TWO DECADES OF INNOVATION IN HOUSING TECHNOLOGY

1946-1965

Prepared by

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and

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for

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LIST OF ABBREVIATIONS

CMHC - Canada Mortgage and Housing Corporation (formerly Central Mortgage and Housing Corporation)

CPAC - Community Planning Association of Canada

CSA - Canadian Standards Association

DBR - Division of Building Research [National Research Council of Canada] (now The Institute for Research in Construction)

DHA - Dominion Housing Act

DND - Department of National Defence

NAC - National Archives of Canada

NHA - National Housing Act

NHAA - National Housing Act Administration

NHBA - National House Builders' Association (now Canadian Home Builders' Association)

NRC - National Research Council of Canada

ORF - Ontario Research Foundation

TRC - Technical Research Committee (NHBA)

LIST OF FIGURES

EXECUTIVE SUMMARY

The report studies the evolution of housing technology, house design and urban planning in Canada from 1946 to 1965 with special attention to the role of Canada Mortgage and Housing Corporation (CMHC) and other federal agencies.

It is based on manuscript and other written sources, as well as extensive interviews. Among the latter, lengthy interviews with Sam Gitterman were especially important. Gitterman had been involved with technical and planning aspects of the housing work of federal agencies from 1939 to 1974.

General Conclusions of the Report

- Technological development in building materials and techniques was evolutionary, interdisciplinary and cumulative. CMHC and allied agencies contributed most to improving housing technology when they followed these principles.

- A high degree of co-operation characterized the relationship among CMHC, National Research Council's Division of Building Research (DBR), and other agencies, such as the Forest Products Laboratories. This co-operation also extended to the private sector, especially through the National House Builders' Association (NHBA, now Canadian Home Builders' Association).

- Technological change in building technology was aided by the work of CMHC and other agencies through direct encouragement, financial assistance, and inspiration.

- Technology transfer initiatives were achieved through the use of test research houses, publications, material acceptance standards, the National Building Code, CMHC residential and urban planning standards, and the work of the Technical Research Committee of the NHBA, where housing industry and government representatives worked together to identify and try innovative products and methods.

Content of Chapters

The report is divided into three Parts.

Part I consists of Chapters 1-3 which together examine the context of postwar government housing programs, the main players in the housing field, and technology transfer initiatives.

Chapter 1: Government and Housing Before 1946

Before the Dominion Housing Act of 1935, federal involvement in housing was minor. Although the 1935 Act had only a minimal impact because of the Depression, it was an important precedent. Subsequently, the National Housing Act (NHA) was passed in 1938, and a new NHA was passed in 1944. After 1946, federal involvement in housing through CMHC became a substantive part of Canadian life.

Chapter 2: The Context and the Players of the Postwar Years

The housing market was taxed by the severe shortage of housing in Canada after the war. The residential construction industry was largely concerned with production of single family detached houses, usually built by small firms operating at a local level. The housing market was highly cyclical because of changes in the composition of the Canadian population. By the 1960s, the market was very different than in 1946, with more single and elderly people living alone, often in apartments.

Against this backdrop, the main organizations active in housing technology in Canada were CMHC, DBR and the NHBA.

CMHC was created on January 1, 1946. It was the central player in postwar housing in Canada. Through Part V of the NHA (1944) it was involved in research in housing, including design, planning and technology. It also built houses for a number of government departments and for returned veterans. In 1947, the staff and assets of Wartime Housing Ltd were transferred to CMHC, which strongly established its national presence.

DBR was created in 1947 and served as CMHC's technical "research wing," but also independently carried out work on building technology. As well, it was responsible for providing technical and administrative support services for the Associate Committee on the National Building Code and for assisting CMHC and other agencies with research for setting minimum requirements for material performance.

The NHBA was created in 1943 to represent the building industry's interests. It played a significant role in establishing links between private builders and public agencies, like CMHC and DBR. These three organizations co-operated on a number of research projects.

Chapter 3: Shaping the Building Process and Product

The National Building Code and CMHC's materials acceptance program were important forces in the introduction of new materials and techniques, in making them uniform across the country, and in the transfer of technology in Canada. The uniform standards created for houses built under the NHA simultaneously became the general standards for residential construction in Canada, whether NHA-financed or not, and were often later incorporated into the National Building Code.

The co-operative aspects of technology transfer and research were exemplified by a series of experimental houses, called the Mark series, undertaken by CMHC, DBR and the NHBA.

Part II consists of chapters 4-6 and examines technical aspects of experiments, tests, and other technical initiatives by CMHC in conjunction with other agencies.

Chapter 4: Finding New Ways to Build

A major concern in postwar building was the reduction of costs through use of prefabrication, reduced use of material and greater streamlining of construction. As well, modular co-ordination, a system that aimed to establish uniform dimensions for building design and materials, was promoted to make construction more efficient.

Important changes in use of materials took place, often with the encouragement of CMHC. Use of roof trusses, sheet materials and alternative materials to wood was assisted by CMHC and DBR. On a different scale, the principles of prefabrication and industrial systems of organization in building were also applied in important innovations developed in Canada in high rise construction in the 1960s.

Chapter 5: Coping with Environmental Factors

The severity of the Canadian climate created special problems for builders and home owners. As well, Arctic conditions required special house designs. Federal agencies played an important role in designing such housing, and in testing materials and developing standards for windows, vapour barriers, and heating and ventilation.

CMHC and DBR also played a significant role in persuading builders to build year round. On another front, Canadians resisted basementless houses because they saw a basement as essential in the Canadian climate. CMHC participated in important experimental work on wood basements.

Chapter 6: Sanitation.

While plumbing and sanitation showed little fundamental change in technological terms after 1945, CMHC promoted innovative approaches to sanitation through research and development in alternate sewage systems which continuously recycled the water. One such system was used in two of the Mark houses, and this technology evolved by the early 1970s into a comprehensive system called CANWEL, designed to recirculate water in large multiple dwelling projects.

Part III consists of two chapters dealing with CMHC's role in urban planning and house design.

Chapter 7: Planning the Urban Residential Landscape

CMHC had a significant impact on the type of planning that was used in postwar urban development. Relying in part on urban planning precedents developed before World War II, CMHC created minimum planning and site development standards for areas containing NHA-financed houses. It was also involved in various programs to encourage professional planning in Canada. Like material and construction standards, these minimum requirements were adopted throughout the country, increasing the quality of all housing, not just NHA-financed projects. The Corporation was also involved in planning a number of new towns, as well as in urban renewal programs.

Chapter 8: House Design

From 1947, CMHC had an extensive program to help improve the design of Canadian homes. Through commissioned plans, architectural competitions, and other design sources, plan books were published featuring houses of modern design which met minimum requirements under the NHA. As in other programs, these designs became standard throughout the country. CMHC also furthered improved design through sponsorship of the Canadian Housing Design Council.

The report concludes with a short conclusion and a bibliography.

ACKNOWLEDGEMENTS

This report was prepared by Clayton Research Associates Ltd. and D.G. Wetherell and Associates Ltd., and studies the evolution of Canadian housing technology, design and planning during the 1940s, 50s and 60s. Several federal agencies, especially CMHC, were important players in this evolutionary process and their critical role provides a focal point for the study.

Many individuals have contributed to the study. Extensive interviews were conducted with a number of people who worked in building technology with Canada Mortgage and Housing Corporation and the National Research Council. A list of those interviewed can be found in the bibliography. All made important contributions to the research, but special recognition and thanks are owed to Sam Gitterman, whose recollections provided the core material for this study. Gitterman graduated from McGill with a degree in architecture in 1935 and joined the staff of the National Housing Act Adminstration in 1939. In 1942, when a town planning section was created in the Administration, he took on responsibility for town planning as well as serving as Chief Architect. With the formation of CMHC in 1946, he moved to the new corporation as Chief Architect and Planner. In 1955, Gitterman became a member of CMHC's Advisory Group. He remained with CMHC until 1959 when he entered private practice and also became the Technical Director of the National House Builders' Association. In 1965 he returned to CMHC as Senior Advisor, Technology, and continued with the Corporation until his retirement in 1974. In light of Gitterman's involvement in technical activity during a significant period in Canadian housing history, CMHC was interested in focusing the study around his recollections.

INTRODUCTION

The years from 1946 to the mid 1960s were ones of major change in Canadian housing. Despite high levels of population change and household formation, more Canadians became better housed in this period than ever before. Significant changes took place in the materials and methods of construction of ordinary houses, in their design, and in urban planning.

In 1941, the Census showed that the Canadian population stood at 11.5 million, half of whom lived in urban areas. While there were significant urban, rural, and regional differences, the average age of private dwellings was estimated to be 30 years, and about 27 percent of all private dwellings needed major repair, especially on the Prairies and in rural areas. Just over 60 percent used a stove or a space heater for heating, and about the same number had piped running water. A slightly lower percentage had an inside flush toilet. Most farms had neither running water nor electricity. For the poor, housing was expensive and often overcrowded and unsanitary. In 1951, 19 percent of Canadian households were defined as crowded--meaning more than one person per room. This figure had declined to 16 percent by 1961, and stood at 9 percent by 1971.[1]

During World War II, little could be done to correct poor housing conditions. After the war, however, the federal government took a number of initiatives to assist the building industry and ordinary Canadians to upgrade the country's housing stock, provide new housing, and improve community infrastructure to support adequate housing. For residential construction, the objectives of reducing labour costs, increasing speed of construction, improving quality of houses, and applying new materials and methods of construction led to far-reaching changes in Canadian house building in the period from 1945 until the mid 1960s.

A number of events in the mid 1960s mark the end of one phase in the history of postwar housing policy in Canada and the beginning of another. In 1964, the emergence of a federal-provincial partnership in housing led the provinces to take their constitutional responsibilities for housing more seriously, which brought a number of significant changes in Canadian housing policy, ranging from a new commitment about public housing to the beginning of greater provincial involvement in building codes and regulations. Moreover, a cultural change was underway, and greater recognition of demands for citizen participation in planning issues, such as urban renewal, influenced government policy.

By this point as well, significant changes in building technology had occurred, and various building techniques and materials which encouraged cost and production efficiency had been widely adopted. While technological change in building is evolutionary, interdisciplinary, cumulative, and rarely falls into neat chronological categories, the two decades after World War II were years of particularly important innovation and thought about building practices and use of materials. Although our focus is on the years up to 1965, in some cases the narrative extends beyond this date in order to provide a more complete explanation. Overall, however, as one observer has remarked, product developments in the 1970s and 1980s were not fundamental to average home construction, but rather were "geared to enhancing performance, quality and appeal to the substantial number of higher-income buyers." Moreover, while speed and on-site productivity were as good, if not better, in the 1970s and 1980s as before, neither were they "pushed persistently ahead as they were in the earlier period."[2] And while houses of the 1970s and 1980s had better heating, windows, insulation and air tightness than those of the 1960s, some of the technology behind these developments was based on research and development that took place between 1946 and 1965.

Canada Mortgage and Housing Corporation (CMHC), a Crown corporation established on January 1, 1946, was a major force in postwar housing technology, house design and urban planning. Other federal agencies, especially the National Research Council (NRC), Division of Building Research (DBR), and the Forest Products Laboratory (now Forintek), an agency of the Department of Forestry, also played an important role. Acting in conjunction with the private building industry, these agencies stimulated increased affordability of good quality houses for ordinary Canadians, as well as better standards of building. In terms of exploring new building technology, there was a significant level of co-operation among these agencies and between public and private sectors. CMHC also had a significant impact on the design of houses and the residential landscape. The influence that CMHC, in concert with other agencies, exerted on Canadian housing was both direct and indirect. Through the standards that it demanded for houses built under the National Housing Act, it had a direct influence on how houses were built and designed, and how residential areas were laid out. Less directly, but of equal importance, it, along with NRC, created a climate conducive to innovation and experimentation in house construction technology in Canada.

Coverage and Structure of the Report

This report documents and examines this evolution of housing technology, design and planning in Canada during the period from 1946 until the mid 1960s, and highlights the role of federal agencies in this process.

The report is divided into three sections. Part I contains three chapters and provides a brief discussion of the context of Canadian housing policy and an overview of important federal agencies and other groups which played a part in research and development in building technology after 1946. It also contains a discussion of broad efforts in research and development and technology transfer by looking at the National Building Code and building standards, and the development of an important series of demonstration/test houses built by the National House Builders Association in co-operation with CMHC and NRC.

Part II also contains three chapters and examines a range of specific initiatives in building technology such as prefabrication, sewage systems and winter building. Part III contains two chapters, and looks at the impact of federal agencies on postwar town planning and house design in Canada. A short conclusion, endnotes and bibliography complete the study.

PART I

THE CANADIAN HOUSING SCENE

CHAPTER 1: GOVERNMENT AND HOUSING BEFORE 1946

Direct government involvement has been a feature of housing in Canada only in the past 75 years. Although such involvement was relatively minor before World War II, prewar federal policies and programs were precedents for federal housing policies that were enacted after the war. The history of housing initiatives before 1946 was thus more than a backdrop; as part of a continuum in Canadian housing policy, it helped to inform and shape the activity that came later.

One of the first federal government housing projects occurred in 1917 after a munitions ship exploded in the Halifax harbour, levelling a part of the city. The federal government assisted in rebuilding the city. Included was a housing project called the Hydrostone Project (named after the concrete product from which the houses were built). Completed in 1920, it used what was called a Garden City plan, and expressed the latest ideals in urban planning.[1]

The Hydrostone Project was more an immediate response to a disaster than part of a concerted federal housing and urban planning policy, but more broadly formulated projects were soon developed. In 1919, fearing high unemployment, as well as social unrest at the end of the war, the federal government lent money to the provinces, which in turn lent it to local governments, for construction of low cost housing. This was the first deliberate foray by the federal government into the housing field, but it was unsuccessful overall. Implementation was left to local governments, but many were too inexperienced or uninterested to make the program work. Built during a time of inflation, the houses became uneconomic because of the deflation that followed in the early 1920s. Although a number of houses were built under this scheme, most successfully in Winnipeg, the overall failure of the plan helped discredit government-assisted house construction and helped discourage the government from direct intervention in housing for a number of years.[2]

Similar conditions of unemployment and social unrest characterized the 1930s. By 1935, the country remained in the grip of the Depression that had begun in 1929. In its dying days, the government of R.B. Bennett passed the Dominion Housing Act (DHA) as an employment scheme. Under the DHA, the federal government provided money for housing on a joint loan basis with private lenders, mainly insurance and trust companies, then the major sources of mortgage funds. Interest rate subsidies and loan guarantees to the lenders were provided. Down payments were set at 10 percent for houses costing less than $2,500 and 20 percent for higher cost houses. Both were low down payments at the time. The DHA also used blended payments--another innovation--by which the mortgage was paid off in monthly instalments consisting of interest and principal. In keeping with the employment objectives of the program, it was administered by the Department of Finance. While the government hoped that this scheme would stimulate the construction industry, the Depression and an inherent bias in the program towards new and upscale urban housing restricted its success. By 1938 only about 5,000 houses had been built under the DHA.[3]

The DHA was replaced in 1938 with new legislation, the National Housing Act (NHA). Some of the provisions of the DHA were retained (such as the amount of down payment required and the use of joint lending), but new provisions were included. The legislation permitted the federal government to make loans for low income rental housing, and, although this section of the NHA was not enacted, it served notice that housing policy, at least in theory, no longer served only to stimulate the economy but now formed a part of Canadian social policy. A separate administration, the National Housing Act Administration (NHAA) was created to process loans and set construction standards for housing built with NHA funds.[4] The NHA was only slightly more successful than the DHA--the persistence of the Depression ensured that relatively few ordinary Canadians could afford new houses, even if financed with government guaranteed loans. In any event, the NHA of 1938 had little chance; when World War II began the next year, the concerns of the Canadian government shifted to war production.

The DHA and the NHA (1938) were important milestones in Canadian housing policy. Their organization and practices, both in terms of their achievements and failures, demonstrated ways to implement and run a national housing policy. Administratively, both the DHA and the NHA were highly centralized: all loans were processed in Ottawa, and the only inspector was in Toronto. Elsewhere, inspections were carried out by the lending agencies. Combined specifications and standards[5] had been developed to guide construction of houses built under the DHA. This system was not entirely satisfactory--inspections were poorly done and the whole system was too centralized--but in light of the limited staff employed, it worked relatively well.[6]

The lessons learned were not only administrative. Frank Nicolls, the first director of the DHA, was concerned with the place of technology in house building, but immediate opportunities to express his concerns were limited. He believed that prefabrication was one way to lower costs, and while he stimulated interest in prefabrication, this bore no immediate results. He also thought that the public should be educated about building, and in the first DHA-financed house (built in Montreal in 1936), the DHA directed that a wall be left temporarily exposed so that the public could see and learn about construction.[7]

The war provided a major incentive for the application of innovations in building technology in Canada. It was evident that wartime production was, in some places, dependent on workers being housed adequately, and the NHAA was assigned responsibility for constructing temporary houses for such workers. (See figures 1-1 and 1-2) Since rapid construction was required, many of these houses used prefabricated construction and had a crawl space instead of a basement. Their temporary character was graphically shown by their reliance on stoves, rather than furnaces, for heat. The NHAA also administered other programs to increase the housing supply. For example, under the Home Conversion Plan of 1943, the government provided grants to owners to convert large single family dwellings to rental suites.[8] (See figure 1-3)

In 1941, these government efforts were supplemented by the creation of Wartime Housing Ltd., a Crown corporation which exclusively built houses in connection with the war effort. It was Canada's first truly national building company. Between 1941 and 1945 Wartime Housing Ltd. built 16,849 rental single detached houses, plus almost 9,000 houses for returning veterans from 1944 to 1946. These houses, like some of the earlier wartime houses built by the NHAA, used some prefabrication and innovative construction techniques to help speed up construction. (See figures 1-4 and 1-5)

These precedents confirmed that the federal government's role in housing went beyond the supply of mortgage funds. It embraced a view that government leadership could also encourage and apply technical innovation to solve supply problems. This pattern continued after the war. In early 1944, the Housing and Community Planning Subcommittee of the Advisory Committee on Reconstruction, chaired by W.A. Curtis, released its recommendations for postwar housing policy. The Curtis report recognized that government involvement was necessary to assure affordability. It recommended a range of new policies to stimulate construction, repair and renovation of urban and rural houses to provide affordable and good quality homes and also to create employment. In formulating a plan to meet postwar demand for housing, it established targets for rehabilitating existing housing and for new construction, setting a goal of 70,000 new units per year for the first postwar decade. Moreover, it recommended that

Fig 1-1. These houses constructed by Wartime Housing Ltd. in Winnipeg were part of Canada's war effort.

National Archives of Canada/PA-190629

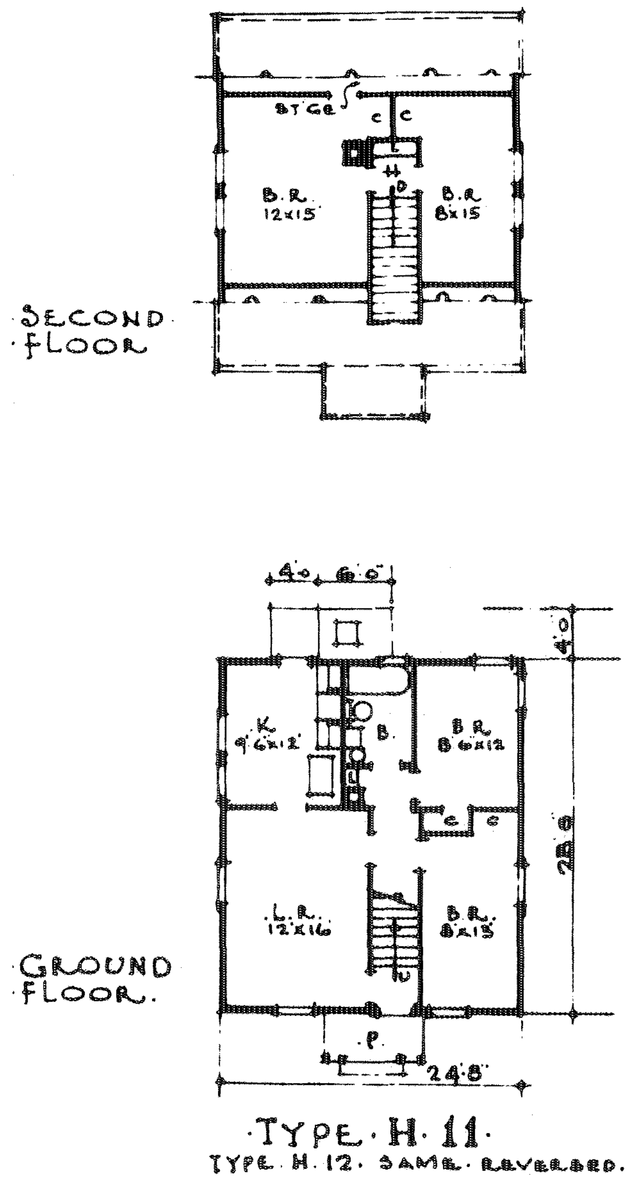

Figure 1-2. This was a typical floor plan for a small four bedroom house built by Wartime Housing Ltd.

National Archives of Canada/PA-187712

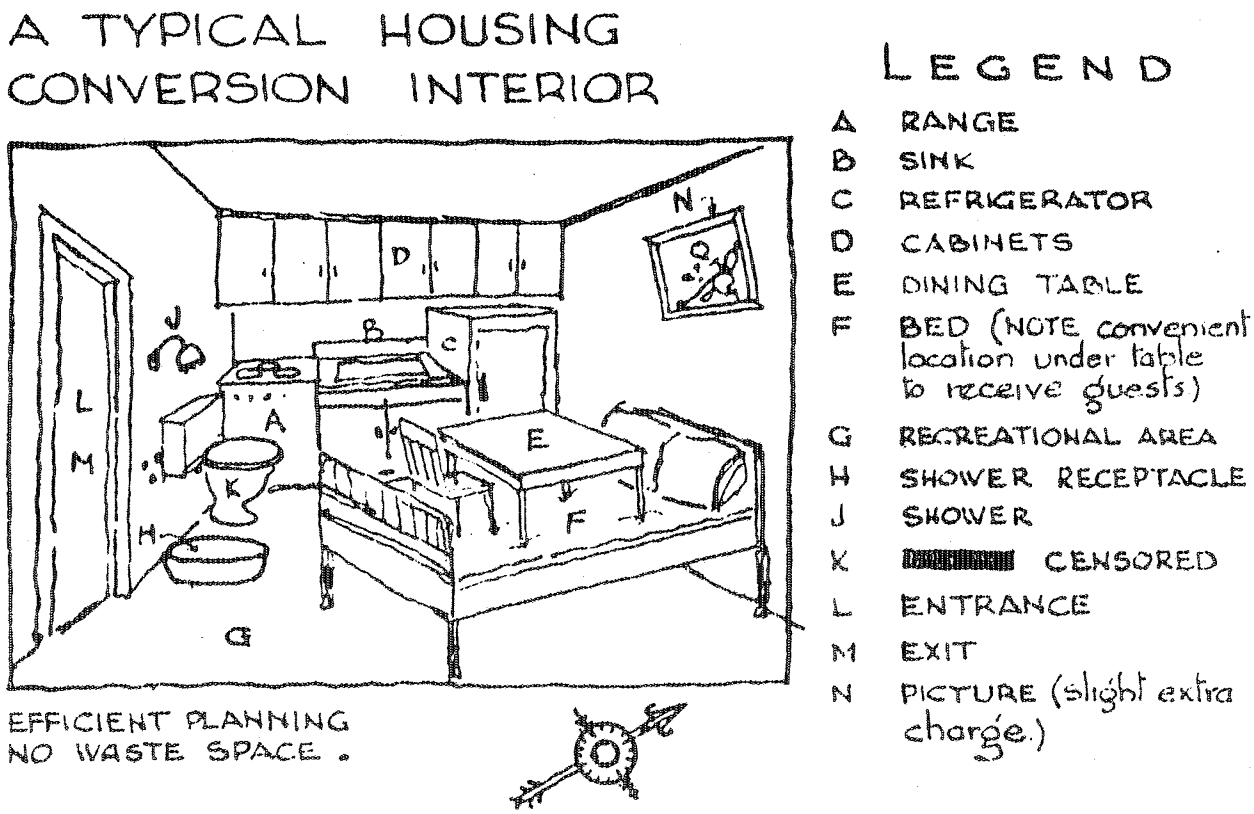

Figure 1-3. In the 1943 program for the NHAA's staff Christmas party, a joke was made at the expense of the Home Conversion Plan.

National Archives of Canada, MG31 vol. 8, File 8-18.

Figure 1-4. During World War II, prefabrication was used to reduce construction time. This photograph shows construction of house component parts in Halifax in 1941 for the DHAA.

National Archives of Canada/PA-187702

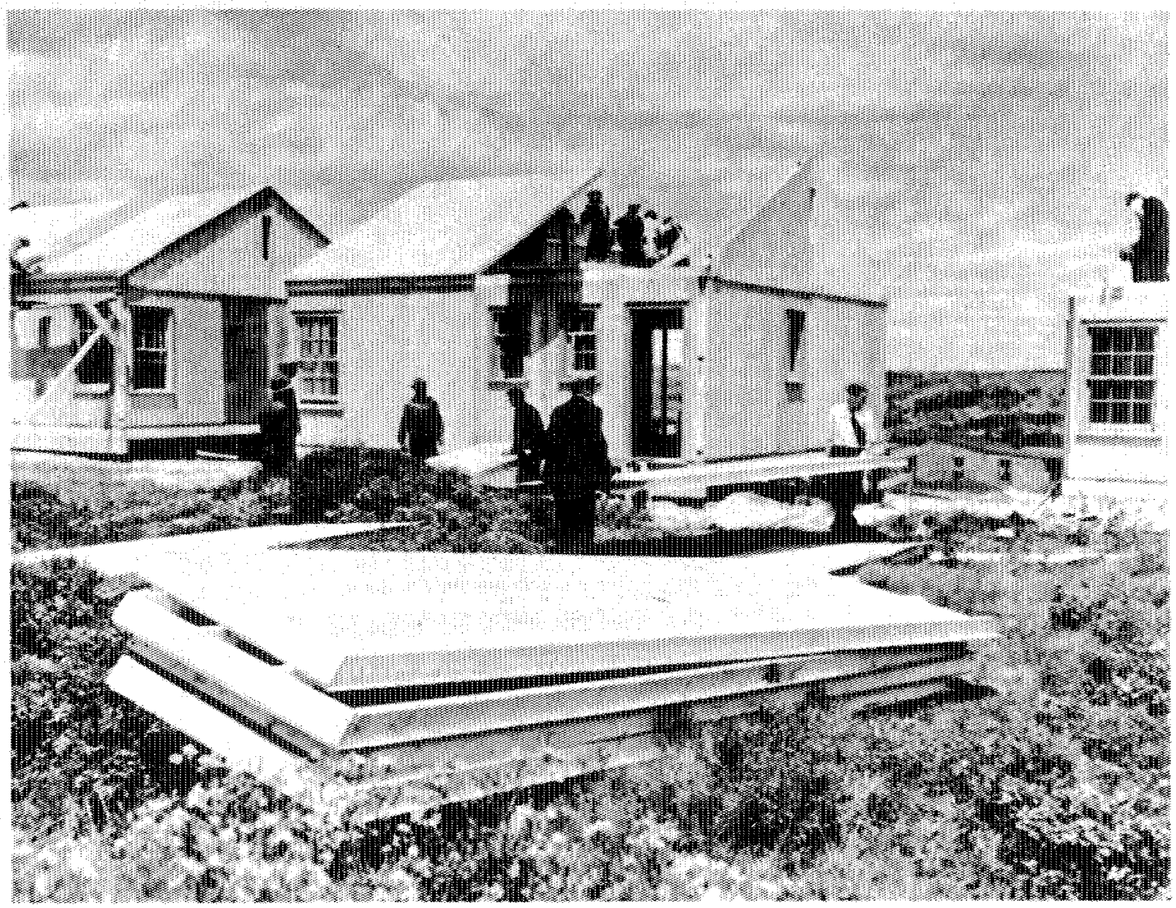

Figure 1-5. This photograph shows installation of prefabricated roofs on wartime houses in Moncton, New Brunswick in 1941.

National Archives of Canada/PA-187721

more attention be paid to urban planning. Significantly, it recommended that a single agency be created to administer Canadian housing policy.[9]

Many of these approaches were implemented later the same year in a new National Housing Act, which would prove to be crucial in remaking Canadian housing policy. It retained many of the features of the 1938 Act, such as the joint lending approach, in which 75 percent of mortgage funds came from the private lending institutions and the balance came from the federal government. While some public figures continued to justify housing policy principally as an employment scheme, the NHA (1944) in fact had a much broader scope. Loans to a greater variety of housing projects (such as co-operatives), loans to builders, and assistance for low income housing projects were introduced. The Act also contained a new section, Part V, which revealed the broader scope of the federal government's housing policy. Under Part V, the federal government could encourage and support training, education and research in housing, design and planning.[10] Although some of these provisions, especially relating to public housing, were implemented slowly, and sometimes with reluctance, a major change in federal housing objectives had taken place. And the prime player in this respect was Central Mortgage and Housing Corporation (now Canada Mortgage and Housing Corporation), a Crown corporation that came into existence on January 1, 1946 to administer the NHA and to focus Canadian housing policy.

CHAPTER 2: THE CONTEXT AND THE PLAYERS OF THE POSTWAR YEARS

The housing market in 1946 reflected problems created by the Depression and compounded by the war. Indicating the severity of its housing shortage, Toronto published warnings that newcomers should not move to the city.[1] Everywhere in Canada, housing was in critically short supply. Housing starts during the Depression and World War II had been too low to meet need, and repair of existing houses had often been neglected. Thus, in 1946, the country's housing stock was old and often in poor repair. A substantial number of Canadians lived in high cost, crowded homes. Many communities lacked municipal services to handle sewerage and to provide water. These conditions were much worse in villages, on farms, and especially in Native communities.

By the mid 1960s, while many problems remained (especially in Native housing), the extraordinary level of construction and renovation in the preceding 20 years had raised Canadian housing standards to among the best in the world. And while houses of the postwar period had a recognizable design and stylistic link with those built before the war, their construction and servicing embodied an unprecedented degree of technological change. These changes are summarized in Appendix 1, Exhibit 1.

The reasons for this technological change were varied, but generally revolved around efforts to increase production and lower costs by increasing speed of construction and reducing the need for skilled labour. House buyers played relatively little role in stimulating this technological change.[2] Given the costs of research and development, private house builders did not make an appreciable contribution to the development of new materials, although they often developed new methods to speed up on site construction. Moreover, their national organization, the National House Builders' Association (NHBA), undertook some research and educational work. As shown in Appendix 1, Exhibit 2, the research and development undertaken by private manufacturers was highly important, as was the work of public agencies, such as NRC/DBR, which evaluated and tested new materials and construction systems. Much of this work was done by DBR for CMHC, but CMHC also carried out work independently.

The Housing Industry and its Market

Demonstrating the traditional orientation of the Canadian housing market, 70 percent of all dwellings in Canada (and 50 percent in urban areas) in 1941 were single family detached houses. Only in Quebec, where apartments, row houses, and semi detached housing were common, was this pattern less prevalent. (See figure 2-1) The concerns of the Canadian housing industry thus generally focused on constructing single family detached houses, or, possibly, row or other forms of linked housing units. Apartment construction was, in many respects, a marginal part of the industry, and in the period 1945-1955 the market for apartments was largely concentrated in Quebec. By the late 1940s, however, small apartment blocks began to appear in greater number elsewhere, and from 1955 to 1969 the apartment development industry grew dramatically. Apartment buildings were becoming larger in size and height, and by the early 1960s high rise apartments were no longer unusual.[3] Indeed, while 85 percent of new homes built just after World War II were single family houses, by 1964 almost half were apartments and other multi-family structures. This trend continued for the balance of the decade. By 1969, more than 50 percent of all housing starts were apartment units. With no exaggeration, the 1960s have been described as the "golden era for apartment developers" in Canada.[4]

With some significant year-to-year variations, the volume of housing starts in Canada increased steadily from 1946 until the mid 1970s. In 1948, annual single family house starts stood at almost 83,000 units, almost double the number in 1945. Aside from a slump in the early 1950s, and despite periodic shortages of mortgage funds, housing starts increased every year until 1960. It was a period of massive construction, unmatched until the 1970s, when housing starts reached new highs.

This growth, as well as the new sorts of housing being built, reflected rapid population growth, a relatively young population that was beginning to form households, increasing urbanization, and more diverse households such as single and elderly people living on their own. The immediate postwar boom was the result of efforts to meet pent-up demand due to the Depression and World War II. This demand was met in part because low unemployment, low interest rates, and the availability of mortgage money through CMHC made housing affordable to a wider range of people. Indeed, house construction was held back largely because of shortages in building materials, skilled labour and contractors.

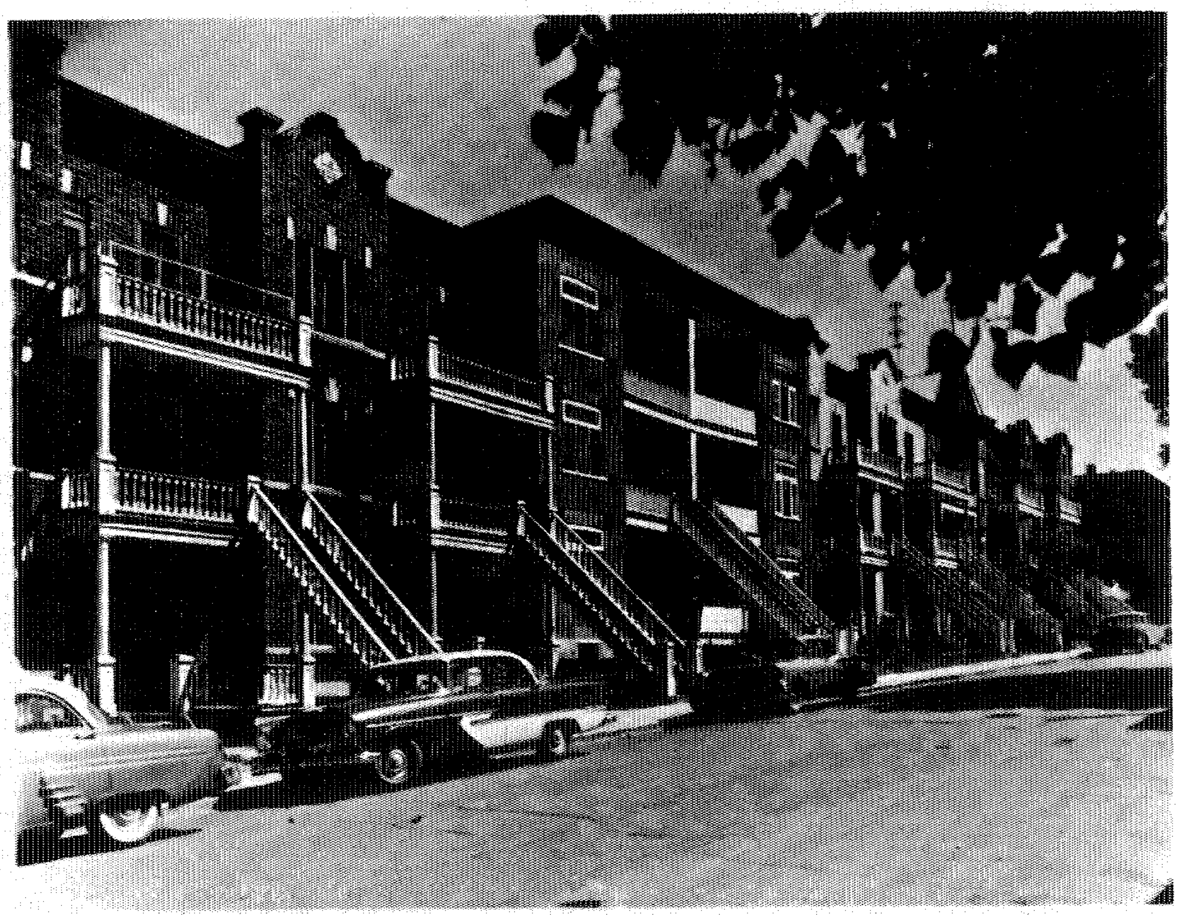

Figure 2-1. This 1959 photograph shows characteristic Montreal homes built before World War II. Usually, the exterior staircases were iron, unlike these wooden ones.

National Archives of Canada/PA-113447 (courtesy of CMHC/NAC)

The building industry in Canada was dominated by builders who ran small operations, although some large scale builders emerged after 1945, especially in apartment construction and in large suburban developments. In the decade after the end of the war, an increasing number of firms operated on a large scale in one area or region, but builders of national scope were never successful for long in Canada. Overall, the residential construction industry continued to be dominated by a large number of small contractors and tradesmen.[5]

The nature of the postwar industry was shaped by a number of factors that distinguished it from other industries. Construction took place on site across a vast country instead of being manufactured centrally and transported to purchasers; demand for the product was highly varied (from single family homes in various sizes and configurations to apartments); it was cyclical in response to economic and demographic cycles; and building regulations varied across the country.[6] One commentator observed that the residential construction industry in Canada after World War II operated "with a minimum of capital investment, little standardization, varying skill levels in the labour force, an aversion to technological innovation, and a reliance on a myriad of subcontractors, suppliers and material producers." While the comment about technical innovations might be debated, some of these characteristics of the building industry were the source of both its strength and weakness. While it was vulnerable because of cyclical demand for its product, the industry was highly flexible and responsive.[7]

These characteristics shaped the way the building industry responded to technological change. Speed of construction was important for builders because most relied on interim financing during construction, which meant that a short construction period would achieve cost savings. Thus, innovations that brought faster completion of projects were embraced. So too, developments which reduced demand for skilled labour were welcomed. Yet, in other respects, technological change was never an end in itself. Building was unlike consumer product manufacturing where new product development was often essential for success. Indeed, financing and land costs were as important (and often more so) as technological innovation in determining the price of new houses. Large scale builders made profits from land, financing and property management, while all builders benefitted from efficient site management.[8] All of these factors--the level and type of housing construction, the nature of the housing industry, and the focus of innovation--helped shape the relationship between public agencies involved in the housing market and the residential construction industry.

Canada Mortgage and Housing Corporation

The critical player in Canadian housing after 1946 was CMHC. The NHA was under constant amendment after 1946 to bring in new programs and policies to stimulate private house construction and to increase the amount of rental accommodation, housing for low income Canadians, and improved rural housing. Postwar housing policy involved two broad efforts. First, it provided assistance for private market production of decent, safe and sanitary housing through financing, research and development, and building regulations and standards. Second, it aimed to promote equity and social justice with low income rental housing schemes, urban renewal programs and various subsidies to enhance affordability. The latter efforts were less consistent and often more contentious than those to assist private market production.[9]

The impact of these initiatives was extraordinary. Between 1946 and 1950, about 20 percent of all housing units built in Canada were NHA assisted. This trend continued, and of the approximately 1.7 million housing units built in Canada between 1946 and 1961, approximately 660,000, or about 38 percent, were built under the NHA.[10] As George Anderson, then President of CMHC, commented in 1987, this meant that every one of these houses had CMHC's "stamp of approval on it." CMHC had touched "people's live where it counts most"--their homes.[11] Many of these initiatives have been ably analyzed elsewhere, although less attention has been given to CMHC's role in the technological changes of the postwar years.[12]

Recognizing that affordability to consumers was the key to increased production of housing, the immediate concerns of CMHC and its first President, David Mansur, were with the financial aspects of the housing market and in ensuring a sufficient supply of housing.[13] In part, this increased housing stock was promoted by the creation of a speculative building industry enabled by CMHC financing. At the same time, the Corporation recognized its social role. As was noted in one of its publications in 1947, "home building signifies many things--a lasting source of happiness, a kindly environment in which to raise children, a closer tie with community life, a new stake in the land."[14] Moreover, CMHC showed from the beginning a willingness to explore better ways to provide and build houses. Part V of the NHA (1944) explicitly allowed the federal government to undertake research, planning and public education about housing. This authority was used effectively by CMHC, and legitimatized spending on social and design aspects of housing.

On January 1, 1947, CMHC took over the staff and assets of Wartime Housing Ltd. To this point, the Corporation had been a small organization with less than 100 staff, mostly from the old NHAA. With Wartime Housing Ltd. staff, CMHC became a large organization with offices and about 2,000 employees across Canada. Overnight, it had become a truly national agency.[15] In addition, it inherited about 26,000 housing units, as well as responsibility for postwar housing programs and resettlement of veterans. As part of the Corporation's commitment to private home ownership, efforts began almost immediately to sell the wartime housing stock, but CMHC also had a more proactive role. Among other programs, it operated the Veteran's Rental Housing program, which produced about 24,000 additional units in the next three years. CMHC had become the nation's largest builder, and innovative use of various types of prefabrication were applied to ensure rapid construction and lower consumer costs.

Further responsibilities came in 1948 when CMHC was given the task of constructing houses for the Department of National Defence (DND). By the end of 1955, it had built about 12,600 units for the armed forces, as well as schools and other buildings on military bases.[16] (See figure 2-2) Although these veterans and DND projects were dominated by the priority to provide needed housing as quickly as possible, they also gave CMHC a practical venue for trying new construction techniques and materials that might be applicable to civilian housing.

While many of the Wartime Housing Ltd. offices were closed once its housing in a community had been sold, CMHC kept offices in strategic locations for its own needs. Perhaps recalling the problems of a too centralized system under the NHAA and inadequate inspection of projects, CMHC had five regional and twenty branch offices by 1949. These offices had important functions. Their engineers and inspectors (and later their architects and planners) helped educate, inform, and assist postwar private builders, and became a "nation wide means of technology transfer."[17] These efforts served not only builders and the public who were building NHA houses, but also affected the building industry at large.

CMHC was not, however, content to leave its technology transfer responsibilities at this level. After the late 1940s, it ensured that its technical pamphlets, housing studies, and publications and other programs relating to house design were given wide exposure. By 1948, CMHC was also producing films on housing and urban planning, and circulating travelling exhibitions about house design. (See figures 2-3 and 2-4) As well, its staff answered numerous enquiries relating to building products and practices from "builders,

Figure 2-2. These houses at Fort Osborne, Winnipeg, were typical of those built by CMHC for the Department of National Defence.

National Archives of Canada/PA-190657

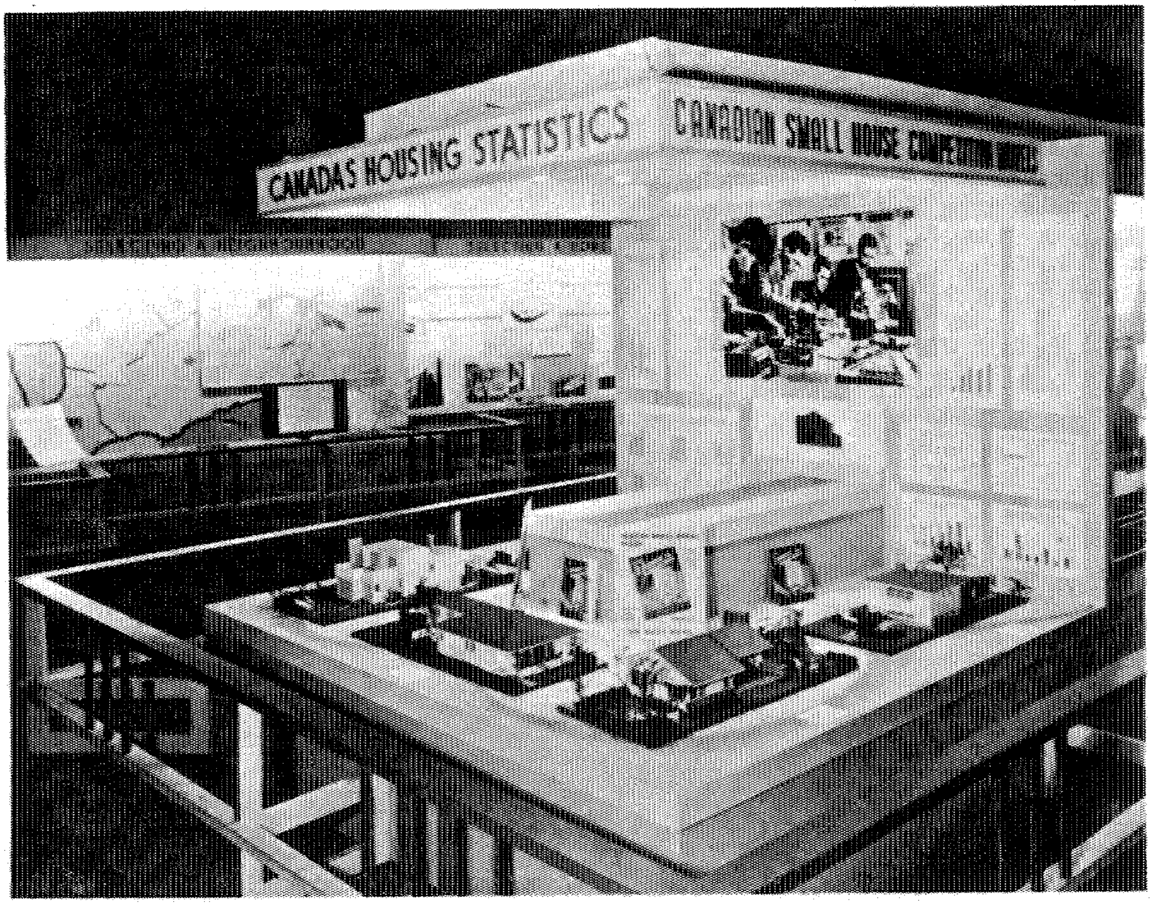

Figure 2-3. This 1947-48 CMHC exhibit helped draw public attention to the need for urban planning and professional house design.

