal to the vertical surface. Windows and doors shall develop no leakage as defined in and tested in accordance with ASTM E331-67T, Test for Water Resistance of Windows by Uniform Static Air Pressure Differential, with a test pressure of 3.5 pounds per square foot. Frames shall be designed and constructed to transfer the wind loads to the wall assembly.

(5) Patio roofs and other similar structures shall be designed and constructed as independent structures to withstand the same design loads as set forth in Section 5 (c) (2) for roofs. Flashing and rain strips are permitted between such structures and mobile homes. Structural members shall be designed and constructed to withstand the uplift load by adequate connection to concrete slabs, piers, foundations, or anchors. See illustrated acceptable adequate connections recommended.

(d) Rigidity.

(1) Components, including the roof, walls, floor, and frame shall be connected together in an adequate manner to transfer forces, including the overturning moment, developed by the live loads set forth in Section 5 (c) and the dead

loads of the unit to the supports and the anchorage system.

(2) Exterior walls shall be designed and constructed to withstand the following racking loads on an 8 foot section of walls:

(a.) With 100 pounds per linear foot, the displacement shall not exceed 1/8 of an inch.
(b.) With 225 pounds per linear foot, sustain the load.
(c.) With 225 pounds per linear foot, residual displacement shall not exceed 25 percent of maximum displacement.

SECTION 6. SUPPORTS.

(a) Supports shall be installed under the frame to support the uniformly distributed vertical loads as set forth in Section 5 (c) (1) and the dead load of the mobile home.

(b) Supports shall be located at those points where connections are made to fasten ties to withstand the overturning load. See illustrated locations and chart.

(c) Supports shall be constructed of noncombustible materials.

(d) Supports of masonry units shall be constructed as piers using mortar between the units.

(e) Supports shall be set on a footing consisting of masonry, reinforced concrete, or steel grillages. Footings of wood may be used if they are pressure treated (impregnated) with creosote or other approved preservatives.

(f) Footings shall be designed and constructed so the full dead load of the mobile home plus the live loads do not cause a pressure under the footings exceeding the bearing capacity of the soil. Footings made of plain concrete shall be not less than 16 inches by 16 inches and x 4 inches.

SECTION 7. ANCHORAGE.

(a) Mobile homes shall be anchored to withstand the forces, including the overturning moment, developed by the live loads as set forth in Section 5 (c). Anchorage systems shall not incorporate a foundation wall.

(b) Mobile homes specially designed and constructed to transfer the forces, including the overturning moment, developed by the live loads as set forth in Section 5 (c) to factory installed tie-down connections shall be approved as a result of test or design calculations.

(c) Specially designed and constructed mobile homes shall be anchored with factory furnished ties approved for the loads as a result of test or design calculations and installed in accordance with such approval and with engineered anchors approved for holding power of the loads as a result of tests or by engineering data and soil classification for anchors. Such mobile homes may be anchored to reinforced concrete slabs conforming to Section 7 (i) (1) and having approved inserts in the concrete for attachment of ties. See suggested ties as illustrated. Inserts shall be approved as a result of tests and shall be installed in accordance with such approval and located for tie-down connections and factory furnished ties.

(d) Mobile homes that have not been specially designed and constructed to transfer the forces, including the overturning moment, developed by the live loads as set forth in Section 5 (c) to tie-down connections shall be anchored with over the roof devices of metal cables or metal straps complying with Section 7 (e), connections to the frame complying with Section 7 (f), ties complying with Section 7 (g), and anchors complying with Section 7 (h) or concrete slabs complying with Section 7 (i).

(e) Over the roof device.

(1) Over the roof devices shall be located within 2 feet of the ends of the mobile home and at intervals not to exceed 15 feet, at the outer edge of each tip-out room and at each end of the raised section of a clerestory roof, and shall be as follows:

(a.) Not less than 3/16 inch diameter steel aircraft cables; or
(b.) Corrosion-resisting chromium-nickel steel, AISI Types 201, 202, 301, 302, 304, and 316, straps having a cross-sectional area of not less than 0.185 square inches; or
(c.) 3003-H14 aluminum straps having a cross-sectional area of not less than 0.35 square inches; or
(d.) Zinc-coated (galvanized) steel straps conforming to ASTM A446-69, Standard Specification for Zinc-coated (Galvanized) Steel Sheets of Structural Quality, Coils and Cut Lengths, having a cross-sectional area of not less than 0.185 square inches.

