

Conferees of States



National Conference of States on Building Codes and Standards, Inc.

481 Carlisle Drive, Herndon, Virginia 22070

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1989

**COASTAL ZONE
INFORMATION CENTER**

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INTRODUCTION

In December 1988, NCSBCS contracted with the U.S. Department of Housing and Urban Development (HUD) to investigate the cause of failures, sustained by manufactured homes following natural disasters. Historically, it has appeared that the number of manufactured homes and the severity of damage caused to those homes have been disproportionate to site built homes which have been exposed to the same disasters. This report covers four separate investigations conducted by NCSBCS at disaster sites involving manufactured homes. The purpose of the investigations was to determine which structural components of manufactured homes are most likely to fail in disaster situations and to recommend possible remedial actions to the Department. Data was collected at disaster sites as an attempt to identify consistent patterns of component failures. Findings from these investigations are intended to identify not only the cause of failures but also which systems are most apt to fail.

Several areas will be examined when determining the cause of failures, such as: 1) whether the design met the standard, 2) manufacturer's installation instructions, 3) proper field installation of units, and 4) the degree to which the construction standards appropriately address the structure and its components. The information obtained from these investigations can be utilized to prevent future damage to manufactured homes to the greatest extent possible, by recommending appropriate changes to the above listed items. Such recommendations would prevent similar nonconformances from being constructed in future units and would possibly serve to identify the affected units in the field and allow for their repair prior to a disaster.

Between May and October of 1989, four disaster site investigations were conducted. The types of natural disasters which damaged or destroyed manufactured homes at these sites are as follows: 1) Tornadoes in central Texas; 2) Hurricane Hugo in South Carolina; 3) Hurricane Jerry in Galveston, Texas; and 4) a California earthquake in the Santa Cruz area.

Shortly following each disaster, a NCSBCS engineer investigated the affected sites, utilizing an inspection form developed by NCSBCS (see Appendix A). This form identifies the critical points of a manufactured home which are subject to failure. The form describes the environmental conditions in which the home is located, such as soil conditions and terrain. The form also provides details of the disaster, such as wind speeds, and flood levels. Photographs were taken at each disaster site. Additionally, camcorder tapes of the damage caused by hurricanes Hugo and Jerry were also made.

A background of each disaster and the findings from the investigations are described as follows.

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

As a result of the investigations conducted at the four disaster sites, several weaknesses in manufactured homes have been identified. Failures witnessed in the wind related disasters were of a different nature than those discovered after the earthquake, although some weaknesses were generic in nature to both failures that occurred with the manufactured home supports. Based on the structural failures found at these disaster sites, NCSBCS offers the following preliminary conclusions and recommendations:

1. Tie-Down/Anchoring

The most severe damage observed at the disaster sites resulted from homes shifting off their piers or overturning. This was generally caused by failure of the ground anchors due to saturated soils or improper installation of the anchoring devices.

Improper Installation

Several examples of improper installations were witnessed at the disaster sites and are described in this report. The two most common of these being ground anchors that were installed at angles contrary to installation instructions and the improper attachment of anchor straps to I-beams. Since DAPIA approved installation instructions are provided with all manufactured homes, proper set up and securement of homes can be enforced by state and/or local jurisdictions.

There are approximately twenty one (21) states that have not adopted any tie-down regulations (see Appendix H). Until adoption and enforcement of tie-down regulations is achieved nationwide, manufactured homes will continue to be destroyed and damaged by disasters regardless of the structural integrity of the home.

Anchor Failure

Hurricanes and tornadoes are usually accompanied by heavy rains and occasional flooding. Water saturated soil provides little resistance to uplift forces and the anchors are easily pulled from the ground (see Appendix E, photos 23 and 24). The HUD Standards require anchoring equipment to resist an allowable working load of 4725 pounds. However, most installation instructions provided by the anchor manufacturers do not adequately address the performance of ground anchors in various types of soil, particularly when the soil is saturated.

As a result of the tie-down failures witnessed at the disaster sites, it is NCSBCS' recommendation that HUD consider implementing the recommendations contained in the manufactured home installation report, prepared by NCSBCS and submitted to HUD in January of 1989 (see Appendix I). As a supplement to that report, NCSBCS proposes to research literature in the area of soil resistive capacities as related to ground anchors. This information would serve to assist HUD and the applicable ASTM committees in the development of future standards and guidelines.

2. Negative Wind Pressure

The most common damage observed after Hurricanes Hugo and Jerry was the loss of siding at the ends of homes. This damage may have been the result of the construction of the manufactured homes which are designed according to the Standards to resist only an inward wind pressure on the windward side of the unit. When air flows over and around an object, it exerts inward as well as outward pressures on the object. The inward pressure is on windward side and all other sides have outward pressure. On the leeward side of the object there is usually a suction effect, consisting of outward pressure on the surface of the object in comparison to the direction of pressure on the windward side. This is known as negative pressure.

Whenever wind is a major problem, the projected area method which considers negative pressure. All major model building codes, SBC, BOCA and UBC, consider negative pressure, as a viable tool for regulating wind problems. Additionally, the most up-to-date and complex standards for wind design, ASCE 7-88 (ANSI A58.1-1982) addresses negative pressure. Negative pressure is not addressed by the HUD Standards.

NCSBCS recommends the following:

- NCSBCS provides a report to HUD justifying a revision to the standards for negative pressure.
- NCSBCS proposes to conduct calculations of exterior wall siding connections based on other model building codes and compare them with HUD standards.

3. Metal Roofs

Extensive damage to metal roofs on manufactured homes occurred in all three wind-related disaster sites. Roofs were either completely or partially lifted off the homes and scattered around the surrounding area. The metal roof connections to the side walls or trusses were the most frequent failure points. Design of these connections required dynamic analysis for vibration and flutter, which are not accountable when using the equivalent static load method. In general, stiffening, bracing, and tightening the metal roof would have helped to minimize the extensive damage.

NCSBCS recommends the following:

- NCSBCS conducts DAPIA package reviews of all manufacturers with metal roof designs and submit recommendations for suitable metal roof connections.

- NCSBCS performs a true dynamic analysis or a wind tunnel test to assure the adequacy of the metal roof, the connections and the capacity to withstand the HUD recommended loads.

4. Re-evaluate the Design Criteria for Wind Loading of Structures in Hurricane Zone II

The HUD standards designate two wind zones, a standard zone (Zone I) and a hurricane zone (Zone II). The standards require that homes located in Zone II be designed to resist horizontal wind loads of 25 psf and net uplift of 15 psf.

The most widely used standard for calculating wind loads for structures in this country is ASCE 7-88, formerly ANSI A58.1 (minimum design loads for buildings and other structures). This standard is referenced by all three model building codes, BOCA, UBC, and SBC. Depending on the wind exposure of a manufactured home, it can be shown, per ANSI A58.1, that the current design criteria of 25 psf/15 psf does not apply to wind conditions in excess of 95 mph. In areas where homes are not afforded wind protection by hills, trees etc., this figure would drop to 80 mph. When calculating wind loads, using ANSI A58.1, many variables affect the design value assigned to a structure, i.e., wind exposure, terrain, dimension of home etc. The current design values from the HUD standards do not address any of these variables.

Considering that a category one hurricane (74-95 mph) can have wind gusts in excess of 125 mph, as was the case with hurricane Jerry, and that category four hurricane Hugo sustained winds of 135 mph, it is apparent that the current Zone II design values are not appropriate for hurricane conditions.

NCSBCS recommends the following:

- The standards be revised to include earthquake zones.
- The manufacturer be required to provide one acceptable method for secondary bracing of the foundation for homes located in "earthquake zones". This method should be approved by a registered professional engineer or architect.

To assist HUD in further evaluating this recommendation, NCSBCS proposes to provide a report that will include:

- Information on which HUD may pursue the establishment of "earthquake zones" in the Federal Standards.
- Overview of information on earthquake braces, jacks and other means of protection that are used on manufactured homes in potential earthquake areas.
- Recommended language for inclusion in the Standards.

Section 3280.305(c)(2)(ii) of the Standards allows the department to establish more stringent requirements in those areas which experience winds of 125 mph or greater. This section however is vague and does not provide any guidance on how these "more stringent requirements" would be derived.

Therefore, NCSBCS recommends that HUD establish a hurricane Zone III and assign correlating design values for homes located in those areas. Further, NCSBCS proposes the following:

- To gather data documenting those areas which experience re-occurring high winds that exceed the current Zone II design values.

The data used to substantiate the new zone will be collected from sources such as the National Weather Service, Federal Emergency Management Agency (FEMA) National Oceanic and Atmospheric Administration (NOAA) etc.

- To develop design criteria for those homes which are to be located in Zone III areas.

This criteria will be derived from ASCE 7-88 (ANSI A58.1).

5. The primary damage observed in manufactured homes affected by earthquakes was caused by the support piers penetrating the bottom board and flooring after the homes had shifted.

All model codes contain provisions for protecting structures from earthquake loads. Similarly, it is recommended that the Federal Standards provide protection of manufactured homes. Although many manufactured home foundations are currently installed with means of earthquake protection, requirements for such protection and the adequacy of such protection is not governed by the Standards.

BACKGROUND

Tornadoes in Central Texas

On Tuesday night, May 16, 1989, a strong storm front consisting of hail, heavy rains and tornadoes swept across central Texas. NCSBCS investigated the damage at White's Mobile Home Park located thirty miles south of Ft. Worth, in the town of Cleyburne, which was among those areas hardest hit by the storm. Approximately eight manufactured homes in the park sustained damage from the tornadoes and associated high winds. Damage to the homes varied from minor shifts off of foundations, loss of roofs, and overturning of units to total destruction of units.

SUMMARY OF FINDINGS

Tornadoes in Central Texas

Due to the small number of homes left in tact following the storm and since very few structures, whether they be manufactured homes or site built, can withstand a direct hit by a tornado, the data collected during the first inspection was limited. However, two consistent weaknesses appeared in all of the homes that were inspected.

1. Improper Anchoring of Units: The installation of ground anchors was not coaxial with the straps. (Anchors were angled in towards the home, see Appendix B.) This method of anchor installation, while not uncommon, is contrary to the installation instructions of all anchor manufacturers. When anchors are installed at this angle there is a tendency for the anchor to slice through the soil thereby creating slack in the tie-down strap which allows the unit to shift off its foundation. (See Appendix C for installation guidelines.) Also, the soil in which the units were anchored did not appear

to be suited for the anchoring method. The soil was a medium dense sand to firm silt mixture. The anchors were screw augers installed at a depth of 2'-0". During the storm the soil was saturated and provided little resistance from the vertical and lateral forces that the winds imposed on the homes. It was the opinion of the inspector that the condition of the soil was such that "two men could have pulled an anchor from the ground."

2. Improper Attachment of Anchor Straps to the I-beams: The straps were hooked to the bottom of the I-beams, on all of the homes inspected, as opposed to being wrapped around the I-beams or attached to the top of the I-beams as recommended by installation manuals. This unapproved method of attachment allows the clip to fall off the beam when there is slack in the strap, such as when the home is rocked by strong winds.

The anchoring and attachment described above resulted in the anchors being pulled from the ground on the windward side of all the homes and the straps dropping off the I-beams on the leeward sides.

See Appendix D for photos of disaster site.

BACKGROUND

Hurricane Hugo, South Carolina

On Friday, September 22, 1989, Hurricane Hugo struck Charleston, South Carolina leaving over 20 people dead and tens of thousands homeless. Hugo was a category 4 hurricane, on a scale of 5, with winds of 135 mph and a tidal surge of 12 to 17 feet. Hurricane force winds extended 140 miles from its center. Although South Carolina was the hardest hit, damage from Hugo was reported from as far north as Maine and as far inland as western Pennsylvania, where 55 mph wind gusts were reported. (See Appendix E.)

The investigation of damaged homes was concentrated in the Charleston area, which was hardest hit. Homes in Georgetown, SC, approximately 60 miles north of Charleston and in Columbia, SC, which lies 115 miles inland were also inspected. Wind speeds in Georgetown and Columbia were reported to be between 100 and 110 mph.

SUMMARY OF FINDINGS

Hurricane Hugo, South Carolina

Three manufactured home parks in the Charleston area, containing a total of approximately 125 homes, were inspected on September 25 and 26 following the storm. The primary damage observed at these parks is as follows.

1. Tie-down/anchors

Approximately 70 percent of the homes had shifted from their piers to varying degrees. One-half of those had totally fallen off their supports. (See Appendix E, photos 7, 17, 18 and 21.) The reasons for the shifting are as follows:

- Anchor failure occurred after heavy rains had saturated the ground and greatly reduced the anchors resistance. Many anchors were totally pulled out from the ground or had sliced through the soil and were bent (see Appendix E, photos 19, 23 and 24).
- Strap failure was not an uncommon observation. In some instances the tie down straps had broken when subjected to the excessive wind pressures (see Appendix E, photo 17).
- The anchor straps were improperly attached to the I-beams. The strap clips on many homes were clipped to the bottom flange of the I-beams as opposed to being wrapped around the beams as required by installation instructions. (See Appendix E, photo 22.) When installed in this manner, minor rocking of the home allows the clips to fall off the I-beams.
- Ground anchors were installed at wrong angles (see Appendix B). Ground anchors should generally be coaxial to the tie-down straps (see Appendix C).

2. Metal Roofs

Approximately 15 percent of the inspected homes were missing between 20 to 100 percent of their metal roof covering. Several also suffered minor truss damage. (See Appendix E, photos 3, 4, 7 and 8.) Homes with shingled roofs experienced damage to a lesser extent, generally missing a dozen or less shingles. Typically, individual sections of roofing were completely torn from the homes exposing the units to the massive amounts of rain that accompanied the hurricane and created further damage. In all cases, when the roof covering was torn from the home, the staples fastening the roof to the edge rail were also torn out of the edge rail.

3. Siding

Approximately 15 percent of the homes suffered damage to siding and/or soffit covering. The primary damage was concentrated at the end of the units and affected only homes with metal and vinyl siding (see Appendix E, photos 14, 15 and 16). The primary reason for the loss of siding is the leeward suction forces at edges and ends of homes. When air flows over and around a stationary object, it exerts both inward and suction pressure on the surface of the object.

4. Demolition

In addition to the above mentioned damage, approximately 8 percent of the homes were totally destroyed (see Appendix E, photos 1, 2, 5, 6, 9, 10, 11, 12 and 13). It was observed that the homes which had overturned, the anchor and strap failed. Other homes were destroyed as a result of wind pressures that severed the entire roof from the home. Hence, the exterior walls collapsed when the roof trusses no longer helped stabilize the wall. The floor systems remained intact in all of the demolished homes.

Damage to homes in Georgetown and Columbia where wind velocity was reported at 100 to 110 mph, was similar to that found in Charleston, except to a lesser extent. Approximately 55 percent of the homes had shifted either totally or partially from their piers. One to two percent of the homes were destroyed. Siding and roof damage was observed in approximately 15 percent of the homes. Although slightly fewer homes were damaged in these areas, the type of damage observed was identical to that experienced in Charleston.

BACKGROUND

Hurricane Jerry, Galveston, Texas

On Sunday October 15, 1989, Hurricane Jerry swept across Galveston Island from the Gulf of Mexico with sustained northerly winds of 80 mph, with gusts of more than 125 mph and several reported tornadoes (see Appendix F). Although Jerry was a category one hurricane, the weakest on a scale of five, it left three people dead and caused an estimated 8 million dollars in property damage. Galveston is located in hurricane Zone II, as defined by the Manufactured Home Construction and Safety Standards. Galveston is a 32 mile long island located in the Gulf of Mexico just off the Texas coast. The damage caused by the hurricane was concentrated on a path of approximately 4 miles wide across the island. This tourist resort island is primarily occupied by apartments, condominiums and hotels. It contains only a few manufactured homes. One of the manufactured home parks on the island, the Villa Del Sol, was located in that 4 mile wide path. The Villa Del Sol is currently located approximately 1/4 mile from the Gulf and is virtually protected from the wind by an existing seawall. Approximately 8 of the 25 homes in the park were damaged to varying degrees.

The following observations were noted during a site investigation conducted by NCSBCS on October 17 and 18, 1989.

SUMMARY OF FINDINGS

Hurricane Jerry, Galveston, Texas

All of the damaged manufactured homes were produced prior to HUD's adoption of the Manufactured Home Standard on June 1976. The average home was 14 to 15 years old. The majority of homes in the park were pre-HUD, single wide units. Only one home was completely destroyed, which was reportedly hit by a tornado. (See Appendix F, photos 1 and 2.) The primary damage sustained by the manufactured homes was 1) loss of roof and soffit coverings and 2) loss of siding. (See Appendix F, Photos 3, 4, 7, 8, 11 and 12.)