National Archives of Canada/PA-187706

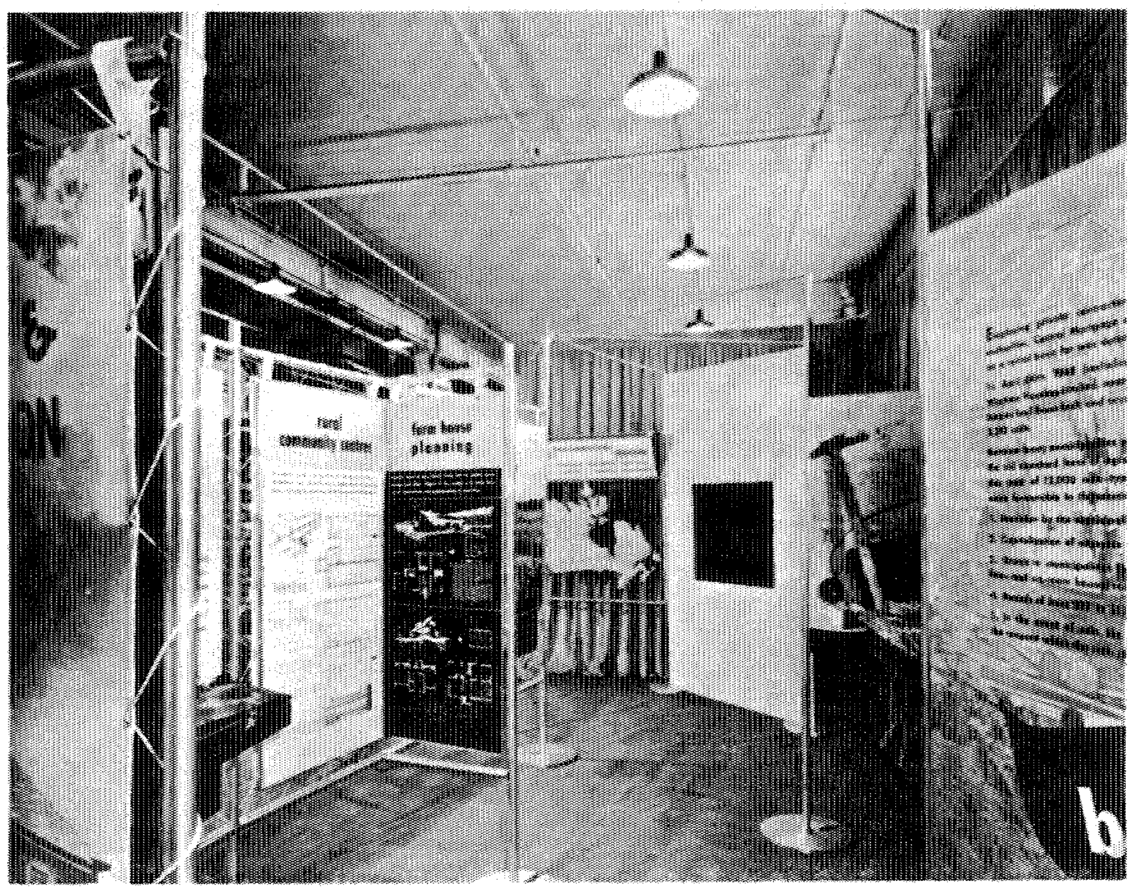

Figure 2-4. Improvement of rural housing was the objective of this CMHC travelling exhibit in 1947-48.

National Archives of Canada/PA-187704

home owners, suppliers and producers." Many of these were answered directly, while others were forwarded to DBR for reply.[18]

One example of the way in which CMHC encouraged technology transfer was the work of the Prairie Rural Housing Committee. The Committee had been established by the Prairie governments after World War II in an effort to improve farm housing, which was generally of poor quality. After 1946, CMHC became a major partner in this effort, paying 55 percent of the costs of the Committee, with the three provinces covering the balance. In conjunction with CMHC, each Prairie university carried out work on the basis of its research strengths: the University of Manitoba produced pamphlets on architecture for farm homes, the University of Saskatchewan wrote about insulation and heating, while the University of Alberta produced publications on farm sewage systems. A subcommittee also investigated, among other topics, the best materials and construction methods to build new farm homes and remodel existing ones. These publications were distributed by the provinces as well as by CMHC. In 1947, a similar committee was established in British Columbia and another in the Maritimes.[19]

After the mid 1950s, with changes to the mandate of CMHC and its management style, such efforts became more aggressive.In 1954, amendments to the NHA introduced mortgage loan insurance and made CMHC responsible for reviewing loan applications. The Corporation was also directed to become more involved in quality of housing and urban planning. Under the direction of Stewart Bates, CMHC's second President, this broadened mandate was implemented with verve and imagination. One example of the Corporation's new approach to housing was the introduction of architects and urban planners to its regional offices in 1954.[20] Bates rejected the view that housing policy was only a matter of housing starts and mortgages. While financing naturally remained a core responsibility of CMHC, he challenged the standardization and conventionality that had become dominant in housing. As he remarked, "if environment has any influence on character, the one we seem to be providing has severe limitations. It seems aimed at diminishing the individual."[21] Various innovations in the technology and methods of building were already being sponsored or encouraged by CMHC, but to broaden the scope of innovative thinking within the Corporation, in 1955 Bates established an Advisory Group made up of creative people to develop and provoke new ideas about how Canadian housing and urban life could be improved, and to be "a general thrust into the future for the whole corporation."[22]

The Advisory Group had five members whose interests demonstrated the scope of inquiry that CMHC was embarking upon. Under the chairmanship of Humphrey Carver, Bob Adamson was responsible for economic aspects of housing, Alan Armstrong looked at community planning and Andrew Hazeland focused on house design. Social needs and public housing were the responsibility of Fred Coll, while Sam Gitterman dealt with technology. The group made legislative and policy proposals and, individually, each reached out to the interested people across the country.[23] It was evidence that, as Ian Maclennan (who succeeded Sam Gitterman as Chief Architect and Planner in 1955) phrased it, the Corporation now had "a finger in every pie." In association with NRC and other agencies, it tested and approved building materials, and was actively involved in housing standards, house design, and town planning.[24]

There was no established system for publicising the work of the Advisory Group. There was, however, a general approach in which industry, universities and educational agencies were encouraged to expand their activities into areas of concern to CMHC. In respect to technology, Sam Gitterman recalled that he visited universities to advise them of the facilities and funds that CMHC could offer and its areas of interest. He also visited manufacturers, "not only seeking new products and new materials, but encouraging them to undertake research and development on new products and materials."[25]

Division of Building Research of the National Research Council

The National Research Council of Canada was established by the federal government in 1917 as a result of the research demands of World War I. Its interest in applied research was broad, and some research was carried out on building materials and construction. By 1933, recognition of the special research needs related to building gave rise to plans to establish a building research unit. At this point, the only existing national building research institution was Britain's Building Research Station, which had been established in 1921. While implementation of NRC's new unit was planned for 1937, this came to naught. By 1947, however, sufficient forces had combined to make the establishment of a Division of Building Research in Canada imperative. For one, it was apparent that the newly created CMHC needed assistance in dealing with various technical matters relating to housing. As well, a research body was required to assist with the continued revision of the National Building Code, first issued in 1941.[26]

CMHC encouraged the creation of DBR, and an agreement was struck between the two agencies. While CMHC was responsible for research on housing needs, architecture, planning and economic and social aspects of housing, DBR became the technical "research wing" of CMHC and was responsible for investigating special technical problems as well as matters concerning building codes and regulations. CMHC did not approach DBR with every technical problem because it had its own technical staff, but when uncertain, CMHC referred questions to DBR. Indeed, CMHC was the only organization "deemed to be a client" by DBR, and CMHC made an annual grant to DBR to assist in its work. CMHC also agreed to make information and research resulting from its wide connections available to the Division.[27]

This arrangement had a "profound influence on the development of the DBR" because, even though research into all types of building came under its purview, housing research became one of its chief responsibilities. DBR was not primarily concerned with reducing housing costs but with increasing technical and scientific knowledge about house building and performance problems. Accordingly, its early activities often took the form of "trouble shooting" to resolve problems in the field. While more than half of DBR staff time in 1950 was taken up with assistance to CMHC, this decreased over time as the size of the Division increased.[28]

The complexity of building construction and the fragmented nature of the building industry, coupled with Canada's huge range of soil and climactic conditions and its regional, economic and social differences, gave Canadian building research "a challenge all its own." It was recognized that the entire range of building research could not be covered by a single organization. This, in conjunction with the inherent interdisciplinary nature of building research, led DBR to forge formal links with other research agencies (such as the Forest Products Laboratories) and technical research committees of trade associations to eliminate duplication of effort and to share information. This also ensured that research responded to as many needs as possible. This co-operation was international in scope. From its inception, DBR kept in close touch with its sister organizations in Europe and the United States.[29]

These factors were recognized in the organization of DBR. By 1951, five areas of research were highlighted in the Division's mandate: fire research, soil and snow mechanics, building materials, heating, and housing. Of these, housing research was "one of the chief responsibilities." Equally significant was the Codes and Specifications Section which serviced the Canadian Government Specifications Board and the National

Building Code. As well, regional stations were established, the first being the Prairie Regional Station, set up in Saskatoon in 1948.[30] By 1957 additional stations were operating, including the Atlantic Regional Station, established in Halifax in 1955, and a summer Northern Research Laboratory, established in 1952 in Norman Wells, NWT. An office had also been established in Vancouver, and the central office in Ottawa continued to look after research concerns in Ontario and Quebec.

Each station had the same status as the head office and, as well as more broadly based work, each carried out research on problems unique to its area. The Prairie station, for example, specialized in the relation between cold weather and buildings, the Atlantic office studied problems with masonry unique to that region, and the Norman Wells station studied issues related to building on permafrost. This regional network also provided liaison between DBR in Ottawa and the building industry and architects and engineers in the regions.[31]

These approaches ensured that research responded as much as possible to actual problems, although theoretical research was often integral to such undertakings. Essential to the whole building research program was an effort to "bridge the gap" between research and practice through an "extension service," that is, educational and technology transfer activities. A section was established to distribute research publications in a wide variety of formats for a range of audiences, including the building industry, individuals and manufacturers. As well, the Division responded directly to written and telephone inquiries about building technology.[32] Initially, it had insufficient staff or resources to handle many inquiries, and avoided publicizing the service. Even so, by 1950 the Division was receiving more inquiries than it could properly handle. By 1959, however, the public inquiry service had become a major part of DBR's programming. In that year, inquiries averaged over 100 per month and ranged "all the way from detailed technical matters, such as corrosion of hot water tanks, to requests for advice on how to build on permafrost."

The importance of this service cannot be underestimated. It not only helped disseminate information about new technology, but also played a significant in advising against practices which presented too many technical difficulties or had poor potential. CMHC was also extensively involved in providing such cautionary advice to its clients, and sometimes referred sceptics to DBR to reinforce its arguments about a particular issue.[33] Further information, both of a supportive and cautionary nature, was also provided to the Canadian building industry in 1959 when the Division began making its library accessions publicly available on request. As well, it began publishing abstracts of articles written about building from Canadian journals and periodicals.[34]

National House Builders' Association

Frank Nicolls, Director of the NHAA, believed that a national association was needed in Canada to help focus and create a single voice for the fragmented house construction industry.[35] While there had been builders' associations in some cities, such local bodies did not enjoy the influence that a national institution could expect. In 1943, such an organization was formed with the creation of the National House Builders' Association (NHBA). It aimed to promote co-operation among builders, ensure higher standards in home building, and keep an eye on government legislation affecting residential construction. In part, it hoped to pre-empt government regulation of house construction by raising standards and self-policing of the industry.[36]

The NHBA soon broadened its efforts. In the mid 1950s it set up a Technical Research Committee (TRC) to explore innovative methods of building, to solve technical building problems and to try and "move technology forward."[37] This Committee reflected the Association's desire to expand its mandate and broaden its participation in housing policy. In early 1956 the TRC met for the first time with CMHC and DBR, and further meetings were held the next year. Benefits accrued to all participants; CMHC and DBR provided technical advice and the meetings in turn provided a channel through which house builders could bring technical problems to the two public agencies.[38] This new approach quickly brought tangible results, one of the first of which came in 1957 when the NHBA built a model house to demonstrate cost-saving building techniques. This was the first of what became the Mark series of houses. Both CMHC and DBR were actively involved in the project, demonstrating a positive interaction among public and private agencies concerned with housing.

As part of an effort to expand the Association's research program, the NHBA hired Sam Gitterman as Technical Director in 1959. The objective was "to mesh more closely the research activities of the NHBA, manufacturers, and government organizations" in cases where they related to lowering costs of construction and using and developing new building materials and techniques.[39]

The NHBA had high aspirations for its research program. As C.J. McConnell, Chairman of the TRC, wrote in 1962, the NHBA was "best qualified to assume leadership in a house research program" because it could direct research "along the most useful channels" and publicize and translate it "into terms which every builder can understand." In this way, the organization could contribute to lowering housing costs.[40] In keeping with the objective of educating its members, the TRC established a newsletter in 1964 featuring articles and correspondence on technical problems, recent literature and house construction technology.[41]

Conclusion

The postwar housing scene in Canada was marked by an evolving partnership between government and the private sector. Government was important in financing, in developing building regulations and standards, in low income housing, in stabilizing the industry in hard times, and in supporting, developing and promoting alternate building technology. Private builders helped improve on-site construction practices, built the houses, applied the technology and marketed the houses.[42]

Housing research by federal agencies after 1946 had three main objectives: to reduce construction costs; to improve the quality of housing and ensure that it met Canadian conditions and needs; and, finally, to assess new building materials that were flooding onto the market. These objectives evolved as a result of the emerging issues of the period, as well as from an ongoing dialogue between government research and regulatory agencies and builders' groups rather than as a result of an explicit government policy.

These developments were possible because of the overall co-operation with respect to building technology that existed among the three main players--CMHC, DBR and the NHBA. Gus Handegord, who worked at DBR's Saskatoon research station, recalled that the CMHC inspectors were very co-operative and provided DBR researchers with an "in" to the construction industry. This also applied to the relationship with local house builders. In a revealing anecdote, Handegord recalled that during a discussion about the Mark houses at a meeting of the TRC, a United States visitor expressed amazement at the co-operation he saw. He remarked, "I can't believe this. You have the government people sitting there, you have the house builders sitting there, and the research organizations." This would never happen in the United States, he commented, and Handegord was struck by the significance of the observation.[43] This contrast in approaches reflected differences in the culture of the two nations and the more harmonious relationship between public and private sectors in Canada, and also characterized the level of co-operation that existed in the technical work of public agencies and the Canadian house building industry.

CHAPTER 3: SHAPING THE BUILDING PROCESS AND PRODUCT

The agencies involved in building technology helped shape building in Canada through their policies and programs. The most important of these policies and programs aimed to regulate the quality of building through building codes and standards for building materials and construction. In addition, various agencies co-operatively built experimental houses to apply and test new ideas and innovative techniques, and to provide information to private builders and the public. This chapter reviews these related elements through an examination of the evolution of the National Building Code and an important series of experimental dwellings, the Mark series of houses, built jointly by the NHBA, CMHC and DBR.

Codes and Standards

The practice in Canada of placing responsibility for regulation of building practices with local government meant that each town and city was free to pass its own building regulations. This created a patchwork system across the country since these regulations could vary enormously. Indeed, some places had no, or only minimal, building bylaws. Although more towns and cities had passed building bylaws by the interwar years, in some places construction remained unregulated until after World War II.

With the passage of the DHA in the mid 1930s, the federal government recognized that its investment in housing, as well as the quality of construction and the public good, demanded more uniform regulation. The Department of Finance (responsible for the DHA) and NRC co-ordinated the preparation of a national building code by "representative national committees utilizing the best technical and professional skills available." This code was issued in 1941. Since its enforcement lay outside federal jurisdiction, it was voluntary (or "advisory"), and served as a model which local governments could follow in its entirety or use as a reference document in association with local building bylaws.[1]

With the establishment of DBR in 1947, ongoing revision of the Code was linked with research carried out by NRC. Following considerable research and public input, a substantially revised Code was issued in 1953. As before, it was a model code and thus gained legal force only when adopted by a local government. Like the 1941 version, the 1953 Code aimed to protect safety and health and ensure structural soundness and fire protection. With technical and secretarial assistance from DBR, a new committee, the

Associate Committee on the National Building Code, had been set up in 1948. The Associate Committee members were appointed by NRC on the basis of their expertise, and sat as individuals, not as representatives of any organization. None (except the Deputy Chairman who was responsible for support services) had any connection with NRC, and it did not determine what went into the Code. The DBR "simply provided technical support so that the provisions of the Code would have a sound technical basis."[2] The task of the Associate Committee was "to promote the uniformity of local building regulations in Canada and to maintain the National Building Code as an up-to-date document." It delegated to specialist committees the preparation of technical parts of the Code.[3]

The Associate Committee was thus entirely autonomous in its decision making, but its association with DBR provided fast and expert technical advice. DBR also benefitted from this relationship. Building problems revealed by the use of the Code throughout Canada were directed to the Division, and along with the ongoing revision of the Code, areas requiring research were identified. Many of these research findings were incorporated in later editions of the Code. After the second edition in 1953, subsequent editions were produced in 1960 and 1965 and at regular intervals thereafter.[4]

The 1953 Code was written in the form of a bylaw to facilitate its adoption by local governments, and a shorter version was also available for use in small communities. Issued both as a single volume and in pamphlet form, it was arranged in eight independent parts, permitting revision of single parts.[5] Administrative provisions that often varied across the country were assembled in one section, apart from the technical sections such as plumbing, foundations, and cladding, which had more general application. As well, requirements that varied regionally (such as snow or earthquake loads) were printed as a supplement to the Code. It also referenced standards for materials devised or accepted by the Canadian Standards Association (CSA) and other agencies.[6]

The National Building Code had a profound impact on Canadian building. As a "model" document to be adopted in whole or in part by other jurisdictions, it fit the constitutional complexity of the country. Its quality and impartiality ensured its status as an authoritative guide. It was adopted widely by local governments, none of which could have afforded to prepare a building bylaw of such quality. Over 10,000 copies of the 1941 edition alone were distributed, and by 1960 (on the eve of the third edition), about half of Canadians lived in municipalities which used the 1941 or 1953 edition of the

Code in one way or another. As well, it had official recognition in the Municipal Acts of six provinces and was also used by other federal agencies, including CMHC.[7]

Compliance with the National Building Code was mandatory in CMHC-financed houses. In addition, building standards set by CMHC had to be met. The NHAA had developed relatively broad standards for houses built under the NHA (1938), which were adopted by CMHC in 1946. After extensive revision, they were issued the next year as "Residential Standards." As well, a separate document on apartment standards was devised. Both were based on the National Building Code, but contained additional material to meet "the Corporation's administrative and housing quality control needs" and to protect CMHC's interest in NHA mortgages by improving resale values.[8]

These standards created national requirements for room size, placement of houses on lots, and amenities, as well as for structural soundness, safety, health, and the quality of materials and workmanship. CMHC inspectors ensured that these requirements, as well as those of the National Building Code, were met in NHA-financed construction. CMHC continued to use these standards until 1958 when DBR assumed responsibility for the "Residential Standards," which it renamed "Housing Standards." Amendments were made annually (as had been done under CMHC before 1958), with input from the NHBA, as well as from the technical staff at DBR and CMHC.[9]

Until the early 1960s, builders of NHA-financed houses thus had to meet both the National Building Code and CMHC's standards. The transfer of responsibility for the Housing Standards to DBR was "the first step in the planned reorganization of Canadian house construction standards." Since it was obvious that a single set of standards would be easier for the building industry to work with, the Associate Committee, on the urging of CMHC, began work on a new set of standards for residential construction. A Special Housing Committee was appointed by the Associate Committee on the National Building Code to study the existing standards and co-ordinate the preparation of a separate section on housing for the 1960 edition of the National Building Code.[10]

When the 1960 edition of the Code was issued, it contained, for the first time, a special section (Part 9) on housing. It thus formed a single set of standards for houses and apartments up to 6,000 square feet and three storeys in height and gave "detailed requirements for residential construction from the National Building Code which are based on safety considerations as well as additional quality and amenity requirements needed for regulating construction under the National Housing Act." Requirements under the National Building Code were printed in bold face while NHA requirements appeared in lighter type face.[11] In 1965, this rationalization of building standards was completed when the "Residential Standards Canada 1965" was issued. It represented a complete revision of minimum requirements for housing and was completely integrated with the provisions of the National Building Code.

There were a number of other codes, such as the Canadian Electrical Code prepared by the CSA, that were relevant to house construction. Material standards, which governed the physical properties of building materials, were also produced by a number of agencies. In many cases, United States standards were simply adopted by Canadian organizations like the CSA, although in some cases standards were developed in Canada. In either case, most of these standards were referenced in the National Building Code.[12] Federal housing agencies also dealt with materials standards and testing. Sam Gitterman recalled that as early as the late 1930s at the NHAA,

> sometimes we would see materials called for which we didn't know about and we had a section that would look at it. The section was one man, Ira Ashfield...And Ira Ashfield would check on the hardware and often call me in and...we'd take the hardware apart, look at, put it between our teeth and try to bend it. If it resisted, we approved it and that was the approval system of new materials.[13]

After World War II, there were two important federal agencies concerned with material standards. The Canadian Government Specification Board prepared specifications to guide federal government purchases. The other was set up by CMHC. By 1946, "a virtual flood of new materials," as well as new forms of old materials, had appeared on the market. To cope with this influx, CMHC developed a materials acceptance program.[14] Initially designed for internal use to assist CMHC staff in evaluating uncertified or new products for the Corporation's DND projects (and later in NHA-financed houses), CMHC informed manufacturers of its acceptance of their product for use in CMHC projects. CMHC based its response on the experience of its staff or, if necessary, on tests carried out by independent laboratories and agencies like NRC. From 1947 to 1951, CMHC accepted about 220 products, and practical considerations led to the preparation of a manual of acceptable building materials which listed the product name, the proponent's name, a brief description of the product, any conditions for its use, and the "CMHC Acceptance Number." Because of CMHC's role as the national authority on housing standards, the manual gradually came into general use throughout the Canadian housing industry. In 1953 CMHC and NRC formally agreed that DBR would provide technical expertise in developing criteria and testing procedures.[15] By this point, the number of acceptances had risen to an extraordinary level. In the 20 years after 1947, a total of 5,611 products were accepted, and CMHC's materials acceptance program became an important force for technology transfer in the Canadian building industry.[16]

Experimental Houses

By the time DBR was created, certain research conventions existed in respect to experimental work on housing and building materials. Ideally, there were four stages of research. The first stage consisted of laboratory experiments under controlled conditions. This was followed by tests under uncontrolled conditions, such as exposure to weather. The third stage involved incorporating these findings in plans for a full scale test building. The fourth and final stage was to build the test building and analyze (often for a number of years) the behaviour of the structure.[17]

DBR used a number of facilities to carry out the tests required in the second and fourth stages of such research. It used test "huts" at some of its research stations, as well as in Ottawa, to study problems relating to use of materials, stress, air and vapour movement in walls, and other topics. These "huts" ranged from little more than a wall enclosed in a field building to more complete structures. In other cases, existing houses were sometimes used as test facilities as part of the fourth stage of research. Some of the Wartime Housing Ltd. houses that CMHC had inherited in 1947 were used as "experimental houses," especially for testing insulation and humidity problems.[18] As well, special test houses were built. This approach was favoured because the effect of the use of one component could be observed throughout the structure. For example, while a test wall could reveal its strength, this did not always accurately indicate the strength and rigidity of the building as a whole.[19] Sometimes, these test houses were occupied on a regular basis to subject them to normal use. This became a form of field testing which supplemented more technical observation, and the experiences of the occupants provided ideas for modifications in design.

DBR built a number of test houses, but the most ambitious was the Mark series, a co-operative program among the NHBA, CMHC and DBR. Other agencies, like the Forest Products Laboratory, were also involved. The general objective was to test and demonstrate methods and materials "which would result in a better product at less price," disregarding current codes, bylaws, and common practice if necessary.[20] Up to 1965, four houses were built in the Mark series. The experiments tried in one house were often refined and reapplied in successive models. All houses were occupied permanently after construction. While specific details and various perspectives on the innovations and materials used in these houses will be detailed in later chapters, a brief outline of the projects at this point helps establish their context and objectives.

The concept for the first Mark house arose in early 1957 during a meeting of the TRC, CMHC, and DBR to discuss high housing costs. It was agreed that a suitable response would be the construction of a low-cost demonstration house.[21] It was built that year in Hespler, Ontario by N.O. Hipel, an NHBA member. Reflecting the emphasis on cost reduction, it initially was called the Budget Research House, but subsequently became known as the Mark I.

Unlike the test houses that came later, this house did not deviate "from CMHC minimum standards to any great extent."[22] Hipel had designed and built a number of simple, well-constructed, low-cost homes. Rather than sacrificing size and quality, costs were reduced through "proper design, new building techniques, proper planning, scheduling, supervision, use of a practical building code, and standardization of parts and materials." The demonstration house aimed to show that a sound home could be built using Hipel's approach for $8,000 including land. In 1957, such a house was affordable for a family earning $3,000 per year. It was a single storey bungalow of 864 square feet (80 square metres) with a crawl space. CMHC provided a direct loan to the project and DBR agreed to test and report on the building's performance.[23]

The Mark I was successful and attracted much public and professional attention. A builder in Nova Scotia used the design in 25 houses in Dartmouth in 1958/59. He also built a number of houses on the same plan but in full conformance with NHA standards (basically using heavier plywood and increasing the number of floor joists), which added about 6 percent to the cost. Larger models, with added features such as a carport and a higher level of interior finishing, were also offered.[24]

The success of the Mark I led to the construction of a second experimental house. The Mark II was built in Calgary and opened in 1959. Again, CMHC made a direct loan to finance the project. Like the Mark I, it showed how costs could be lowered, but the original design was more experimental and specified use of materials and techniques that were not approved by existing building codes. Its size and floor plan were the same as the Mark I to permit direct comparisons. Five such houses were planned, each in different climactic regions, but most municipalities refused to grant a building permit for a house which violated building codes. This restricted the experimental nature of the project, and so only one house was built. Constructed in Calgary, the original design was modified to meet local building codes.[25]

In light of the problems in obtaining building permits from local authorities for such test construction which did not comply with code requirements, the next experimental house, the Mark III--which violated code in several respects--was built in 1961 on the federal government's Rockcliffe Air Station in Ottawa. A building permit was therefore not needed. Its location in Ottawa also allowed regular assessment of the building by CMHC and DBR officials.[26]

The Mark III was the most radical in design and approach of the experimental houses yet built. Although it was a refinement of the earlier houses, experimental building technology now took precedence. While the demonstration of low-cost building techniques remained important, the Mark III was more directly experimental. Sam Gitterman, then NHBA's Director of Research, commented that the house was "a vehicle for trying out new ideas with the full knowledge that some won't prove practical, but with the hope that something useful will come out of it." That said, the project also used, when possible, experimental building techniques of potential benefit to small builders.[27]

Ideas for new materials and construction techniques came from a variety of sources, most importantly from manufacturers of building materials and the NHBA Technical Research Committee, which included representatives from CMHC and DBR. Building product manufacturers were invited to participate in the project and it gave them an opportunity to test products that had not been tried outside the laboratory.[28] To provide information on actual living conditions, the house was rented to Staff Sergeant Turner and his family, who agreed to report to the TRC on the adequacy of the house's design and living conditions. In recognition of their lively and considered co-operation, they were made Honourary Members of the TRC.

Demonstrating the cumulative nature of the research, the next house, the Mark IV, extended many of the experimental elements of the Mark III. New features included a different interior layout and the use of a split-level entrance and a full wood basement.

To observe its performance better, the basement was left unfinished. The house was built beside the Mark III, and the Turners, who had lived in the Mark III, moved into the Mark IV to help observe the daily functioning of the house.[29]

As with the Mark III, CMHC and the NHBA equally shared the costs of the project.[30] Planning for the Mark IV was the most involved of any of the Mark houses. As C.J. McConnell of the NHBA commented, past projects had been developed by "a small group of people," and he believed planning would benefit from as many participants as possible.[31] Thus, a large number of manufacturers and interested associations were asked for ideas and products for inclusion in the house, and NHBA members across the country were canvassed for suggestions. CMHC and DBR had direct input through their membership on the TRC. Once these views were known, Sam Gitterman drew up preliminary sketches, and after over two years of planning, the house opened in late 1964.[32]

Conclusion

The National Building Code and CMHC's standards met little prolonged resistance from builders. Initially, it was claimed that the Code increased costs of construction and held back technological change. As well, some builders feared that the Code "would remove the rather protected status of small local builders and open the doors to larger regional builders." Nonetheless, one of the early supporters of the National Building Code was the NHBA.[33] Early fears about the Code were proven incorrect, and ultimately it assisted technological change by creating uniform rules and regulations for the construction industry across Canada. As one expert concluded, it promoted technology transfer because once a change was incorporated in the Code, it became entrenched in the country's building practices and became a uniform practice across Canada.[34] Similarly, CMHC's material standards, like its "Residential Standards," were an important force in technology transfer because public acceptance of new products was strongly affected if CMHC approved them for NHA-financed houses.[35]

Technology transfer was also an objective of the Mark experimental houses. They received extensive press coverage, and CMHC, DBR and the NHBA used them for both experimental and educational purposes. The NHBA kept its members informed of the performance of the materials being used and of the construction techniques under trial, while CMHC and DBR subjected the procedures and materials to rigorous testing and reported their findings. All participants freely used the houses as an opportunity to test and refine theories and new materials for their particular needs. It is unlikely that the Mark houses would have enjoyed the reputation that they gained, nor would they have offered such a comprehensive opportunity for scientifically and progressively testing new materials and methods of construction, had it not been for the co-operation among the builders, scientists and technical experts from CMHC, DBR and the NHBA.

PART II

THE HOUSE PRODUCTION PROCESS

CHAPTER 4: FINDING NEW WAYS TO BUILD

In the two decades after 1946, major changes took place in the way that Canadian housing was built. Much of this activity was encouraged by CMHC and DBR in an effort to help reduce housing costs and to make construction more efficient. Many innovative techniques were also demonstrated publicly in the Mark houses. Paralleling the changing nature of housing, important developments also took place in high rise construction.

To understand the impact of technological developments between 1945 and 1965, it is necessary to appreciate the building practices and materials commonly used at the end of World War II.[1] Historically, house construction was based on traditional, or nonengineered, construction practices. Thus, methods had been developed and proven to be satisfactory by trial and error. In contrast, in engineered construction, performance of a particular system was determined scientifically. While traditional construction practices continued to be significant, engineered construction began to play a greater role in Canadian housing after World War II.

In 1946, one storey bungalows and one-and-a-half storey houses, often called semi bungalows, were typical. Less common, but of growing importance, were full two storey houses. Most of these houses ranged from about 750-1200 square feet (70 to 93 square metres) and almost all had basements constructed of brick, cement block, or, most often, concrete.

Most house construction in Canada relied on labour intensive "stick building" and houses were composed of many layers of different elements. Framing methods varied regionally. The insistence of some Quebec municipalities on noncombustible housing construction, even in single detached houses, encouraged the use of particular framing systems. Indeed, until 1972 the city of Montreal prohibited wood frame construction, and instead, Madrier (or plankwall) framing was commonly used. In Madrier construction, planks were stacked horizontally on edge and nailed within a plank framework. The building was then veneered with brick.[2] (See figure 4-1) In the rest of Canada, platform framing was favoured, although post and beam construction was used in a small number of houses, first in British Columbia, and by the 1960s in the rest of the country.[3] (See figure 4-2)

Figure 4-1. These Montreal apartments utilized Madrier construction covered with brick veneer. Not dated.

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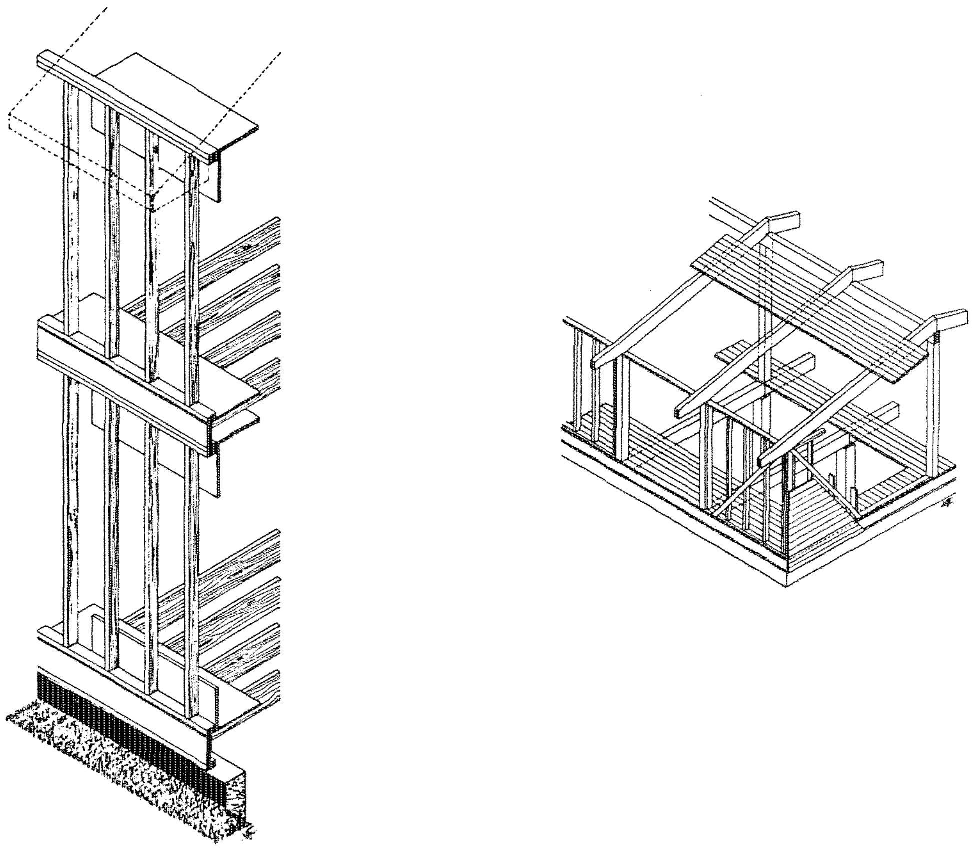

Figure 4-2. These two drawings show platform framing (left) and post and beam construction (right).

Maurice J. Clayton, Canadian Housing in Wood (Ottawa: CMHC, 1990), pp. 120, 124. Reproduced with the permission of Canada Mortgage and Housing Corporation and Maurice Clayton.

Floors employed wood joists, usually on 16" (400 mm.) centres, with the first floor centrally supported on a wooden main beam running the full length of the house. The second storey floors were supported by some of the first floor partitions. Floors were made up of a subfloor of boards running diagonally across the joists. (See figure 4-3) The floor joists were often cross-braced and a finished floor of strip hardwood was often laid over the subfloor. For sanitary reasons, linoleum or tile was used in bathrooms and kitchens.

Roofs were usually pitched and framed with rafters built on site. (See figure 4-4) Each rafter was notched at one end and was fitted and nailed onto the top plate of the exterior wall. The other end of the rafter was nailed to a ridge board. The rafters were connected to each other with a collar tie located in about the middle third of the rafters. Boards were nailed to the rafters, and were covered first with building paper and then with asphalt shingles. Roof load (both the weight of the roof itself as well as snow) was carried by the joists and rafters on the exterior wall, as well as by interior partitions that supported the joists.

Exterior walls were also sheathed with boards, although manufactured fibreboard sheathing was used in some cases. The sheathing was covered with building paper (usually an asphalted type) to keep out the wind and moisture. The wall was finished in a variety of ways: wood siding and stucco were used throughout Canada, and brick veneer was most common in urban central Canada.

Prefabrication

Houses built in this fashion were slow to construct because they were essentially composed of layers, each applied one at a time using much material and labour. Such building techniques led Clifford Clark, Deputy Minister of Finance, (who had drafted the NHA of 1944) to characterize the Canadian house building industry at the end of the war as relatively little changed "in form of organization and in technical processes from that which catered to our forefathers prior to the Industrial Revolution." Instead of finding inspiration in factory methods and machine production, Canadian house builders continued to use techniques more appropriate to "a localized, handicraft process."[4]

For Clark, like many of his contemporaries, the solution for lower costs, increased production, and improved quality of housing lay in applying the organization and

Figure 4-3. This 1958 photograph shows an Ottawa work crew building a floor by nailing boards diagonally across the joists.

National Archives of Canada/PA-190660

Figure 4-4. Traditionally constructed rafters, as on this Ottawa house, were labour intensive to build. Photograph not dated, probably late 1950s.

National Archives of Canada/PA-190697

methods of factory-produced consumer goods like automobiles. Prefabrication was most commonly seen as the means to this end. The term had broad application. At one extreme, it meant that complete houses would literally come off an assembly line like cars. In other cases, it meant factory or shop-made component parts that could be assembled on the work site. This would eliminate, it was thought, the inherent inefficiencies of constructing houses one at a time on site. It was also assumed, at least by some, that building could only become more efficient through large construction companies which could realize the economies of scale and organization of a factory.

The hope that prefabricated building would make construction more efficient was a very old one. In 1551, as part of the Russian struggle against the Tatars, Tsar Ivan the Terrible used prefabricated churches and fortifications which were floated 640 kilometres by river to create an instantly fortified town near Kazan.[5] Such practices were by no means unique, but more prosaic, and of greater import for human comfort, were later attempts to prefabricate housing. Houses using varying degrees and methods of prefabrication were manufactured in the late nineteenth century in the United States.[6]

Early settlers in the Canadian west also saw prefabricated houses as a solution to high labour costs and the need for rapid construction. The prefabricated houses manufactured in the United States were usually poorly suited to prairie Canada's winters--the joints let in the cold--and Canadian builders applied their ingenuity to surmount these problems.[7] While they were efficient to construct, structurally sound, and competitive in cost to conventional building, houses that were obviously prefabricated seem to have been unpopular, even on the frontier. People wanted their houses to look custom built, and thus the more popular route to more efficient construction was found in "ready-cut" houses. These were manufactured by a large number of firms throughout Canada from the turn of the century until World War II. They came in a wide range of contemporary styles and relied on pre-cut lumber. Each piece was numbered or colour coded to permit easy assembly. Assuming the use of unskilled labour, an instruction manual was included with the package. All necessary materials were provided, including studs and rafters, stairs, shingles, windows, doors, inside finishing materials, and sometimes even paint and linoleum.[8] In other cases, a greater level of prefabrication was used by combining factory-constructed wall panels with pre-cut framing.

These precedents, along with much theorizing during the interwar years about the promise of factory-produced homes, demonstrated alternatives to conventional construction methods. Such alternatives became of national importance during World War II. With the intensification of the war in early 1940, the NHAA announced that "there was a great need for new ideas and methods of construction and that if such were forthcoming the inventors would get immediate contracts." Many proposals were received, ranging from "the use of wood to sprayed concrete and from complete on-site to complete off-site building. None worked out very well."[9]

Instead of revolutionary new systems, proven techniques were most often refined. The houses built by the NHAA and later by Wartime Housing Ltd. used some prefabrication. (See figure 4-5) Wartime Housing Ltd. purchased materials in large volumes for the private builders who constructed the houses on contract. Because designs were standardized, a semi-fabricated approach was used in which plywood floor, wall, interior partition and ceiling panels were built in shops and assembled on the building site. Since they were designed as temporary houses, most had neither a furnace nor a basement--only a space heater and a crawl space.[10]

A bolder approach was used when constructing a 150 bed staff hotel at the Canadian Industries Ltd. plant at Brownsburg, Quebec. NHAA staff, along with an outside designer, developed plans for the hotel based on a system using jig tables and modular co-ordinated dimensions. Called "Precision Built," the system was designed by an American firm established to encourage modular co-ordination. Material was pre-cut, and windows and doors were fabricated on an assembly line system. Panels were then assembled from these parts and finished with a pre-cut sheet material called Homasote (a recycled paper product). Some panels were also pre-finished on the exterior face with Tentest to provide some insulation. Holes were pre-drilled for plumbing and wiring. The panels were numbered and stacked in proper order to be shipped to the work site for assembly. The building went up in three months, a remarkable pace of construction at the time. While cost effective for a large project, it was more expensive than conventional construction for single detached houses and provided little immediate inspiration for private builders.[11]

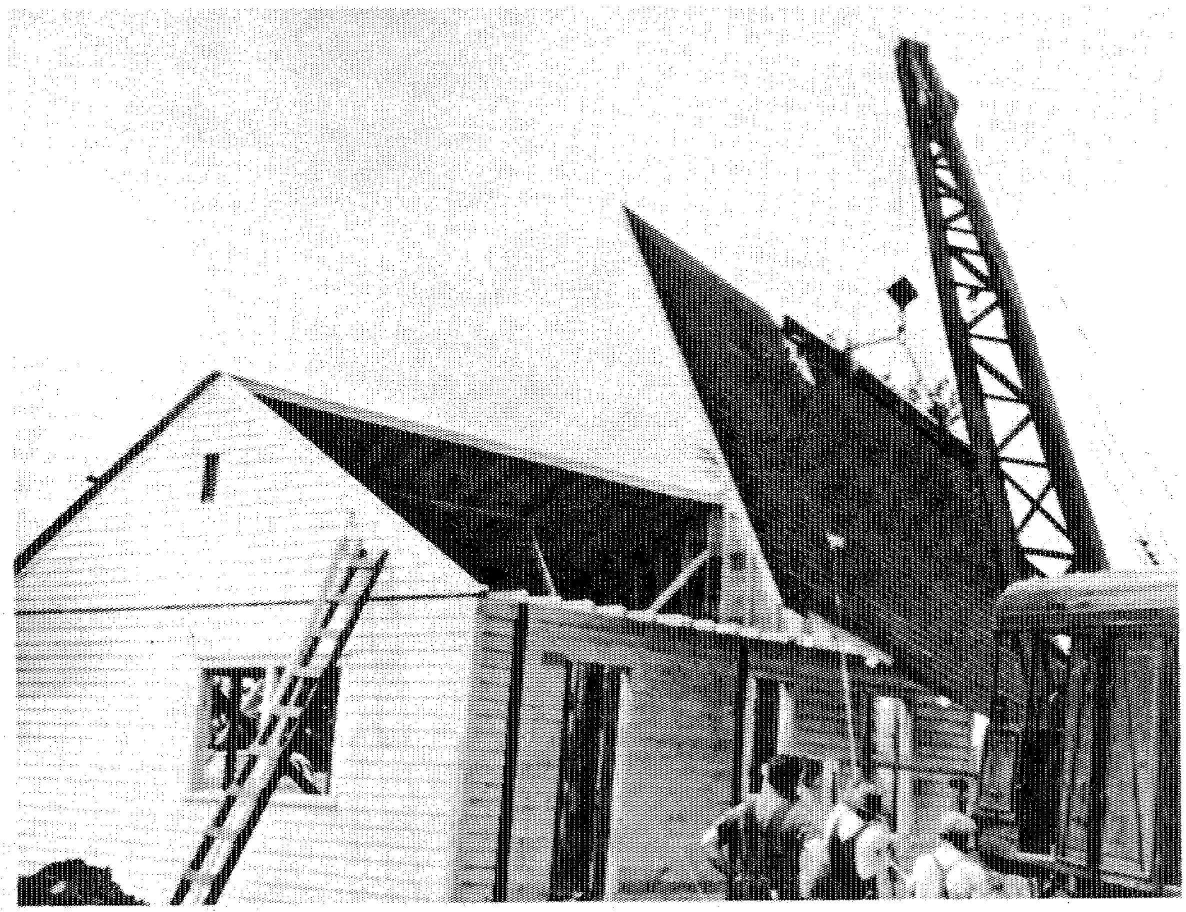

Figure 4-5. This 1941 photograph shows a roof panel being hoisted into place on a wartime house in Moncton, New Brunswick.

National Archives of Canada/PA-187720

Postwar Experiments in Alternate Building Systems

Canada's postwar housing shortages led to a huge number of proposed solutions. Houses built of "rammed earth, bottles, straw, and plastics, as well as new formulations for wood, prefabrication, insulation and suggestions bordering on the idea of growing houses from seed were being advanced."[12] The more serious of these schemes often used prewar and wartime technical precedents and applied factory methods of production to housing. The war had reinforced already powerful notions that technical innovation and factory methods of production and organization could solve all problems--whether social or material. For a time, these heightened expectations revived the idea that houses could be produced like automobiles in factories. Yet, as Sam Gitterman observed, the "difference was that when a car comes to the end of the [assembly] line, it goes into its natural habitat designed for it, which is a road to travel down. But the poor little house, when it comes to the end of the plant, is just at the beginning of the journey to a site which has to be prepared for it."[13] Significantly, the only successful completely prefabricated houses were mobile homes, which were based on the model of the automobile.