(2) Where cable is used for over the roof devices, each end shall have a connection using the proper size thimble and not less than 3 drop-forged steel base wire rope clips.

(3) Where cable is used for over the roof devices, blocks of wood or metal shall be placed under the cable to keep the cable from making a sharp bend. These blocks shall be shaped to have a curved surface for the cable and a surface to fit the configuration of the corner where each is placed. The curved surface shall have a radius not less than 16 times the diameter of the cable. Near the ends of the curve, the radius shall be reduced or the edges rounded to minimize wear of the cable.

(4) Where steel straps are used for over the roof devices, loops shall be formed on the ends forming an eye for the thimble or bolt used as part of the ties and the dead ends of the straps. The enforcing official may permit connections without loops on the straps where turnbuckles with a jaw end are to be connected. The hole in the straps shall be the same diameter as the bolt for the jaw and shall be placed not less than two diameters from the end of the strap.

(5) Where over the roof devices are used and the horizontal members at the intersection of the walls and the roof are not adequate to transfer forces to the cables or straps, auxiliary horizontal members adequate in size to resist a bending

moment of 7200 inch-pounds and extending the full length of the roof shall be placed on the roof directly above the wall under the cables or straps. Such members shall have provisions, such as notches or holes, to permit drainage of water from the roof. Notches and holes shall be no larger than necessary so as not to materially affect the strength of the members.

(6) Where over the roof devices are used and the cables or straps bear upon the roof at other than the blocks or auxiliary members at the intersection with the walls, auxiliary horizontal members extending the full length of the roof shall be placed under the cables or straps if the roof framing members are not adequate to transfer forces to the cables or straps.

(7) Where auxiliary members are used on the roofs to distribute the forces and cable is used as the over the roof device, provisions shall be made to keep the cable from making sharp bends. Auxiliary members having corners shall have devices that form a curved surface under the cable. The curvature of devices and shaping of wood members shall have a radius not less than 16 times the diameter of the cable. Near the ends of the curve, the radius shall be reduced or the edges rounded to minimize wear of the cable. Devices used to protect cables shall have provisions to prevent movement along the auxiliary member.

(f) Connections to the frame for ties shall be steel, forged eye bolts not less than 3/4 inches in diameter placed in the main frame members not more than 5 feet from the ends of the mobile home and at spacing not to exceed 10 feet.

(g) Ties.

(1) Ties shall be not less than 3/16 inch diameter steel aircraft cable and/or turnbuckles not less than 5/8 inch size.

(2) Where steel aircraft cable is used as a tie, each end shall have a connection using a proper size thimble and not less than 3 wire rope clips with drop-forged steel bases.

(a.) Wire rope clips shall be attached with the base of the clip against the live load of the wire cable or rope.
(b.) Wire rope clips shall be equally spaced not less than one clip base to approximately six cable diameters with one clip adjacent to the apex of the thimble.

(3) Ties to frame connections shall be at an angle not to exceed 40 degrees with the horizontal and 90 degrees with the axis of the frame except that the end ties shall be at an angle of approximately 45 degrees with the axis of the frame.

(4) Turnbuckles used as a tie or as part of a tie shall have either eye or jaw ends and shall be of drop-forged steel.

(5) All ties shall be fastened to anchors or inserts in concrete slabs and be drawn tight with turnbuckles.

(h) Anchors.

(1) There shall be an anchor for each tie end and each anchor shall be installed so that the rod is in line with the tie.

(2) Integral eye screw anchors 8 inches in diameter having a rod of one inch in diameter shall be used. Plate anchors not less than 6 inches by 27 inches with a rod of 5/8 inch diameter, 6 feet in length, may be used for ties from the frame.

(3) Anchors shall be installed to a depth of 4 feet or to a depth approved by the enforcing official.

(i) Reinforced concrete slabs.

(1) Reinforced concrete slabs used as a component of the anchorage system shall comply with the provisions of this Section 7 (i) (1).

(a.) Shall have a minimum thickness of 4 inches.
(b.) The minimum width and length of the slab shall be at least 2 feet greater than the width and length of the mobile home being anchored.
(c.) Temperature reinforcement shall be placed in the concrete. Slabs of 4-inch thicknesses shall have not less than 0.086 square inches of reinforcement per foot. Slabs thicker than 4 inches shall have reinforcement as required by nationally recognized standards for the thickness of the concrete slab. See illustrations for details recommended.
(d.) Welded wire mesh may be used for temperature reinforcement.
(e.) Top surface of the slab shall have a crown at the axis to provide for drainage of surface water.
(f.) Slabs shall be placed on undisturbed soil or on a base of stone or gravel.

