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NATIONAL BUREAU OF STANDARDS REPORT

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THE EFFECTS OF THE FAIRBANKS ALASKA FLOOD ON RESIDENTIAL CONSTRUCTION

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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Mr. William C. Cullen, Materials Technologist
Mr. Clinton W. Phillips, Mechanical Engineer

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In May 1968, Mr. Cullen and Mr. Phillips made a return visit to Fairbanks, Alaska to assess the value and utility of their recommendations and results of the special on-site investigation and the follow-up trip.

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by
William C. Cullen
Building Research Division
Institute for Applied Technology
National Bureau of Standards

Sponsored by
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Washington, D. C. 20234

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Preface

On August 15, 1967, the Chena River at Fairbanks, Alaska crested at 18.8 feet, 6.8 feet above flood stage. The flood waters caused severe property damage in Fairbanks, Alaska and the surrounding areas. At the request of Ernest Gruening, U.S. Senator Alaska, a special on-site investigation of building damage was made on August 24-25, 1967 by a two-man team from the Building Research Division of the National Bureau of Standards. The team members were:

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Key words: Alaska Flood, on-site investigation, property damage, observations, recommendations.

The Effects of the Fairbanks Alaska Flood on Residential Construction

by

William C. Cullen

Introduction

Four times since 1930 the city of Fairbanks, Alaska has experienced serious flooding when the Chena River overflowed her banks. On August 15, 1967 the Chena River crested at 18.8 feet, 6.8 feet above flood stage. This unusual event was the highest of record. The other major floods occurred in August 1930, May 1937 and May 1948 when the river crested at 15.2, 15.9 and 14.2 feet respectively. The hydrological conditions associated with the August flood were a very wet July and very heavy rainfall measuring 6.1 inches during the period August 9-15. The August 1930 flood is the only other high-magnitude flood caused by rainfall. The other two major floods were the result of spring snow melt and ice breakups.

The toll the floods take involves millions of dollars and this amount is likely to grow as the population increases and man builds more houses and other structures in river valleys. The ultimate solution obviously lies in adequate flood control measures for the flood susceptible areas. However, when the benefit/cost ratio for such flood control programs are not sufficiently high to warrant their implementation, other risk-reducing approaches must be explored. The following questions immediately arise: Is it possible and feasible that departures from the conventional can be made in the utilization of building materials and construction techniques to reduce the

Figure 1 The Diastrous Fairbanks, Alaska Flood of August 1967

potential damage from flood waters? Can the knowledge gained in past experiences such as the August 1967 flood be used to advantage in the reduction of potential damage in future floods? The answer to each question is a categorical yes!

This report documents the effects of water on materials of construction and the building service systems and is based on a survey of flood damage to residential structures and their subsequent rehabilitation following The Disastrous Fairbanks, Alaska Flood. In a disaster of such magnitude, certainly not all damage can be eliminated but, we contend, it can be minimized. We have observed that what at first appears to be terminal damage to building components and systems is, in fact, very often relatively minor. Frequently the component or system, upon drying, will function adequately for a period of time with maintenance and minor repair. Further experience has indicated that much of the damage observed could be avoided by the application of simple, inexpensive, common sense principles during the construction period. This report demonstrates some of the principles which can be applied during the construction phase and others for use immediately after the flood waters have receded to ameliorate losses, both comfort and financial. While the contents of this report primarily deal with water damage and rehabilitation of residential structures associated with the Fairbanks, Alaska flood, many of the principles identified here are applicable to other geographical areas when struck by flood, hurricane or similar disasters.

Residential Constructions

Although many types of houses are constructed in the flood-susceptible areas of Fairbanks, Alaska, the typical residential structure consists of a wood-frame construction over a basement or crawl space which was located below-grade level. Footings were of poured concrete on solid ground which penetrated the earth to a minimum depth of four feet. The foundation walls were constructed of poured concrete, concrete blocks or similar masonry units and the space within the perimeter served as the basement or crawl space. The basement floor was of poured-in-place reinforced concrete, generally applied over a polyethylene vapor barrier. It appears relevant to mention here that, due to the severity of the winter weather in the Fairbanks area, a garage, generally adjoined each structure. The open cavity which was excavated to the same depth as the basement or crawl space beneath the garage was backfilled with available soil and covered with a reinforced concrete slab which served as the garage floor. The compaction, or lack of it, of this backfill contributed to the slabs performance during the disastrous flood. It should be noted here that the basements of many of the older residential constructions were of a wood-crib construction, i.e., both floors and walls consisted of wood planking.

While the interior sub-flooring consisted of plywood (both exterior and interior grade) and in the case of some older houses the traditional wood-board sub-flooring, little if any hardwood was employed as the exposed floor surface. For the most part the resilient floor coverings were employed. These included vinyl, asphalt or vinyl-asbestos tiles and the continuous-type coverings such as linoleum or

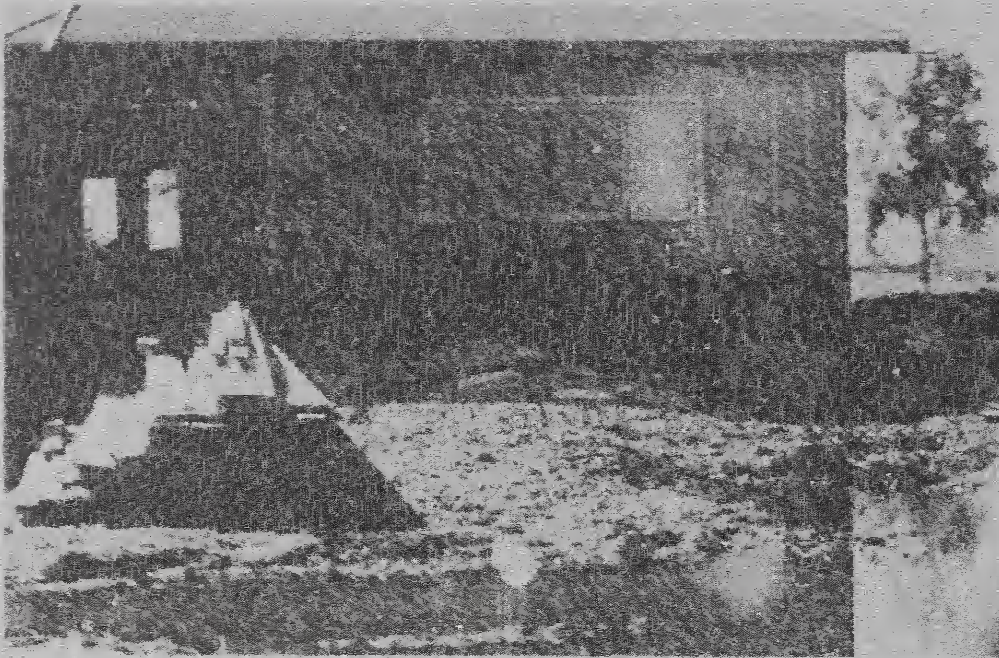


Figure 2 Typical residential construction in Fairbanks, Alaska. Note the high water mark of the flood.