Nonetheless, serious attempts to achieve factory-produced houses were made. After World War II, airplane manufacturers in both the United States and Canada attempted to diversify into peace time production, and some looked to housing. In Canada, with the encouragement of the NHAA, Fairchild Aircraft of Montreal built a totally prefabricated house based on American designs. Called the Faircraft House, it used stressed skin construction and featured large piano hinges, so that it could be folded up for transport and "opened up" at the site and placed on a foundation. In theory, this was workable, but in practice the problems were daunting: transportation, marketing and distribution were especially difficult, and the house cost more than a conventional stick-built house. Moreover, the roof leaked along the hinges. Production was discontinued in 1947. Because the NHAA had encouraged the project, CMHC assumed responsibility for the leaky roofs and replaced them at its expense.[14]

The NHAA's support for the concept of the Faircraft House arose from a desperation in Canada to find ways to meet postwar housing shortages. CMHC continued this search after 1946 and attempted to maintain public awareness of the possibilities of prefabrication. It also investigated the potential of a number of prefabricated building systems. One of these was the Lustron house, manufactured in the late 1940s by a consortium of U.S. aircraft manufacturers. Using a steel frame to which were snapped small metal panels with a porcelain enamel finish, it promised rapid construction and a sound structure. It was found unsuitable because of its cost and because the enamel finish tended to chip. Another system that CMHC investigated in the late 1940s was a house manufactured by the General Panel Corporation, another United States firm. (See figure 4-6) Developed in association with the architect Walter Gropius, it was a basementless house constructed of wood panels connected by means of an ingeniously designed system of joints. It also was found to be too expensive. As well, CMHC looked into a plastic structure, called the Monsanto House, but found it too experimental. (See figure 4-7) Another prefabricated system CMHC investigated was a British system called the Riley Newsum house. (See figure 4-8) One of these houses was purchased and erected at Ajax, a wartime community near Toronto that CMHC was redeveloping. Using plywood glued to studs and roof trusses that were hinged for ease of transport and which opened at the site, the Riley Newsum house too was found to exceed the costs of a conventionally built house.[15]

At the same time that CMHC was investigating these prefabricated systems, it was carrying out its own experimentation on alternate building systems. One effort was a project that aimed to explore methods of reducing the labour intensive and costly layers of a conventional stick-built house. As Sam Gitterman observed, "if we could find one material of a homogenous character which could be put in place, easily assembled, possibly automatically without nails or clamps or cleats," labour costs could be reduced substantially. One material so tested was foam glass, a material used in refrigerators. While never considered an alterative to wood because of its greater cost and friability, it was hoped that foam glass might demonstrate the benefits of using a single homogenous waterproof material.[16]

The concept was applied by CMHC in 1948-49 in Ajax. Foam glass panels, measuring 8' x 4' (2400 x 1200 mm.) and 4" (100 mm.) thick were made from smaller pieces held together with a rubber-based adhesive. The panels were then joined by a quick- setting adhesive to form walls on top of a slab on grade foundation. This formed the shell of the house--"no steel studs, no wood studs, nothing but the foam." Because of the brittleness of the foam glass, a cheesecloth covering was glued to the panels after the walls had been erected. A wooden plate on the top of the walls spread the roof load. The roof was flat, built conventionally with 2" x 8"(38 x 184 mm.) joists. It took four workers about 16 hours to put up the house.[17] (See figures 4-9 and 4-10)

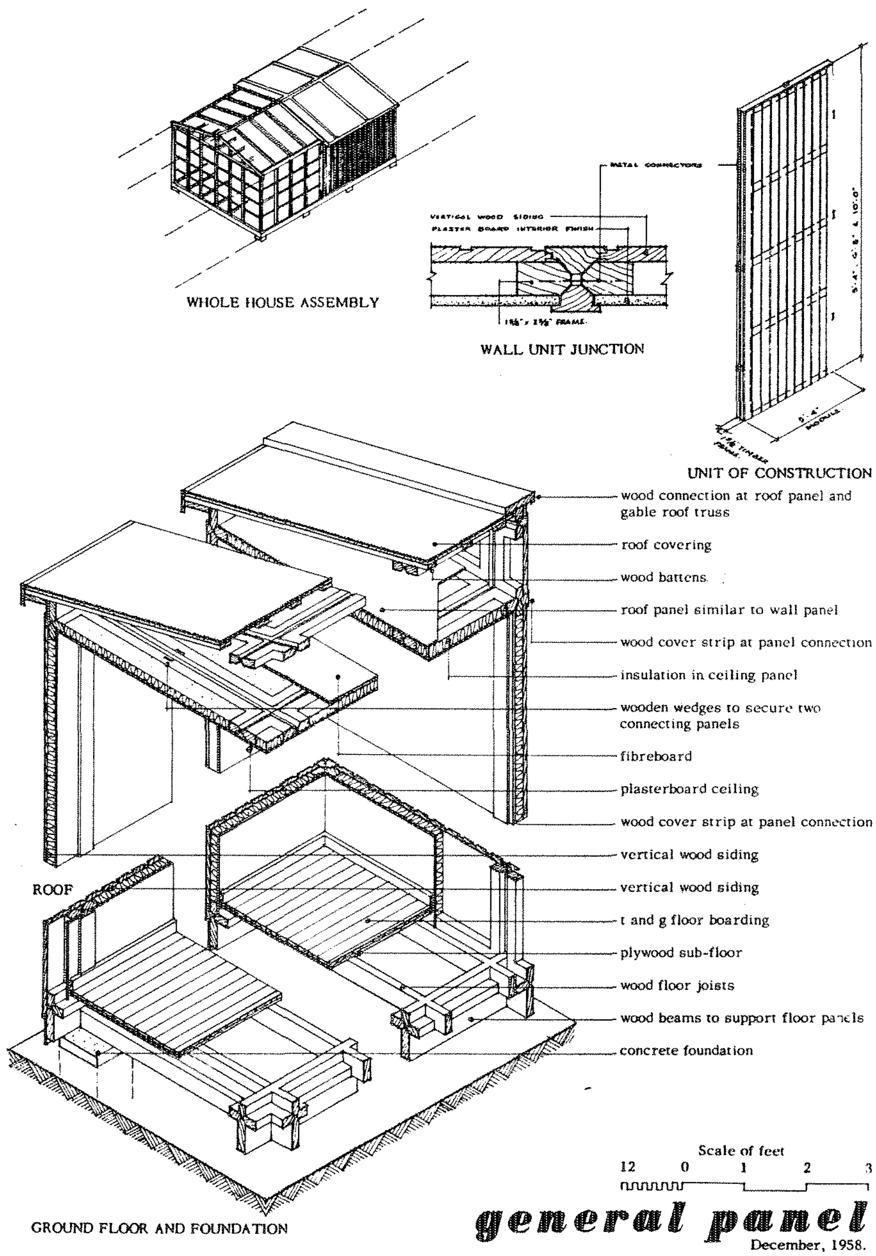

Figure 4-6. The General Panel Corporation, a United States firm, manufactured this prefabricated house in the late 1940s.

CMHC, Catalogue of House Building Construction Systems (Ottawa: CMHC, 1960), not paginated. Reproduced with the permission of Canada Mortgage and Housing Corporation.

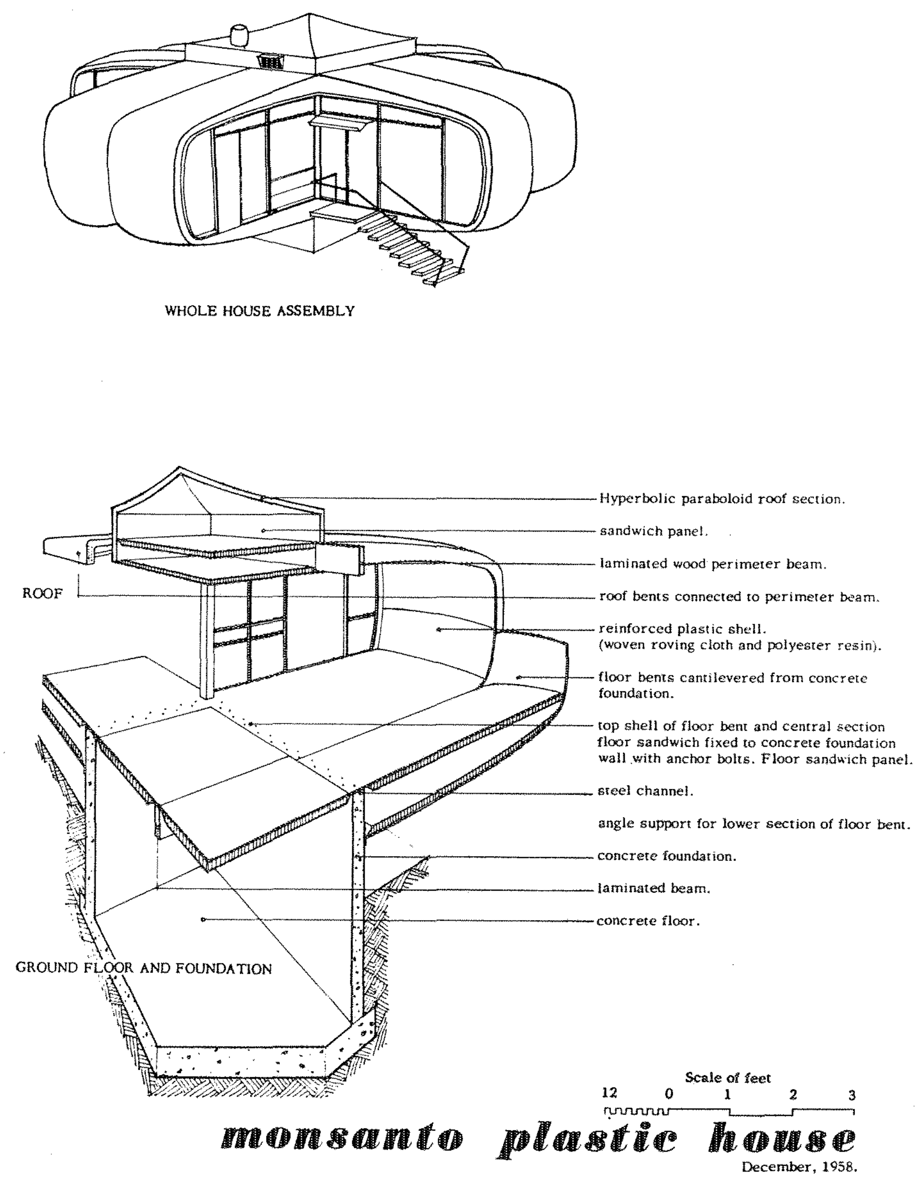

Figure 4-7. A CMHC study in the late 1940s found that the prefabricated Monsanto plastic house was impractical.

CMHC, Catalogue of House Building Construction Systems (Ottawa: CMHC, 1960), not paginated. Reproduced with the permission of Canada Mortgage and Housing Corporation.

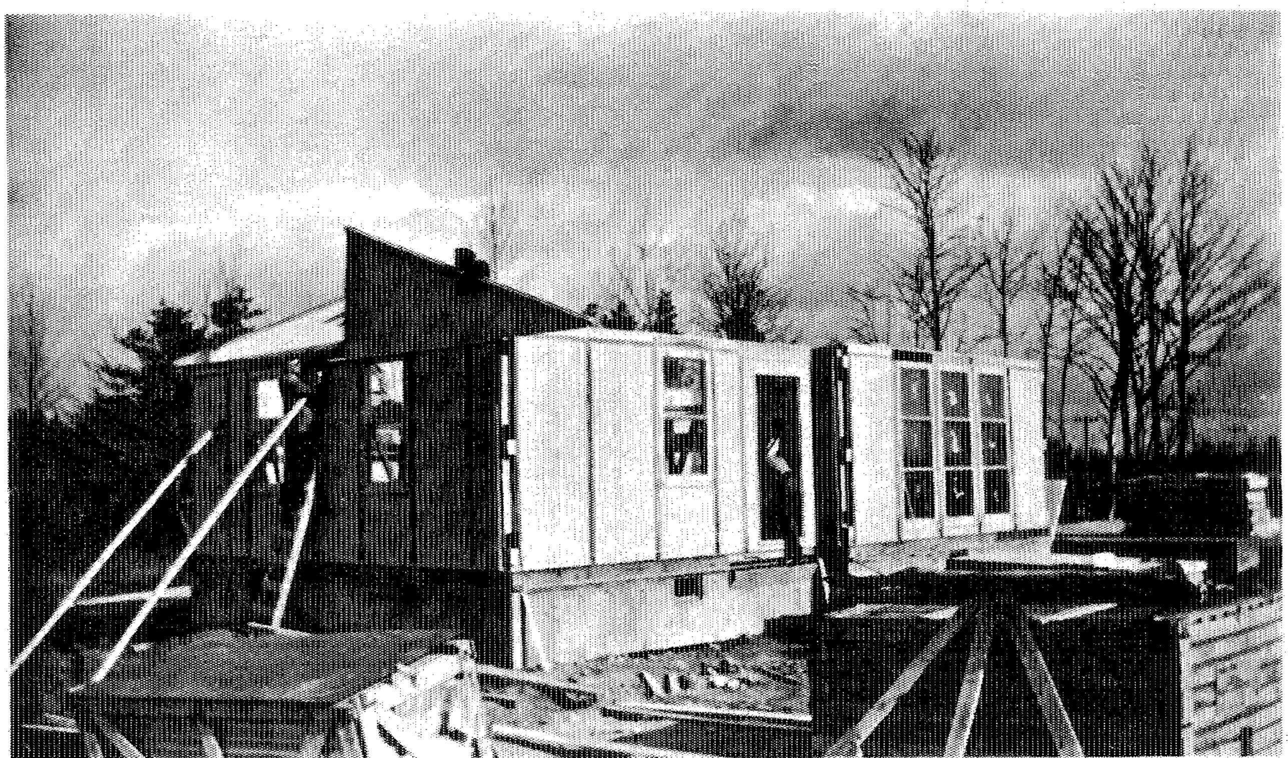

Figure 4-8. The Riley Newsum house, a prefabricated house manufactured by a British firm, was tested by CMHC at Ajax Ontario, in 1952.

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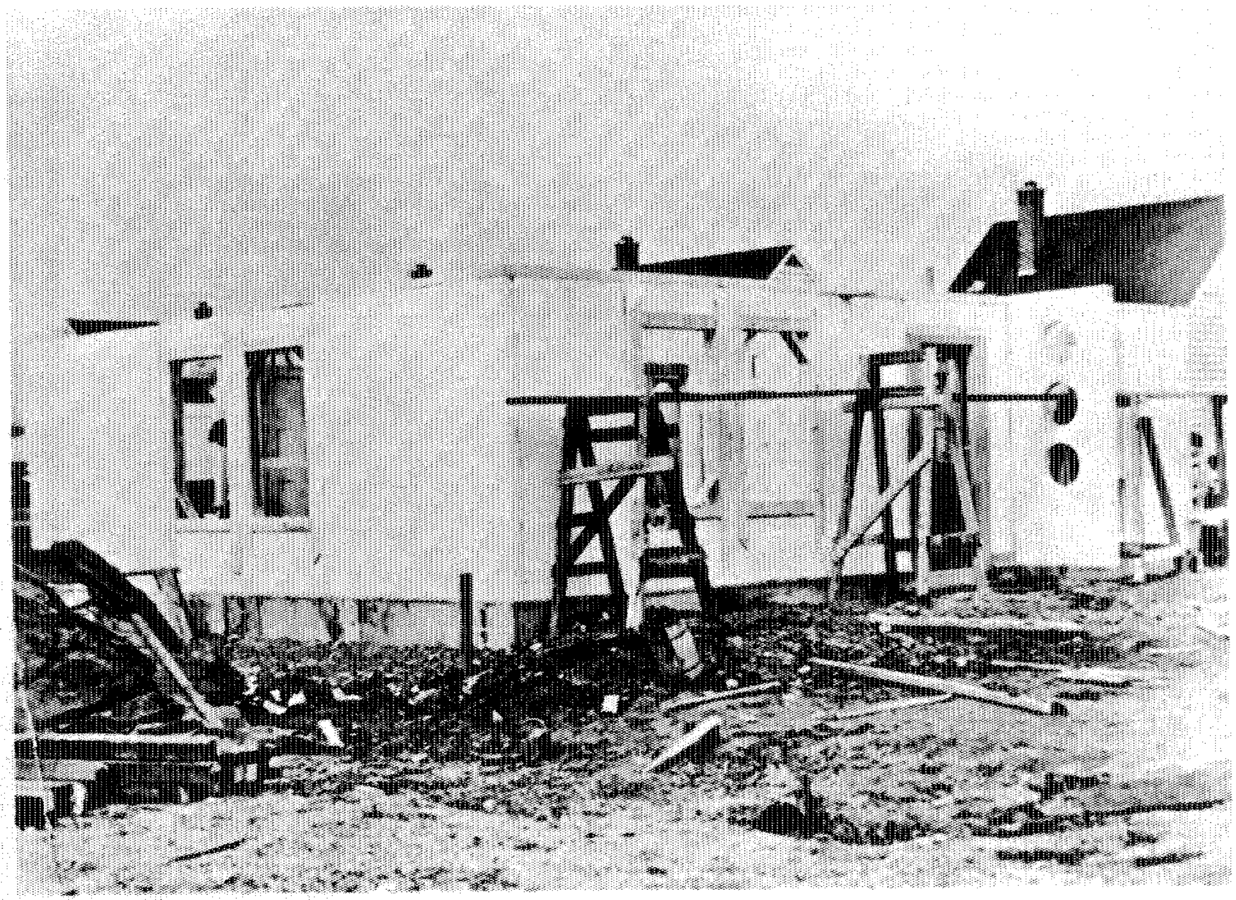

Figure 4-9. The foam glass house under construction in Ajax, Ontario in 1948-49.

National Archives of Canada/PA-187733

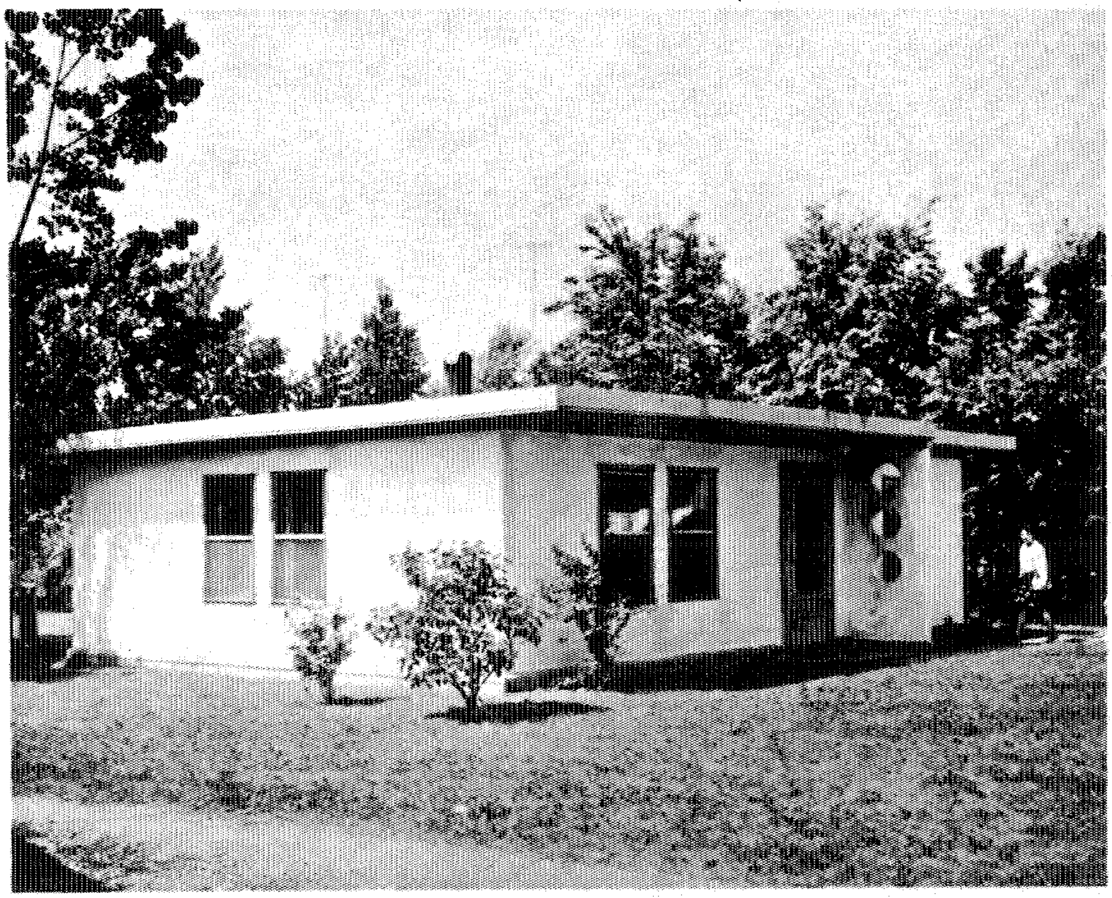

Figure 4-10. The foam glass house in Ajax continued in use until 1971. Photograph not dated.

National Archives of Canada/PA-187731

As Sam Gitterman recalled, the structure "looked so reasonable" that it was decided to finish the interior walls with plaster (applied directly over the foam glass) and to install bathroom and kitchen equipment. Plumbing and electrical service was simple to install because the foam glass cut easily with a knife. The house was then rented and continued in use for about 20 years. Although still structurally sound, various problems were beginning to occur by 1971, and the house was demolished. It had stood up well--there was only minor damage around the windows from water and frost.[18] It had been a bold expression of the view that costs could be saved by reducing the layers used to build a house. A similar demonstration was repeated by CMHC and DBR in a test house in the mid 1950s when plastic foams became available. Such practices, however, never gained public or technical acceptance due to their cost and competing developments that were making more conventional building practices more efficient. (See figure 4-11)

Modular Co-ordination

The belief after World War II that prefabrication and higher factory content could help solve supply and affordability problems also led to hopes that traditional building could become more efficient through "modular co-ordination." This idea had originated in the United States in the 1920s, and was based on the premise that the first step in industrialized production was standardization of dimensions.[19] Modular co-ordination had been used by the NHAA in some of its wartime construction projects. Robert Legget, director of DBR, explained in 1957 that "dimensions of materials and equipment used in the construction of a building should be co-ordinated with one another and with the dimensions of the building so as to minimize wasteful cutting and fabrication on the construction site." The unit measurement chosen for use in Canada was 4 inches (100 mm.), which was the commonest unit already in use with many materials. If buildings were designed in terms of the same module used uniformly for all materials and equipment, it was believed that they "could be erected with stock items requiring a minimum of cutting or fitting at the site" without restricting design possibilities.[20] This was called an "open system" approach and anticipated a building system in which any manufacturer's components could fit with those of any other manufacturer to form any building.[21]

Both CMHC and DBR were early proponents of this concept. In the late 1940s, DBR convened a meeting of architects, building manufacturers and others to discuss modular co-ordination. Despite the endorsement of this meeting's participants, there was insufficient time and money to promote the system, and it was not until 1956 that the

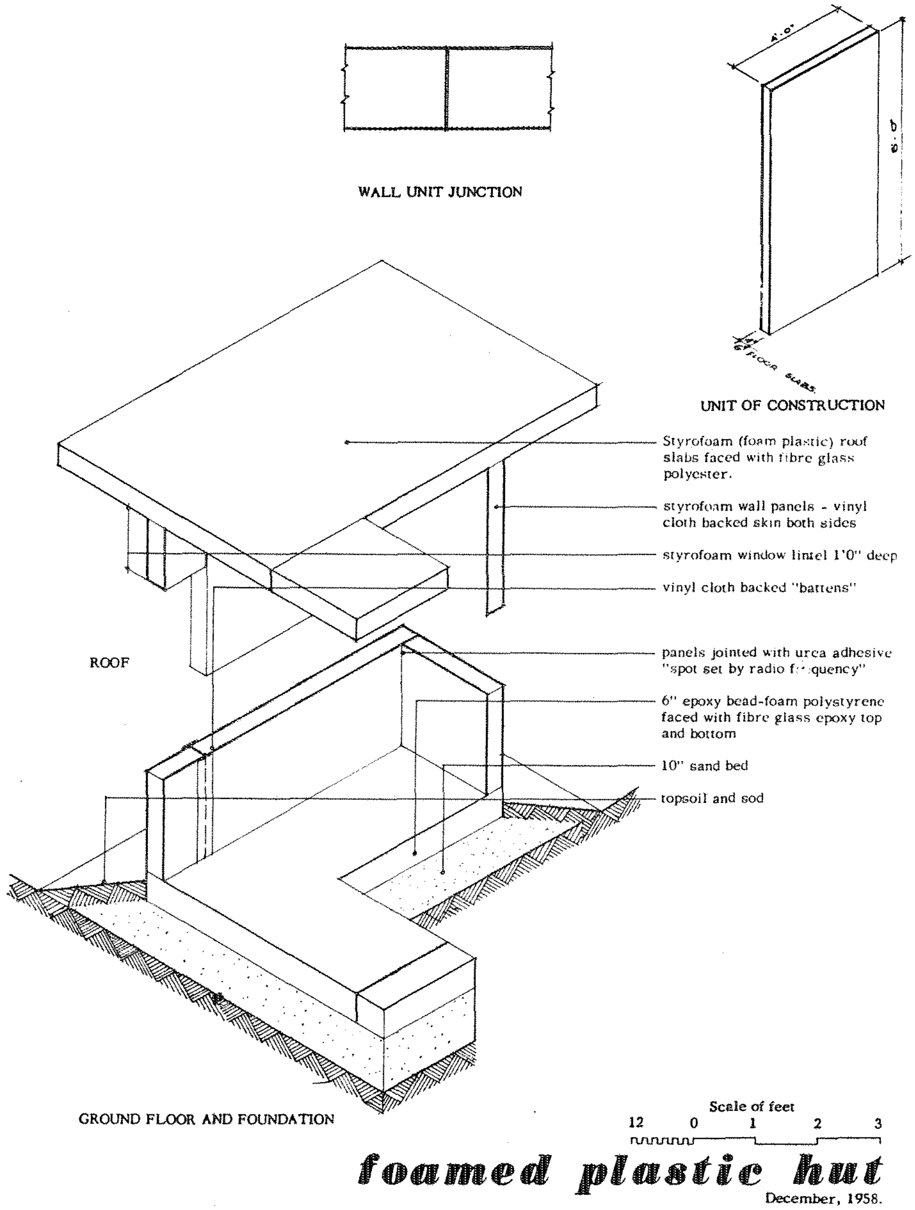

Figure 4-11. In the mid 1950s, CMHC and DBR built this demonstration house using plastic foams.

CMHC, Catalogue of House Building Construction Systems (Ottawa: CMHC, 1960), not paginated. Reproduced with the permission of Canada Mortgage and Housing Corporation.

Division was able to sponsor lectures and publications on modular co-ordination. At the request of DBR, the CSA formed a committee to work on basic issues associated with modular co-ordination.[22] The NHBA also supported the concept, as did the Ontario Association of Architects. The National Concrete Producers' Association sponsored a CSA standard on concrete masonry products to establish modular sizes for the industry.[23] These efforts continued until the late 1960s, and other federal government departments joined in the move to promote modular co-ordination.[24] As part of this effort, the Mark houses were built on a 4" (100 mm.) module.

Despite such backing, modular co-ordination never became a general housing industry practice. Its implementation necessitated resolution of many complex questions about sizes of materials, types and shapes of joints, and construction practices in general.[25] Many important materials (such as standard size plywood, which came in a 96 x 48," or 2400 x 1200 mm., sheet) were already available on a 4" (100 mm.) module, and the number of such materials continued to increase. In any event, builders could easily adjust differing dimensions to fit the material when working on a small house. As one commentator has observed, the wood frame system used in Canada was so adaptable in terms of changing dimensions that "modular co-ordination never really offered much of a potential for saving" beyond products already on the market.[26]

Improving On Site Productivity

In the 1950s there was steady growth in the use of prefabrication to speed up construction and reduce costs. Robert Platts, who worked with DBR, notes that there were two major "streams" in prefabrication in the 1950s: what he called the "project prefabricator" and the "open market prefabricator." The project prefabricator, or project builders, had their own shops producing panels, trusses, windows, and, among other components, cabinets and stairs for use in their building projects. The open market prefabricator, who Platts calls "the prefabrication idealists," tried to produce "house systems as a complete package" for any buyer using panels, pre-cut floor joists, roof trusses and other materials. These tended to have a largely rural and summer cottage clientele.[27]

Open market prefabricators, in particular, occasionally also used stressed skin plywood laminated panels to form walls, and sometimes floors and roofs. This system had been developed in the United States and had been used by the Canadian military during World War II in its "General Purpose" huts. In this system, structural studs were all but eliminated. Instead, "laminated panels with plywood or hardboard covers"--the "skin"--were glued to a framework made up of "web" members which transferred stresses between the sheets to create a strong unit.[28] Usually, the panels were pre-wired and finished on both sides in the factory.[29]

A third, and distinctive, group of prefabricators consisted of modular builders, who produced a house in one or two large sections, or modules, which were transported to the site on a flat bed and put on a permanent foundation.[30] A related effort was the production of modular pre-finished, wired and plumbed units, such as those for bathrooms and kitchens, which were transported as a single unit to the building site and installed in the house under construction.[31] (See figure 4-12)

Despite its theoretical appeal, modular construction proved not as cost effective in practice as in theory. Like any factory-built product, high levels of production were needed to realize economies of scale and organization. Transportation costs also often made them uncompetitive. More importantly, the whole building system had to be changed to accommodate them since it was difficult simply to fit them into a traditionally built structure. In the case of stressed skin houses, similar limitations were inherent in the system. Because of the way stress was distributed across the panels, their strength could be altered if they were cut, making some later renovations (such as adding windows) difficult. And among other technical problems, low-cost methods of finishing the inside of the exterior walls were not available.[32] Moreover, while stressed skin panel houses were used successfully in northern housing, they met with some consumer scepticism and resistance by lenders in the south. Open market prefabricators were most successful in rural and small town areas in southern Ontario, Saskatchewan and Alberta. In small town and rural markets, where costs tended to be higher for conventionally built houses than in cities, the open market prefabricators were highly competitive. In cities, however, their cost advantages were not so great, and they also encountered opposition from trades dependent on stick building. Moreover, it was difficult to obtain the necessary changes in building codes in large cities. At best, given the fragmented nature of Canadian building regulations, open market prefabricators gained acceptance in one place but not another.[33]

At the same time, conventional stick builders were, in Robert Platts' words, "getting smarter and smarter and picking up the same thinking and basic components of the prefabricator."[34] During the 1950s and 1960s, the lines between conventional building and prefabrication were beginning to blur. Stick builders found that preassembly of

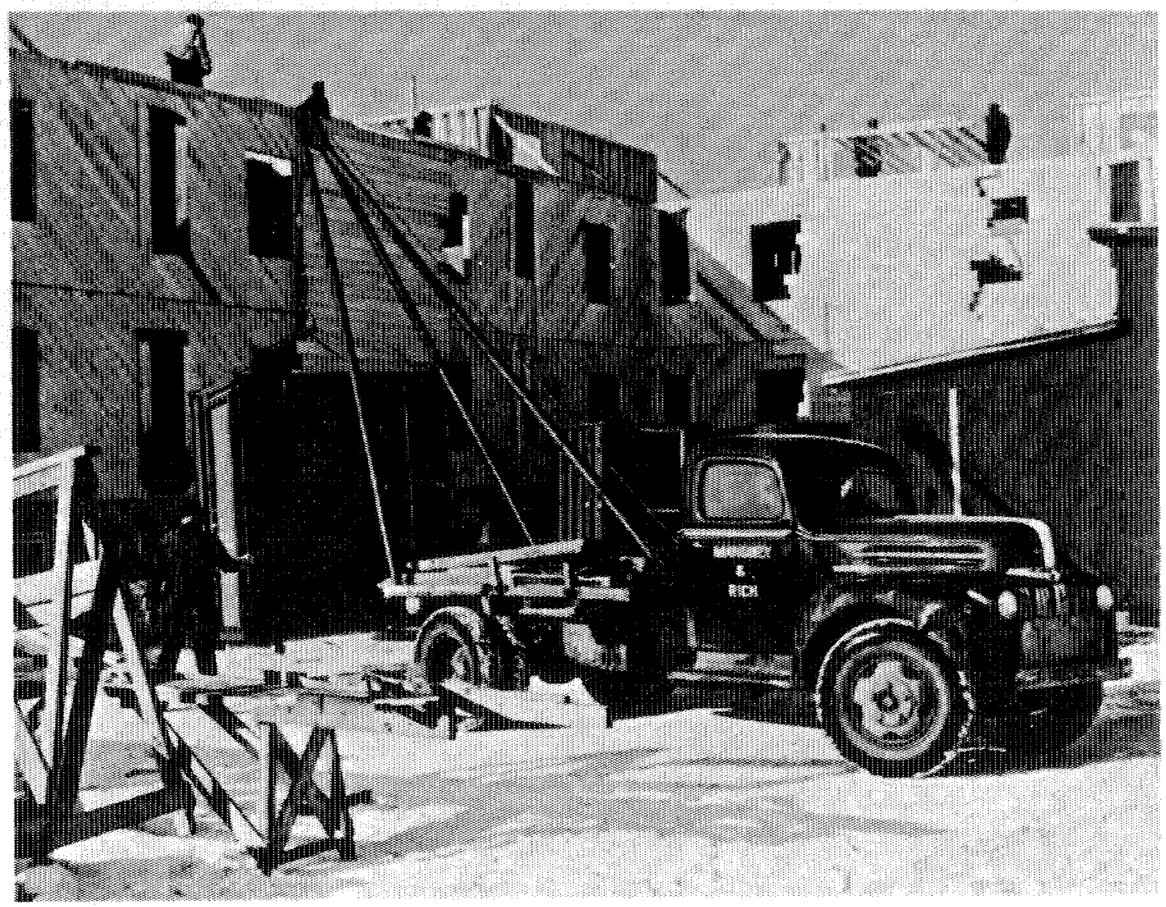

Figure 4-12. This prefabricated bathroom unit was installed in an Ottawa apartment building in 1947.

National Archives of Canada/PA-187708

component parts and standardization were cost effective. Increasingly, they pre-cut framing and wall panels and built cabinets, stairs and other components in their own shops, or, alternatively, purchased such components from a growing number of local manufacturers. (See figures 4-13 and 4-14) Such developments began to make building more of an assembly process than one of craftsmanship, and reduced on-site construction time and the amount of skilled on-site labour needed. At the same time, quality could be increased through production in controlled shop conditions.[35] While only about 12 percent of the 76,000 houses built in Canada in 1961 were prefabricated, almost all house builders by this time relied in varying degrees on prefabricated items like windows, doors, cabinets and roof trusses.[36]

All of these developments in prefabrication and component parts can be characterised as a form of industrialized building. In addition, industrial methods of organizing the work site were beginning to appear in conventional construction. The houses that CMHC built for veterans in the late 1940s used standardized design, employed mass produced components like windows and doors, and tried labour-saving new materials like aluminum siding. Because of the large number of houses being built, large production runs of components were feasible and helped reduce costs. While this approach was not particularly innovative since it had been given wide application earlier by the NHAA and Wartime Housing Ltd., it helped popularize and further promote the concept of using component parts and different ways of organizing building operations.[37]

Wartime and veteran's programs essentially applied a system of industrial organization to building by using component parts, better sequencing of operations and other organizational techniques to secure efficiency, speed and economy. Throughout the 1950s and early 1960s, such principles were increasingly applied to house building, and by the 1960s, such organizational issues were being analyzed in a number of studies by DBR. By this time, the assembly line principle had been brought to the building site. As Sam Gitterman wrote in 1967, on large projects

> the earth moving machinery excavates for each house in a successive progressive manner; then prefabricated forms are placed, moving from one excavation to the next and concrete foundations poured; the floor-framing crews come next, then the wall framers and other specialists with particular crews moving across the project from house to house in an orderly, prearranged manner. In all cases the greatest advantage is taken of the latest equipment and tools for assembly.

Figure 4-13. Traditionally, kitchen cabinets were built on site by carpenters, such as these ones in Capetown, New Brunswick in 1959.

National Archives of Canada/PA-190693

Figure 4-14. By the late 1950s, prefabricated kitchen cabinets, such as these in a Lethbridge, Alberta house, were beginning to replace cabinets built on site.

Glenbow Archives, Calgary, Alberta, A.E. Cross Collection, NA-5327-297

> This is assembly line production geared to a field operation and designed to suit the construction of immoveable objects.[38]

These changes reflected an ambition to speed up construction and reduce the need for skilled labour. They also helped counter rising costs after 1945. Wood prices, for example, were four times their prewar level by 1951, making techniques for reducing use of wood attractive.[39] So too, a greater demand by the public for low maintenance houses helped confirm the shift away from wood. By the 1950s, for example, pre-finished aluminum or hardboard sidings were appearing, and although traditional sidings remained typical until the 1960s, the trend was clear.

Many of these changes came about because of a better understanding of the structural dynamics of buildings. In the late 1940s, DBR built a special testing apparatus to apply simulated snow and wind loads to a full scale test house. (See figure 4-15) It was found that interior cladding was the "predominant influence in racking strength and stiffness." This significant discovery led to important changes in housing standards. It was apparent that sheathing under some exterior claddings could be eliminated, that diagonal bracing was unnecessary, that the size of lumber needed for some members could be reduced, and that framing could be simplified through "standardization and modular dimensioning."[40]

These findings dovetailed with a growing use of sheet wood and wood by-product materials. After World War II, plywood became less expensive and more widely available. Early stressed skin systems had relied on plywood, and it also came into wide use after 1945 in conventionally built houses. It was a revolutionary product because its strength, durability, and the ease with which it could be worked, especially with power tools, reduced construction time, improved building quality, and used less wood. When plywood was used instead of boards for subfloors, walls and roofs, tighter joints between floors and walls were created. As well, when used as an exterior sheathing, plywood was more airtight than boards. (See figure 4-16) In addition, by the 1960s, sheet materials made from wood products formerly thought of as waste were beginning to be developed, and plastics and wood fibre were being combined to produce sheet building materials. These materials were cheaper than plywood, but often could be used in the same manner and with the same advantages.[41]

There were, of course, limits to the savings that could be realized through these approaches. One study in 1966 found that almost 60 percent of the total cost of a house

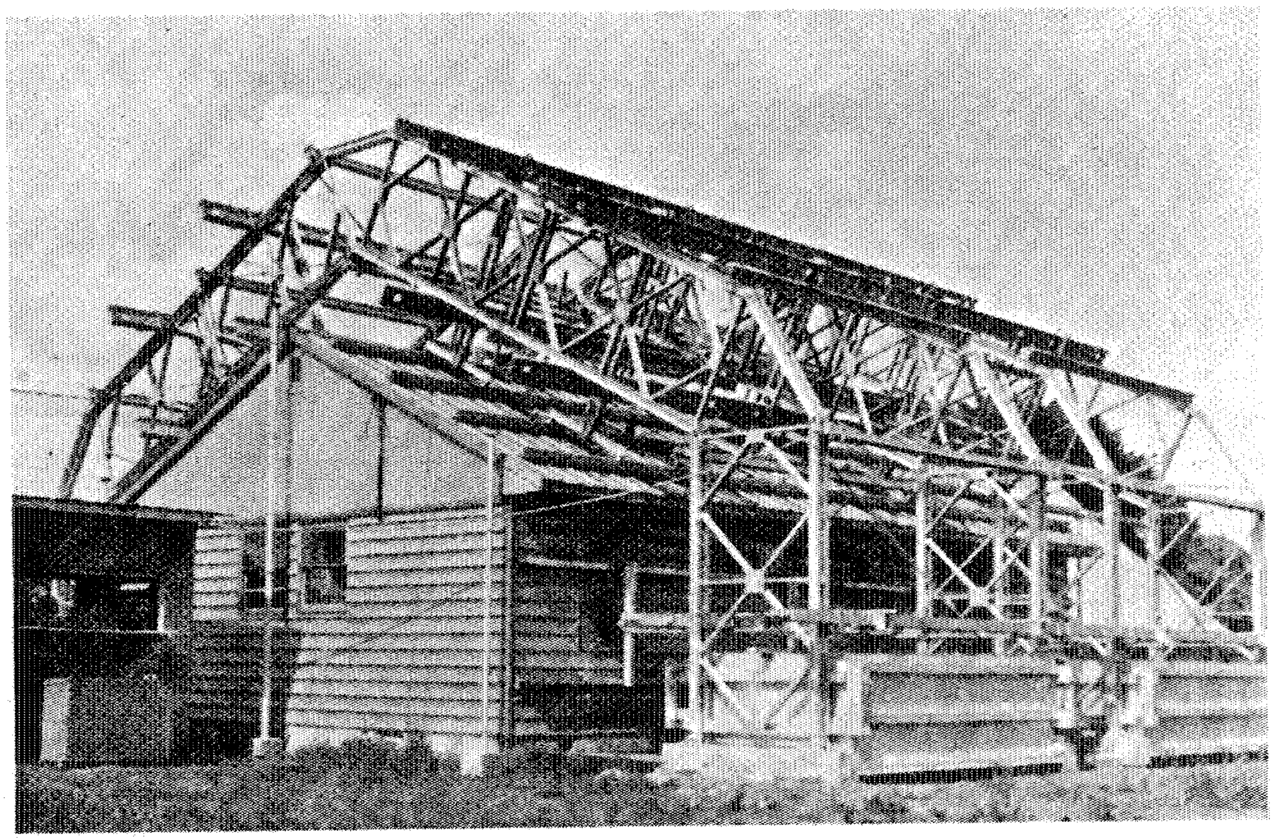

Figure 4-15. In the late 1940s, DBR invented this apparatus to test roof loads.

D.B. Dorey and W. R. Schriever, Structural Tests of a House Under Simulated Wind and Snow Loads (Ottawa: National Research Council, 1957), p.34. Reprinted, with permission, copyright ASTM and with permission of the National Research Council of Canada.

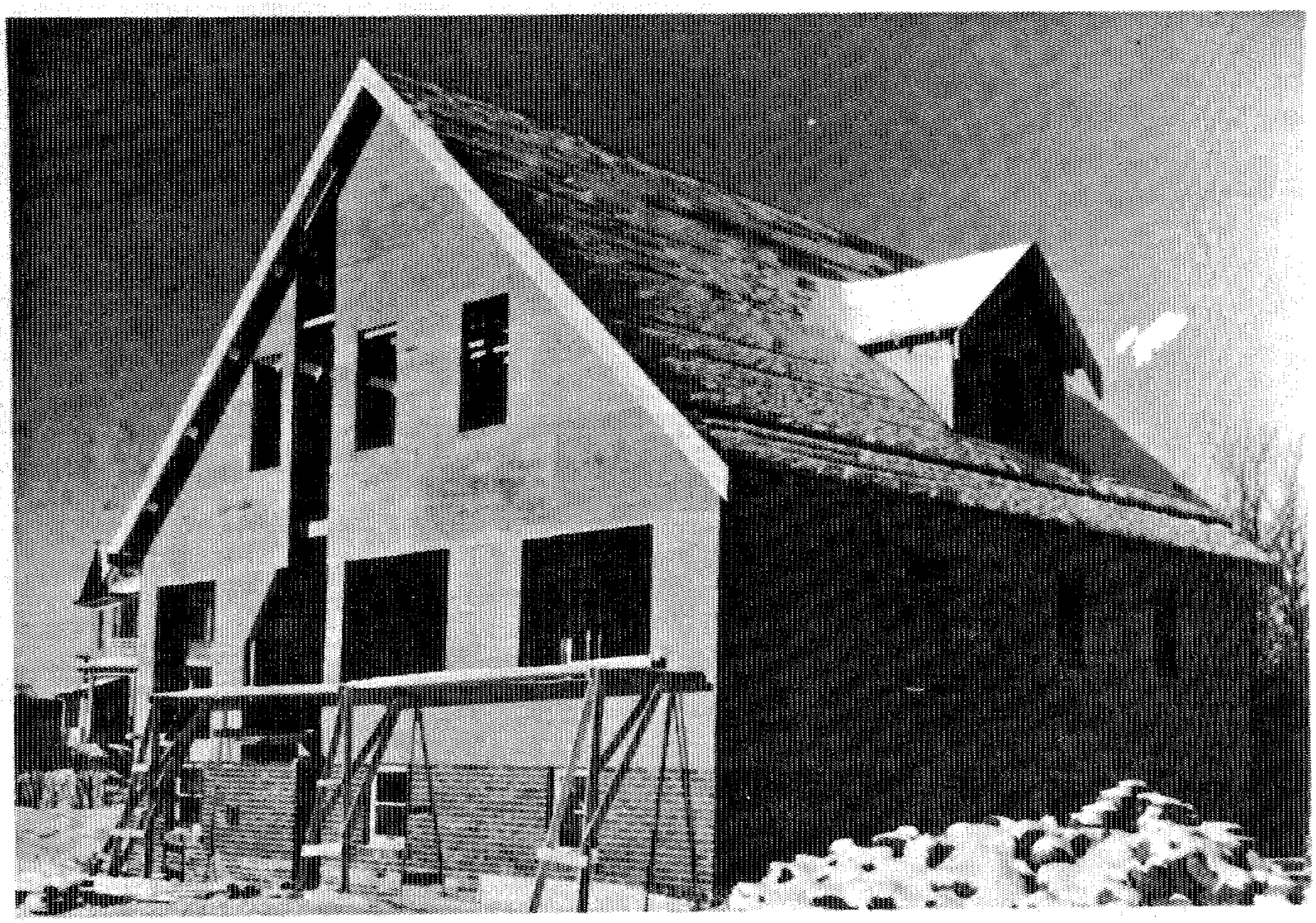

Figure 4-16. This photograph of the Muttart's house in Edmonton in 1938 shows an early use of plywood for sheathing. Following World War II, such use of plywood came into wide use.

City of Edmonton Archives, Hollingworth Collection, EA-160-352 was made up of elements that were already prefabricated or included such aspects as land, builder's profits and excavation costs. In other words, further savings were minimal or impossible to find in these areas through refinements such as prefabrication, either because they were not applicable or had already been realized.[42] As was concluded in a DBR report in 1965, "wood frame construction has been developed to the point where further significant savings are difficult to achieve by refinements of the basic systems itself." Further savings would have to be found in further prefabrication of the rough shell of the building or by developments in structural sandwich systems which used plastics for the adhesive, the core and sometimes the surface "skin."[43] As an indication of the way that research and development were cumulative, some findings from the DBR-CMHC plastic foam house of the mid 1950s found application a decade later in this development of structural sandwich systems. Even so, by the 1960s plastics were still not used for structural purposes in construction, although they had become the dominant material in nonstructural applications such as claddings, coverings and coatings.[44]

Roof Trusses

The advantages of component parts were exemplified by the use of roof trusses. Traditional roof framing with joists and rafters was labour intensive and used a great deal of wood. In contrast, lightweight wood roof trusses offered a way to frame a roof quickly without sacrificing strength or durability.

Trusses had been built laboriously from timber for centuries, but were complicated structures to engineer. By the late nineteenth century, trusses were being made of metal, but metal shortages in Europe after World War I once again led to the use of wood. Improved methods of fastening wood members together were devised. Research in the United States in the 1930s also produced new types of fasteners, and following World War II, further research and experimentation developed additional types of fasteners. As a result, lightweight wood roof trusses were in fairly wide use in the United States by the late 1940s.[45]

Lightweight wood roof trusses offered important advantages. They used about 50 percent less wood than conventionally framed roofs. Moreover, because they transferred stress onto the outside walls, interior partitions no longer had to support the roof joists, leading to further economies and greater freedom in interior layout. (See figure 4-17) Further, they were built in a shop which helped reduce the need for skilled on-site

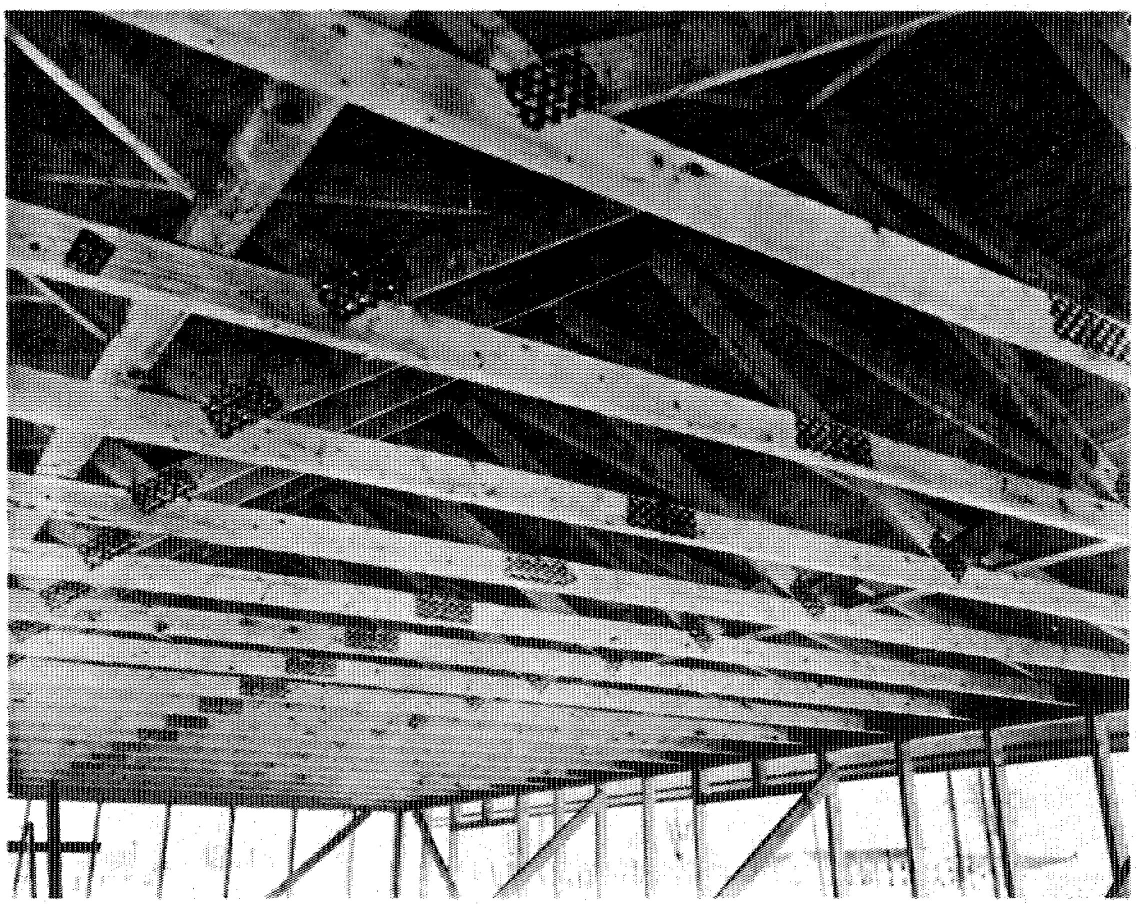

Figure 4-17. Roof trusses, such as these in the Mark IV experimental house in 1964, permitted greater freedom in interior layout because interior partitions were no longer required to support the roof.