Unlike other wind related disaster sites, none of the homes had overturned or shifted from their pier supports, including the home struck by the tornado. Most homes were anchored with frame and over the roof ties. However, several units were not properly tied down and had an insufficient number of anchors. (See Appendix F, photos 5 and 6.) The fact that none of the homes had shifted may partially be due to the protection afforded the park by the seawall. The roofs of the homes were approximately 5'-0" lower than the roadway which separates the park from the beach.

1. Roof Damage

A total of six homes were inspected in the Villa Del Sol park and immediate vicinity. Five of those homes lost 20 to 90 percent of their roof coverings. All homes had metal roofs. In all cases, entire sections of roofing were blown off, from one sidewall to the other. (See Appendix F, photos 7 and 8.) With the exception of the tornado struck unit, all homes had either the staples fastening the roof to the perimeter roof rail or the staples fastening the perimeter rail to the top plate pulled out of the wood members to which they were fastened. On five out of six homes, roof trusses remained intact and sustained only minor damage. The unit hit by the tornado lost 75 percent of its trusses. (See Appendix F, photos 1 and 2.)

2. Siding Damage

Siding and/or soffit covering on five of the six units was pulled loose or torn completely off (see Appendix F, photos 9 and 10). All of the affected units had metal siding with damage occurring at the ends (see Appendix F, photos 9, 10, 11 and 12). (See hurricane Hugo for explanation.) Similar to the roofing situation, the staples which fastened the siding were pulled away from the wood members.

BACKGROUND

California Earthquake

On Tuesday October 17, 1989 an earthquake, measuring 7.1 on the Richter scale, struck northern California killing over 50 people and causing over a billion dollars in damage. The epicenter of the quake was located 10 miles north of Santa Cruz, CA. (See Appendix G.)

Investigations of earthquake damage to homes were conducted by NCSBCS on October 23, at four manufactured home parks in Santa Cruz County, CA. Two of the parks were located in Santa Cruz, CA, approximately 10 miles from the epicenter, and two parks were in the town of Watsonville, CA, approximately five miles from the epicenter. The average age of the damaged single and double wide units ranged from 10 to 15 years.

SUMMARY OF FINDINGS

California Earthquake

Minor damage was observed in both Santa Cruz parks. Although a majority of the homes showed no signs of physical damage, several homes were slightly damaged when a few of the piers had either been loosened from the I-beams or had broken. This was evidenced by the sagging ends of these homes. It was observed that one home had completely shifted off its piers.

The first of the two parks investigated in Watsonville was Meadows Manor. Approximately 10 to 20 percent of the homes in Meadows Manor had completely fallen from their piers (see Appendix G, photos 1 and 2) while other homes, like those in Santa Cruz, had only partially shifted. The second park, investigated in Watsonville was Rancho Cerritos. Approximately 75 to 85 percent of the homes had fallen from their piers.

One of the homes in Rancho Cerritos was totally destroyed by fire reportedly caused by the gas service line rupturing when the home shifted (see Appendix G, photo 5). The primary damage to the homes was caused by the piers penetrating the bottom board and, in several instances, penetrating the floor decking (see Appendix G, photos 7 and 8). The skirting around the homes was also damaged, as was service entrance fixtures (see Appendix G, photo 6).

Most of the homes had no means of anchoring, however, those homes that were anchored still shifted from their piers (see Appendix G, photo 9). A possible reason why the homes, both anchored and unanchored, fell is that the majority of piers used in these parks had a small surface bearing area (4 inch x 4 inch) for the I-beams. (See Attachment G, photo 10.) Therefore, the slightest movement would allow the beam to slip off the pier.

Several homes in the Watsonville park, which had shifted off their piers, were equipped with earthquake braces or jacks. These particular homes sustained no damage to the underbelly, because the jacks prevented the homes from falling onto the piers. (See Appendix G, photo 11 and 12.) Homes which still had axles and wheels attached to their frames sustained less damage than those in which the axles had been removed. The wheels provided temporary support for the homes, prevented floor penetration by piers and allowed the homes to be jacked up and reset more easily. (See Appendix G, photos 1 and 2.)

Appendix A - Manufactured Home Disaster Damage Inspection Report

MANUFACTURED HOME DISASTER DAMAGE INSPECTION REPORT

INSPECTOR: _____ DATE: _____

ADDRESS: _____

CITY/COUNTY: _____ STATE/ZIP: _____

1. DATE OF DISASTER _____

DISASTER TYPE (WIND) ___ HIGH WINDS ___ HURRICANE ___ TORNADO ___ OTHER

WIND SPEED: _____ WIND ZONE: ___ ZONE 1 ___ ZONE 2

COMMENTS: _____

DISASTER TYPE (FLOOD) ___ FLASH FLOOD ___ GRADUAL FLOOD ___ FLOOD PLAIN

WATER DEPTH ABOVE GROUND SURFACE OR FLOOR LEVEL OF UNIT (SPECIFY): _____

COMMENTS: _____

2. SIZE OF UNIT: ___ SINGLE WIDE ___ DOUBLE WIDE ___ FIELD INSTALLED ADDITIONS

DIMENSION OF UNIT: _____

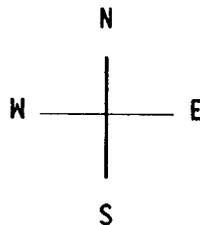
UNIT TYPE: MANUFACTURER/MODEL/SERIAL NO./AGE/COMMENTS: _____

3. TERRAIN: ___ FLAT ___ HILLY ___ MOUNTAINOUS ___ WOODED ___ OPEN FIELD TYPE

COMMENTS: _____

SOIL TYPE: (SAND, CLAY, SILT, GRAVEL ETC.) _____

POSITION OF UNIT



(SKETCH IN UNIT AS ANCHORED)

PREVAILING WIND DIRECTION: _____

4. FOUNDATION/PIERS: PERIMETER FOUNDATION PIERS ONLY COMBINATION

MATERIAL: _____

DIMENSION: _____ HEIGHT: _____

SPACING: _____ REINFORCED

SHIMMING METHOD AND MATERIAL: _____

SKIRTING TYPE: _____

FOOTING: TYPE (CONCRETE, GRAVEL, PRECAST) _____

DEPTH: _____ DIMENSION: _____

COMMENTS: _____

5. TIE DOWN METHOD: FRAME TIES (SPACING) _____

OVER-THE-TOP TIES (SPACING) _____

COMMENTS: _____

STRAP CONNECTION TO I-BEAM: WRAP AROUND BEAM OTHER

COMMENTS: _____

I-BEAM DIMENSION (DEPTH) _____ I-BEAM SPACING: _____

6. ANCHORING METHOD: SCREW AUGERS DIMENSION: _____

EXPANDING ANCHORS DIMENSION: _____

CONCRETE DEAD MEN DIMENSION: _____

OTHER DIMENSION: _____

COMMENTS: _____

ANCHOR INCLINATION (ANGLE, DEPTH) _____

COMMENTS: _____

7. FLOOR TO CHASSIS ATTACHMENT: OUTRIGGER ATTACHMENT I-BEAM ATTACHMENT
LAG SCREW SIZE: _____ LAG SCREWS PER OUTRIGGER: _____
 I-BEAM CLIP ATTACHMENT SPACING OF CLIPS: _____
 WELDED CLIPS PRESSURE FITTED CLIPS
COMMENTS: _____

8. FLOOR TO WALL ATTACHMENT: UPLIFT STRAPS
SIZE AND SPACING OF STRAPS: _____
SIZE AND NUMBER OF FASTENERS PER STRAP: _____
COMMENTS: _____

9. ROOF TO WALL ATTACHMENT: UPLIFT STRAPS SIZE & SPACING OF STRAPS: _____
SIZE AND NUMBER OF FASTENERS PER STRAP: _____
SHEARWALLS - NUMBER AND SPACING: _____
COMMENTS: _____

10. UNIT CONDITION: SAFE FOR OCCUPANCY HABITABLE, REPAIRS NECESSARY
 UNINHABITABLE DEMOLISHED
 SHIFTED OFF FOUNDATION/
PIERS OVERTURNED
 ANCHORS FAILED CHASSIS INTACT - DAMAGE TO SHELL
COMMENTS: _____

11. STRUCTURAL SEPARATION AT: CHASSIS TO FLOOR: _____
 FLOOR TO WALL: _____
 WALL TO ROOF: _____

12. FLOOR CONDITION: STRUCTURAL DAMAGE DESCRIBE: _____
 BOTTOM BOARD DAMAGE DESCRIBE: _____
 BOTTOM BOARD MANUFACTURER: _____

COMMENTS: _____

13. EXTERIOR WALL CONDITION: TYPE AND MANUFACTURER OF SIDING: _____
 SIDING DAMAGE: _____
 WINDOW/DOOR DAMAGE: _____
 WALL DAMAGE: _____

14. ROOF TYPE OF ROOF: GABLE BOW OTHER _____
TYPE OF FRAMING: SCISSOR TRUSS ARCH TRUSS TRADITIONAL TRUSS
 2 x RAFTERS OTHER

SPACING: _____ COMMENTS: _____

ROOF COVERING: ASPHALT SHINGLE METAL OTHER _____

OVER HANG/EAVE: NONE PARTIAL PERIMETER

DEPTH: _____ COMMENTS: _____

ROOF VENTILATION DESCRIBE: _____

ROOF CONDITION: NO DAMAGE SHINGLE DAMAGE - DESCRIBE: _____

SHEATHING DAMAGE - TYPE OF FASTENERS AND SPACING: _____

DESCRIBE DAMAGE: _____

RAFTER DAMAGE - SPECIFY RAFTER SIZE, SPAN, RATING, FASTENING: _____

DESCRIBE DAMAGE: _____

COMMENTS: _____

15. DOUBLE WIDE UNITS: SIZE OF INTERIOR WALL OPENINGS AT MATELINE: _____

TYPE, SIZE AND QUANTITY OF FASTENERS USED TO CONNECT HALVES AT:

ROOF: _____

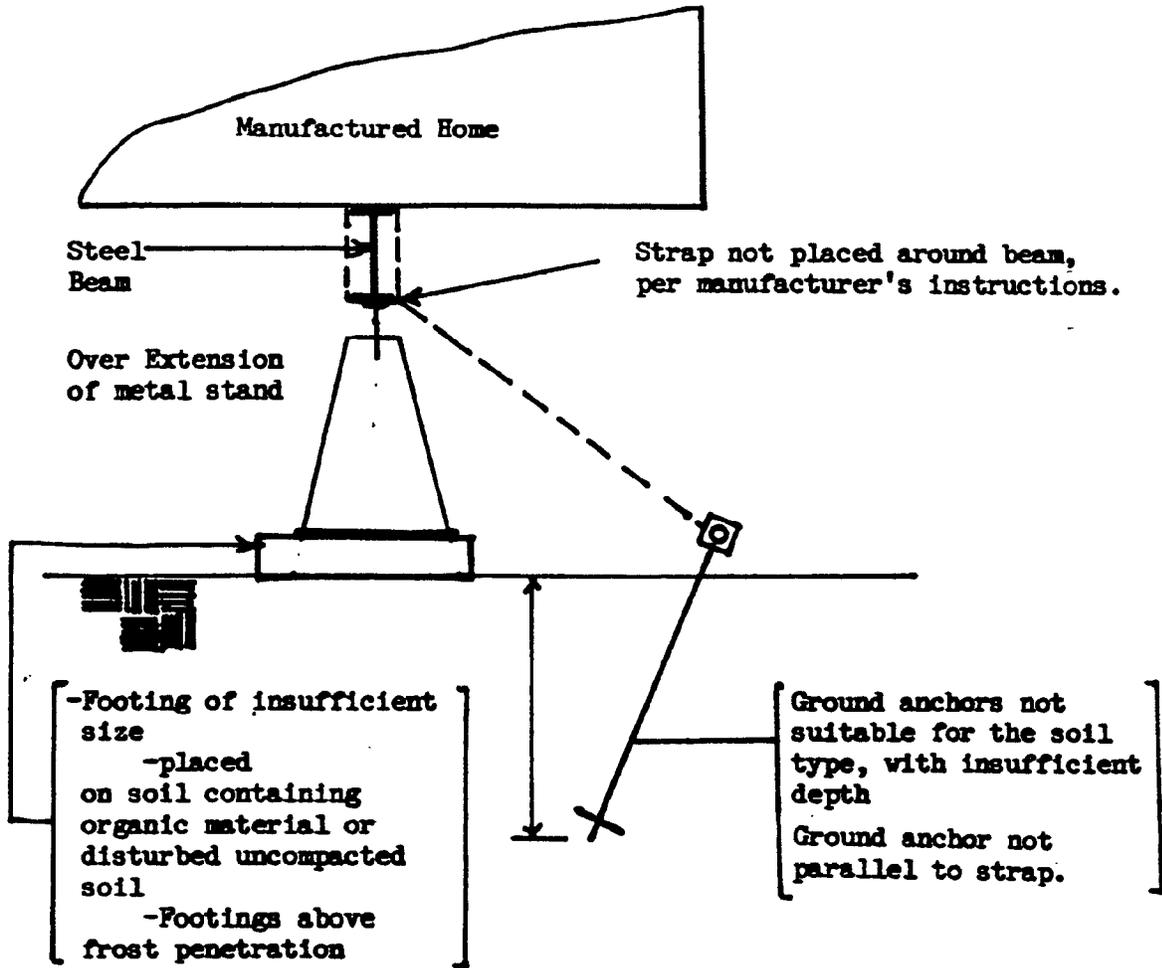
FLOOR: _____

SIDEWALLS: _____

GENERAL COMMENTS: _____

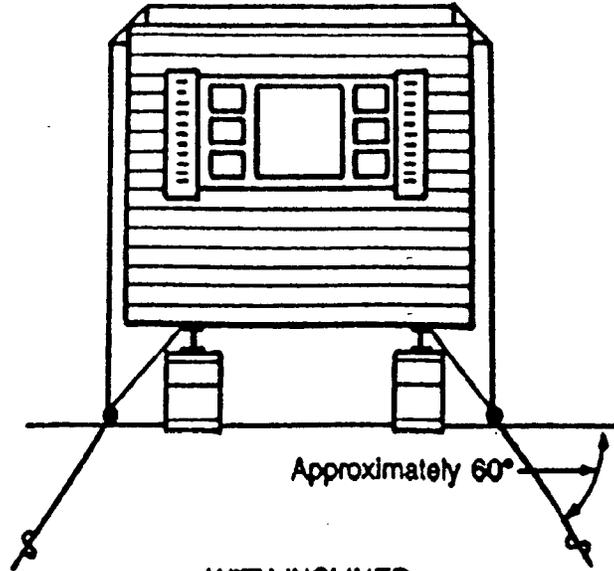
Appendix B - Incorrect Method of Installation

INCORRECT METHOD OF INSTALLATION

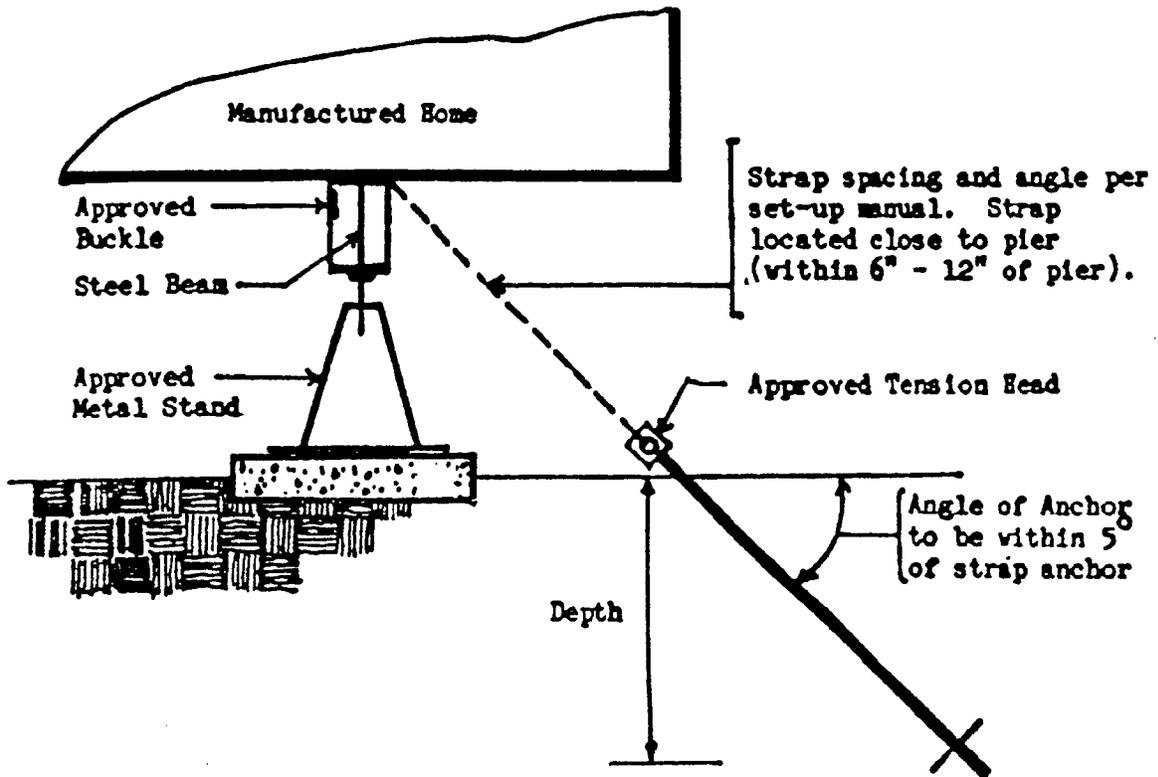


Appendix C - Correct Method of Installation

CORRECT METHOD OF INSTALLATION



WITH INCLINED ANCHORS



¶ ILL

SID: 06142

IL

Beginning of record displayed.