Figure 3 The compaction of backfill around foundation walls had a significant influence on performance during the flood.

sheet vinyl applied to the sub-floor with an adhesive. However, living rooms and recreation rooms were frequently decorated with wall to wall textile type coverings.

The wall system of a wood-frame structure serves many purposes. It supports the loads of the roof and of the second floor. It serves as a fastening base for exterior and interior coverings. Further, it serves as a weather and thermal barrier; a most important function in Alaska. A common wall system for recent constructions from the inside to the outside consisted of painted gypsum board or a decorative wood paneling applied to wood studs, a sheet-type vapor barrier, insulation of fibrous glass, mineral wood or similar materials, a bituminous impregnated insulated sheathing and an exterior cladding of wood, asbestos-cement, or other weather-resistant materials. Here again, the construction practices in the older houses differed significantly from the more recent ones in that a wood cavity wall filled with wood sawdust served as the basic wall construction. The indoor and outdoor surfaces were covered with gypsum board and a weather-resistant material respectively.

The ceiling-roofing system consisted of a sloping wood roof deck generally covered with asphalt shingles or prepared asphalt roof covering. In some cases where low slopes were involved, a bituminous built-up roof provided weather protection. Gypsum board fastened to ceiling joists provided the interior surface which was insulated with loose mineral wool, fibrous glass battens and in the case of older houses a wood sawdust fill placed on the top surface of the gypsum board between the ceiling joists. The ventilation, or lack of it, of the attic space between the ceiling and the roof had a significant impact on the performance of exterior protective coatings during the post-flood period and the rate of drying of wetted homes.

Flood Damage Survey

The Department of Housing and Urban Development approved funds to help the state of Alaska survey damage to the Fairbanks area and to plan a rehabilitation program. The funds, together with local supplementary funds, were used to finance the project activities of 94 two-man survey teams coordinated through the office of the Governor of Alaska in cooperation with the Alaska State Housing Authority. The survey was conducted under the direction of Dr. Elbert F.Rice, University of Alaska. The survey teams determined by house to house inspections the damage to private property. Further, based on the data which were developed the preparation of projections of loss of income and revenue to state and local governments, and the inventory of available manpower and housing needs was accomplished.

The results of the survey showed that over 4800 residential structures suffered extensive water damage. The findings also revealed that of the 4800 residences some 1300 had a water level of over 3 and one-half feet while another 1200 had experienced a high water mark of one foot or more above the first floor level. Basements, of course, were completely flooded and many basements had been finished as living quarters which compounded the resultant damage. In respect to heating units, the results showed that in excess of 500 were submerged over the burner itself and approximately 4000 in which the controls were under water.

The monetary loss to structures, not including their contents, was estimated to be $29,114,251 on the basis of the field survey. Specifically, these losses were categorized in Table 1.

Table 1. Monetary Losses (Estimated)

Number	Description	Loss
4837	Residential Structures	$ 23,357,743
490	Commercial Buildings	$ 5,025,653
31	Tax Exempt Buildings	$ 201,758
85	Trailer Houses	$ 110,687
--	Unclassified	$ 418,410

National Bureau of Standards Participation

At the request of Senator Ernest Gruening of Alaska, representing the United States Senate Public Works Committee, two representatives of the National Bureau of Standards' Building Research Division accompanied the Senator and two staff members of the Senate Public Works Committee to Fairbanks, Alaska. After briefings by various Federal, State and local authorities at the site as to the current status of the flood and its subsequent damage, a comprehensive inspection was made of residencial structures in the more severely affected areas of Fairbanks.

Based on the information developed during the various briefings, observations and critical examinations of damaged structures, discussions with flood victims, and on considerable laboratory and field experience in the properties and performance of building materials and systems, a set of recommendations were prepared for the rapid drying of the structures to facilitate the early rehabilitation of water damaged houses. The recommendations were communicated to the Citizens of

Fairbanks by radio, newspapers and by leaflets distributed by various organizations.

As suggested by Senator Gruening and approved by the Director, National Bureau of Standards, a return trip was made to Fairbanks, Alaska by representatives of the Bureau approximately one year after the flood. One purpose of the trip was to assess the value of the NBS recommendations. Another purpose was to observe the effects of water submersion and subsequent drying on various materials of construction as well as on the electrical, mechanical and plumbing systems associated with residential structures.

Observations - August 1967

Foundations

Foundation problems, although not as prevalent as problems with other building components, accounted for the more serious and costly type associated with residential constructions during the Fairbanks flood. Failures were observed in foundation walls and in concrete slabs used for basement and garage floors. In some cases the failures were experienced during the early stages of the flood while in others the evidence of damage appeared subsequent to the recession of the flood waters. Various and sundry opinions have been proposed to explain the failures of foundations. The validity of a number of the opinions can be supported by observations and theoretical considerations. Further and more important many of the foundation failures were preventable either initially or by taking immediate action during the flood. The compaction of backfill around foundation walls, beneath slabs and traffic surfaces during construction had a significant influence on the stability of the particular system or the surrounding ground during the flood or after the recession of the flood waters. For example, observations were made of many residences where the backfill was washed away from basement walls. Further the garage concrete floors as well as sidewalks and other traffic surfaces of many residences settled and consequently deteriorated to such an extent that replacement was indicated.

Ironically the immediate action implemented by the conscientious homeowner to keep his basement relatively free of water during the initial stages of the rising of the flood water, frequently resulted in the most serious and costly flood damage observed in residential houses. In some cases, the foundation walls actually imploded due to the hydrostatic pressure against the exterior walls. In others where the basement walls were sufficiently strong to resist the forces generated by the differential pressure, the basement floor actually heaved and cracked.