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labour, and reduced construction time. It was estimated in 1963 that three workers could install trusses on an average sized house in about an hour.[46]

These advantages were recognized by Canadian builders, but it was difficult to apply American truss technology because Canadian lumber design requirements were different than those in the United States. In 1954, CMHC's Building Standards required, in effect, that roof trusses be designed using conventional engineering methods, making them uneconomical in comparison to conventional rafter and joist construction. In addition, Canadian building codes set higher snow load requirements for roofs.[47] These conditions had encouraged CMHC and DBR by 1956-57 to study how trusses could be made more economical for Canadian conditions. DBR discovered that while traditionally framed roofs were weaker than lightweight wood trusses, they rarely failed because of snow loads. Thus, it was obvious that the higher standards demanded for trusses were unnecessary. As Oz Hansen, who worked at DBR, remarked, by reducing the standards "we were justifying a much lower factor of safety for roof trusses."[48]

A committee of representatives from CMHC, DBR and the Forest Products Laboratory assessed these test results and decided that the most sensible approach would be to produce "benchmark strength values against which roof truss systems could be compared." Specific criteria setting out snow loads were devised and adopted by CMHC for its future evaluation of new truss systems. These criteria were incorporated in NRC's 1962 edition of the housing standards and became part of the National Building Code.

The impact of these developments was considerable. Truss manufacturers could now use traditional engineering analysis (as before) or demonstrate compliance with CMHC standards by tests results proving the performance of their trusses. New designs emerged quickly. Based on NRC and Forest Products Laboratory tests, CMHC published a series of plywood truss designs in 1958. A further series of designs produced in 1962 featured trusses that could be built by a builder without special equipment.[49] By this point, however, truss manufacturing was becoming specialized. As Oz Hansen remarked,

> in the earliest periods there were no truss connectors. There were split ring connectors and there were glued plywood trusses and nailed plywood trusses, initially fabricated by builders. The big leap forward in roof trusses came about with the development of these truss plate connectors--these little metal connectors. They required special equipment to fabricate, and this was usually

too expensive for the average small builder, so it just naturally led into specialized roof truss companies.[50] (See figure 4-18)

The adoption of roof trusses was rapid. While the Mark III house had used a type of roof truss as an innovative feature in 1961, by 1970 about 90 percent of single family houses built in Canada used roof trusses.[51]

Demonstrating New Building Methods

The advantages of using new building products and semi fabricated component parts, as well as new building techniques, to reduce the number of layers and amount of material in a house were demonstrated and promoted in the Mark houses. This experimental approach was reinforced by a general philosophy (popular among scientists in DBR and CMHC) that house construction should not contain elements "that do not have to be there."[52]

In the first two Mark houses, extensive use was made of thinner plywood than allowed by building codes and standards. In the Mark II house, plywood was also used as a combined sheathing and siding. As well, special 14' (4200 mm.) sheets of plywood which stretched in a single piece from ridge board to eave were used to form the roof. In the Mark III house, the roof and walls were constructed from prefabricated panels which had been built indoors at the nearby shops of the Forest Products Laboratory and assembled at the site. (See figure 4-19) Such wall panels were being used by private builders, but in this case they were made larger "to reduce the duplication of materials at each joint." They consisted of 2" x 4" (38 x 89 mm.) studs 24" (600 mm.) on centre (16", or 400 mm., was customary) to which was nailed a combined sheathing siding of a laminated sheet board product finished on the exterior face with a hard asbestos cement finish. The inside face was finished with standard gypsum board. This reduced the number of layers and material used. No lintels were built over the windows or doors because "the surface skins of plywood and gypsum board combined with the framing" made them structurally unnecessary.[53]

These principles were also applied to the floor system in the Mark III which used stressed skin panels about 14' x 8' (4200 x 2400 mm.) manufactured off site. (See figure 4-20) Studs 2" x 6" (38 x 140 mm.) at 24" (600 mm.) centres were nailed together to form a framework which was covered completely by a skin of plywood panels glued and nailed to the frame. The underside was open except for a single sheet of plywood

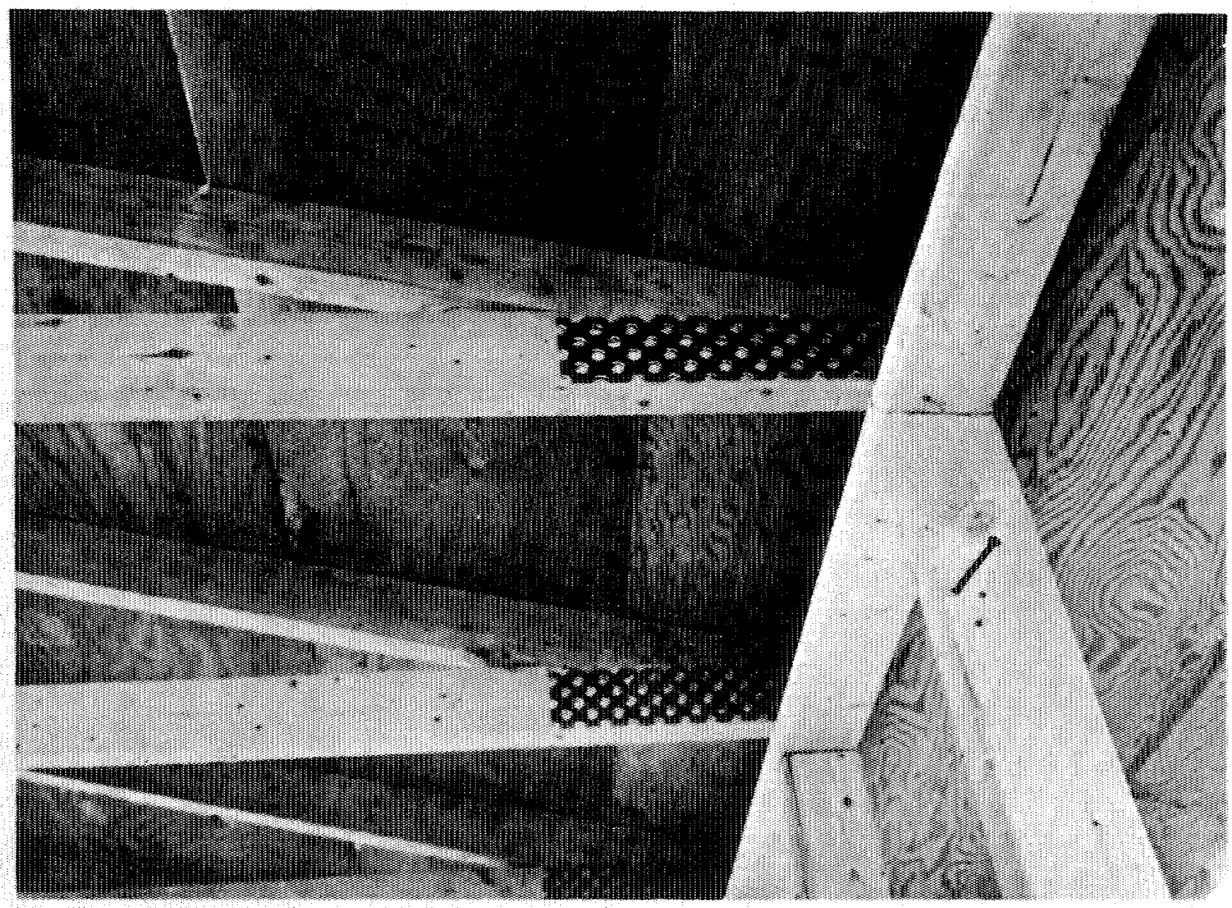

Figure 4-18. This photograph shows the truss connectors used on the Mark IV house in 1964.

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Figure 4-19. Prefabricated panels were used to build the walls of the Mark III house in 1960-61.

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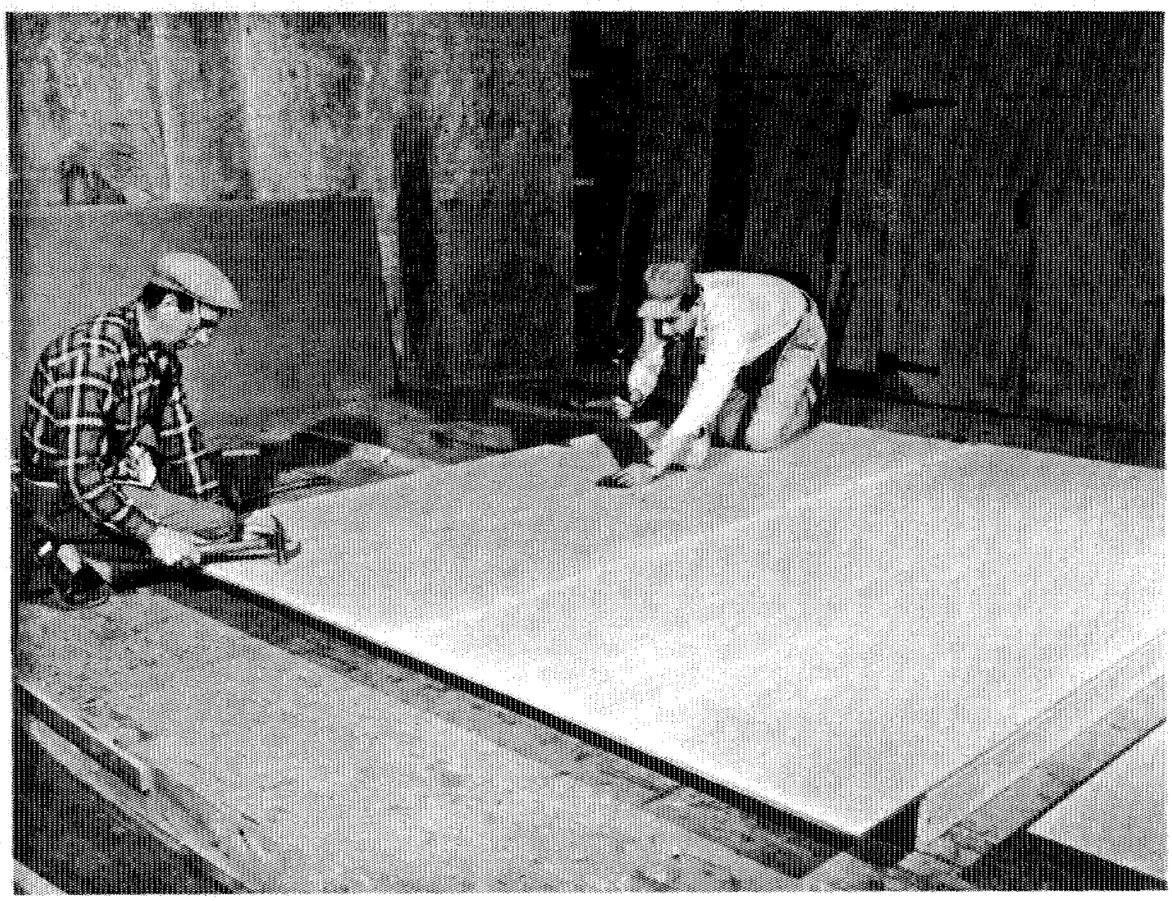

Figure 4-20. The floor of the Mark III house used stressed skin panels.

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fastened in the centre to stiffen the panel. The panels, which were pretested by the Forest Products Laboratory, were easy to build, transport, handle and erect. This design took advantage of the inherent strength of a lumber assembly and helped reduce "springiness" in the floor.[54]

Efforts to reduce the layers of material needed in roof finishes were also made. In the Mark III and IV houses a single uniform material was used instead of asphalt shingles. On the Mark III, a sprayed-on styrene polymer was used, but it failed quickly. On the Mark IV, the joints of the plywood roof were finished with a strip of cotton tape and a coat of asphalt was applied. This, like the plastics used on the Mark III, failed. It was apparent that asphalt shingles would retain their advantages for the foreseeable future.[55]

Equally important demonstrations of new approaches and materials were made with respect to interior finishings, traditionally time consuming and highly skilled work. In the 20 years after World War II, major changes took place in this phase of construction. Use of component parts, such as prefabricated bathroom and kitchen cabinets made from plywood or various kinds of waferboard, was beginning to appear by the late 1960s and significantly lessened the need for skilled on-site labour.

Of equal significance was the replacement of plaster with gypsum drywall. Drywall was installed once the interior partitions were in place, and the joints between the sheets were taped and plastered to provide a smooth surface. This demanded skilled labour, although much less so than for lath and plaster. In 1955 plasters had made up about 7 percent of total cost of on-site labour, but by 1969 this had dropped to less than 1 percent.[56] (See figures 4-21 and 4-22)

All of these trends were expanded in the Mark houses. In the first two houses, the plywood subfloor was finished by painting it. This was not successful because the paint stood up poorly. In any event, by the mid 1960s the fashion of wall-to-wall carpeting led to the installation of carpet directly over the plywood subfloor. Another alternative to conventional practice was the use in the Mark III of a Norwegian method of interior wall finishing recommended by DBR. Dampened heavy Kraft paper was stretched over unfinished gypsum board on the outside walls. The paper was glued around the perimeter of the wall and at openings. (See figure 4-23) It was kept damp until the glue set. When allowed to dry, it formed a "taut, even surface held in place only around the perimeter of the walls and openings." It could be painted if desired, and provided an

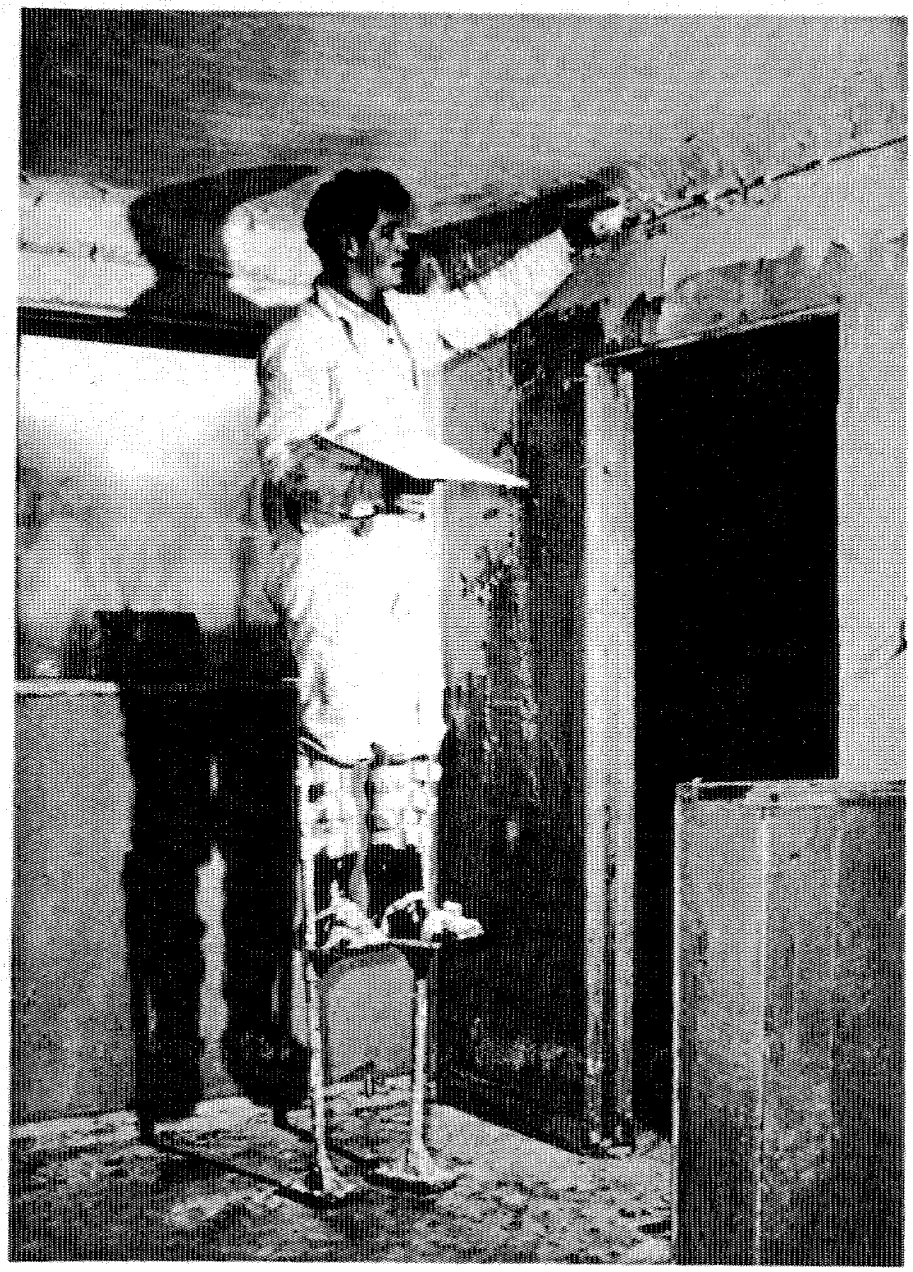

Figure 4-21. Plastering was highly skilled and labour intensive work. Photograph not dated, but probably mid 1950s.

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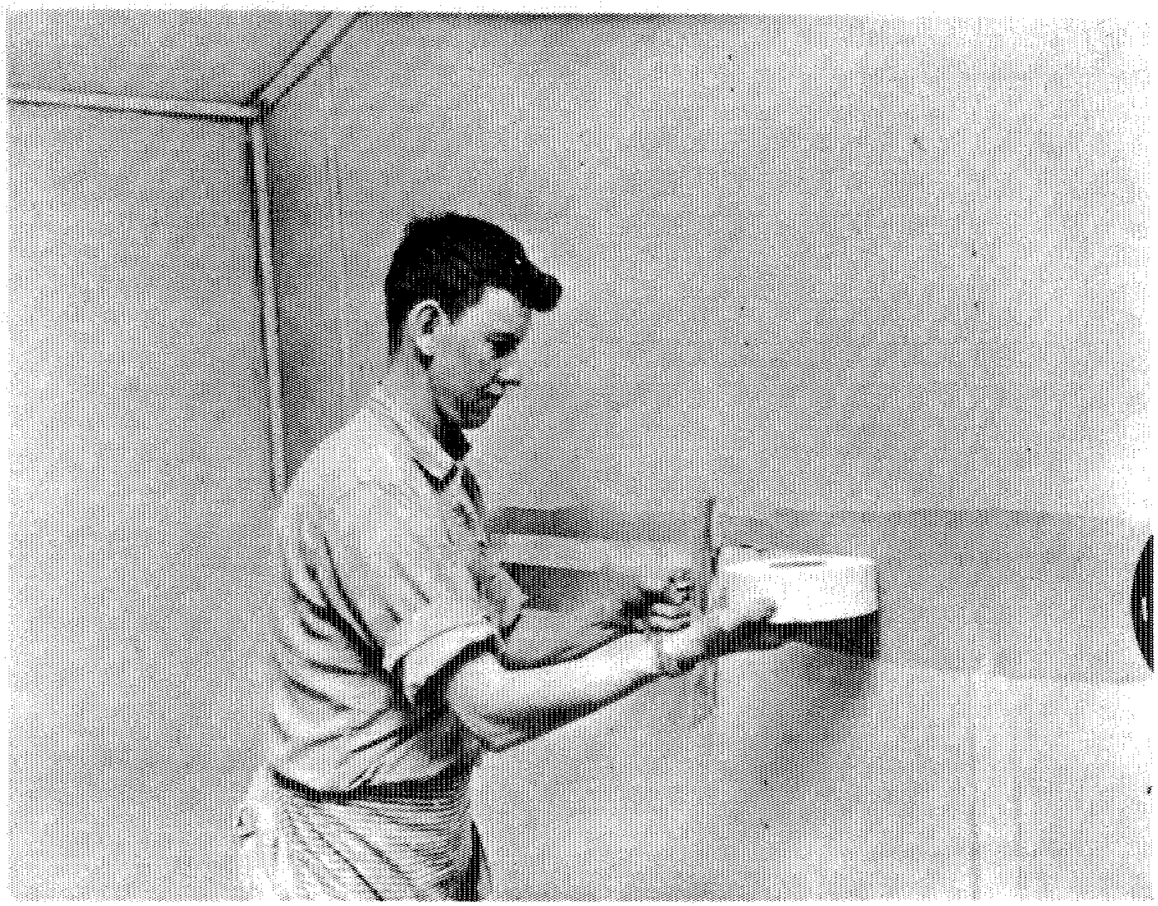

Figure 4-22. Use of sheets of gypsumboard reduced the labour needed for interior finishing. This Ottawa worker in 1960 is taping the joints between the panels.

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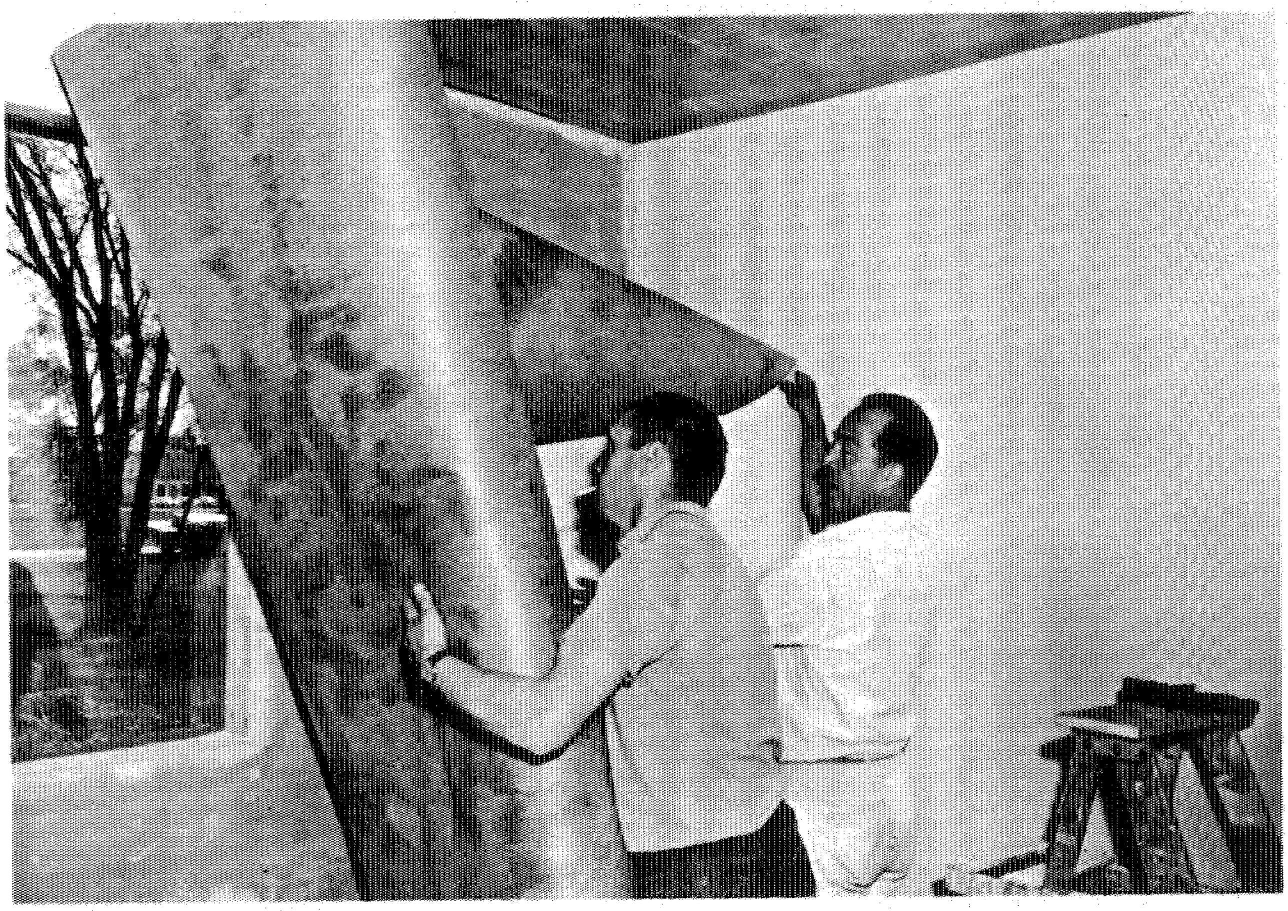

Figure 4-23. The Mark IV house employed a Norwegian system using Kraft paper for the interior wall finish.

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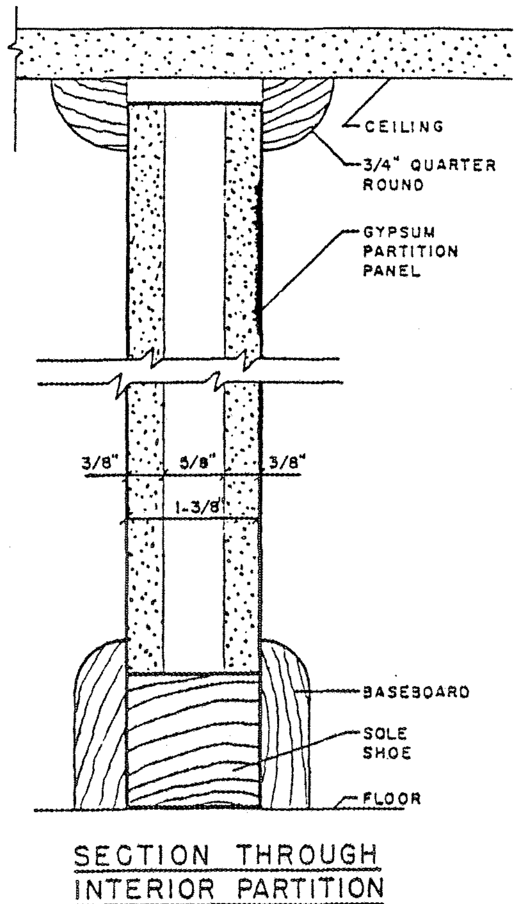
inexpensive alternative to taped and plastered drywall joints. Because of the success of this experiment, it was repeated with some refinements in the Mark IV house.[57]

The construction of the interior partitions in the Mark III and IV houses also demonstrated an alternative to traditional practice. In the earlier Mark houses, (which had conventionally framed roofs), partitions had been built with studs, although some prefabrication had been used. In the Mark III, however, greater flexibility was possible because the house had roof trusses and so the interior partitions were non-load bearing. They only needed to be rigid enough to give adequate sound insulation and resist knocks and bumps.

The partitions were built from two sheets of gypsum board formed into panels 2' (600 mm.) wide. The sheets were separated by two filler strips of gypsum board, leaving a 5/8" (15.9 mm.) hollow core. The filler strips were spaced 1" (25.4 mm.) back from the edges of the sheets to form a slot. (See figure 4-24) During assembly, a wood spline 5/8" x 1 3/4" (15.9 x 44.5 mm.) and the height of the sheet of gypsum board was fitted into this slot and into the groove of the adjoining panel to fasten them together.[58] Erection of the panels was simple. A runner was nailed to the floor and a baseboard which projected slightly above it was nailed on one side. A strip of coving was nailed to the ceiling directly above. The panel was then placed on the runner and was held in place on one side on top and bottom by the coving and the baseboard. The adjoining panel slid into place, and the first panel was secured in place by nailing a baseboard and ceiling coving on the other side.[59] (See figure 4-25) The same sort of partitions were used in the Mark IV except that the installation system was refined. A groove was cut in the top of the panel, which then fit over a runner nailed to the ceiling.[60]

In the Mark III, these panels were pre-finished with a paper-backed vinyl. The joints were left unfinished because they were uniform and formed a regular pattern. In the Mark IV the panels were covered with the same Kraft paper finish used in the rest of the house. In both cases, the whole approach was cost effective. Assembly was fast, and the thin panels occupied 34 square feet (3.2 square metres) less floor space than did conventionally framed partitions using 2" x 4" (38 x 89 mm.) studs. Because these partitions were hollow, electrical wiring could be run inside them, although special electrical boxes were required because of the thinness of the walls.[61]

Not all these techniques led to changes in building practices. The Kraft paper finish never came into general use, nor did the panel system for partitions. In other cases, the



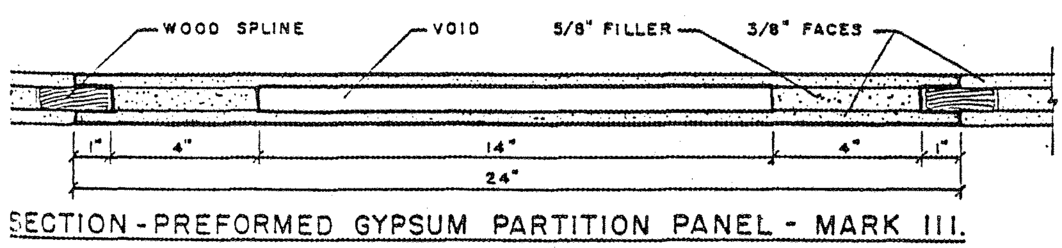


Figure 4-24. This drawing shows how the interior wall panels were constructed in the Mark III house.

Patrick Hailstone, HUDAC Experimental Projects, Mark I, Mark II, Mark III, Mark IV (Toronto: Housing and Urban Development Association of Canada, 1973), p. 63

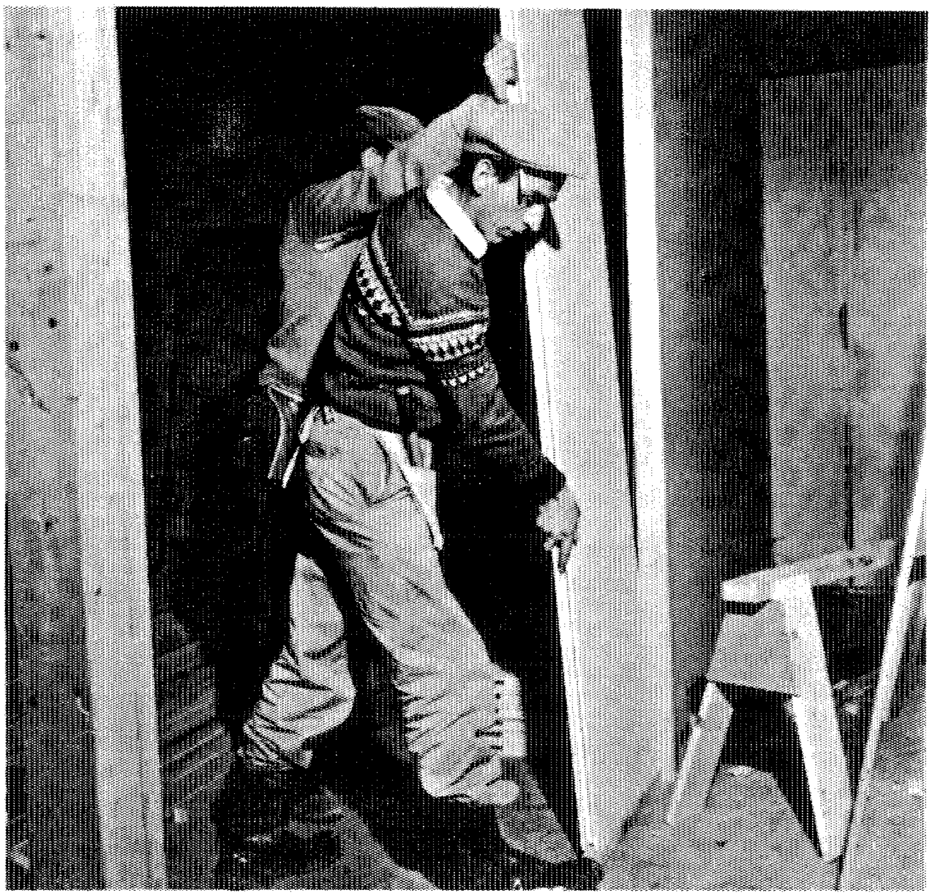


Figure 4-25. This photograph shows workers fitting together the interior partitions in the Mark III house.

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use of stressed skin demonstrated the possibilities of using this technique in conventional construction. So too, the use of combined sheathing and siding confirmed that this practice was sound. Yet, the importance of the Mark experiments cannot be judged only in terms of whether or not they led to the general adoption of a specific practice. Their significance also lay in the broader process of technological change. By demonstrating the range and possibilities of different approaches that could be achieved by rethinking conventional practice, they helped to legitimize and encourage innovation in many fields of housing technology.

High Rise Apartment Construction

The walk up apartments of the late 1940s and 1950s were constructed in the same way as detached houses, using solid masonry, platform frame, or madrier construction in Quebec. By the mid 1950s higher apartment buildings--often 7 to 10 storeys--were appearing in the larger Canadian cities. These required different building techniques, and usually employed reinforced concrete construction, as used in many other high rise buildings. These systems also required complicated shoring and formwork, and as the building height increased, the movement of workers and materials became increasingly cumbersome.[62]

In the 1960s, new construction techniques for high rise buildings emerged in Toronto which introduced assembly line efficiencies to this type of construction. Tower-type construction cranes (based on European technology) were initially used but were limited to buildings about 20 storeys in height. These were soon replaced with climbing cranes which used "the building structure as its support base." The crane was "jacked up to higher support levels" as the building grew. Usually mounted in the elevator shaft, it provided good coverage of the building site and "literally removed the lid on building height." (See figure 4-26) At about the same time, the "Hi Rise" hoist was developed in Canada to lift workers and materials quickly and safely to the working level.[63]

Another development, flying formwork, was related to the efficiency of the climbing crane. Forming and shoring floor slabs had been labour intensive and slowed production time. The flying form saved costs because the builder moved, with the aid of the centrally placed crane, "large sections of shoring and forming as whole units, eliminating the need to dismantle, move and re-erect the formwork and support system." Accompanying this development was the emergence of flat slab floors of uniform thickness. This eliminated obstructions, such as spandrel beams around the perimeter of

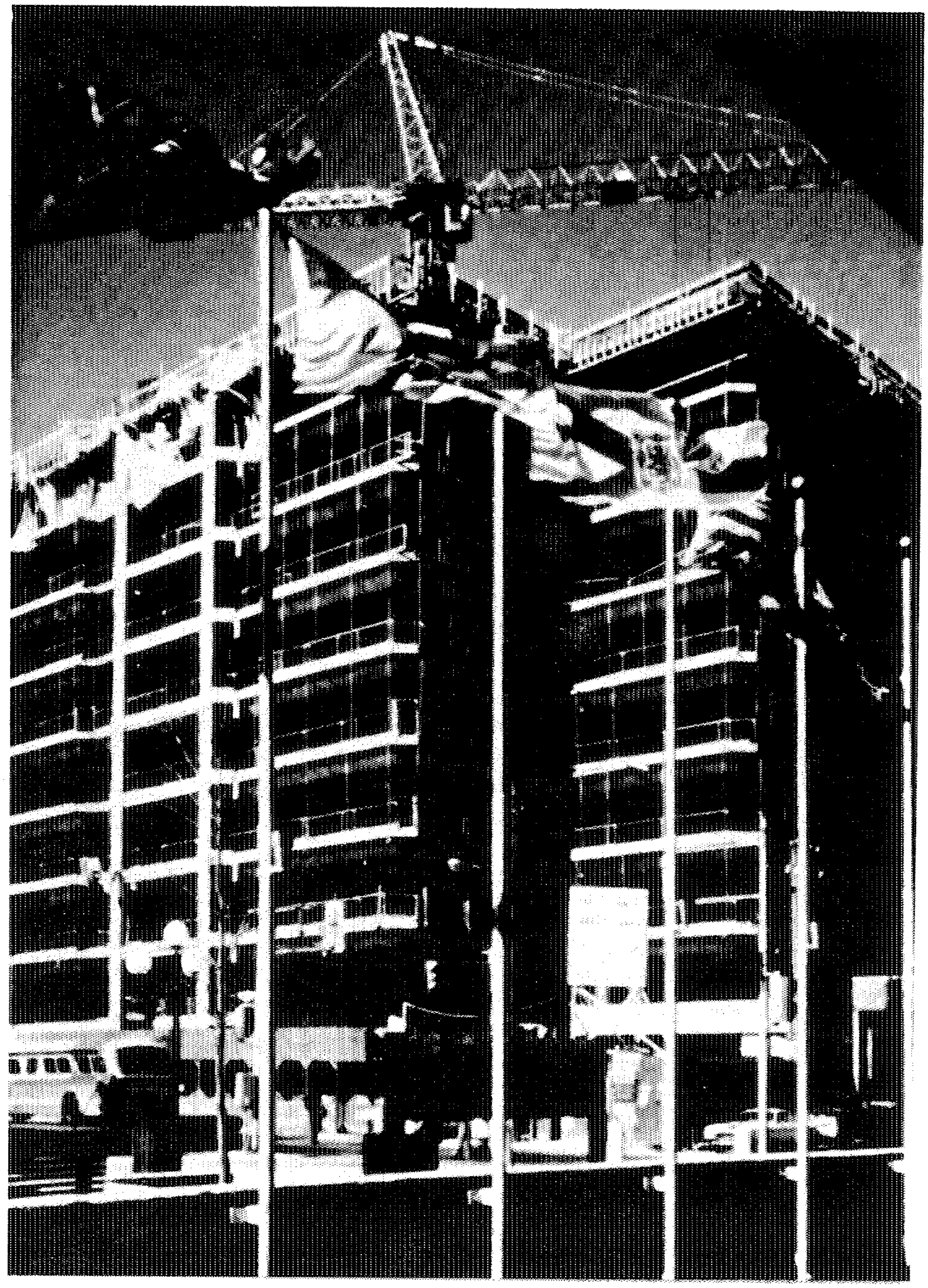

Figure 4-26. The use of climbing cranes and flat slab construction, as on this Ottawa building, revolutionized high rise construction in Canada.

Reproduced with the permission of Canada Mortgage and Housing Corporation.

the floor, that made removing and lifting the forms to the next level difficult. In combination, these elements became known as the Toronto flat slab/climbing crane/flying formwork system and, along with the hoist for workers and materials, revolutionized high rise construction. It became the model for apartment construction throughout North America and introduced what essentially were production line techniques to high rise construction.[64]

Other efforts to use industrialised building practices in high rise construction did not meet with the same success. There was much interest in Canada in the 1960s in European precast systems. DBR studied them in the mid 1960s, but found that only limited cost savings could be realized even if volumes were consistently high. There were a variety of systems available, but among the commonest were those in which precast building parts (such as floors, walls, stairs and landings, balconies and columns) were hoisted into place and fitted together to form the building. Modular components, such as windows, doors and service core or core wall units for bathrooms and kitchens, were also used. These systems worked well in Europe, but transplanted to Canada poorly. Re-engineering was required to fit them to popular Canadian apartment designs, and they presumed a costly level of project co-ordination and engineering. With the maturity of the Toronto flat slab system, they were uncompetitive and, to all intents and purposes, had been abandoned in Canada by the early 1970s.[65]

High rise buildings met an emerging need in the Canadian housing market, and the technological developments that they utilized were significant. This technology was developed almost entirely by the private sector, perhaps because apartment developers had sufficient size and wealth to handle the design and engineering necessary to bring the technology to fruition.

The area where public agencies were significant in these developments was in the area of safety. A few near catastrophes in high rises alerted DBR to fire safety problems in these buildings. In preparation of the 1970 National Building Code, the Associate Committee established a task group to study intensively the behaviour of fire in these buildings and develop new safety measures for fire and smoke control. Because DBR had the best resources for studying air movement in buildings (due to its research in insulation and vapour barriers), it began studying smoke movement and how to control it. DBR's work filled a technological "vacuum" in this area, and its findings were incorporated in the National Building Code as "deemed to satisfy clauses," thus offering guidance to designers on ways of controlling smoke in high rise buildings.[66]

Conclusion

By 1965, a number of cost saving refinements had been developed and incorporated into the country's building codes and standards. Broadly, these changes developed from the climate of innovation and research that was so marked in postwar house building technology. The view that innovation held possibilities for improving house construction and reducing costs had been stimulated and encouraged by public agencies such as CMHC. More precisely, it had been encouraged by the experimental houses built by the NHBA in association with CMHC, DBR and other federal agencies such as the Forest Products Laboratory. By applying new materials, these projects had demonstrated new possibilities and shifted thinking in different directions. At the same time, they explored precise research issues. Requirements for sheathing and bracing, for example, had been eliminated in many instances because of study by DBR and Forest Products Laboratory on racking forces on exterior walls.

Clearly, not all builders took immediate advantage of these new approaches or refinements of established customs. Reflecting that the Canadian house building industry was composed of many small builders working independently across a large and varied country, and that the industry overall relied on nonengineered building practices, acceptance of technological change was inevitably evolutionary. It has been remarked that "areas with abundant lumber were slower to convert to fibreboard and gypsumboard sheathings, particularly where on-site labour was cheap. In many areas, old and new ways of doing things existed side by side for many years until economic advantage and builder familiarity tilted the scales in the direction of the new."[67] Nevertheless, change had been marked between the end of World War II and the mid 1960s. In the mid 1940s, construction time for an average sized and equipped house was seven months and took 2,400 site person hours. By the mid 1960s, the same type of house took only 8 weeks to build and required 950 site person hours.[68]

CHAPTER 5: COPING WITH ENVIRONMENTAL FACTORS

As the distinguished Canadian architect, James A. Murray, remarked, few climates "exceed the demands of Canadian weather in its extremes of heat and cold, dryness and moisture."[1] This affected the design and construction of houses in various ways. While climactic conditions in Arctic and other northern communities necessitated special consideration, a variety of climactic conditions uniquely shaped housing everywhere in Canada. Construction normally ceased during winter, and this seasonal cycle was a factor in decreased house production. Materials and design also responded to climactic conditions. The need for insulation was a direct response to climate, as were design of windows and heating systems, while the typical Canadian desire for a basement was also partly a product of the climactic influence on house building.

Winter Building

Before the 1960s, house construction in most parts of Canada stopped almost entirely during the winter. It had long been recognized that year-round construction would help smooth out fluctuations in building activity and seasonal unemployment in construction trades. This became especially important as the level of capitalization of building companies grew. By the mid 1950s, DBR was studying the problems associated with winter construction and was distributing information on its findings.

A major impediment to winter construction was the near impossibility of excavating basements and service lines once the ground was frozen. There was no practical solution to this problem until suitable power equipment became available in the 1960s. Even then, winter excavation remained difficult. For example, the basement of the Mark IV house was excavated when the ground was frozen to a depth of about 600 mm. Although the ground was broken with a bulldozer equipped with ripper equipment, it was "the opinion of all concerned" with the project that winter excavation and other subsoil ground work created "severe difficulties" and that additional research was necessary to find ways either to avoid "winter excavation or simplify ground work during frost periods." This problem was subsequently minimized with improvements in excavating equipment.[2]

Other difficulties involved, at least in part, the overturning of deeply seated attitudes and customs. Before the 1950s, for instance, it was assumed that concrete would not cure properly if poured in winter. While this view seems to have been based as much on custom as scientific evidence, adding salt to the concrete was one tactic used by the 1950s to encourage proper setting. By the 1960s, other additives had been developed that allowed concrete to be poured in winter.[3]

A more important task lay in developing methods to enclose building sites to protect workers from the cold. By the late 1950s, basements were sometimes enclosed (usually in heavier construction projects) and large heaters were installed to keep the site warm while construction went on.[4] More significant developments came as part of broader technological change. The use of plywood and roof trusses allowed a building to be quickly enclosed and polyethylene, which was affordable by the late 1950s, further helped to shelter the work site from the cold. (See figure 5-1) Some builders preferred to close in the building quickly in the fall rather than use temporary shielding. As CMHC observed in 1958, house construction in winter was now feasible when carefully planned. When the building was roughed-in by fall, and the frame covered with plastic and heaters used inside, interior finishing could be completed during winter.[5]

As part of a general effort to encourage winter construction, DBR developed and tested shelters to protect workers from the cold.[6] These findings were distributed publicly, and with the National Film Board, DBR produced a promotional film on winter construction.[7] In 1963, the federal government brought in a Winter House Building Incentive Programme through CMHC. It provided speculative builders (firms building houses which were not pre-sold) with a $500 grant for each house begun in the first quarter of the year. The program encouraged winter building, both through its direct incentives and by making winter construction more familiar and accepted.[8]

Northern Building

Permafrost and cold weather were traditional problems encountered when building in the far north and the Arctic. By the early 1960s, technical research into the special needs of northern building had been underway for several years, but the results were only just becoming available. Permafrost studies had been undertaken by DBR at its Norman Wells station, and American technology, in which heated buildings in permafrost areas were constructed on stilts, had been used in Canada since the 1940s. (See figure 5-2) While these techniques were used in places located on permafrost, they were not entirely satisfactory for ordinary single detached housing.