ILL Pending 19990611

Record 2 of 2

CAN YOU SUPPLY ? ▶YES ▶NO ▶COND ▶FUTUREDATE

¶

▶ :ILL: 1606680 :Borrower: TMA :ReqDate: 19990610 :NeedBefore: 19990710
 ▶ :Status: PENDING 19990610 :RecDate: :RenewalReq:
 ▶ :OCLC: 37690639 :Source: OCLCILL :DueDate: 7/15 :NewDueDate:
 ▶ :Lender: *NO@ ¶

▶ :CALLNO: ¶ TA 604.8 P27

▶ :TITLE: Preliminary report : disaster site investigation of manufactured homes / ¶

▶ :IMPRINT: Herndon, Va. : National Conference of States on Building Codes and Standards, 1989. ¶

▶ :VERIFIED: OCLC ¶

▶ :PATRON: a martin DEPT: hist STATUS:grad ¶

▶ :SHIP TO: ILL/University of Memphis Lib./Campus Box 526500/Memphis, TN 38152-6500 ¶

▶ :BILL TO: same FEIN # 62-0648618/WE MUST HAVE YOU FEIN# ON INVOICES. ¶

▶ :SHIP VIA: LIBR RATE :MAXCOST: \$20ifm :COPYRT COMPLIANCE: CCG ¶

▶ :E-MAIL: INTERNET: ILLLIB@MSUVX1.MEMST.EDU ¶

▶ :BORROWING NOTES: TRS PARTICIPANT, TENN-SHARE, SOLINE, ASERL, ARIEL 141.225.193.14 ¶

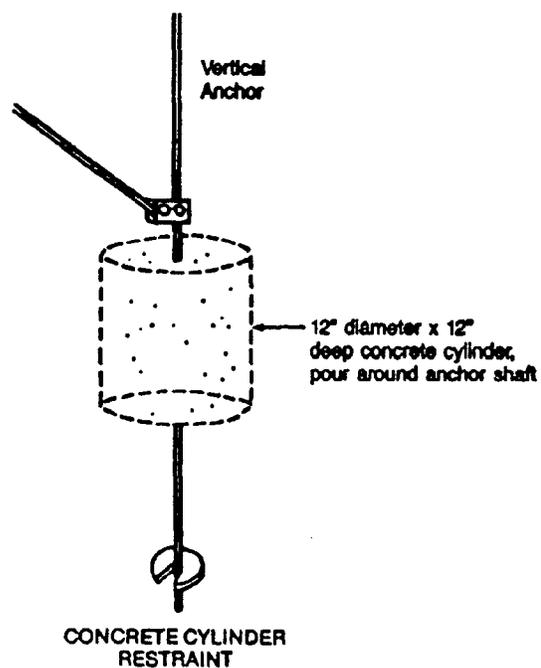
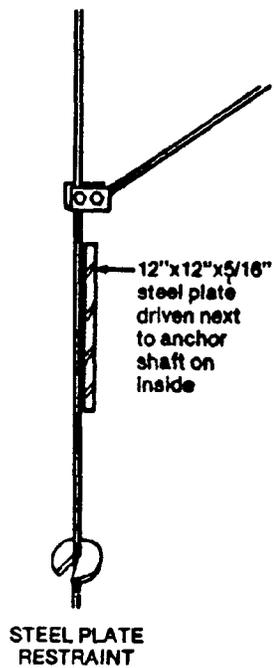
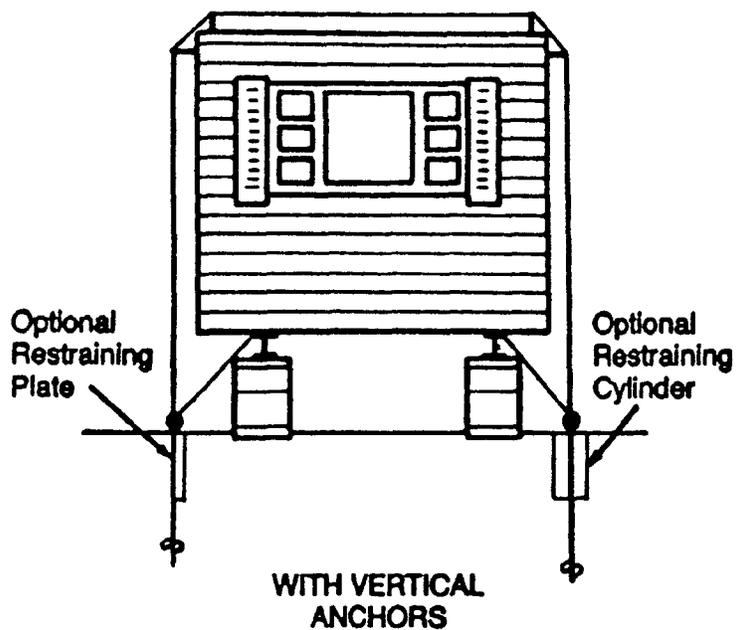
▶ :LENDING CHARGES:

:SHIPPED:

:SHIP INSURANCE: ¶

5716

ALTERNATE VERTICAL ANCHORING METHOD



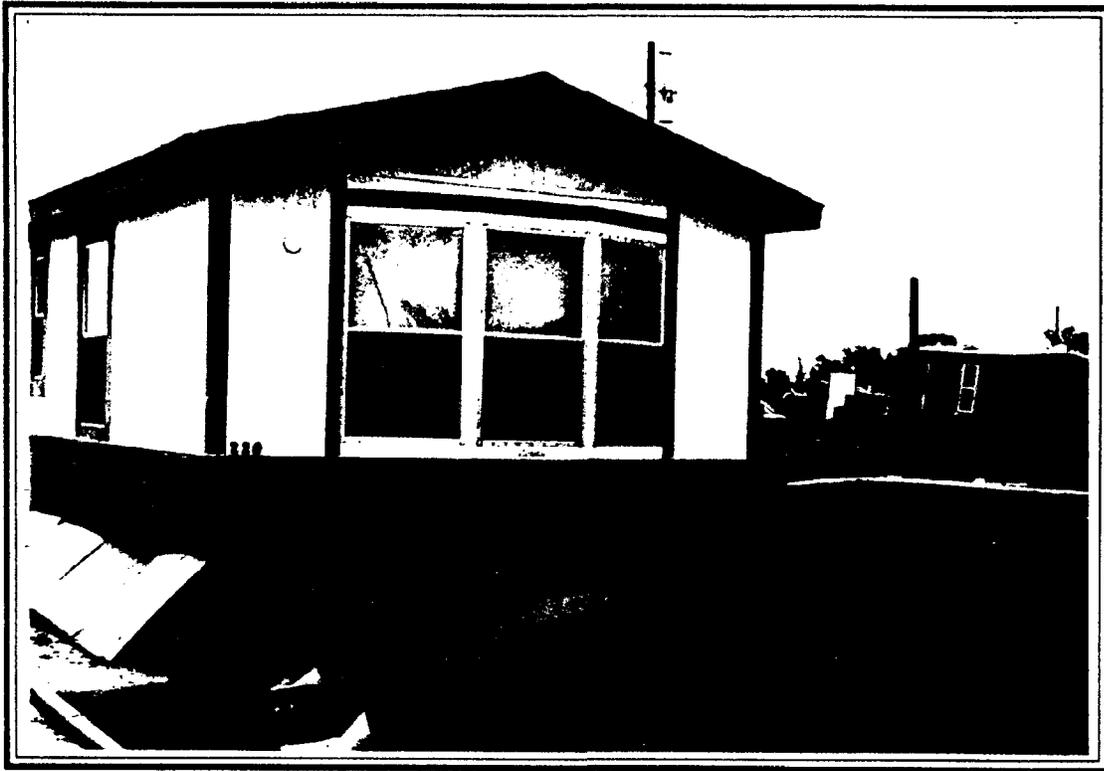
Appendix D - Texas Tornado Photos

PHOTOGRAPH INDEX

Photographs of Manufactured Homes Following
May 16, 1989 TORNADOS in Cleyburne, Texas

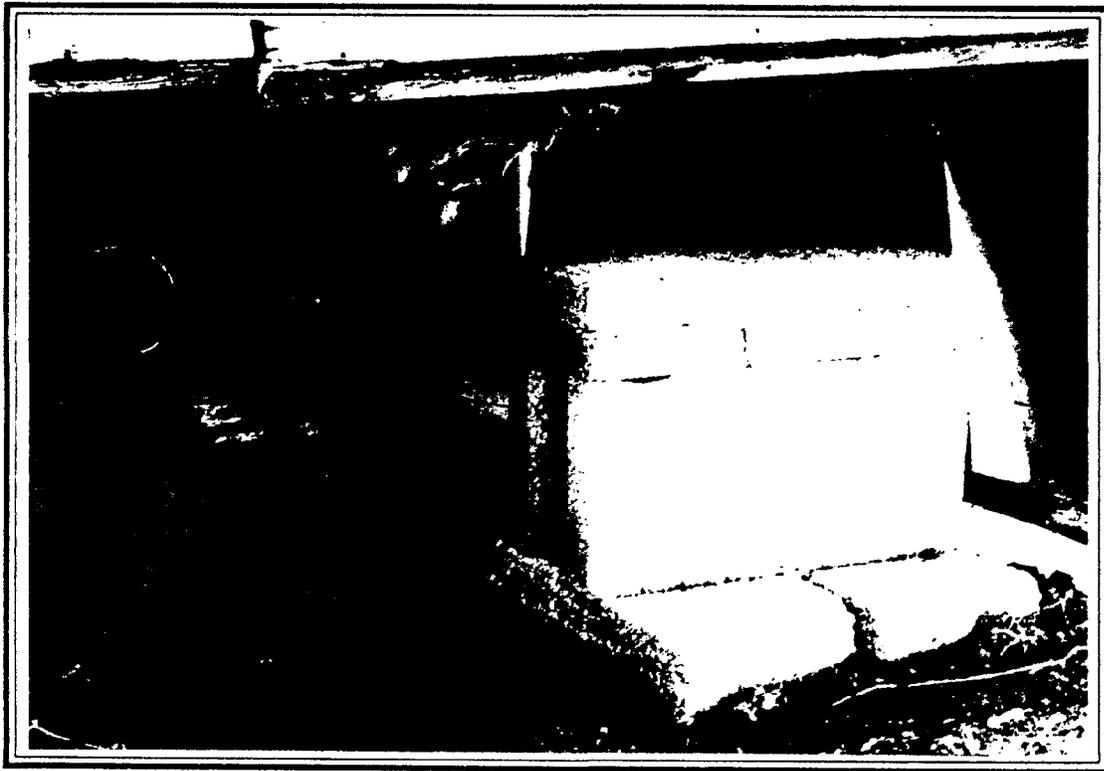
- Photo #1 - High winds shifted home off of foundation.
- Photo #2 - Typical improper attachment of anchor strap to I-beam. Clip is attached to bottom of beam. Proper installation would show strap wrapped around beam with clip attached top of beam.
- Photo #3 - Home flipped on its side.
- Photo #4 - Typical tie-down straps located on leeward side of manufactured home. Due to improper attachment, as described in Photo #2 above, clips fell off of I-beam while anchors stayed in place.
- Photo #5 - Home flipped up-side-down. Note anchors hanging from the side of home.
- Photo #6 - Close-up of anchor and strap on flipped home from Photo #5.
- Photo #7 - Three demolished homes. The white one near post was airborne and destroyed the other two. All three units are at least 20 ft. from their original sites. White unit is approx. 100 ft. from its original site. There was no evidence of tie-down anchors at the original site of the white house.
- Photo #8 - Demolished homes. Note undamaged neighboring units.

Photo #1



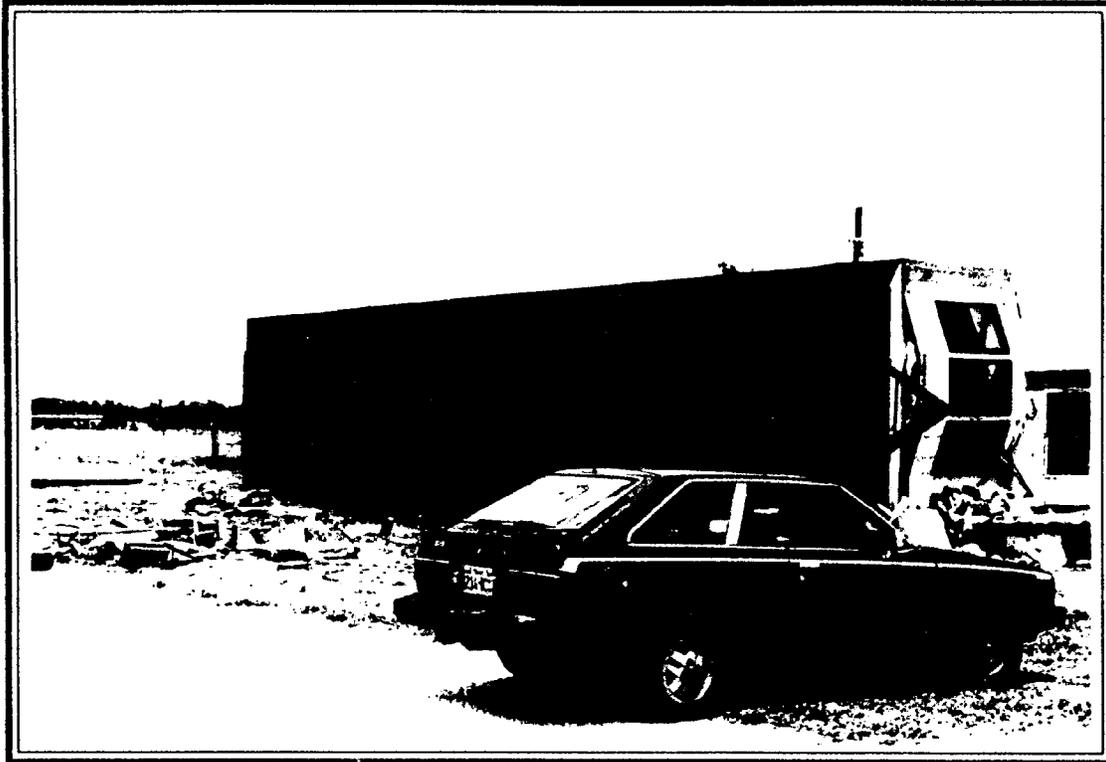
Home shifted off foundation

Photo #2



Improper attachment of strap to I-beam (see circled area)