<u>Interior Walls</u>

At the time of the inspections, the flood waters had receded. However, the gypsum board interior walls were still in a wet condition up to the high water mark. Although the wall board for the most part appeared to be intact and in place, the material, as expected from the properties of its components, had lost a great deal of its original strength. The covering of the board, which serves as a reinforcement for the gypsum core, was substantially weakened and consequently was susceptible to damage even from the slightest abrasion. It was the opinion of the observers that if the walls were allowed to remain in

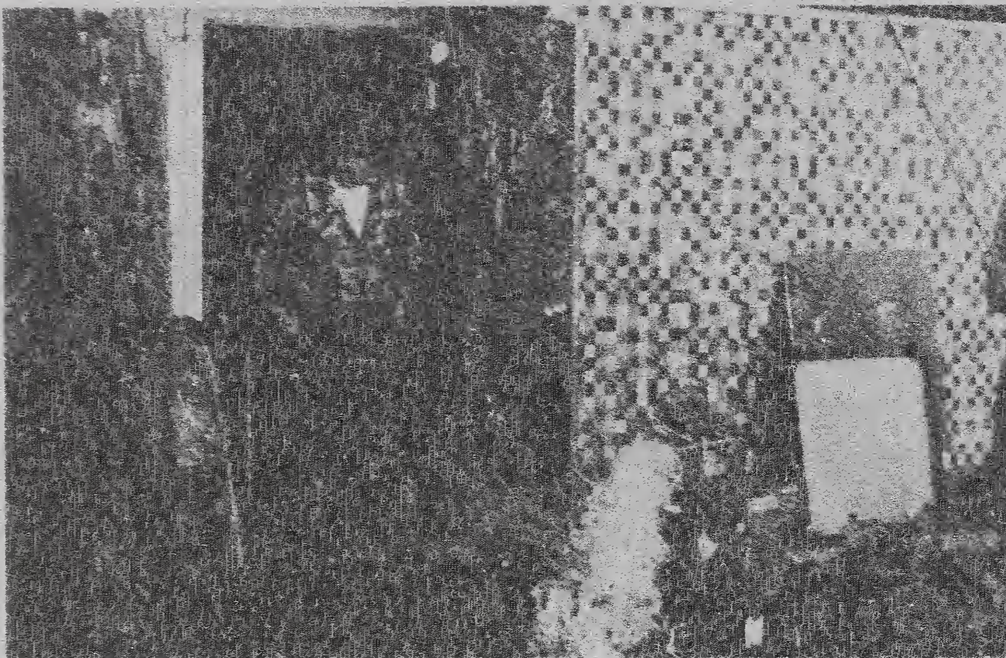
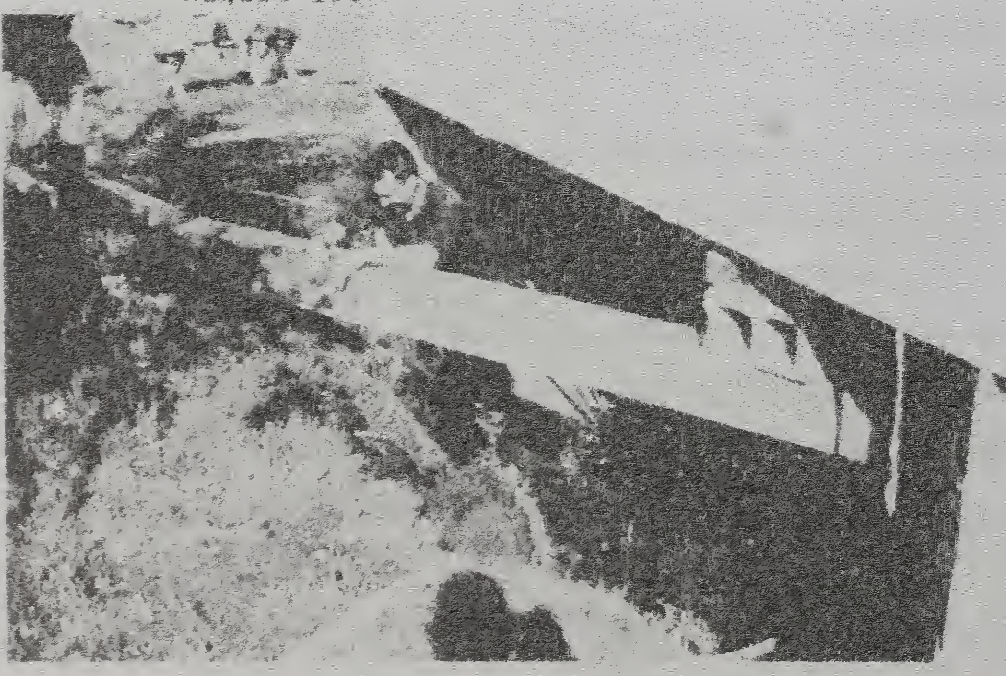


Figure 4 Removal of water should be delayed until the flood water has reached a safe level to prevent interior collapse.

Figure 5 Collapse of basement wall due to hydrostatic pressure against exterior wall. August 1967



place, they could be expected to regain, upon drying, a sufficient portion of their initial strength properties to serve adequately in the future.

Wood paneling which was frequently used in living quarters at below-grade levels showed evidence of warpage and initial delamination at this early stage. Obviously where this condition was severe, replacement was indicated.

Vapor Barriers and Insulations

Materials used as vapor barriers are, per se, resistant to water. Therefore, no damage to these materials, be they polymeric or metallic, was expected nor observed. Further, there was no indication that the vapor barriers had been disturbed by the rising or falling of the flood water. Consequently the evidence indicated that the vapor barriers would continue to function as intended for some time to come.

As indicated previously a number of basic materials were employed as between the wall cavity insulations. The materials included wood sawdust which was common in the pre World War II residences, mineral wool type fills, aluminum backed fibrous glass composites and other types. It was difficult to observe many insulations because of their concealed position. Therefore, the following observations are based on a relatively few samples. The insulations, regardless of composition, had been wetted to the high water level and at the time of inspections were still in such a saturated condition that liquid water could be squeezed from the materials. The portions of the insulation which were observed above the high water mark appeared to be relative dry even at this early stage thus indicating minimal water transmission within the insulation itself. In all cases of the fibrous glass type observed, the wet insulation was still in place, was apparently undamaged and little if any settlement had occurred. These observations indicated that upon drying the insulations would serve adequately as intended. Unfortunately, the condition of all types of insulations were not observed because of their inexcessability. However, reports from reliable sources indicated that some of the fill-type insulations had sagged and compacted leaving a void at the top of each stud space. In summary the conclusion was made that the wetted insulations were capable of being forced dried in place and, upon drying, would regain sufficient thermal resistance properties to produce the desired results. Therefore, except in unusual cases, the replacement of the insulation was not indicated.

