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EFFECT OF THE 1950 WINNIPEG FLOOD ON HOUSE FOUNDATIONS

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Winnipeg, Spring of 1950

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HOUSE FOUNDATIONS

by A. BARACOS

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THE RECENT PUBLICATION of the Report of the Red River Basin Investigation, by the Federal Department of Resources and Development, and of the Report on House Damage in the Winnipeg Flood of 1950, by the Division of Building Research of the National Research Council, suggests that the present may be an opportune time to release detailed information on the effect of the 1950 flood upon house foundations in the Winnipeg area.

Soil moisture changes in southern Manitoba, and particularly in the built-up area of Greater Winnipeg, have been known to cause damaging differential movements to buildings. The most severe damage has been to buildings with shallow footings such as are found in houses and other light structures. Approximately 8,200 houses in Winnipeg suffered from the spring flood of the Red River in 1950. The possible effects of the inundation of the foundations of this large number of domestic buildings therefore caused much concern to those familiar with local soil and foundation conditions.

Because of this concern, and as an aid to the rehabilitation of the flooded areas, the Division of Building Research, National Research Council of Canada, initiated an investigation of the effects of the flood on foundations. The scope of the investigation included observations of actual flood damage to foundations, gathering of information on soils and soil moisture variations, soil testing, and a continuing study of the after-effects of the flood on house foundations. Residents of the flooded areas had so much to worry about during the long period of rehabilitation that it seemed wise not to invite public attention to this study of foundation conditions at that time. It was carried out, however, as a contribution to local welfare and it is satisfactory to be able now to report that almost all original fears of serious new foundation troubles have proved to be groundless.

PRE-FLOOD INFORMATION

As early as 1926 foundation movements were associated with soil moisture changes in the Winnipeg area. The level of the Red River in Winnipeg is lowered in the autumn to prevent ice forming against the spillways on the Lockport Dam which is downstream from Winnipeg. Slides along the river banks have coincided with the annual opening of the spillways. It has been reported that buildings near the River have settled when the water was lowered. Of particular interest is the Report of the Committee on Foundations in Winnipeg, of the Winnipeg Branch of the Engineering Institute of Canada. It is there stated that during the dry years prior to 1937, drying had in many cases removed as much as half of the natural moisture from the soil and that the loss of moisture had caused a substantial decrease in the volume of the clays, particularly in the upper layers. The drying had also caused

vertical cracks and horizontal laminations in the soil. Many foundations were damaged by the resulting movements and expensive underpinning was necessary.

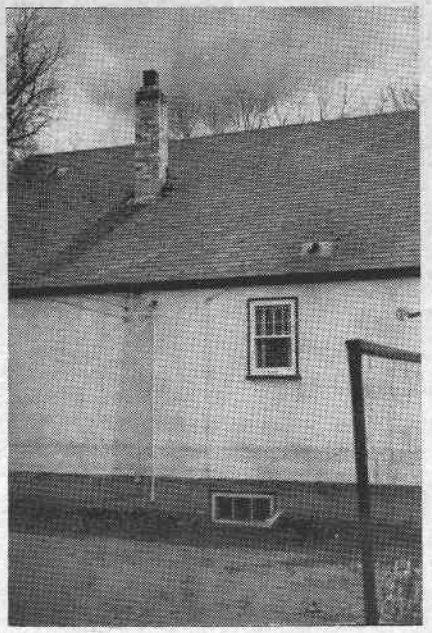
It was also stated that restoration of the soil moisture should not be expected. Buildings, sewers and pavements would not permit precipitation to penetrate into the ground. Lighter buildings, particularly in residential areas, were found to have suffered most because of their shallower footings.

A study of building practice in the Winnipeg area provided additional significant information. Differential movements associated with soil moisture changes and large settlements are eliminated in the more expensive buildings by using piles supported on glacial till and boulders locally called "hard pan") or limestone. Houses with basements usually have the basement floor separated from foundation wall, post, and chimney footings. The basement floor may thus move independently of the foundations. Partitions supported on the basement floor are not connected to the ceiling. This prevents the transmission of any differential movements between basement floor and foundations to the superstructure. During recent wet years, the heave of basement floors and footings has been appreciable. The occurrence of the flood of 1950 therefore suggested that house foundation troubles would be one of its most serious consequences.