Photo #3



Home flipped on side

Photo #4



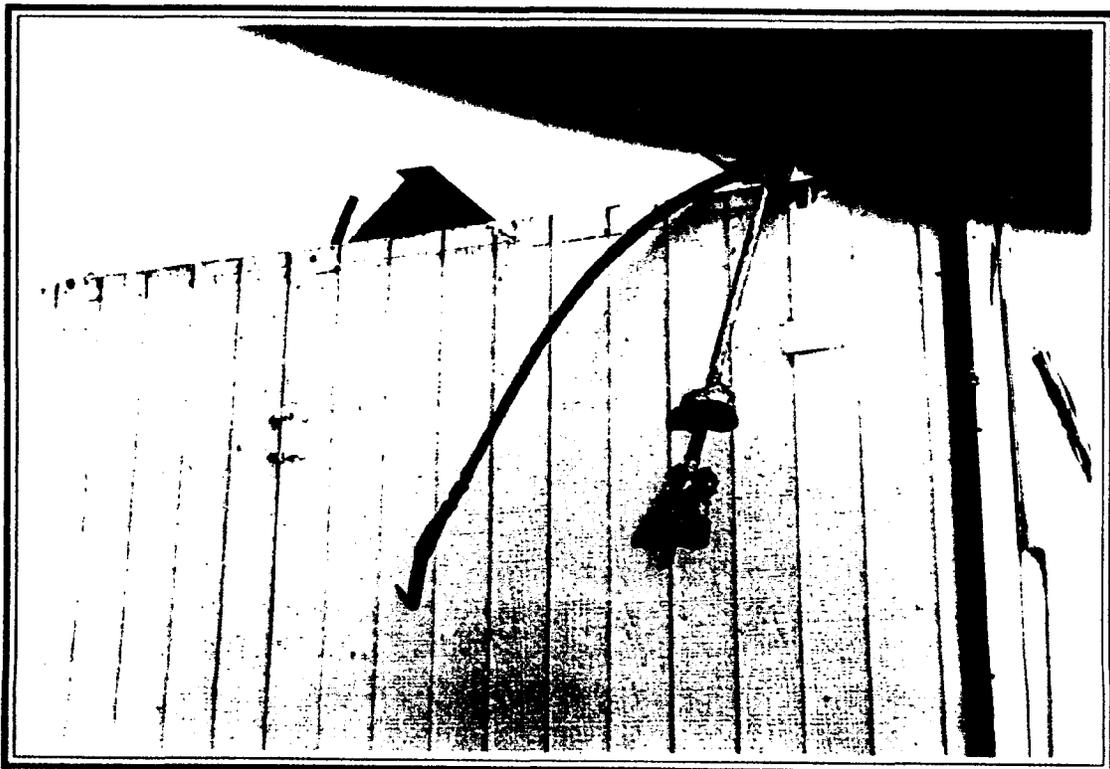
Hooks fell off I-beam due to improper attachment

Photo #5



Home flipped upside down

Photo #6



Anchor pulled from soil. Hook fell off I-beam

Appendix E - Hurricane Hugo Photos

PHOTOGRAPH INDEX

PHOTOGRAPHS OF MANUFACTURED HOME SITE INVESTIGATION
HURRICANE "HUGO", SOUTH CAROLINA
SEPTEMBER 22, 1989

- Photo #1 - Demolished home (Note: chassis and floor intact)
- Photo #2 - Major damage from overturning onto side
- Photo #3 - Metal roof partially removed
- Photo #4 - Roof loss and side wall failure
- Photo #5 - Home flipped on its side (Note: floor and chassis intact)
- Photo #6 - Demolished home
- Photo #7 - Metal roof loss and leeward wall collapsed
- Photo #8 - Metal roof loss and windward wall damaged
- Photo #9 - Demolished home blown off piers
- Photo #10 - Demolished home
- Photo #11 - Demolished home
- Photo #12 - Home rolled over the next mobile home
- Photo #13 - Demolished home
- Photo #14 - End wall siding pulled out at marriage line
- Photo #15 - Portion of end wall overhang siding pulled out
- Photo #16 - End wall overhang siding and corner siding pulled out
- Photo #17 - Home shifted from foundation
- Photo #18 - Home shifted from foundation
- Photo #19 - Tie-down anchors pulled out of ground
- Photo #20 - Tie-down strap fastened to outriggers and home shifted
- Photo #21 - Home shifted off the blocks (Note: strap clip at bottom of I-beam)
- Photo #22 - Leeward tie-down strap

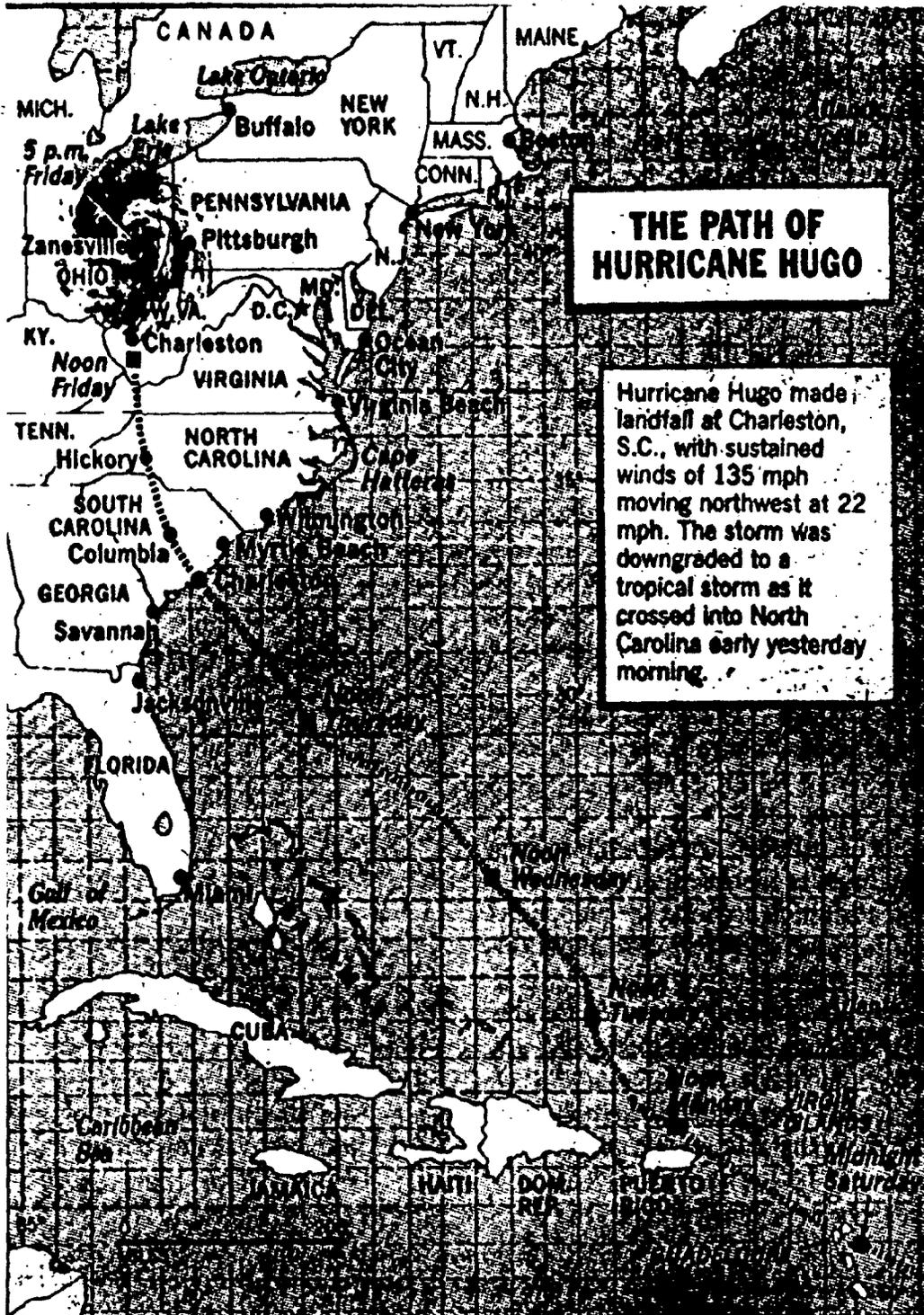
HURRICANE "HUGO", SOUTH CAROLINA (Continued)

Photo #23 - Tie-down anchors pulled out of flooded ground

Photo #24 - Tie-down anchor failure

Photo #25 - Foundation blocks and anchors after hurricane relocated the home 200 ft. away

Photo #26 - Roof truss to sidewall strap failure



THE PATH OF HURRICANE HUGO

Hurricane Hugo made landfall at Charleston, S.C., with sustained winds of 135 mph moving northwest at 22 mph. The storm was downgraded to a tropical storm as it crossed into North Carolina early yesterday morning.



Photo # 1

Demolished home (Note: chassis and floor intact)



Photo #2

Major damage from overturning onto side



Photo #3

Metal roof partially removed

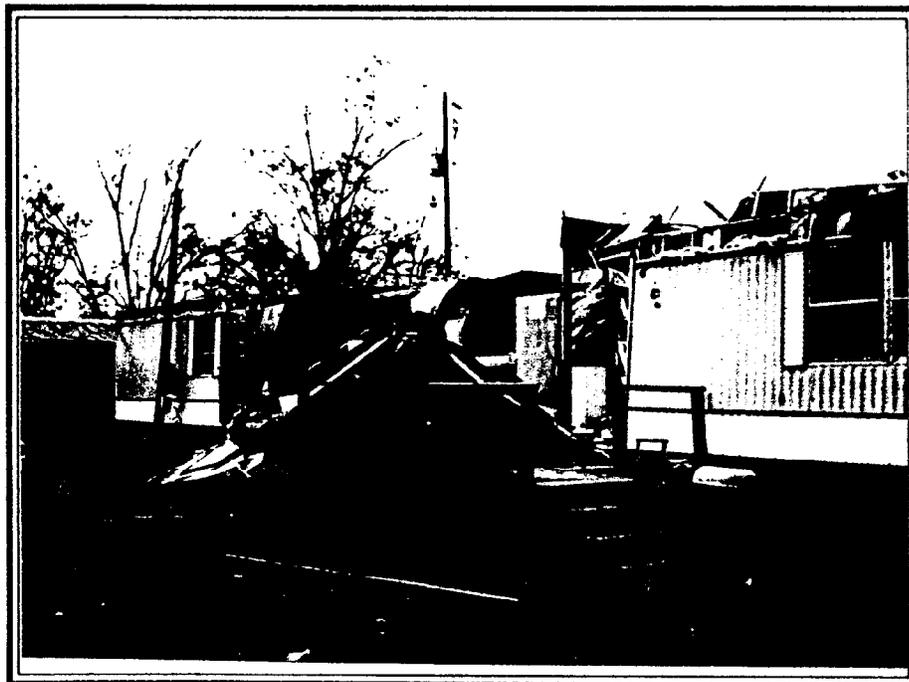


Photo #4

Roof loss and side wall failure



Photo #5

Home flipped on its side (Note: floor and chassis intact)