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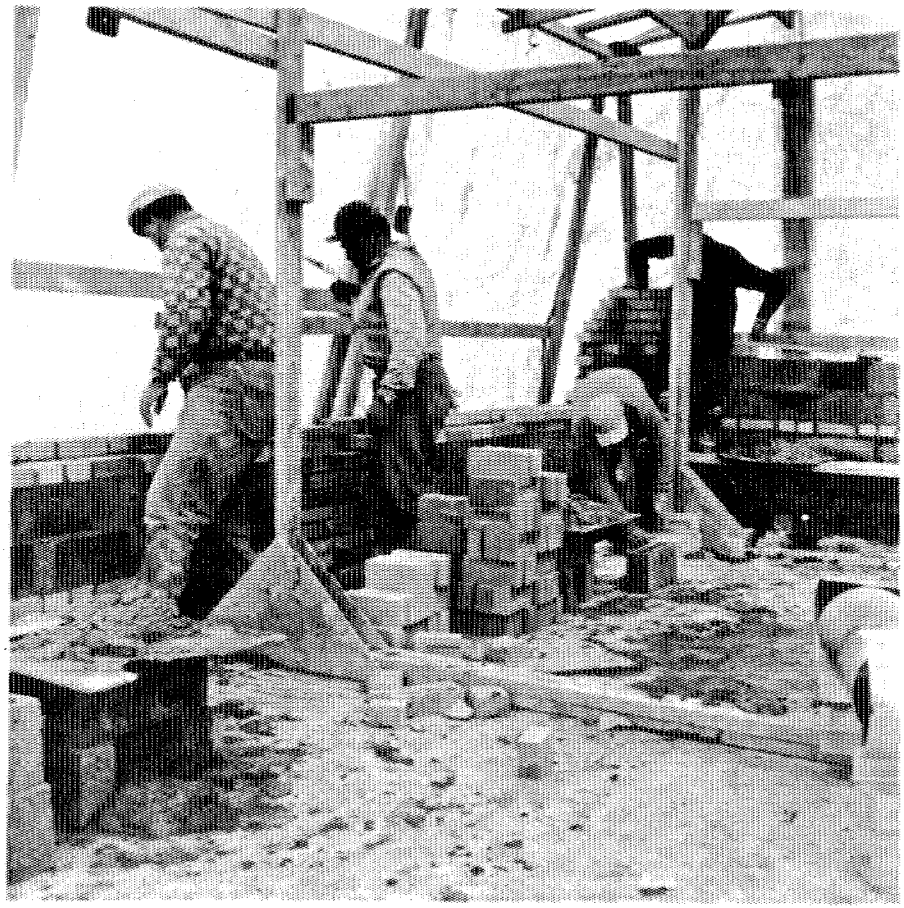

Figure 5-1. Enclosing work sites with polyethylene helped shelter workers from the cold and permitted construction throughout the year. Photograph not dated.

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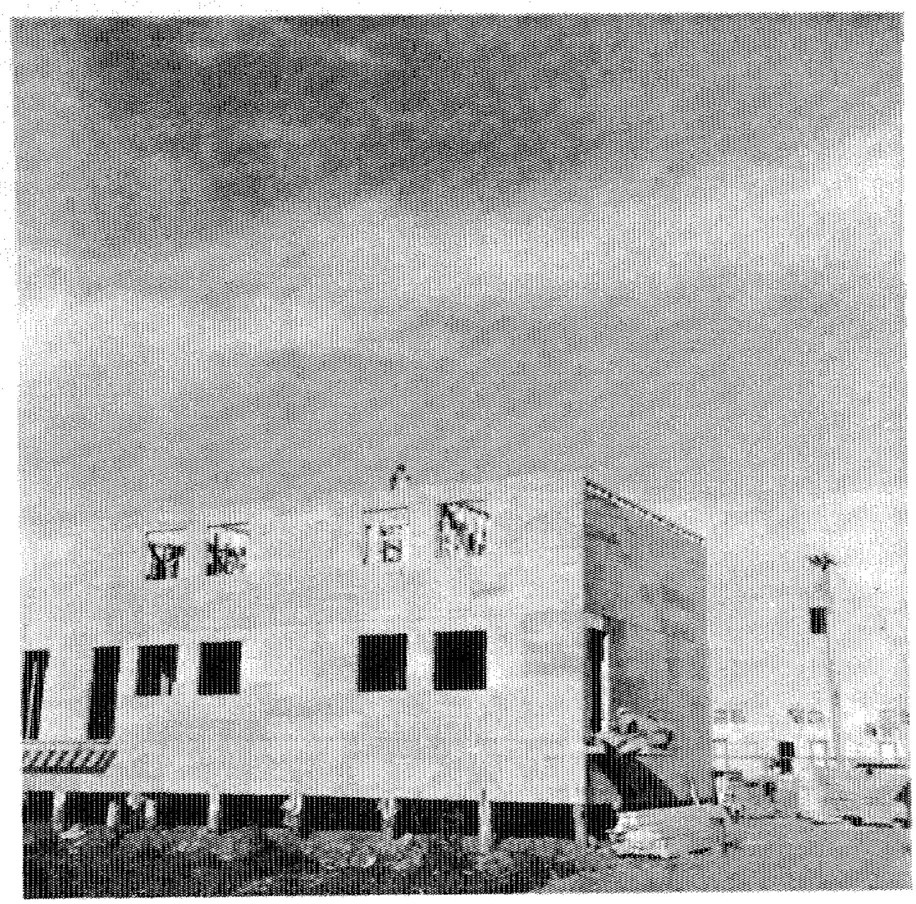

Figure 5-2. Because of permafrost, this Inuvik apartment was built on stilts in 1959.

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In 1960, northern housing had been made a responsibility of the housing section of DBR. The Division reported in that year that "the technical aspects of house superstructure design" in northern and Arctic regions differed "only in degree and not in kind" from those in other parts of Canada. Because of high transportation costs and a short building season, prefabrication (especially using stressed skin systems) was of obvious value in reducing costs and construction time.[9] These advantages were confirmed in a 1960 study by DBR about prefabrication of northern housing which concluded that the technical problems of northern housing were similar to those in the south. Accordingly, these findings were regarded as "a most useful basis for future studies of prefabrication and component construction in Canadian housing."[10]

Yet, it was soon evident, as Sam Gitterman would observe, that the problems with northern housing were not just southern issues writ large. In 1967, Gitterman made a fact finding visit to the Arctic on behalf of the CMHC-Indian Affairs and Northern Development Committee on Housing (established in 1966). He observed a range of problems with Arctic housing: water supply and sewage disposal were seriously inadequate and the construction and design of the houses were unsuited to the region's climate and social needs. Snow drifting against the houses blocked entrances and sometimes even windows, and worked its way into the house through windows, doors and cracks in the walls. Problems in the house interior were even more serious. Cold floors, cold outside walls and uneven heat distribution made houses uncomfortable and unhealthy. Residents tried to meet these problems through various improvisations, including building snow porches. (See figure 5-3) Most houses also lacked storage space, and bathrooms, designed for southern conditions, were unusable because they were bitterly cold and water was difficult to obtain. Gitterman recommended a number of specific design, construction and planning alternatives to help alleviate some of these problems. Because of the wretched housing he encountered, it was clear to him that housing could not simply be transplanted to a different culture and physical environment. As he commented, since there were "so many problems that show up acutely in the north," a great deal of specialized research was justifiable.[11] Such research was already underway. By 1964, for example, DBR had entered into a co-operative project with the Department of Northern Affairs and National Resources on design, construction and testing of small stressed skin houses for use in the Arctic. Care was taken to develop and evaluate specialized inexpensive and simple joints for northern prefabricated buildings. As Robert Platts, who was involved with the project, recalled, this was part of the attempt to "do a better job" with Arctic housing. This approach also led to the development of an "Arctic House" called the "Angirraq."[12] (See figure 5-4)

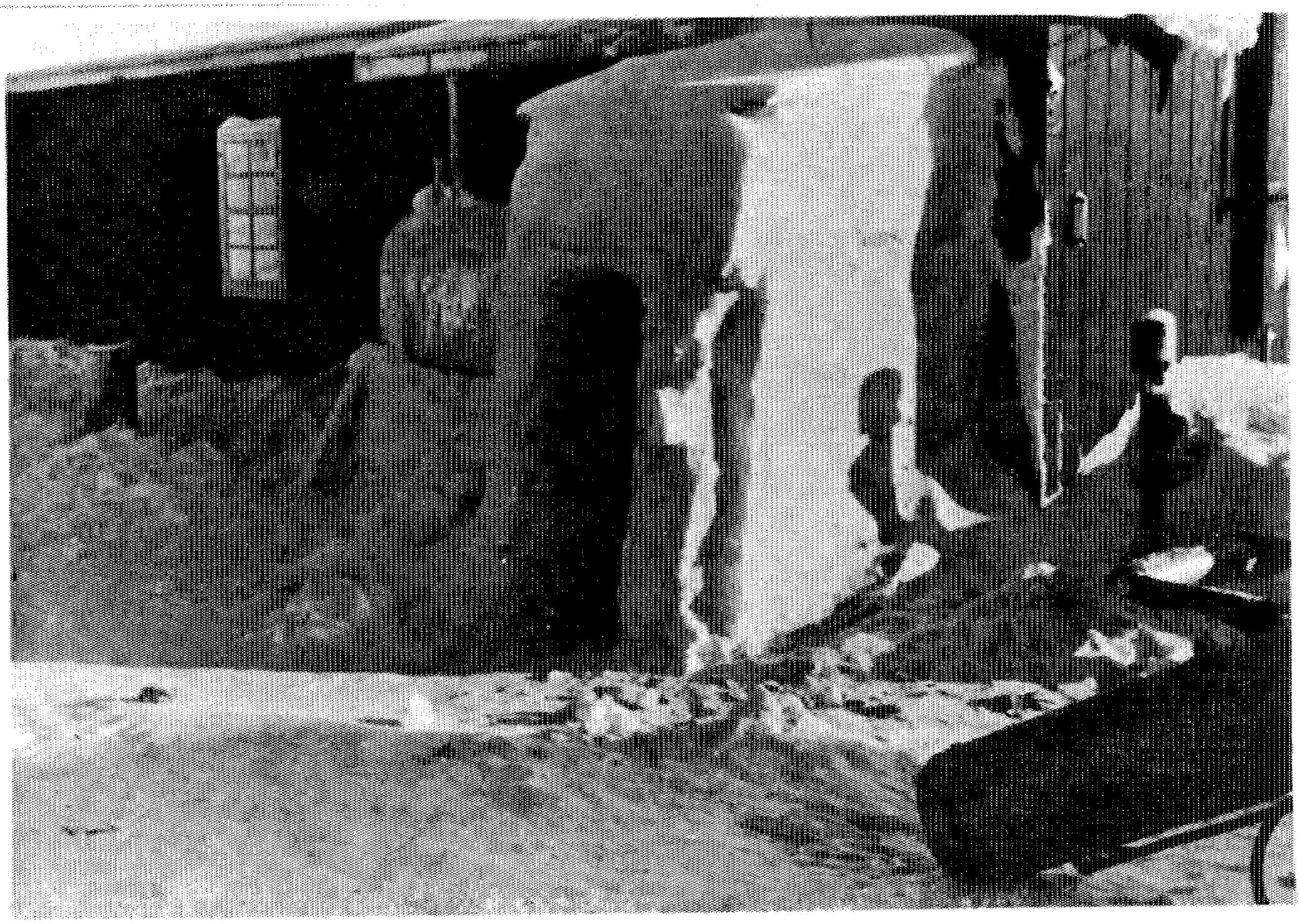

Figure 5-3. In an effort to keep the cold out of their homes, some northern residents built porches from snow. The photograph was taken in the early 1960s.

Photograph courtesy of Sam Gitterman

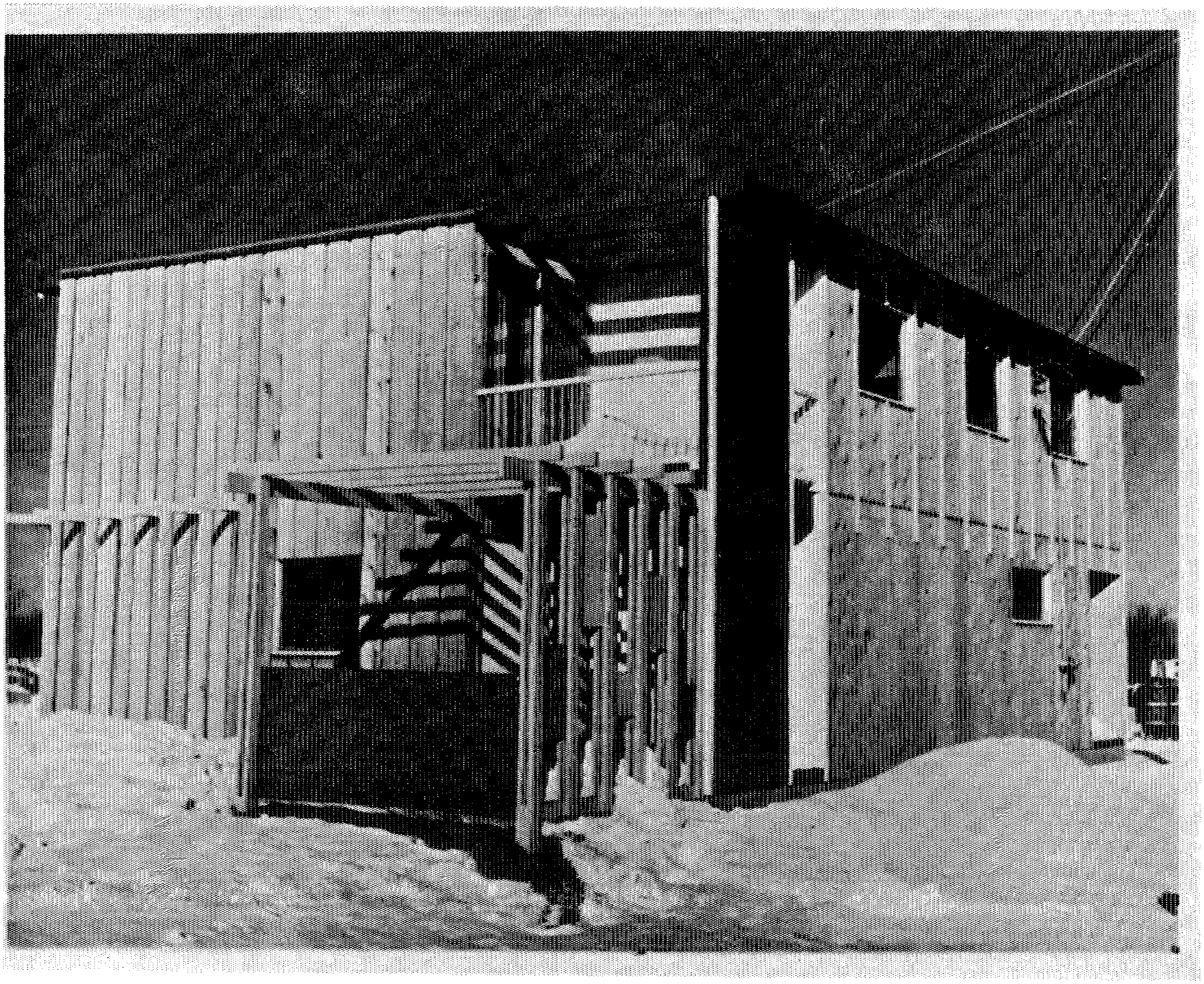

Figure 5-4. The "Angirraq" was a house designed by DBR for use in Arctic communities.

Photograph courtesy of Robert Platts

The Angirraq used stressed skin panels for the roof, floor and walls. DBR had carried out some limited developmental work on stressed skin systems in the late 1950s, and some of this knowledge was applied in the Angirraq. The house also broke technical ground by not having a vapour barrier, which had proved ineffective in Arctic buildings, since it was now known that air movement, not vapour diffusion, was the main factor leading to condensation problems. Thus, the plywood panels were sealed at the edges and served as the air barrier. Designed to sit on permafrost, the house was so light and rigid that it could be picked up by one corner, but still retain its structural shape and integrity. The house was basically a "small hut," but it was immediately followed by a two storey version. Built on the same principles as the hut, it used the first floor as a utility room. The final laboratory and exposure tests were completed in 1965, manufacturing was undertaken at various points in the south, and the houses were then shipped north for assembly.[13]

Basements

Among the first renovations undertaken by owners of houses built by Wartime Housing Ltd. was the installation of a basement. While partly a matter of custom and habit, most Canadians liked to have a basement for storage and a furnace and believed that only a house with a basement was adequate in the Canadian climate. Thus, there was widespread public resistance to basementless houses. They were extremely difficult to sell, and so formed a very small part of newly constructed Canadian housing. Although basements added to the cost of construction, the extra costs were not as great as might be expected. Given deep frost action in Canada, substantial footings were needed even with basementless houses. Moreover, improved methods of constructing basements appeared in the late 1940s and 1950s which reduced their cost. Backhoes, for example, required less backfilling than was needed with bulldozer excavation. As well, reusable plywood forms had replaced plank forms by this point, creating further efficiencies. (See figure 5-5)

While CMHC did not oppose basementless houses, it did not, in light of public attitudes, promote them to any great extent. In 1949 it built four test houses on floating concrete slabs instead of traditional footings and foundations.[14] More concerted work in this respect was undertaken by DBR because it saw basementless houses as a way to reduce costs and eliminate serious maintenance problems. In clay soil areas of the Prairies, for example, floors in concrete basements tended to heave. Moreover, because of developments in forced air heating, basements were no longer so essential. In the

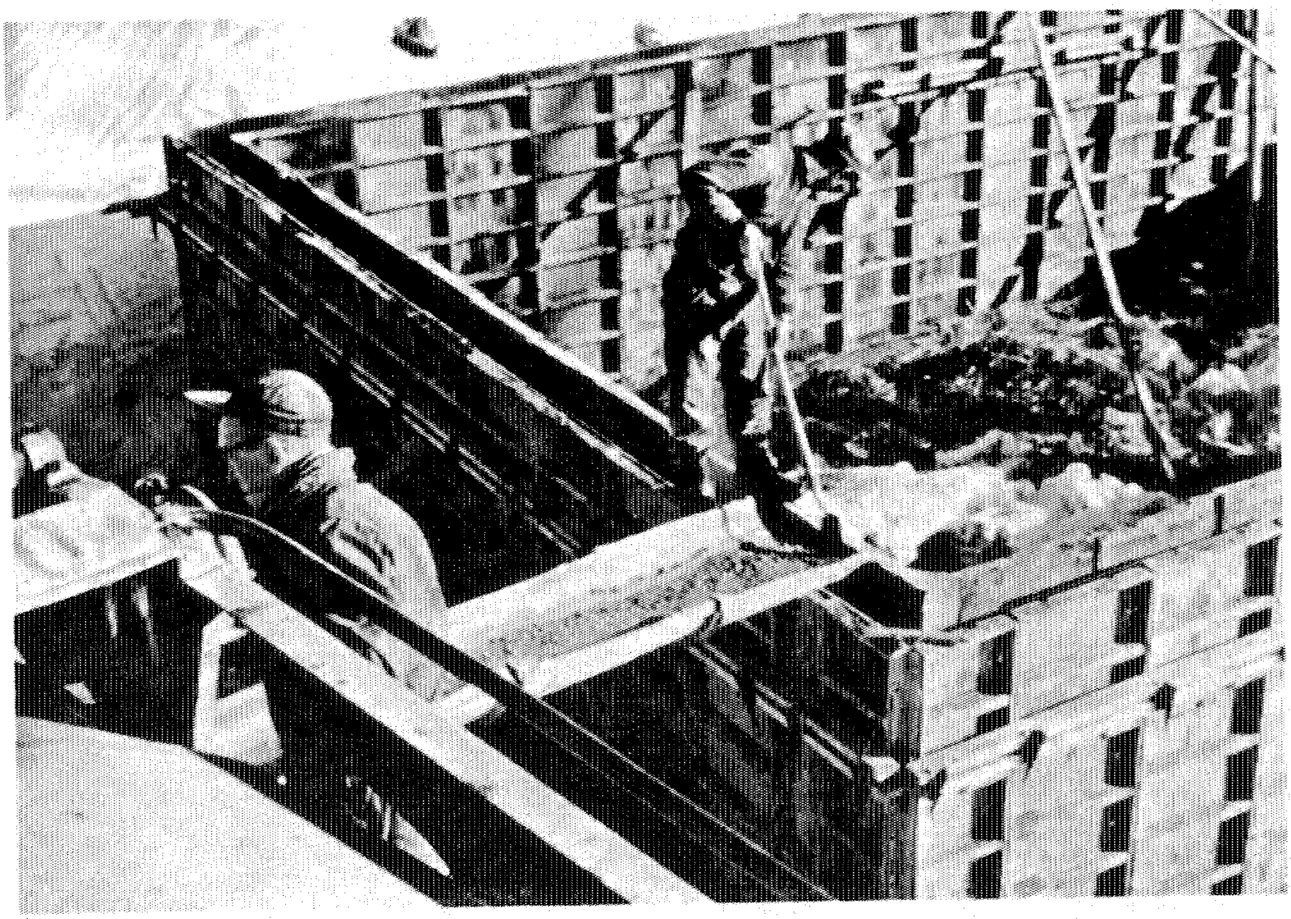

Figure 5-5. Reusable plywood forms offered one method of increasing efficiency when constructing concrete basements.

National Archives of Canada/PA-190762

early 1950s, DBR built test houses on slab in Ottawa and Winnipeg in order to develop recommendations for basementless houses.[15] These tests were wide ranging, and the house in Winnipeg, for example, was operated without heat in the winter of 1956-57 to test its performance when the ground below the slab froze.[16]

In a similar effort, the first three experimental Mark houses did not have basements. The Mark I house even dispensed with footings and used only an 8" (200 mm.) thick foundation wall. A centre wall of poured concrete supported the floor joists at mid span. These trials were continued in the Mark II, which had foundation walls built of concrete blocks. In the Mark III, the foundation was built of preserved wood. This was a wholly new approach to foundation construction in Canada. Sam Gitterman recalled that he and Oz Hansen of DBR concluded that since railway ties treated with creosote lasted up to 75 years in "worse conditions than a foundation," creosoted wood might work for house foundations. The Forest Products Laboratory concluded that such material would be safe, and the Canadian Wood Development Council and the Plywood Manufacturers Association of British Columbia also co-operated in the developmental work. If successful, it would represent a new use for wood and would help streamline building with a plentiful, easily worked material. As well, because it was not dependent on weather, "it could solve many winter building foundation problems." The foundation walls were about 3' (900 mm.) in height and were built from creosoted 2" x 4" (38 x 89 mm.) studs 16" (400 mm.) on centre. Because the site was poorly drained, and because this was the first trial of a wood foundation, a small concrete footing 2' (600 mm.) below grade was used. The outside of the foundation was sheeted with creosoted plywood.[17]

The Mark IV house extended this experimentation. Perhaps in response to continued public resistance to basementless houses, it had a full wood basement, the first to be built in Canada. The poorly drained site where it was built was thought to present a particularly good testing environment. The basement had wood footings, a wood floor over a crawl space, and walls built of treated 2" x 4" (38 x 89 mm.) studs 16" (400 mm.) on centre to which treated plywood was glued. (See figure 5-6) On the recommendation of the Forest Products Laboratory, the wood was treated with a new product, pentachlorophenol petroleum, instead of creosote, which was unpleasant and difficult to handle. The experiment was a success, and by the early 1970s, tests indicated that the wood foundation of the Mark III had at least 50 years of useful life remaining.[18]

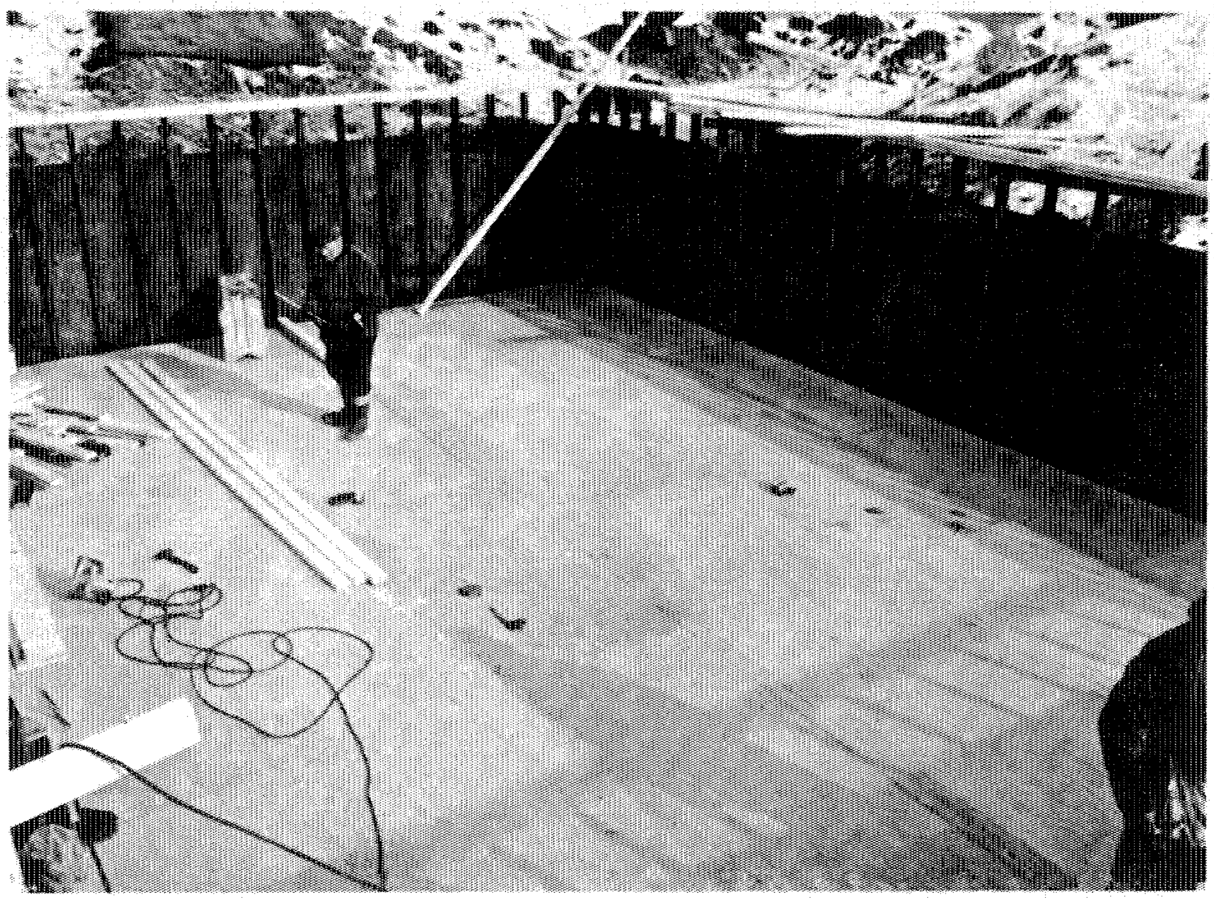

Figure 5-6. The wood basement in the Mark IV house was the first all wood basement in Canada.

National Archives of Canada/PA-190677

Although these tests and findings were widely reported in the press and in building journals, Canadian builders showed little initial enthusiasm. Instead, as Oz Hansen recalled, United States builders "looked over our shoulders and saw what we were doing." They developed a design approach for wood basements and used less objectionable preservatives, and in this form, the approach came back to Canada during the early 1970s. By this time, wood basements and foundations had found their way into the National Building Code, and were also being strenuously promoted by lumber associations. As a result, their number began to increase in Canada.[19]

Insulation and Vapour Barriers

While Canadians have naturally always tried to insulate their dwellings against the cold, there seems to have been an assumption that life in a northern climate meant one had to endure a cold house in winter. Yet this attitude was changing, and by the 1940s NHAA's, and later CMHC's, residential requirements contained minimum standards for insulation. The optimum standard was set at 2" (50 mm.) of mineral wool. By this time, ceilings were usually insulated with vermiculate, treated wood shavings or loose mineral wool. Walls used mineral wool batts, although shavings poured between the studs were also commonly used. The inside of the exterior walls received an extra layer of building paper, covered with lath and plaster.

Almost as soon as these higher insulation standards were established, condensation problems began to appear. In some cases, water vapour was moving into the exterior wall and condensing in the insulation. Some type of vapour barrier on the inside was needed, and this requirement was almost immediately included in the NHAA's standards. This, in turn, sometimes created problems with condensation on windows because moisture was being trapped inside the house.[20]

Relatively little scientific work had been done before the 1920s about insulation and vapour barriers. Early experimental work at the University of Saskatchewan in the 1920s had attempted to rank the values of different types of insulation and these findings had some influence on building practices in the prairies in the interwar years.[21] In the 1930s, Jack Babbitt of NRC had conducted important research on water vapour diffusion in insulation and other building materials, and his findings formed the basis for the insulation and vapour barrier standards set by the NHAA.[22]

Such research accelerated during the late 1940s to deal with specific problems CMHC was experiencing. Residents of veterans' houses in Prince Albert and Saskatoon, Saskatchewan, complained that during cold weather, frost formed on the studs around the baseboards. The houses were semi bungalows heated with space heaters placed in the centre of the house. Two sorts of insulation were used: either a reflective blanket type, or rockwool batts. Condensation problems were worst in houses with reflective blanket type insulation. (See figure 5-7)

CMHC asked DBR's Saskatoon research station to investigate the problem. Using a recently developed device for measuring heat transfer into walls, it was discovered that heat flow into the walls was not uniform. It was greater at the bottom than at the top and the suspected reason was convective air flow in the wall cavity. The placement of the heater near the centre of the house contributed to the lower temperature at the bottom parts of the walls. In conjunction with related research by Gus Handegord at the DBR station in Saskatoon, these findings ultimately initiated a whole research series on convective air flow in walls. Using this theoretical knowledge, CMHC and DBR launched a program to test blown-in cellulose fibre insulation in the walls of the veterans' houses with frost formation problems. CMHC also banned the use of reflective insulations in NHA houses in Western Canada.[23]

Additional research in insulation and vapour barriers expanded knowledge about thermal performance in the next decade. CMHC required answers to a broad range of problems with insulation and vapour penetration which were referred to DBR. As part of this research, DBR studied the performance of various types of materials by exposing whole walls to natural conditions in test "huts" in Saskatoon, Ottawa and elsewhere to study air leakage and moisture movement in walls.[24]

At the same time, additional developments were occurring in materials used for insulating houses.[25] In the early 1950s, CMHC accepted glass fibre insulation, a product which had superior performance over mineral wool, and it rapidly became the standard insulating material in Canada. (See figure 5-8) While coated paper (usually with a wax finish) continued to be used as a vapour barrier, polyethylene had become available in the mid 1950s. (See figure 5-9) It was used for the vapour barrier in the Mark I house in 1957, and it soon became a standard material. In an effort to take this approach one step further, a vapour barrier latex paint (instead of polyethylene) was used in the Mark III house, but it proved to offer no cost savings.

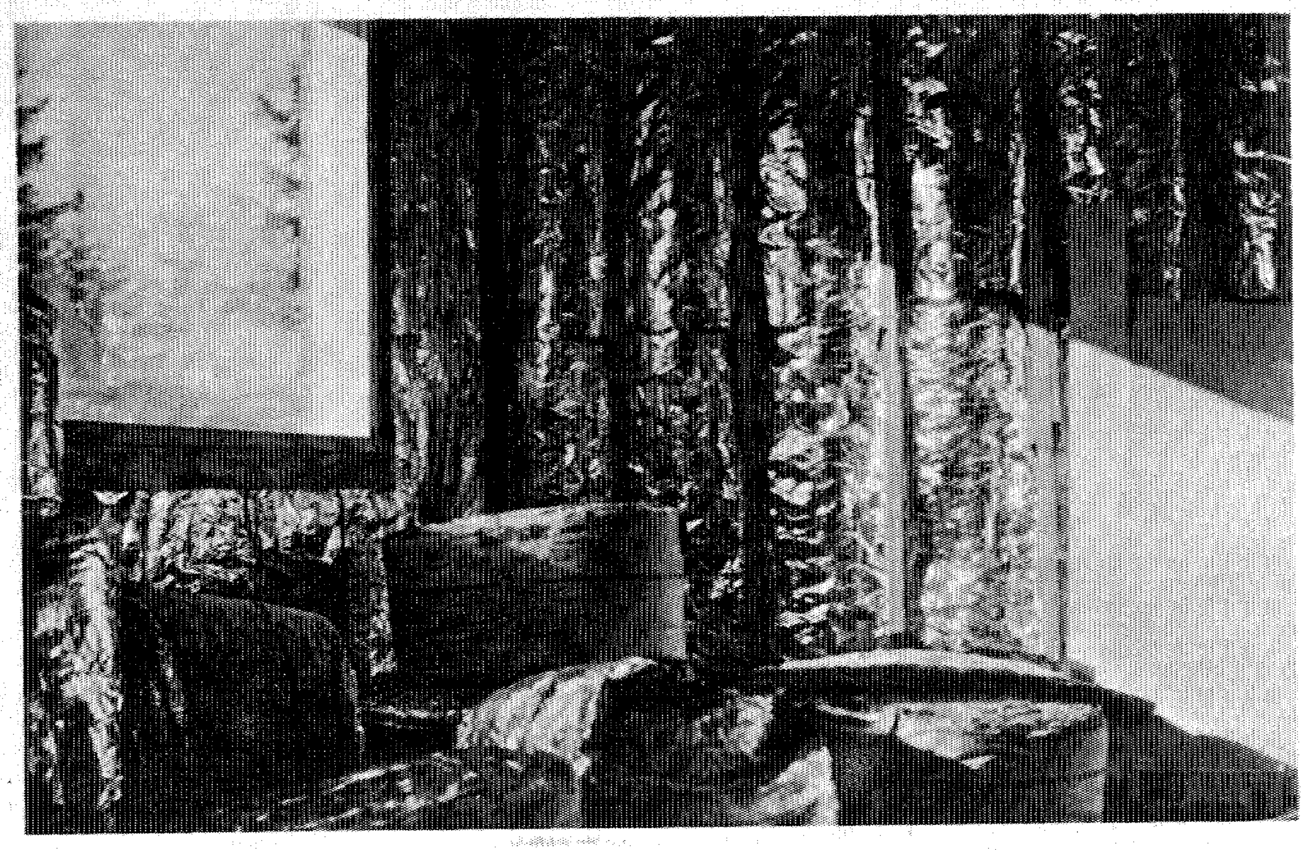

Figure 5-7. Such reflective types of insulation proved to be unsuitable in some parts of Canada. Photograph not dated.

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Figure 5-8. By the late 1950s, glass fibre batts stapled between the studs had become a standard type of insulation. Photograph dated 1959.

National Archives of Canada/PA-190599

Figure 5-9. Polyethylene vapour barrier, as shown in this 1959 photograph, was in common use in Canada by the late 1950s.

National Archives of Canada/PA-190597

These developments in materials and research were enhanced by DBR's development in the early 1960s of pressurization techniques for measuring air infiltration in houses. At the same time, the Division was studying the relationship between the rate of natural air leakage and humidity in houses. Records were taken of temperatures, humidity and fuel consumption in houses in Saskatoon, Ottawa, Halifax and elsewhere. The objective was to establish the relationship between moisture and air leakage. It was found that, on average, the rate of exchange of natural air in these houses was about half an air change per hour. At the same time, pioneering research undertaken by Grant Wilson at DBR used the pressurization technique on test houses to measure precisely the relative leakage of air through walls, windows, doors and ceilings. Similar work was carried out on buildings which CMHC controlled.[26]

This work had important implications for insulation use, and helped confirm, for example, the importance of insulation in attics. Demonstrating the interdisciplinary nature of building research, it also found applications unrelated to insulation problems--such as in DBR's research work on smoke movement in high rises. While higher standards of insulation were beginning to be implemented in houses by the mid 1960s, they were usually "thermally barely distinguishable from that of the mid 1940s." But attitudes were changing: higher insulation standards were being promoted by utility companies and, as a selling feature, some builders were applying better insulation with glass fibre batts fitted between the studs in attics and walls. In the West, blown-in cellulose fibre was used for attic insulation, and wide roll polyethylene film provided a vapour barrier to give the walls greater protection from moisture.[27] But, in general, public concern about insulation did not become significant until the energy crisis of the 1970s. By then, the ground-breaking work done by CMHC and DBR over the past two decades had established basic understanding about insulation and moisture problems. This meant that higher insulation standards could be applied widely and quickly in Canadian homes in response to higher energy costs.

Windows

Window area equalling about 10 percent of floor area was typical in most houses of the mid 1940s. Windows tended to be sash types which slid upwards to open. In preparation for winter, storm windows were installed on the outside each fall. In the early 1950s, American manufacturers began offering double glazed sealed windows. These units were welcomed, particularly because they met the demand for large "picture" windows which provided some insulation, did not frost or fog in the winter, and were easy to clean.

They also put an end to the need to install storm windows in the fall. Although they were complicated to manufacture, they performed well, and their only drawback was their high cost. Manufactured by two experienced large American firms, CMHC accepted them for use in NHA-financed houses.[28]

In the late 1950s, new types of sealants were developed which made it easier to manufacture double glazed sealed windows. As a result, many firms started manufacturing windows, including companies operating "essentially in garages." While some of these windows performed well, others did not. Problems with fogging and discolouration were occurring, which had rarely been encountered with earlier versions. CMHC approached DBR for advice on which of these windows it should accept. This research was complex and ongoing, and provisional standards for acceptance were developed from the initial research to respond to immediate needs. Once sufficient research had been carried out, DBR published standards of performance which manufacturers used to develop better sealing materials and production standards, and they began to back their products with warranties.[29]

Much the same process took place in regard to other developments in window use. While the Mark houses had completely sealed windows, this was unusual. People liked windows that opened, but they increasingly were installing horizontal sliding glass units instead of sash windows. Although wood frames were still common, aluminum was coming into use. Problems with draughts were experienced, and condensation and rain penetration were also occurring.[30] These concerns came to DBR as a technical issue, referred from CMHC as well as other government agencies. Grant Wilson, the scientist involved with this matter, recalled that while "there was quite a lot known about how to measure leakage...none of it was standardized." Work being done elsewhere (especially in Norway) on rain penetration was referenced as part of this study, and DBR measured "thermal performance of windows, at least surface temperature performance, which was the primary factor in surface condensation problems." From this varied base, broader information was developed to standardize performance evaluation of these windows.[31] This work, like the previous testing of sealed unit windows, was further evidence of the way that building products were improved through the ongoing relationship between CMHC and DBR.

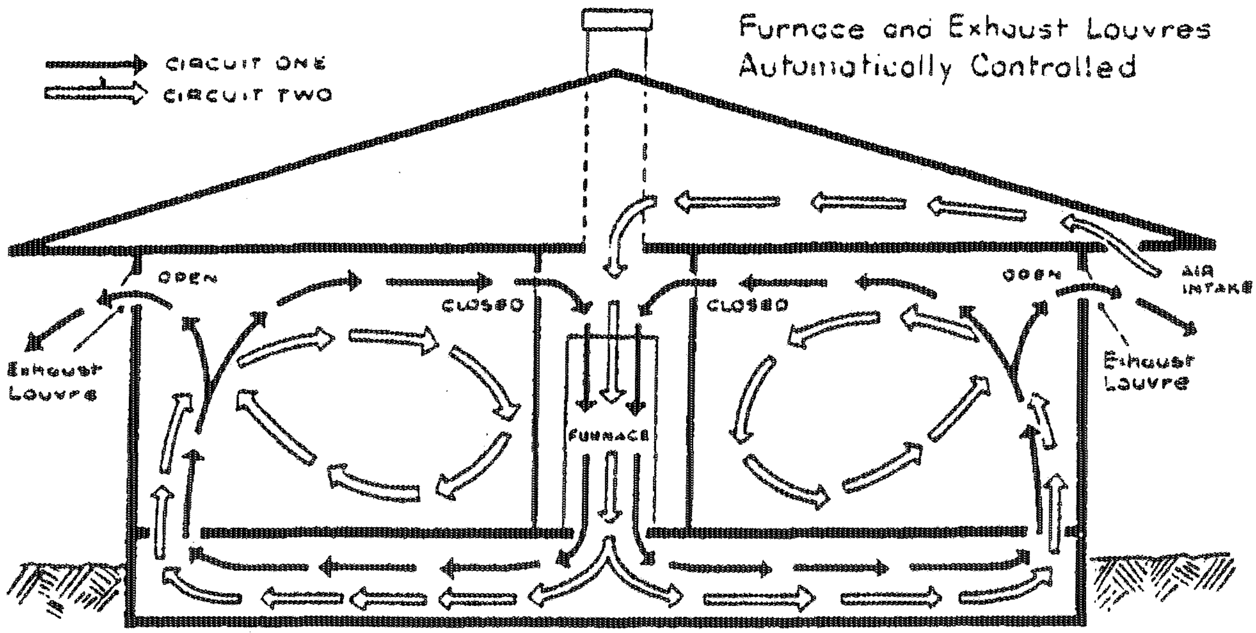
Heating and Ventilation

In the mid 1940s, most houses with central heating used gravity furnaces in which the heat rose naturally through the house and was distributed through registers placed in the centre of the building. Gravity furnaces were subsequently replaced with forced air systems, which soon became standard in Canada, although electric baseboard heating was coming into use in some parts of the country by the mid 1960s. Forced air systems initially used the configuration of a gravity system, in which the registers remained in the centre of the house. This tended to create convection problems which left the outside perimeters of the house cold. Thus, registers were soon placed on the outside walls under the windows and the cold air returns were placed in the centre of the house.

Innovations in heating were demonstrated in the Mark experimental houses. A centrally placed counter-flow furnace was used -- that is, a reverse-flow furnace blew the air downwards instead of upwards. The heated air was blown down into the crawl space which was insulated and became, in effect, the hot air plenum. In the Mark I house, ducts were used in the crawl space to direct the warm air to the registers which were placed around the perimeter of the house. In the Mark II and III houses, the whole crawl space was used as the warm air plenum. As warm air blew down into the crawl space, pressure built up and the air filtered up into the living areas. (See figure 5-10) Holes were drilled in the floor around the perimeter of the house to serve as heat grilles, and the baseboards were set about half an inch away from the wall. (See figure 5-11) The warm air blowing into the crawl space thus was evenly distributed throughout the house. The heat could be controlled by dropping a narrow piece of wood into the gap behind the baseboard which temporarily blocked the heat.[32]

In the case of the Mark IV (which had a basement), the hot air plenum was placed beneath the basement floor in a crawl space. It was an opportunity to try out the ductless heating system in a house with a full basement.[33] The crawl space under the basement floor acted as a plenum, and holes were drilled in the perimeter of the basement floor, as well in the main floor, on the theory that the warm air would rise through the whole house. This proved to be unworkable and resulted in a hot basement and a cold main floor, so ducts were installed from the plenum area to the main floor.[34]

Equally innovative, the heating unit in the Mark houses doubled as ventilation and humidity control systems. The Mark IV system built on the precedents of the earlier



THIS DIAGRAMMATIC SKETCH *shows the air flow in the heating and air-conditioning system of Experimental Project Mark III. White arrows indicate fresh air, black arrows, used air.*

Figure 5-10. This diagram shows the air circulation system used in the Mark III house.

Patrick Hailstone, <u>HUDAC Experimental Projects, Mark I, Mark II, Mark III, Mark IV</u> (Toronto: Housing and Urban Development Association of Canada, 1973), p. 69

National Archives of Canada/PA-190592

Figure 5-11. The Mark III house used an ingenious but simple system to distribute heat evenly throughout the house.

National Archives of Canada/PA-190592

houses and serves as a good example of the approaches taken. Because all windows were sealed, the only way to get air into the building was through an intake duct which led to the return air of the furnace. In winter, this air passed through the furnace to be heated, and after being blown into the floor plenum, came back up through the house. A humidistat was installed in the cold air intake. If the relative humidity in the house increased in winter, the humidistat could be set to open the intake automatically. "The fresh air would come in and the relatively humidity would change almost instantly. You could dehumidify a house in the winter time in no time." In summer, the furnace fan could be started and the damper arranged manually to bring in cool night air. The fan was then shut off in the early morning.[35]

Conclusion

The Canadian climate, especially its cold winters, created some of the most technically complex challenges for postwar housing technology. The study of air movement in buildings and heat movement in walls was central to finding solutions for condensation and various insulation problems, and the co-operative relationship between CMHC, DBR, and the housing industry helped to advance the complex research required. A similar co-operative stance in research and technology transfer worked to popularize winter construction to help smooth out cycles in the building industry.

Northern and Arctic housing presented unique cultural and technical problems, and as in other cases, co-operation among various agencies, including CMHC, DBR and the Department of Northern Affairs and National Resources, led to the development of the Angirraq house. This structure also demonstrated the way that solutions often were the product of accumulated research. Its successful use of stressed skin systems and its adaptation to the special characteristics of vapour movement in Arctic conditions applied research that had taken place in unrelated projects during the previous two decades.

CHAPTER 6: SANITATION

Of all housing components, plumbing and sanitation showed the least technological change between 1946 and 1965. Bathroom design changed substantially after the late 1940s by including more cabinets and by enclosing the area under the sink, a practice that previously had been believed would lead to unsanitary conditions. But these were only cosmetic changes, and the configuration of plumbing systems in most new houses in 1965 was close to that of the 1940s. Of course, there were technical problems that required attention. For example, hot water tanks made of galvanized steel tended to corrode, a problem that was solved by research by DBR. By the early 1960s, plastic pipe was beginning to be substituted for metal. This was still experimental, as shown by its use for all drainage piping and hot and cold water lines in the Mark III house--the first installation in Canada of all plastic piping. As well, studies were beginning in an effort to discover if plumbing codes required more venting of drains than was actually necessary.[1]

None of these developments, however, could be described as radical. Significant developments in postwar sanitation lay not in new technology but in extending more efficient traditional sanitary networks and systems in urban areas. Yet, in this respect, alternatives were being considered that posited sweeping change in methods of sanitation.

Conventional Sewage Systems

In the late 1940s, as a result of the housing shortage, "large housing developments with as many as 700 lots were being built without central sewage systems, but only on septic tanks." Indeed, 30 percent of all NHA loans in 1955 were for houses with septic tanks. These systems were adequate in places with sufficient distance between houses, but there were growing concerns about the safety of such arrangements in areas with higher density. In 1954, the province of Ontario stopped approving subdivision plans based on septic tank systems. At about the same time, a CMHC study found that 64 percent of Canadians "lived in municipalities where pollution was a threat to health."[2]

To solve the problem, amendments to the NHA in 1960 authorized CMHC to make loans to the provinces and municipalities for sewage treatment projects. The program was highly successful and, by the end of its first phase in 1964, $170 million in loans had been extended.[3] By this time, only 2 percent of NHA loans were for houses with septic tanks. Without doubt, this was the result of the new infrastructure, but it also reflected CMHC's growing discouragement of septic tanks in urban areas.[4]

While these modern sanitation systems did make a difference, it was increasingly apparent by the early 1960s that water pollution in Canada was a growing problem.[5] Of greater immediate concern, however, the massive infrastructure of water and sewer mains used for urban sanitation was expensive to install and operate and used immense amounts of water. Alternative methods of disposing of sewage would help reduce land costs, and as Sam Gitterman noted, "while we were thinking up ways to reduce building costs by two or three hundred dollars, the value of the building site was going up from five hundred to one thousand dollars every year. People would not live where there were no sewers, and the cost of installing sewers got built into the price of land." Gitterman contended that if expensive municipal sewer and treatment systems could be eliminated in favour of a system which purified and reused the "water within the building itself," an important advance would have been made.[6] It would permit urban development on rocky or other nonarable lands, "thus conserving agricultural lands." Further, by making the building autonomous, housing development could be freed "from the constraints of the umbilical cords of water and sewer lines." As Gitterman phrased it,

> if one can imagine standing and looking down at our cities and having the earth removed suddenly, completely exposing what is there...it would be quite a shock. In the downtown under the pavement and under the earth, there will be a mess of pipes and concrete of such significance that I understand sometimes it is difficult to dig through...All these connections are very big, very costly and restrictive. There is no question about how they have affected the physical shape of our cities.[7] (See figure 6-1)

Reducing this infrastructure would save costs, reduce pollution and allow more imagination in urban planning and building design.