(2) Existing concrete slabs may be accepted after being inspected by the enforcing official and found to be without cracks and having dimensions of approximately those set forth in Section 7 (i) (3).

(3) Except as provided in Section 7 (i) (4), approved inserts shall be placed in the concrete during pouring of the concrete in accordance with the provisions of Section 7 (i) (3).

(a.) Inserts shall be of a type used for the lifting of precast concrete members.
(b.) Inserts shall have a safe working load of 3700 pounds in tension and shear as determined by test.
(c.) Inserts shall be placed in the concrete directly below the ends of each over the roof device and at proper locations to accommodate the ties set forth in Section 7 (g) (3) and/or as illustrated.

(4) When existing concrete slabs have been accepted as being adequate, ties shall be fastened to steel devices which shall be fastened to the concrete by foundation bolts, or fastened to foundation bolts with eye.

(a.) The devices shall be capable of transmitting a force of not less than 3700 pounds.

(b.) The foundation bolt or combination of foundation bolts for fastening each device to the concrete shall be capable of withstanding a withdrawal force of 3700 pounds.

(c.) Where foundation bolts with eye are used, the bolts shall be not less than 5/8 inch diameter and shall be capable of withstanding a withdrawal force of 3700 pounds normal to the surface of the concrete and a shearing force of 3700 pounds at an angle of 30 degrees to the surface of the concrete.

SECTION 8. ROOF COVERING.

(a) Roof covering shall be of a type tested and listed by a nationally recognized testing laboratory as a Class A, B, or C roof covering, or metal.

(b) The roof covering shall be applied in compliance with the manufacturers' instructions for installation in areas subject to extreme wind conditions.

SECTION 9. LIGHT AND VENTILATION.

(a) For the purpose of providing adequate light and ventilation, every mobile home shall be built, arranged, and equipped to conform to the provisions of this Section 9.

(b) No mobile home, including existing units, shall be altered, added to, or rearranged so as to reduce the size of a room or the amount of window area to less than that required by this Section 9, or so as to create an additional room, unless such additional room is made to conform to the requirements for rooms in this Section 9.

(c) Every habitable room shall be provided with natural light and ventilation by one or more windows or doors in the exterior walls, opening onto a street, public place, public way, or court not less than 7 1/2 feet in width.

(d) Habitable rooms, except kitchens, shall be not less than 5 feet wide in any part and shall have not less than 50 square feet of floor area.

(e) The minimum ceiling height in the main structure of the mobile home shall be not less than 7 feet.

(f) The aggregate area of glazing material in windows of habitable rooms shall be not less than 10 percent of floor area of the room served by them.

(g) Windows or other openings required for ventilation shall have an openable area of at least 50 percent of the glazed area required for lighting.

(h) Where the openable portion of windows in the kitchen is less than 3 square feet in area, an electrical powered exhaust fan having a rated capacity of not less than 100 CFM shall be provided. Such fan shall exhaust air to the outside of the mobile home, not into any concealed space.

(i) Every bathroom shall be provided with natural or artificial light and be ventilated by one or more windows in an exterior wall opening onto a street, public place, publicway, or court not less than 7 1/2 feet in width, or by an electrical powered exhaust fan having a rated capacity of not less than 25 CFM. Such fan shall exhaust air to the outside of the mobile home, not into any concealed space.

SECTION 10. EXITS.

(a) Mobile homes exceeding 50 feet in length shall have at least two doorways, remote from each other, on the exterior walls.

(b) The minimum clear width of required doorways shall not be less than 24 inches.

(c) Doors shall be equipped with locks or latches that will permit opening from the inside by a knob, handle, or other simple type of releasing device.

SECTION 11. HEAT PRODUCING APPLIANCES, HEATING, AIR CONDITIONING, AND EXHAUST SYSTEMS.

(a) Heat producing appliances and systems, ventilating, air conditioning, and exhaust systems shall be installed so as to be reasonably safe to persons and property. Installation of appliances and systems in conformance with the provisions of the standard specified for this Section 11 (a) in Section 17 of this Ordinance shall be evidence that such appliances and systems are installed to be reasonably safe to persons and property.