Photo#6

Demolished home

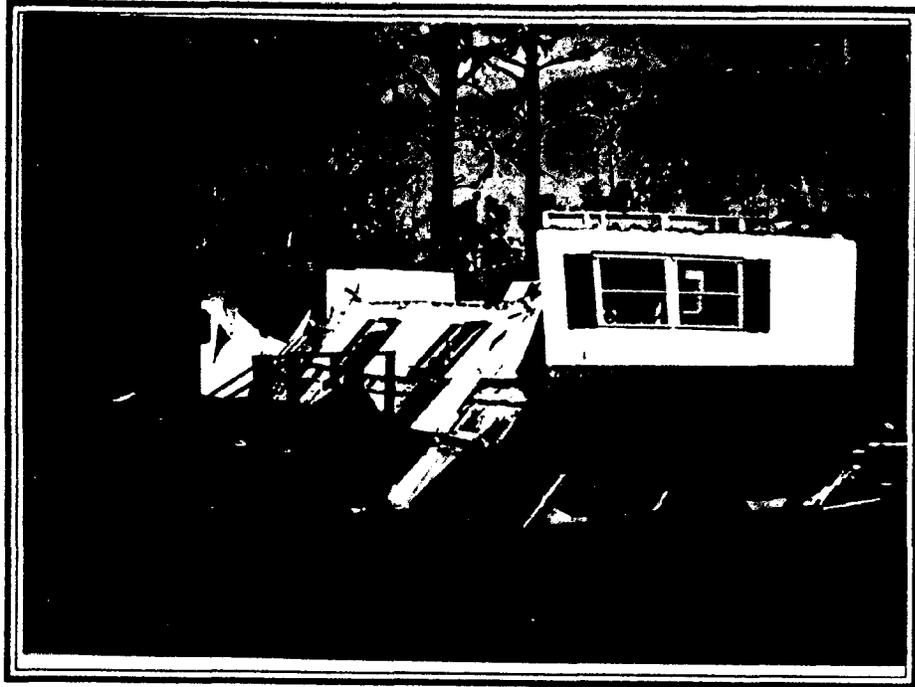


Photo #7

Metal roof loss and leeward wall collapsed



Photo #8

Metal roof loss and windward wall damaged



Photo #9

Demolished home blown off piers



Photo #10

Demolished home



Photo #11

Demolished home



Photo #12

Home rolled over the next mobile home



Photo #13

Demolished home

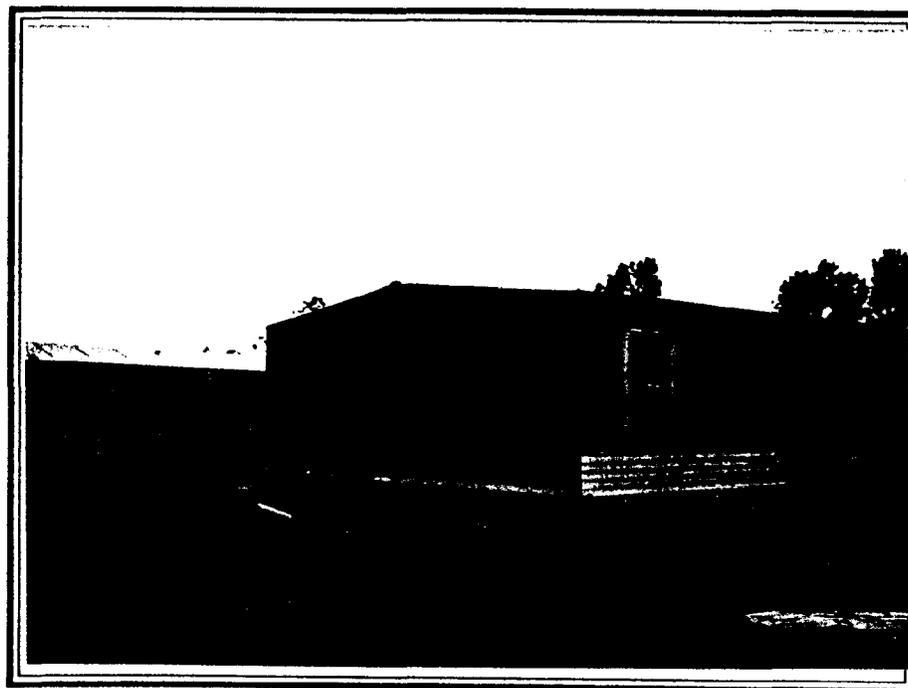


Photo #14

End wall siding pulled out at marriage line

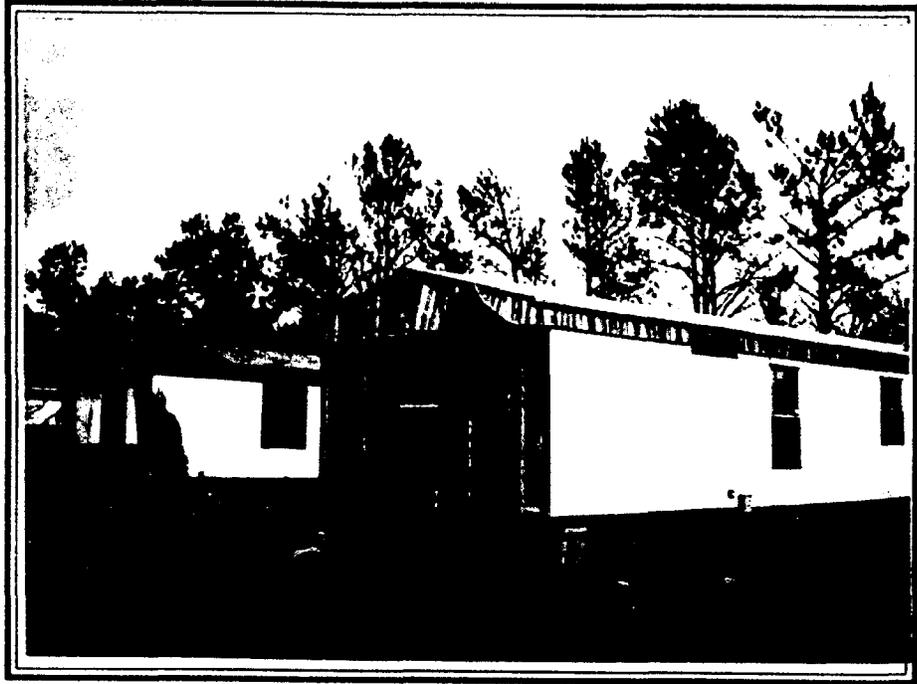


Photo #15

Portion of end wall overhang siding pulled out



Photo #16

End wall overhang siding and corner siding pulled out

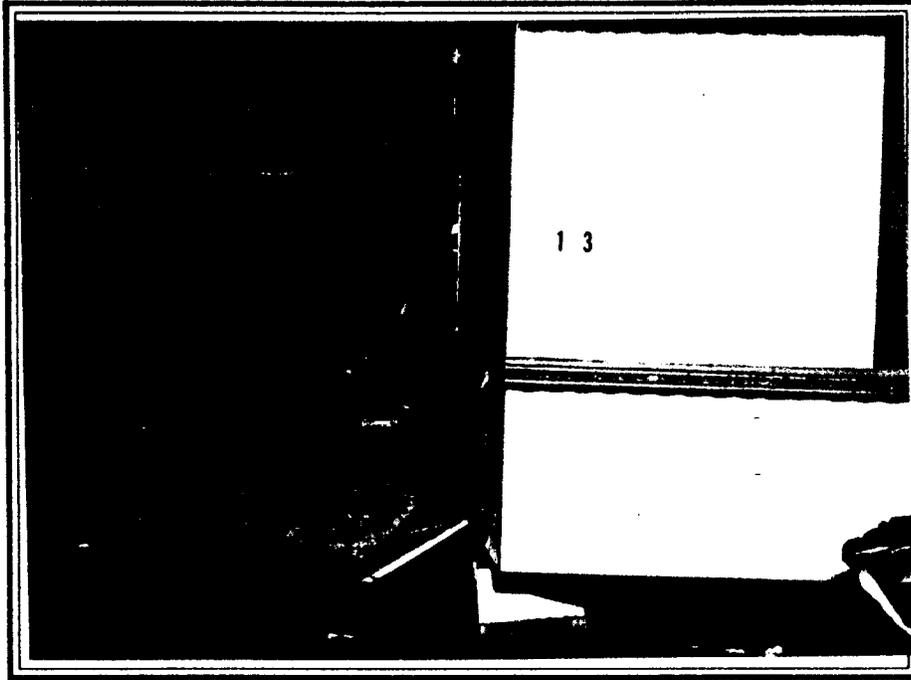


Photo #17

Home shifted from foundation

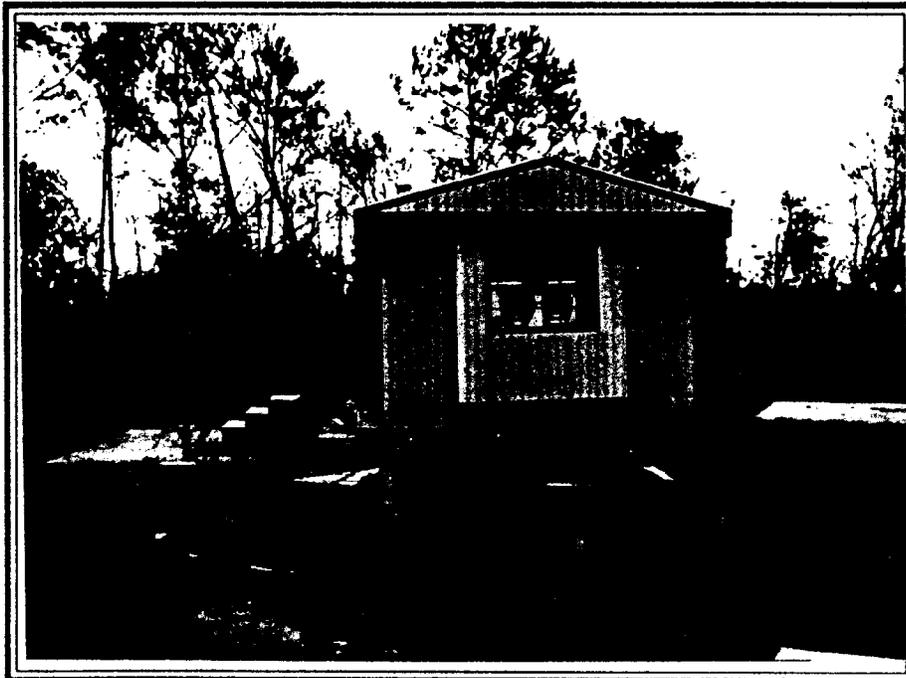


Photo #18

Home shifted from foundation



Photo #19

Tie-down anchors pulled out of ground

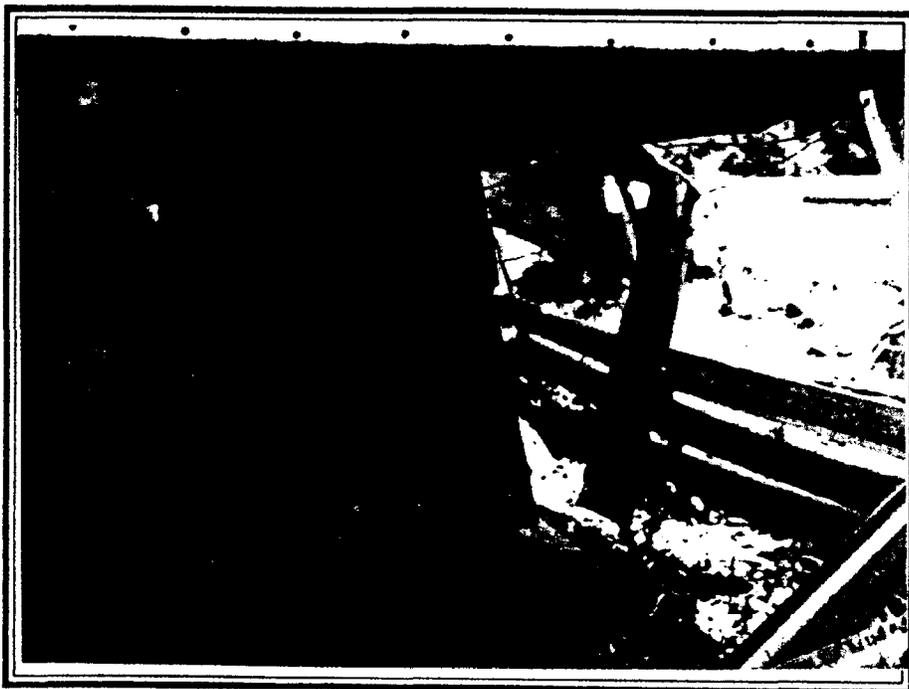


Photo #20

Tie-down strap fastened to outriggers and home shifted

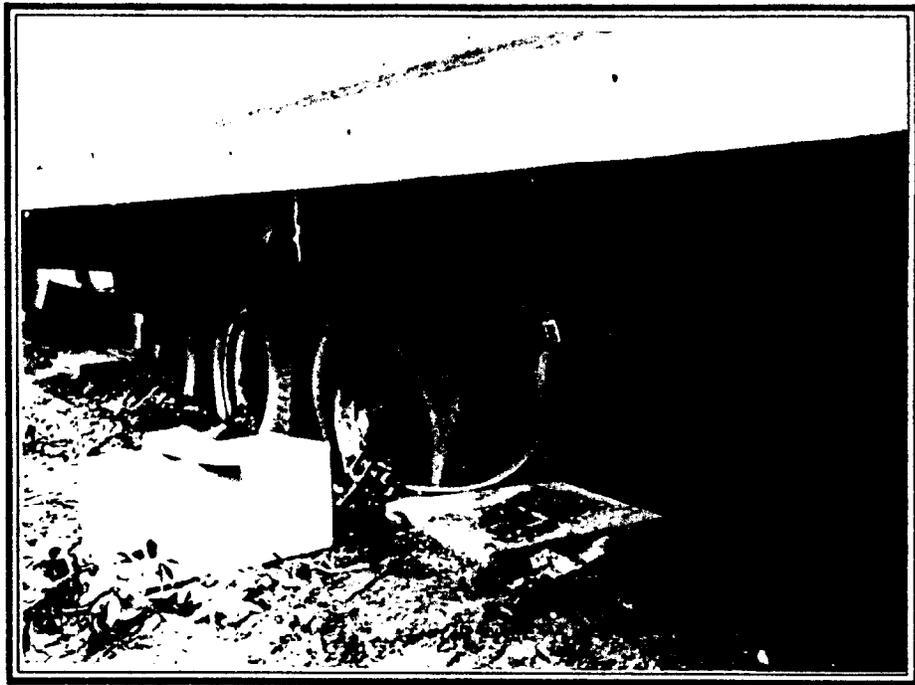


Photo #21

Home shifted off the blocks (Note: strap clip at bottom of I-beam)



Photo #22

Leeward tie-down strap

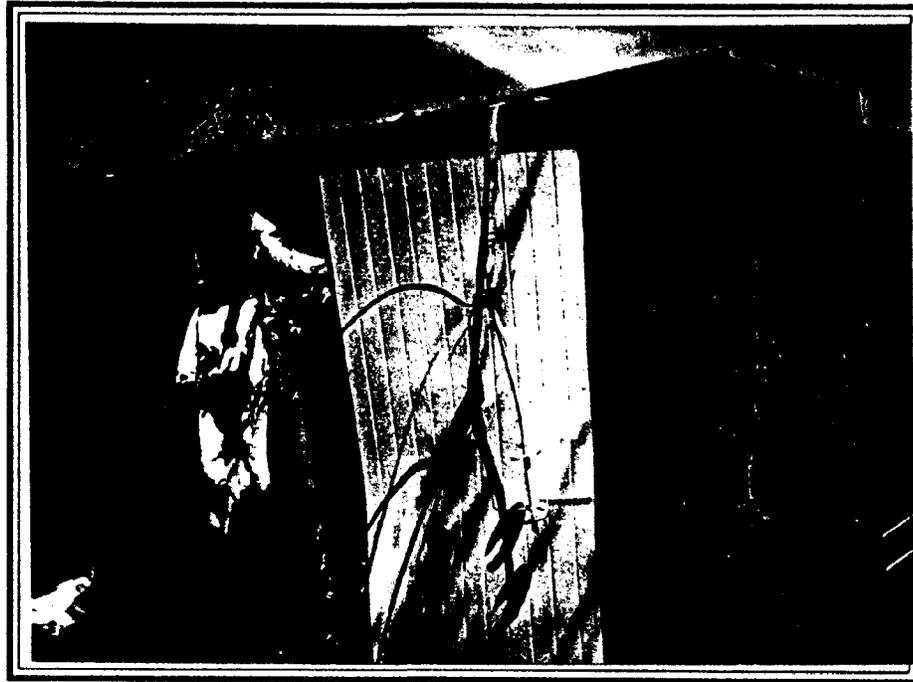


Photo #23

Tie-down anchors pulled out of flooded ground

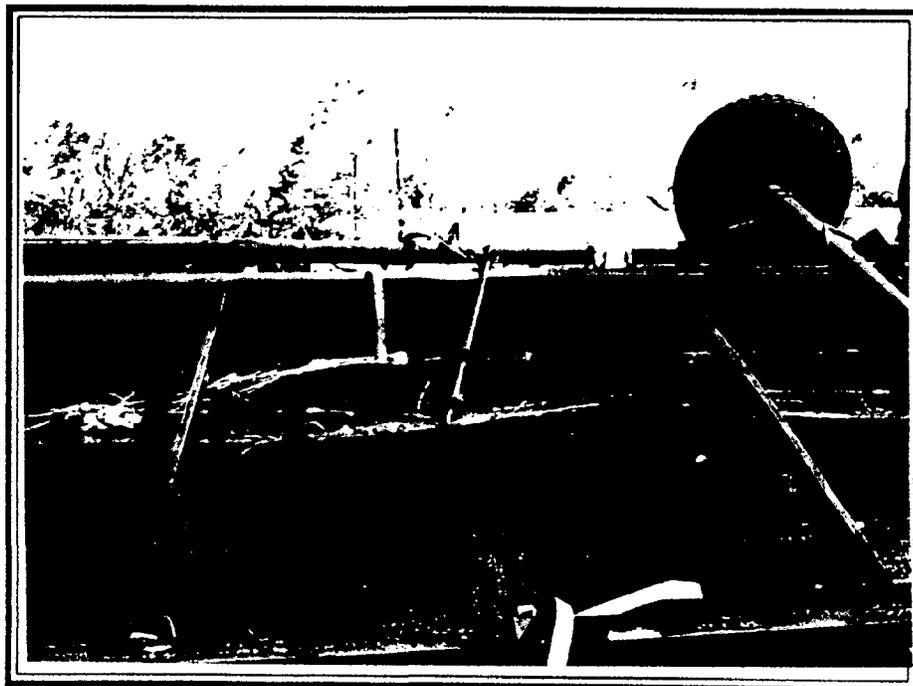


Photo #24

Tie-down anchor failure

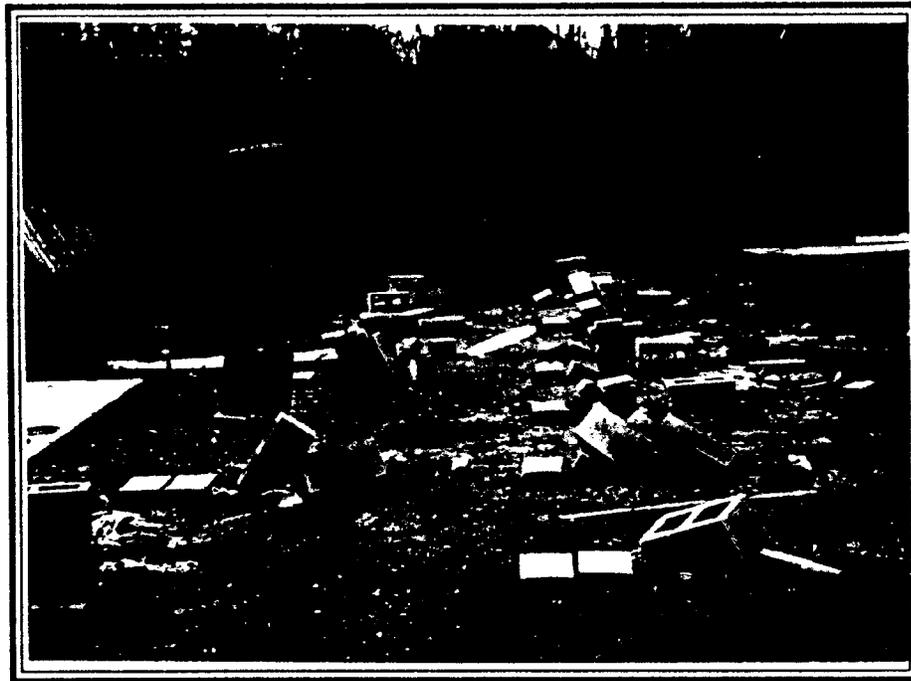


Photo #25

Foundation blocks and anchors after hurricane relocated the home 200 ft. away

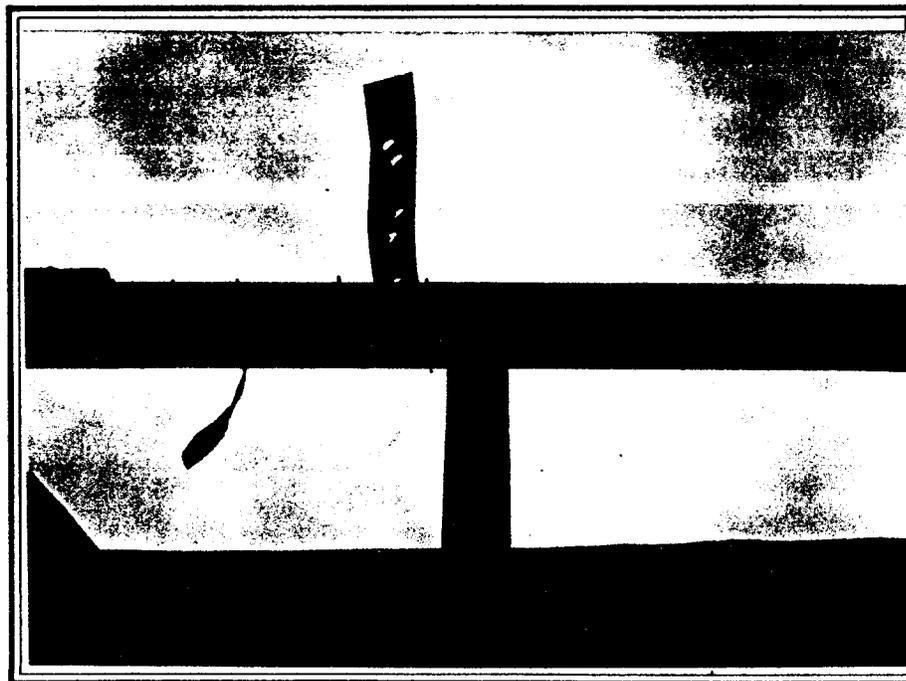


Photo #26

Roof truss to sidewall strap failure

Appendix F - Hurricane Jerry Photos

PHOTOGRAPH INDEX

PHOTOGRAPHS OF MANUFACTURED HOME SITE INVESTIGATION
HURRICANE "JERRY", GALVESTON, TEXAS
OCTOBER 15, 1989

- Photo #1 - Major damage to home
- Photo #2 - Major damage to home
- Photo #3 - Roof and siding loss
- Photo #4 - Roof loss
- Photo #5 - Improper anchoring
- Photo #6 - Improper blocking
- Photo #7 - Roof damage
- Photo #8 - Roof damage
- Photo #9 - Eave damage
- Photo #10 - Siding and eave damage
- Photo #11 - Siding damage
- Photo #12 - Siding damage