Such an approach had great potential for use in arid parts of the Prairies and especially in the North, where sewage disposal was a problem because of permafrost or rocky land and the very cold winters. One method developed to deal with the problem, called the utilidor, employed a large heated above ground pipe containing the sewer and water lines. Enclosed with wood and insulated, the pipe was connected to each house. It was "our whole [urban] system taken out of the earth and put above" ground. CMHC helped

Figure 6-1. Modern urban sewage and water systems were complex and expensive. This photograph shows installation of storm sewers in Thunder Bay, Ontario. Not dated.

National Archives of Canada/PA-190673

design and install such a system in Hay River, NWT, in the 1960s, but it was an awkward and disruptive approach because people had to clamber over the pipes.[8] For such communities, the benefits of a self-recirculating system were even more obvious than they were in the south.

Developing Self-Contained Sewage Systems

In light of these conditions, CMHC began working on alternative sewage systems. As a preliminary step, it arranged in 1956 for a literature search on recirculating water systems. It found that little research was being done and that the United States was the only place where such ideas were being investigated.[9] CMHC's first effort centred on using one such American recycling system called the "Sanitoi." It was "just a tank with a toilet on top of it. Air was bubbled through the tank to provide oxygen and support the microbic life that helped break down the wastes."[10] Once the waste water had been processed in the tank, it was used again for flushing the toilet. A cleanable filter caught any solids that remained. It thus essentially used the same principles as conventional septic tanks, where bacteria reduced waste to sludge, which was then pumped to a disposal field where another type of bacteria completed the reduction and purification process. In the Sanitoi, this whole process took place in the aerated tank, and the water was reused.[11]

NRC was not interested in the project and CMHC contracted with the Ontario Research Foundation (ORF) in 1957 to test this system. It was installed in the home of an ORF scientist for testing. His report that "it stinks" was brutally simple. Redesign was obviously needed, and the first modification involved adding a settling tank between the aerating tank and the toilet. Sediments dropped to the bottom of the settling tank and were periodically pumped back to the aerating tank for further processing. The settling tank idea was new and was patented.[12]

This system was then exposed to normal trial by eight people at the offices of the ORF for just over a year. It worked satisfactorily. There was no odour and very little water was added to compensate for that lost by evaporation. While the water was an unpleasant colour, it was safe. Further tests were carried out by installing it in the Mark III house, and the ORF continued to test the performance of the system.[13] In the Mark III, the system consisted of a 250 gallon tank, a grinder (or reducing) unit immediately between the toilet and the aerated tank, and a water pump to draw water back up to the toilet. The system was restricted to toilet wastes. Because the house did not have a basement, a large pit was dug below the house to contain the sewage disposal system. A bypass valve was installed to permit wastes to pass into the sewers should the system fail.

The use of a self-recirculating system in the Mark III house showed that the system was feasible but needed refinement. It worked well for two or three months and then broke down because the valves became clogged with paper.[14] While the same system had worked well in the ORF offices, "it could not cope with the paper resulting from an average family of four people." As Sam Gitterman observed, it was an instance "where field testing shows greater complications than could be determined from laboratory testing."[15] As well, the colour of the water in the toilet continued to be unpleasant because of oxides, although regular tests of the water showed that it was safe.[16] Nonetheless, because of the problems with the system, it was removed from the house and permanent sewer connections were made to the municipal lines.

Experimentation with the system continued in the Mark IV house in 1963, but it was redesigned to use four large aerated tanks instead of one. (See figures 6-2 and 6-3) The liquid passed from one tank to the other in turn. It was hoped that this would overcome the problems experienced in the Mark III. While four tanks were unnecessary for normal family use, they were included for test purposes. They proved more effective because the wastes were being held long enough for the bacteria to destroy the paper. The toilet was a pressure-operated type which used about one gallon of water per flush. This low volume helped increase the time "available for purification without adding to the total volume of the system."[17] The apparatus performed quite well. In co-operation with the Department of Northern Affairs and National Resources, another self-contained recirculating system was also undergoing field tests in a 75 pupil school in Cape Dorset, NWT.[18]

At the same time that these tests were underway, CMHC was involved in other research in sanitation. Discussions with private industry about use of new materials and techniques were ongoing, and CMHC funded numerous research projects. In 1958 a grant was made to the Pulp and Paper Research Institute to develop a process to break down solid particles. Although successful, it proved uneconomical at the time. Among others, a project at the University of Toronto was funded in 1964 to study designs for septic tank disposal fields.[19]

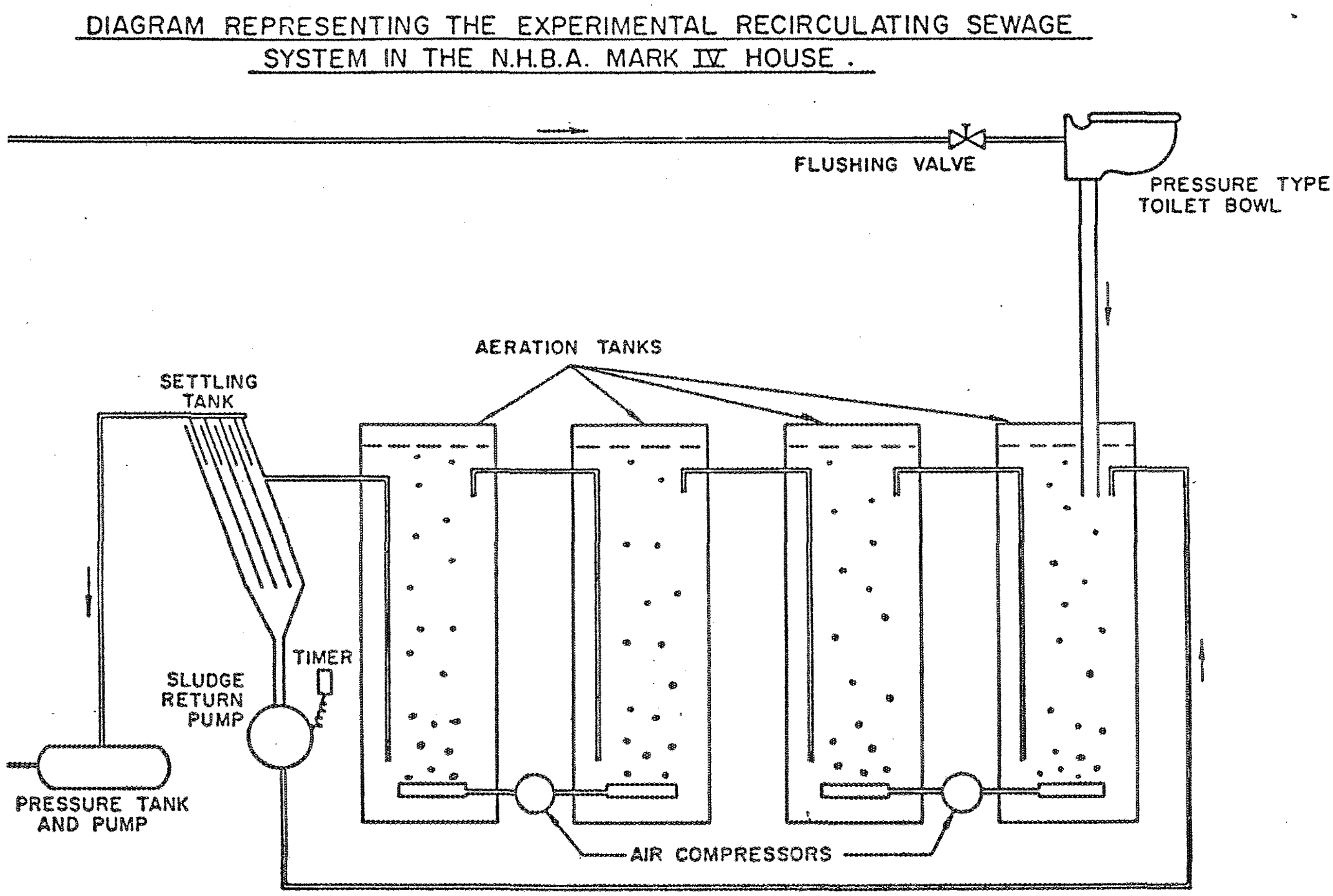


Figure 6-2. This drawing shows the configuration of the recirculating sewage system used in the Mark IV house.

National Archives of Canada MG31 B49 File 4-14.

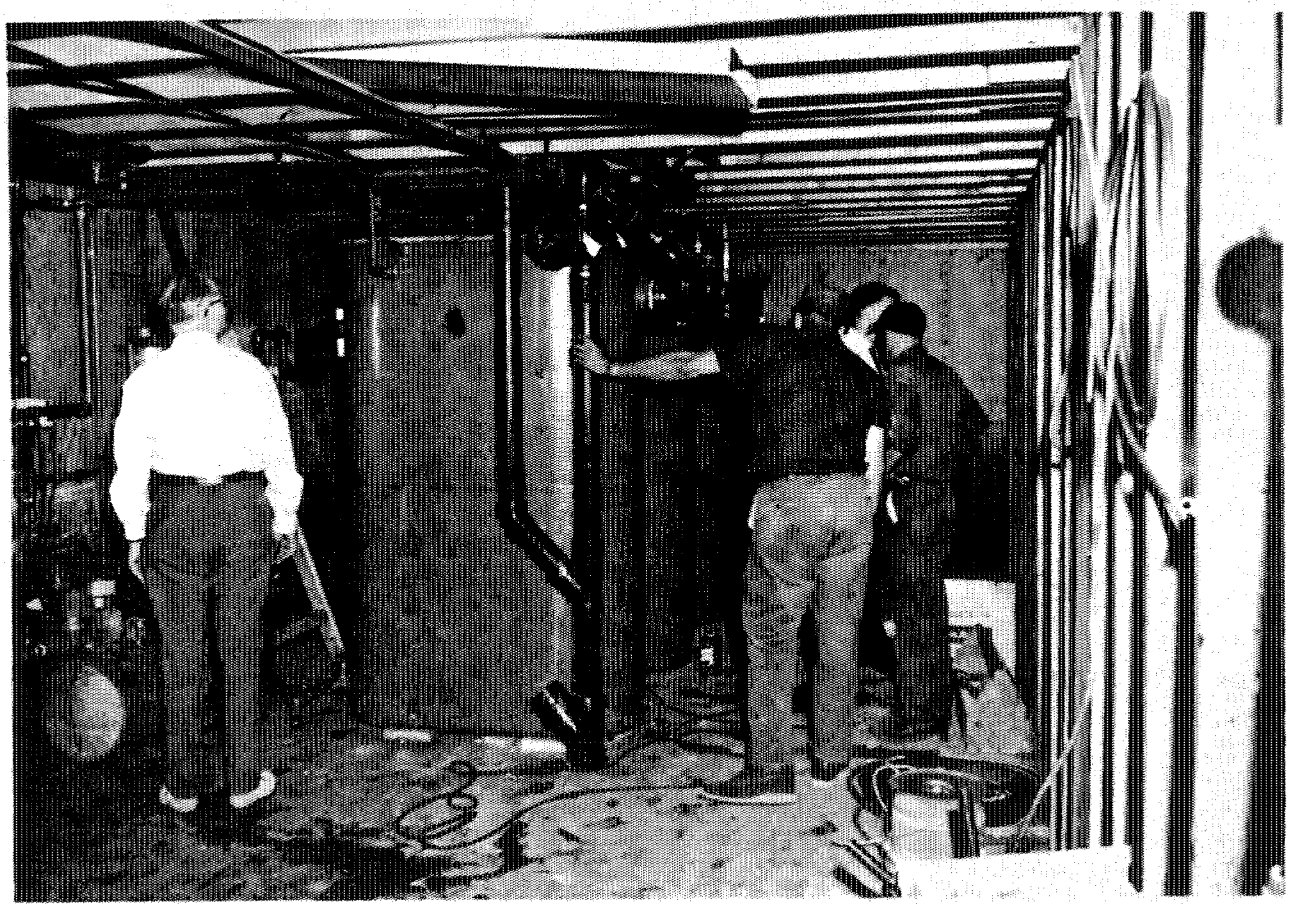


Figure 6-3. This photograph shows the recirculating sewage system used in the Mark IV house.

National Archives of Canada/PA-190642

Sponsorship of these projects did not, however, signal that CMHC was shifting away from its commitment to alternate sewage systems. In an effort to apply the technology tested by the ORF and in the Mark houses, the system was modified to operate as a "flow through" unit similar to a septic tank. While the discharged effluent was unsafe because it was not totally processed, a tile field only half the size needed for a septic tank was required to complete the process. A license to manufacture the system was issued to a Montreal firm. Called the "Converto," it was tested and approved by the Quebec Water Board in 1965 for use with half the field tile required for septic tanks.[20]

The Converto units were not successful. The effluent was found to be impure, and although the manufacturer received funding from CMHC for further research to improve the system, the company was not commercially viable. It did not develop an adequate national sales network, nor did it provide adequate servicing. Trouble with the compressors and deficiencies in manufacturing and installation led to so many complaints that Converto manufacturing was discontinued by 1973.[21] The principle, however, was picked up by another company in the late 1960s and was successfully marketed as the "Aquarobic" until 1980. This system was used instead of septic tanks and not for recirculating water. Although somewhat more expensive than conventional septic tank systems, it found application in rural areas across the country.[22]

CANWEL

Despite the problems experienced with the Converto, the principle of self-contained sewage systems appeared sound. In 1971 CMHC and the ORF began a program to develop an apparatus for recycling all wastes (including garbage) for use in large building complexes. This was called the Canada Water Energy Loop, or CANWEL. The objective of the program was to develop "an integrated closed system for the purification and recycling of domestic waste water and the recovery of energy from [burning] domestic solid waste (garbage)." A prototype was developed and tested by the ORF. The water discharged was "very clean," so clean, in fact, that the Honourable Ron Basford, the Minister responsible for CMHC, was photographed drinking the refined water.[23] (See figure 6-4) The cost estimates showed that the system was less expensive than the combined costs of conventional water, sewer and garbage disposal systems.[24]

The unit was descended technologically from the earlier systems used in the Mark houses. It was "an extended aeration micro-biological system," consisting of

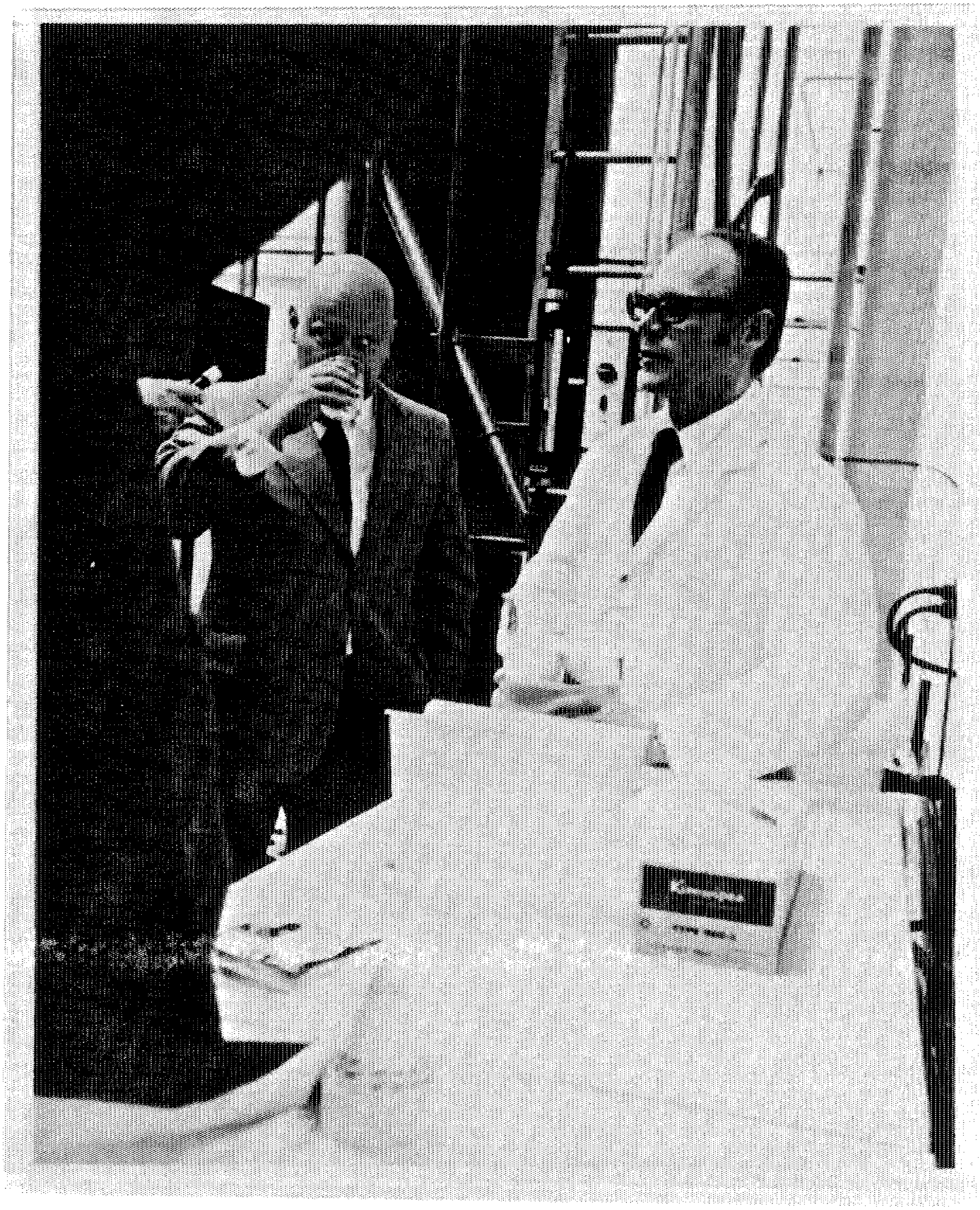


Figure 6-4. The Honourable Ron Basford drinking water processed by the CANWEL system.

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interconnected tanks which purified in different stages. Carbon, nitrogen and phosphates were removed in different stages from the sludge and were burnt in an incinerator. This continuous action was a distinguishing feature of CANWEL. The water was then disinfected by ozone and a sophisticated filtration method was also used as an added guarantee. Even though this water was potable, it was used only in toilets or for watering plants and washing cars, which represented a retraction of the earlier hope of a complete recycling operation.[25]

In 1975 Cadillac Fairview, a large Canadian real estate and development company, agreed to have the system installed in one of its Toronto apartment buildings so that it could be "tested in a realistic situation. The water would not actually be recirculated to the tenants' apartments but would be tested and discharged into the sewers." The basement of the building had to be deepened and equipment installed. (See figure 6-5) The cost of $500,000 was paid by CMHC.[26]

The original design of the system comprised three subsystems which could operate independently or together as a single system. The "Liquid Waste Treatment Subsystem" treated domestic liquid wastes with biological and physical-chemical processes and produced a "high quality effluent suitable for undiluted surface discharge." The second subsystem was the "Water Polishing Subsystem," which upgraded the water to a level suitable for domestic use. The third component, the "Solid Waste Treatment Subsystem" incinerated domestic refuse, as well as the wet solid byproducts of the two other subsystems. The heat generated was used to heat water. This system, without the Water Polishing Subsystem, was installed in the apartment complex.[27] In 1976/77 another plant was installed at Vaudreuil, Quebec to test its performance as a conventional water treatment system in an exposed environment similar to that of an ordinary sewage treatment plant.[28]

The Cadillac Fairview tests were successful and attracted much attention. Sam Gitterman, however, had retired from CMHC by this point, and with the project's guiding light off the scene, its promotion slackened.[29] The tests at Vaudreuil did not demonstrate the promise of the system in that they were not designed to achieve any innovation or contribute to a new approach to municipal sewage treatment. By 1978, financial constraints limited further developmental work and the project was shut down. As well, Canadian municipal authorities had shown little enthusiasm for the system. Its appeal was further restricted because water was plentiful in most parts of Canada, and, most importantly, the existing pricing system for water and waste treatment discouraged

Figure 6-5. Installation of the CANWEL system in a Toronto apartment building in 1975.

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alternative systems. CMHC restarted the CANWEL plant in 1981 to develop a record of performance, but this did not involve further technological development or refinement. A short time later, Cadillac Fairview sold the apartment building which contained CANWEL, and the new owners did not wish to extend the agreement. By 1987, CMHC had, to all intents and purposes, abandoned CANWEL.[30]

Conclusion

The experiments that culminated in CANWEL were boldly conceived challenges to conventional methods of dealing with wastes. In principle, CANWEL was more complicated than conventional sewage treatment systems with their massive and costly infrastructure. Yet, conventional systems offered a psychological comfort that such alternatives could not emulate. The principles behind CANWEL and its predecessors were logical and sustainable, but they were so far ahead of their time that they were fated to remain prototypes. They nonetheless represented one solution to a great number of ecological and urban planning problems that have become, if anything, even more daunting. In pioneering an alternate vision, they serve as models for the future.

PART III

URBAN PLANNING AND HOUSE DESIGN

CHAPTER 7: PLANNING THE URBAN RESIDENTIAL LANDSCAPE

As with other aspects of the housing industry, the availability of serviced land after World War II was shaped by the Depression. In 1946, most municipalities were in debt and owned a great deal of land which had been forfeited by the original owners because of nonpayment of taxes during the 1930s.[1] During the postwar boom, local governments eagerly serviced this land by installing streets, sewer, and water systems and sold it to private builders. By the early 1950s, most of this inventory had been sold, and builders assembled raw land for housing projects. By the end of the 1950s, many local governments (except in Quebec) no longer serviced raw land. Rather, developers installed services and recovered the cost from the selling price of the new home. In other words, the purchasers, rather than local ratepayers, bore the costs. By the 1960s, this reliance on private land development was beginning in some provinces to be supplemented by municipal and provincial land development policies that aimed to control costs and ensure that adequate land was available for housing development.[2]

In general, most of this land, however it came on to the market, was subject to some subdivision controls and regulations imposed by local governments. Immediately after World War II, much of this planning was piecemeal. During the 1950s and 1960s, however, it became more comprehensive, in large part because of the policies of CMHC.

Urban Planning

Although urban planning was an ancient art, many Canadian cities had grown quickly and with little attention to planning for sanitation, efficiency and beauty. The favoured system was a simple gridiron--a relentless and infinitely expandable system of square or rectangular blocks. To be sure, small, high income portions of most cities were laid out differently--making up the original suburbs. In the late 1920s, many provinces set up planning departments to stimulate more imaginative planning in new areas, and it was hoped that these agencies would also begin to reverse the damage of earlier unplanned development. In almost all cases, however, the Depression put an end to these efforts. Until the postwar period, there was only limited federal activity in planning, which in any case lay outside its jurisdiction. The DHA "Minimum Standards of Construction" contained a few provisions relating to lot coverage, and NRC devised a model zoning bylaw in the late 1930s, but it apparently was not applied by any local governments.[3]

These precedents nonetheless demonstrated alternatives to the rigidity of the gridiron and possible solutions to the problems caused by unplanned urban growth. Among the most popular approaches to urban planning before World War II was the Garden City concept in which residential land uses were rigidly separated from industry and a "natural" environment with extensive trees and green spaces was created. First developed in Britain in the early twentieth century, a few Canadian neighbourhoods were laid out on this principle (usually in exclusive districts). But the inspiration for most Canadians was the plan drawn by Clarence Stein for Radburn, New Jersey in 1927. (See figure 7-1) By 1946 Canadians referred to plans derived in varying degrees from these principles as "community" planning. Later, it was commonly called "neighbourhood" planning.

Such "community" or "neighbourhood" planning was less a precise model than an approach. As Humphrey Carver interpreted it in 1948, a "community plan" recognized that a residential area should be designed so that its occupants could "identify themselves as a social group enjoying collective responsibility for the amenities of their neighbourhood." This usually meant that a school, small retail services and a community centre, or perhaps a church, were located in a central location and became the focus of the "community." Ideally, the neighbourhood was sheltered from arterial traffic and industry, and dwellings possessed architectural variety and were sited to admit a maximum of natural light and fresh air into the house. Open green spaces accessible from all dwellings were also necessary to create a healthy environment.[4] Usually these principles created a low density subdivision with curved streets, cul-de-sacs and extensive green space, all leading to the community's central point. Indeed, in the Radburn plan, pedestrian and vehicular traffic was separated completely, with the houses accessible from both the street and the green spaces. Radburn plans sometimes often sited houses so that the living room faced the green space. In other plans (also sometimes called "Radburn" plans), less separation of pedestrian and vehicle movement was featured.

Wartime Housing Ltd. applied some of these principles to several of its housing developments. The NHAA did so as well, and in 1942 it set up a planning department under Sam Gitterman, who also continued to act as chief architect. Among the early efforts to understand urban growth, Sam Gitterman spoke with managers of retail chains to find out how they determined store locations. They told him that it was usually based on guesswork. To develop a more scientific approach, he and O.J. Firestone (a statistician and real estate analyst) studied various locational dynamics in Smith Falls, Ontario. While they were able to isolate a number of factors crucial to the town's economic life, they found it difficult to draw strong conclusions "on a technical level."[5]

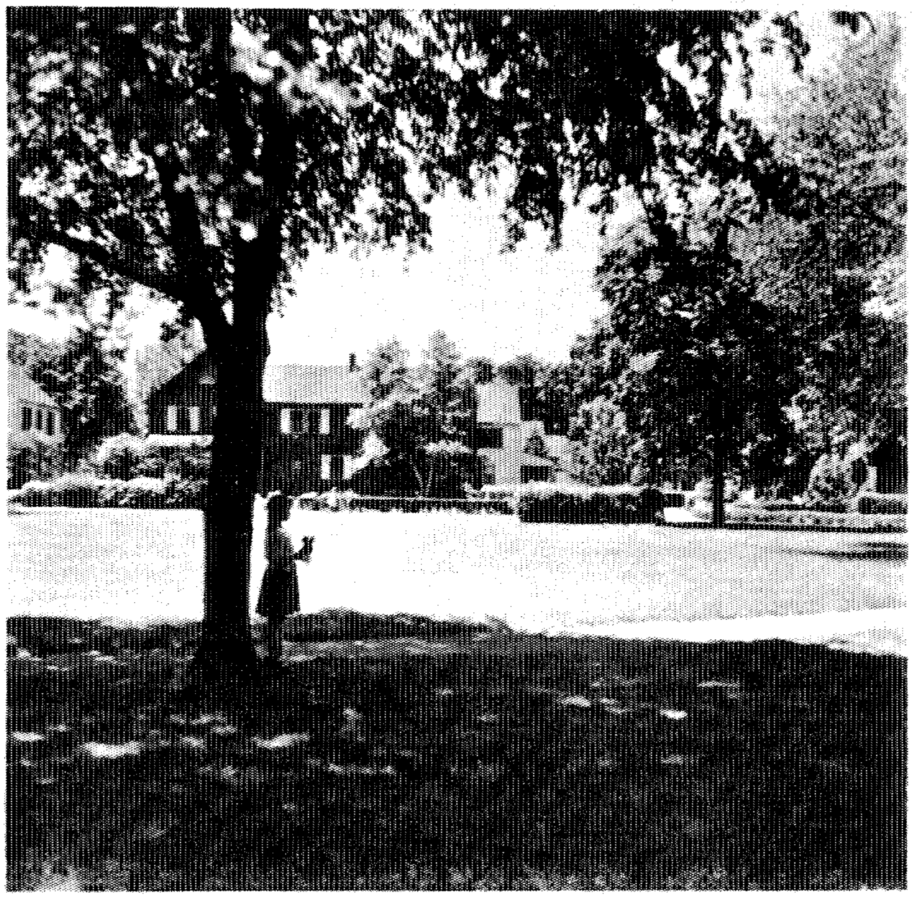

Figure 7-1. Radburn, New Jersey, with its green spaces and internal separation of vehicle and pedestrian traffic, was an influential precedent for Canadian urban planning after World War II.

National Archives of Canada/PA-190578

Such general inquiries aside, few cities employed planners. Because of this vacuum, the NHAA "encouraged" proponents to consider using Radburn principles, such as separation of vehicle traffic and pedestrians and other neighbourhood planning principles. Gitterman recalled that the NHAA proposed modifications to plans and while "not all of the provinces and municipalities were very pleased," they accepted it because it cost them nothing.[6] Further showing the popularity of such planning principles, the Curtis report recommended neighbourhood planning as a requirement for NHA loans.

These precedents formed the basis for CMHC's planning efforts. In late 1946, it established a Research Division under Part V of the NHA to encourage community planning and research. As with the NHAA, CMHC did not plan private developments but tried to encourage municipalities to participate in planning and "take their rightful position." In a related effort, CMHC organized a conference of representatives from the provinces, the Royal Architectural Institute of Canada, the Town Planning Institute of Canada (an organization moribund since 1932 and revived only after the war), as well as representative of local governments and other interested parties to discuss planning issues. The conference led to the formation of the Community Planning Association of Canada (CPAC) in early 1947. CPAC was dedicated to encouraging every city to hire professional planners. It was, as Humphrey Carver recalled, "a sort of missionary body for planning," and to stimulate public interest, it organized conferences and set up branches across the country to lobby local governments on planning issues.[7]

In support of these goals, CMHC provided CPAC with an office, a secretary, and financial assistance; an investment that paid high dividends in the level of interest and local commitment to planning that CPAC generated. By 1955 it had over 1,700 members, including municipalities, corporations and individuals.[8] CMHC also met the immediate need for professional planners by importing them from Britain. These individuals were kept busy at CMHC until they were hired by provincial or municipal governments. This was not, of course, a satisfactory permanent approach, and in 1948 CMHC established scholarships for planners at architectural faculties at Canadian universities.[9]

CMHC also used other techniques to encourage urban planning. In the preface to its house plan book of 1947, it warned home buyers that the resale value of their property depended on adequate financing, good house design, and an appropriate site. Purchasers were advised to select a site which was protected "by adequate zoning ordinances which are strictly enforced." CMHC placed heavy emphasis on planning as a means of protecting property values.[10] This served a dual purpose: it protected CMHC's mortgage investments, and it helped create housing of long term value for all Canadians.

While CMHC assumed that it could lead, but not dictate, in general planning matters, its views were clear from its admonition that "any municipality which does not protect prospective house builders by providing an approved master plan, or at least adequate zoning restriction properly enforced, is failing in its duty to its citizens.[11] In any event, municipal planners were eager to accommodate CMHC's views to ensure that houses in new developments would be eligible for NHA mortgages. In the 1950s, for example, the city of Calgary included CMHC in its approval process for development proposals, and proposed plans were sometimes changed to comply with CMHC's wishes.[12] Often, however, this process was more indirect. As R.J. Boivin of CMHC recalled, branch managers in the field had enormous influence. As he described it, "the town planner would invite you over to discuss a new development--where to put the streets, the parks, the schools. Later, when the bylaw was passed, you realized that he had taken your advice. It was a municipal decision, made with the approval of the province, but you had a hand in it."[13]

This process ultimately was neither random nor voluntary. In 1947, CMHC's residential standards and apartment standards included some planning requirements, such as size of setbacks and side yards for NHA-financed houses and apartments. Yet given the scale of postwar urban development, a more comprehensive approach was necessary. In 1952, CMHC's Toronto office developed a plans review service and the next year CMHC devoted an issue of its publication, Builders Bulletin, to site planning issues.[14] These developments helped shape the housing projects and subdivisions that contained NHA-financed houses. When CMHC appointed regional architects and planners in 1954, the plans review service was extended across the country. By 1955, CMHC required that "every developer proposing 25 or more NHA dwelling units on a single tract of land" submit a site plan showing the "community context." In 1955, over 46,500 residential lots were examined under this provision.[15] This served many communities whose minimal planning staff was fully occupied with planning basic services. It was also part of CMHC's increased emphasis on planning under the guidance of Stewart Bates. For him, planning was not merely laying out streets but an effort to achieve "a workable and inspiring setting for life itself, for all its infinite variety."[16] By the early 1960s, however, an increasing number of high density housing projects were being built in contravention of CMHC's planning standards. As John Archer noted, because "CMHC's site planning requirements and local office interpretation of them became an issue with the development industry," CMHC agreed to revise its structural, planning and design standards, as well as amalgamate them, into a single document.[17]

The requirement for this work, as well as a general need to overhaul the whole building standards system, led CMHC to ask the Associate Committee of the National Building Code to prepare new standards. This resulted, it will be recalled, in the production of new Residential Standards. The Associate Committee found, however, that site planning requirements could not be accommodated because "they lacked a demonstrably direct relationship to public health and safety." As an interim measure, CMHC prepared a supplement for the Residential Standards on site planning and immediately began work on "a comprehensive set of site planning standards that would cover the new forms of housing being produced by the development industry." (See figure 7-2) This document, which served as a companion to the Residential Standards, was published in 1966 as the Site Planning Handbook. It provided, in a single format, CMHC's requirements for lot sizes, setbacks, space between buildings, amenity areas, and separation of residential and nonresidential uses, as well as suggestions about the design of facilities for pedestrian and vehicular traffic. The general objective was to protect the public interest through minimal physical standards and to ensure long term value and quality of CMHC-financed houses.[18]

The 1966 Site Planning Handbook marked the end of one phase in CMHC's involvement in planning. In the following decade, its planning requirements were the subject of debate and, at times, dispute. In 1980 mandatory site planning standards for NHA-financed housing were dropped, except in respect to social housing programs. Yet CMHC's earlier involvement in creating planning standards in Canada had established parameters that could not be discarded easily. During the 1950s and 1960s, it had established national standards for residential environments that ensured minimum standards of space, amenities, and safety. These were standards which few local governments were capable of, or interested in, providing, and created a legacy of well planned developments that were a permanent asset to the country.[19]

Figure 7-2. New forms of housing, such as the "Link House" had appeared by the mid 1960s.

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The Postwar Suburbs

Garden City planning principles had been used in exclusive subdivisions well before World War II, but one of the first efforts to use them more broadly was in a project for a workers' subdivision in Montreal. Drawing on interwar thinking about the need for worker, or industrial, housing, two social activists, M. Joseph-Auguste Gosselin and Father Jean D'Auteuil, formed a nonprofit co-operative society in 1940 to provide low income workers with decent housing in a healthy urban environment. The co-operative organization--a type of housing association--organized and financed the project under the NHA. Gosselin drew up some rough plans, which Sam Gitterman refined to emphasize curved cul-de-sacs to take better advantage of the green space. (See figures 7-3 and 7-4) The central focus for the community was to be a church, school and retail centre.[20] While this plan was subsequently modified, it became the basis for the plan of the Cité jardin de tricentenaire, which opened in 1947 with 167 houses.[21]

Some CMHC veterans' housing projects also used the principles of winding streets and self-contained communities set apart from major traffic routes and industry. But postwar suburban development was exemplified by Don Mills, near Toronto. It was a massive, and highly influential, expression of contemporary planning principles. Using curved streets centring on core areas, it showed a link with the earlier Garden City concepts, but it also contained important modifications. Most subdivisions of the 1950s showed the same pattern -- streets were curved and the community was separated from arterial traffic, although pedestrian and vehicular traffic were rarely rigidly separated. The use of a community centre was common, but in smaller developments this was sometimes not implemented immediately and a school often became the plan's focal point. In general, density was higher and green spaces were less extensive than in the Radburn plan. As well, the living room of houses almost invariably faced the street.

Such modifications came about for a number of reasons. It was found that having the living room at the back was inconvenient because guests had to approach the house from the rear. In Canada, it was also found that winter restricted the value and accessibility of the green spaces and that irregular streets were difficult to clean and manage in winter. Further, easements to loop water lines back into the water system were often cumbersome to obtain and so water lines tended to come to a dead end at the end of a cul-de-sac. In these cases, water often became stagnant if consumption was low. In response, a more continuous layout of streets was used so water lines could be run in a continuous line. This resulted in what was colloquially called "can of worms"

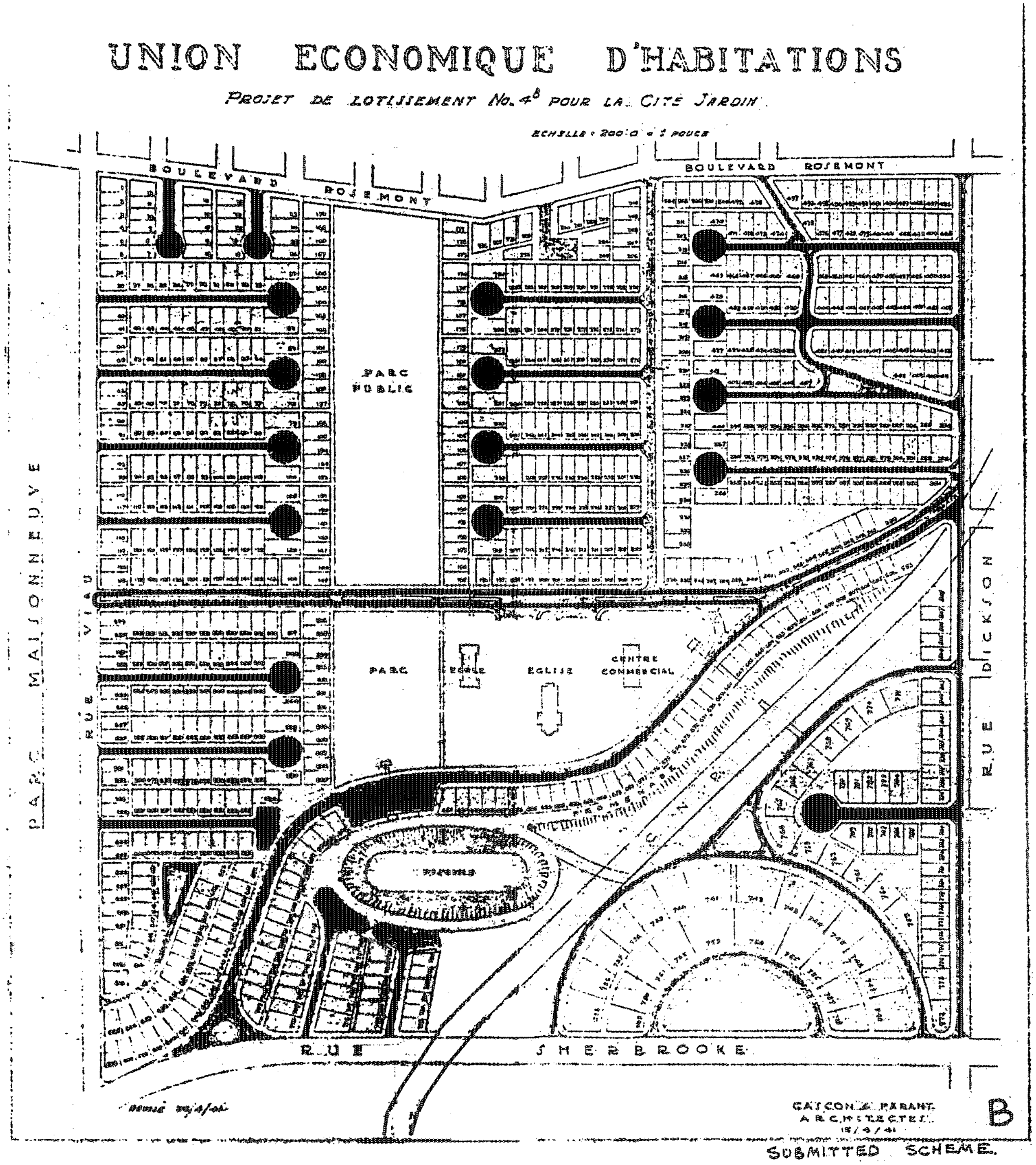


Figure 7-3. This 1941 drawing shows the original plan for the Cité jardin de tricentenaire.

Drawing courtesy of Sam Gitterman

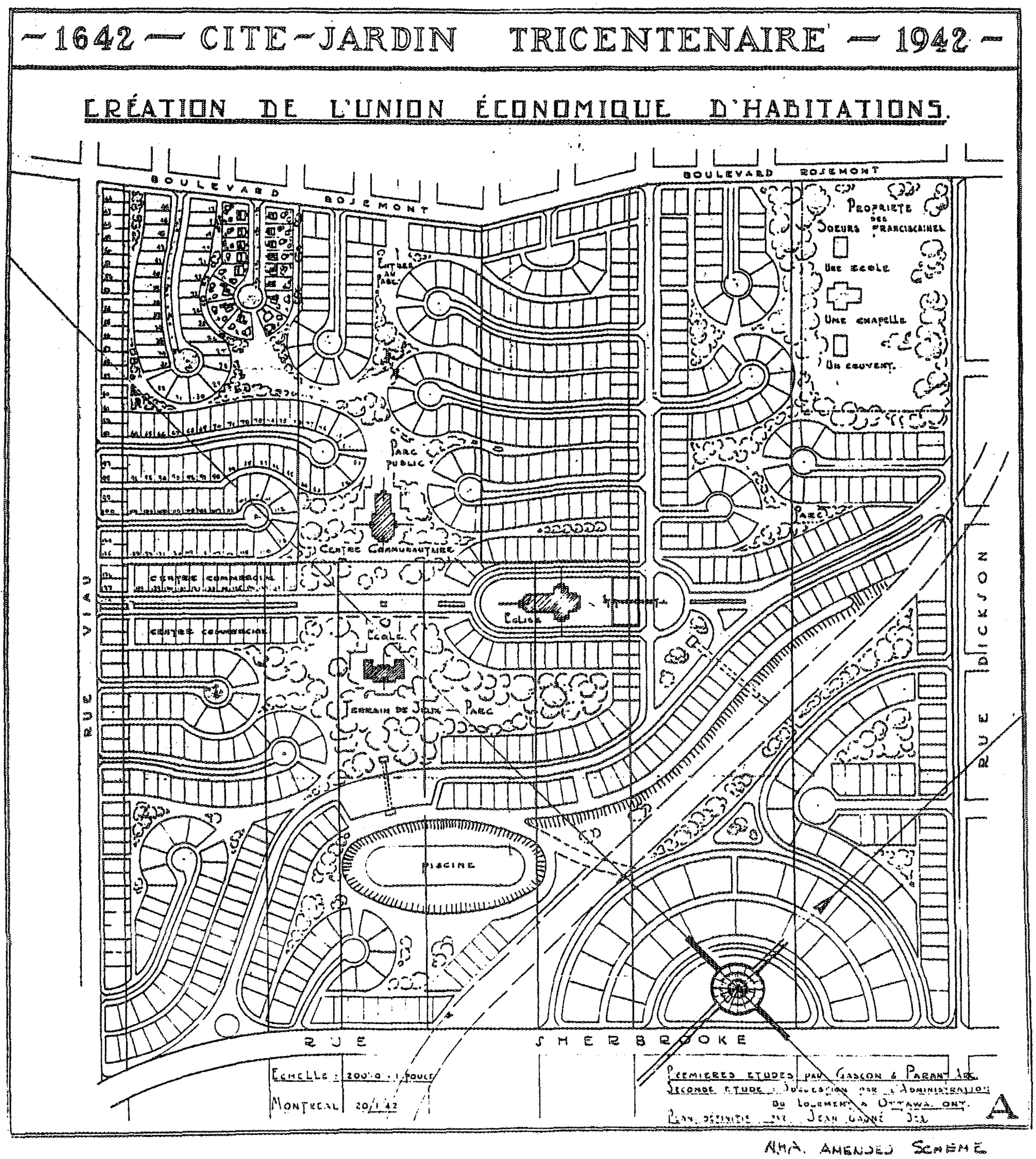


Figure 7-4. As shown in this revised drawing, the NHAA suggested revisions to the original plan of the Cité jardin de tricentenaire.

Drawing courtesy of Sam Gitterman

planning because of the extended curved streets in these subdivisions.[22] Moreover, it seems that land developers resisted what they considered an extravagant use of land in green spaces. Nonetheless, these plans were highly influential. As Humphrey Carver recollected, Don Mills served as the "lead off to a new generation of communities that were based on very ambitious plans of community separation from industry, and each community being a separate neighbourhood with its own public facilities and parks."[23]

The suburbs of the 1940s and 1950s tended to be devoted exclusively to low density single family dwellings. As Ian Maclennan of CMHC phrased it, people were "enchanted by the thought of a home of their own at a reasonable price, and the verdant delights of suburban pastures for their children." Yet, despite good quality house construction and design ensured by CMHC requirements, the resulting suburbs were too socially and architecturally uniform to be satisfying for many, and their low density and extensive use of land increased costs of servicing and public transportation.[24]

Before World War II, Sam Gitterman recalled that even though it was recognized that house costs could be reduced by using variations on a standard plan, this practice was rarely followed in middle class areas. Developments carried out by a number of small contractors helped ensure architectural variety along a street, but as well, "the idea of having a subdivision with houses of similar design was not a common one."[25] After World War II, standardized house plans were increasingly used by large tract builders to reduce costs and construction time. As CMHC noted in 1951, "a large proportion of the houses built in Canada are constructed by builders in the form of projects which have frequently consisted of a number of identical houses." To relieve the monotony this created, CMHC prepared advice for builders which set out "simple variation of plan and better grouping of houses on the site without removing the economies of such project building."[26]

These suggestions on how to avoid monotony were not mandatory and, in general, suburbs continued to show the same character as before. By the mid 1960s, however, planning theory began to shift towards encouraging a greater mix of housing types and higher density in all developments.[27] It was anticipated that this would counter the social and architectural monotony of the suburbs, and CMHC encouraged this trend in an effort to reduce rising housing costs because of high land prices.

