HOUSE DAMAGE COSTS IN WINNIPEG

DUE TO SHIFTING FOUNDATIONS

by

JERZY KOSTANSKI

A Thesis
Presented to the University of Manitoba
In Partial Fulfillment of the
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To My Wife

ABSTRACT

Most of the single-family dwellings in Winnipeg are supported on shallow spread footings which rest on an expansive clay. Soil volume changes have caused the foundations to move causing cracks, uneven floors, distorted door frames, and water leakage through cracked basement walls.

A survey was conducted to ascertain the extent and severity of house damage in Winnipeg caused by shifting foundations. The survey revealed that approximately 94% of the houses surveyed had suffered some damage, most of the damage was minor, and generally only about 7% was classified as major.

A cost-study of the damage showed that the repair costs ranged from \$150 to \$300 for minor damage, \$580 to \$2,120 for moderate damage and \$2,540 to \$12,480 for major damage. Based on the survey results and an estimate of the frequency of damage, the average annual maintenance cost was calculated to be \$60 per year.

The cost of using pile foundations that would eliminate the repairs was estimated to be \$3,700 for an average-sized house, and an additional cost of \$3,800 for a basement floor with a structural floor. Thus from an economic point of view the use of piles was not judged to be economically justifiable.

It is recommended that other alternative foundation systems, that would minimize or prevent house damage associated with shifting foundations from occurring, be studied.

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CHAPTER 1

INTRODUCTION

1.1 STATEMENT OF THE PROBLEM

The phenomenon of soil volume changes arising from seasonal moisture changes in clays has been known for many years; indeed, some 140 years ago in Britain, Bartholomew (1841) was aware of the problem when he wrote "... but in open country situations during drought, it (strong clay) is apt to split and cause fracture to the building unless the foundation is to be laid down below the range of fissures which occur in it ..."

The problem has been reported in the United States, South Africa, Australia, Canada and many other countries. The amount of damage caused worldwide each year by the differential volume change of active soils is extensive. It has been estimated (Jones & Holtz, 1973) that in 1973 the annual cost of subsidence drainage to dwellings only, in the United States, was 300 million dollars. In terms of 1983 dollars the loss figure may be closer to 950 million dollars. The estimate in Britain (Reece, 1980) indicated that the total cost of repairs of the dwellings for the period 1971-1980 was 750 million dollars.

The severity of this damage is most prominent in lightly loaded structures. In western Canada, shallow foundations have had a long history of heaving and settlement problems due to subsoil expansion and shrinkage. Winnipeg is one of the western Canadian cities, in which the problem exists.

There are approximately 160,000 single-family dwellings in Winnipeg supported on shallow spread footings which rest on a clay which has the capacity to undergo volume changes, associated with soil-moisture changes. The clay was deposited during the Pleistocene age when Lake Agassiz covered a vast area including parts of Manitoba, Saskatchewan, Ontario, North Dakota, South

Dakota and Minnesota. The deposits of lacustrine clay are the most troublesome expansive soils for shallow foundations on the Canadian prairies. In Winnipeg, the thickness of the lacustrine clay varies from about 3 m in the northwest corner to over 18 m in the southeast corner of the city (Render, 1970). In general, when the water content is increased, the soil swells, likewise, a decrease in moisture content causes soil shrinkage. The degree of shrinkage-swelling capacity is related to the clay mineralogy. Active clay minerals such as montmorillonite and mixed layer combinations of montmorillonite together with other assorted clay minerals in pure form, may swell up to 15 times their dry volumes and may generate swelling pressures in the order of 500 kPa (Godfrey, 1978).

Expansion is mainly caused by the hydration or attraction and absorption of water molecules into the expansible lattice of the clay minerals as illustrated in Figure 1.

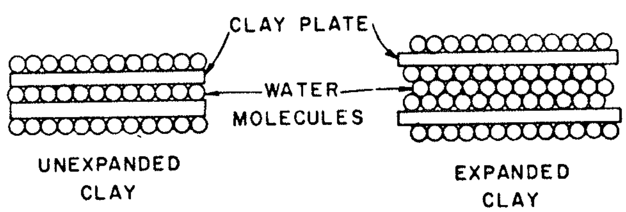


Fig. 1 Simplified Sketch of Expanding Clay Plates

Soil shrinkage occurs when the process is reversed and the water is removed from the clay lattice. The amount of water available to the clay lattice depends on various environmental factors. Of these, climatic conditions probably represent the most dominant factor affecting expansive clays. In this respect, the most important aspect of climate is the relationship between rainfall and the rate of evaporation and evapotranspiration (Hamilton, 1980). Vegetation, particularly trees, withdraw moisture from the soil to satisfy their moisture demands causing shrinkage. Poor drainage, a function of topography, can cause surface water to pond thereby resulting in localized swelling. Other environmental sources of moisture supply or depletion are basically related to the development of an area and can be controlled. Faulty or leaking subsurface utility systems (i.e. water and sewage) or local watering of lawns and gardens can affect ambient moisture conditions. Also a building may reduce the rate of water evaporation from the foundation soil, resulting in swelling. The above factors represent only a few of the many factors which can affect expansive soils.

Some of the factors mentioned above may cause movements of the foundations and consequent damage to the house. The damage takes the form of cracked interior and exterior walls, heaved basement slabs, distorted door frames and uneven floors.

1.2 PREVIOUS STUDIES

Since the drought in Britain, (1975-76), the performance of 200 low-rise buildings have been examined. All buildings have suffered damage associated with foundation movement. In the study a classification of damage (Building Research Establishment - 1981) was adapted as a basis for comparison. The classification, which uses ease of repair as the main measure of severity, but also takes into account the nature, location and magnitude of cracking distortion and loss of function, is shown in Table 1.

The results of the survey revealed that about 75% of the surveyed houses fell within and below the category of slight damage, 20% in the category

TABLE 1 Classification of Visible Damage to Walls with Particular Reference to Ease of Repair of Plaster and Brickwork or Masonry

Category of Damage	Description of Typical Damage+	Approximate Crack Width : mm
Negligible	Hairline cracks of less than about 0.1 mm width are classed as **negligible**.	Up to 0.1
Very slight	Fine cracks which can easily be treated during normal decoration.	Up to 1
Slight	Cracks easily filled. Redecoration probably required. Cracks not necessarily visible externally. Doors and windows may stick slightly.	Up to 5
Moderate	The cracks require some opening up and can be patched by a mason. Doors and windows sticking.	5-15 (or a number of cracks up to 3)
Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Floor sloping noticeably.	15-25 (but also depends on number of cracks)
Very severe	This requires a major repair job involving partial or complete rebuilding. Beams lose bearing, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	Usually greater than 25 (but depends on number of cracks)

of moderate damage and about 5% were classified as severe and very severe. The average repair bill for a case of major damage was estimated (Reece, 1980) at about £4,000 ($Can. 8,000) at 1980 prices. No data are available for the categories of slight and moderate damage.

A similar study was carried out in Dallas, Texas, U.S.A. (Smith and Allen, 1974). The study indicated that homeowners in Dallas County, Texas, experience approximately 8,470 residential foundation failures annually. All the failures were associated with movement of expansive soils. The criteria used in this study were related to the swell/shrink potential of the clay. The study indicated that approximately 84% of foundation failures occurred within high expansive soil areas, 14% occurred in moderate expansive soil areas and 2% occurred in low expansive soil areas. The average foundation repair cost was $1,650 (i.e. in 1974 U.S. dollars). The average annual damage cost in high expansive soil areas was estimated to be $90 per foundation per year. Foundation costs in moderate and low expansive soil regions were estimated to be $23 and $3 per foundation per year, respectively. The average annual damage cost per foundation in Dallas for high, moderate and low expansive soil was $45 (i.e. in 1974 US dollars). To adjust this value to Canadian 1983 dollars, a cost index of 2.6 was used, giving an average damage loss per foundation of $115 per year.

1.3 OBJECTIVES

The economic loss associated with the occurrence of cracks in houses, is the cost of repairing the cracks, taking steps to prevent additional cracks from occurring and loss in the resale value of the home. With respect to the latter, some homes have been so severely cracked and distorted that the homeowners would have difficulty in selling the home at any price. Thus unquestionably there is an economic loss to the community related to shifting foundations and the associated cracking and distortion of houses in Winnipeg.

To avoid the above mentioned problems a different type of foundation, such as pile foundation, may be used. This entails a higher initial cost and is the main reason why such foundations are not generally used. To justify the added expenditure of a more stable foundation in the construction of new homes, a better knowledge of the monetary loss associated with the use of standard shallow foundations was required.

The purpose of this thesis was to establish the extent and severity of cracking of houses in Winnipeg and to carry out an economic study of the viability of using pile foundations which would eliminate the problem.

CHAPTER 2

WINNIPEG SOIL

2.1 SEDIMENTATION HISTORY

The soils in the Winnipeg area are largely lacustrine deposits formed in glacial Lake Agassiz which drained into Hudson Bay about 7,000 years ago. The total area covered by Lake Agassiz was about 520,000 km^2 (200,000 sq. mi.) although the lake did not cover more than 208,000 km^2 (80,000 sq. mi.) simultaneously (Baracos et al., 1983). The city of Winnipeg is located in a former major sedimentation basin where the Assiniboine River joins the Red River and continues its northward flow to empty into Lake Winnipeg. The thickness of the clay in this region varies from about 3 m in the northwest corner of the city to over 18 m in the southeast corner (see Fig. 2). Underneath the lacustrine clay lies glacial till and limestone bedrock. A typical borehole log is shown in Fig. 3. The thickness of till varies from 3 to 6 m (Baracos et al., 1983). Although occasionally the tills can be classified as potentially expansive, the most troublesome expansive soils for shallow foundations are the lacustrine deposits.

2.2 GEOTECHNICAL PROPERTIES OF THE LACUSTRINE CLAY

The stratigraphy of the lacustrine deposits can be considered as two separate units or zones (Baracos et al., 1983) which are the Complex Zone and the Glaciolacustrine Clay. The upper Complex Zone consists of stratified silty clay and silt layers. The zone ranges from 2.5 m to 4.5 m thick extending to the bottom of the tan silt layer. The glaciolacustrine units extend from the bottom of the tan silt layer to the top of the till. The upper layer is light brown to mottled grey-brown in colour; the lower level varies from grey-brown

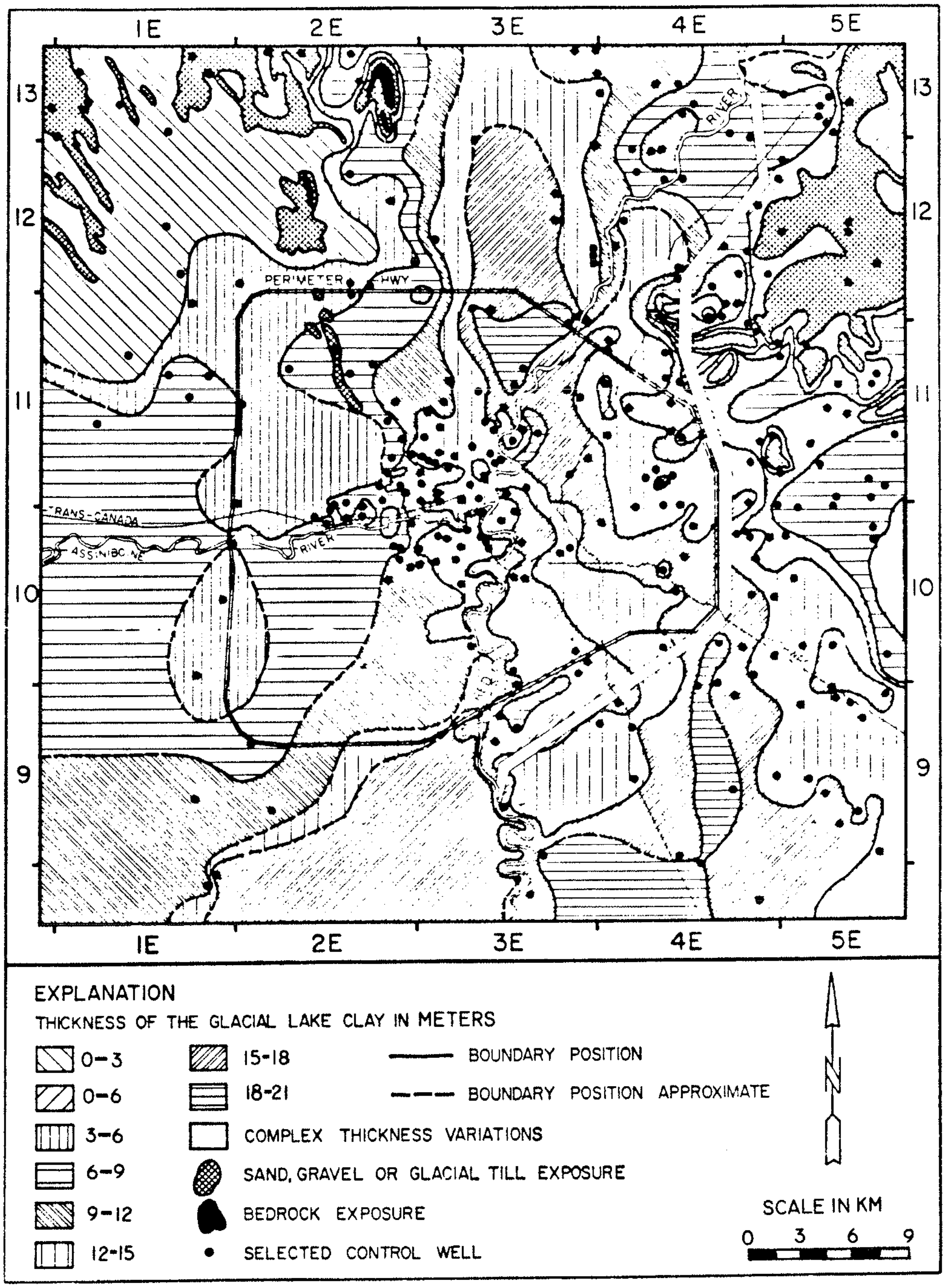


Figure 2 Thickness of Lake Agassiz Clay in Winnipeg (Render, 1970)

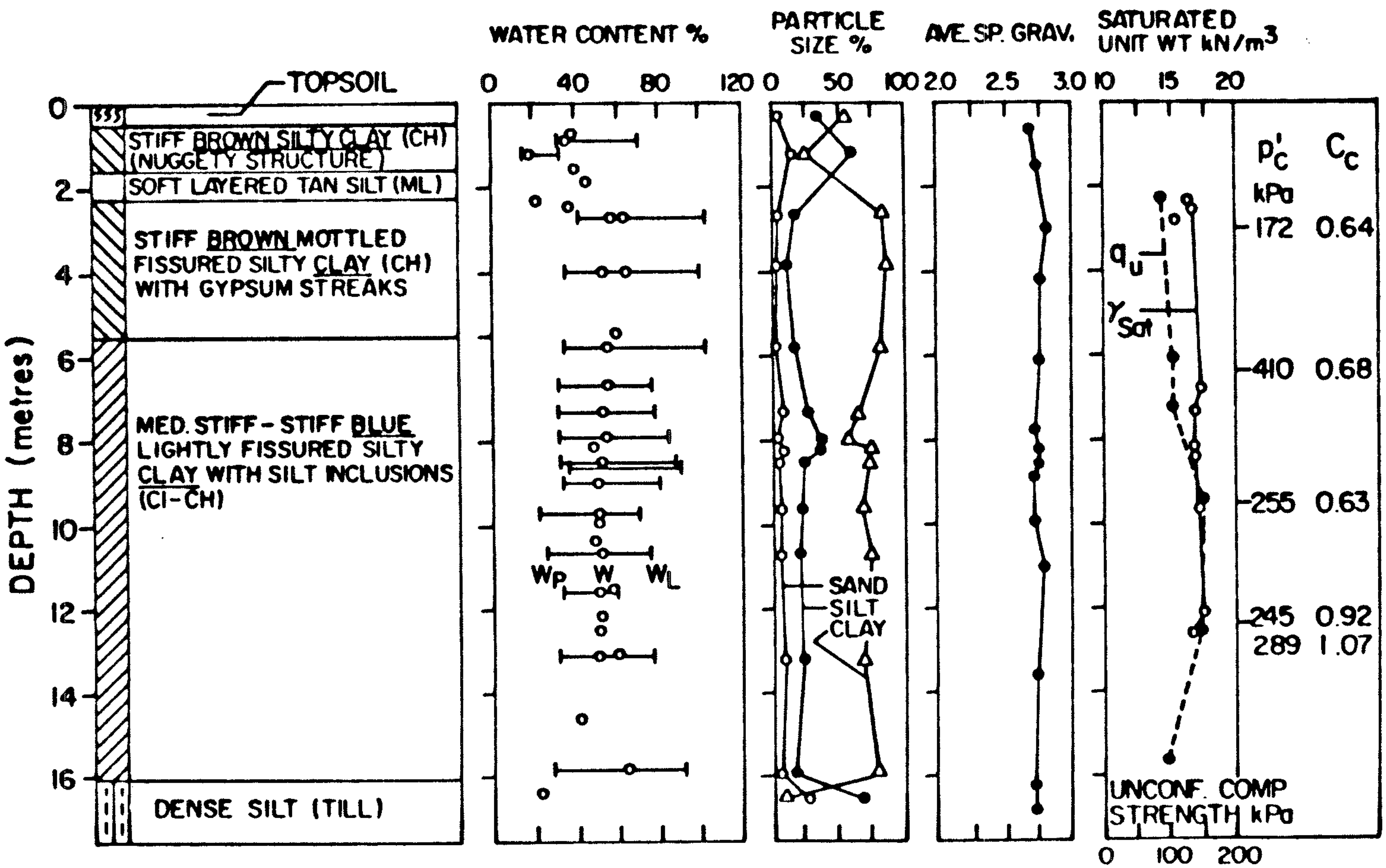


Figure 3 Average Borehole Log. Information, University of Manitoba Campus (Baraccs et al., 1979)

tc blue grey becoming darker with depth. The colour change is due to oxidation. The upper brown clay has fissures and joints, some of which extend to the till surface.

Principal clay minerals are montmorillonite and illite in roughly equal amounts, plus a minor amount of kaolinite. Some researchers have found mixed layer illite - montmorillonite minerals, Baracos (1977). Since the clay contains a large proportion of montmorillonite, Winnipeg clay has a high swelling potential.

A summary of the geotechnical properties of this clay is given in Table 2 (Baracos et al., 1983). The moisture content of the lacustrine clay is normally within the range of 40 to 60%. The plasticity index which ranges from 40 to 75% and the percentage of clay in the soil, which ranges from 70 to 85%, indicate the high swelling potential of the lacustrine clay. The swelling pressures based primarily on oedometer tests range from 0 kPa to approximately 75 kPa. Oedometer tests carried out by the National Research Council on samples of Winnipeg clay from the annually frozen layer showed lower void ratios, lower preconsolidation pressures, lower swelling pressures and much lower swelling tendencies than clay samples below the maximum annual freezing depth (Hamilton, 1980). An undisturbed sample from a depth of 0.76 m had a free-swell, swelling pressure of 50 kPa and a free-swell of approximately 3%. A sample from a depth of 2.5 m had a free-swell, swelling pressure of 230 kPa and a free-swell of 10.5%. The lacustrine clay is over-consolidated to a depth of about 15 m, having over-consolidation ratio (OCR) of 1 to 5 due to a variety of processes such as ground water level changes, cementation, porewater chemistry changes, dessication and freeze-thaw effects.

The unconfined compressive strength of the clay ranges between 48 kPa and 120 kPa.

TABLE 2 Geotechnical Properties: Glaciolacustrine Lake

Agassiz Clay (Baracos, et al. 1983)

Geotechnical Property	Typical Range Lower	Upper
Unit weight (moist) (kN/m^3)	15.7	18.0
Unit weight (dry) (kN/m^3)	10.2	13.3
Liquid limit	65	110
Plasticity Index	40	75
Clay size fraction (%)	70	85
Sensitivity	2	4
Compression Index (normally consolidated)	0.5	1.0
Overconsolidated ratio	1	5
Swelling pressure (kPa)	0	74
Unconfined compression strength (kPa)	48	120
Normal consolidated angle of shearing resistance, peak (degrees)	17	23
Normal consolidated angle of shearing resistance, residual (degrees)	8	12
Deformation modulus (MPa)	3.5	21
Modulus/undrained strength, E/s_u	230	360

CHAPTER 3

STRUCTURAL DEFECTS ARISING FROM GROUND MOVEMENTS

3.1 PLANAR AND DIFFERENTIAL SETTLEMENT

Ground movements due to moisture depletion of the soil cause settlement and consequently some structural defects of the house. The settlement may be planar, (see Fig. 4) and unless it is very large it remains undetected and does not cause structural defects, or it may be differential or non-planar, where one part of the structure moves to a greater extent than the remainder (see Fig. 5). The effect of differential vertical movement between any two points A and B on a building depends on how far apart they are. It is therefore useful to measure differential movement as angular distortion, defined as H/AB (Fig. 6).