THE PATH OF HURRICANE JERRY

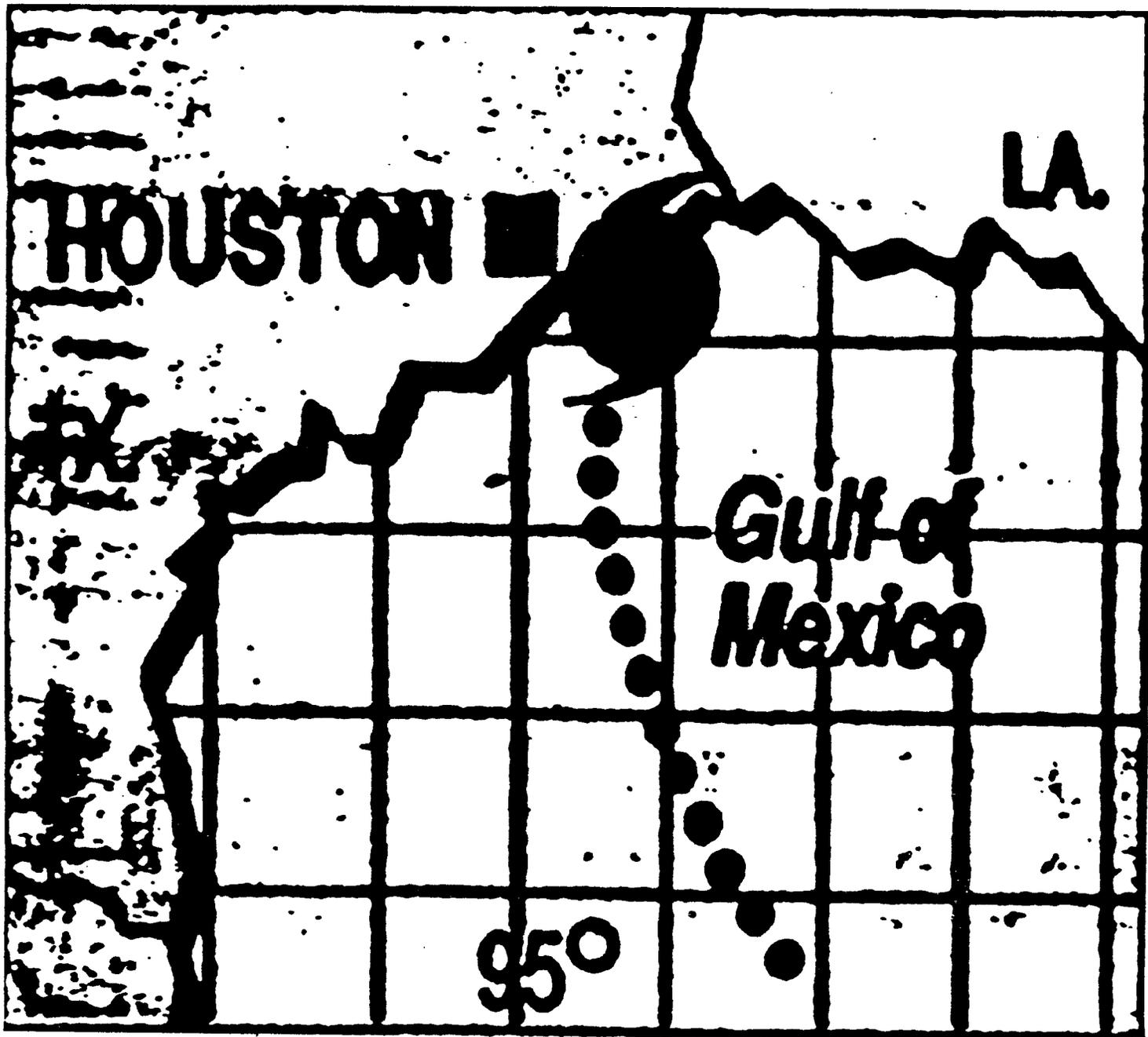




Photo #1

Major damage to home

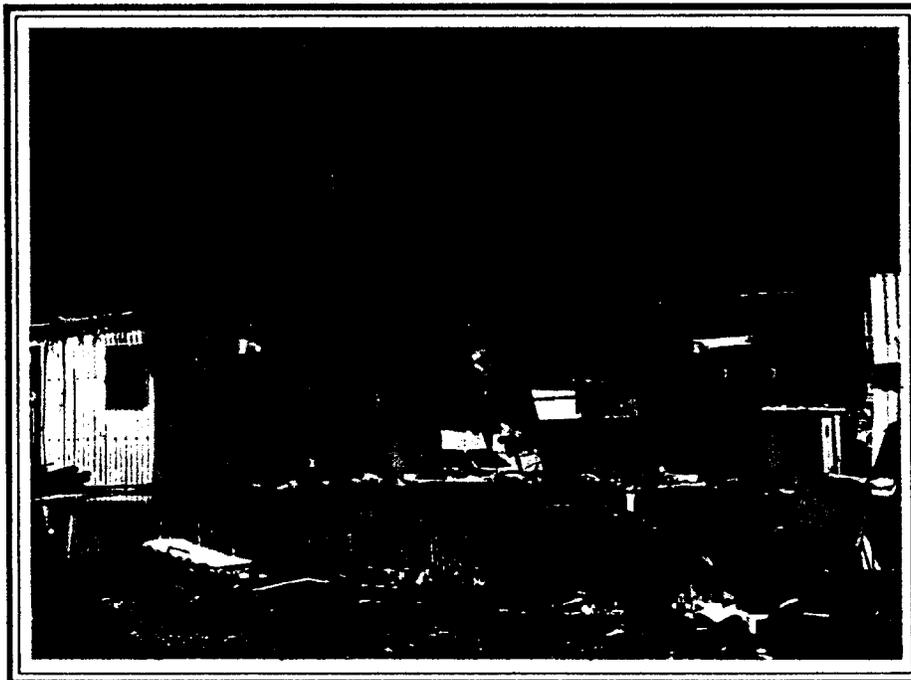


Photo #2

Major damage to home

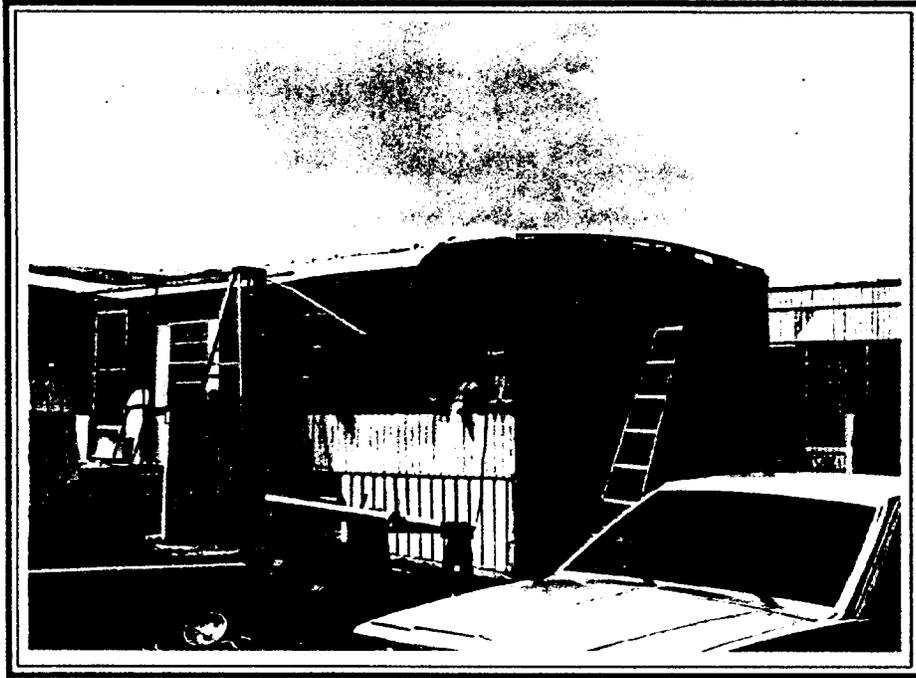


Photo #3

Roof and siding loss

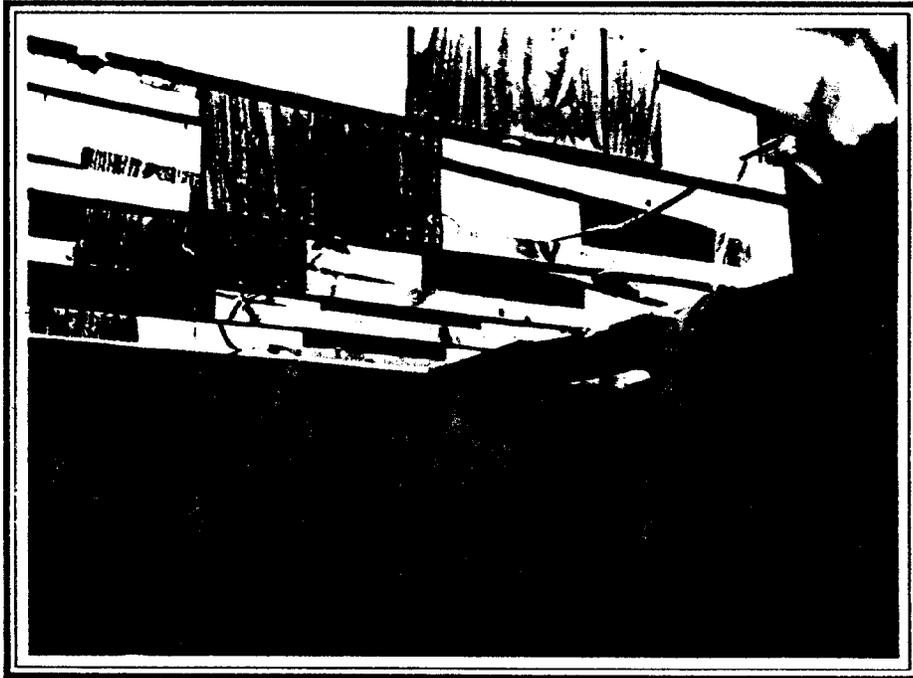


Photo #4

Roof loss



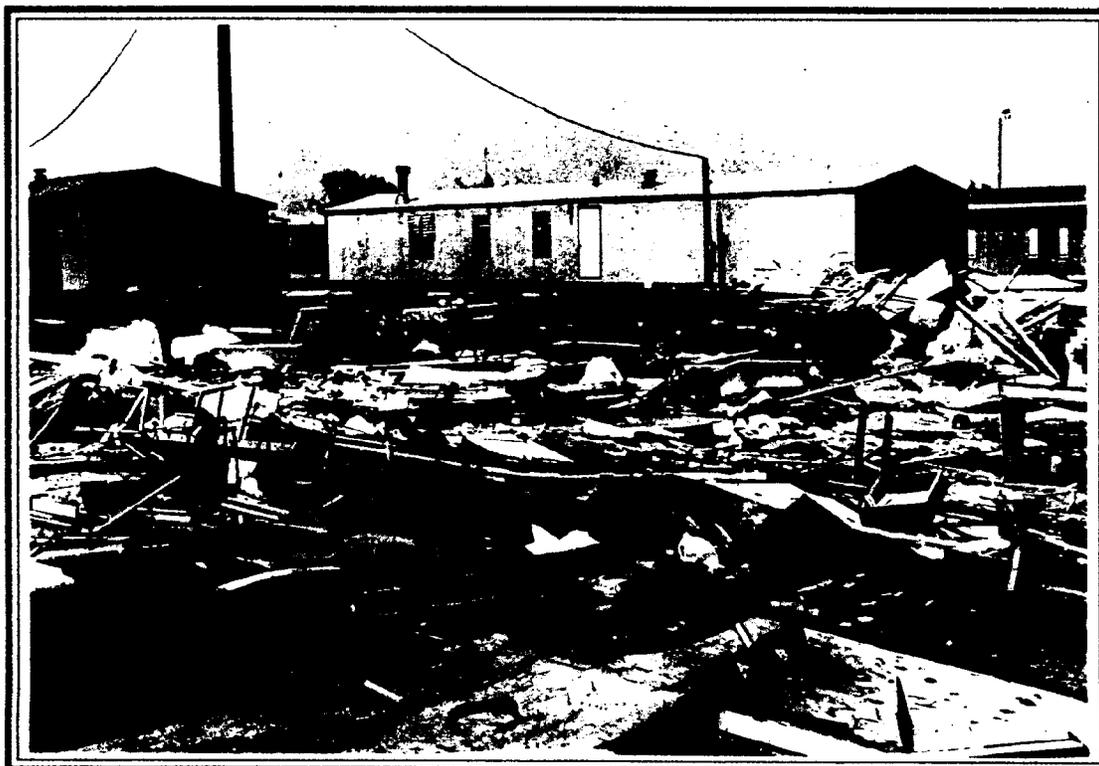
Photo #5

Improper anchoring



Three demolished homes.

The white one (near post) was airborne and destroyed the other two.