THE 1950 FLOOD

Records show that heavy spring floods had been experienced in the Red River Valley in 1826, 1852 and 1861. These floods and the flood of 1950 were preceded by a combination of the following factors: wet autumn, continued and severe frosts prior to the snowfall, heavy winter snowfall, late and sudden thaws in the spring, and heavy rains accompanying the spring thaw. Any one of these factors alone would not produce an abnormally high flow in the Red River. The combination, however, has resulted in floods of disastrous proportions.

The topography of the Valley also tends to prolong flooding and give high peak river levels. Because of the south-to-north direction of the Red River, the break-up in the spring may advance northward at the same rate as the peak flow. When this occurs, the flow increases very rapidly in its downstream course with the east and west tributaries contributing their flow to the Red River which has already reached its peak. (Fortunately, the peak flows of the Assiniboine and Red Rivers did not coincide at Winnipeg in 1950.) The decreasing slope of the tributaries as they enter the valley tends to decrease their capacity and thus causes the water to over-top the banks.



CHIMNEY lifted 3 inches by differential movement between foundation walls and chimney footings.

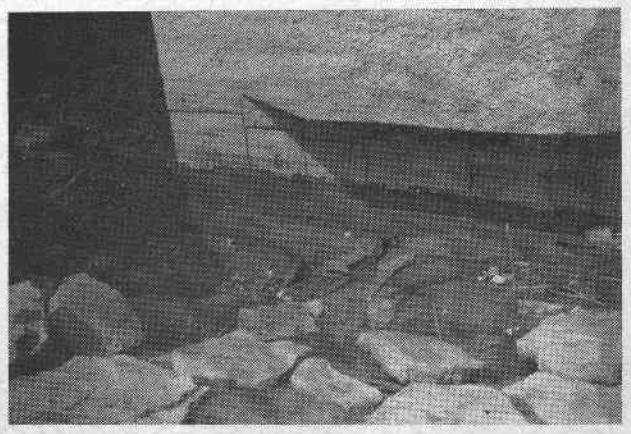
Early in April of 1950, the level of the Red River in North Dakota and parts of Minnesota began to rise and by mid-April the River was flooding villages and cutting communications. Flood warnings were issued in Winnipeg on April 11 and by April 20 flood stage was reached in the City. Records kept by the City of Winnipeg Engineering Department show that for fifty-one days the river remained above normal flood level and that at its peak the flood was 12.9 feet above this level.

PROCEDURE USED IN THE INVESTIGATION

It was expected that damage to flooded foundations would not necessarily be apparent during or immediately after the flood. Changes in the volume of clays are generally slow processes. Prolonged investigation was necessary and observations were therefore continued for about sixteen months.

Not only were there 8,200 residences in the flooded areas to be studied but backing-up of water in sewers brought water into many basements in non-flooded areas. Practical considerations, therefore, did not permit an extended individual investigation of a very large percentage of the buildings involved. Similarity of construction and the nature of the flood damage found in many of the houses permitted representative sampling. Inspections of flooded buildings were also conducted by other organizations. The Red River Valley Board was assessing damage to all flooded houses in the Red River Valley. Building inspectors of the City of Winnipeg were visiting flooded buildings in the City. Further information was being obtained by the staff of Central Mortgage and Housing Corporation on their houses in both flooded and non-flooded areas. All three organizations kindly provided to the Division of Building Research extensive information which permitted the planning of visits to both representative and unusual examples of flood damage.

Visits were made to flooded houses immediately after the flood and notes were made on flood damage which was evident at that time. The inspection of foundations was carried on concurrently with the study of flood effects on house superstructures. No particular attention was drawn to this foundation study when tenants were interviewed. It was thought that, with all the concern the tenants had in rehabilitating their homes, it would be unwise to suggest new worries over possible effects of the flood on house foundations. After initial visits to a large number of houses, twenty-six buildings were selected for extensive investigation. As complete information as possible was obtained on these structures



Erosion caused by scouring action of flood waters.

and periodic visits were made to them during the next sixteen months.