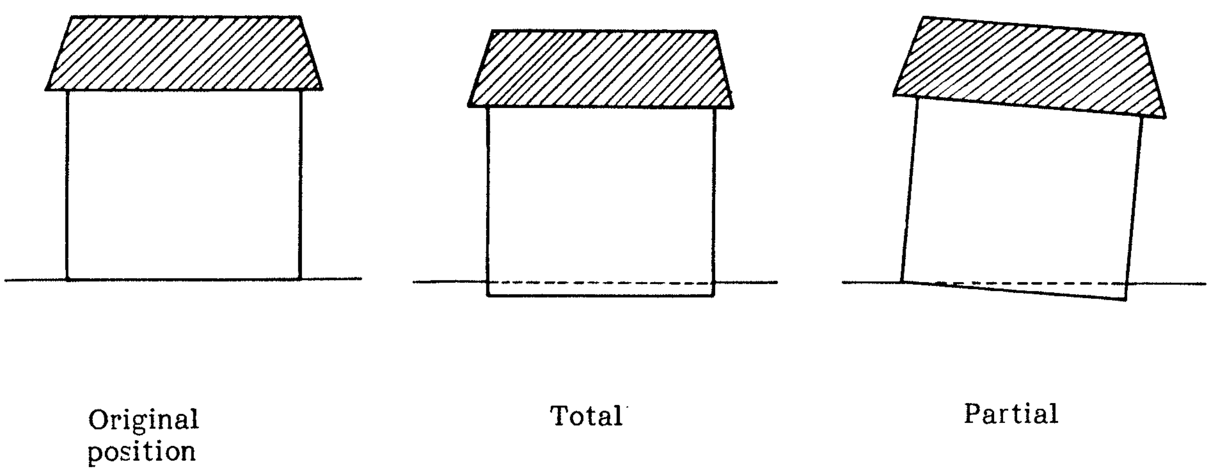
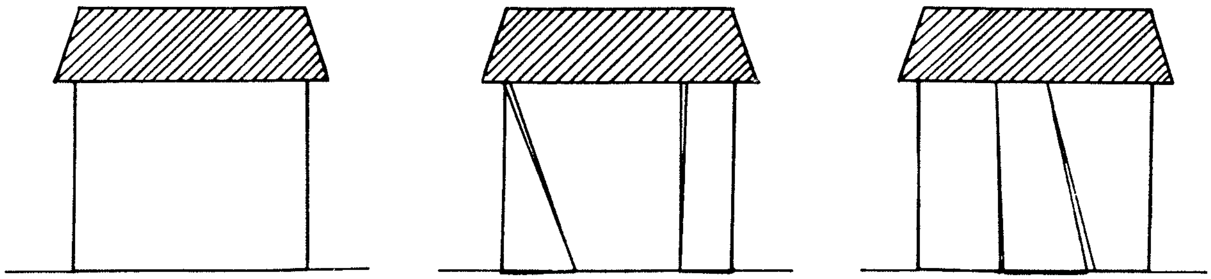


Figure 4 Planar Settlement



Original position

Settlement in the ends of a wall with the centre stable

Settlement in the centre of a wall with the ends stable

Figure 5 Differential Settlement Within a Single Structural Unit

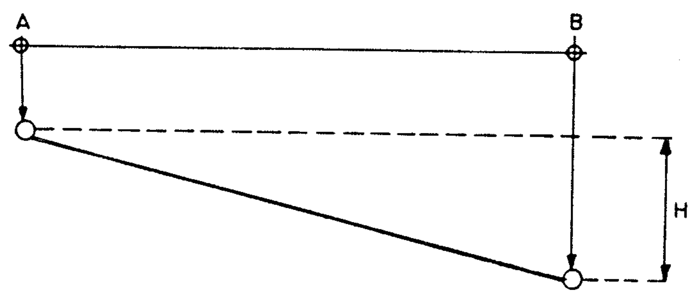


Figure 6 Angular distortion, defined as H/AB (Fig. 6).

Stucco and plaster are very prone to cracking caused by differential movement and from the limited data available the onset of cracking can be associated with an angular distortion of 1/300. Typically a house has a width of 12 m and hence a differential settlement of 40 mm may cause cracking of stucco or plaster walls.

It is sometimes said that the origin of the settlement lies below the highest point of a diagonal crack but while this is very often the case, it is not invariably so, and confirmation must be sought elsewhere. Cracks tend to follow a pattern consistent with the movement of a part of the building and there is often a rotational effect in panels as they move about an axis. If the ends of a wall settle more than the centre, the cracks increase in width with height. The formation of cracks in an actual building is complicated by the planes of weakness introduced by windows, docrs and other constructional features so that careful consideration must be given to the pattern of cracks and damage to ascertain how the building would have had to move for such a pattern to be produced.

Another problem arising from ground movements is differential settlement between structional units (see Fig. 7).

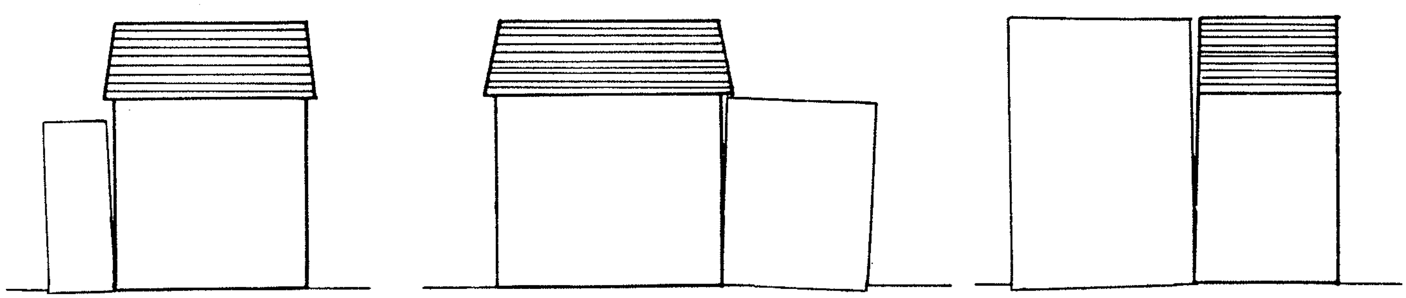


Figure 7 Differential Settlement Between Structional Units

Many houses are made up of more than one structural unit. There is often a main structure with an addition, frequently of inferior design and construction. The connection between two units governs the type cf damage which results when differential settlement occurs. Use of flexible joints rather than rigid connections can help reduce the fracturing. Bonding, while it provides some restraint, is not sufficiently strong to prevent fracturing frcm occuring. Although the bond might hold, fracturing will occur at the first plane of weakness, usually in the vicinity of window openings but sometimes in the main structure.

Another form of ground movement is soil heave. For the case where the ground swells and the exterior points of a building are forced upwards, the cracks which form diminish in width as the height increases (see Fig. 8a).

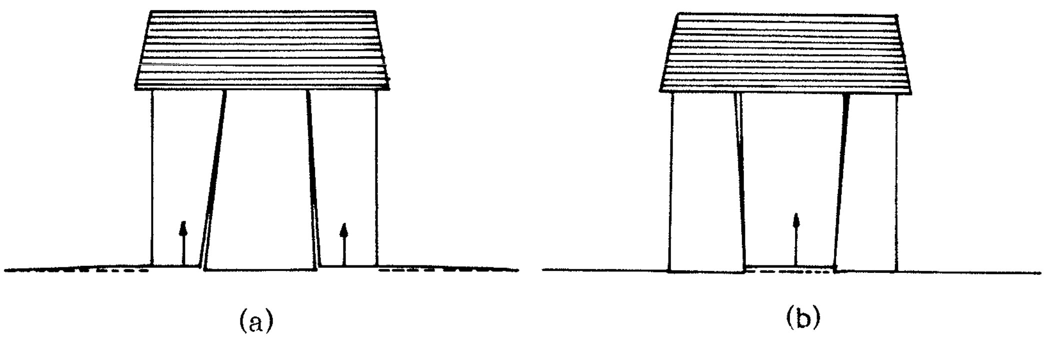


Figure 8 Effects of Soil Heave

If the center moves up relative to the walls, the width of cracks increases with height (see Fig. 8b).

In the survey conducted, which is described in subsequent chapters, no distinction was made between cracks caused by settlement and heaving.

CHAPTER 4

THE SURVEY

4.1 THE TARGET AREA

As mentioned previously, the purpose of the survey was to determine the percentage of homes that had been adversely affected by shifting foundations and to assess the severity of the damage. In order to obtain the necessary information, on-site inspections combined with personal interviews were carried out. Due to the limited resources available for the survey and time limitations, the number of houses included in the survey had to be relatively small. For this reason it was decided to conduct the survey in only one residential area of Winnipeg.

The survey was carried out in the River Heights area, which was assumed to be a representative sample for the entire city of Winnipeg. It contains both "old" and "new" houses. The location of River Heights is shown in Fig. 9, a Winnipeg Urban Growth Map (Economic Atlas of Manitoba, 1960). The target area borders are defined as Lindsday Street and Cambridge Street running in a north-south direction and Wellington Crescent and Taylor Avenue running in a east-west direction (see Fig. 10). Only houses with shallow foundations were included in the survey.

The target area was mainly developed in three separate time periods and the areas are categorized according to the age of the houses within them (see Fig. 10). The houses have been grouped into those built:

a. prior to 1914 (predominantly large 3-storey)

b. 1915 to 1945 (predominantly 2-storey)

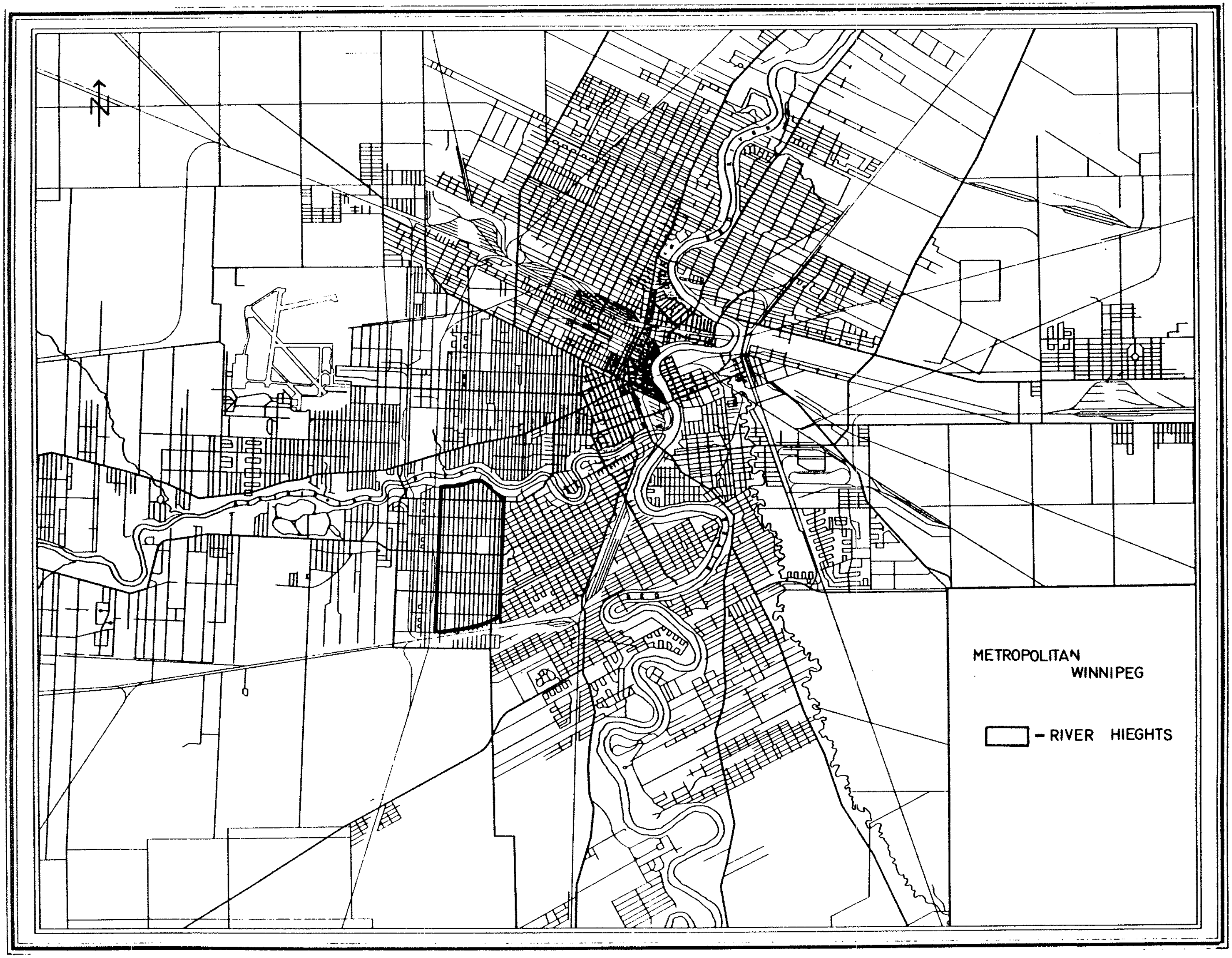
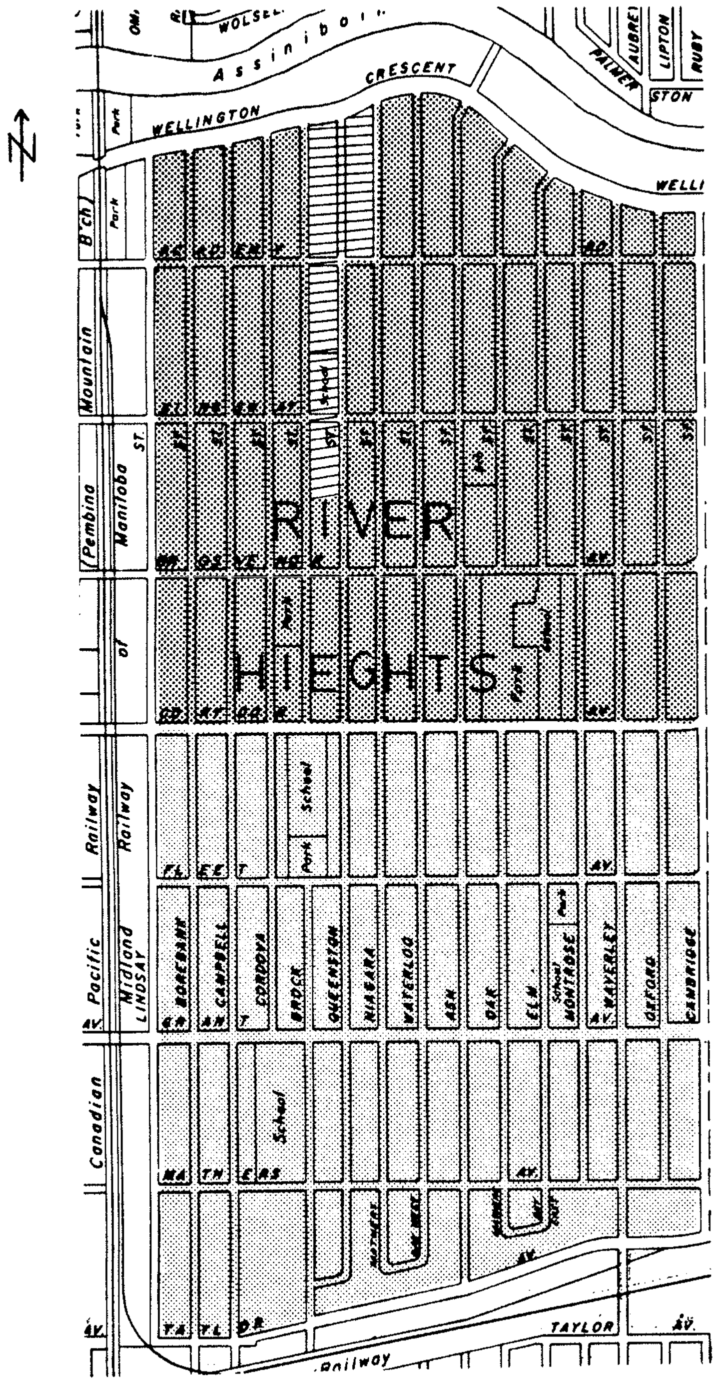


Figure 9 The Location of River Heights



Extent of built-up area in 1914

1945

1956-60

Figure 10 Growth of River Heights

c. 1946 to 1956 (2-storey and bungalows)

d. 1957 to 1960 (predominantly bungalows)

The entire area of River Heights had an abundance of large deciduous trees, predominantly elm, ash, and oak. The height of these trees decreased from approximately 15 m in the old area to approximately 7 m in the new area. The trees were planted 2 meters from the street curb and about 10 to 15 meters from the front of the houses. Additional trees and shrubs planted by homeowners adorned the front and backyards. Fig. 11, an aerial photograph of River Heights area, provides a good indication of the density of the vegetation. Vegetation has a very significant influence on moisture conditions in the soil. The active tree roots remove moisture from the soil, producing local differential soil shrinkage. If this occurs under shallow foundations, it may lead to house movement and structural damage. Recent studies in the U.K. (Cutler and Richardson, 1981) on tree root behaviour and the extent of the zone of influence of trees in clays, have produced the data which are illustrated for elm, ash and oak in Fig. 12. The figure shows the reduction in percentage of cases of damage recorded, as the distance of trees from buildings increases. According to this figure and the distance from tree to house in River Heights, all three species of trees, especially oak may have significanct influence on the performance of house foundations.

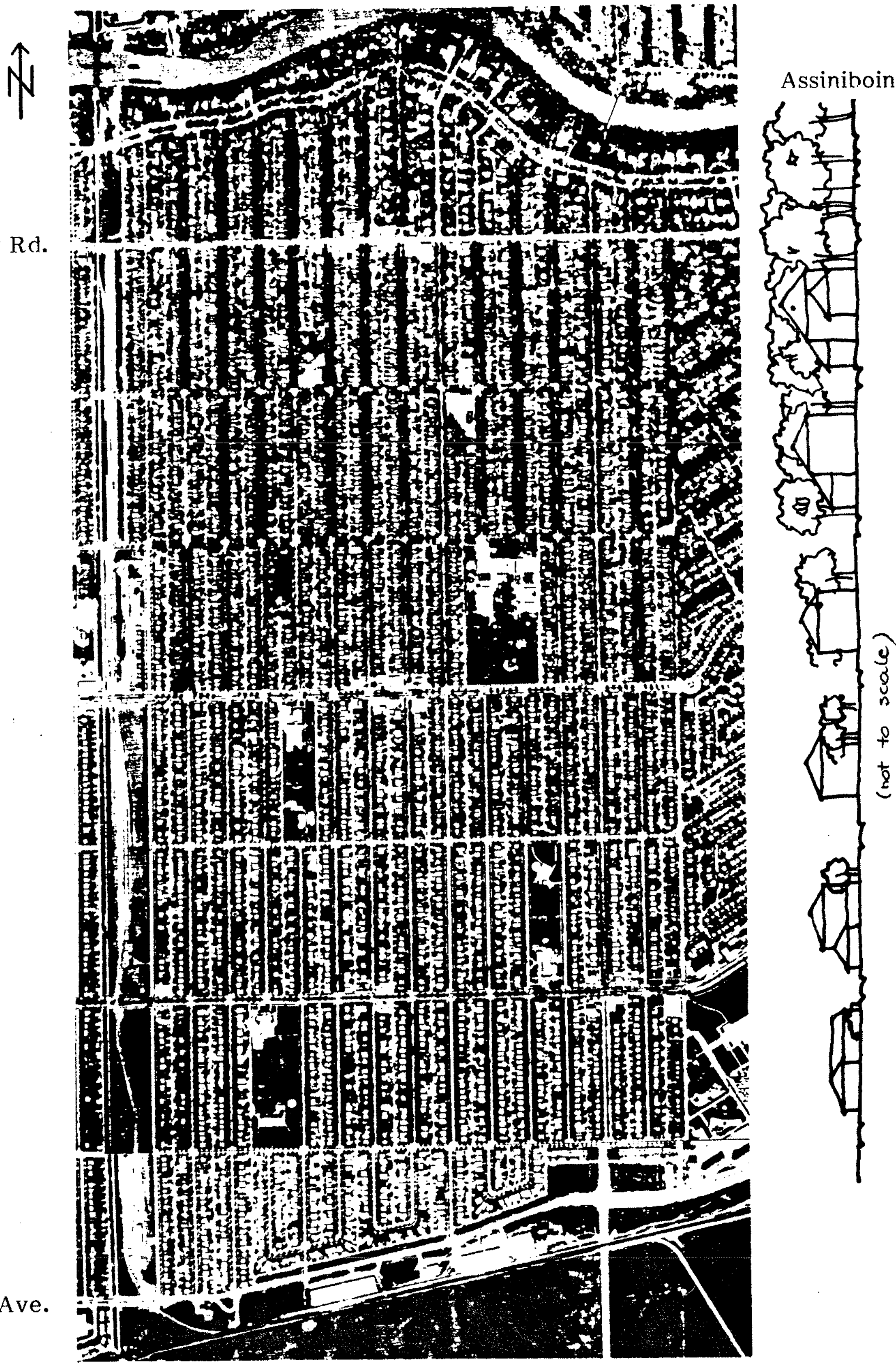


Fig. 11 Aerial photograph and pictorial cross-section of River Heights

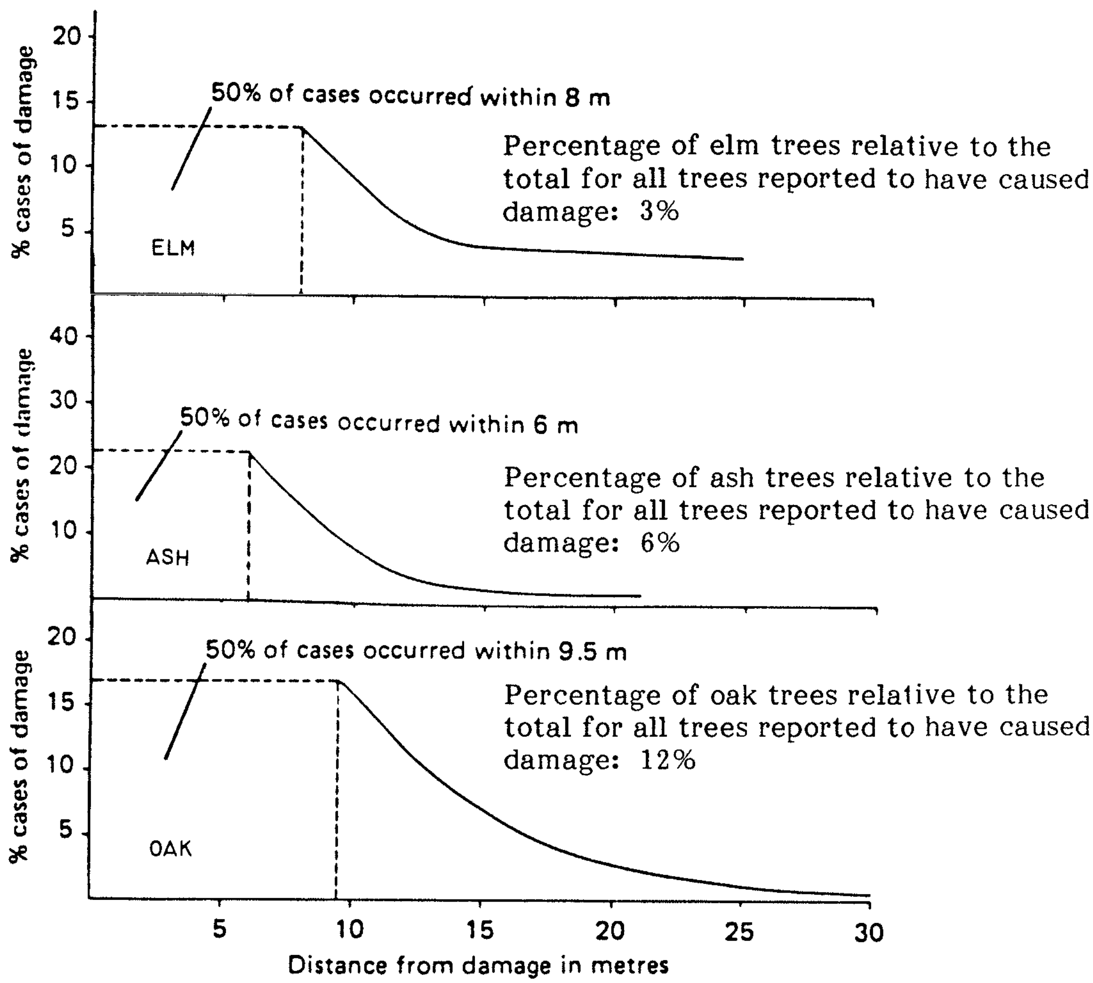


Figure 12 Elm, Ash, Oak Damage Ranking (after D.F. Cutler and I.B. Richardson, 1981)

4.2 POPULATION AND SAMPLE SIZE

There were 4,822 houses in the River Heights area which constituted the population size. In order to represent the population, an appropriate sample size had to be determined. The sample size required for statistical significance was based on a method used in "Sampling Techniques", Cochran, W., 1977 and Marketing Research", Kress, G., 1979. Samples usually are not perfect replicas of the populations from which they are drawn and therefore it is not known how close the sample value is to the population value. While sample data won't determine the exact population value, these data can be used to establish an interval which should contain the population value. This interval is called a "confidence interval" and it depends upon the degree of confidence desired in the sample's results and the type of survey. The confidence interval most commonly used is 95% and it is related to the dispersion of values in the form of a normal distribution, (see Fig. 13).

