#627

REVISED 346/A810811

ADDENDUM TO MANAGEMENT SUBMISSION

FOR MOISTURE INDUCED PROBLEMS IN HOUSING

We have reviewed the submission to Management related to moisture induced problems in housing and offer the following comments:

1. Financial Implications

- 1981 Part V funds in the amount of $230,000 for the research activities related to moisture induced problems in housing have been provided for in the approved Consolidated Research Plan under the sub-activity Technical Research.

- the total cost is estimated at $685,000 and will be provided for within the "A" base resources for 81/82 and future years.

- all expenditures will be arms-length transactions.

- the risks associated with the above problem are that structural damage to NHA insured housing may lead to widespread defaults on mortgages, with CMHC having to repossess these units and then rectify them at an estimated cost of $10,000 per unit.

2. Recommendations

- Replace recommendation iii) and iv) with the following:

  iii) Management approve an allocation of $230,000 for Technical Research to undertake studies related to moisture induced problems in housing. These funds are to be accommodated within the 1981 Part V budget approved for Technical Research. Additional requirements in future years are to be included within the "A" base resources.

  iv) The National Office Support Centre, subsequent to the Part V research study and report, coordinate a comprehensive submission to Management which will include terms of reference, action plans and other additional budget resources and dependencies.

- Add recommendation v) as follows:

  v) All research activities identified in this submission will be subject to the guidelines, procedures and authorities for research contracting.

Director, Research Administration & Coordination Division

Treasurer's Directorate

346-810810

ADDENDUM TO MANAGEMENT SUBMISSION

FOR MOISTURE INDUCED PROBLEMS IN HOUSING

We have reviewed the submission to Management related to moisture induced problems in housing and offer the following comments:

1. Financial Implications

- 1981 Part V funds in the amount of $230,000 for the research activities related to moisture induced problems in housing have been provided for in the approved Consolidated Research Plan under the sub-activity Technical Research.

- the total cost is estimated at $685,000 and will be provided for within the "A" base resources for 81/82 and future years.

- all expenditures will be arms-length transactions

- the risks associated with the above problem are that structural damage to NHA insured housing may lead to widespread defaults on mortgages, with CMHC having to repossess these units and then rectify them at an estimated cost of $10,000 per unit.

2. Recommendations

- Replace recommendation iii) and iv) with the following:

iii) Part V funds for the research activities identified in i) and ii) of the recommendation totalling $230,000 are presently available within the 1981 allocation for Technical Research. Further funds required for moisture-related studies will be included in future year research plans within "A" base resources.

iv) Following a review of Research recommendations by participating Divisions, the National Office Support Centre will coordinate a comprehensive submission to Management which will include terms of reference, action plans and other additional budget resources and dependencies for Technical Services, N.O. Support Centre and I.C.O.M.

- Add recommendation v) as follows:

v) All research activities identified in this submission will be subject to the guidelines, procedures and authorities for research contracting.

Director, Research Administration & Coordination Division

Treasurer's Directorate

MEMORANDUM TO MANAGEMENT

DATE: August 4, 1981

1. TITLE - Moisture Induced Problems in Housing

2. PROBLEM - Since 1976 an increasing number of complaints have been made to CMHC regarding the performance of hardboard sidings which has tended to buckle. Similar moisture related problems have also been reported with aluminum siding. To date, one manufacturer has received claims for over 200 units from the Port aux Basques and Borin Peninsula areas where rain penetration, due to heavy rains and high winds may be a contributing factor. It is expected problems exist elsewhere in similar proportions but have hither to gone undetected.

Many flueless houses in Newfoundland are showing signs of condensation within the exterior walls. Today's building energy standards which require tight air/vapour barriers, can result in higher relative humidity within the houses and a reversal of air flow through the exterior walls. In many houses the outward flow of warm wet air is condensing within the exterior walls.

The nature, extent and severity of the problem has yet to be determined. Its solution may be complex because this is not simply a siding problem. The "problem" has different dimensions for the various CMHC programs. It is unlikely that the introduction of regulations and rigid inspections will resolve all of these problems. Homeowner education may remain the larger and most difficult issue.

This condition demands early action by Builders and Homeowners, otherwise, early deterioration by rot of wood frame houses in Newfoundland, and most likely other parts of Canada, will reach major proportions.