(b) Only approved appliances designed specifically for installation in mobile homes shall be installed. Approval shall be based on tests and listings of such appliances by a nationally recognized testing laboratory.

(c) Appliances using gasoline as a fuel shall not be permitted in mobile homes.

SECTION 12. ROOF JACKS.

(a) Only approved roof jacks designed specifically for the appliances installed in accordance with Section 11 shall be used as flue gas outlets.

(b) Approval of roof jacks shall be based on tests and listings of such devices by a nationally recognized testing laboratory.

(c) Roof jacks shall be installed in accordance with the conditions of the approval.

SECTION 13. ELECTRICAL SYSTEMS.

(a) All electrical wiring for light, heat, or power installed in or on a mobile home and the connection to an electrical supply, and all alterations or extensions to an electrical wiring system shall be reasonably safe to persons and property. Installation of electrical wiring systems in conformance with the standard specified for this Section 13 (a) in Section 17 of this Ordinance shall be evidence that such systems are reasonably safe to persons and property.

(b) Only approved materials, fittings, and devices shall be used in electrical wiring systems.

Approval shall be based on tests and listings of such items by a nationally recognized testing laboratory.

(c) Outside electrical distribution systems in mobile home parks and all alterations or extensions to such systems shall be reasonably safe to persons and property. Installation of electrical distribution systems in conformance with the standard specified for this Section 13. (c) in Section 17 of this Ordinance shall be evidence that such systems are reasonably safe to persons and property.

(d) The mobile home park operator shall provide facilities for electrical supply to each mobile home through approved service-entrance equipment with readily accessible means of disconnecting the electrical supply.

(e) Electrical connection and disconnection between electrical supply and the mobile home shall be made only under the supervision of the park operator or his authorized agent.

SECTION 14. GAS PIPING.

(a) Piping for any and all types of gas used for fuel or lighting shall be designed and installed so as to be reasonably safe to persons and property. Gas piping systems designed and installed in conformance with the applicable provisions of this Ordinance shall be deemed to be reasonably safe to persons and property. On matters not detailed in this Ordinance, installation of gas piping systems in conformance with the provisions of the standard specified for this Section 14 (a) in Section 17 of this Ordinance shall be evidence that such systems are reasonably safe to persons and property.

(b) Gas piping service systems in mobile home parks extending from the outlet of a meter set assembly or the outlet of a service regulator when a meter is not provided to the terminal of the gas riser at each site shall be installed so as to be reasonably safe to persons and property. Installation of gas piping service systems in conformance with the provisions of the standard specified for this Section 14 (b) in Section 17 of this Ordinance shall be evidence that such systems are reasonably safe to persons and property.

(c) The gas supply shall be connected to the mobile home only by a qualified installing agency which shall determine that the piping is properly purged and is free from leaks and that appliances are suitable for the gas to be supplied.

(d) Adequate arrangements shall be made to assure that gas connections are disconnected before the mobile home is moved. Disconnections shall be made by the park operator or his authorized representative.

(e) Portable Cylinders.

(1) Portable cylinders not exceeding 105 pounds water capacity used for containers of liquified petroleum gases shall be placed in an approved rack mounted on the chassis outside of the mobile home or in a recess that is gas tight to the inside of the mobile home, accessible only from the outside, and ventilated at top and bottom to facilitate diffusion of vapors.

(2) Portable cylinders mounted on the mobile home shall be so located that the

discharge from safety relief devices shall be not less than 3 feet horizontally from any opening into the mobile home below the level of such discharge.

(3) When portable cylinders are located in a ventilated recess, vent openings in such recess shall not be less than 3 feet horizontally from any opening into the mobile home below the level of these vents.

(4) Portable cylinders exceeding 105 pounds water capacity used for containers of liquified petroleum gases shall be placed in racks that are separate from the mobile home and are constructed to withstand a wind load of 35 pounds per square foot. The racks shall be so located that the discharge from safety relief devices shall be not less than 3 feet horizontally from any opening into the mobile home below the level of such discharge.

(f) Before any mobile home is occupied, the gas piping system with appliances connected shall be tested for tightness at the site after the mobile home is positioned on the supports and the anchorage has been completed. Test shall be conducted in conformance with the standard specified for this Section 14 (f) in Section 17 of this Ordinance.

SECTION 15. FUEL OIL.