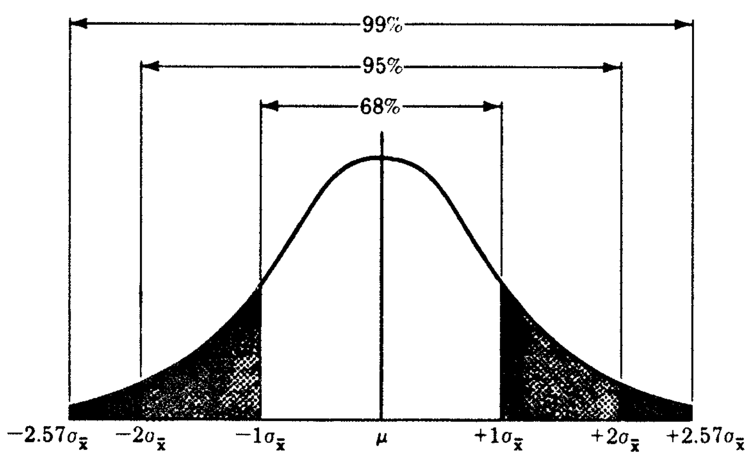


Figure 13 Possible Values of Sample Means for Different Confidence Intervals

As shown in Fig. 13, the 95% of the sample means will be within ± 1.96 standard errors of their population mean. Since the sample involves proportions or percentages of a certain attribute, the concept of standard error of the proportion (s_p) can be used. The formula for deriving the standard error of proportion is:

$$s_p = [\frac{N-n}{(n-1).N} .p.q]^{\frac{1}{2}}$$

in which:

p = proportion of sample possessing a certain attribute

q or (1-p) = proportion of sample not having that certain attribute

N = population size = 4,822 houses in River Heights

n = sample size

Allowing p to be equal to 50% guarantees that the sample will be large enough to provide the desired confidence interval no matter what the real value of p might be.

A 95% confidence interval involves 1.96 s_p. If the confidence interval is ± 7% then;

$$1.96\ s_p = \pm 7\%$$

$$1\ s_p = \pm 7\% / 1.96$$

$$s_p = \pm 3.57\%$$

$$n = N + \frac{s_p2 \cdot N}{p \cdot q} \quad / 1 + \frac{s_p2\ \ N}{p \cdot q} \qquad = 180$$

Thus the required sample size is 180.

The sample size thus computed does not include non-responses. Assuming that only one of three homeowners would willingly participate in the survey, 550 homes were selected to achieve the necessary sample size of 180 houses. This translated into four houses per city block for the selected area and the houses were selected at random on each side of the street in each block.

4.3 THE SURVEY - DETAILS AND CRITERIA

The survey was personally conducted by the author, between July, 1982 and February, 1983. Prior to the actual survey, letters were placed in the mailboxes explaining the objectives of the survey and informing the homeowners that someone would come in about a week's time to collect information. This was followed by a personal visit.

The information collected included style and age of the house, the repair work to the walls and foundation, the effectiveness of using teleposts and existence and extent of cracking, which was categorized as minor, moderate or major. The categorization was made in accordance with Table 3. It takes into account the form distortion and loss of function. Typical examples of the common forms of distress are shown in Fig. 14.

TABLE 3

CRITERIA USED FOR CLASSIFYING SEVERITY OF DISTRESS

Form of Distress	Minor	Moderate	Major
Cracks	Less than 1 m long, no separation.	More than 1 m long, minor separation.	Open cracks, repair requires filler.
Water leaks	Moisture stain only.	Leakage during heavy rains.	Open cracks, requiring filler material for repair.
Sloping floors	Barely noticeable.	Noticeable, no damage to floor.	Very noticeable, separation of floor boards.
Door frame distortions	Uneven space between door and frame.	Doors stick, slight trimming required.	Trimming of doors required, frames require repair.

Figure 14 Common Forms of Distress

CHAPTER 5

DATA AND ANALYSIS

5.1 RESULTS OF THE SURVEY

Data was ultimately collected from 180 houses located on 15 different streets in the River Heights area. The extent and severity of cracking is shown in the form of bar graphs (Figs. 15 through 23). Each bar represents the percentage of homes affected on each street and the severity is indicated by different shading. Each graph shows a different form of distress. Figure 15 shows basement slab cracks, Fig. 16 shows foundation wall cracks, Fig. 17 shows basement water leaks, Fig. 18 shows interior wall cracks, Fig. 19 shows ceiling cracks, Fig. 20 shows main floor slope, Fig. 21 shows interior doors jam, Fig. 22 shows exterior wall cracks, Fig. 23 shows exterior doors jam.

The summary of the survey results are listed in Table 4. They were also represented in the form of a bar graph (Figure 24). Each bar indicates the percentage of houses surveyed that demonstrated a particular form of distress. The severity of distress (minor, moderate, major) is indicated by shading. The survey revealed that over 85% of the houses surveyed had developed cracks in walls, ceilings and foundations. The percentage of houses with the above distresses ranged from 55% of those surveyed on some streets to 100% of those surveyed on other streets. Most of the cracks were minor and generally only about 7% were classified as major. Approximately 80% of the houses were found to have uneven floors which reflect differential movement of the house. In about 5%, the differential movement was sufficient to create a gap at the transverse joint of the floorboards. Eighty five percent of the houses had distorted interior door frames and 70% had distorted exterior docr frames. In about 5% of the houses the doors required trimming to permit their opening