It has been estimated, by one consultant, that 20 to 30% of houses in Newfoundland built without active flues are rotting to a disturbing degree. A small task group, with representation from:

Atlantic Region
N.O. Support Centre
Technical Research Division
CMHC Technical Services

has been formed to make recommendations for immediate and longer term actions.

3. OBJECTIVE - To present the recommendations of the Task Force to CMHC Management and to obtain approval to pursue the courses of action arising from them and identified in this submission.

i) The Technical Research Division to proceed with the first phase of its proposed research program, as outlined in Appendix B. This includes:

Project A1 - Telephone and Field Survey Design
A2 - National Surveys of N.H.A. Housing
A3 - Analysis and Report
B1 - Preliminary Analysis and Research Design
C1 - Design of Venting Stack for Newfoundland

The results of these studies will determine the extent of the problem and allow management to decide on future courses of action.

ii) The National Office Support Centre to co-ordinate the development of Terms of Reference and Action Plans to be approved by management for the technical recommendations having direct operational impact.

4. FACTORS -

i) In 1980, a technical study was started in Technical Research Division, for which the services of Scanada consultants was used. Prior to this Mr. J. Kerr was sent to Newfoundland, from NOSC, to report first hand. Mr. Kerr's report, though not alarmist in character, left the clear impression that there was indeed a problem, and it needed defining with more precision. A subsequent report titled, "Moisture Related Problems in Housing in Newfoundland", dated May 1981, was prepared by E. Burnett. This report pulled together existing documentation and attempted to assess the nature, extent and severity of the known moisture related problems in Newfoundland.

ii) The problem appears to affect more than NHA insured and subsidised housing. Being aware of the problem, CMHC could be delinquent in not bringing appropriate aspects of it to the attention of others. Government departments, such as EMR, could unwittingly exacerbate the problems. Manufacturers of siding and Industry Associations are anxious to take corrective actions; to curtail the problems; and prevent recurrence, if possible.

iii) The role of other organisations, besides those already mentioned, which are pursuing technical investigations and providing information bulletins and warnings, should also be considered.

iv) The problem affects the security of NHA insured housing and, because of this, CMHC should consider what actions are appropriate to reduce risk and possible loss.

v) The Department of Energy Mines and Resources are promoting "Super Chip" and "Chip" programs. Unless informed by a thorough knowledge of the moisture related problems, these programs could lead to the promotion of structural deterioration.

vi) Enforcement of the provisions of the National Energy Program requiring the adoption of "reasonable alternatives" to oil for house heating. This could promote a further spread of the problem by encouraging the wide use of electric heating, with inadequate ventilation and inappropriate wall construction.

5. ALTERNATIVES -

i) The more immediate actions are generally technically straightforward.

ii) The longer term actions involving information gathering and technical research activities, will require further submissions and may well present alternatives.

iii) Most of the work flowing from the recommendations will fall on the Policy Sector, and on the Technical Research Division in particular. Nevertheless, the problem is not easily characterised as an isolated 'research' activity, having overriding operational characteristics for which the Operations Sector is accountable.

6. PRODUCTIVITY CONSIDERATIONS - N/A.

7. FINANCIAL AND BUDGETARY CONSIDERATIONS -

i) This question will have resource implications in the 1982 Research Budget.

ii) Adoption of the recommendations will have resource and budgetary dependency implications for TRAINING and INFORMATION AND COMMUNICATIONS.

iii) The research projects for which approval is requested are outlined in the attached research program. The estimated cost for these projects are:

Project A1 - Survey Design	-	$ 55,000
Project A2 - Surveys	-	$ 75,000
Project A3 - Report	-	$ 15,000
Project B1 - Preliminary Analysis	-	$ 40,000
Project C1 - Design Venting Stack	-	$ 40,000
Total Funds Requested	-	$225,000

iv) The advisory committee will consist of approximately 15 members. Funds will be required for meetings and expenses for members representing external organizations. This amount is estimated to be $5,000.