Exterior Walls

There was no serious damage to the exterior siding of houses despite the severe and prolonged wetting from the flood water. However, it was predicted that paint failures in the form of blistering, cracking and peeling, would become apparent as the forced drying process progresses. Fortunately the water-vapor permeance of the exterior siding materials, wood and asbestos-cement, were such as to offer little resistance to the transmission of water-vapor during the drying process.

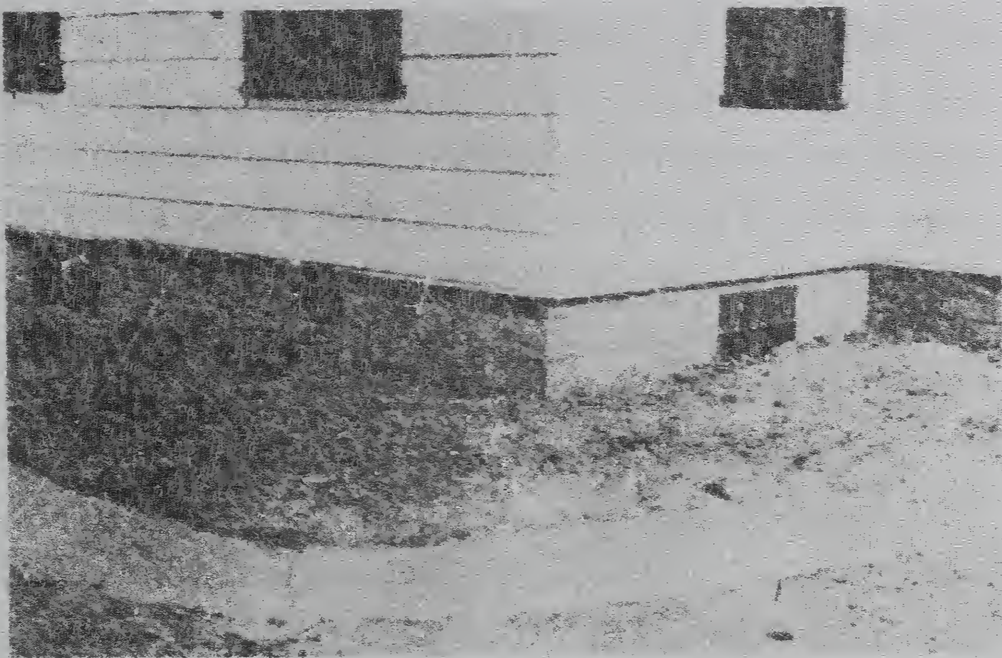
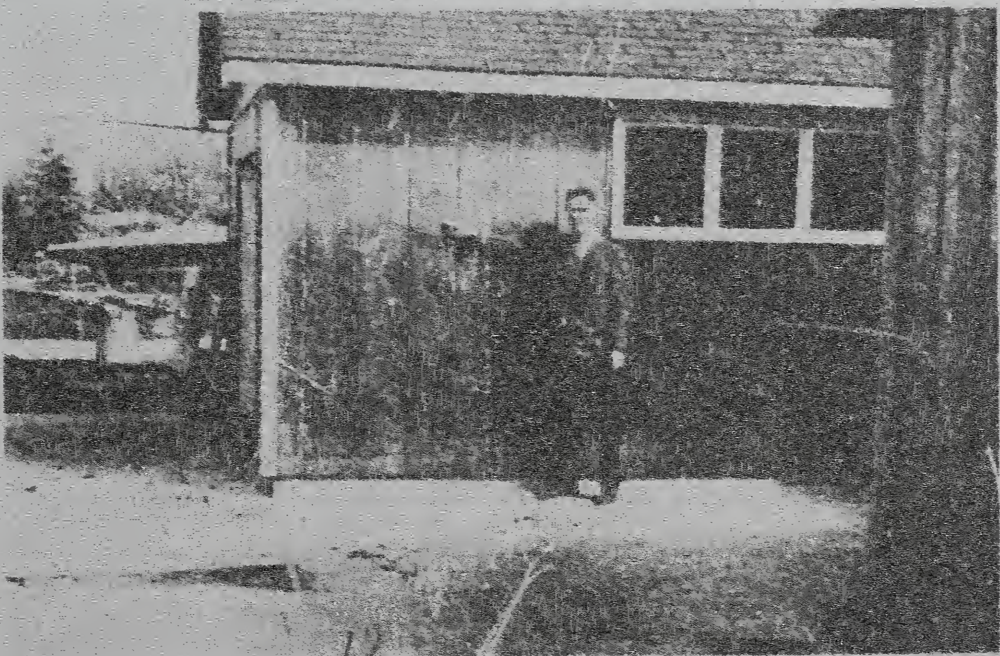


Figure 6 Restored basement wall shown in Figure 4. May 1968

Figure 7 High-water mark exceeded five foot level in some cases.



The asphalt-saturated insulating sheathing which serves as a base for the exterior siding was saturated with water at the time of the inspection, but no deformation or other signs of deterioration were apparent. Therefore the prospect of this material serving its intended function after drying in place appeared good. The question frequently arose about the possible adverse effects of the soon to arrive subfreezing temperatures on the water soaked sheathing and siding. In replying, it was recognized that the complete drying of these wall system components together with the insulation before the advent of freezing weather was highly improbable. However, it appeared remote that these materials would be adversely affected. In any event any damage which resulted from subfreezing temperatures would present problems less serious than ventilating cavity walls by removing sections of the exterior walls. A major factor in this conclusion was the shortage of labor and materials in the Fairbanks area to repair the hundreds of structures affected before the advent of freezing weather.

Ceiling Systems

In only one case reported did the water level go above the first floor ceiling. Consequently the only ceilings which were affected were those of finished living quarters in the basement. In the majority of cases, the damage sustained by ceiling materials, regardless of type, was substantial. As opposed to its performance on vertical surfaces, gypsum board exhibited two types of failures on ceilings. On one hand it was weakened by water to the extent that its nail pull-through resistance was reduced and the cumulatiave weight of the gypsum plus the absorbed water caused failure. On the other hand, where the strength of the fasteners was sufficient to keep the board in place, a permanent deformation exhibited by a sagging between the floor joists was apparent. It appeared doubtful that the material would regain its original dimensions after drying. Removal and replacement was indicated. In cases where ceiling tiles were used, irreparable damage was often sustained. Failures were attributed to dimensional instability of the fibrous type tiles and to the failure of mechanical fasteners or both. In instances where organic adhesives were employed to adhere tiles to the ceiling, it appeared that failure of the adhesives accounted for a large portion of the failures observed.