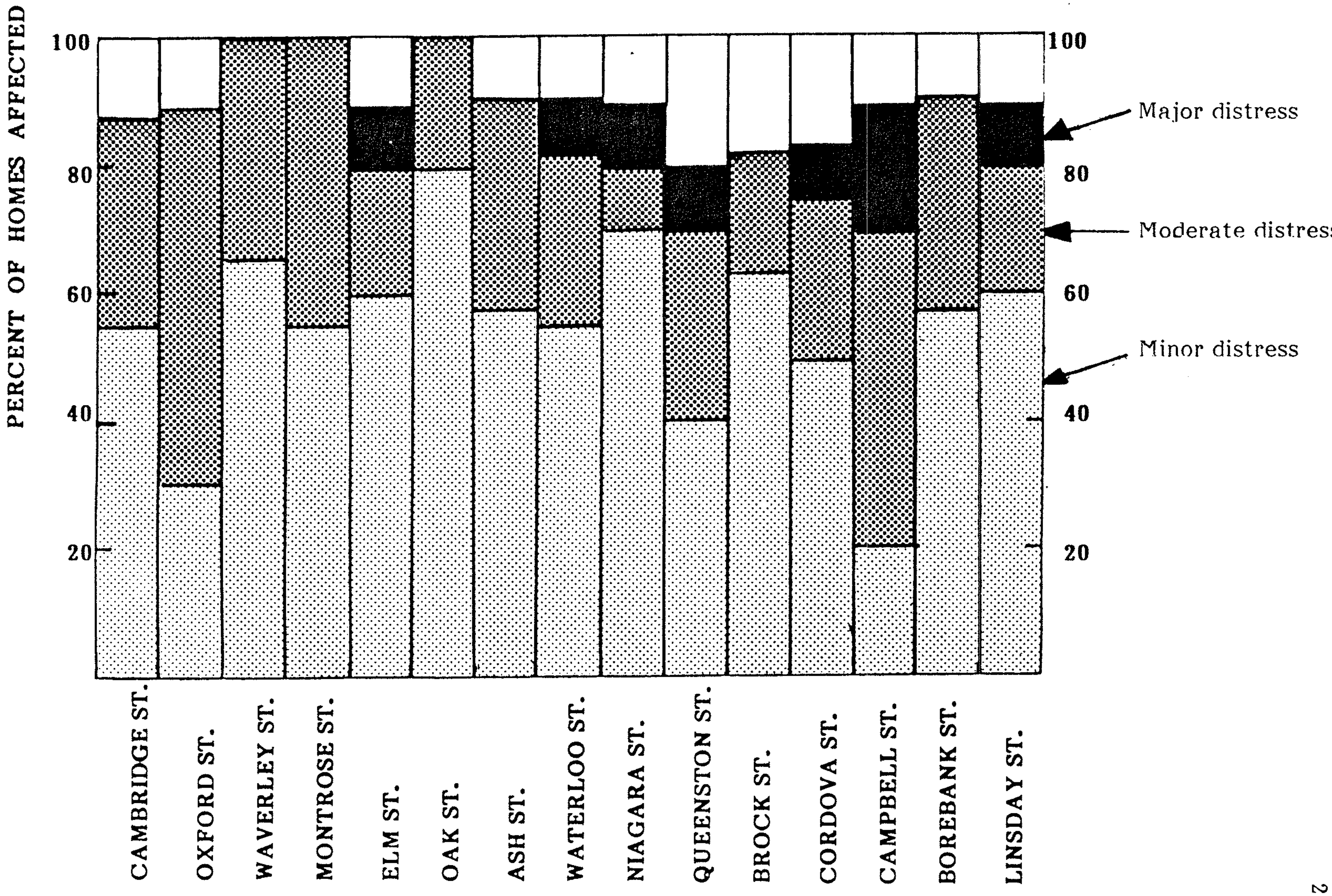


FIGURE 15 PERCENT OF HOMES WITH BASEMENT SLAB CRACKS

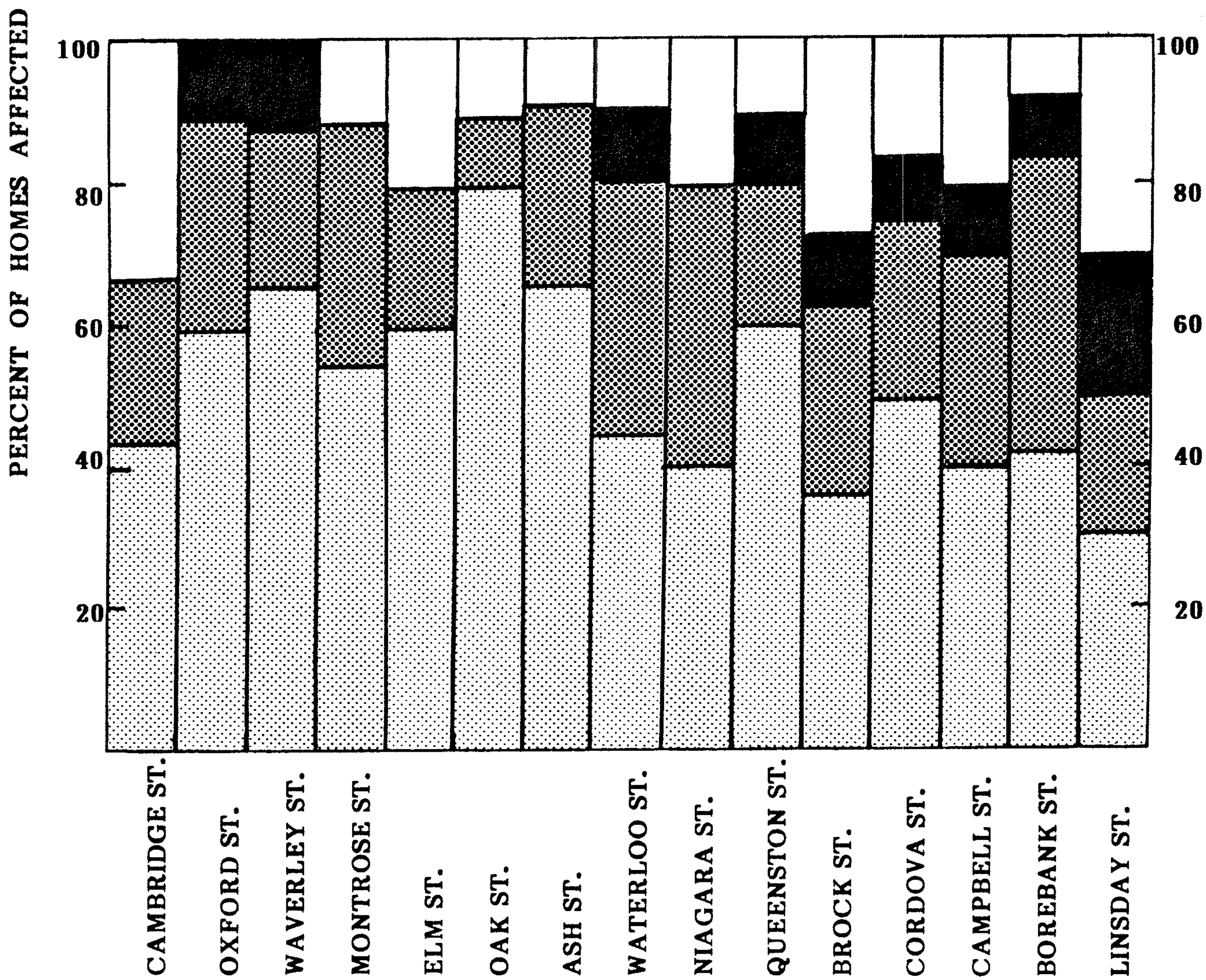


FIGURE 16 PERCENT OF HOMES WITH FOUNDATION WALL CRACKS

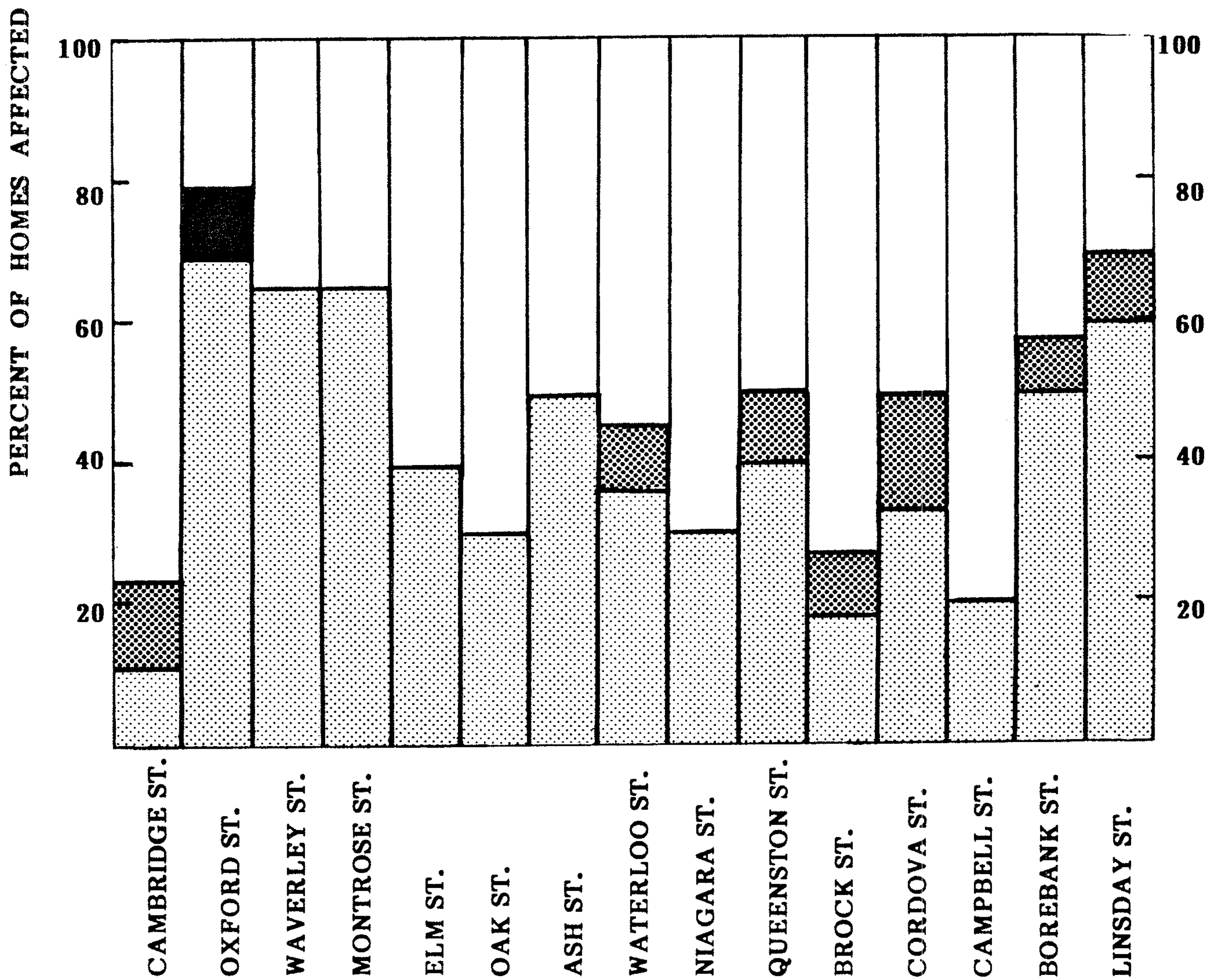


FIGURE 17 PERCENT OF HOMES WITH BASEMENT WATER LEAKS

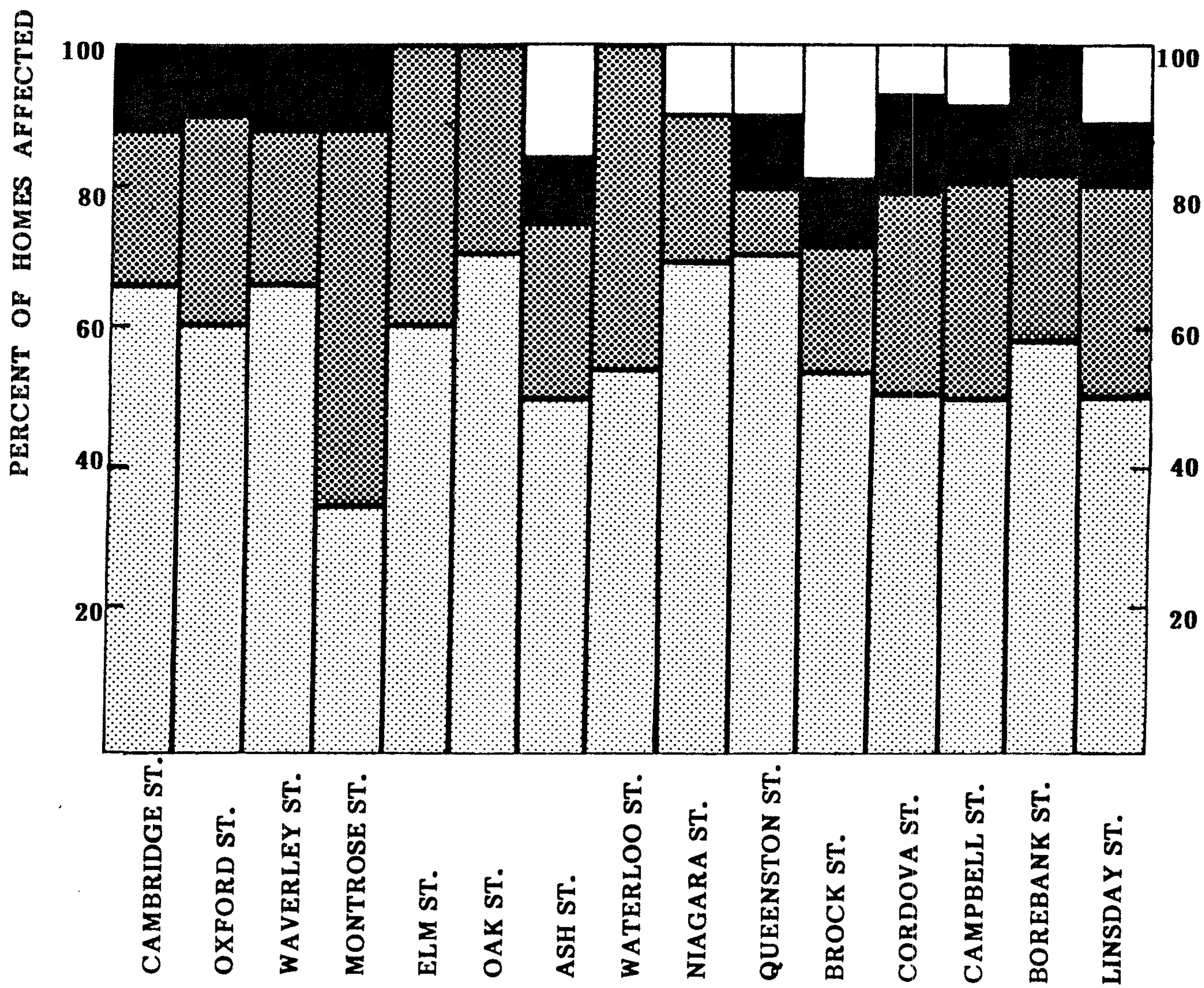


FIGURE 18 PERCENT OF HOMES WITH INTERIOR WALL CRACKS

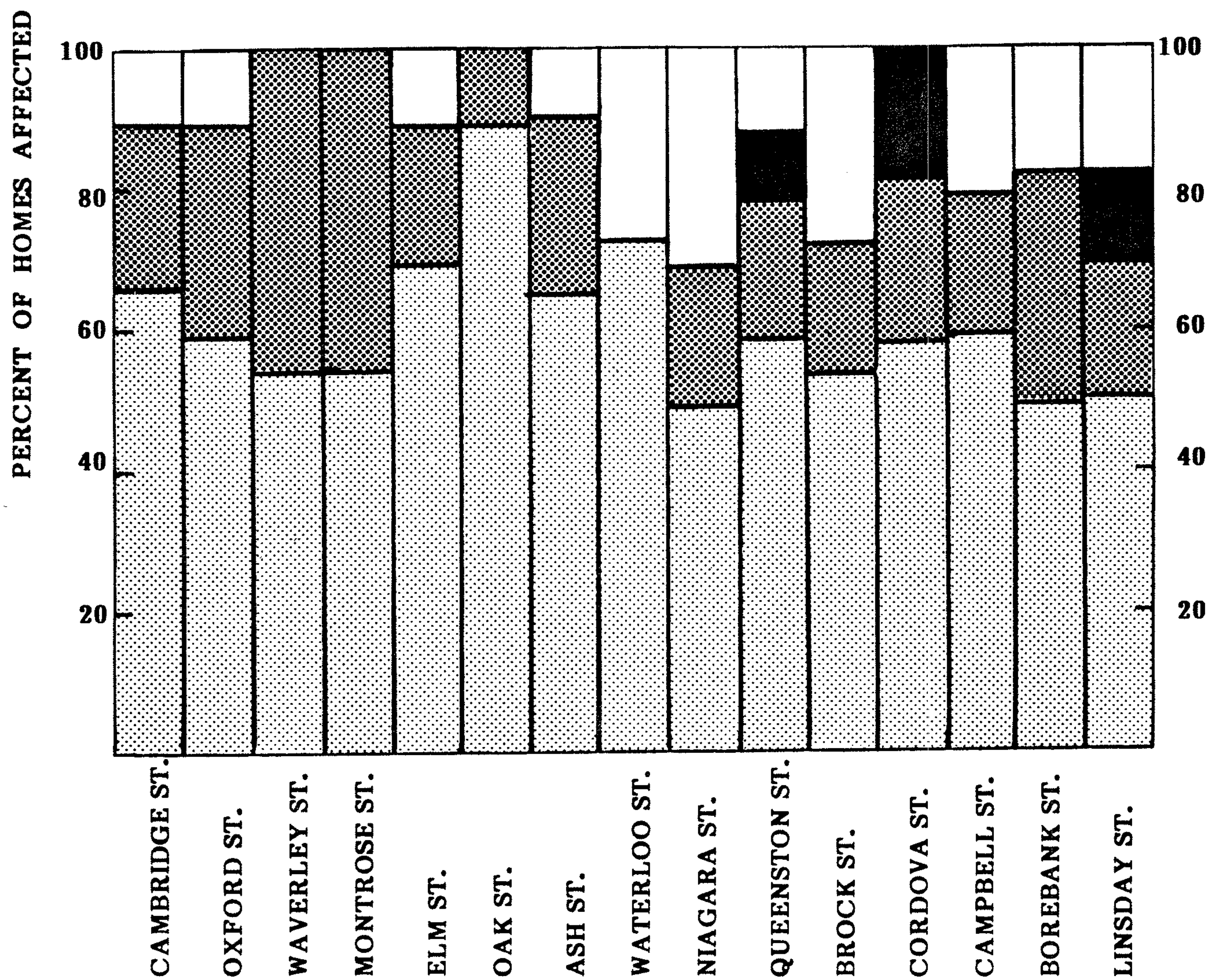


FIGURE 19 PERCENT OF HOMES WITH CEILING CRACKS

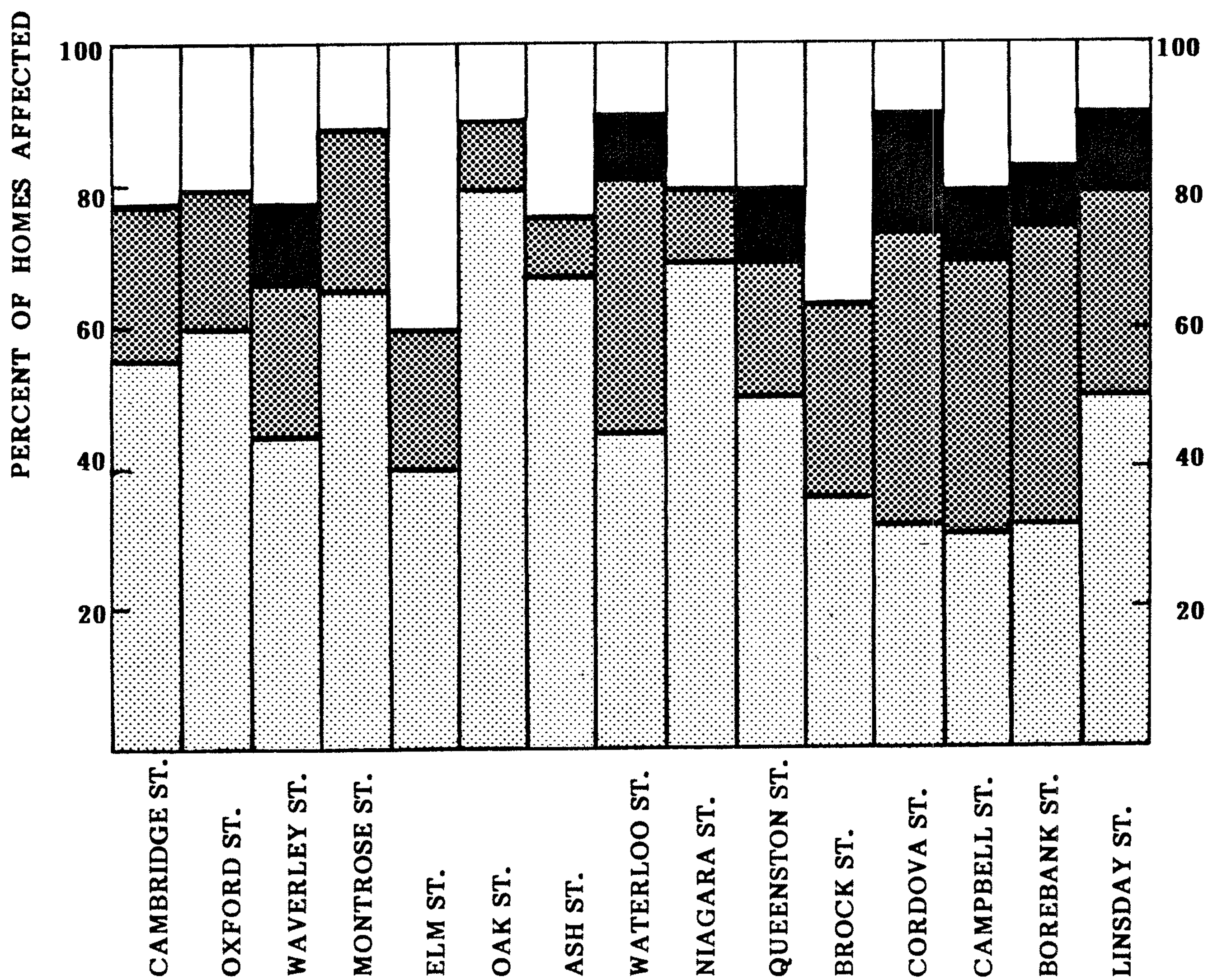


FIGURE 20 PERCENT OF HOMES WITH MAIN FLOOR SLOPE

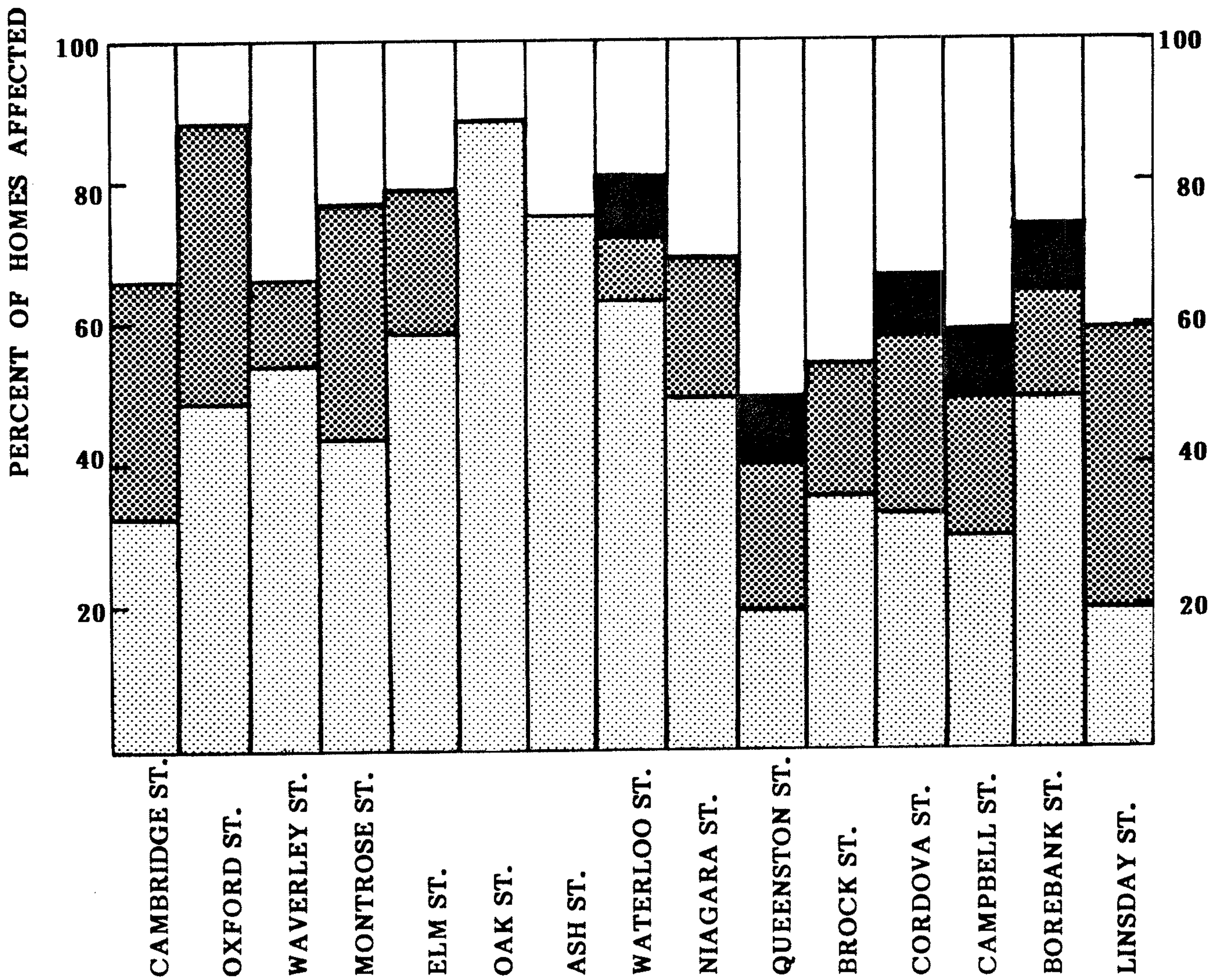


FIGURE 21 PERCENT OF HOMES WITH INTERIOR DOORS JAM

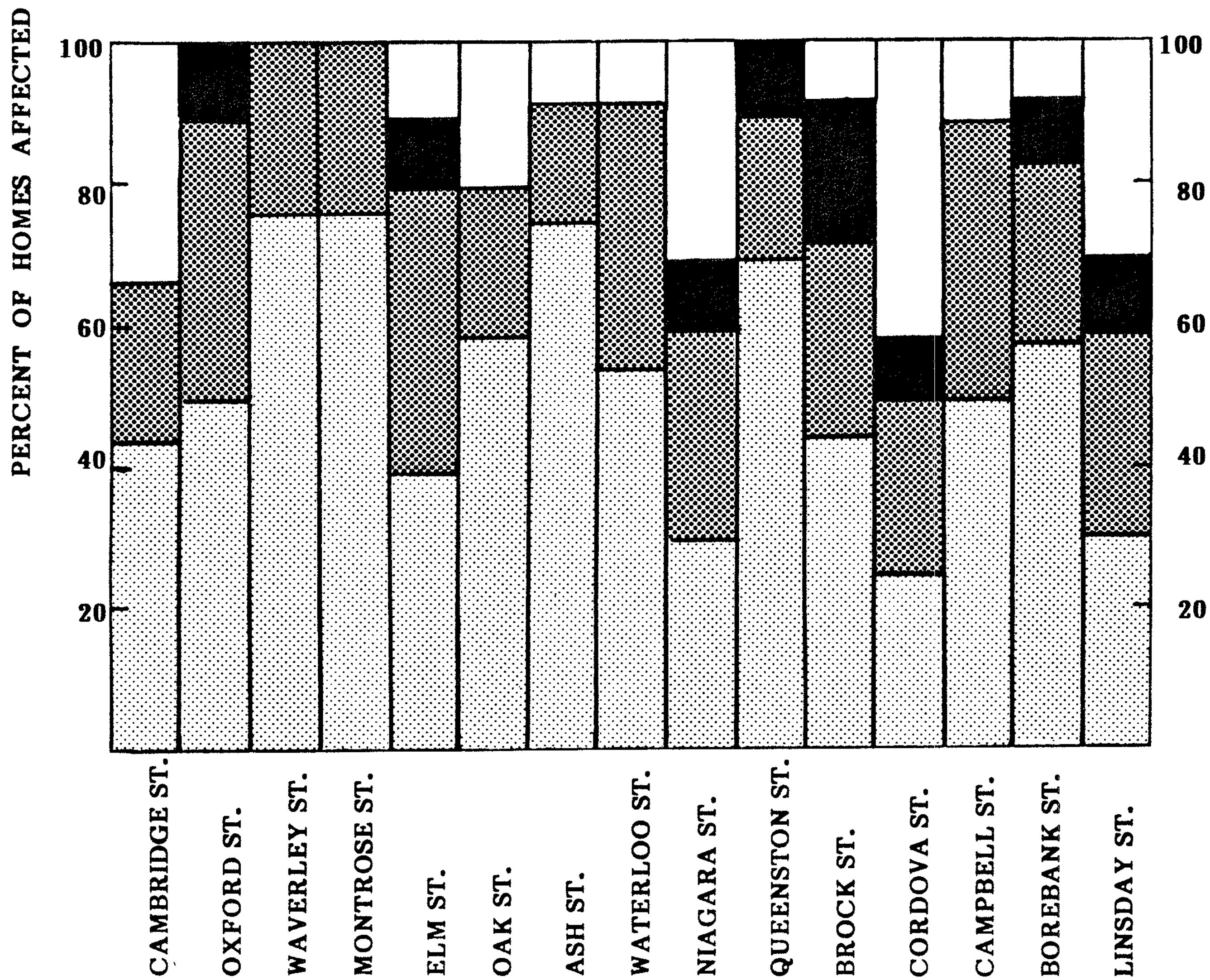


FIGURE 22 PERCENT OF HOMES WITH EXTERIOR WALL CRACKS

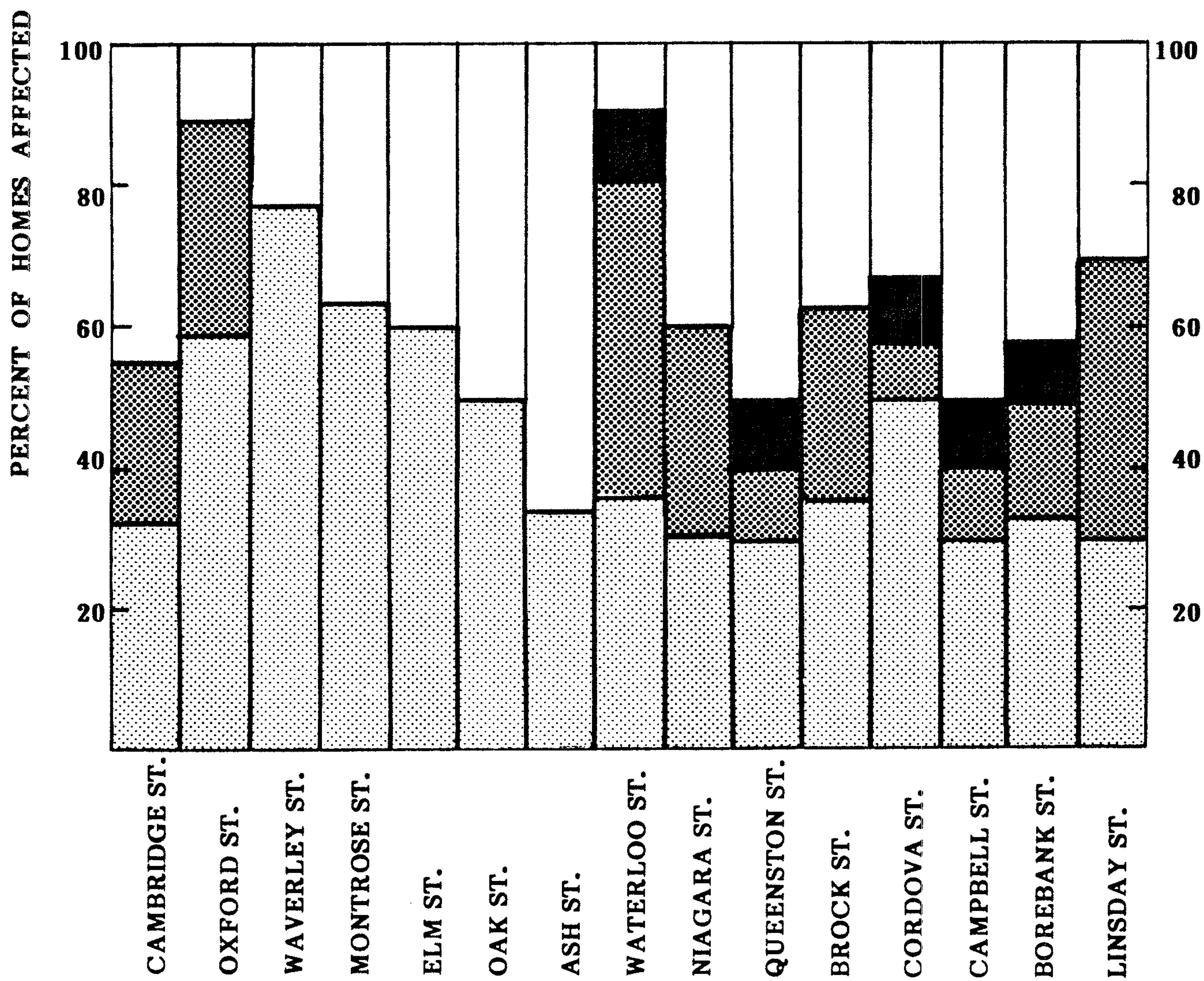


FIGURE 23 PERCENT OF HOMES WITH EXTERIOR DOORS JAM

TABLE 4 Summary of Survey Results

DAMAGE	FREQUENCY (%) PER ST. MIN.	MAX.	SEVERITY (MEAN FOR ALL STREETS) (%) NONE	MINOR	MODER.	MAJOR
Cracks in Basement Slab	55	100	10	53	32	5
Cracks in Foundation Wall	55	100	15	52	26	7
Leaks into Basements	20	80	54	40.5	5	0.5
Cracks in Interior Walls	80	100	6	58	29	7
Cracks in Ceilings	70	100	14	61	23	2
Sloping (main) Floor	60	90	20	51	24	5
Distorted Door Frames (Int.)	50	90	30	48	19	3
Cracks in Exterior Walls	55	100	15	52	27	6
Distorted Door Frames (Ext.)	30	90	15	52	28	5

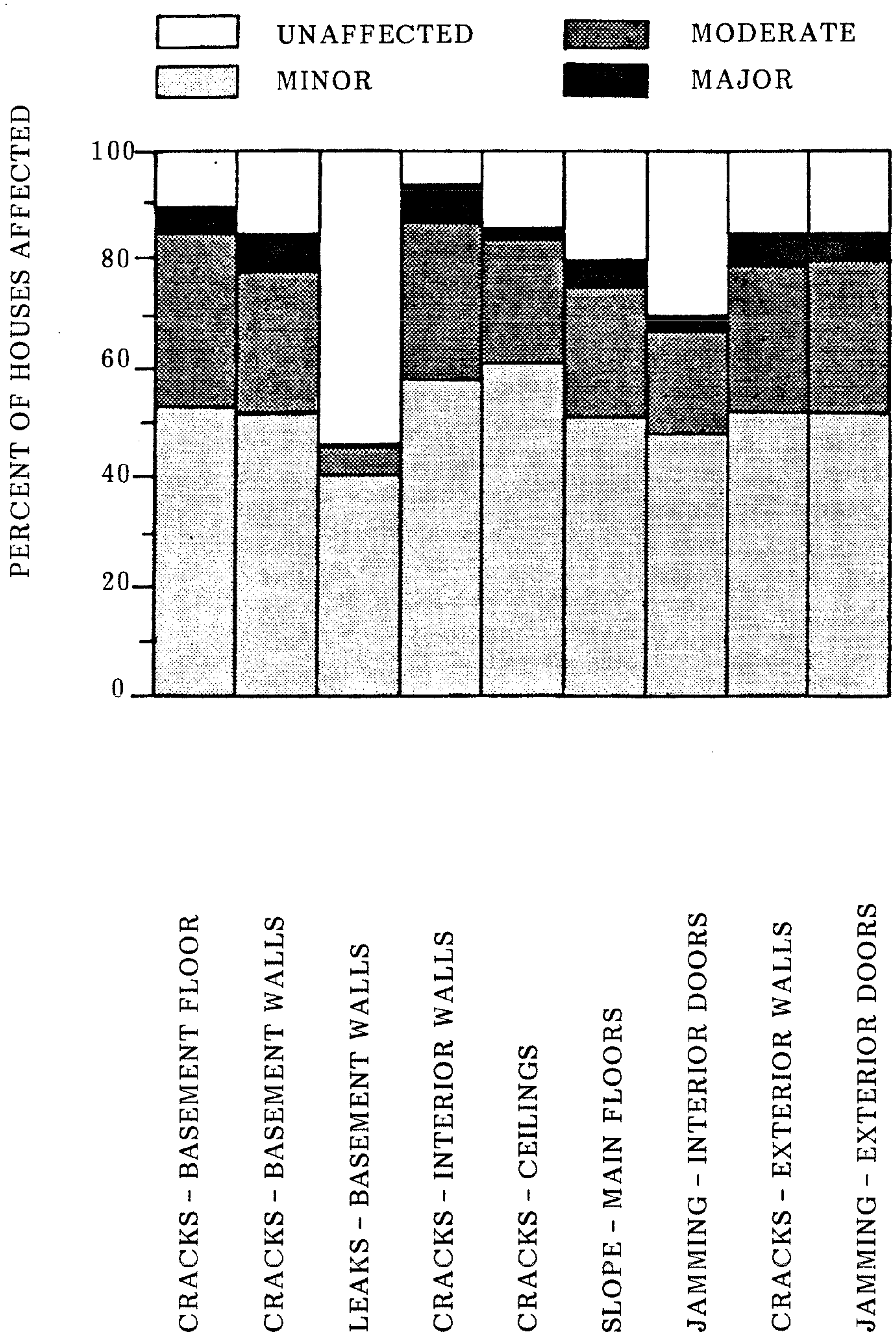


Figure 24 Occurrence and Severity of Various Forms of Distress

and closing. The percentage of houses, which had water leaks through basement walls ranged from 20% to 80%. In general, the damage due to leaks through basement walls was less prevalent and only one-half of a percent of the surveyed houses had major leakage. Considering all forms of distress, almost all houses surveyed had undergone one form of distress or another, with the severity ranging from minor to major.