OBSERVATIONS MADE DURING THE FLOOD

A few indications of foundation damage were observed when the water was still at a high level. In one particular house, differential movements between foundation wall and chimney footings had caused the chimney to lift 3 inches above the rest of the house. The metal flashings attached to the chimney had lifted above the roof shingles by this amount. Later examination revealed that non-uniform soil swelling under the footings had been responsible. Smaller wood frame structures such as garages and outbuildings were lifted off their footings by the buoyant force of the water and often carried several miles away.

In one industrial building, efforts were made to keep the basement dry by sealing all openings in the floor and walls and pumping to remove seepage water. When the flood waters reached a height of 14 feet above the basement floor, an upward hydrostatic pressure under the floor caused it to lift as much as 3 feet. The floor was broken into many fragments and much of the backfill along one wall of the building was washed inside. The foundation walls and columns which were supported by piles were left undamaged. Later examination showed that the material in the backfill and under the floor was sand. The basement floor was approximately 10 feet below the ground level outside of the building. "Quick-sand conditions" were said to have been encountered during the construction of the foundations.

One house only was found to have suffered similar damage, but on a much smaller scale. A faulty basement floor around a sewer clean-out broke and material from under the floor and some backfill were washed into the basement. Examination again revealed sand under the floor and a very loose backfill around the basement walls. This form of damage was not more common because most basements were flooded before the upward hydrostatic pressure became excessive. It is significant that both the examples noted were associated with sandy soil which has a high permeability compared with clay.

The Winnipeg Building Code permits weeping tile drains around the foundations to be connected to the sanitary sewer system. These are connected to the basement floor drain above the sewer trap a few inches below the floor level. Most home owners placed a plug in the sewer immediately above the trap. Seepage water which would normally flow into the sewer from the tiles flowed into the basement. Additional water entered through cracks in the basement walls and floors and finally, when the flood level was sufficiently high, through windows, coal chutes and over the top of the walls. Where sewers were left unplugged or the plugs failed, water backed up through the sewers. Although apparently unfortunate at the time, this flooding of basements minimized structural failure of basement floors and walls.

WINNIPEG School Board members inspect flood damage to a Winnipeg school.

POST-FLOOD OBSERVATIONS

Examination of foundations in many cases was not possible immediately after the recession of the flood waters. Basements with plugged drains had to be pumped dry and much slime and debris removed. From one to three weeks often elapsed before workmen were able to start the pumping and cleaning operations. When inspection became possible, it was apparent that flood damage to foundations was less extensive than had been anticipated.

Flood damage to foundations, where it occurred to better built homes, was caused by soil swelling under basement floors and to a lesser extent under foundation, wall, and other footings. In two examples of severe soil swelling, the centre of the basement floor had heaved 2½ inches relative to the basement wall. The floor had cracked and water collected at the low spots rather than flowing to the drain.

Straight cracks were often found in basement floors parallel to, and about 4 to 6 inches away from the basement walls. The floor slabs in these cases had been placed with the edge along the perimeter supported on the footings and often considerably thinner than the main part of the slab. Floors were generally 3 to 4 inches thick of non-reinforced concrete. Measurements revealed that more heave occurred under floors than under the footings and formed cracks along the edge of the unsupported section. Cracks also formed over sewer pipe, weeping tile drains and along construction joints.

Some houses with footings of timber sills or stones were found to have suffered differential movements. It was apparent that much of this type of damage was due to the poor condition of the footings before the flood. Rot in timbers resting on the ground, vegetation and frost action, and previous changes in soil moisture content had affected the footings. "Dug-outs" or excavations under part of a building had often been made to house furnaces and to serve as storage spaces. The sides of such excavations were commonly supported by a thin brick or concrete wall, sometimes by timbers, or in some cases were not supported at all. Irrespective of the type of support the sides of such excavations generally collapsed when the soil became inundated.