To encourage alternatives to the single family detached house, the NHA was amended in the early 1960s to make the same maximum loans available for all forms of family housing.[28] While most suburban developments in the late 1940s and 1950s would have consisted almost exclusively of single family detached houses, by the late 1960s, this stood at only 70 percent, with the balance being apartments, row houses, and various types of semi detached structures.[29]

New Communities

As well as subdivision planning in new areas of established cities, CMHC was involved in replanning wartime communities for civilian use. Among these was Ajax, Ontario which had been established 25 miles west of Oshawa during World War II to manufacture explosives and heavy ammunition. Ajax lost its military function with the end of the war, but it contained many serviceable buildings, including 600 housing units. The University of Toronto, crowded with veterans returning to university, used Ajax as an overflow site. In 1948 Ajax was turned over to CMHC to convert "what would otherwise be a ghost town into a balanced peacetime community."[30] CMHC planned a shopping centre and an industrial area and also prepared a general plan for the town. It actively promoted the town through films, displays and other promotional efforts, and recruited industry to locate there. With a population of 6,000 and 34 new industries, Ajax was incorporated as a town in 1954.[31]

The planning of new communities was also undertaken by CMHC. It participated in planning housing projects with the DND, as well as with other departments and the private sector. In the early 1950s it had been instrumental in planning new town sites for Frobisher Bay and Hay River, two widely separated communities in the NWT. In the same period it was also involved with recruiting Clarence Stein to plan the new town of Kitimat, B.C. in association with Alcan. (See figure 7-5) In 1952 it undertook the planning and developing of a new townsite at Gander, Newfoundland. Gander had become important for commercial transatlantic flights, but the buildings at the airport were obsolete wartime structures and the town was too small for the increasing population. Along with the Department of Transport and the government of Newfoundland, CMHC laid out a new town. It acquired the property, planned the site, drew up zoning bylaws, and constructed rental housing for immediate use. To encourage home ownership, NHA loans were also available to purchasers. The centre of the town contained a large park and recreational area along with churches, schools and a shopping centre.[32]

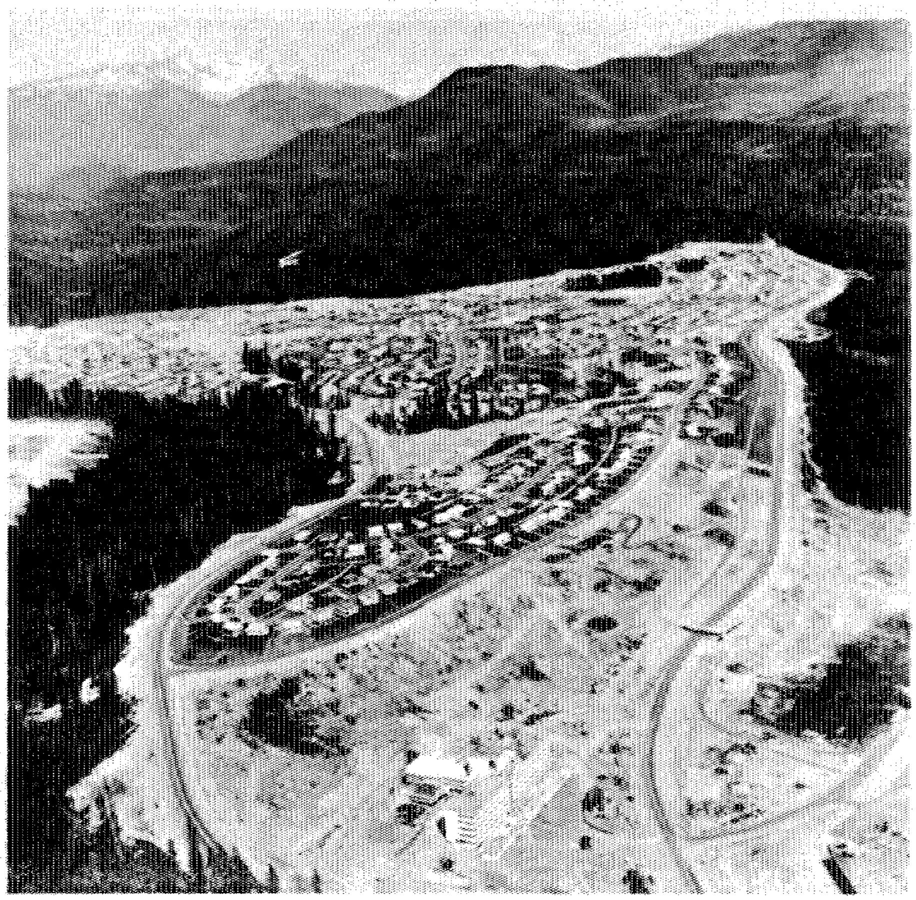


Figure 7-5. Kitimat, British Columbia was a postwar town planned by Clarence Stein.

National Archives of Canada/PA-187739

CMHC was also involved in urban planning through urban renewal projects in established cities. The clearance of slums had been one of the objectives of the 1918 federal housing program, and it showed renewed appeal after World War II when slum clearance (by then called urban renewal) became part of CMHC's efforts to preserve and enhance established urban areas. It was commonly assumed that crime, poverty, and other social problems grew from urban decay. Building on this premise, it was accepted that if the blight was removed, the social problems would disappear or, at least, be lessened.[33] Initially, it was argued that once the slums had been removed, public housing (in which rent was subsidized in some form by the state) would be constructed on the cleared land by nonprofit associations. Yet only a few projects, such as Regent Park North in Toronto, were completed because such undertakings were too complex and expensive for voluntary agencies to undertake.[34]

Urban renewal subsequently shifted its emphasis and became the joint responsibility of local, provincial and federal governments. A number of projects were completed, including ones such as Regent Park South in Toronto and Mulgrave Park in Halifax.[35] (See figures 7-6 and 7-7) By the early 1960s, however, urban renewal was no longer concerned solely with housing. Instead, cleared land was also used for other purposes, including commercial and institutional facilities. Nonetheless, between 1948 and 1968, about 18,000 new dwellings were built through 48 urban renewal projects.

By this point, urban renewal had become "the source of increasingly bitter confrontations between residents clinging to their neighbourhoods and city administrations implementing federally-financed renewal schemes." The range of political, public housing and urban development issues involved in urban renewal lie beyond the scope of this study. It is sufficient to say that by the early 1970s CMHC had devised alternate programs that provided tighter financial control of urban renewal projects, divested considerable power to local governments, and demanded greater sensitivity to concerns of the people affected by renewal. This rethinking resulted in the Neighbourhood Improvement Program in 1974 which emphasized rehabilitation of existing building stock, as well as new construction to revitalize run-down parts of Canada's cities.[36]

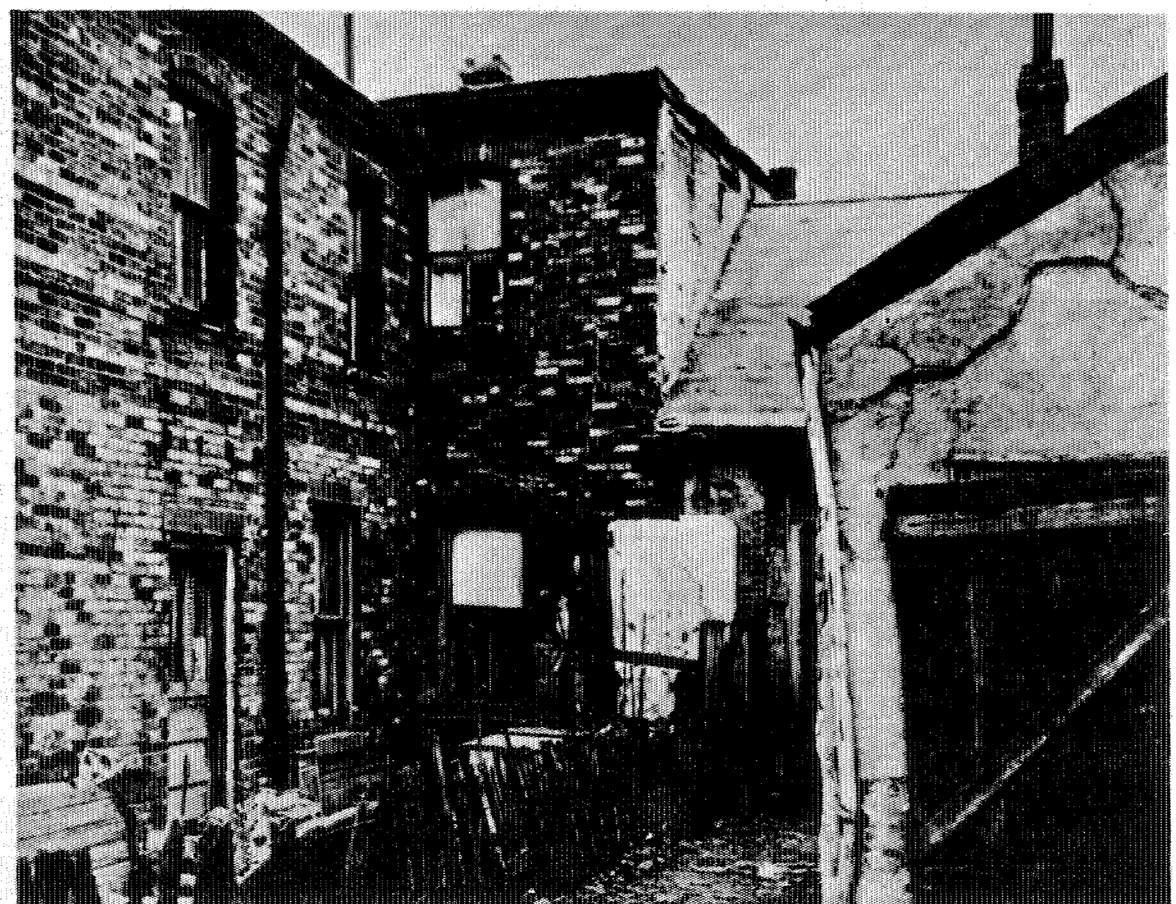


Figure 7-6. The Regent Park area, Toronto, had become a blighted area by the 1960s.

National Archives of Canada/PA-187725

National Archives of Canada/PA-187724

Figure 7-7. Regent Park South typified the scale of urban renewal projects in the 1960s.

National Archives of Canada/PA-187724

Conclusion

In its planning efforts, CMHC, like all other agencies involved in planning at the time, attempted to anticipate future population and economic growth. This could be extrapolated mathematically, but the equally important predictive ability to analyze the dynamics of urban economic life was limited and often contradictory. As Sam Gitterman observed about Gander, by 1974 it no longer resembled the original plan. Higher growth than anticipated and changed public expectations about convenience had created anomalies. The shopping centre had been "cut right through the middle with a big major [traffic] artery. So if you want to cross from one side of the shopping street to the other, its all your life is worth."[37] These changes resulted from economic and population growth, but were also the product of Canadians' changing expectations about convenience, standard of living, and the nature of urban life.

Despite complaints about their monotony, most postwar suburban residential areas were well planned and gained character as vegetation grew and time softened the community's outlines. Given the general lack of planning by local governments in the 1940s and early 1950s, CMHC played an important role in postwar planning. By encouraging the training of planners and by stimulating public interest in planning through organizations like CPAC, it created an environment in which local governments' responsibility for planning could be realized. At the same time, CMHC was directly involved in planning through its urban renewal programs and through its field offices which ensured local compliance with its minimum planning requirements for developments containing NHA-financed houses. As in other cases in which CMHC's minimum requirements were applied, these benefits spread out to improve all housing, whether NHA-financed or not.

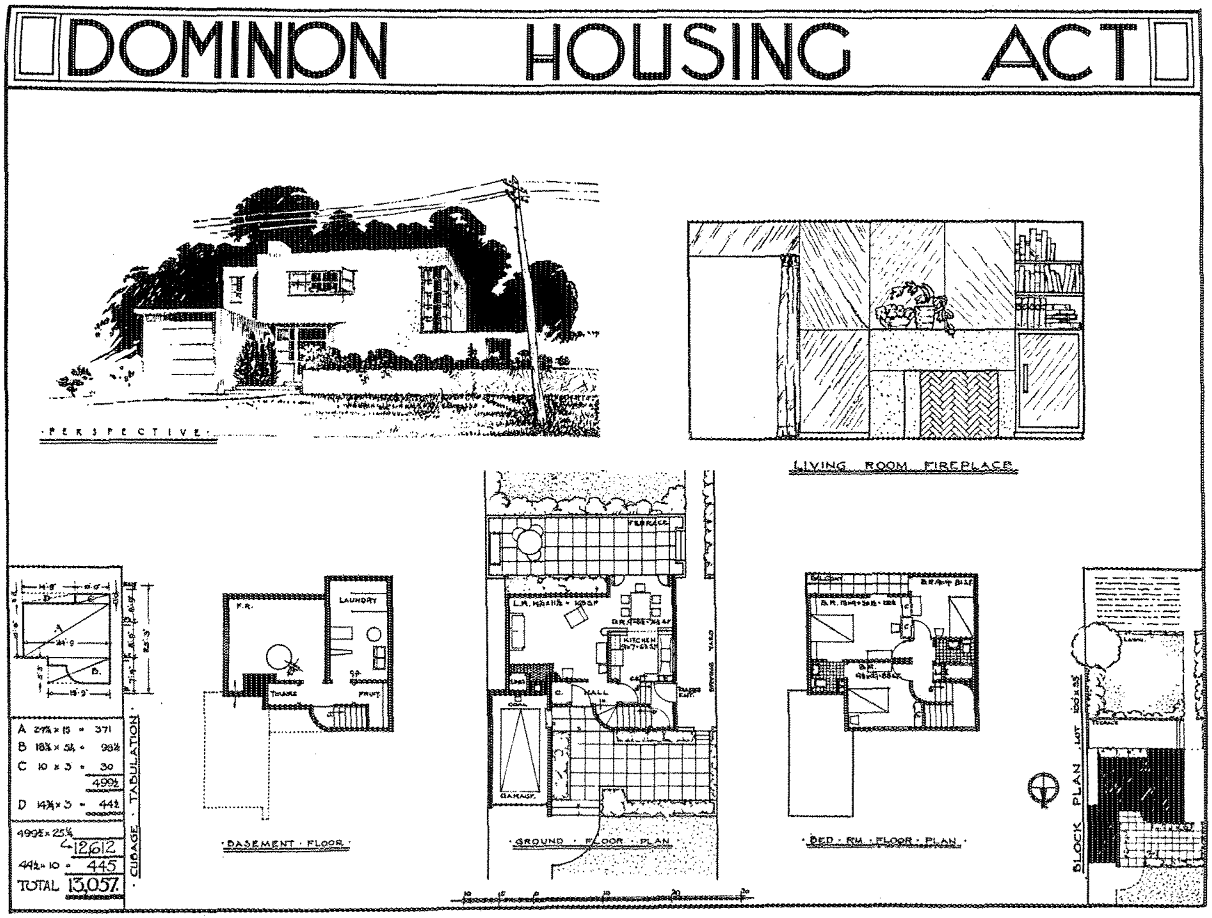
CHAPTER 8: HOUSE DESIGN

Before World War II, house design was not a matter in which government was usually involved. One exception was the federal government's 1918 housing program which had set out room sizes and provided floor plans for houses built under the program. In the same year, the Manitoba Agricultural College held a design competition for farm houses, and published the designs as models in an attempt to improve house design. Similar competitions were also commonly sponsored by corporations and architectural associations.[1] None of these efforts expressed, however, a consistent design philosophy and attempted only to promote good serviceable designs which might provide inspiration for builders.

Much the same approach was used by the federal government. Given the interest in design of its Director, Frank Nicolls, the DHA sponsored a design competition in 1937. Since most houses were designed without any contribution by architects, it was hoped that the competition would result in architect-designed plans for ordinary Canadians.[2] Architects across the country submitted 526 designs and a jury of professionals selected the winners. It was hoped that "model" designs, with particular attention to lower cost houses, would result. The first prize was awarded for a flat roof "modern" house. (See figure 8-1) Most designs used an open plan in which the living room and dining room opened into each other to eliminate costly passages and halls and use space more efficiently.[3] A selection of the best plans was later published by the NHAA and plans were sold for $10 per set--a very reasonable fee for professionally designed plans.

The design competition was successful in persuading architects to prepare plans for ordinary houses--a task most had so far ignored. Yet, as one reviewer rather sharply remarked in the Journal of the Royal Architectural Institute of Canada, the designs were "still to a great extent on paper only" and were likely to remain so because they were too expensive and, "like ultrafashionable clothes, too far in advance of popular fancy to be acceptable to owners in the price class."[4]

The NHAA subsequently reworked some of these 1937 designs for its war worker and other housing,[5] and CMHC later refined them further to bring them up-to-date. The overhang of the eaves was increased, and the roof pitch and the configuration of the windows were changed. Consequently, as Sam Gitterman observed, "we got, at that time, what we considered to be a pleasant looking house." A number of standard plans were devised, the most popular of which was a storey-and-a-half semi bungalow of just under



W. Ralston, Architect,
16 Rowanwood Ave., Toronto, Ont.

Design No. 386
(First Prize)

Figure 8-1. This "modernist" house won the first prize in the NHAA's 1937 house design competition.

DHA, Architectural Competition, Low-Cost House Designs (Ottawa: King's Printer, 1938), p. 15. Reproduced with the permission of Canada Mortgage and Housing Corporation.

1,000 square feet. The main floor had a kitchen, bathroom, living room and a separate dining room that could also be used as a bedroom if necessary. The bathroom adjoined the kitchen to minimize the amount of plumbing needed. The stairs to the second storey ran up the centre of the house and two bedrooms were located on either side of the landing. There were no dormers "because we were saving costs" and windows were instead located in each gable end.[6]

The simple Cape Cod style of these houses spread out into the society in general. They were simple, cost efficient designs, and responded to what postwar Canadians wanted, and could afford. New and different plans were subsequently issued by CMHC after 1946. The Corporation operated an extensive plans service, which provided both NHA-financed home builders and the public in general with inexpensive, professionally designed house plans which met minimum standards of construction, amenities and space. These plans were distributed widely through three sources: newspapers, travelling exhibitions, and plan books.

From 1947 until the mid 1950s, CMHC offered a feature service on request to newspapers. Contained in the series were house plans and a range of information about the NHA and CMHC programs and policies. House plans were sometimes published as the "NHA Design-of-the-Month," a service used by 92 English language and 44 French language publications in 1955. Travelling exhibitions using a variety of formats, including three dimensional models and display panels, were also circulated throughout the country and were mounted at fairs and other special events like home shows, as well as in public spaces like libraries, art galleries and department stores. CMHC staff were in attendance at these displays to answer any questions that the public might have about the designs or NHA loans. As well, the Corporation distributed books of house plans and sold the featured plans. As shown in Table 8-1, these books had wide distribution. Through such efforts as the plans service and its other educational programs, CMHC exerted a profound influence on postwar house design in Canada.

Table 8-1

CMHC House Plans Service 1947-1958

Year	Plan Books Distributed	Plans Sold	% of NHA-Financed Houses Using CMHC Designs
1947	18,884	N/A	N/A
1948	10,316	3,485	12%
1949	160,000	7,277	16%
1950	215,650	7,922	7%
1951	75,000	4,932	13%
1952	N/A	N/A	12%
1953	N/A	10,577	*
1954	N/A	11,286	N/A
1955	N/A	12,374	10%
1956	N/A	8,852	N/A
1957	60,000	6,400	N/A
1958	N/A	8,017	N/A

* The percentage was "estimated" in the **Annual Report** as 40%. It is too anomalous for citation.

Source: **CMHC Annual Reports** for years given.

CMHC and Principles of Design

After World War II, house design became a more conscious part of public housing policy. Given its investment in new housing, CMHC naturally demanded that houses financed under the NHA meet the Residential Standards, which influenced house design by requiring separation of sleeping, working and living spaces.[7] Yet this did not interfere with style or aesthetics, and recognizing the need to respect individual tastes, CMHC never set down stylistic guidelines. It did, however, promote certain approaches to design to improve Canadian domestic architecture and maintain housing values. In 1947 the Corporation advised Canadians that a home of lasting value should have a logical and adequate floor plan and an exterior appearance that fit into the community. "At all costs," it warned, avoid "applied decoration" which would "date your house," because "from that moment obsolescence becomes effective." In addition, CMHC noted that good building materials helped avoid high maintenance costs. "Do not attempt to cover up sound structural materials that will resist wear and weather. If necessary, decorate construction, but do not construct decoration."[8]

Such ideals were integral in the design competitions that CMHC sponsored in the late 1940s and in its plan books. In 1946, CMHC, under the auspices of the Royal Architectural Institute of Canada, launched one of its most successful design competitions. As a preamble to the competition, it set minimum standards for size, cost, and construction. Regional prizes for the West Coast, the Prairies, Ontario, Quebec, and the Maritimes were awarded. The objective was to develop sensible and well planned houses suited to Canadian conditions. To this point, most house plans sold in Canada had originated with American plan distribution agencies. Often unsuited to Canadian conditions, these plans also expressed the notion that house "style" was merely another dimension of fashion. While these American plans remained influential in the postwar period, CMHC's encouragement of Canadian house design helped to counter their influence.[9]

The results of the 1946 competition were published by CMHC in a book, 67 Homes for Canadians. It contained 30 "new designs for essentially Canadian homes" drawn by three Canadian architects, as well as the winning designs from the competition. Blueprints were sold by CMHC for $10.[10] The designs featured in 67 Homes for Canadians included a variety of one storey and one-and-a-half storey, or semi bungalow, houses of the sort used earlier by the NHAA and Wartime Housing Ltd. As well, it included one storey bungalows and some single storey low profile "ranch style" houses. The latter were said to be suitable mainly for the West Coast.

67 Homes for Canadians was among the most influential house plan books of the immediate postwar years. By the end of 1948, 29,200 copies of the book had been sold.[11] The house designs it promoted formed the basis for typical Canadian houses of the next two decades. Of course, not all NHA houses used designs produced by CMHC or its design competitions, but as shown in Table 8-1, a good number of NHA-financed houses used CMHC designs. More importantly, these designs, or copies of them, were appearing in every new housing development in the country. In the next decade, CMHC produced additional design booklets which emphasized modest houses. These publications provide a good index of changing public tastes and the evolution of the Corporation's views about house design.

In 1950, CMHC produced three further books of house designs. Some of the designs from 67 Homes for Canadians were reprinted, but new ones were also featured. The booklets were organized by house type--bungalows, one-and-a-half storey, and two storey. A fourth was issued in 1950 which offered special designs for Quebec. Overall, the houses used relatively sober, traditional designs but showed a refined sensibility through good detailing and proportion. In the booklet of two storey designs, there were five "Modernist" houses with flat roofs. The Quebec plans were in some respects the same as those intended for English Canada, but there were some significant differences. One design, inspired by traditional Quebec domestic architecture, featured a sharply gabled roof. And reflecting the greater importance of multi family dwellings in Quebec, four plans for two storey duplexes were offered.[12]

While Table 8-1 indicates that a huge number of plan books were distributed and many plans were sold, evidence of the popularity of specific designs is fragmentary. However, sales statistics for the first four months of 1950 give some indication of their acceptance by the public. About 1,000 plans were sold in this four month period, and the top selling designs were of bungalows and semi bungalows. The most popular plan (No. 50-41) was a three bedroom 1,056 square foot (98.10 square metres) semi bungalow which had appeared in 67 Homes for Canadians in 1947. (See figure 8-2) It was modeled on the Cape Cod style popularized in Canada by Wartime Housing Ltd. and CMHC's postwar housing programs. The second most popular design (No. 50-2) was an L shaped 1,008 square foot (93.64 square metres) single storey three bedroom bungalow. Its floor plan was less open than that of the most popular semi bungalow design. The third most

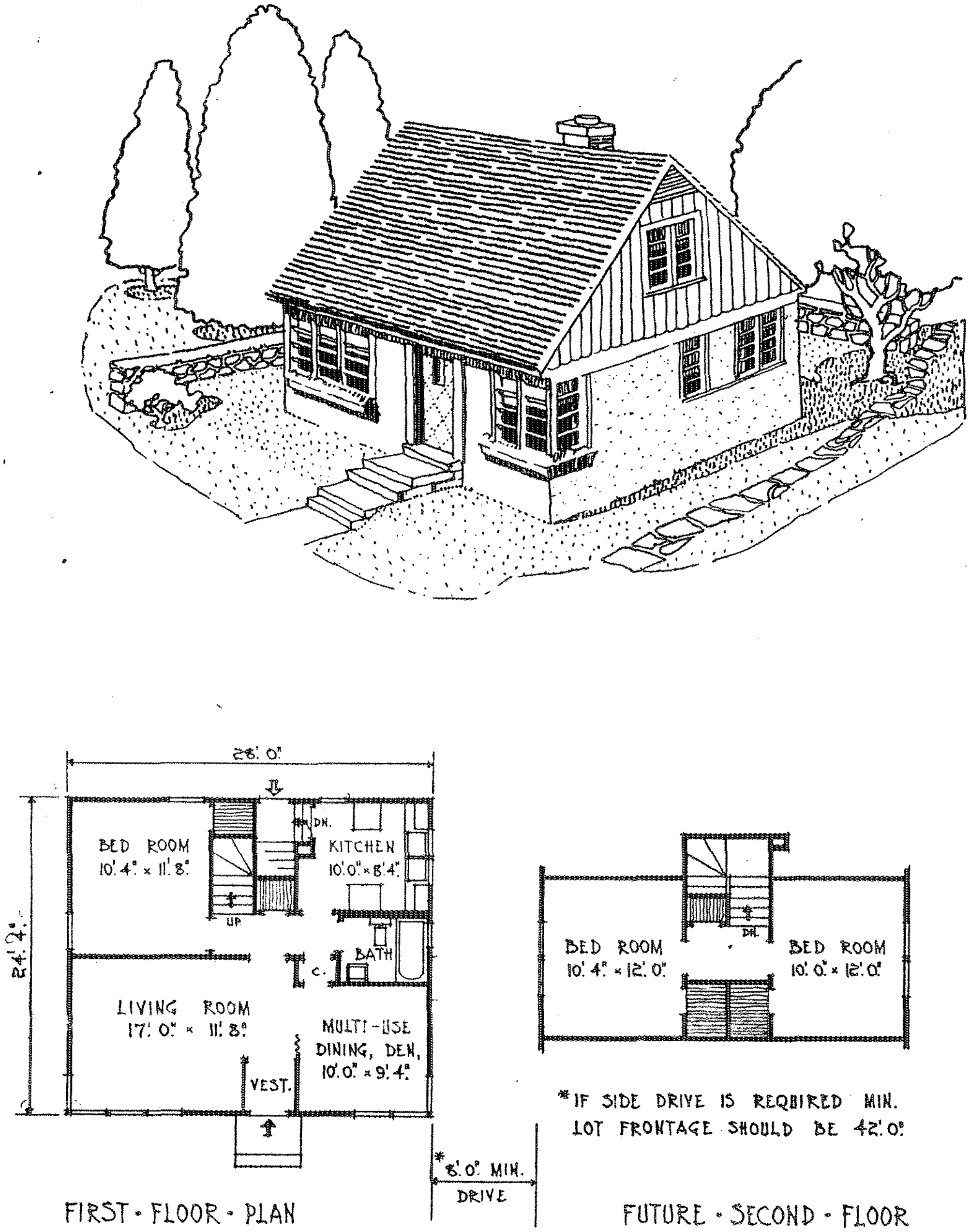


Figure 8-2. This plan first appeared in CMHC's book, 67 Homes for Canadians in 1947. With slight modifications it was reprinted in CMHC's 1950 plan book. It was one of the most popular designs in 1950.

CMHC, 67 Homes for Canadians (Ottawa: CMHC, 1947), pp. 20-21. Reproduced with the permission of Canada Mortgage and Housing Corporation.

popular design (No. 50-42) was another semi bungalow. Basically, it had the same configuration as the most popular design, except it had a cross gable on one end. All of these plans expressed a somewhat sober idealization of domesticity that evidently corresponded with postwar yearnings for stability and continuity. In this context, it was perhaps significant that flat-roofed "Modernist" houses were not overly popular.[13]

In 1952, CMHC issued another house plan booklet. The plans were similar to those of the 1947 and 1950 publications, but sizes had increased slightly in some cases, new perspectives were offered, and a few designs had been deleted. A few "Modernist" flat-roofed bungalows were included, but only two "Modernist" designs for two storey houses were now offered. In general, most of the designs were either directly or vaguely "colonial."[14] In the same year, CMHC published a separate booklet of plans for houses for the West Coast. Complaints had been expressed that CMHC's designs showed "no recognition of regional differences." It was contended that British Columbia had "such different cultural and climactic conditions" that a book addressing these needs was required. In response, CMHC commissioned a special book of plans drawn by B.C. architects. The main difference seemed to be in "quantities of insulation" and most of the designs were "more severe than the usual." In any case, none of them sold very well, either in British Columbia or elsewhere--in 1952 only 43 plans were sold from the West Coast book-- and British Columbians continued to favour the plans issued for general use.[15]

Another in CMHC's series of plan books came out in 1954. It presented two and three bedroom split level plans for the first time. This wholly new design became highly popular, especially in Central Canada and in the West, and offered more useable space by efficiently incorporating part of the basement into the living area of the house. This design typically featured an open plan, offered more light, and contained labour saving designs. Although the bungalows in this book continued to express a direct stylistic linkage with the 1947 houses, their profile was more horizontal and more "ranch style." (See figure 8-3) Indeed, such houses were no longer defined as suitable only for the West Coast, but were said to be appropriate for any part of the country.[16] These lower profile ranch houses and split levels remained the dominant forms in ordinary housing until the 1960s.

The trend to lower house profile reached its zenith in CMHC's 1965 Small House Designs. As before, CMHC sold working drawings at very reasonable rates. Anyone, whether they were using CMHC financing or not, could purchase plans for $15. Over

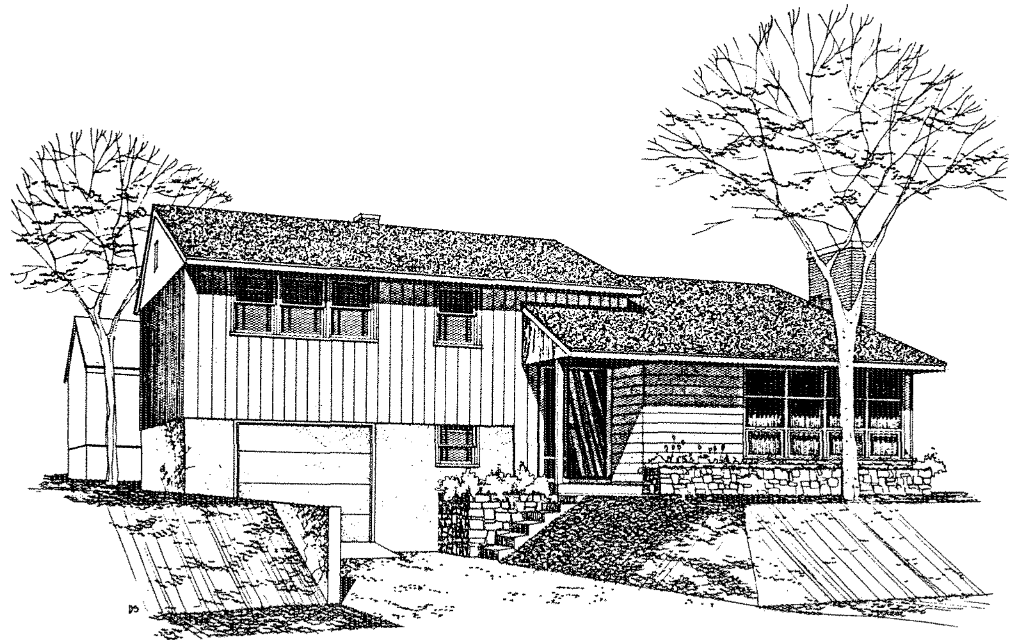
Figure 8-3. By the mid 1950s, houses typically featured a low "ranch style" profile, as in West Kildonan, Winnipeg. Photograph not dated.

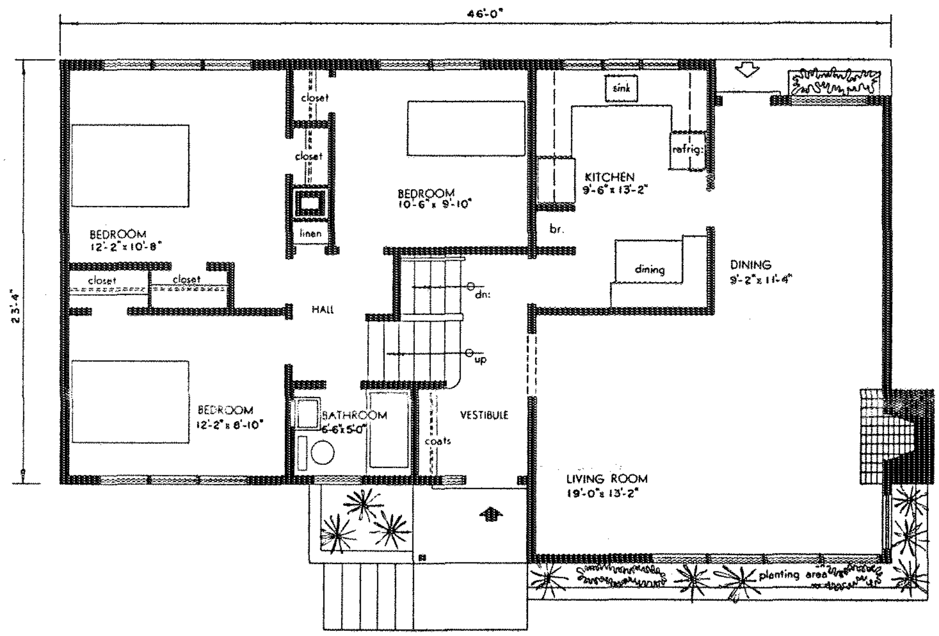
National Archives of Canada/PA-190654

100 plans were offered in the 1965 book, mostly for bungalows, although a number of split level and two storey houses were available. (See figure 8-4) Semi bungalows had disappeared almost entirely, and only five plans were featured. As well, there were a number of other significant differences in design. While an emphasis on single storey three bedroom bungalows continued, house profile was now markedly lower and the interior plan was even more open than in designs featured in earlier plan books. A new emphasis on storage space was also apparent, and while some of the earlier designs had featured attached carports, almost all of the bungalow designs now did so. Patios, or terraces, as well fireplaces, were also featured in many designs--indicating new dimensions in home entertainment and social life. While glass area had probably increased only marginally overall from the 1950s, house size had increased somewhat--many of the 1965 bungalow plans were between 1,100 and 1,200 square feet (102 and 111 square metres).

There were some wholly new features in the 1965 designs as well. A few used post and beam construction, and a number of others imitated the post and beam look. In these designs, the slope of the roof was followed by the ceilings in the living-dining area (and sometimes in the kitchen) to create a sense of spaciousness. Another important change in the bungalow designs was the use of the basement as a living space. In some cases, this was made possible by placing the main floor about six steps above grade to permit greater height and larger windows in the basement. In almost all of the designs, the basement was planned so that a recreation room or bedrooms could be easily installed. This served to increase the livable areas of relatively small houses, but larger sized two storey and split level plans were also available. Even so, CMHC did not generally encourage large houses in its plan books, and house size was usually kept under 1,200 square feet (111 square metres).

By 1957, concern over costs had grown because of a huge increase in demand for loans and higher construction costs due to the popularity of larger houses. High demand for more expensive housing threatened to exceed the housing loans available, which led the federal government to institute its Small Home Program. Since the average house built in 1957 was 1,150 square feet (106 square metres), CMHC believed that house size had to be reduced to 1,060 square feet (98.5 square metres) or less to lower costs.[17] For the next decade, such programs, as well as the natural impact of affordability, kept house size in the range of that common in the 1950s. Only a slight increase was evident by the mid 1960s, when the average size of new Canadian houses was 1,100-1,300 square feet (102-120 square metres).





AREA: 1,158 square feet (excluding garage).

Figure 8-4. This split level design was featured in CMHC's 1965 plan book.

CMHC, Small House Designs (Ottawa: CMHC, 1965), pp. 168-69. Reproduced with the permission of Canada Mortgage and Housing Corporation.

Sources for Design

The designs in CMHC's small house plan books came from a variety of sources. From the beginning, CMHC used architects in private practice to draw plans for the plan books. The Corporation specified minimum structural and space requirements, and architects submitted plans to CMHC for consideration. The first working drawings were checked, and if approved by CMHC, the final working drawings were prepared. By 1962, an architect was paid $1,000 for the working drawings, plus a royalty of $3 for each plan sold. The architect retained copyright in the plan.[18] This meant that small houses, which in other circumstances would not have benefitted from professional input, were designed by architects who in turn could now receive a reasonable return for such work.

In a few cases, designs were also prepared in-house or by agencies working in the field. For instance, in 1961 the NHBA Technical Research Committee concluded that the knowledge it had gained from the Mark series should be used in a house plan which met CMHC requirements. Sam Gitterman, then the NHBA's Technical Director, assembled the most successful features of the three Mark houses and developed a model that met the National Building Code and the Canadian Housing Standards. He sought the opinion of DBR's Housing Section, and while DBR staff liked his plan, they pointed out that since the design was based on the Mark III plan, it was "more suited to a basementless design than one with a basement." Since there seemed to be "few good basementless house designs in CMHC's booklet," DBR staff thought that the plan should be included as it was "originally designed."[19] In response to such comments, the NHBA submitted three designs to CMHC--one with a basement, one without, and one with the house placed endwise to the street. CMHC chose the design with a basement for its 1965 plan book, but noted that it could be built with or without a basement.[20]

The principle of design independence that lay behind design competitions and the use of architects in private practice also informed CMHC's sponsorship of the creation of the Canadian Housing Design Council in 1956. CMHC hoped that as an independent nonprofit organization, the Council would become a link among private builders, architects and consumers. To assist the Council, a CMHC official acted as Secretary Treasurer, and CMHC provided office space and administrative assistance.

The Council aimed to encourage and demonstrate good design for all housing, NHA-financed or not. It reflected an effort to make Canadians more design conscious and to counter the tendency to view house design as a matter of fashion. As the Honourable John Nicholson, then the Minister responsible for CMHC, remarked in 1964, Canada had achieved great success in housing Canadians through national housing legislation, but "you cannot, however, legislate good design any more than you can legislate great art, hence the importance to Canada of this Council."[21] In pursuit of such goals, the Council instituted its first national design awards competition in 1957 and these awards became a regular feature of its work. (See figure 8-5) It also organized lectures on architecture and design and published an extensive range of materials on house design.

Because the Design Council was more market oriented, the house designs it promoted tended to be of higher cost than those promoted in the CMHC plan books.[22] Nonetheless, it was responsive to changing Canadian conditions and needs. In 1962, it added low rise multiple housing to the categories of eligible housing in its awards program, and in recognition of the growing importance of this form of housing, high rises were included in the multiple housing category in 1964. Noting that site planning was one of the most difficult aspects of multiple family housing to design, the jury paid special attention to such issues in awarding the prizes. Thus, in addition to more conventional criteria regarding privacy, the layout of the dwelling units and the architectural character of the building, the handling of matters such as parking, relationship between buildings, the use of space between buildings and pedestrian circulation were also important. In keeping with this emphasis on multiple family housing, the Council issued a special publication on multiple housing in 1964.[23]

Conclusion

A distinctive aspect of the design of ordinary housing in the twentieth century has been the way that it has increasingly become tied to the images and concerns of popular culture. Ideas about what was fashionable were the product of a complicated mix of personal wishes and traditions, and the fashions promoted by newspapers, magazines and even movies. In an environment with such a broad range of influences, no single agency can be said to have dominated the design process. Yet CMHC had tremendous influence in the late 1940s and 1950s. It has been contended by some critics that this led to the obliteration of regionally distinctive housing forms, or, at the least, served as a barrier to the emergence of regional forms. This had been implicit in British Columbia's complaints about CMHC house plans in the early 1950s, and the same argument had been made with respect to Quebec. As Michel Lessard and Huguette Marquis have observed, however, in their history of Quebec housing, house design occurs within a

Figure 8-5. This Ottawa house won the Canadian Housing Design Council regional prize in 1960.

National Archives of Canada/PA-190667

specific economic and social context.[24] And as the noted Quebec architect Guy Desbarats observed in 1968, despite the success of CMHC's plans service, and the work of agencies like the Canadian Housing Design Council, plan distribution agencies selling American mass produced plans were still the largest distributors of house plans in Canada. As a result, he concluded that these plans exerted more influence on house designs in Quebec than did "all the Quebec architects."[25]

Even so, CMHC's designs were highly influential models for the whole country. Their appeal was grounded in CMHC's pragmatism and sensibility -- it did not offer plans that were highly sophisticated in theoretical terms but of little popular appeal. The rapid abandonment of the "Modernist" designs in the early 1950s was evidence of this pragmatism and it demonstrated one key to the success of CMHC's design programs. The Corporation did not push unwanted designs on an unwilling public; such an approach was neither possible nor in CMHC's interest. What it did achieve was to bring a standard of design and planning to ordinary housing that had often been lacking in earlier times. Its insistence on using architects and its commitment to designs which suited the lives of ordinary people, combined with its commitment to structural soundness, quality construction, and adequate urban planning, provided a sound and rational living environment for Canadians.

CONCLUSION

At the end of the 1960s, more than one-third of houses constructed since 1945 had been built under the auspices of CMHC or other federal agencies.[1] Thus, the direct impact of the Corporation had been substantial, but its indirect influence was even greater. Standards of construction and the definition of acceptable materials demanded by CMHC for houses built under the NHA became the standards used by almost all house builders in Canada. So too, its requirements for house design and urban planning became the accepted minimum standards for Canada. No other agency had such impact on postwar housing.

In large part, CMHC was able to accomplish these goals because its standards were set as minimum requirements for mortgages under the NHA. If its standards were not met, the financing would not be approved. Yet its standards were widely accepted because they were based on a reasonable assessment of benefits. They were also accepted because CMHC did not view itself as an isolated entity. Its co-operation and interaction with other federal agencies, especially DBR and the Forest Products Laboratories, testified to this, while its work with the NHBA pointed to a similar relationship with the private sector.

CMHC's impact thus cannot be appreciated without also assessing the work of other agencies with which it collaborated. Collectively, they had a profound influence on Canadian house construction. Their work in improving construction techniques and materials provided the impetus for a broad range of efforts to transfer this technology to the housing industry. New ideas were incorporated into the National Building Code and helped to unify construction practices across the country because of the Code's impartial and authoritative qualities. Similarly, CMHC's acceptance standards (which often utilized DBR expertise) fulfilled a similar function. While work by CMHC and DBR on materials acceptance contributed to public safety and quality of materials, it at the same time stimulated research and development. For Grant Wilson, DBR research in support of CMHC's work on materials acceptance was "a primary entry to the real world" and launched many of DBR's subsequent research projects.[2] DBR also influenced construction in its work on smoke movement in high rise buildings, in its work on vapour barriers and insulation, and in its efforts to gain acceptance of roof trusses for residential construction.[3] As Robert Platts observed, these efforts made a significant contribution to the quality of house construction. Indeed, he concludes that the quality of Canadian houses is better than that of equivalent houses in the northern United States, in part because of the work of DBR.[4]

These patterns emphasize the interdisciplinary and evolutionary nature of research in housing technology, and point to the importance of co-operation among agencies concerned with these issues. Problems with materials or methods of construction were never solved immediately. In part, this was inevitable because one change often led to other changes--and sometimes to problems that demanded further solutions. Changes in insulation, for example, showed this pattern. As Sam Gitterman recalled, when insulation was first used, "it seemed to be an answer, but then it created problems with condensation."[5]

Equally important, the interrelation of the components that made up a house meant that innovation in construction and materials could never be an isolated process. One observer has commented that in the residential construction industry, innovation "is not a synonym for invention; it is not the result of isolated sparks of insight or the discovery of some hitherto unknown physical principle or production technique." Instead of "breakthroughs," technological innovation in house building took place by gradual "acceptance of many less significant developments." New materials and methods of construction had to be compatible with other less sophisticated products to find favour with builders.[6] This evolutionary character did not invalidate the importance of research, but, as Sam Gitterman observed, "the innovators will always try something drastic," but "I cannot think of any one [development] that has come out of a drastic nature that has got into the stream immediately."[7]

These characteristics of technological change in house building were demonstrated in the efforts to achieve prefabricated construction. At its most extreme, the dream that houses could be made in factories foundered because houses were simply not amenable to such production. Such ambitions experienced revivals during periods of housing shortages or rising costs, but their appeal was also part of the society's conviction that technological change in itself held meaning and promise for the future. The late 1960s saw particularly strong expressions of such thinking. Habitat 67, part of Expo '67 in Montreal, expressed this futuristic appeal of technology by construction of dwellings from concrete boxes assembled on site. This housing also used complete bathroom units made from reinforced fibreglass. Such ideas were hardly new--they had been around since at least the 1920s--and despite their continual failure in practical terms, they continued to have a broad emotional appeal. Canadians also observed with interest similar undertakings in the United States. There, the U.S. government created "Operation Breakthrough" in 1969 in an attempt to find, through technological innovation and prefabrication, a solution to the problem of housing the poor. Needless to say, it made no dramatic contribution to the problem of affordability.

The hope of finding technological solutions for social problems was part of the appeal of Habitat 67. Yet while the theoretical appeal of prefabrication was strong, it remained that even less complete forms of prefabrication (such as the stressed skin houses manufactured in the 1950s) could not overcome opposition of lenders, some consumers, and interested parties such as builders and trades people. Significantly, the prefabricated components that were accepted and came into use were ones that met a variety of technological, economic and personal requirements in the house construction industry. Prefabricated roof trusses, like prefabricated cabinets, stairs, windows, and other elements, were quickly accepted because they were compatible with a range of other products and methods of construction and could be used by a range of builders, from the smallest to the largest.

While the use of new materials and techniques had wide-ranging effects, Sam Gitterman has observed that all the efforts to cut costs through use of new materials and new techniques resulted in relatively small savings on a per house basis.[8] Yet for housing built with conventional mortgages under the NHA, the savings were significant cumulatively and represented a massive savings in terms of the national economy. At the same time, these savings were not without costs in social terms. By decreasing the need for skilled labour in house construction, they contributed, as CMHC recognized, to unemployment and a loss of individuality in the building process.[9] And as a solution to the problem of producing housing for the poor, Gitterman concluded that technological innovation was "not reasonable." As he remarked,

> We found out the hard way that the most useful approach is not just to create cheaper housing but to devise ways of helping people to afford the kind of housing we've got. If people don't earn enough to get access to a house which conforms with the lowest acceptable physical standards, and you are not prepared to lower your standards, then you have a financial problem, not a technical one.

And this issue was made more complex because of rising expectations, for "we could still build lower cost housing if people were prepared to accept a less elaborate house than they now expect."[10]

At the same time, CMHC's influence on housing did not lie only in technological aspects aimed to improve performance of materials or lessen costs. Its impact on urban planning was also substantial. In its contention that the context of the home was an equally important dimension of its function, CMHC developed and applied minimum standards in urban design that affected all urban areas in Canada. The same can be said in respect to house design. Through its encouragement of the preparation of professionally drawn house plans, and by ensuring their wide distribution, CMHC exerted considerable influence on the nature of housing of ordinary Canadians.