8. CMHC DIVISION CONSIDERATIONS - This problem has impact on

PROGRAM OPERATIONS
- INSURANCE OPERATIONS - UNDERWRITING
- REAL ESTATE ADMINISTRATION
- NATIONAL OFFICE SUPPORT CENTRE
- RESIDENTIAL IMPROVEMENT DIVISION

CMHC TECHNICAL SERVICES
- QUALITY ASSURANCE-FIELD OPERATIONS
- MATERIALS EVALUATION DEPARTMENT

POLICY AND RESEARCH SECTOR
- TECHNICAL RESEARCH DIVISION

ORGANIZATION DEVELOPMENT
- CORPORATE COUNSEL AND LEGAL DIVISION
- ICOM

In the field, the General Manager Atlantic Region and his staff, particularly the Provincial Director, Newfoundland, are directly involved in, and affected by, the problem.

Both Divisions and Regions of CMHC need to be informed of the nature and extent of the problem.

9. FEDERAL-PROVINCIAL RELATIONS - It is reasonable to assume that the problems of which CMHC is aware can have an impact on and consequences for Provincial Housing Ministries and Energy Ministries particularly in the Atlantic Region.

10. INTERDEPARTMENTAL CONSULTATION -

DIVISION OF BUILDING RESEARCH NRC -

This division should continue to be consulted and kept advised.

ENERGY, MINES AND RESOURCES -

This ministry should be kept fully informed of programs and developments.

11. PUBLIC RELATIONS CONSIDERATIONS - The issues are sensitive and management should be aware of the severity of the possible problems resulting from early deterioration.

12. INTERNAL COMMUNICATION CONSIDERATIONS - Four divisions and one region.

13. CORRECTIVE ACTION - A course of action is provided in the Task Force recommendations.

14. CONCLUSION -

i) Most of, but not all of the work to deal with this problem falls on Technical Research Division. Activity in this Division should be in accordance with clear terms of reference, agreed to by management.

ii) Most of the accountability for monitoring, project evaluation, standards, inspection procedures, training and communication requirements falls on the Operations Sector where the prime liaison responsibility should be assigned.

iii) The recommendations of the Task Force have been received and reviewed in the Policy and Research Sector - by Technical Research Division and in the Program Operations Sector - by National Office Support Centre.

iv) The recommendations fall under four major headings and responsibility centres:

- RESEARCH	- Technical Research Division
- FIELD TECHNICAL ACTIONS	- Technical Services
- STANDARDS AND PROCEDURES	- N.O. Support Centre
- COMMUNICATIONS	- I.C.O.M.

Not all of the recommended actions fall clearly under one or the other of these headings exclusively, some require input from several units in CMHC and from outside bodies.

v) The items which are primarily concerned with RESEARCH:

- National survey to determine the nature, extent and severity of the problem,
- Development work on alternative controlled ventilation for flueless housing,
- Field investigation and testing,

are components of a Technical Research Division action plan and should be managed there as mentioned in CONCLUSION 14 (i).

vi) The items which primarily affect the Program Operations of CMHC are:

FIELD TECHNICAL ACTIONS
- Review of vertical framing recommendation, and its technical evaluation. - N.O.S.C./T.R.D. Technical Services.
- Implementation of related inspection procedures and reporting monitoring. - Technical Services/N.O.S.C.
- Field investigation of M.I.F. units in Newfoundland. Technical Services/F.S.C.

STANDARDS AND PROCEDURES
- Program related technical guidelines. - N.O.S.C./T.R.D./DEAS/ICOM
- Training modules, training aids, training delivery. - ICOM/NOSC/DEAS/TRD

COMMUNICATION
- NHA moisture information paper for Newfoundland. - ICOM/NOSC/DEAS/TRD

5. RECOMMENDATIONS -

It is recommended that:

i) Management approves an allocation of $225,000 to the Technical Research Division to undertake the first phase of its research program as outlined in Appendix B. This includes:

Project A1A
A1b
A2a
A2b
A3
B1
C1

Funding to be provided under Part V of the N.H.A.

ii) Management approves an allocation of $5,000 to the Technical Research Division to cover external expenses for a meeting of an advisory committee. Funding to be provided under Part V of the N.H.A.

iii) As these items have not been fully identified under the 1981 Research Plan final commitment approval is contingent on the Vice President, Policy and Research, assuring that the required amounts can be provided within the 1981 Research Budget.

iv) The National Office Support Centre co-ordinate a comprehensive submission of Terms of Reference, Action Plans and Budget for the

FIELD TECHNICAL ACTIONS
STANDARDS AND PROCEDURES
COMMUNICATIONS ACTIVITIES

identified in the CONCLUSION of this submission.