Another form of construction which caused trouble was the use of hollow concrete blocks with lime mortar for basement walls in municipalities outside the City of Winnipeg which does not permit this type of construction below ground level. Two such walls collapsed after saturation had increased the lateral pressure against the wall and water had weakened the mortar. Similar difficulty, but to a smaller extent, was experienced where cracked concrete or poorly constructed stone foundation walls bulged inwards into the basement. Well built stone foundation walls suffered little or no damage even where poor mortar had been used. No damage to reinforced concrete walls was noted and only minor cracks resulted where no reinforcing had been used in solid walls of good quality concrete.

The velocity of the water flowing past houses directly in the path of the flood was sufficient in many cases to cause soil erosion. The scouring action removed backfill around basement walls, from under door steps, and from the edges of shallow footings. No damage resulted to the basement walls thus scoured although the soil in some cases was removed down to the base of the footings, exposing weeping tile drains. Concrete door steps and sidewalks resting on back fill often settled, appreciably.

Two buildings near the river banks were affected by slides when the water receded. The slides were of the type that accompany a rapid lowering of river levels.

Uplift tended to lift inundated posts out of the ground. Examples were found where fence posts had been lifted about 18 inches. In one house where a large porch was supported on posts, this action had caused the porch to separate by 5 inches from the rest of the house.

RESULTS OF LONG RANGE OBSERVATIONS

The greater part of foundation damage due to soil swelling was evident during and immediately after the flood. Except for additional heaving which occurred in one location where soil conditions were studied, no heaving subsequent to the flood was observed. Visits to homes a year after they were flooded showed that in a large number of houses the heaved footings had settled slightly. Cracks that had opened after the flood heaving had occurred in many cases closed. A case was found where a house was repaired too soon after the flood. The basement columns were shortened to make the superstructure level. Settlement of the column footings later caused cracks to form in the plaster of the superstructure which also had to be repaired.

Most flooded buildings were repaired during the year that followed the flood. In general, substandard foundations damaged by the flood were restored using superior construction and following the accepted building practices employed in Winnipeg. The replacement of basement floors was one of the most numerous repairs made to flooded buildings. A few cases were observed where the new basement floor was rebuilt on heaved clay which later settled and caused some minor cracks.

DISCUSSION

A study of the observations made during this investigation shows that such house foundation damage as did result from the 1950 flood was practically all evident soon after the peak of the flood. This was particularly true where poor construction, inferior material or faulty design had been employed. Such soil swelling as did develop took place during inundation or soon afterwards. Rapid penetration of water into the clay in some locations may be explained by the presence of shrinkage cracks due to previous drying. It is also likely that weeping tile drains under many basement floors provided paths for the water to reach soil under the basement floors. That the Winnipeg clays crack and laminate during drying has been shown by drying undisturbed samples in the laboratory. Removal of water from the soil under the footings would be much slower than its penetration because the cracks close as soon as the soil becomes saturated and swells. Although some shrinkage has occurred causing settlement of footings which were affected by soil swelling, it has not been extensive enough yet to restore pre-flood conditions. All indications are that no further heaving will result from the after-effects of the 1950 flood.

Test holes showed that large portions of the flooded areas were fluvial sands and silts rather than the clay found elsewhere in the City. It is a matter of conjecture what would have happened if more of the clay areas had been flooded. From the examples of heave found in clay areas inundated, it is likely that foundation difficulties would have been much more extensive. And, as has been found in similar studies, good construction practice again showed itself up as the best protection against damage even from so serious an inundation as the 1950 flood in Winnipeg.

ACKNOWLEDGEMENTS

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This study is a part of the co-operative investigation which was carried out into damage caused by the Winnipeg flood jointly by the Central Mortgage and Housing Corporation and the Division of Building Research of the National Research Council. This study of the soils was initially suggested by Mr. D. B. Mansur, President of the Corporation. He followed the investigation with his personal interest and officers of the Corporation were of great assistance. This paper is a contribution from the Division of Building Research, National Research Council, Canada, and is published with the approval of the Director of the Division, Mr. R. F. Legget, who took part in some of the early field investigations.

Complete destruction of walls of hollow concrete blocks.

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