Flooring Systems

Floor coverings and subflooring were adversely affected by the flood water. In almost every instance the coverings including asphalt, vinyl and vinyl-asbestos tiles, sheet vinyls and textile type carpeting were soiled and damaged. The most common type of damage observed with the resilient type coverings was a failure of the adhesive used to bond the tiles to the substrate. The performance of the subflooring was certainly a factor in the performance of both the finished floor covering and the adhesive selected for its application. In cases where the substrate was concrete or exterior grade plywood and a water resistant adhesive was employed, it appeared that the flooring systems resisted major damage other than that due to soiling. However, where delamination or warpage of interior grade plywood occurred or where a water susceptible adhesive was employed, removal and replacement of the damaged flooring was indicated.

Figure 8 Staining of exterior siding due to forced drying procedure.

Figure 9 Failure of adhesive used to bond floor tile to substrate.

Carpeting was still saturated with water at the time of the inspection and without exception was heavily soiled with silt. Much of it already had been removed and was being dried and cleaned by various tehcniques.

Recommendations - August 1967

On August 24th when the on-site inspections were in progress, the flood waters had receded and many residents were returning or had returned to their homes. They had started the rehabilitation process by removing household furnishings, clothing and other personal articles to the outdoors to expedite drying. In fact a number of homeowners, showing the initiative of the typical resident of Alaska, were already in the process of taking rather drastic steps, such as the removal of interior walls, to replace or repair flood damaged building materials and systems. Although the immediate action of these ambitious citizens was to be commended, it was felt that the remedial measures being implemented frequently were unnecessary and uneconomical. Therefore, the urgency of preparing guide lines for the drying and repair of the homes was apparent.

Immediately after the inspections were completed, a set of recommendations capable of being implemented by the average home owner was prepared and communicated to the citizens of Fairbanks by various means. It should be pointed out here that two major influencing factors were considered in the development of the recommendations. First, subfreezing temperatures were expected within six weeks. Next, the disastrous flood precipitated a severe shortage of labor and material which would have been required to accomplish major repairs to the hundreds of affected buildings before the advent of freezing weather.

The recommendations as promulgated to the homeowners of Fairbanks, Alaska on August 24, 1967 were:

1. Remove standing water from buildings as quickly as possible by pumping, boiling or other means.
2. Repair the heating system as quickly as feasible and/or obtain supplementary heater.
3. Operate the heating system or systems at higher than normal thermostatic settings of 80° to 90°F or higher.
4. Open windows and doors sufficiently to maintain desired temperature but to accomplish drying of interior.
5. When interior has been reasonably dried, continue to operate the heating system at a higher than normal temperature with doors and windows only partially open. This procedure will tend to force-dry the insulation, insulated sheathing through the exterior walls.
6. Do not remove or disturb the interior walls and vapor barriers unless it is absolutely necessary to replace them because of severe damage.
7. Do not remove the exterior siding. Drying of insulation and sheathing will be hastened if the top and bottom of the exterior siding can be opened at each stud space to provide for increased ventilation of each stud space. This procedure should be followed only if it can be accomplished easily and repaired easily.

8. Provide ample ventilation of attic space during the heating season.
9. All residences including those that will not be occupied should be heated during the coming winter to avoid serious and sometimes catastrophic damage by water freezing in walls and foundations.

COMMENTS ON RECOMMENDATIONS

In May 1968 a second visit was made to Fairbanks, Alaska area after the spring thaw had occurred. This visit served a number of purposes. One was to assess the value and utility of the National Bureau of Standards recommendations made immediately after the flood to the residential property owners regarding the methods and procedures for drying and repairing their flood-damaged homes. Another was to obtain, first hand, a knowledge of incipient damage which was not readily apparent to the observers immediately after the flood waters had receded. It should be mentioned here that in making the recommendations the observers gave serious consideration to the probable synergistic effects of wetted building materials and prolonged subfreezing temperatures which they believed would be of major concern to federal, state and city officials and homeowners alike. Certainly a major purpose of the return visit was to collate the knowledge and experience obtained in the natural disaster so that they can be used to advantage in reducing potential damage of similar disasters which may occur in the future.

The procedures agreed upon for accomplishing these objectives included meetings and discussions with federal, state and city officials, representatives of building contractors and building materials suppliers, representatives of service organizations, citizens coordinating committee and numerous homeowners. Each of these factions gave freely of their time and talents to assist the observers. The frank opinions and comments about both their professional and personal experiences prior to, during and after the flood proved to be invaluable in not only preparing the recommendations but also in assessing their worth.

To the casual observer it might have appeared that the initial recommendations made immediately after the flood waters had receded were extremely elementary. This was the intent so that drying and rehabilitation procedures would be as practicable as possible. Other recommendations may have even appeared to be illogical especially when they dealt with the drying and reuse of a more complex building system such as a complete wall system. Yet each of the recommendations was intended to serve a specific purpose and were made only after careful consideration of how effectively they could be implemented within the limitations of the very critical situation. Therefore after-the-fact comments on each of the recommendations appears to be useful here in order to review their utility and effectiveness. Further some additional observations were made which are not directly related to the specific recommendations. However their identification will prove helpful in demonstrating certain building practices which may ameliorate damage from future floods.

Recommendation Number 1

The removal of water from a building as quickly as possible obviously appears to be the first step in the drying process. Experience during the Fairbanks flood has shown that in instances where this was accomplished when the exterior water-level was at ground level or above, serious and costly basement floor and wall problems were created by differential hydrostatic pressures between outside and inside. Therefore, removal of water should be delayed until such a time the water has reached a safe limit.

Recommendation Number 2

The prompt repair of the heating system rates a very high priority in the rehabilitation schedule. Experience at Fairbanks showed that the supposedly water susceptible parts such as burners, controls and motors upon being cleaned and dried can function adequately at least during the critical period. Supplementary heating in the form of portable units proved to be effective in the drying operation. Unfortunately these were not available in sufficient numbers to assist the many who had a need.

Recommendation Numbers 3 and 4

The implementation of these recommendations are predicated on the fulfillment of recommendation Number 2. The purpose of operating the heating systems at higher than normal temperatures with the doors and windows open are obvious. The effectiveness of this recommendation was confirmed during the initial inspections in August 1967.