Demolished homes (note undamaged neighboring homes)



Photo #6

Improper blocking

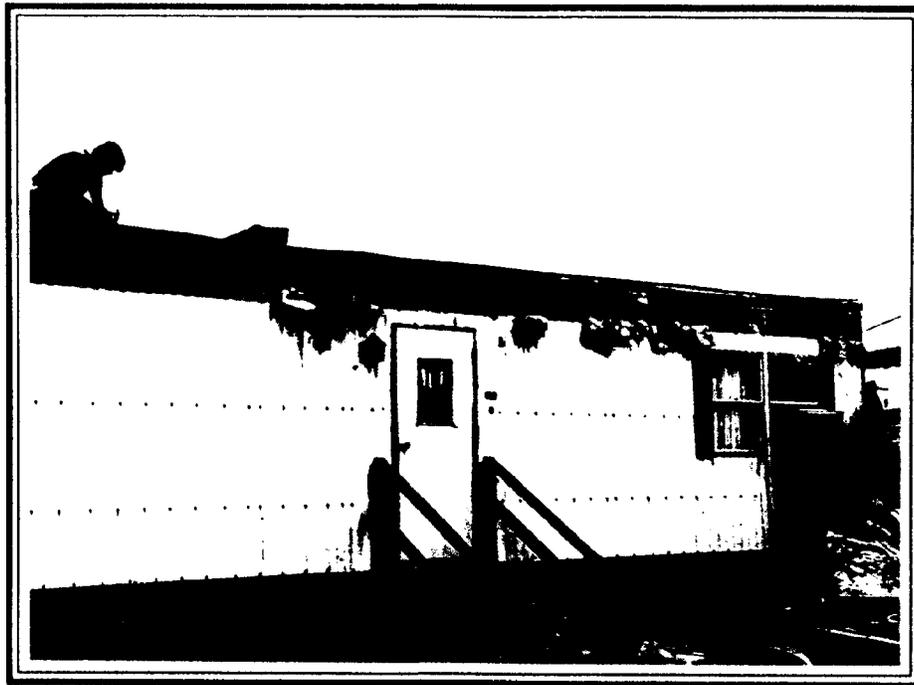


Photo #7

Roof damage

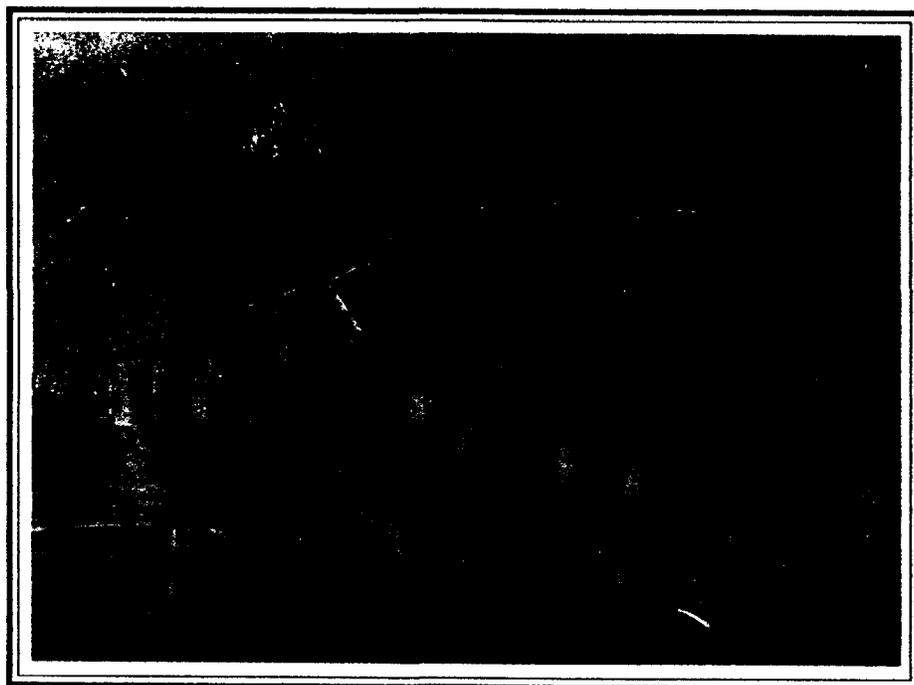


Photo #8

Roof damage

Photo #9



Eave damage

Photo #10



Siding and eave damage



Photo #11

Siding damage

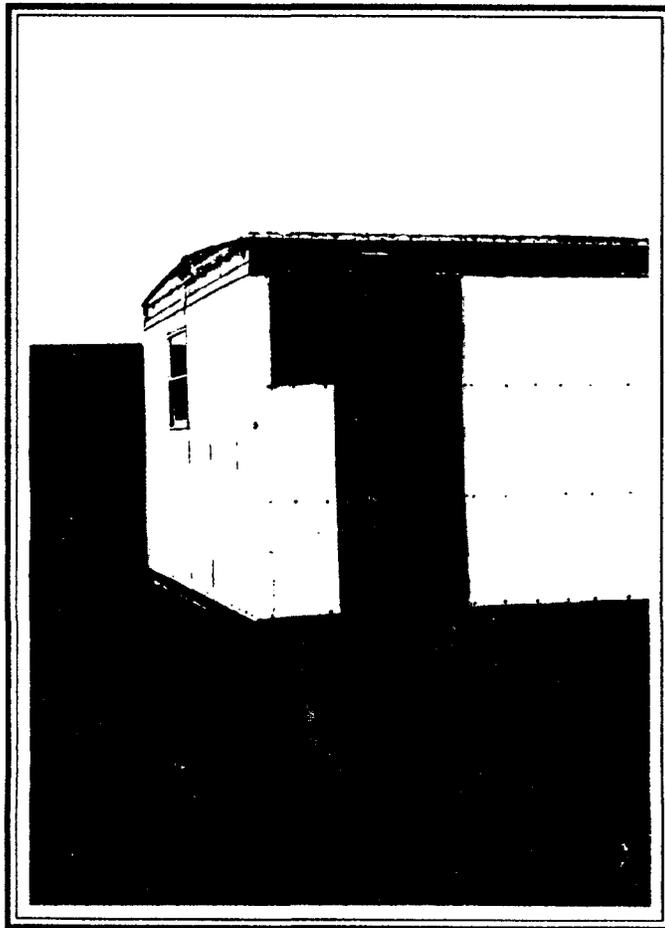


Photo #12

Siding damage

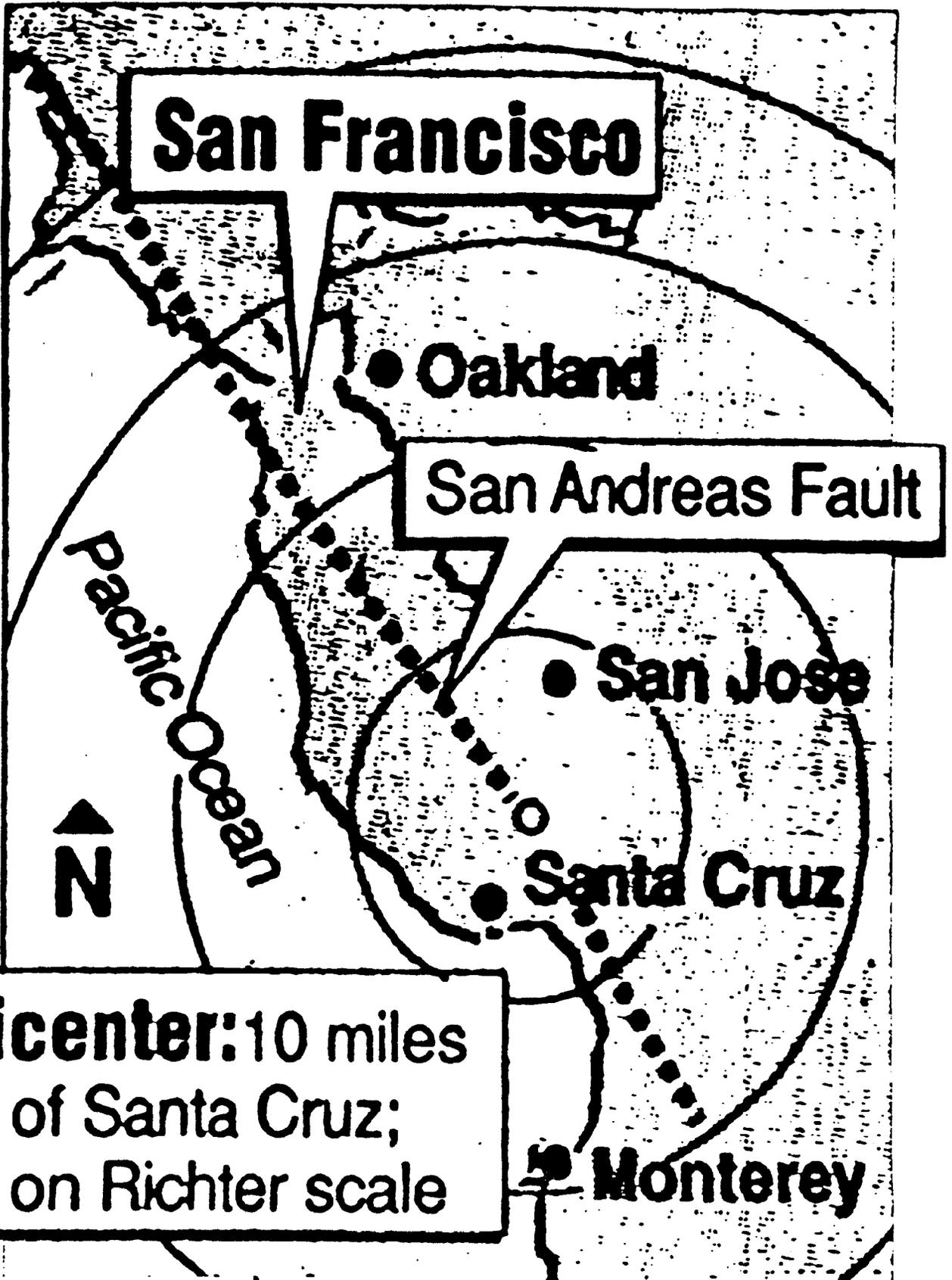
Appendix G - California Earthquake Photos

PHOTOGRAPH INDEX

PHOTOGRAPHS OF MANUFACTURED HOME SITE INVESTIGATION
EARTHQUAKE, CALIFORNIA
OCTOBER 17, 1989

- Photo #1 - Homes completely shifted off piers, supported by wheels
- Photo #2 - Homes completely shifted off piers, supported by wheels
- Photo #3 - Homes partially shifted off piers
- Photo #4 - Homes partially shifted off piers
- Photo #5 - Home destroyed by fire
- Photo #6 - Damaged skirting and electrical service pedestal
- Photo #7 - Home damaged by piers
- Photo #8 - Home damaged by piers
- Photo #9 - Ground anchor of shifted home
- Photo #10 - Typical pier with small bearing surface
- Photo #11 - Earthquake jacks
- Photo #12 - Earthquake jacks