In summary, the survey revealed that approximately 94% of the houses surveyed had suffered some damage due to shifting foundations and the damage was severe in approximately 7% of these houses. This pointed out the need for a cost study of the damage and a study of the economic viability of using a foundation system that would eliminate the damage.

5.2 EXAMPLES OF DIFFERENT FORMS OF DAMAGE

Examples of cracking illustrated in Figures 25, 26, 27 were categorized as major, requiring costly professional repair work. Unfortunately repairing the cracks can be of a very temporary nature, as further cracking will occur as the foundations continue to shift. Thus homeowners are faced with the prospect of undertaking costly maintenance with no guarantee that the problem will not reoccur within a short period of time.

The severity of some of the exterior wall cracks are shown in Figures 28 and 29. There again repairs are costly and may be of a very temporary nature. Even when repaired, the cracks cannot be totally camouflaged, which can only adversely affect the resale value of the house.

Photographs of interior distorted door frames are shown in Fig. 30. The distorted exterior door frames become major sources of heat loss during the winter months because of the inevitable poor fit between door and the frame. Unlike cracks that can be obliterated by careful repair work, uneven floors

Figure 25 Cracks in Basement Floors

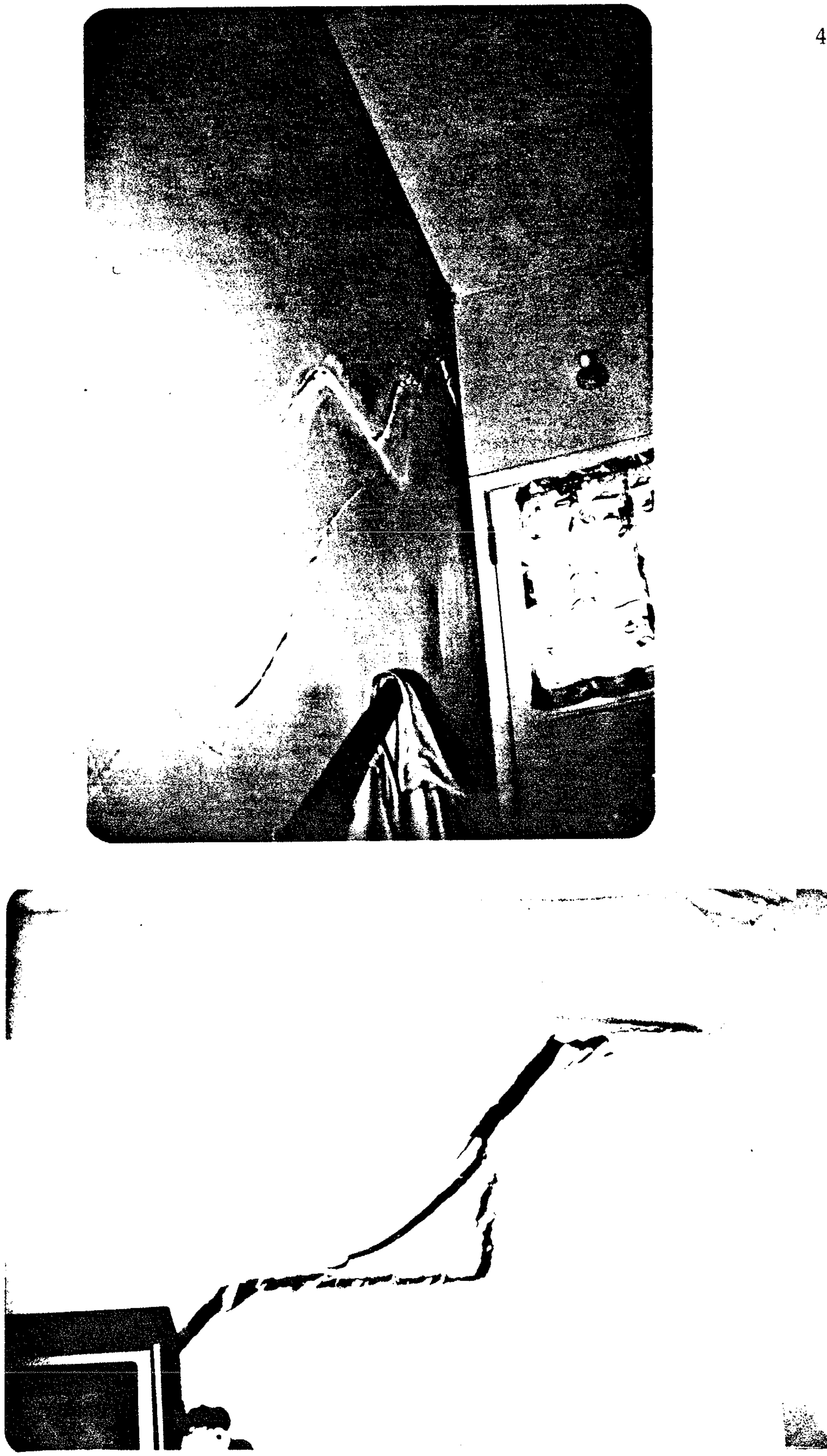


Figure 26 Cracks in Interior Walls

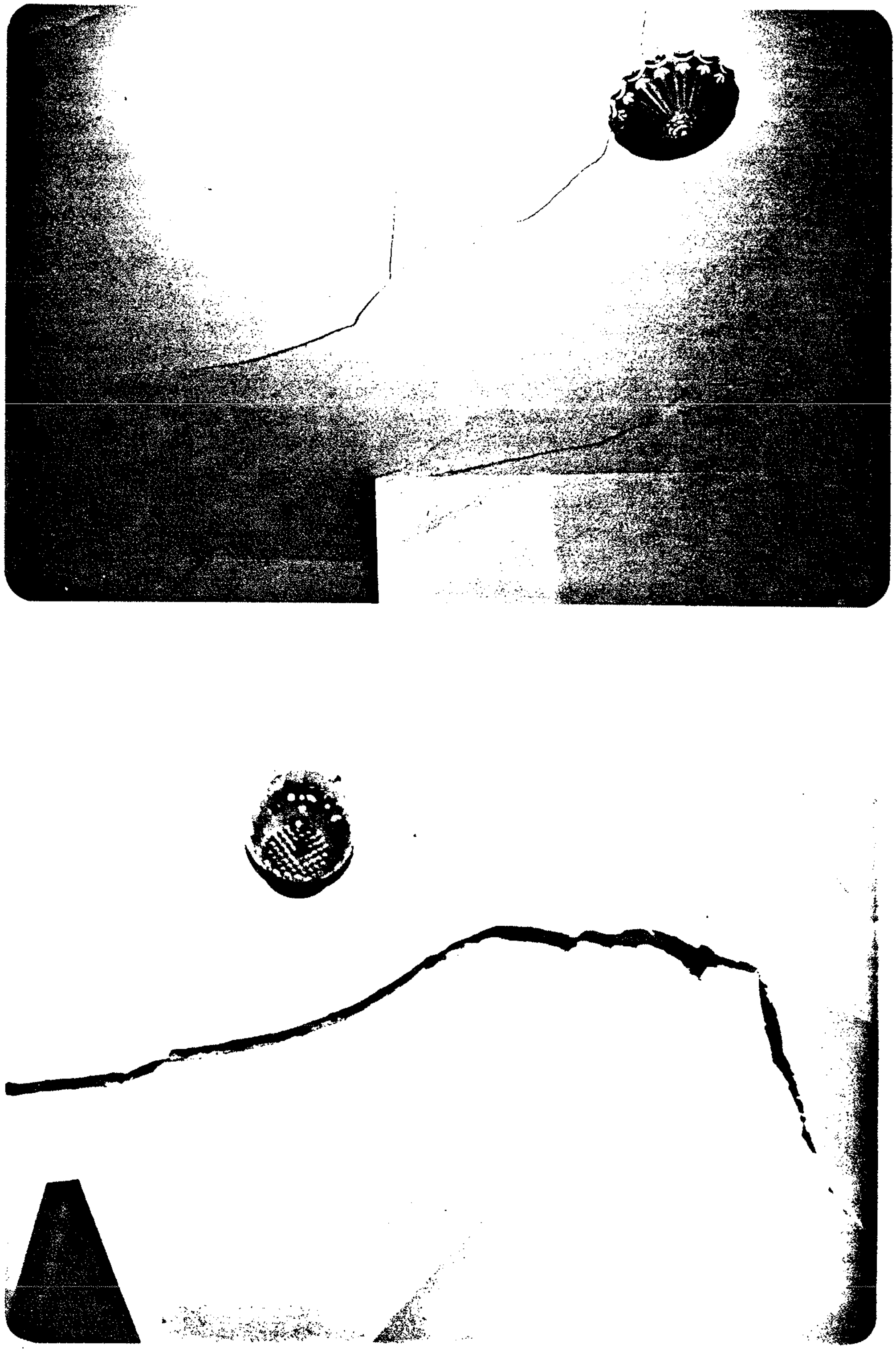


Figure 27 Cracks in Ceilings

Figure 28 Cracks in Exterior Walls

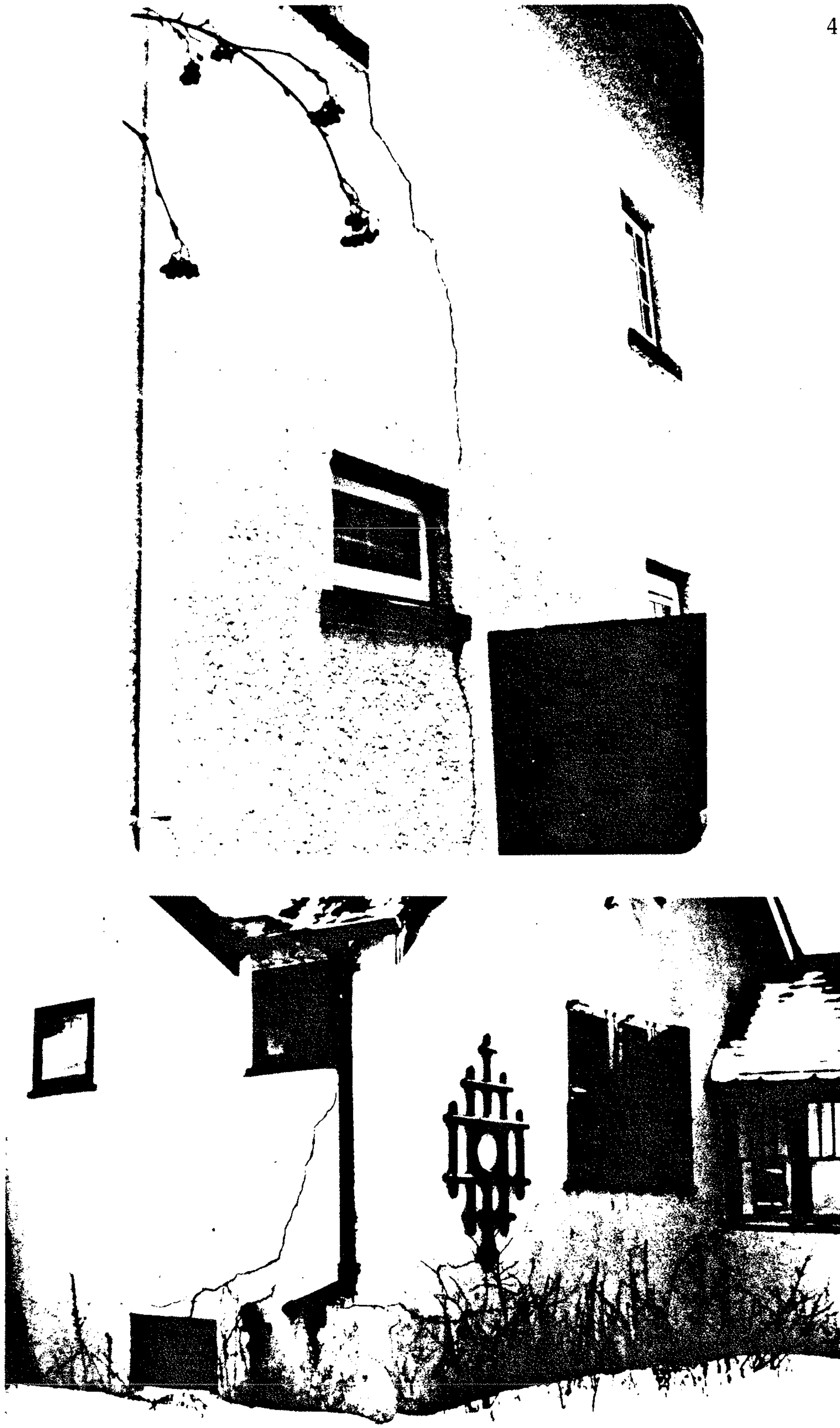


Figure 29 Cracks in Exterior walls

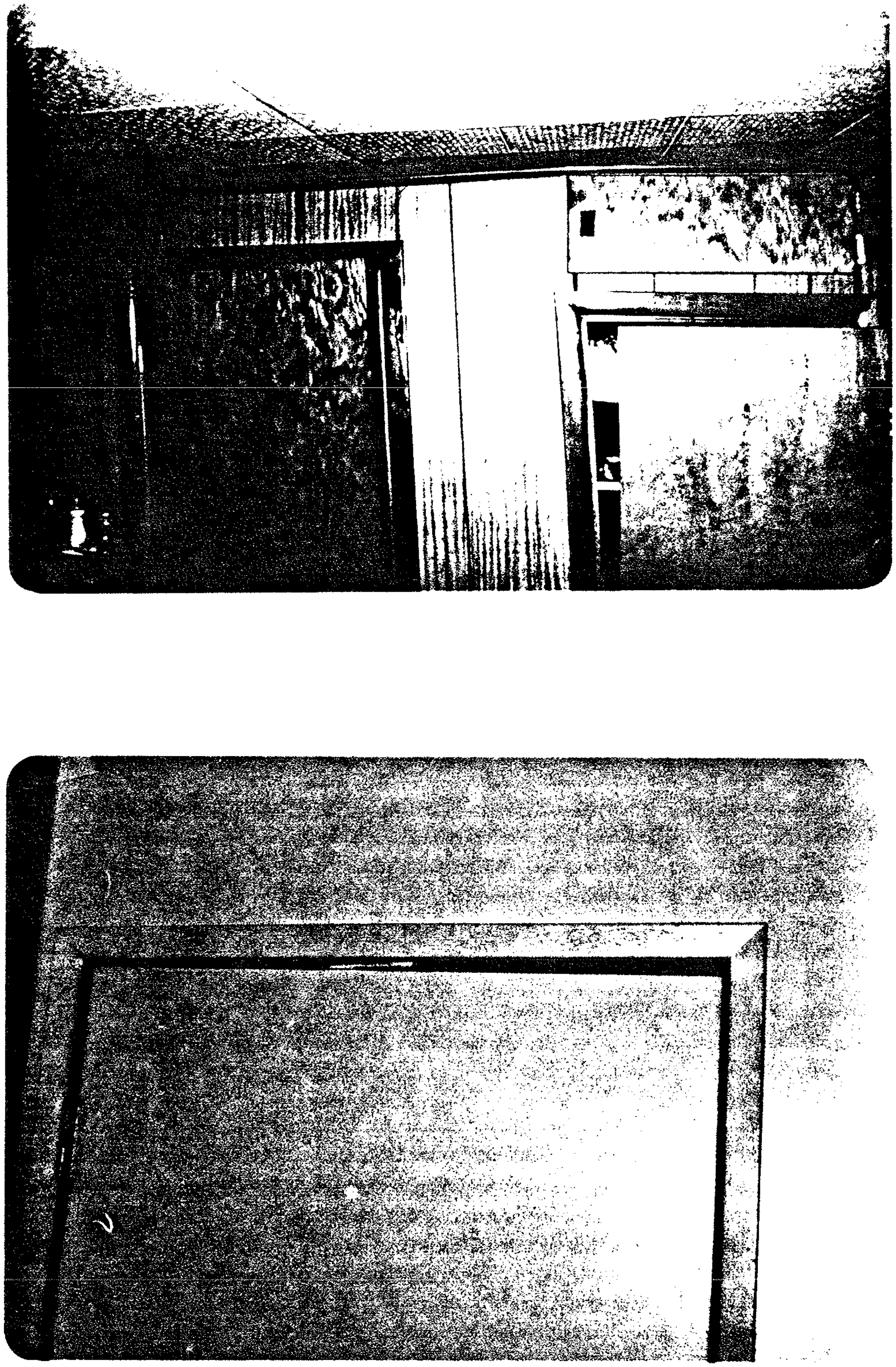


Figure 30 Distorted Interior Door Frames

and distorted door frames remain as permanent evidence of foundation movements.

Certain construction practices accentuate the problem of shifting foundations. In the older houses the main floor beams were supported by wooden posts which meant that the main beams could not be readily levelled if the exterior walls moved vertically relative to the centre columns (see Fig. 31). In the new houses, the wooden posts have been replaced with adjustable steel teleposts. However these were seldom adjusted because either the posts were rendered inaccessible by basement renovations or the homeowner had no idea of when and how much adjustment was required.

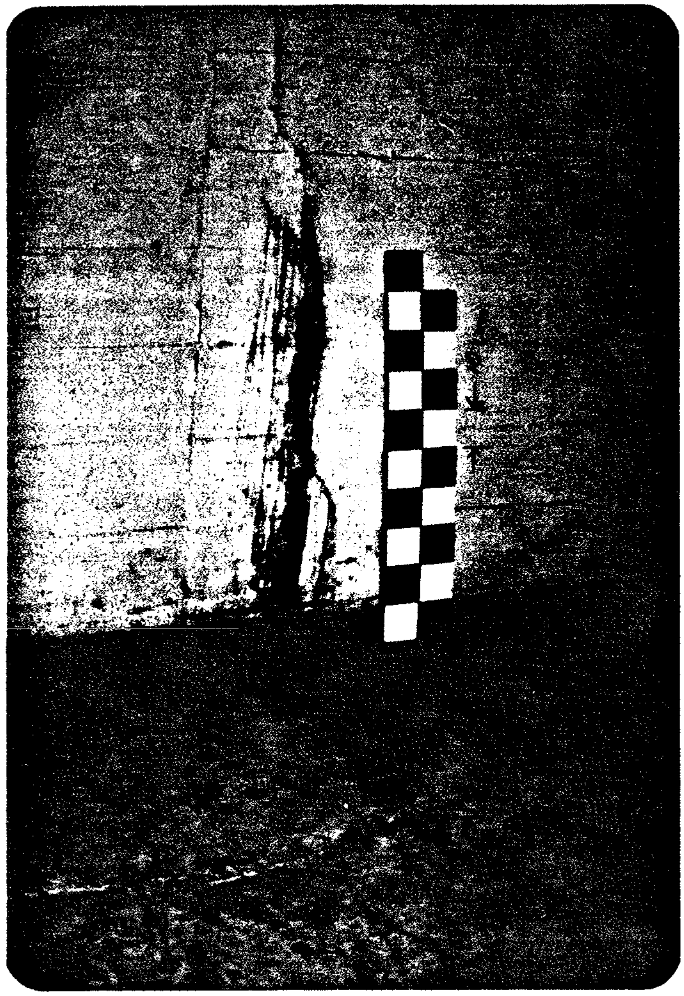
Other undesirable construction practices included adding such things as verandas, sunrooms and porches to the house without taking necessary steps to avoid differential movement between the addition and the house. Fig. 32 shows cracking that occurs where an addition has been attached to the main structure.

5.3 AGE OF HOUSE VERSUS DAMAGE

An effort was made to find a correlation between the extent and severity of structural distress with the age of the house. An average distress number, ranging from 0 to 6, was given to each house, taking into consideration the severity of each form of distress, namely; minor 0 to 2.0, moderate 2.1 to 4.0, major 4.1 to 6. That number was then plotted against "age of the house" as shown in Fig. 34. Minor distresses were associated primarily with houses less than 24 years in age. Houses from 24 to 49 years of age showed moderate distress. The major distress occured most frequently in houses that were 50 years old and older. These ratings were listed for each category in Table 5.