Recommendation Number 5

This recommendation to continue the high temperature operation of the heating system with doors and windows only partially open or preferably in the closed position is less obvious. The objective here is to create a high water vapor pressure, which increases as the temperature is raised, in the interior of the structure. This condition in conjunction with the extremely low winter vapor pressures common to Alaska literally forces moisture contained within the wall cavities through the exterior walls. The success of this procedure is dependent on the water vapor permeance of the exterior siding. Furtunately wood and asbestos-cement sidings which are common to the Fairbanks area are relatively permeable to moisture. Where moisture vapor impermeable sidings such as aluminum, plastic or masonry are used, procedures must be initiated to obtain ventilation of stud-space to the outside. It should be noted that the successful conduction of this operation may result in failures of exterior paints which have low water vapor permeance values. These failures as evidenced by blistering, flaking and general deterioration were expected and observed during the May inspections. This is a natural consequence of the drying technique utilizing differential water-vapor pressures.

Recommendation Number 6

Considerable opposition was received from many sources regarding the wisdom of the recommendation against disturbing or removing the interior walls. The apparent weakened condition of the wet gypsum board together with a curiosity to discover damage hidden within the confines of the wall system would seem to support the objections. In

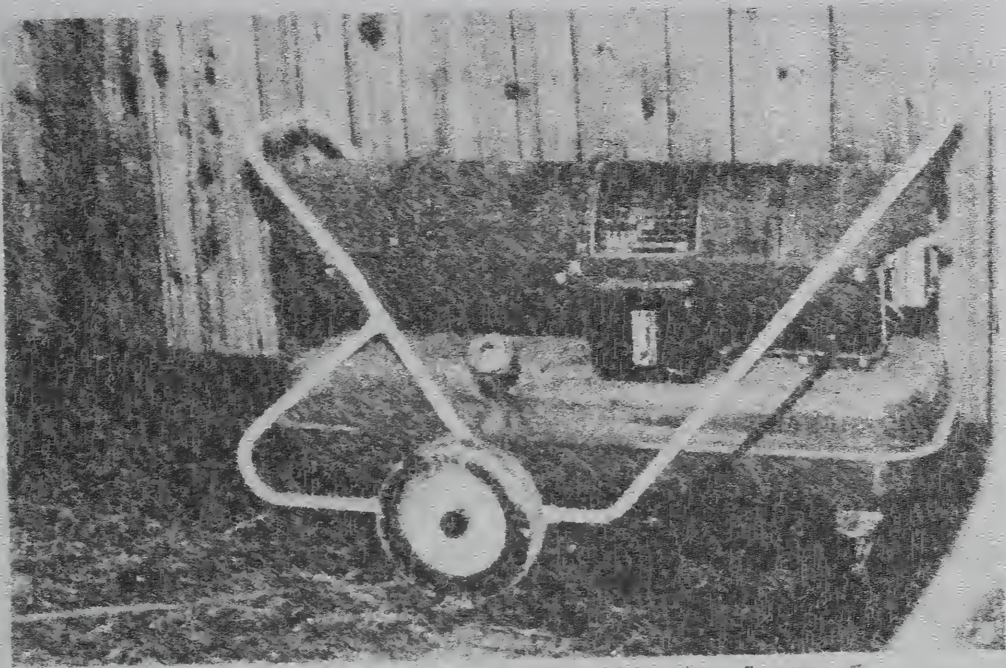
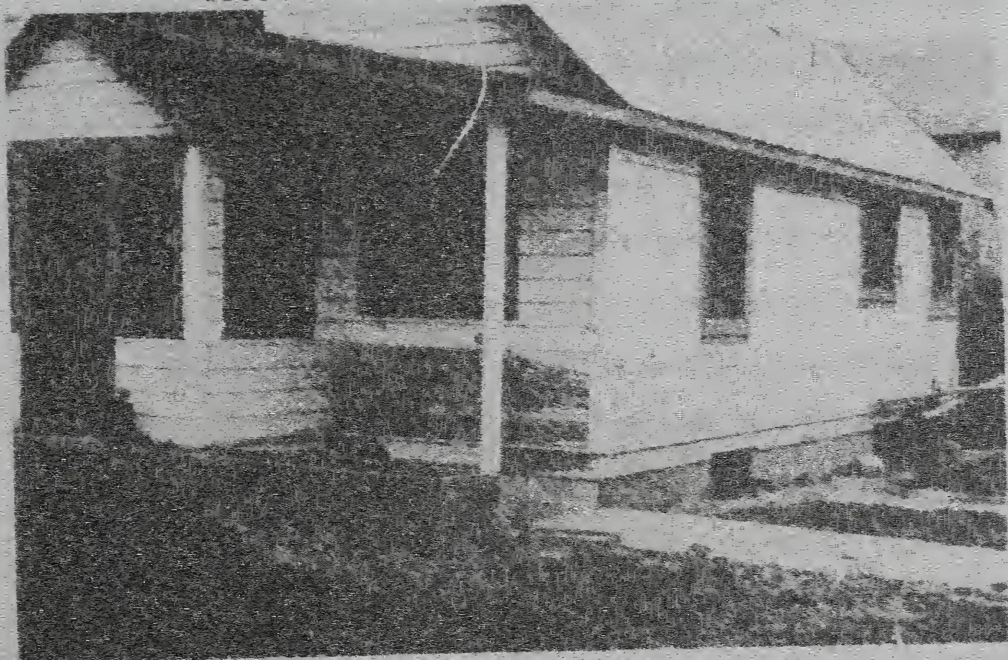


Figure 10 Supplementary heating in the form of portable units proved to be effective in the drying operation.

Figure 11 Paint failure clearly indicates level of flood waters. May 1968



fact before making the judgment, the observers called upon may years of experience with properties of materials and their behavior in service. The gypsum wall board used on vertical surfaces did regain, upon drying many of its original characteristics and was performing in a satisfactory manner after minor repair and routine maintenance. On the other hand, wetted gypsum board used in ceiling applications required removal and replacement. It had softened and sagged under its own weight and upon drying was permanently deformed.

Recommendation Number 7

This recommendation against the removal and replacement of exterior siding, sheathing, and wetted insulation probably contributed more in decreasing monetary outlays for repairs by homeowners than any of the other recommendations. A prime factor in this suggestion was the shortage of materials and labor to repair the large number of residences affected before the advent of freezing weather.

The observations made during the Spring visit confirmed the predictions that the replacement of these components of the wall system was not required except in a very few cases. Further the inspections failed to reveal a single instance where damage to insulation, sheathing or exterior siding was attributed to the freezing of the wetted components. Apparently the drying procedures in conjunction with the fair weather which followed the flood and the late arrival of winter in the Fairbanks area were effective in the elimination of such damage.

Recommendation Number 8

The practice of providing adequate ventilation of the attic space during the heating season was required not only to facilitate the drying of the wet house but is a recommended and necessary practice for homes in all cold climates. The difference between houses with and without adequate attic ventilation was readily apparent by observing the condition of exterior paint coatings after exposure to the winter weather.