CALIFORNIA EARTHQUAKE



San Francisco

● **Oakland**

San Andreas Fault

● **San Jose**

● **Santa Cruz**

● **Monterey**

N

Pacific Ocean

**Epicenter: 10 miles
NE of Santa Cruz;
7.1 on Richter scale**

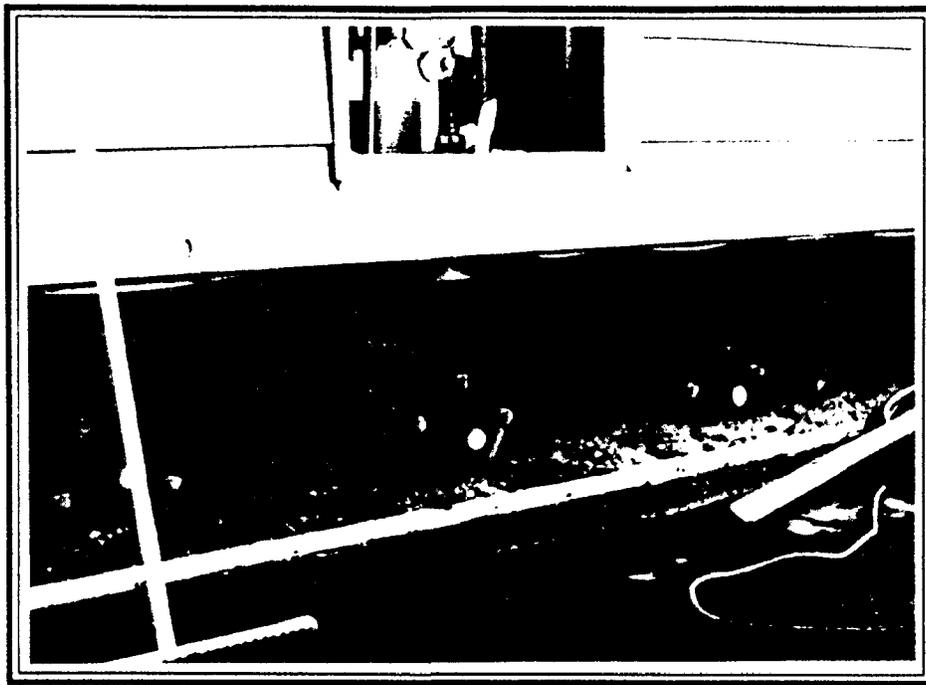


Photo #1

Homes completely shifted off piers, supported by wheels

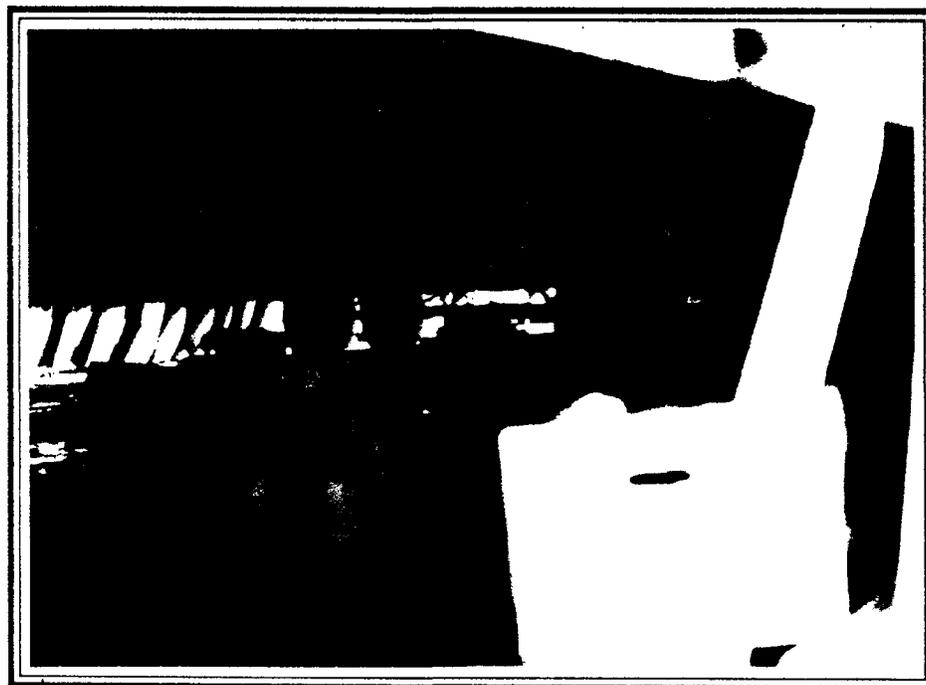


Photo #2

Homes completely shifted off piers, supported by wheels

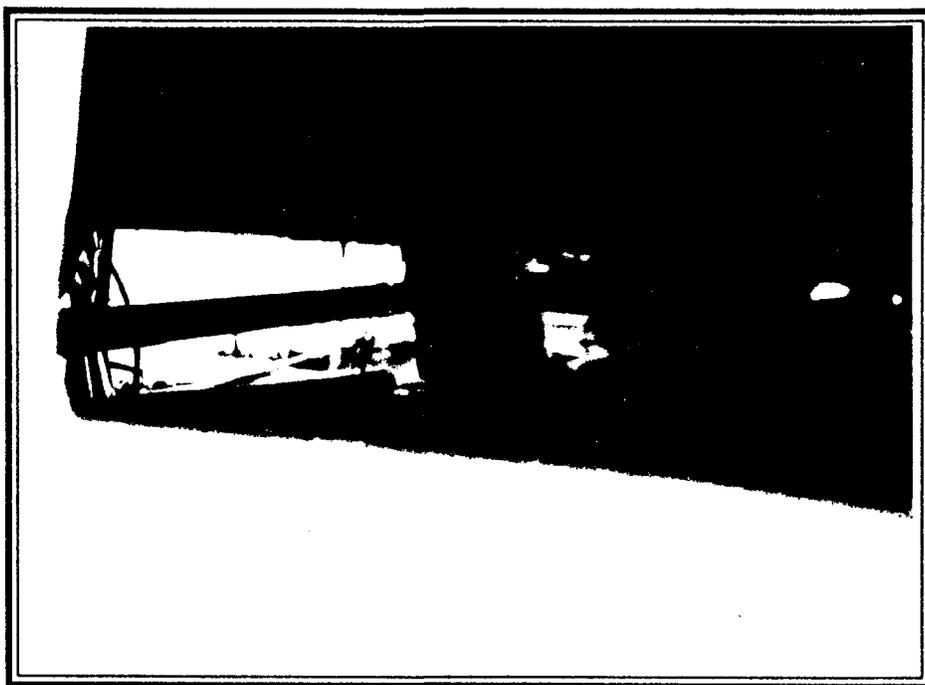


Photo #3

Homes partially shifted off piers



Photo #4

Homes partially shifted off piers

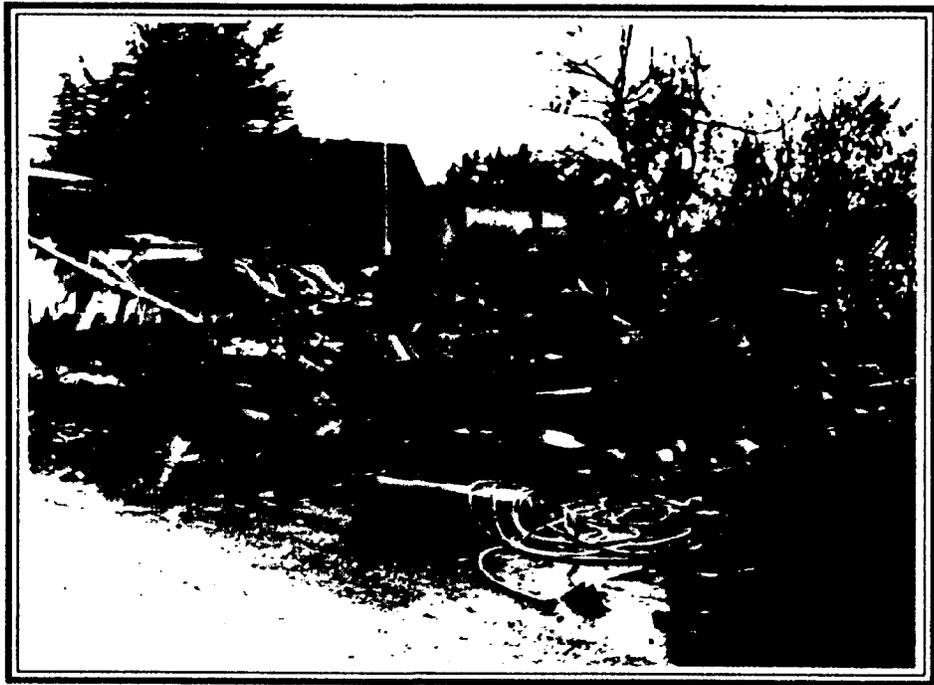


Photo #5

Homes destroyed by fire



Photo #6

Damaged skirting and electrical service pedestal

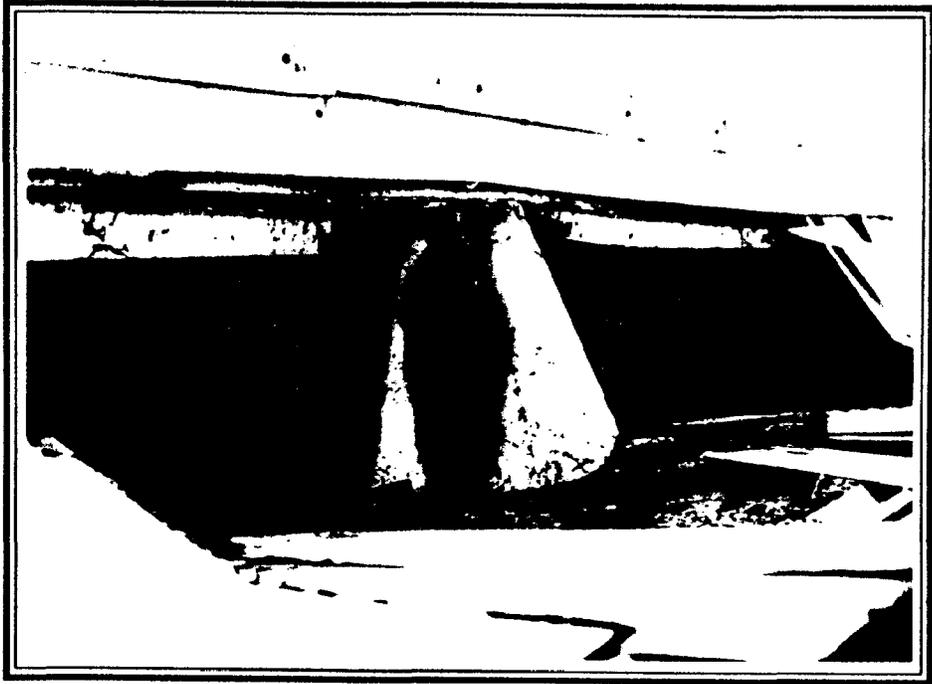


Photo #7

Home damaged by piers

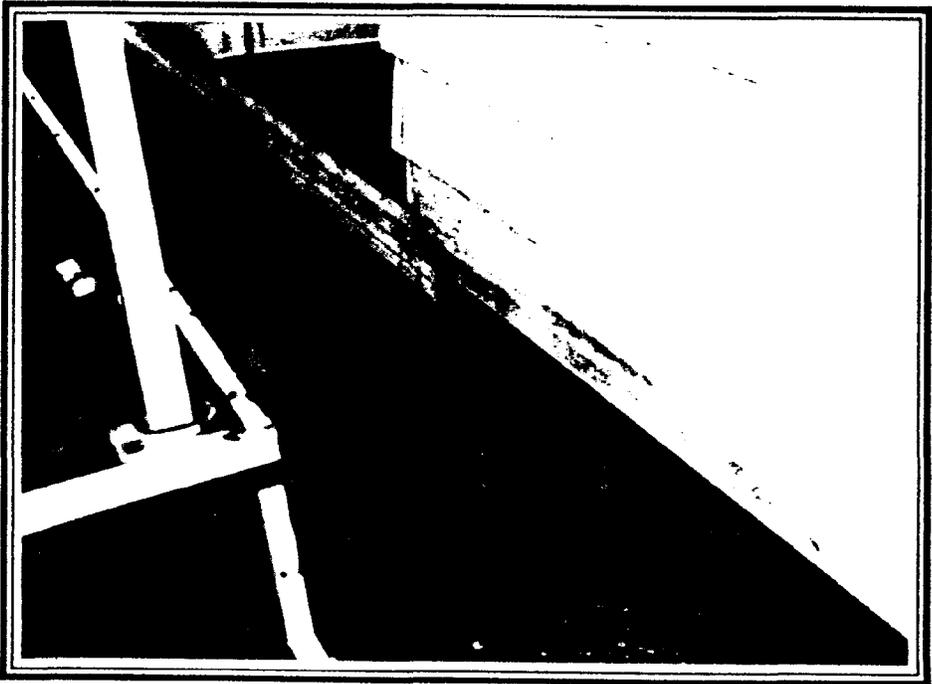


Photo #8

Home damaged by piers



Photo #9

Ground anchor of shifted home

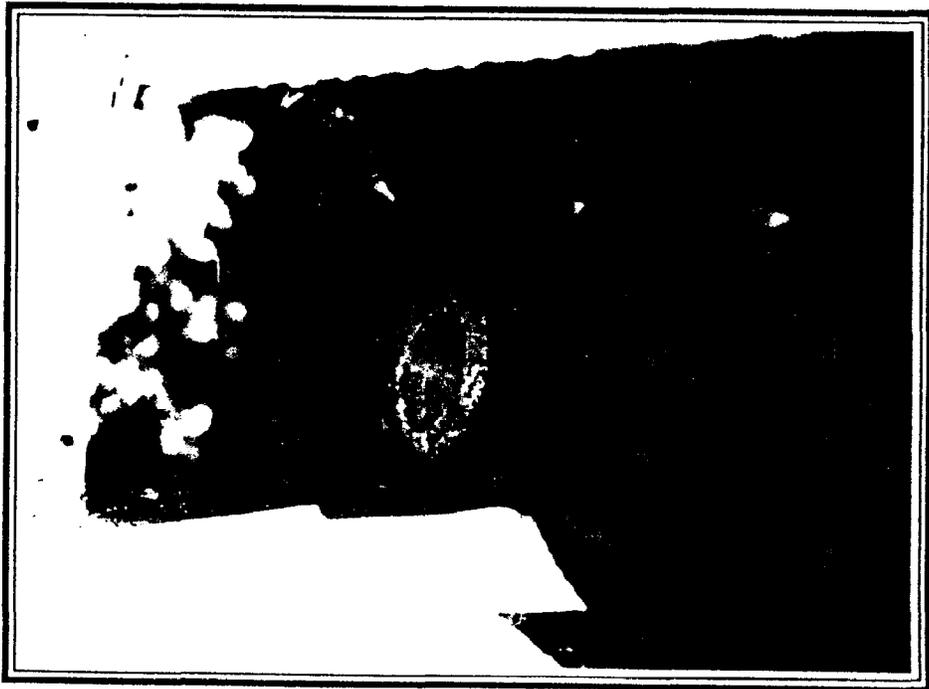


Photo #10

Typical pier with small bearing surface



Photo #11

Earthquake jacks

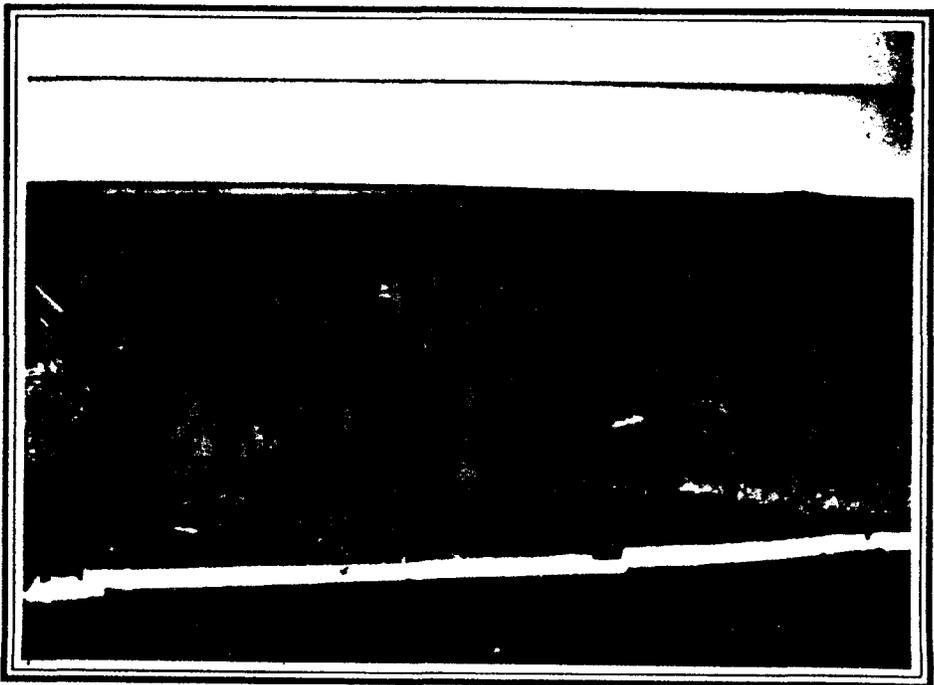


Photo #12

Earthquake jacks

Appendix H - National Profile of Tie-down Regulations

**NATIONAL PROFILE OF STATE REGULATIONS
REGARDING INSTALLATION OF MANUFACTURED HOMES**

State Program Criteria	States (percentage of homes potentially affected)
1. Scope of regulation and effectiveness of enforcement programs.	
a. States having little or no installation regulations and no enforcement programs.	(21 States) AK, CO, DE, GA, (43%) ID, IL, LA, MT, NE, NH, ND, OH, OK, PA, SC, SD, UT, VT, NV, WI, NY
b. States having some installation regulations and no enforcement programs.	(11 States) CT, IN, KA, KY, (22%) MD, ME, MO, NJ, NY, RI, VA
c. States having significant installation regulations but ineffective enforcement programs.	(9 states) AL, AR, FL, MA, (18%) MI, MN, NC, OR, WA
d. States have significant installation regulations and also effective enforcement programs.	(8 states) AZ, CA, IA, MS, (16%) NV, NM, TN, TX
2. Monitoring by state of the local government for compliance with state laws.	
a. States that monitor performance of local inspection agencies and provide training to local inspectors.	(4 states) AZ, CA, IA, OR (8%)
b. States that do not monitor performance of local governments.	(11 states) AL, AR, FL, MA, (22%) MN, MO, NC, OR, RI, VA, WA
3. Bonding of dealers and installers.	
a. States that require bonding of dealers.	(7 states) FL, MS, NC, NM, (14%) TN, TX, WA
b. States that require bonding of installers separate from dealers.	(5 states) NM, NC, TN, TX, (10%) WA
4. States that require licensing of installers.	(13 states) AZ, CA, MS, MI, (27%) ME, MN, NV, NM, NC, RI, TN, TX, WA

**NATIONAL PROFILE OF STATE REGULATIONS
REGARDING INSTALLATION OF MANUFACTURED HOMES**

State Program Criteria	States (percentage of homes potentially affected)
5. Installation Standards	
a. States that require compliance with home manufacturers installation instructions.	(24 states) AL, AZ, AR, CA, (49%) FL, IA, IN, KY, MO, MA, MI, MN, MO, NV, ME, MS, NC, NY, OR, TN, RI, TX, VA, WA
b. States having blocking and tie-down standards	(22 states) AL, *AZ, AR, CA, (45%) FL, IA, IN, KY, KS, MI, MN, NV, NJ, NM, NC, OR, MO, RI, TN, TX, VA, WA (* No tie-down standards)
6. States that require systems component manufacturers to seek approval from the state	(17 states) AL, AZ, AR, CA, (35%) FL, IA, KS, MI, MA, MN, MS, MO, NV, NM, OR, TN, TX
7. States that have state inspection or permit fees. (This does not include any requirement of additional fees established by the local government.)	(6 states) CA, IA, NM, OR, (12%) TN, TX

¹ DEFINITIONS OF SCOPE OF REGULATION AND EFFECTIVENESS
OF ENFORCEMENT PROGRAM

- a. The states may not have any state-wide laws or programs such as the following: state licensing or bonding of installers; blocking and tie-down standards; routine state inspection of installation of homes; reporting mechanism for installation; components listings. The local government in these states may or may not have related laws.

Appendix I - NCSBCS Tie-down Recommendations

Recommendations/Steps to Improve Installation of Manufactured Homes

The chart below lists recommended steps that HUD, the states, home manufacturers, manufacturer associations, ground anchor or other component manufacturers, insurance companies, and state associations of manufactured home dealers and manufacturers can or should take to improve installation of manufactured homes.

SUGGESTED LIST TO FOLLOW TO HELP IMPROVE INSTALLATION OF MANUFACTURED HOMES

HUD

- Develop training manuals, video training modules for installation of homes.
- Collect existing technical data about components used in installation; provide a central source to all state and local offices.
- Hold series of workshops with SAA, manufacturer's associations, dealer's associations, local county officials, HUD area offices on installation.
- Place emphasis on the optional responsibilities of the SAAs, such as dealer lot and installation inspection by making them mandatory.
- Develop brochures and small handbook for homeowners which contain information about key installation issues and coordinate distribution of such material through manufacturers, dealers, and homeowner associations.
- Consider developing Federal standards on installation hardware, such as ground anchors, buckles, piers, etc.; or work with building codes or standards' organizations such as ANSI and ASTM to develop such standards.

SUGGESTED LIST TO FOLLOW TO HELP IMPROVE INSTALLATION OF MANUFACTURED HOMES

HUD (continued)

- Notify lenders of problems (Title 1 program).
- Enhance review of DAPIA approved set-up manuals.
- Require additional data collection and evaluations on the following:
 - On-site investigations in the remaining 40 states not covered by the study.
 - On-site investigations in all 50 states of manufactured homes on permanent foundations.
 - State programs including detailed comparison of current state standards and regulations.
 - County and city programs.
 - Listing programs of installation hardware and verification of their performance by testing.
 - Homeowner manuals in compliance with CFR 3283.
 - Cost/benefit evaluation of improved installation procedures.
 - Cost/benefit evaluation of state/local regulation of installations.
 - Reduced durability and consumer satisfaction by improper installation (relationship of consumer complaints with improper installation).

SUGGESTED LIST TO FOLLOW TO HELP IMPROVE INSTALLATION OF MANUFACTURED HOMES

STATES

- State task force should work in development of MODEL PROGRAM for states (including laws, regulations, and standards).
- Work toward developing uniform installation laws and effective inspection programs.
- Team up and develop training programs for state and county inspectors.
- Establish standards for components used in installation.
- If states do not have necessary laws, coordinate meeting with the state manufactured housing associations and HUD to develop support for laws.
- Place more emphasis on the "optional SAA responsibilities," such as dealer lot monitoring and installation inspections.

HOME MANUFACTURERS

- Improve the set-up manual and homeowner manual (the design and clarity of details).
- Provide technical training to the service personnel either independently or in coordination with other manufacturers.
- Coordinate the training of dealers and installers with other manufacturers.
- If HUD or states offer training programs, participate in those programs.
- Identify on each home by "flag" or other means where piers and anchors are required.
- Promote consumer awareness.

SUGGESTED LIST TO FOLLOW TO HELP IMPROVE INSTALLATION OF MANUFACTURED HOMES

MANUFACTURER ASSOCIATIONS

- Coordinate the suggestions to HUD, the states, and home manufacturers.

GROUND ANCHOR or OTHER COMPONENT MANUFACTURERS

- Include installation instructions with their hardware.
- Provide training to installers.
- Conduct more testing and research.

INSURANCE COMPANIES

- Offer better rates for homes that are installed properly and are certified for proper installation by reputable inspection agencies.

STATE ASSOCIATIONS of MANUFACTURED HOMES

- Coordinate with states the bonding, licensing, and training programs for dealers and installers.

NCS **BCS**