Figure 31 Separation Between Main Beam and Wocden Post

Figure 32 Differential Settlement of Additions



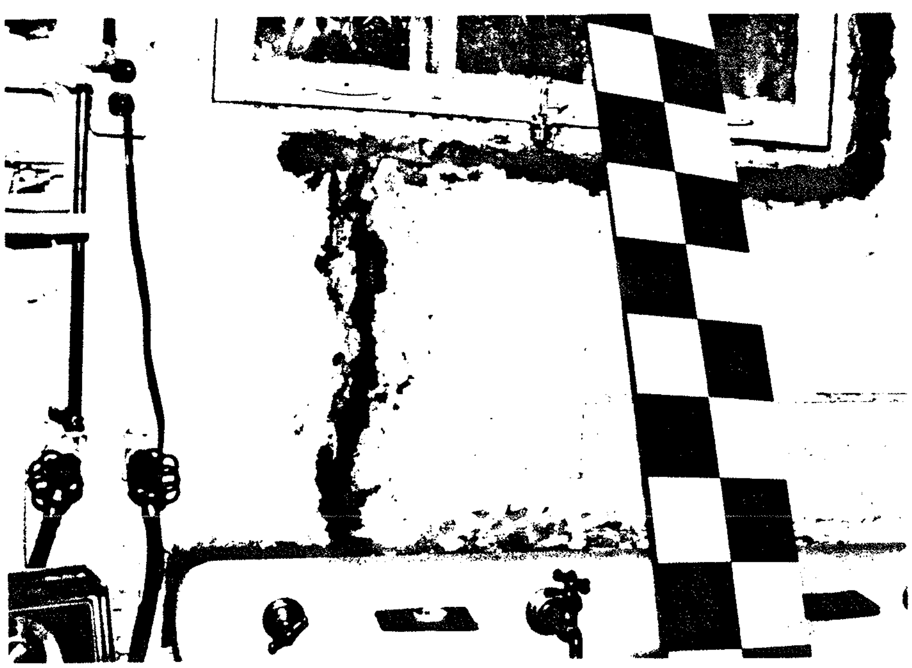


Figure 33 Cracks in Basement Walls

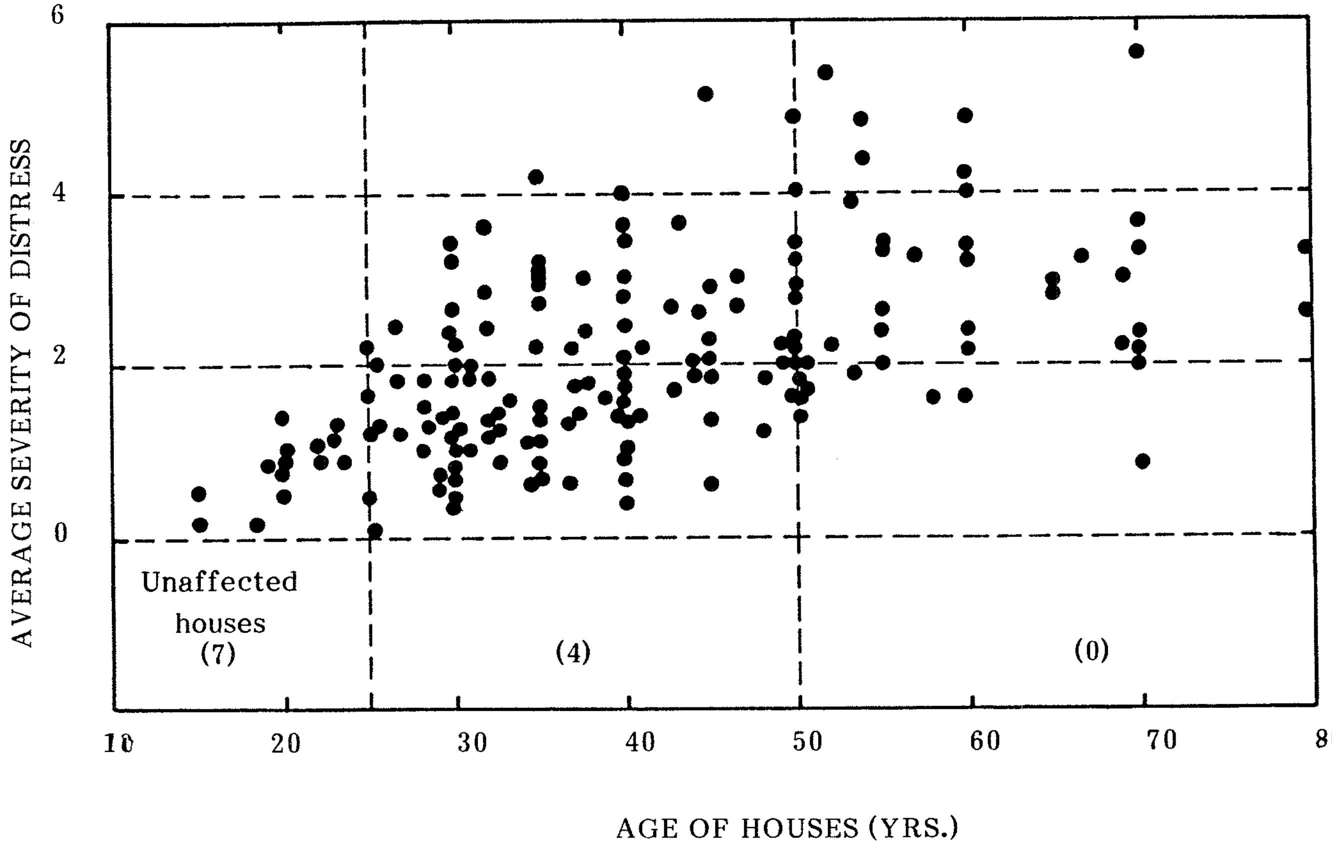


Figure 34 Severity of Damage Versus Age of House

TABLE 5

AGE GROUP AND SEVERITY OF DISTRESS

Age (years)	Overall Distress Rating			
	Unaffected	Minor	Moderate	Major
15-24	32%	64%	4%	0%
25-49	3%	60%	34%	3%
50-80	0%	26%	59%	15%

The overall configuration of all points in Fig. 34 suggests that a correlation between age of house and distress can be found but it is recognized that climatic factors play a far more important role in the performance of shallow foundations than age alone. Age simply reflects the frequency of climatic alterations that influence foundation performance. There have been cases where houses of 15 to 24 years of age have undergone severe damage.

CHAPTER 6

COST ANALYSIS AND ECONOMIC ANALYSIS

6.1 COST PER "INSTANCE" OF DAMAGE

The following procedure was chosen in order to translate the extent of damage into economical terms. Houses were selected in which the overall damage was categorized as minor, moderate or major. Published cost data and estimates provided by local constructors were used to assess the cost of repairing these houses. Detailed costs for houses experiencing minor, moderate and major damage are shown in Table 6. The estimated range of total costs of repairing houses was $150 to $300 for minor, $580 to $2,120 for moderate, and $2,540 to $12,480 for major damage (see Appendix (2) for examples). The corresponding average repair costs were $225, $1,350 and $7,510 for minor, moderate, and major respectively.

On the basis of the number of houses with overall distress ratings of minor, moderate and major, a total cost for all affected houses in the target area was calculated. An average repair cost per house in the target area, including non-affected houses, was then computed. The data is given in Table 6 and the average repair cost per house in the target area obtained in this manner was $975. This cost represents a "per instance" cost which does not take into account the number of times that a house may have to be repaired during its lifetime.

6.2 ANNUAL REPAIR COST

To ascertain the economic viability of using pile foundations, which would eliminate the repair costs associated with shifting foundations, an annual repair cost per house was computed. In order to get the annual cost, the

TABLE 6

REPAIR COSTS[1]

ITEM	MINOR	MODERATE	MAJOR
REPAIRING INTERIOR WALL CRACKS	$75-150	$150 - 250	$250 - 1,000
REPAINTING INTERIOR WALLS		200 - 530	530 - 1,300
REPAIRING CEILING CRACKS	75-150	150 - 200	250 - 500
REPAINTING CEILINGS		80 - 190	190 - 530
REPAIRING EXTERIOR WALL CRACKS		0 - 200	200 - 500
REPAINTING EXTERIOR WALLS			420 - 1,150
TRIMMING INTERIOR DOORS		0 - 100	25 - 100
REPLACING OR REPAIRING INTERIOR DOOR FRAMES			200 - 500
TRIMMING EXTERIOR DOORS		0 - 50	25 - 50
REPLACING OR REPAIRING DOOR FRAMES			0 - 100
LEVELLING MAIN FLOOR			
- adjusting or replacing centre columns		0 - 250	100 - 250
- relevelling walls			0 - 3,500
SEALING BASEMENT WALL CRACKS		0 - 150	150 - 2,000
REPAIRING OR REPLACING PORTION OF BASEMENT FLOOR		0 - 200	200 - 1,000
TOTALS:	$150-300	$580-2,120	$2,540-12,480
AVERAGES:	$225	$1,350	$7,510

1 All costs are in 1983 Canadian Dollars

frequency of minor, moderate and major damage occurrences was estimated. It was assumed that minor damage could occur very frequently, but that repairs would only be carried out when a homeowner decided to redecorate. The presence of minor cracks in walls and ceilings of many houses testifies to the fact that people will tolerate minor forms of distress and will only correct them when redecorating. It was assumed that a house is completely redecorated every ten (10) years.

The frequency of moderate and major repairs was computed on the basis of climatic considerations. It is well known that foundation movements are related to soil-moisture changes. Among the factors which have an influence on changes in soil moisture, the climatic factor plays the most significant role. Therefore the cumulative departure from the long term Average Annual Precipitation was used for identifying periods during which extensive soil-moisture changes could be expected. The cumulative departure from the long term Average Annual Precipitation in Winnipeg for the period 1875 to 1983 is shown in Figure 34. For example, during the period 1979 - 1983 there was a steady cumulative decline of approximately 400 mm of precipitation from the long term average. During this same period there was a dramatic increase in the number of houses undergoing major damage. It was, therefore, assumed that major repairs would be associated with any period in which there was a cumulative change in precipitation of at least 400 mm. Five such periods (1885-1899, 1922-1925, 1935-1940, 1952-1957, 1978-1983) occurred during the past 99 years. In order to identify periods of "moderate" damage, a criterion of 250 to 400 mm of continual accumulative change in precipitation was used. This was based on verbal information, on the severity of damage to houses that occurred in the 1960's, a period in which the continual cumulative change in precipitation was of that order. There were six such periods; 1928-1933, 1940-1945, 1950-1952,

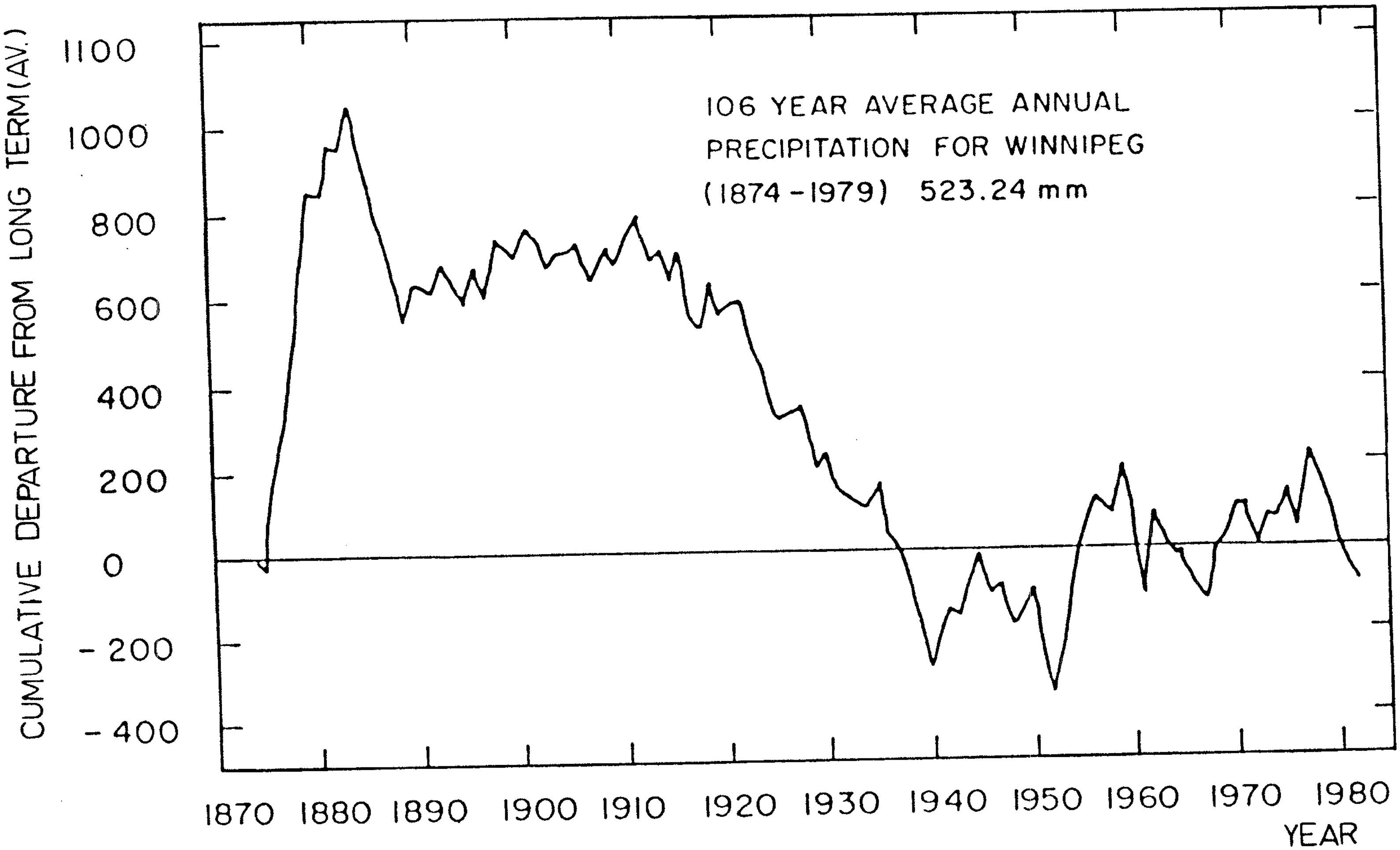


Figure 35 Cumulative Departure From Long Term Average Annual Precipitation for Winnipeg
(Hamilton, 1980)

1960-1962, 1963-1966, 1967-1970 during the past 99 years.

Knowing the average repair cost, the number of houses affected and the number of instances per 99 years, the cost in a 99-year period was computed. From this total cost, an average repair cost per house was calculated to be \$60 per year. The costs and calculations are shown in Table 7. The total annual expansive soil damage for single family dwellings in Winnipeg was estimated to be approximately 9 to 10 million dollars (i.e. 1983). This estimate is based on the assumption that the average annual cost of repairs associated with shifting foundations is \$60 per family dwelling, that River Heights is a representative sample of the entire city and the number of single family dwellings in Winnipeg is 160,000.

6.3 PILE FOUNDATION COSTS

The commercial buildings in Winnipeg are commonly supported on pile foundations. Deep foundations undergo little or no movement because they gain their support in more stable ground conditions below the active zone. In the long run, piles (end bearing or friction piles), grade beam and structural slab construction has proved to be highly successful for structures on Winnipeg clay.

In order to obtain the cost of a pile foundation system for a house, a floor plan of a common-size bungalow (110 m^2 in area) was submitted to four contractors for estimates. All contractors chose 406 mm diameter friction piles, ranging in depth from 6 to 10 m for supporting the house. It was estimated by the contractors, that eighteen such piles would be required and the cost of the piles and grade beams ranged from \$3,600 to \$4,050, with an average

TABLE 7

COST ANALYSIS OF HOUSE DAMAGE

Damage Category	Average Repair Cost[1]	Houses Affected	Cost per Instance	Instances per 99 years	Cost per 99 year
Minor	$225	96	$ 21,600	10	$216,000
Moderate	1,350	64	86,400	6	518,400
Major	7,510	9	67,590	5	337,950
Unaffected	-	11	-	-	-
	TOTALS	180	$175,590		$1,072,350

Average cost per house: Per instance = 175,590/180 = $975.50

$$\text{Per year} = \frac{1,072,350}{180 \times 99} = \$60.00$$

1 All costs in 1983 Canadian Dollars

of about \$3,700.[1] Estimated costs of constructing different types of basement floors for the same house were obtained from contractors and the "Yardsticks for Costing" manual. The detailed costs are given in the Appendix and the total costs are listed below.

Concrete grade-supported floor \$1,500

Wooden structural floor with crawl space \$6,100

Concrete structural floor with void space \$5,350

Thus the additional cost of providing a structural basement floor, which would not be affected by soil-moisture changes, was approximately \$4,600 for a wooden floor and \$3,850 for a concrete floor.

6.4 ECONOMIC ANALYSIS

The cost of construction and maintenance, including repairs are spread over the life of a house. The average cost of house repairs associated with shifting foundations was calculated to be \$60 per year.

The average additional cost of using a pile foundation system was estimated to be \$3,700 and the additional cost of using piles and a structural basement floor with void space was estimated to be approximately \$7,550.

In order to compare the present worth of \$3,700 or \$7,550 with an annual maintenance cost of \$60, each present worth must be converted into an equivalent uniform annual series. This can be done by multiplying present worth by the capital recovery factor (Grant E., Ineson G., Leavenworth R.,

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1 Typical purchase cost of such a house in 1983 was \$75,000.

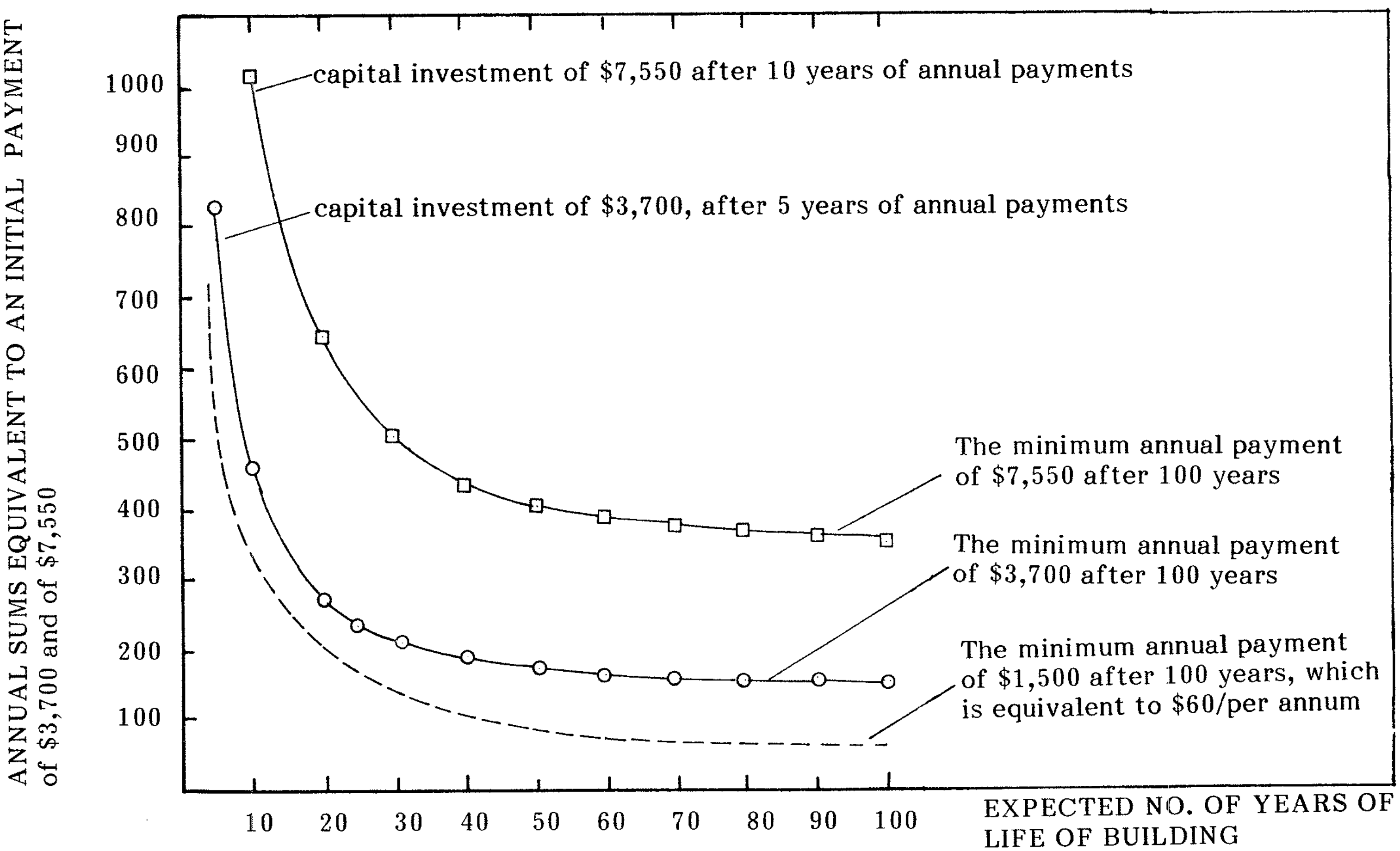

Figure 36 Annual Payments, Equivalent to an Initial Payment of $3,700 and of $7,550 when Net Interest Rate is at 4%

Principles of Engineering Economy, 1976). Both investments in the form of annual payments are illustrated in Fig. 36. A zero-inflation interest rate of 4% per annum was assumed in computing the justifiability of capital investment. The figure shows clearly, that from a purely economic point of view, neither a capital investment of \$7,550 nor \$3,700 is justifiable to eliminate an annual maintenance cost of \$60. The justifiable amount of money equivalent to \$60 per annum maintenance cost is approximately \$1,500, as shown in Fig. 36. Thus from a collective or community point of view, replacing shallow foundations with pile foundations is not economically justifiable.

From the homeowners point of view, the question of economic justifiability has to be examined in the context of risk during the homeowners period of occupancy. The likelihood of damage occurring and range of repair costs that a homeowner might encounter in an occupancy period of 50 years, and the maximum justifiable capital expenditure which would eliminate the repair costs, are given in Table 8. According to the analysis, a capital expenditure equal to the cost of pile foundations, and a structural floor slab, is only economically justifiable to prevent major damage from occurring. As indicated by the Survey (Table 5) major damage took place in 3.0% of the houses less than 50 years old and in 15.% of the houses 50 years old and older. The above statistics are risk indicators to homeowners planning to build a house as well as to buyers of older homes.