Recommendation Number 9

The heating of unoccupied houses during the winter season was stressed in the early recommendations to prevent serious and sometimes catastrophic damage by freezing of the wet floor, wall and foundation systems. The validity of this recommendation was confirmed during the May inspections. Many severely wetted homes which were dried and heated survived the severe Alaska winter with little apparent damage. One the other hand observations were made of two houses (others were reported) which were unoccupied and unheated during the cold months. Severe damage evidenced by warping, heaving and structural dificiencies resulted. The correction of these preventable conditions will prove costly and in some cases will be prohibitive.

Additional Observations

The recommendations of August 1967 were formulated to meet the immediate need to facilitate the early rehabilitation of flood damaged homes. Therefore, of necessity, a number of factors were omitted or overlooked. A knowledge of these factors can be of considerable value in the directions to victims of future floods. The more relaxed inspections of residential constructions together with discussions

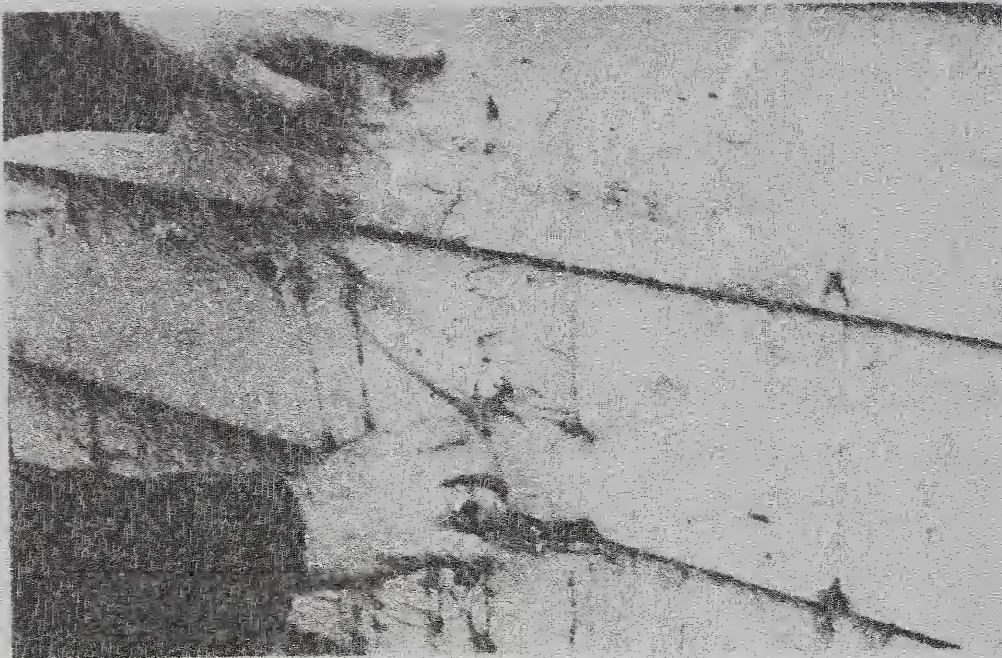


Figure 12 Blistering and flaking of paint coatings were predicted in August 1967 and observed in May 1968.

Figure 13 Paint failure due to drying operation. Ventilation of attic space will assist in reducing failures of this type.

with numerous informed people during the May visit afforded the opportunity to explore these factors. It appears useful that they be considered in this paper.

Electrical Distribution Systems

Experience in the Fairbanks flood has indicated that these systems can be operated safely and effectively after drying. The cleaning of silt and other flood deposited materials from fixtures, outlet and switch boxes was frequently required. The plastic sheathed conductors performed satisfactorily after drying. Latent failures were reported for copper wire conductors contained in metal conduits. These were attributed to electrolysis.

Heating Systems

Heating systems which were completely submerged for a number of days functioned in a satisfactory manner after being cleaned and dried. The cleaning procedure for electric motors, burners and controls consisted of flushing with water, drying, treating with a water-displacement liquid and placing in service. As expected there was a high incidence of premature failure of various parts of the system such as bearings in motors, contacts in coils, etc. during the subsequent heating season. The failures were mainly attributed to abrasive silt and corrosion. The important fact reamins that despite the severe exposure conditions, the systems upon drying, were able to function when the need for heat was most critical.

Oil is the predominate fuel used in the Fairbanks area. Consequently oil storage tanks are required and are frequently placed underground. Tanks which were totally or partially empty literally popped out of the earth due to their bouyancy in the flood waters.

Flooring Systems

Resilient type floor coverings applied to concrete and exterior grade plywood sub-floors with water-resistant adhesives suffered only minor damage and were ready for immediate use with drying, cleaning and minor repair. Similar type coverings applied with other than water resistant adhesives or over interior grade plywood frequently suffered major damage and in some cases had to be completely removed and replaced in kind.

Many textile type coverings (carpets) including the wall-to-wall variety which initially appeared to suffer terminal damage were 100% salvaged for reuse by flushing free of silt with water followed by professional treatment and cleaning.

Organic Coatings

In contrast to the severe and costly damage to other systems of the structure, paint failures were considered relatively minor. However they were common. Ironically many of the failures were a direct result of the force drying of the wall system. The deficiencies appeared as blistering, flaking and peeling and, as anticipated appeared more frequently on the portions of the exterior walls which were submerged during the flood. The extent of the failures may be reduced somwhat by employing exterior coating which have relatively high water vapor permeance values. Further the provision of adequate