(a) The storage of fuel oil and the installation of piping systems, pumps and valves shall be reasonably safe to persons and property. Tanks, piping systems, pumps, and valves installed in conformance with the standard specified for this Section 15 (a) in Section 17 of this Ordinance shall be evidence that the storage of fuel oil and installation of piping systems, pumps, and valves are reasonably safe to persons and property.

(b) Above ground fuel oil storage tanks shall be installed on supports of non-combustible materials and anchored to withstand wind pressure of 35 pounds per square foot.

(c) Before any mobile home is occupied, the fuel oil piping system shall be tested for tightness at the site after the mobile home is positioned on supports and the anchorage has been completed. Tests shall be conducted in conformance with the standard specified for this Section 15 (c) in Section 17 of this Ordinance.

SECTION 16. PLUMBING.

The plumbing and drainage system of a mobile home shall be installed so as to be reasonably safe to persons and property. Installation of plumbing and drainage systems in conformance with the provisions of the standard specified for this Section 16 in Section 17 of this Ordinance shall be evidence that such systems are installed to be reasonably safe to persons and property.

SECTION 17. LIST OF STANDARDS AND PUBLICATIONS.

Compliance with the standards and publications listed under the section numbers in Section 17 shall be evidence of compliance with the provisions of the section of the Ordinance referring to Section 17.

The abbreviations preceding these standards and publications shall have the following meaning and are organizations issuing the standards and publications listed:

ANSI - American National Standards Institute
1430 Broadway, New York, New York 10018

NFPA - National Fire Protection Association
60 Batterymarch Street
Boston, Massachusetts 02110

Section 11 (a)
Part III, Heating Systems, of NFPA No. 501B-1968, ANSI A119. 1-1969, Standard for Mobile Homes.

Section 13 (a)
Article 550, Mobile Homes, NFPA No. 70-1968, ANSI C1-1968, National Electrical Code.

Section 13 (c)
ANSI C2.2-1960, Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines and Supplements C2.2a-1965 and C2.2b-1967.

Section 14 (a)
Part 1, General, and Part 2, Gas Piping Installation, NFPA No. 54-1969, Standard for the Installation of Gas Appliances and Gas Piping.

Section 14 (b)
Section 2.5, Gas Piping in Mobile Home and Recreational Vehicle Parks, NFPA No. 54-1969, Standard for the Installation of Gas Appliances and Gas Piping; NFPA No. 58-1969, Standard for the Storage and Handling of Liquified Petroleum Gases.

Section 14 (f)
Sections 2.12, Test of Piping for Tightness, and 2.13, Leakage Check After Gas Turn On, NFPA No. 54-1969, Standard for Installation of Gas Appliances and Gas Piping.

Section 15 (a)
Chapter 2, Tank Storage, and Chapter 3, Piping, Pumps and Valves, NFPA No. 31-1968, ANSI Z95.1-1968, Standard for the Installation of Oil Burning Equipment.

Section 15 (c)
Section 390, Tests of Piping, NFPA No. 31-1968, ANSI Z95.1-1968, Standard for the Installation of Oil Burning Equipment.

Section 16
Part II, Plumbing Systems, NFPA No. 501 B-1968, ANSI A119.1-1969, Standard for Mobile Homes.

SECTION 18. PENALTIES FOR VIOLATION.

Any and all persons who shall violate any of the provisions of this Ordinance or fail to comply therewith, or who shall violate or fail to comply with any order or regulation made thereunder, or who shall locate or occupy a mobile home in violation of any detailed statement of specifications or plans submitted and approved thereunder shall be guilty of a ____ (offense and penalty established by law).

SECTION 21. REPEAL OF CONFLICTING ORDINANCES.

In case any ordinances or parts hereof are inconsistent herewith, then this ordinance is to take precedence.

SECTION 22. DATE OF EFFECT.

This Ordinance shall take effect and be in force from and after its passage and legal publication.

Recommended Model Code No. 2

SUGGESTED CODE FOR PROTECTION OF LIFE AND PROPERTY DUE TO HIGH VELOCITY WIND STORMS RELATED TO MOBILE HOMES AND MOBILE HOME PARKS

PURPOSE, APPLICATION AND SCOPE: The requirements set forth in this appended information shall apply specifically to all new mobile homes, and shall provide minimum standards for construction of mobile homes installed upon or connected to utilities on land within the corporate limits and approved for occupancy by the City as of the effective date of this ordinance.

GENERAL. Mobile homes shall comply with ANSI Standards A119.1, 1969 and the amendments herein.