Much of the damage that occurs in houses can be eliminated by replacing the basement floor slab with a structural floor having a void space below. Such construction has been used successfully in several Winnipeg homes, however, the high cost limits wide use, and therefore, other alternatives can be considered. One alternative is to isolate the floor from the perimeter walls

TABLE 8

RANGE OF REPAIR COSTS ASSOCIATED WITH SHIFTING FOUNDATIONS

Damage Category	Range of Costs "per Instance"	Instances per 99 yrs	Range of Annual Costs	Range of Costs per 50 yr	Max. Capital Invest.@ 4%	% Houses Affected < 50 yrs	> 50 yrs
Minor	$ 150-300	10	$ 15- 30	$ 750- 1,500	$ 750	61.0	25.6
Moderate	580- 2,120	6	35-128	1,750- 6,400	3,200	29.1	59.0
Major	2,540-12,480	5	128-630	6,400-31,500	15,750	2.1	15.4
Unaffected						7.8	0

and from the interior columns, and to construct basement partitions capable of accommodating basement floor movements without transmitting the movements to the superstructure. This system can be used with either the conventional shallow spread footing or deep pile foundations.

"Commonly", the concrete basement floor is placed against the interior columns. When the concrete hardens, it grips the interior columns (teleposts) and subsequent basement floor movements are transferred to the superstructure. This practise should not be permitted in view of the vulnerability of floor slabs to movements associated with soil-mositure changes. A requirement that house plans be approved by a Professional Engineer, with the stipulation that approval pertains to both structural adequacy and performance, would eliminate poor design and construction practices.

6.5 THE ECONOMIC LOSS OF HOUSE VALUE

Economic loss, associated with the occurrence of cracks, uneven floors and distorted doors, is the cost of repairing the damage and loss in the resale value of the house. The preceding economic analysis was based on repair costs only and did not include other factors such as loss in resale value of a house. Some houses have been so severely cracked and distorted that the homeowner would have difficulty in selling the house at any price. Even after repairs, the house may shows signs of distress, such as uneven floors and patched walls and ceilings which lower the resale value. There is also another factor not taken into account: the psychological distress associated with living in a cracked house which is hard to express in terms of dollars. While conducting the survey the author was informed that in extreme cases, some people could not sleep because of the noise produced by cracking houses. Even after repairs, there is no guarantee that damage would not occur again.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 OBSERVATIONS AND CONCLUSIONS

1) The survey revealed that over 85% of the houses surveyed had experienced cracking of interior and exterior walls, ceilings, basement floors and foundation walls.

2) More than 70% of the houses had distorted interior door frames and 85% had distorted exterior door frames. In about 5% of the houses the doors required trimming to permit opening and closing.

3) In about 10% of the houses there was a noticeable slope in the main floor and in about 5%, the differential movement was sufficient to create a gap at the transverse joint of the floor boards.

4) Basement wall and basement floor cracks were frequently observed near furnaces, particularly when the furnace was located within a meter of the wall.

5) Additions to houses, such as verandas, sunrooms and porches very often had settled more than the house.

6) Only 6% of the houses surveyed were free of any noticeable damage. The damage was categorized as minor, moderate and major and the survey indicated that the occurrence was 46.7%, 40.6% and 6.7% respectively.

7) A comparison of severity of distress with age of the house indicated that most of the houses less than 24 years old suffered only minor damage and major damage occurred primarily in houses older than 49 years of age.

8) Based on precipitation patterns, it was assessed that during the past 99 years, there were 6 periods conducive to the occurrence of moderate

damage and 5 periods conducive to the occurrence of major damage.

9) The "per instance" cost of repairs was estimated to be $150 for minor damage and up to $12,480 for major damage.

10) The average annual cost of repairs associated with shifting foundations was estimated to be $60 for every single family dwelling.

11) The total annual expansive soil damage for single family dwellings in Winnipeg is estimated to be approximately 9 to 10 million dollars (i.e. 1983).

12) The average additional cost of using a pile foundation system was estimated to be $3,700 and the additional cost of using piles and a structural floor with void space was estimated to be approximately $7,750.

13) From a purely economic point of view, the additional cost of a pile foundation system, to eliminate repair costs associated with the use of spread footings, was not justifiable.

14) Use of pile foundations and a structural basement slab to eliminate repair costs is only economically justifiable to prevent major damage from occurring. In this respect, the survey indicated that there was major damage in 3% of houses less than 50 years old and in 15% in the houses older than 50 years. Thus from a homeowners' point of view the question of using shallow spread footings versus pile foundations is primarily one of risk.

15) The use of piles and a grade-supported basement floor constitutes a less costly but an effective method of eliminating repair costs providing measures are instituted for preventing basement floor movements from being transferred to the superstructure.

16) The problem of poor performance of houses could be partially eliminated

by the requirement that a foundation should be designed and inspected by a registered professional engineer specializing in foundation engineering.

7.2 RECOMMENDATIONS FOR FUTURE INVESTIGATIONS

The present investigation has shown substantive monetary loss associated with the use of shallow foundations for supporting single family dwellings. To avoid problems, a different type of foundation, such as a pile foundation with a structural floor slab may be used, but according to the study, this was not an economically viable alternative.

This is based on a pile arrangement that is designed primarily to provide adequate support for basement walls rather than to carry the weight of the superstructure. This is because the walls are not designed to act as beams. It is recommended that a study be undertaken to investigate other pile and grade beam arrangements which would require fewer piles and would therefore reduce costs.

Distortion and cracking of walls and ceilings are caused by the house being subjected to a twisting action. If the main floor could be kept in a common plane, the only consequence of shifting foundations would be sloping floors. Keeping the main floor in a common plane could be accomplished by ensuring that the basement walls formed a rigid structure incapable of undergoing distortion. This would also require the elimination of central columns. The engineering and economic feasibility of using such a foundation should be investigated.

Further economical study should be carried out to investigate the monetary loss related to damage of commercial and multi-storey buildings (with shallow foundations only), walks, streets, etc.

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APPENDIX 1

THE UNIVERSITY OF MANITOBA

FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
FACULTÉ EN GÉNIE
DÉPARTEMENT DE GÉNIE CIVIL

342 Engineering Building
Winnipeg, Manitoba
Canada R3T 2N2

(204) 474-9221
Telex 075-87721

Dear Resident:

The Civil Engineering Department of the University of Manitoba will be conducting a survey to determine the extent of cracking of walls and basement floors associated with shifting foundations. The survey consists of a brief visual inspection and a few moments of your time to complete a short questionnaire about the condition of your home.

Due to time limitation, a fairly small, random sample of 180 houses was selected. Thus, your response is vital to the projects success. Permission to include your home in the survey would be greatly appreciated.

Contact will be made shortly to seek your permission and to arrange a convenient date and time for meeting.

Thank you for your time.

Sincerely

Len Domaschuk

Professor L. Domaschuk
Associate Head

LD/ikt

UNIVERSITY OF MANITOBA
DEPARTMENT OF CIVIL ENGINEERING
SOIL MECHANICS LABORATORY

FOUNDATION PERFORMANCE SURVEY

address: ______________________________

home style: ______________________________

section: ______________ age: ______________

letter delivery: ______________________________

callback: ______________________________

appointment: ______________________________

Homeowner's Questionnaire

1 How old is the house? ______

2 How long have you lived here? ______

3 Have you ever noticed any problems associated with foundation movement? If so, when?

______

______

4 Has there ever been any repair work to the walls or foundation? ______

______

______

5 When was it done, and why? ______

______

______

6 Have the posts ever been adjusted? ______

7 Was the work effective in eliminating the problem? ______

8 Additional comments: ______

______

______

______

______

House Evaluation

	none	minor	moderate	major
interior wall cracks				
ceiling cracks				
main floor slope				
interior doors jam				
basement slab cracks				
basement slab heave				
basement water leaks				
foundation cracks				
exterior wall cracks				
exterior doors jam				

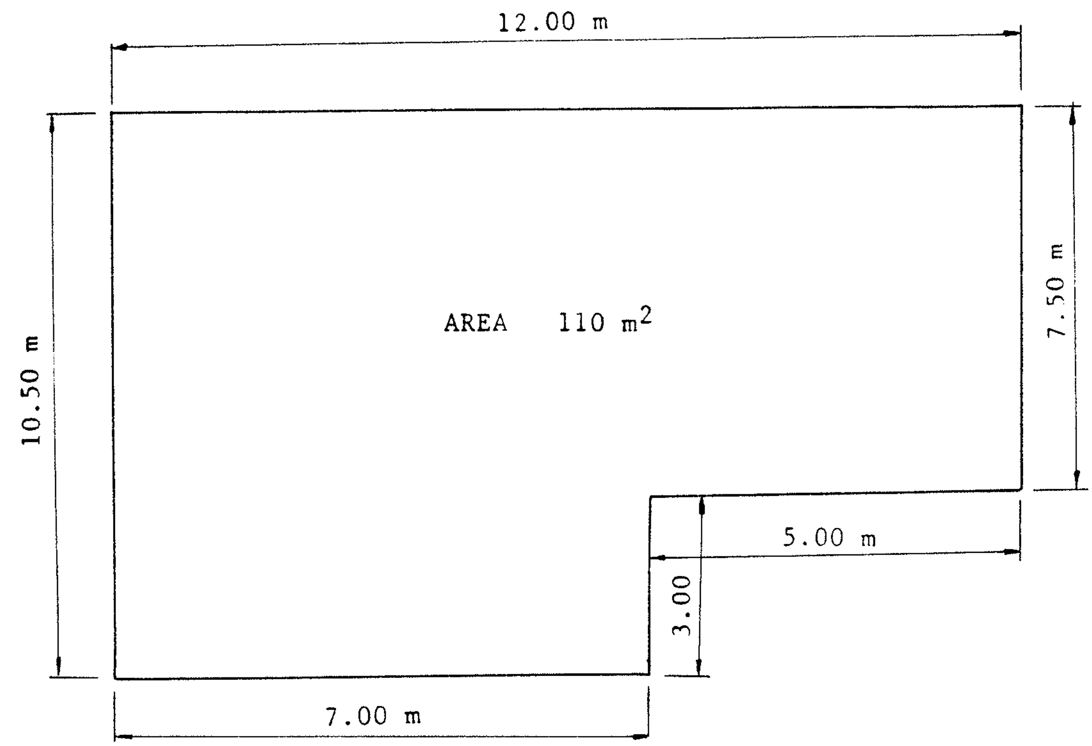
comments: ______________________________

APPENDIX 2

APPENDIX

COST OF ALTERNATIVE BASEMENT FLOORS

Plan



Reference: 1982 Yardsticks for Costing - Construction Cost Data for the Canadian Building Industry, 1982 Costing Update - 3, April, 1983.

1.0 CONCRETE SLAB-ON-GRADE

1.1 Concrete slab, 100 mm thick, 20 mPa

1.2 Gravel base, 150 mm thick
Unit cost* = $13.65/m^2 (excluding reinforcement)
Total cost = 110 m^2 x 13.65 = $1,500.

---

* Costs include federal and provincial taxes, delivery and placement of materials.

2.0 WOODEN STRUCTURAL FLOOR WITH 1 M CRAWL SPACE BELOW DECK

2.1 Beams
- made up of four 38 mm x 235 m planks nailed together
Beam lengths: 12 m and 7 m
Volume = 4 x .038 x .235 x 19 = 0.68 m^3
Supply cost = $230/$m^3$
Installation cost = $250/$m^3$
Cost of beams = 0.68 x $480 = $330.00

2.2 Wood joisted floor

i) Joists: 39 mm x 184 mm at 400 mm spacing
ii) Bridging: 39 mm x 39 mm
iii) Plywood subfloor: 12 mm thick

Unit cost = $19/$m^2$

Cost of wood-joisted floor = 110 m^2 x $19 = $2,090

2.3 Additional basement wall height required to provide 1 m crawl space below floor deck.

i) Concrete wall 300 mm thick, 45 m long

Unit cost = $75/m

Cost of additional wall height = 45 m $75 = $3,375.

2.4 Damp-proofing of floor (2 coats)

110 m^2 x $2.70/$m^2$ = $300

Total cost of wooden structural basement floor
$330 + $2,090 + $3,375 + $300 = $6,095 $6,100.

3.0 CONCRETE STRUCTURAL BASEMENT FLOOR WITH VOID SPACE

3.1 Formwork

Unit cost = $32.50/$m^2$
Cost = 110 m^2 x $32.50/$m^2$ = $3,575

3.2 Concrete

Placing = $7.00/$m^3$
Supply = $63.00/$m^3$
Volume: Slab = 110 m^2 x 0.10 m
Beams = 0.3 m x 0.3 m x 19 m
Volume = 12.71 m^3

Cost = 12.71 m^3 x \$70/m^3 = \$890.

3.3 Steel reinforcement

Volume = 1% of concrete volume
= .01 x 12.71 = 0.127 m^3
Weight = 0.127 m^3 x 7840 kg/m^3 = 996.5 kg
Unit cost = \$0.68/kg
Cost = \$0.68/kg x 996.5 kg = \$678.
Cost of installing steel = \$200 (assumed)
Cost of steel reinforcement = 678 + 200 = \$878.

Total cost of concrete structural slab

= \$3,575 + \$890 + \$878 = \$5,343 \$5,350.

LOCATION - (1) Oxford **HOME STYLE** - 2 storey **AGE** - 54 years

DESCRIPTION OF DEFECTS AND WORK REQUIRED	HOUSE EVALUATION	COST OF REPAIR
INTERIOR WALL CRACKS	MAJOR	$800
CEILING CRACKS	MODERATE	250
MAIN FLOOR SLOPE	MINOR	-
BASEMENT SLAB CRACKS	MAJOR	200
BASEMENT WATER LEAKS AND FOUNDATION CRACKS (Sealing from Outside)	MAJOR	2,000
EXTERIOR WALL CRACKS	MODERATE	200
INTERIOR DOORS JAM (2 doors)	MODERATE	50
EXTERIOR DOORS JAM (1 door)	MODERATE	25
Average Distress Rating	4.5 = MAJOR TOTAL	$3,525

LOCATION - (2) Queenston **HOME STYLE** - 2 storey **AGE** - 70 years

DESCRIPTION OF DEFECTS AND WORK REQUIRED	HOUSE EVALUATION	COST OF REPAIR
INTERIOR WALL CRACKS	MAJOR	$2,300
CEILING CRACKS	MAJOR	1,050
MAIN FLOOR SLOPE (Relevel Walls)	MAJOR	3,500
BASEMENT SLAB CRACKS (Replace Portion)	MAJOR	1,000
BASEMENT WATER LEAKS AND FOUNDATION CRACKS (Repair from Outside)	MINOR MAJOR	2,000
EXTERIOR WALL CRACKS	MAJOR	1,650
INTERIOR DOORS JAM (4 doors)	MAJOR	500
EXTERIOR DOORS JAM (Replace 1 Door Frame)	MAJOR	100
Average Distress Rating	5.6 = MAJOR TOTAL	$12,100

* For publication purposes street addresses have been replaced by numbers to prevent positive identification of house location. This was done to protect the homeowner from possible adverse publicity.

HOUSES WITH MODERATE DAMAGE

LOCATION - (3) Campbell **HOME STYLE** - 1½ storey **AGE** - 45 years

DESCRIPTION OF DEFECTS AND WORK REQUIRED	HOUSE EVALUATION	COST OF REPAIR
INTERIOR WALL CRACKS	MINOR	$150
CEILING CRACKS	MINOR	75
MAIN FLOOR SLOPE	NONE	-
BASEMENT SLAB CRACKS (Repair Portion)	MODERATE	200
BASEMENT WATER LEAKS AND FOUNDATION CRACKS	MODERATE	150
EXTERIOR WALL CRACKS	MODERATE	150
INTERIOR DOORS JAM	MINOR	-
EXTERIOR DOORS JAM	MINOR	-
Average Distress Rating	2.2 = MODERATE	TOTAL $775

LOCATION - (4) **Waterloo** **HOME STYLE** - 2 storey **AGE** - 40 years

DESCRIPTION OF DEFECTS AND WORK REQUIRED	HOUSE EVALUATION	COST OF REPAIR
INTERIOR WALL CRACKS	MINOR	$150
CEILING CRACKS	MINOR	75
MAIN FLOOR SLOPE (Adjust Centre Columns)	MODERATE	250
BASEMENT SLAB CRACKS (Replace Portion)	MAJOR	1,000
BASEMENT WATER LEAKS AND FOUNDATION CRACKS (Seal from Inside)	MODERATE	150
EXTERIOR WALL CRACKS	MODERATE	200
INTERIOR DOORS JAM (4 doors)	MODERATE	100
EXTERIOR DOORS JAM	MINOR	-
Average Distress Rating	3.6 = MODERATE	TOTAL $1,925

HOUSES WITH MINOR DAMAGE

LOCATION - (5) Borebank **HOME STYLE** - 1 storey **AGE** - 30 years

DESCRIPTION OF DEFECTS AND WORK REQUIRED	HOUSE EVALUATION		COST OF REPAIR
INTERIOR WALL CRACKS	MINOR		$75
CEILING CRACKS	MINOR		$75
MAIN FLOOR SLOPE	NONE		-
BASEMENT SLAB CRACKS	NONE		-
BASEMENT WATER LEAKS AND FOUNDATION CRACKS	NONE		-
EXTERIOR WALL CRACKS	MINOR		-
INTERIOR DOORS JAM	NONE		-
EXTERIOR DOORS JAM	NONE		-
Average Distress Rating	0.7 = MINOR	TOTAL	$150

LOCATION - (6) Ash **HOME STYLE** - Bungalow **AGE** - 38 years

DESCRIPTION OF DEFECTS AND WORK REQUIRED	HOUSE EVALUATION		COST OF REPAIR
INTERIOR WALL CRACKS	MINOR		$150
CEILING CRACKS	MINOR		$100
MAIN FLOOR SLOPE	MINOR		-
BASEMENT SLAB CRACKS	MINOR		-
BASEMENT WATER LEAKS AND FOUNDATION CRACKS	MINOR		-
EXTERIOR WALL CRACKS	MINOR		-
INTERIOR DOORS JAM	MINOR		-
EXTERIOR DOORS JAM	NONE		-
Average Distress Rating	1.8 = MINOR	TOTAL	$250

HOUSE EVALUATION - CAMBRIDGE ST.

DISTRESS / HOUSE NR & AGE	1 / 70				2 / 55				3 / 35				4 / 40				5 / 35				6 / 22							
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS				■			■				■					■		■				■						
CEILING CRACKS			■			■					■				■			■				■						
MAIN FLOOR SLOPE		■				■					■				■		■					■						
INTERIOR DOORS JAM			■		■					■					■		■					■						
BASEMENT SLAB CRACKS			■			■					■				■			■					■					
BASEMENT SLAB HEAVE			■			■					■				■		■				■							
BASEMENT WATER LEAKS		■			■						■		■				■				■							
FOUNDATION CRACKS			■				■			■				■			■					■						
EXTERIOR WALL CRACKS			■				■			■				■			■				■							
EXTERIOR DOORS JAM			■			■					■		■				■					■						

DISTRESS	7 / 36				8 / 30				9 / 31				10 / 30				11 / 35			
INTERIOR WALL CRACKS		■			■					■			■					■		
CEILING CRACKS		■			■					■			■					■		
MAIN FLOOR SLOPE		■			■					■			■					■		
INTERIOR DOORS JAM	■				■						■		■					■		
BASEMENT SLAB CRACKS		■			■					■			■					■		
BASEMENT SLAB HEAVE		■			■				■			■					■			
BASEMENT WATER LEAKS	■				■				■			■					■			
FOUNDATION CRACKS		■			■					■		■					■			
EXTERIOR WALL CRACKS		■			■					■			■				■			
EXTERIOR DOORS JAM		■			■				■				■				■			

HOUSE EVALUATION - OXFORD ST.

DISTRESS / HOUSE NR& AGE	1 /54				2 /80				3 /80				4 /55				5 /70				6 /44							
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS				▬			▬			▬					▬			▬				▬						
CEILING CRACKS			▬				▬			▬					▬			▬				▬						
MAIN FLOOR SLOPE		▬					▬			▬					▬				▬		▬							
INTERIOR DOORS JAM			▬				▬				▬				▬			▬				▬						
BASEMENT SLAB CRACKS			▬				▬				▬				▬		▬					▬						
BASEMENT SLAB HEAVE				▬			▬				▬		▬				▬						▬					
BASEMENT WATER LEAKS				▬		▬				▬			▬					▬				▬						
FOUNDATION CRACKS				▬			▬			▬				▬					▬			▬						
EXTERIOR WALL CRACKS			▬					▬		▬					▬			▬				▬						
EXTERIOR DOORS JAM			▬				▬			▬			▬					▬				▬						

	7 /40				8 /32				9 /35				10 /37				11 /30				12 /23							
INTERIOR WALL CRACKS			▬			▬				▬					▬			▬						▬				
CEILING CRACKS			▬			▬			▬				▬					▬					▬					
MAIN FLOOR SLOPE		▬			▬					▬				▬				▬				▬						
INTERIOR DOORS JAM			▬			▬				▬			▬					▬					▬					
BASEMENT SLAB CRACKS			▬			▬				▬					▬				▬				▬					
BASEMENT SLAB HEAVE			▬			▬				▬			▬				▬							▬				
BASEMENT WATER LEAKS		▬				▬			▬					▬			▬							▬				
FOUNDATION CRACKS			▬			▬				▬					▬		▬							▬				
EXTERIOR WALL CRACKS			▬			▬					▬				▬		▬						▬					
EXTERIOR DOORS JAM		▬				▬				▬					▬		▬						▬					

HOUSE EVALUATION - WAVERLY ST.

DISTRESS / HOUSE NR & AGE	1 / 65				2 / 60				3 / 40				4 / 50				5 / 50				6 / 40							
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS			▬			▬						▬		▬					▬			▬						
CEILING CRACKS			▬				▬				▬			▬					▬			▬						
MAIN FLOOR SLOPE		▬					▬					▬		▬				▬					▬					
INTERIOR DOORS JAM		▬				▬					▬							▬				▬						
BASEMENT SLAB CRACKS			▬				▬				▬			▬					▬			▬						
BASEMENT SLAB HEAVE		▬				▬						▬		▬					▬			▬						
BASEMENT WATER LEAKS	▬					▬			▬				▬					▬				▬						
FOUNDATION CRACKS			▬				▬					▬		▬				▬				▬						
EXTERIOR WALL CRACKS		▬					▬				▬			▬					▬			▬						
EXTERIOR DOORS JAM		▬				▬				▬								▬			▬							

	7 / 30				8 / 40				9 / 30				10 / 30				11 / 25				12 / 20				
INTERIOR WALL CRACKS		▬				▬					▬			▬			▬					▬			
CEILING CRACKS		▬				▬					▬			▬			▬					▬			
MAIN FLOOR SLOPE	▬					▬					▬		▬				▬					▬			
INTERIOR DOORS JAM	▬				▬					▬				▬			▬				▬				
BASEMENT SLAB CRACKS		▬				▬				▬				▬			▬					▬			
BASEMENT SLAB HEAVE	▬				▬						▬		▬				▬				▬				
BASEMENT WATER LEAKS		▬				▬			▬					▬			▬				▬				
FOUNDATION CRACKS		▬					▬			▬				▬			▬					▬			
EXTERIOR WALL CRACKS		▬				▬				▬				▬			▬					▬			
EXTERIOR DOORS JAM		▬				▬				▬				▬			▬				▬				

HOUSE EVALUATION - MONTROSE ST.