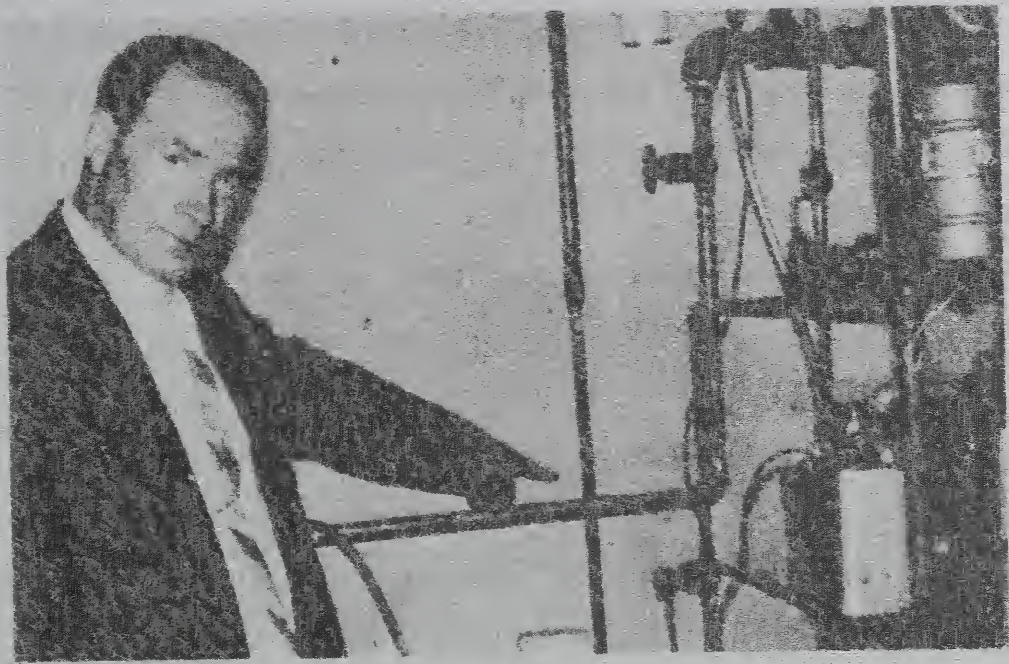


Figure 14 Furnace units which were completely submerged for a number of days functioned after cleaning and drying.

Figure 15 Buoyancy of partially empty oil tanks caused them literally to pop out of the ground.

ventilation to allow moisture to escape would also assist.

Interior coatings appeared to perform better except where the surface of the softened wall board was damaged mechanically. Generally the condition of the interior, decorative surfaces could be made presentable by a thorough cleaning. However, complete repainting will be required in the near future.

Wood Products

Kitchen cabinets which were constructed of wood or plywood were severely damaged and in most cases required removal and replacement.

Interior wood paneling of the plywood variety which was submerged, generally required replacement.

Conclusion

In summary, the National Bureau of Standards recommendations which were promulgated to the citizens of Fairbanks, Alaska on August 25, 1967 were effective, practical and valuable. The recommendations set forth procedures for drying, dehumidification and repair of flood damaged residential structures. This conclusion is based on observations of many stricken residences as well as meetings and discussions with federal, state and city officials; local citizens involved in construction, building material supply, and services to homeowners; and on numerous interviews with homeowners themselves. It was most gratifying that a large number of owners of the 4800 affected residences substantially reduced their potential dollar losses by the implementation of the recommendations. The monetary value of the assistance provided by the National Bureau of Standards is difficult to asses. A member of the Citizens Coordinating Committee expressed his views

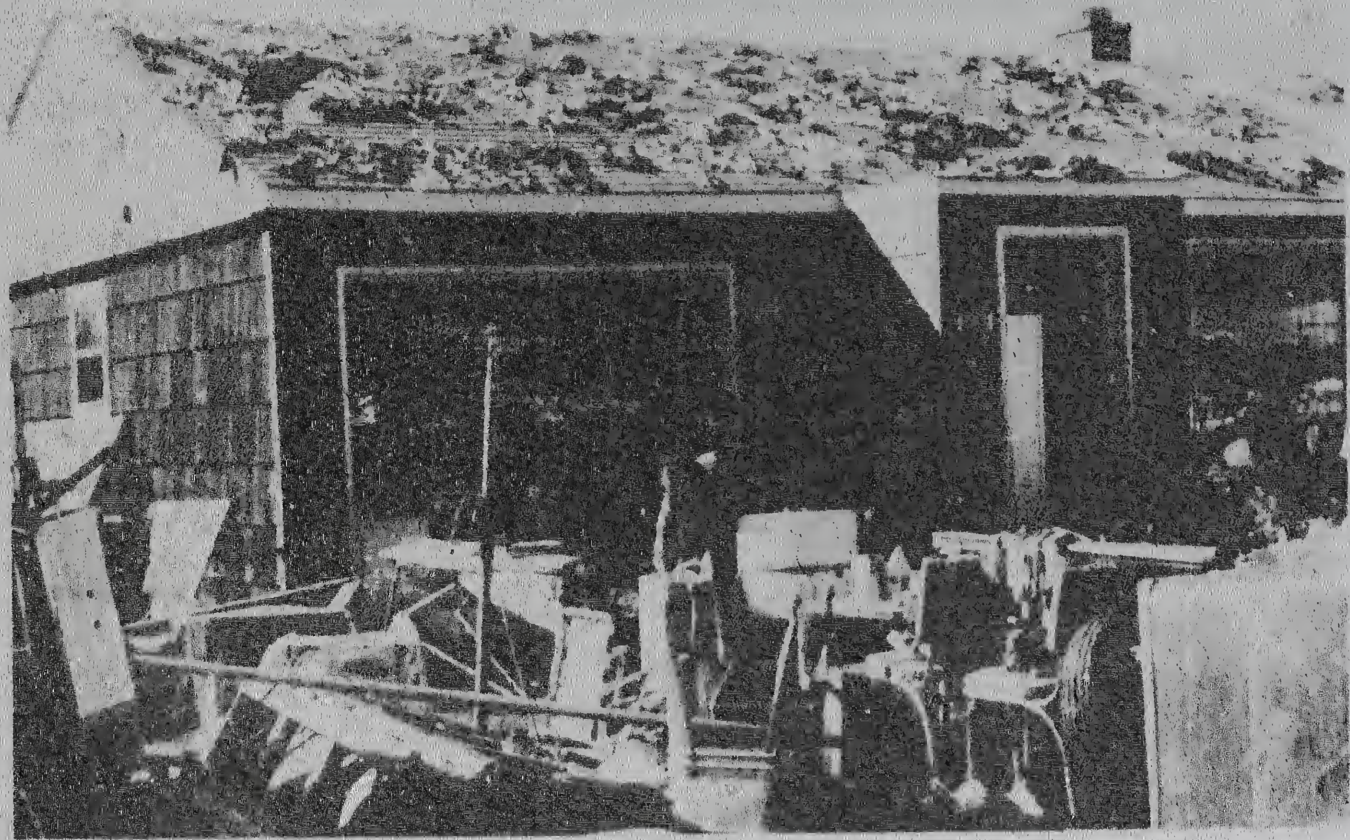


Figure 16 In addition to building damage, flood victims suffered large losses in clothing and household effects.

on the subject which was reported in the Fairbanks Daily News-Miner paper on May 21, 1968: "I know many people who saved many thousands of dollars last winter by following the advice you (National Bureau of Standards) gave them." If this was generally the case and we believe it was, the recommendations directly resulted in decreasing the monetary losses due to the flood by several millions of dollars.

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