STRUCTURAL DESIGN. All mobile homes shall be designed to meet leading conditions as specified in Part B of ANSI Standards A119.1. Units not factory built and assembled must meet the Building Code requirements for small structures in your particular city, but may not be less than ANSI Standards A119.1 just mentioned.

DEFINITIONS. Mobile home–A vehicular, portable structure built on a chassis and designed to be used without a permanent foundation as a dwelling for year-round living when connected to indicated utilities (per ANSI Standards A110.1). It may consist of one or more units that can be telescoped when towed and expanded later for additional capacity, or of two or more units, separately towable, but designed to be joined into one integral unit.

IDENTIFICATION. A mobile home unit may bear the label or seal of compliance with the Standard for mobile homes A119.1, of a recognized independent engineering testing laboratory or agency having a follow up inspection services. Such label or seal shall be deemed to be in full compliance with the Standards for mobile homes prescribed by the Building Code within the Governmental Jurisdiction which has approved such independent recognized testing laboratory for this service.

All mobile home units bearing such label or seal shall be acceptable within such City, County, and State Jurisdiction, which has approved such labeling service.

Any mobile home unit not bearing such label or seal of independent testing laboratory approved by the Government Jurisdiction wherein the unit is to be erected is subject to inspection and approval requirement in the same manner as other structures subject to this code.

All mobile homes shall be anchored and tied down in a manner equivalent to or better than the following on or before June 1, 1971, as follows:

1-6. Anchorage–Minimum Hurricane Tie-Down Requirements
(Approved Blocking and Anchorage is Illustrated in This Appendix)

1. NUMBER OF TIES

A. Up to 30' mobile home length - 2 frame ties per side
B. 30' to 50' mobile home length - 3 frame ties per side
C. 50' to 70' mobile home length - 4 frame ties per side
D. Over 70' mobile home length - 5 frame ties per side
E. Plus–Over-the-Home ties as close to each end as possible with straps at stud and rafter location.

2. ANCHORS

Soil Test to Assure That Following Will Withstand 3750 Pounds of Pull Per 10' of Mobile Home.

A. Auger or dead man, 6" in diameter–arrowhead 8".
B. Auger or arrowhead depth 4'–dead man 5'. All augers must be screwed into the earth the full four-foot depth.
C. Anchor rod 5/8" diameter with welded eye at top. Must be hooked into concrete when used in dead man anchors.
D. Anchors to slabs must equal above in pull resistance.

3. CONNECTORS

A. Galvanized or stainless steel cable–3/8" (7 x 7 - 7 wires each), or
B. Galvanized aircraft cable 1/4" x (7 x 19 - 7 strands of 19 wires each), or
C. Steel strap–1-1/4" x .035"–galvanized, with tensioning device.
D. Cable ends secured by 2 U-bolt clamps.
E. Steel rods–5/8" with ends welded closed to form an eye.
F. Turnbuckles 5/8" drop forged–closed eyes. Other tensioning devices of similar strength approved.

4. PIERS AND FOOTINGS

A. Spaced at 10' intervals on both frame rails with end ones no further than 5' from end of mobile home.
B. Footings of solid concrete 16" x 16" x 4", or
C. Piers of standard 8" x 8" x 16" solid concrete block.
D. Wood blocks used for leveling shall not exceed a minimum thickness of four (4") inches. Such blocks must be of nominal 8" x 16" dimensions.
E. Other equivalent piers accepted. An adjustable screw-anchor-type column fastened to both frame rail and to a concrete pad of 4" thickness extending the length and width of the mobile home is especially recommended.

5. PATIO AWNINGS AND CABANA ROOFS

A. Two rows of vertical support bars–spacing 12'. Second row to be down middle or at mobile home edge, anchored to concrete floor or equivalent footings.
B. Other structures on lot must be secured.
C. Tip-out rooms to be held by over-the-home tie at outer edge.
D. Clerestory roof requires over-the-home tie at end of each raised section.

6. TRAVEL TRAILERS (LOCAL RULE)

Travel trailers to be left at parking site during United States Weather Center Hurricane Warning or alert periods shall be lashed to rigid construction and lashed to the ground, or stored securely in permanent buildings, conformable as practicable to the terms and conditions of Sections 101.6 and 108.3 of this code. A "travel trailer" is vehicular, portable structure built on a chassis and designed to be used without a permanent foundation as a dwelling, primarily and independently of utility connections at the parking site.