APPENDIX

EXHIBIT 1: OUTLINE OF CHANGES IN THE MAINSTREAM PRODUCTION PROCESS

Mid-1940s	Mid-1960s	Mid-1980s
Excavation Wartime construction marked the almost-complete disappearance of of the horse-drawn scraper. The bulldozer took over.	The bulldozer yielded, in large part, to the back-hoe. Hand shovel final shaping and trenching for services essentially disappeared.	No change.
Basement Concrete blocks gave way (substantially) to poured concrete, site-mixed, with site-built board formwork. The boards were then reused as wall and roof sheathing. But the first transit-mix and the first oiled-plywood forms were already being used by a few leaders.	The concrete was transit-mixed and the formwork prefabricated (high-density overlaid) plywood. But concrete blocks still served in rural areas and board formwork sheathing was still used in Atlantic Canada, although was disappearing.	Broadly no change, but the preserved wood foundation begun in Canada in 1961 gains some acceptance.
Wall framing Typcal builders used platform frame; some in the west already used tilt-up, precutting and "stationary assembly line" processes; very few used much equipment or peice-work sub-trades.	Pre-cut studs, tilt-up, "stationary assembly line" with sequencing of piece-work paid subs, the "factory with no walls" was by now really producing. The basic advantages of *platform frame* construction came into full play: The floors provided the "assembly table" areas for the walls, partitions and roofs.	Little change – some reversion to less productive custom building because of scattered smaller projects and large complex, ornate houses.
The roof was still laid out and erected by skilled carpenters, with site-cut and fitted rafters.	Engineered, manufactured roof trusses have taken over the typical house production line.	Little change.
Plumbing and heating site-fitted and installed.	Little change, but plastic Drain-Waste-Vent (DWV) piping speeded up on-site plumbing process. Ductwork sub-assemblies were used effectively. Prefabricated chimmneys became common.	Little change, except in bathroom component noted below and in easier, faster fittings and all-plastic plumbing. Chimmneys and flues are typically prefabricated types.
Interiors wet finished (plaster), cured, then brush-painted.	Interiors were dry-finished (drywall) and roller-painted: Both raised productivity greatly.	Little change. Prefinished plastic trim enhances speed and quality.
Windows, cabinetry, stairs, millwork still fabricated on site.	Builders installed manufactured windows, cabinetry and countertops.	Little change, but pre-hung doors and prefabricated stairs are often used too.
Bathrooms Bathtub and tile (or linoleum) all installed separately.	Little change.	Typically, little change. But plastic tub-shower units gain a foothold in some areas, at least for the second bathroom.
Scheduling, job control, costing and cost control were generally all rudimentary; "builders don't know their own costs" — except for a few leaders.	Generally effective costing and control was established among larger builders, but "builders don't know their own costs" was still an industry refrain.	Little change. Some builders now using computer-based costing and job control with better knowledge of the whole process and costs.
Wall and roof sheathing used boarding (stripped from the basement forms).	Plywood sheets were widely used (fibreboard sheets retained their place in walls where final cladding was brick or stucco).	Waferboard sheets dominate.
Siding was often clapboard-applied, trimmed and painted on-site using scaffolding, but brick and stucco retained their dominant position in some areas.	Pre-coated aluminium and hardboard competed strongly with wood. (Brick and stucco remained dominant but often only on the first storey.)	Little change. Vinyl sidings compete with other claddings. On-site painting essentially disappears.

CMHC, The Housing Industry: Perspective and Prospective. Working Paper 2. The Evolution of the Housing Production Process 1946-86 (Ottawa: CMHC, 1989. A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd.), p. 10.

Exhibit 2: Apparent Origins and Causes of Technological Changes in Housebuilding Mainstream

Change in Product and/or Process (with approx. date of widespread acceptance)	Research and Development by: Mfctrs. of materials, equipment, components	Builders & their associations	Public sector (NRC, etc.)	Universities	Builder's Incentive To Adopt: Speed with less skills and less costs	Enhance quality	Exploit public-sector incentives	Helped or Inhibited by: Bldg. codes	Acceptance (CMHC)
Platform frame; some tilt-up, some pre-cutting (1946)	y	y	y	y	y	y	y		
Insulation (1950)	Y		Y	Y		Y	y	y	Y
Warm air heating counter-convection (1950)	Y		y	y		y			
Manufactured windows with frames (1950)	Y				Y	y			
Transit-mix concrete basements (mid-to-late 1950s)	Y				Y	y			
Manufactured cabinetry (mid-1950s)	Y								y
Plywood sub-floors and sheathing (mid-1950s)	Y	y	y	y	Y	y		n-y	Y
Drywall interior finish (late 1950s)	Y				Y			n-Y	
Prefab formwork basements (late 1950s)	Y	y			Y	y			
"Stationary assembly line" (late 1950s)	y	Y		y	Y		y		
Roof trusses (mid-1960s)	Y		Y	Y	Y	y		n-y	Y
Fork lifts, truck-mounted hydraulic cranes, palletizing ... (mid-1960s)	Y				Y				
Winter construction (mid-1960s)	Y	Y	Y	y	y		y	n-y	Y
Prefinished, low-maintenance claddings (mid-1960s)	Y				Y				Y
More reliable sealed double windows (mid-1960s)	y		Y			Y			Y
Plastic vapour barrier (1970s)	Y		y			Y		Y	Y
Plastic dwv piping (early to mid-1960s)	Y				Y			n-y	Y
Plastic weeper tile (early 1970s)	Y	y			Y				Y
Waferboard sheathing, sub-floor (mid-1970s)	Y		y		y			n-Y	Y
Higher levels of insulation and airtightness (mid-1970s)	y	y	y	y		y	y		
Presently making inroads:									
All-plastic plumbing	Y				Y			n-y	y
Plastic bath/shower units	Y				Y			n-y	y
Computerized cost control	Y	y			Y	y			
Mechanical air-handling and heat recovery	Y	y	y	y		y	y	y	y
Exhaust air heat pump heat recovery	Y	y	y	y		y	y		

Source: Scanada Consultants Limited 1967.

Legend:
Y: "yes" — a substantial positive role or influence
y: some positive role or influence
blank space: no known or consistent role for or against the particular change
n: "no" — an inhibiting or delaying influence, at least in the initial years

CMHC, The Housing Industry: Perspective and Prospective. Working Paper 2. The Evolution of the Housing Production Process 1946-86 (Ottawa: CMHC, 1989. A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd.), p. 19.

ENDNOTES: INTRODUCTION

1. CMHC, Housing in Canada 1945-1986. An Overview and Lessons Learned (Ottawa: CMHC, 1987), p. 6; CMHC, Canadian Housing Statistics 1991 (Ottawa: CMHC, 1992), Table 94. The actual figures are:

Year	Crowded Households	Family and Nonfamily Households
1951	641,820	3,409,295
1961	750,942	4,554,736
1971	569,485	6,041,280

2. CMHC, The Housing Industry: Perspective and Prospective. Working Paper 2. The Evolution of the Housing Production Process 1946-86 (Ottawa: CMHC, 1989. A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd.), pp. 9, 22.

ENDNOTES: CHAPTER 1

1. George Anderson, "Programs in Search of a Corporation. The Origins of Canadian Housing Policy 1917-1946," Lecture No. 1, 1987 (Ottawa: CMHC, typescript), pp. 3-5.

2. John Saywell, Housing Canadians: Essays on the History of Residential Construction in Canada (Ottawa: Economic Council of Canada, Discussion Paper No. 24, 1975), pp. 155-57.

3. Anderson, "Programs in Search of a Corporation," pp. 12-13.

4. Gitterman interview.

5. A standard sets the minimum performance attributes of a material or product. A specification sets the required quality of the product through referencing a standard, the quality of workmanship and the method of installation.

6. Gitterman interview.

7. Gitterman interview.

8. Gitterman interview.

9. Humphrey Carver, "The Expanding Imagination," in CMHC, Housing a Nation. 40 Years of Achievement (Ottawa: CMHC, 1986), p. 38. In fact, 782,000 units were actually built in the first postwar decade.

10. George Anderson, "Canadian Housing Policy 1944-1967," Lecture No. 2, 1988 (Ottawa: CMHC, typescript), p. 3.

ENDNOTES: CHAPTER 2

1. R.G. Lillie, "Twenty Years of Housing, CMHC. 1946-1966," Part I, Habitat 9 (Nos. 3 and 4, 1966), p. 3.

2. CMHC, Paper 2: The Housing Production Process, p. 20.

3. CMHC, The Housing Industry: Perspective and Prospective. Working Paper 1. The Evolution of the Housing Industry in Canada, 1946-1986 (Ottawa: CMHC, 1989, A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd.), pp. 65-71.

4. CMHC, Paper 1: The Housing Industry in Canada, pp. 6-10.

5. CMHC, Paper 1: The Housing Industry in Canada, p. 21.

6. CMHC, Paper 1: The Housing Industry in Canada, pp. 1-3. Single family dwellings can include single detached, row and semi detached units.

7. James McKellar, "Building Technology and the Production Process," in House, Home and Community: Progress in Housing Canadians 1945-1986, John Miron, editor, (Montreal and Kingston: McGill-Queen's University Press and CMHC, 1993), p. 136.

8. Peter Barnard, "Innovation in Housing Technology," in Innovation in Housing and the Urban Environment (Ottawa: Canadian Housing Design Council, 1971), p. 32.

9. CMHC, Housing in Canada 1945 to 1986. An Overview and Lessons Learned, pp. 12-14; Michael Dennis, Low Income Housing. Programs in Search of a Policy (Ottawa: CMHC, Low Income Housing Study Group, 1972), pp. 2-3.

10. CMHC Annual Report for 1961, Table 1, p. 46. The figures for NHA assisted dwellings includes federal-provincial projects.

11. Anderson, "Programs in Search of a Corporation," p. 1.

12. James V. Poapst, "Financing Post-War Housing," in Miron, House, Home and Community, pp. 94-109; CMHC, Paper 1: The Housing Industry, pp. 11-14. See also the Glossary and Chronology in Miron, House, Home and Community, pp. 391-418.

13. Carver interview.

14. CMHC, 67 Homes for Canadians (Ottawa: CMHC, 1947), p. 1.

15. Gitterman interview.

16. CMHC Annual Report for 1955, p. 23.

17. CMHC, Paper 2: The Housing Production Process, p. 20; CMHC, "Five Decades of Canadian Home Building Methods and Materials in Honour of the 50th Anniversary of the Canadian Home Builders' Association," (Typescript courtesy of CMHC, 1993), p. 5.

18. CMHC Annual Report for 1948, pp. 30-31; CMHC Annual Report for 1949, p. 31

19. Handegord interview; "Prairie Rural Housing," n.d. [1950], File 1752A, Premiers' Papers, Provincial Archives of Alberta; CMHC Annual Report for 1948, pp. 27-28.

20. CMHC, Paper 1: The Housing Industry in Canada, pp. 12-13.

21. Stewart Bates, "The Need for an Ideal," in CMHC, Housing a Nation. 40 Years of Achievement, p. 28.

22. Gitterman interview.

23. Humphrey Carver, Compassionate Landscape. (Toronto: University of Toronto Press, 1975), pp. 135-36.

24. Ian Maclennan, "Working with a Purpose," in CMHC, Housing a Nation. 40 Years of Achievement, p. 50.

25. Gitterman interview.

26. Robert Legget, "A Philosophy of Building Research," Building Research in Canada, June 30, 1955, p. 5.

27. "Housing Research," Building Research in Canada, December 31, 1952, pp. 123-24; Wilson interview; Hansen interview; Handegord interview.

28. Division Building Research, National Research Council of Canada, The First Twenty Five Years (Ottawa: NRC, 1973), p. 99; National Research Council of Canada Division of Building Research, Ten Years of Building Research 1947-1957 (Ottawa: Queen's Printer, 1957), pp. 83, 86; Robert Legget, "Building Research 1950," RAIC Journal, August 1950, pp. 275-76; Wilson interview.

29. Legget, "A Philosophy of Building Research," pp. 6-7; Wilson interview.

30. Building Research in Canada, vol 1 no. 1, 1951, p. 25; Building Research in Canada, December 31, 1951, pp. 40, 123.

31. Building Research in Canada June 30, 1957, pp. 127-28; Handegord interview.

32. Legget, "A Philosophy of Building Research," pp. 7-9.

33. Platts interview.

34. Robert Legget, "Building Research 1950," RAIC Journal, August 1950, p. 277; Forty-Third Annual Report of the National Research Council of Canada 1959-60, p. 22.

35. Gitterman interview.

36. Marc Denhez, The Canadian Home. From Cave to Electronic Cocoon (Toronto: Dundurn Press, 1994), pp. 85-86.

37. Gitterman interview.

38. NRC, Ten Years of Building Research, 1947-1957, p. 86.

39. NHBA Press Release, October 16, 1959, File 3-10, Gitterman Papers, MG31 B49, National Archives of Canada (hereafter NAC).

40. C.J. McConnell, "Proposal to CMHC," n.d. (April 1962), File 4-2, MG31 B49, NAC.

41. Emery to Armstrong, April 13, 1964, File 4-3, MG31 B49, NAC.

42. CMHC. The Housing Industry Perspective and Prospective. Summary Report. The Changing Housing Industry in Canada 1946-2001 (Ottawa: CMHC, 1988. A report by Clayton Associates Ltd. and Scanada Consultants Ltd.), pp. vii-viii.

43. Handegord interview.

ENDNOTES: CHAPTER 3

1. H.B. Dickens and A.T. Hansen, "Canada's National Building Code. Its Development and Use," Habitat 18 (No 6 1975), p. 8.

2. Wilson interview.

3. "The National Building Code of Canada 1957," Building Research in Canada, June 30, 1954, pp. 201-02.

4. Dickens and Hansen, "The National Building Code," pp. 8-9; Legget, "A Philosophy of Building Research," p. 9.

5. "A Brief on the National Building Code of Canada Presented to the Royal Commission on Canada's Economic Prospects March 1, 1956," RAIC Journal, April 1956, p. 150.

6. Dickens and Hansen, "The National Building Code," pp. 9-11.

7. National Research Council of Canada, Division of Building Research, Building Research 1960 (Ottawa: 1961), p. 4.

8. John Archer, "A History of Housing Standards," Habitat 24 (No. 4 1981), p. 13; Hansen interview.

9. "Canadian Housing Standards in 1959," Building Research in Canada, December 31, 1958, p. 211.

10. "Canadian Housing Standards in 1959," p. 211.

11. Dickens and Hansen, "Canada's National Building Code," p. 11.

12. See various documents, File 8-11, "Canadian Standards Association 1969-73," MG31 B49 NAC.

13. Gitterman interview.

14. DBR, Ten Years of Building Research 1947-1957, pp. 83-84.

15. Various typescript material courtesy of Gordon Walt; Murphy interview.

16. Material acceptance files, CMHC. Some of these products were similar to one another and differed largely by brand name.

17. "Housing Research," Building Research in Canada, December 31, 1952, p. 125.

18. DBR, The First Twenty-Five Years, pp. 100-01.

19. R.B. Dorey and W.R. Schriever, "Structural Test of a House Under Simulated Wind and Snow Loads," in Symposium on Full-Scale Tests on House Structures (Philadelphia: American Society for Testing Materials, Special Technical Publication No. 210, 1957), p. 32.

20. Gitterman interview. The Mark series continued into the 1980s. In total, 14 experimental houses were built.

21. A.T. Hansen, "Budget Research House," Visit Report No. 38, DBR, September 1958, in File 3-9, MG31 B49, NAC.

22. Gitterman handwritten notes, 1961, File 3-12, MG31 B49 NAC.

23. Patrick Hailstone, HUDAC Experimental Projects, Mark I, Mark II, Mark III, Mark IV (Toronto: Housing and Urban Development Association of Canada, 1973), p. 12.

24. Hailstone, HUDAC Experimental Projects, pp. 22-27.

25. Hailstone, HUDAC Experimental Projects, pp. 28-30; Opie to Gitterman, January 7, 1963, File 3-10, MG31 B49 NAC.

26. Gitterman, "Report on Mark IV Project" (Appendix 2), File 4-14, MG31 B49, NAC.

27. Clipping, Canadian Weekly, File 3-13, MG31 B49 NAC.

28. Gitterman, "Report on Mark III Project," File 3-18, MG31 B49, NAC.

29. "Report on Mark IV Project, 1964," File 4-14, MG31 B49, NAC.

30. "Proposal, Mark IV Project," n.d. (1962) File 4-14, MG31 B49, NAC.

31. Proposal to CMHC, n.d. (April 1962), File 4-2, MG31 B49 NAC.

32. "Suggestions for Mark IV Research Program," n.d. (August 1962), McConnell to Ryan, July 17, 1962, and Gitterman circular letter, December 27, 1962, File 4-2, MG31 B49, NAC.

33. CMHC, Paper 2: The Housing Production Process, p. 17. The 1957 convention of the NHBA recommended that all municipalities adopt the National Building Code.

34. CMHC, Paper 2: The Housing Production Process, p. 20.

35. CMHC, Paper 2: The Housing Production Process, p. 18.

ENDNOTES: CHAPTER 4

1. The information in this section relies extensively on CMHC, Paper 2: The Housing Production Process, pp. 4-5. Additional sources include E.A. Doherty, Residential Construction Practices in Alberta 1900-1971 (Edmonton: Alberta Department of Housing 1984); Thomas Ritchie, Canada Builds 1867-1967 (Toronto: University of Toronto Press for National Research Council, 1967), pp. 65-107 and 171-303; Donald G. Wetherell and Irene R.A. Kmet, Homes in Alberta. Building, Trends, and Design (Edmonton: University of Alberta Press, Alberta Culture and Multiculturalism and Alberta Municipal Affairs, 1991), pp. 278-283; CMHC, 50 Years of Innovation 1943-1993. The Canadian Housing Industry (Ottawa: CMHC, 1993), pp. 4-5.

2. Auger interview. See also Maurice J. Clayton, Canadian Housing in Wood (Ottawa: CMHC, 1990), 98-99; Thomas Ritchie, "Plankwall Framing, A Modern Wall Construction with an Ancient History," Journal of the Society of Architectural Historians 30 (1971): 66-70.

3. In platform framing the house is framed using milled 2" x 4" studs. Studs are one storey in height and each floor level is erected separately with the installed floor serving as the working platform for the next storey. By about 1940, and likely earlier in the West, this system had replaced balloon framing, in which continuous studs ran the full height of the walls. Clayton, Canadian Housing in Wood, pp. 109-17, 120-23.

4. Quoted in CMHC, Paper 1: The Housing Industry, p. 19.

5. Alexander and Yelena Opolovnikov, The Wooden Architecture of Russia: Houses, Fortification, Churches (New York: Harry N. Abrams Inc., 1989), 100.

6. Margaretta J. Darnall, "Innovations in American Prefabricated Houses: 1860-1890," Journal of the Society of Architectural Historians 31 (1972): 51-55.

7. For the history of one such company, see G.E. Mills and D.W. Holdsworth, The B.C. Mills Prefabricated System: The Emergence of Ready-Made Buildings in Western Canada (Ottawa: Parks Canada Occasional Papers in Archaeology and History No. 14, 1975).

8. Wetherell and Kmet, Homes in Alberta, pp. 144-45.

9. Sam Gitterman, "Industrialized Building" (Ottawa: CMHC, typescript, 1967), p. 3.

10. CMHC, Paper 1: The Housing Industry, p. 20. This on-site manufacturing was an early model for the "project manufacturer" builder of later years where builders prefabricated and organized components on site for large housing projects.

11. Gitterman interview.

12. DBR, The First Twenty-Five Years, p. 99.

13. Gitterman interview.

14. Gitterman, "Industrialized Building," pp. 5-6; Gitterman interview.

15. Gitterman interview.

16. Gitterman interview.

17. Gitterman interview.

18. CMHC Perspective, October 1971.

19. Gitterman interview.

20. Robert Legget, "Modular Co-ordination," Building Research in Canada December 31, 1957, p. 151.

21. R.E. Platts, Prefabrication in Canadian Housing (Ottawa: National Research Council of Canada, Division of Building Research, Technical Paper No. 172, 1964), p. 26.

22. Robert Legget, "Common Sense and Building Materials," Reprint of speech, NRC 5146 (1959).

23. Legget, "Modular Co-ordination," p. 152.

24. Gitterman interview.

25. Platts, Prefabrication in Canadian Housing, p. 26.

26. Hansen interview.

27. Platts interview.

28. CMHC, Paper 2: The Housing Production Process, pp. 9-12, 53-54.

29. CMHC, Paper 2: The Housing Production Process, p. 12.

30. Platts interview.

31. CMHC, Paper 2: The Housing Production Process, p. 12.

32. Platts, Prefabrication in Canadian Housing, pp. 45-46.

33. R.E. Platts, "An Expert Reviews A New Roof System," Housing Note No. 4, NRC DBR November 1962; CMHC, Paper 2: The Housing Production Process, pp. 11-12; Platts, Prefabrication in Canadian Housing, pp. 3-6.

34. Platts interview.

35. CMHC, Paper 2: The Housing Production Process, pp. 9, 13.

36. National Research Council of Canada Division of Building Research, Building Research 1962 (Ottawa: 1963), p. 59.

37. Gitterman interview.

38. Gitterman, "Industrialized Building," pp. 11-12.

39. CMHC, "Five Decades of Canadian Housing Innovation," p. 5.

40. DBR, Ten Years of Building Research 1947-1957, pp. 84-85. A report of this test can be found in Dorey and Schriever, "Structural Test of a House Under Simulated Wind and Snow Loads."

41. CMHC, Paper 2: The Housing Production Process, p. 7.

42. Gitterman, "Industrialized Building," pp. 13-15.

43. National Research Council of Canada Division of Building Research, Housing Research 1965 (Ottawa: 1966), p. 51; National Research Council of Canada Division of Building Research, Housing Research 1963 (Ottawa: 1964), p. 50.

44. National Research Council of Canada Division of Building Research, Building Research 1963 (Ottawa: 1964), p. 50.

45. CMHC, The Housing Industry Perspective and Prospective: Working Paper 4. The Housing Industry and Change (Ottawa: CMHC, 1989. A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd), pp. 11-12.

46. A.T. Hansen, "Why Roof Trusses? They Cut Costs, Use Less Lumber, Speed up the Job," Housing Note No. 5, NRC DBR, April 1963.

47. CMHC, Paper 4: The Housing Industry and Change, p. 13.

48. Fortieth Annual Report of the National Research Council of Canada 1956-57, p. 29; Hansen interview.

49. National Research Council of Canada, Building Research 1962 (Ottawa: 1963), p. 56.

50. Hansen interview.

51. CMHC, Paper 4: The Housing Industry and Change, p. 15.

52. Platts interview.

53. Gitterman, "Report on Mark III Project," File 3-18, MG31 B49 NAC.

54. "Floor Panels are Stressed Skin Type," Reprinted from National Builder in Hailstone, HUDAC Experimental Projects p. 59; Gitterman, "Report on Mark III Project," File 3-18, MG31 B49 NAC.

55. Hailstone, HUDAC Experimental Projects, p. 51.

56. CMHC, Paper 2: The Housing Production Process, p. 35.

57. A.T. Hansen, "Two Articles on the Use of Kraft Paper as a Wall Finish," Housing Note No. 2, NRC/DBR, November 1962; Hailstone, HUDAC Experimental Projects, pp. 91-92.

58. William McCance, "Here's How the Interior Partitions were made and Installed," Reprinted from National Builder in Hailstone, HUDAC Experimental Projects, p. 62.

59. William McCance, "Here's How the Interior Partitions were made and Installed," Reprinted from National Builder in Hailstone, HUDAC Experimental Projects, p. 62.

60. Hailstone, HUDAC Experimental Projects, p. 60.

61. William McCance, "Here's How the Interior Partitions were made and Installed," Reprinted from National Builder in Hailstone, HUDAC Experimental Projects, p. 62.

62. CMHC, Paper 2: The Housing Production Process, p. 24.

63. CMHC, Paper 2: The Housing Production Process, pp. 24-26.

64. CMHC, Paper 2: The Housing Production Process, pp. 24-26.

65. CMHC, Paper 2: The Housing Production Process, pp. 26-28.

66. Dickens and Hansen, "Canada's National Building Code," pp. 8-9; Hansen interview.

67. CMHC, "Five Decades of Canadian Housing Innovation," p. 6.

68. CMHC, Paper 2: The Housing Production Process, p. 22.

ENDNOTES: CHAPTER 5

1. James A. Murray, The Architecture of Housing (Ottawa: Canadian Housing Design Council, 1962), p. 18.

2. Gitterman, "Report on Mark IV Project," File 4-14, MG31 B49 NAC.

3. Gitterman interview; CMHC, 50 Years of Innovations 1943-1993 (Ottawa: CMHC, 1993), p. 14.

4. Gitterman interview; Hansen interview.

5. CMHC, A Review of Housing in Canada (Ottawa: CMHC, 1958), p. VI-3.

6. Forty First Annual Report of the National Research Council of Canada 1957-58, p. 28.

7. National Research Council of Canada, Division of Building Research, Building Research 1960, (Ottawa: 1961), p. 56.

8. CMHC, The Housing Industry Perspective and Prospective. Working Paper 3. The Housing Industry and the Economy in Canada 1946-1986. (Ottawa: CMHC, 1988. A report by Clayton Research Associates Ltd. and Scanada Consultants Ltd.), pp. 32-33.

9. R.C. Platts, Prefabrication in Northern Housing (Ottawa: National Research Council, Division of Building Research, Technical Paper No. 110, 1960), p. 1.

10. National Research Council of Canada Division of Building Research, Building Research 1960 (Ottawa: 1961), p. 56.

11. Gitterman to Goyette, April 20, 1967 File 1-15, MG31 B49 NAC; Gitterman interview.

12. National Research Council of Canada Division of Building Research, Building Research 1964 (Ottawa: 1965), p. 49; Platts interview.

13. Platts interview; National Research Council of Canada Division of Building Research, Building Research 1965 (Ottawa: 1966), p. 52.

14. CMHC Annual Report for 1949, p. 31.

15. Thirty Second Annual Report of the National Research Council of Canada 1948-49, p. 13; National Research Council of Canada, Division Building Research, Ten Years of Building Research 1947-1957, p. 84.

16. Fortieth Annual Report of the National Research Council of Canada 1956-57, p. 29.

17. Gitterman interview; "Wood Foundations--How They're Made," Reprinted from National Builder in Hailstone, HUDAC Experimental Projects, p. 57.

18. Doyle to Gitterman, November 12, 1963, File 4-2, MG31 B49 NAC; Gitterman interview; Hailstone, HUDAC Experimental Projects, pp. 7, 9.

19. Gitterman interview; Hansen interview.

20. Gitterman interview.

21. Handegord interview.

22. Gitterman interview; Wilson interview.

23. Handegord interview.

24. Robert Legget, "Building Research 1950," p. 276; Wilson interview; Handegord interview.

25. Grant Wilson, "Moisture in Canadian Wood Frame Construction, Problems, Research and Practice from 1975-1991," (Report courtesy of Grant Wilson), pp. 4-9.

26. Handegord interview.

27. CMHC, Paper 2: The Housing Production Process, p. 6.

28. Wilson interview.

29. Fortieth Annual Report of the National Research Council of Canada 1956-57, p. 29; Wilson interview.

30. CMHC, Paper 2: The Housing Production Process, p. 16.

31. Wilson interview.

32. Gitterman interview; Hailstone, HUDAC Experimental Projects, p. 16.

33. Clipping, n.d. [1962] in File 4-3, MG31 B49 NAC.

34. Hailstone, HUDAC Experimental Projects, p. 81.

35. Gitterman, "Report on Mark III Project," File 3-18, MG31 B49, NAC; Gitterman interview; "Report on Mark IV Project," File 4-14, MG31 B49 NAC.

ENDNOTES: CHAPTER 6

1. Hailstone, HUDAC Experimental Projects, p. 83.

2. Gitterman, "Report on an Indoor Household Waste Water Reuse Installation," File 8-6, MG31 B49, NAC.

3. The program was continued and expanded under the Municipal Infrastructure Program from 1964 to 1969.

4. R.G. Lillie, "Twenty Years of Housing. CMHC 1946-1966," Part IV, Habitat 11 (no. 2, 1968), pp. 9, 12.

5. See for example, various material in File 8-2, MG31 B49, NAC.

6. Gitterman, "An Old Challenge," in CMHC, Housing a Nation. 40 Years of Achievement, p. 83.

7. Gitterman interview.

8. Gitterman interview.

9. "Activity of CMHC in Recycling of Waste Water," File 8-3, MG31 B49 NAC.

10. Gitterman, "An Old Challenge," in CMHC, Housing a Nation 40 Years of Achievement, p. 83.

11. Gitterman interview.

12. "The Development of an Individual Household Aerobic Sewage Disposal System," October 25, 1967, File 7-30, MG31 B49 NAC.

13. Gitterman, "Report on Mark III Project," File 3-18, MG31 B49 NAC.

14. Gitterman, "Report on Mark IV Project," File 4-14, MG31 B49 NAC.

15. Gitterman, "Report on An Indoor Household Waste Water Reuse Installation," File 8-6, MG31 B49 NAC.

16. Gitterman interview.

17. Gitterman, "Report on Mark IV Project" (Appendix A), File 4-14, MG31 B49 NAC.

18. Gitterman, "Report on Mark III Project," File 3-18, MG31 B49 NAC.

19. Gitterman interview; "Activity of CMHC in Recycling of Wastes and Water," and CMHC, "Water Pollution Research 1956-1968," File 7-3, MG31 B49 NAC.

20. "The Development of an Individual Household Aerobic Sewage Disposal System," October 25, 1967, File 7-30, MG31 B49 NAC.

21. "Activity of CMHC in Recycling of Waste and Water," January 12, 1973, File 8-3, MG31 B49 NAC.

22. Gitterman interview. The Aquarobic is still manufactured, now in the United States.

23. Gitterman, "An Old Challenge," in CMHC, Housing a Nation. 40 Years of Achievement, p. 84.

24. "Activity of CMHC in Recycling of Wastes and Water," January 12, 1973, File 8-3, MG31 B49, NAC.

25. Montreal Star, February 28, 1976.

26. Gitterman, "An Old Challenge," in CMHC, Housing a Nation. 40 Years of Achievement, p. 85.

27. "CANWEL The Canadian Water Energy Loop Summary Report," A report by Canviro Consultants and MacLaren Engineers for CMHC, 1984, (Typescript of courtesy CMHC) pp. 1-2.

28. Player to Boivin, August 17, 1978, CANWEL files, CMHC.

29. Gitterman, "An Old Challenge," in CMHC, Housing a Nation. 40 Years of Achievement, p. 85.

30. Houston to Stewart, November 21, 1986 (attachments) and Flichel to Mailly, September 18, 1989, CANWEL files, CMHC.

ENDNOTES: CHAPTER 7

1. In some parts of the prairies, this land had been in the hands of local governments even longer, having been forfeited for nonpayment of taxes during the real estate collapse just before World War I.

2. CMHC, Paper 2: The Housing Production Process, pp. 41-42.

3. Gitterman interview.

4. Humphrey Carver, Houses for Canadians (Toronto: University of Toronto Press, 1948), p. 24.

5. Gitterman interview.

6. Gitterman interview.

7. Carver interview; Gitterman interview; RAIC Journal, November 1946, pp. 267-69. See also Carver, Compassionate Landscape, pp. 88-90.

8. CMHC Annual Report for 1955, p. 21.

9. Lillie, "Twenty Years, CMHC," Part I, pp. 12-13; Gitterman interview.

10. CMHC, 67 Homes for Canadians, pp. 2, 8.

11. CMHC, 67 Homes for Canadians, pp. 2, 8.

12. Wetherell and Kmet, Homes in Alberta, p. 256.

13. R.J. Boivin, "Adapting to Change," in CMHC, Housing a Nation. 40 Years of Achievement, pp. 91-92.

14. Archer, "A History of Housing Standards," p. 13.

15. CMHC Annual Report for 1955, p. 21.

16. Stewart Bates, "The Need for an Ideal," in CMHC, Housing a Nation. 40 Years of Achievement, p. 31.

17. Archer, "A History of Housing Standards," p. 13.

18. Archer, "A History of Housing Standards," pp. 13-14.

19. Archer, "A History of Housing Standards," pp. 14-16.

20. Marc Choko, Une Cité Jardin a Montréal. La cité jardin du tricentenaire 1940-1947 (Montréal: Méridien, 1988), pp. 25-45.

21. A Topographical Atlas of Montreal/Atlas Topographique de Montréal (Montreal: McGill School of Urban Planning, 1992), pp. 47-49.

22. Gitterman interview.

23. Carver interview.

24. Ian Maclennan, The Architecture of Urban and Sub-urban Development (Ottawa: Canadian Housing Design Council, 1964), pp. 4-6.

25. Gitterman interview.

26. CMHC Annual Report for 1951, p. 22.

27. Reflections on Zoning. The Report of the Zoning Study Committee of the R.A.I.C. (Ottawa: 1964), pp. 12-13.

28. Maclennan, The Architecture of Urban and Sub-urban Development, p. 10.

29. CMHC, Paper 2: The Housing Production Process, p. 43.

30. CMHC Annual Report for 1948, p. 25.

31. Gordon Murchison, "A Life Remembered," in CMHC, Housing a Nation. 40 Years of Achievement, pp. 14-15; Gitterman interview.

32. CMHC, The Development of Gander Town (typescript, 1954), [Part 1], pp. 1-2, [Part 2] p.2 and attached maps; Lillie, "Twenty Years, CMHC," Part II, p. 6.

33. CMHC, Urban Assistance Study, vol. 2a, p. 62. See also Carver, Houses for Canadians, pp. 18-20.

34. CMHC, Urban Assistance Study, vol 2a, p. 64.

35. Carver, Compassionate Landscape, pp. 141-42.

36. Pierre Filion, "The Neighbourhood Improvement Plan," Urban History Review 17 (1988), pp. 16-17.

37. Gitterman interview.

ENDNOTES: CHAPTER 8

1. Farm and Ranch Review, April 21, 1919; RAIC Journal, April 1930, pp. 138-50.

2. Gitterman interview.

3. DHA, Architectural Competition, Low-Cost House Designs (Ottawa: King's Printer, 1938), pp. 10-11.

4. RAIC Journal, April 1938, p. 81.

5. Gitterman interview.

6. Gitterman interview.

7. CMHC Annual Report for 1948, p. 27.

8. CMHC, 67 Homes for Canadians, p. 2.

9. Guy Desbarats, The Education of the Architect and the Future of Housing Design, (Ottawa: Canadian Housing Design Council, 1968), p. 16.

10. CMHC, 67 Homes for Canadians, p. 1. The architects who drew the 30 plans were M.G. Dixon (Ottawa), H.C. Jarvis (Toronto), and C.B.K. Van Norman (Vancouver).

11. CMHC Annual Report for 1948, p. 31.

12. CMHC, Small House Designs, Bungalows (1950); CMHC, Small House Designs,One-and-a-half Storey (1950); Small House Designs, Two Storey (1950); SCHL, Modèles de Maisons Région de Québec (1950).

13. "Order of Popularity," typescript attached to Small House Designs, Bungalows (1950) in File 1-7, MG31 B49 NAC.

14. 1952 Plan books, (annotated) File 1-18, MG31 B49 NAC.

15. Gitterman interview; CMHC Annual Report for 1952, p. 24.

16. CMHC, Small House Designs: Bungalows and Split Level Houses (Ottawa: CMHC, 1954).

17. CMHC Housing in Canada 1946-1970 A Supplement to the 25th Annual Review of Central Mortgage and Housing Corporation (Ottawa: CMHC, 1971), p. 9.

18. "Small House Designs: Instructions for the Preparation of Working Drawings," n.d. [1961] and Harvey to Gitterman, March 8, 1962, File 3-9, MG31 B49 NAC.

19. Dickens to Gitterman, June 29, 1961, File 3-9, MG31 B49 NAC.

20. Gitterman to Hazeland, September 7, 1961 and Hazeland to Gitterman, November 20, 1961, File 3-9, MG31 B49 NAC. The plan was Design 2317, CMHC, Small House Designs (Ottawa: CMHC, 1965), pp. 100-01.

21. Canadian Housing Design Council, Awards/Prix 1964, (Ottawa: CDHC, 1964), p. 4; Hazeland interview.

22. Gitterman interview.

23. Canadian Housing Design Council, Awards/Prix, 1964, p. 9. The publication on multiple housing was Housing in Cities. Some Examples of Multiple Housing Recently Built in Canada (Ottawa: CDHC, 1964).

24. Michel Lessard et Huguette Marquis, Encyclopédie de la Maison Québecoise, (Montreal: Les Editions de L'Homme, 1972), p.442.

25. Desbarats, The Education of the Architect, p. 16.

ENDNOTES: CONCLUSION

1. Report of the Federal Task Force on Housing and Urban Development (Ottawa: Information Canada, 1969), p. 4.

2. Wilson interview.

3. Hansen interview.

4. Platts interview.

5. Gitterman interview.

6. Peter Barnard, "Innovation in Housing Technology," in Innovation in Housing and Urban Environment (Ottawa: Canadian Housing Design Council, 1971), p. 32.

7. Gitterman interview.

8. Gitterman, "An Old Challenge," in CMHC, Housing a Nation, 40 Years of Achievement, pp. 87-88

9. Lionel Loshak, "Some Views on Industrialization," (Ottawa: CMHC, typescript, 1969), pp. 1-3.

10. Gitterman, "An Old Challenge," in CMHC, Housing a Nation, 40 Years of Achievement, pp. 87-88

BIBLIOGRAPHY

Manuscript Sources

CANWEL files, CMHC, Ottawa.

Materials Acceptance Files, CMHC, Ottawa.

Samuel A. Gitterman Papers, MG31 B49, National Archives of Canada, Ottawa.

Interviews

Interviews were conducted with the following individuals between October 1993 and February 1994:

Jules Auger
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Serials

[Central] Canada Mortgage and Housing Corporation, Annual Report, 1948-1965.

National Research Council of Canada, Annual Report, 1948-1960.

National Research Council Division of Building Research, Building Research, 1958-1966.

National Research Council Division of Building Research, Building Research in Canada, 1951-1958.

Royal Architectural Institute of Canada, Journal, 1930-1956.

Printed Sources

Anderson, George. "Programs in Search of a Corporation. The Origins of Canadian Housing Policy 1917-1946," Lecture No. 1, 1987, "Canadian Housing Policy 1944-1967," Lecture No. 2, 1988, "Housing Policy in Canada" Lecture No. 3, 1989. Ottawa: CMHC, typescripts.

Archer, John. "A History of Housing Standards." Habitat 24 (No. 4 1981).

Canadian Housing Design Council. Awards/Prix, 1964. Ottawa: Canadian Housing Design Council, 1964.

----- Housing in Cities. Some Examples of Multiple Housing Recently Built in Canada. Ottawa: Canadian Housing Design Council, 1964.

----- Innovation in Housing and Urban Environment. Ottawa: Canadian Housing Design Council, 1971.

CMHC. 67 Homes for Canadians. Ottawa: CMHC, 1947.

---- Small House Designs, Bungalows. Ottawa: CMHC, 1949.

---- Small House Designs, One-and-a-half Storey. Ottawa: CMHC, 1949.

---- Small House Designs, Two Storey. Ottawa: CMHC, 1949.

---- Modèles de Maisons Région de Québec. Ottawa: SCHL, 1950.

---- Small House Designs: Bungalows and Split Level Houses. Ottawa: CMHC, 1954.

---- The Development of Gander Town. Ottawa: CMHC, typescript report, 1954.

---- A Review of Housing in Canada. Ottawa: CMHC, 1958.

---- Small House Designs. Ottawa: CMHC, 1965.

---- Report of the Federal Task Force on Housing and Urban Development. Ottawa: Information Canada, 1969.

---- Housing in Canada 1946-1970 A Supplement to the 25th Annual Review of Central Mortgage and Housing Corporation. Ottawa: CMHC, 1971.

---- Housing a Nation. 40 Years of Achievement. Ottawa: CMHC, 1986.

---- Housing in Canada 1945-1986. An Overview and Lessons Learned. Ottawa: CMHC, 1987.

---- The Housing Industry: Perspective and Prospective. Working Paper One. The Evolution of the Housing Industry in Canada, 1946-1986. Ottawa: CMHC, 1989, A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd.

---- The Housing Industry: Perspective and Prospective. Working Paper Two. The Evolution of the Housing Production Process 1946-86. Ottawa: CMHC, 1989. A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd.

---- The Housing Industry: Perspective and Prospective. Working Paper 3. The Housing Industry and the Economy in Canada 1946-1986. Ottawa: CMHC, 1988. A report by Clayton Research Associates Ltd and Scanada Consultants Ltd.

---- The Housing Industry: Perspective and Prospective. Working Paper 4. The Housing Industry and Change. Ottawa: CMHC, 1989, A report prepared by Clayton Research Associates Ltd. and Scanada Consultants Ltd.

---- The Housing Industry: Perspective and Prospective. Summary Report. The Changing Housing Industry in Canada 1946-2001. Ottawa: CMHC, 1988, A report by Clayton Associates Ltd and Scanada Consultants Ltd.

---- Canadian Housing Statistics 1991 Ottawa: CMHC, 1992.

---- "Five Decades of Canadian Housing Innovation. A Review of Canadian Home Building Methods and Materials in Honour of the 50th Anniversary of the Canadian Home Builders' Association." Ottawa: CMHC, typescript, 1993.

---- 50 Years of Innovation 1943-1993. The Canadian Housing Industry. Ottawa: CMHC, 1993.

Carver, Humphrey. Houses for Canadians. Toronto: University of Toronto Press, 1948.

---- Compassionate Landscape. Toronto: University of Toronto Press, 1975.

Choko, Marc. Une Cité Jardin a Montréal. La cité jardin du tricentenaire 1940-1947. Montreal: Méridien, 1988.

Clayton, Maurice J. Canadian Housing in Wood. Ottawa: CMHC, 1990.

Darnall, Margaretta J. "Innovations in American Prefabricated Houses: 1860-1890." Journal of the Society of Architectural Historians 31 (1972).

Denhez, Marc. The Canadian Home. From Cave to Electronic Cocoon. Toronto: Dundurn Press, 1994.

Dennis, Michael. Low Income Housing. Programs in Search of a Policy. Ottawa: CMHC, Low Income Housing Study Group, 1972.

Desbarats, Guy. The Education of the Architect and the Future of Housing Design. Ottawa: Canadian Housing Design Council, 1968.

Dickens, H.B. and Hansen, A.T. "Canada's National Building Code. Its Development and Use." Habitat 18 (No 6 1975).

Doherty, E.A. Residential Construction Practices in Alberta 1900-1971. Edmonton: Alberta Department of Housing 1984.

Dominion Housing Act Administration, Architectural Competition, Low-Cost House Designs. Ottawa: King's Printer, 1938.

Dorey, R.B. and Schriever, W.R. "Structural Test of a House Under Simulated Wind and Snow Loads." In Symposium on Full-Scale Tests on House Structures. Philadelphia: American Society for Testing Materials, Special Technical Publication No. 210, 1957.

Filion, Pierre. "The Neighbourhood Improvement Plan." Urban History Review 17 (1988).

Gitterman, Sam. "Industrialized Building." Ottawa: CMHC, typescript, 1967.

Hailstone, Patrick. HUDAC Experimental Projects, Mark I, Mark II, Mark III, Mark IV. Toronto: Housing and Urban Development Association of Canada, 1973.

Hansen, A.T. "Why Roof Trusses? They Cut Costs, Use Less Lumber, Speed up the Job." Housing Note No. 5, NRC/DBR, April 1963.

---- "Two Articles on the Use of Kraft Paper as a Wall Finish," Housing Note No. 2, NRC/DBR, November 1962.

Legget, Robert. "Modular Co-ordination." Building Research in Canada December 31, 1957.

----- "Common Sense and Building Materials." Reprint of speech, Ottawa: National Research Council, NRC 5146, 1959.

----- "Building Research 1950." RAIC Journal, August 1950.

----- "A Philosophy of Building Research." Building Research in Canada, June 30, 1955.

Lessard, Michel et Marquis, Huguette. Encyclopédie de la Maison Québecoise. Montreal: Les Editions de L'Homme, 1972.

Lillie, R.G. "Twenty Years of Housing, CMHC. 1946-1966." Published in four parts, Habitat 9 (Nos. 3 and 4, 1966), 10 (No. 2 1967), 11 (No. 1, 1968), 11 (No. 2 1968).

Loshak, Lionel. "Some Views on Industrialization." Ottawa: CMHC, typescript, 1969.

Maclennan, Ian. The Architecture of Urban and Sub-urban Development. Ottawa: Canadian Housing Design Council, 1964.

Mills, G.E. and Holdsworth, D.W. The B.C. Mills Prefabricated System: The Emergence of Ready-Made Buildings in Western Canada. Ottawa: Parks Canada Occasional Papers in Archaeology and History No. 14, 1975.

Miron, John. House, Home and Community: Progress in Housing Canadians 1945-1986. Montreal and Kingston: McGill-Queen's University Press and CMHC, 1993.

Murray, James A. The Architecture of Housing. Ottawa: Canadian Housing Design Council, 1962.

National Research Council of Canada Division of Building Research. Ten Years of Building Research 1947-1957. Ottawa: Queen's Printer, 1957.

National Research of Canada, Division Building Research. The First Twenty Five Years. Ottawa: National Research Council, 1973.

----- "Housing Research," Building Research in Canada, December 31, 1952.

Opolovnikow, Alexander and Yelena. The Wooden Architecture of Russia Houses, Fortification, Churches. New York: Harry N. Abrams Inc., 1989.

Platts, R.C. Prefabrication in Northern Housing. Ottawa: National Research Council, Division of Buidng Research, Technical Paper No. 110, 1960.

---- "An Expert Reviews A New Roof System." Housing Note No. 4, NRC/DBR November 1962.

---- Prefabrication in Canadian Housing. Ottawa: National Research Council of Canada, Division of Building Research, Technical Paper No. 172, 1964.

[Royal Architectural Institute of Canada]. Reflections on Zoning. The Report of the Zoning Study Committee of the R.A.I.C. Ottawa: n.p. 1964.

Ritchie, Thomas. Canada Builds 1867-1967. Toronto: University of Toronto Press for National Research Council, 1967.

---- "Plankwall Framing. A Modern Wall Construction with an Ancient History." Journal of the Society of Architectural Historians 30 (1971).

Saywell, John. Housing Canadians: Essays on the History of Residential Construction in Canada. Ottawa: Economic Council of Canada, Discussion Paper No. 24, 1975.

A Topographical Atlas of Montreal/Atlas Topographique de Montréal. Montreal: McGill School of Urban Planning, 1992.

Wetherell, Donald G. and Kmet, Irene R.A. Homes in Alberta. Building, Trends, and Design. Edmonton: University of Alberta Press, Alberta Culture and Multiculturalism and Alberta Municipal Affairs, 1991.

Wilson, Grant. "Moisture in Canadian Wood Frame Construction, Problems, Research and Practice from 1975-1991." Typescript courtesy Grant Wilson.