DISTRESS / HOUSE NR & AGE	1 / 60				2 / 65				3 / 70				4 / 57				5 / 40				6 / 37							
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS				▬			▬				▬			▬					▬				▬					
CEILING CRACKS			▬			▬					▬			▬					▬				▬					
MAIN FLOOR SLOPE			▬			▬				▬					▬				▬			▬						
INTERIOR DOORS JAM			▬				▬			▬				▬					▬			▬						
BASEMENT SLAB CRACKS			▬				▬			▬				▬					▬				▬					
BASEMENT SLAB HEAVE			▬			▬				▬				▬					▬			▬						
BASEMENT WATER LEAKS		▬				▬			▬					▬			▬					▬						
FOUNDATION CRACKS		▬					▬			▬					▬				▬			▬						
EXTERIOR WALL CRACKS		▬					▬			▬					▬		▬					▬						
EXTERIOR DOORS JAM	▬					▬				▬				▬			▬				▬							

DISTRESS	7 / 35				8 / 32				9 / 40				10 / 30				11 / 20			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS			▬			▬					▬			▬				▬		
CEILING CRACKS		▬				▬					▬			▬				▬		
MAIN FLOOR SLOPE		▬				▬				▬				▬			▬			
INTERIOR DOORS JAM		▬				▬			▬				▬				▬			
BASEMENT SLAB CRACKS		▬				▬					▬			▬				▬		
BASEMENT SLAB HEAVE		▬			▬				▬				▬					▬		
BASEMENT WATER LEAKS	▬					▬			▬				▬					▬		
FOUNDATION CRACKS	▬					▬					▬			▬			▬			
EXTERIOR WALL CRACKS		▬				▬				▬					▬			▬		
EXTERIOR DOORS JAM		▬				▬			▬					▬				▬		

HOUSE EVALUATION - ELM ST.

DISTRESS / HOUSE NR & AGE	1 / 50				2 / 60				3 / 70				4 / 56				5 / 55				6 / 39			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS			▬			▬					▬				▬				▬				▬	
CEILING CRACKS		▬				▬				▬				▬					▬			▬		
MAIN FLOOR SLOPE		▬				▬				▬				▬					▬				▬	
INTERIOR DOORS JAM		▬				▬				▬					▬				▬			▬		
BASEMENT SLAB CRACKS		▬						▬		▬					▬				▬			▬		
BASEMENT SLAB HEAVE		▬				▬				▬				▬				▬				▬		
BASEMENT WATER LEAKS	▬					▬				▬				▬			▬					▬		
FOUNDATION CRACKS			▬			▬				▬				▬			▬						▬	
EXTERIOR WALL CRACKS			▬				▬				▬			▬			▬						▬	
EXTERIOR DOORS JAM		▬				▬				▬				▬			▬					▬		

DISTRESS	7 / 27				8 / 22				9 / 27				10 / 24				11 / 25			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		▬				▬				▬				▬				▬		
CEILING CRACKS		▬			▬						▬			▬				▬		
MAIN FLOOR SLOPE	▬				▬					▬			▬				▬			
INTERIOR DOORS JAM	▬				▬					▬				▬				▬		
BASEMENT SLAB CRACKS	▬					▬				▬				▬				▬		
BASEMENT SLAB HEAVE	▬				▬				▬				▬				▬			
BASEMENT WATER LEAKS	▬				▬				▬				▬				▬			
FOUNDATION CRACKS		▬			▬					▬				▬			▬			
EXTERIOR WALL CRACKS		▬			▬						▬			▬				▬		
EXTERIOR DOORS JAM	▬				▬					▬			▬				▬			

HOUSE EVALUATION - OAK ST.

DISTRESS / HOUSE NR & AGE	1/40				2/44				3/55				4/52				5/50				6/50				7/50			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		■					■				■				■				■			■				■		
CEILING CRACKS		■				■				■				■					■			■				■		
MAIN FLOOR SLOPE		■				■					■			■					■			■				■		
INTERIOR DOORS JAM		■				■				■				■				■				■				■		
BASEMENT SLAB CRACKS		■				■					■			■					■			■					■	
BASEMENT SLAB HEAVE	■					■					■			■				■				■				■		
BASEMENT WATER LEAKS	■					■				■			■					■			■					■		
FOUNDATION CRACKS		■				■					■			■					■			■				■		
EXTERIOR WALL CRACKS		■				■					■			■					■			■					■	
EXTERIOR DOORS JAM	■				■					■				■				■			■					■		

DISTRESS / HOUSE NR & AGE	8/33				9/30				10/20				11/30				12/18				13/22			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		■				■				■				■				■				■		
CEILING CRACKS		■				■				■				■				■				■		
MAIN FLOOR SLOPE		■			■				■					■			■					■		
INTERIOR DOORS JAM		■				■				■				■			■					■		
BASEMENT SLAB CRACKS			■			■				■				■				■				■		
BASEMENT SLAB HEAVE	■				■				■					■			■				■			
BASEMENT WATER LEAKS	■				■				■				■				■				■			
FOUNDATION CRACKS		■				■			■					■			■					■		
EXTERIOR WALL CRACKS		■				■			■					■			■					■		
EXTERIOR DOORS JAM	■				■				■								■					■		

HOUSE EVALUATION - ASH ST.

DISTRESS / HOUSE NR & AGE	1 / 50				2 / 50				3 / 50				4 / 50				5 / 45				6 / 48				7 / 38			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		■						■		■					■		■						■			■		
CEILING CRACKS		■				■					■			■				■				■				■		
MAIN FLOOR SLOPE		■				■					■			■				■						■		■		
INTERIOR DOORS JAM		■				■				■			■					■				■				■		
BASEMENT SLAB CRACKS		■					■				■			■				■					■			■		
BASEMENT SLAB HEAVE		■				■				■				■			■					■			■			
BASEMENT WATER LEAKS	■					■			■				■					■				■				■		
FOUNDATION CRACKS		■					■			■				■				■					■			■		
EXTERIOR WALL CRACKS			■				■			■				■				■					■			■		
EXTERIOR DOORS JAM	■					■				■			■				■					■			■			

	8 / 41				9 / 43				10 / 35				11 / 30				12 / 25				13 / 15			
INTERIOR WALL CRACKS		■				■				■					■			■			■			
CEILING CRACKS			■			■				■				■					■		■			
MAIN FLOOR SLOPE		■			■					■				■				■			■			
INTERIOR DOORS JAM		■			■				■					■				■			■			
BASEMENT SLAB CRACKS			■			■				■									■		■			
BASEMENT SLAB HEAVE	■					■			■				■					■			■			
BASEMENT WATER LEAKS		■				■			■				■				■				■			
FOUNDATION CRACKS		■			■					■				■				■				■		
EXTERIOR WALL CRACKS		■				■				■			■					■				■		
EXTERIOR DOORS JAM		■			■				■				■					■			■			

HOUSE EVALUATION - WATERLOO ST.

DISTRESS / HOUSE NR & AGE	1 / 70				2 / 50				3 / 60				4 / 45				5 / 35				6 / 40				7 / 32			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS			■				■				■			■					■				■			■		
CEILING CRACKS	■					■				■				■				■				■				■		
MAIN FLOOR SLOPE			■				■					■		■					■				■				■	
INTERIOR DOORS JAM		■				■			■						■			■				■						■
BASEMENT SLAB CRACKS			■			■				■				■					■					■			■	
BASEMENT SLAB HEAVE		■				■			■				■					■					■				■	
BASEMENT WATER LEAKS	■				■					■				■				■					■			■		
FOUNDATION CRACKS			■					■		■					■				■				■				■	
EXTERIOR WALL CRACKS		■				■					■				■				■				■				■	
EXTERIOR DOORS JAM			■				■			■					■				■					■			■	

DISTRESS / HOUSE NR & AGE	8 / 28				9 / 30				10 / 28				11 / 31				12 / 30				13 / 32			
INTERIOR WALL CRACKS		■				■				■				■					■			■		
CEILING CRACKS		■			■				■				■					■				■		
MAIN FLOOR SLOPE		■				■				■			■					■				■		
INTERIOR DOORS JAM		■				■			■				■					■				■		
BASEMENT SLAB CRACKS		■				■				■				■					■		■			
BASEMENT SLAB HEAVE	■				■				■				■						■		■			
BASEMENT WATER LEAKS	■				■				■				■					■			■			
FOUNDATION CRACKS		■				■				■				■				■			■			
EXTERIOR WALL CRACKS		■				■				■			■					■				■		
EXTERIOR DOORS JAM		■				■				■			■						■			■		

HOUSE EVALUATION - NIAGARA ST.

DISTRESS / HOUSE NR & AGE	1 / 55				2 / 50				3 / 38				4 / 30				5 / 35				6 / 30			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS			▬			▬				▬				▬					▬			▬		
CEILING CRACKS			▬			▬				▬				▬					▬		▬			
MAIN FLOOR SLOPE			▬			▬				▬				▬				▬				▬		
INTERIOR DOORS JAM			▬				▬			▬			▬					▬				▬		
BASEMENT SLAB CRACKS		▬						▬		▬					▬			▬				▬		
BASEMENT SLAB HEAVE	▬				▬				▬				▬					▬			▬			
BASEMENT WATER LEAKS		▬			▬					▬			▬				▬				▬			
FOUNDATION CRACKS			▬			▬				▬				▬					▬			▬		
EXTERIOR WALL CRACKS			▬			▬					▬			▬						▬	▬			
EXTERIOR DOORS JAM			▬			▬				▬			▬						▬			▬		

DISTRESS / HOUSE NR & AGE	7 / 30				8 / 31				9 / 38				10 / 20				11 / 15			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		▬				▬				▬				▬			▬			
CEILING CRACKS	▬					▬				▬			▬				▬			
MAIN FLOOR SLOPE		▬			▬					▬				▬			▬			
INTERIOR DOORS JAM		▬				▬				▬			▬				▬			
BASEMENT SLAB CRACKS		▬				▬				▬				▬			▬			
BASEMENT SLAB HEAVE	▬					▬				▬				▬			▬			
BASEMENT WATER LEAKS	▬					▬			▬				▬				▬			
FOUNDATION CRACKS		▬					▬			▬			▬				▬			
EXTERIOR WALL CRACKS	▬					▬			▬					▬			▬			
EXTERIOR DOORS JAM		▬				▬			▬				▬				▬			

HOUSE EVALUATION - QUEENSTON ST.

DISTRESS / HOUSE NR & AGE	1/60				2/70				3/45				4/48				5/40				6/37			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS			■					■		■				■				■				■	■	
CEILING CRACKS			■					■		■				■				■						
MAIN FLOOR SLOPE			■					■		■				■				■				■		
INTERIOR DOORS JAM			■					■		■			■				■						■	
BASEMENT SLAB CRACKS			■					■		■			■					■				■		
BASEMENT SLAB HEAVE		■					■		■				■				■				■			
BASEMENT WATER LEAKS			■			■			■				■				■					■		
FOUNDATION CRACKS		■						■		■				■				■				■		
EXTERIOR WALL CRACKS		■						■		■				■				■				■		
EXTERIOR DOORS JAM			■					■	■				■				■				■			

DISTRESS / HOUSE NR & AGE	7/35				8/42				9/28				10/20				11/25			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		■				■				■			■					■		
CEILING CRACKS		■				■				■			■					■		
MAIN FLOOR SLOPE			■				■		■				■					■		
INTERIOR DOORS JAM	■					■			■				■				■			
BASEMENT SLAB CRACKS		■					■			■			■						■	
BASEMENT SLAB HEAVE	■					■			■				■					■		
BASEMENT WATER LEAKS	■					■			■				■					■		
FOUNDATION CRACKS		■					■			■			■					■		
EXTERIOR WALL CRACKS		■					■			■				■					■	
EXTERIOR DOORS JAM		■				■			■				■				■			

HOUSE EVALUATION - BROCK ST.

DISTRESS / HOUSE NR & AGE	1 / 53 none	1 / 53 minor	1 / 53 moderate	1 / 53 major	2 / 50 none	2 / 50 minor	2 / 50 moderate	2 / 50 major	3 / 45 none	3 / 45 minor	3 / 45 moderate	3 / 45 major	4 / 45 none	4 / 45 minor	4 / 45 moderate	4 / 45 major	5 / 45 none	5 / 45 minor	5 / 45 moderate	5 / 45 major	6 / 40 none	6 / 40 minor	6 / 40 moderate	6 / 40 major
INTERIOR WALL CRACKS				X			X			X					X			X				X		
CEILING CRACKS			X				X			X				X			X				X			
MAIN FLOOR SLOPE			X				X			X			X				X					X		
INTERIOR DOORS JAM		X					X				X		X				X					X		
BASEMENT SLAB CRACKS		X					X			X				X				X				X		
BASEMENT SLAB HEAVE		X				X				X			X				X				X			
BASEMENT WATER LEAKS			X		X					X			X				X				X			
FOUNDATION CRACKS				X			X				X			X			X					X		
EXTERIOR WALL CRACKS				X			X				X			X				X					X	
EXTERIOR DOORS JAM			X				X				X		X					X				X		

DISTRESS / HOUSE NR & AGE	7 / 35 none	7 / 35 minor	7 / 35 moderate	7 / 35 major	8 / 40 none	8 / 40 minor	8 / 40 moderate	8 / 40 major	9 / 30 none	9 / 30 minor	9 / 30 moderate	9 / 30 major	10 / 28 none	10 / 28 minor	10 / 28 moderate	10 / 28 major	11 / 19 none	11 / 19 minor	11 / 19 moderate	11 / 19 major	12 / 25 none	12 / 25 minor	12 / 25 moderate	12 / 25 major
INTERIOR WALL CRACKS		X				X				X				X			X				X			
CEILING CRACKS		X				X				X				X				X			X			
MAIN FLOOR SLOPE		X			X					X					X			X			X			
INTERIOR DOORS JAM		X			X				X					X			X				X			
BASEMENT SLAB CRACKS		X				X				X					X			X			X			
BASEMENT SLAB HEAVE	X				X				X					X			X				X			
BASEMENT WATER LEAKS	X				X				X					X			X				X			
FOUNDATION CRACKS		X			X					X					X			X			X			
EXTERIOR WALL CRACKS		X				X			X							X		X			X			
EXTERIOR DOORS JAM		X			X				X					X			X				X			

HOUSE EVALUATION - CORDOVA ST.

DISTRESS / HOUSE NR & AGE	1 / 50				2 / 48				3 / 70				4 / 52				5 / 54				6 / 50							
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		■					■				■					■				■		■						
CEILING CRACKS		■					■				■				■					■		■						
MAIN FLOOR SLOPE			■			■										■				■			■					
INTERIOR DOORS JAM	■					■					■					■			■		■							
BASEMENT SLAB CRACKS		■					■			■					■					■	■							
BASEMENT SLAB HEAVE		■				■				■						■			■		■							
BASEMENT WATER LEAKS		■				■			■						■			■					■					
FOUNDATION CRACKS		■					■			■					■				■			■						
EXTERIOR WALL CRACKS			■		■				■						■				■					■				
EXTERIOR DOORS JAM		■			■				■							■			■			■						

	7 / 50				8 / 45				9 / 30				10 / 22				11 / 28				12 / 28				
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	
INTERIOR WALL CRACKS			■			■				■			■					■				■			
CEILING CRACKS				■		■				■				■				■				■			
MAIN FLOOR SLOPE			■			■				■			■						■			■			
INTERIOR DOORS JAM			■			■				■			■				■					■			
BASEMENT SLAB CRACKS			■			■				■				■			■					■			
BASEMENT SLAB HEAVE			■				■		■				■					■			■				
BASEMENT WATER LEAKS	■					■			■				■				■				■				
FOUNDATION CRACKS				■		■				■			■					■			■				
EXTERIOR WALL CRACKS		■			■					■			■				■					■			
EXTERIOR DOORS JAM		■			■					■				■			■				■				

HOUSE EVALUATION - CAMPBELL ST.

DISTRESS / HOUSE NR & AGE	1/60				2/68				3/40				4/65				5/45				6/45				7/60			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		▬				▬					▬				▬					▬		▬					▬	
CEILING CRACKS		▬				▬				▬				▬				▬				▬				▬		
MAIN FLOOR SLOPE			▬				▬					▬			▬				▬			▬				▬		
INTERIOR DOORS JAM			▬					▬			▬			▬			▬					▬			▬			
BASEMENT SLAB CRACKS				▬				▬			▬				▬					▬			▬			▬		
BASEMENT SLAB HEAVE				▬		▬					▬		▬					▬					▬		▬			
BASEMENT WATER LEAKS	▬				▬				▬				▬				▬				▬					▬		
FOUNDATION CRACKS				▬			▬			▬					▬			▬					▬				▬	
EXTERIOR WALL CRACKS			▬			▬				▬					▬			▬					▬				▬	
EXTERIOR DOORS JAM		▬					▬				▬					▬	▬					▬				▬		

DISTRESS / HOUSE NR & AGE	8/40				9/40				10/34				11/32				12/30				13/35			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS		▬				▬			▬						▬		▬					▬		
CEILING CRACKS		▬				▬			▬						▬		▬						▬	
MAIN FLOOR SLOPE		▬					▬		▬					▬			▬					▬		
INTERIOR DOORS JAM		▬			▬				▬					▬			▬						▬	
BASEMENT SLAB CRACKS			▬			▬			▬					▬			▬						▬	
BASEMENT SLAB HEAVE		▬			▬				▬				▬				▬						▬	
BASEMENT WATER LEAKS		▬				▬			▬				▬				▬				▬			
FOUNDATION CRACKS		▬				▬			▬					▬			▬					▬		
EXTERIOR WALL CRACKS		▬				▬			▬						▬		▬					▬		
EXTERIOR DOORS JAM	▬				▬				▬					▬			▬				▬			

HOUSE EVALUATION - BOREBANK STR.

DISTRESS / HOUSE NR & AGE	1 / 62				2 / 46				3 / 70				4 / 41				5 / 44				6 / 43				7 / 42			
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS				▬				▬			▬		▬					▬				▬					▬	
CEILING CRACKS			▬				▬				▬		▬					▬				▬				▬		
MAIN FLOOR SLOPE			▬					▬			▬		▬						▬				▬				▬	
INTERIOR DOORS JAM			▬					▬			▬		▬					▬				▬				▬		
BASEMENT SLAB CRACKS			▬				▬				▬		▬					▬				▬				▬		
BASEMENT SLAB HEAVE			▬			▬				▬			▬				▬				▬				▬			
BASEMENT WATER LEAKS		▬			▬					▬			▬					▬				▬			▬			
FOUNDATION CRACKS			▬				▬			▬			▬						▬			▬					▬	
EXTERIOR WALL CRACKS			▬					▬		▬			▬					▬				▬				▬		
EXTERIOR DOORS JAM			▬				▬				▬		▬					▬				▬				▬		

	8 / 38				9 / 35				10 / 31				11 / 26				12 / 26				13 / 27			
INTERIOR WALL CRACKS			▬			▬				▬				▬				▬				▬		
CEILING CRACKS			▬			▬				▬				▬			▬					▬		
MAIN FLOOR SLOPE			▬			▬			▬					▬				▬				▬		
INTERIOR DOORS JAM		▬				▬				▬			▬					▬			▬			
BASEMENT SLAB CRACKS			▬			▬				▬				▬					▬			▬		
BASEMENT SLAB HEAVE			▬		▬				▬					▬			▬				▬			
BASEMENT WATER LEAKS			▬		▬				▬					▬				▬			▬			
FOUNDATION CRACKS			▬			▬				▬				▬					▬			▬		
EXTERIOR WALL CRACKS			▬			▬				▬				▬				▬				▬		
EXTERIOR DOORS JAM			▬			▬			▬				▬					▬			▬			

HOUSE EVALUATION - LINDSDAY ST.

DISTRESS — HOUSE NR & AGE	1 /				2 / 34				3 / 40				4 / 60				5 / 40				6 / 40							
	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major	none	minor	moderate	major
INTERIOR WALL CRACKS			▬				▬			▬						▬		▬				▬						
CEILING CRACKS		▬				▬					▬					▬	▬					▬						
MAIN FLOOR SLOPE			▬			▬					▬					▬		▬				▬						
INTERIOR DOORS JAM			▬			▬					▬				▬		▬					▬						
BASEMENT SLAB CRACKS			▬			▬				▬						▬		▬				▬						
BASEMENT SLAB HEAVE	▬					▬			▬							▬		▬			▬							
BASEMENT WATER LEAKS			▬			▬				▬				▬			▬					▬						
FOUNDATION CRACKS			▬				▬				▬					▬		▬			▬							
EXTERIOR WALL CRACKS			▬			▬					▬				▬				▬		▬							
EXTERIOR DOORS JAM			▬			▬				▬					▬				▬			▬						

	7 / 35				8 / 33				9 / 33				10 / 32				11 / 15				12 / 18			
INTERIOR WALL CRACKS			▬			▬				▬				▬				▬			▬			
CEILING CRACKS			▬			▬				▬				▬			▬				▬			
MAIN FLOOR SLOPE			▬		▬					▬				▬				▬			▬			
INTERIOR DOORS JAM			▬		▬					▬			▬				▬				▬			
BASEMENT SLAB CRACKS			▬			▬				▬				▬				▬			▬			
BASEMENT SLAB HEAVE			▬		▬				▬					▬			▬				▬			
BASEMENT WATER LEAKS	▬					▬			▬					▬			▬				▬			
FOUNDATION CRACKS				▬		▬			▬					▬				▬			▬			
EXTERIOR WALL CRACKS				▬		▬				▬				▬			▬				▬			
EXTERIOR DOORS JAM			▬			▬			▬				▬				▬				▬			