16. SIGNATURES -

Proposed:

Director,
Technical Research Division

Director,
National Office Support Centre

31/7/81
Manager, Quality Assurance
CMHC Technical Services
(Task Force Chairman)

Concurred:

Vice President,
Insurance Operations

Vice President
Policy Developments Research

31/7/81
General Manager
CMHC Technical Services

Executive Director,
I.C.C.M.

RECOMMENDATIONS -

It is recommended that:

i) Management approves an allocation of $225,000 to the Technical Research Division to undertake the first phase of its research program as outlined in Appendix B. This includes:

Project A1A
A1b
A2a
A2b
A3
B1
C1

Funding to be provided under Part V of the N.H.A.

ii) Management approves an allocation of $5,000 to the Technical Research Division to cover external expenses for a meeting of an advisory committee. Funding to be provided under Part V of the N.H.A.

iii) As these items have not been fully identified under the 1981 Research Plan final commitment approval is contingent on the Vice President, Policy and Research, assuring that the required amounts can be provided within the 1981 Research Budget.

iv) The National Office Support Centre co-ordinate a comprehensive submission of Terms of Reference, Action Plans and Budget for the

FIELD TECHNICAL ACTIONS
STANDARDS AND PROCEDURES
COMMUNICATIONS ACTIVITIES

identified in the CONCLUSION of this submission.

16. SIGNATURES -

Proposed:

Director,
Technical Research Division

Director,
National Office Support Centre

Manager, Quality Assurance
CMHC Technical Services
(Task Force Chairman)

Executive Director,
I.C.O.M.

Concurred:

Vice President,
Insurance Operations

Vice President
Policy Developments Research

General Manager
CMHC Technical Services

SCHEDULE OF RECOMMENDATIONS

The following schedule is the compilation of recommendations agreed to by the Task Force:

1. A countrywide survey or series of surveys be carried out to determine the nature, extent and severity of moisture induced damage to recently built wood frame housing. This survey should be done through the auspices of HUDAC; substantially financed by CMHC with strong technical input to be provided by CMHC and DBR (the study/survey would commence with Newfoundland).

2. An information paper be created for new housing in Newfoundland, addressing the moisture related problems and construction methods which would help to reduce the severity and hopefully avoid the problem. The distribution of this NHA information paper should be limited to Newfoundland. It is recommended that an outside consultant be hired to prepare this document with the Task Force providing the terms of reference.

3. In Newfoundland, all types of horizontal and panel siding should be applied over vertical furring strips (minimum 6 mm thickness) installed on a sheathed wall. The furring strips should be nailed into the studs every 300 mm. It is recommended that this be implemented through negotiations with the Canadian Siding, Soffit and Raingoods Manufacturers Association and supported by Technical Services, Materials Evaluation Department.

4. Development work is required on the feasibility, both technically and economically, of using and controlling a dummy flue in flueless housing. ✳

5. This Task Force foresees the possibility that the severity and consequence of moisture related problems will vary for different types of housing and housing programs. In the upgrading of existing housing this may be an acute problem. It is recommended that a publication or a series of publications be created which would provide guidance to aid in reducing the overall problem for each program (i.e., Underwriting, Social Housing, Rural and Native Housing, RRAP, SUPERCHIP, CHIP).

6. a) Technical Services, St. John's Branch, with input from National Office, to design an inspection procedure and reporting form for moisture induced problems.

   b) Funds be made available to the Chief Inspections Officer, Technical Services, St. John's Branch through the Branch Manager, St. John's Branch to investigate MIF units to determine the extent of the problem.

7. Technical Research Division, in consultation with Technical Services Materials Evaluation Department, DBR, NRC regional offices, and Canadian Electrical Association, to study wall assembly arrangements which provide satisfactory component performance. For example, separate studies should be conducted to:

   - assess the performance of various sheathing materials and asphaltic building paper with respect to air/vapour flow; and
   - establish whether or not, and by what mechanisms, moisture is deposited directly behind siding.

8. Improving the quality of air barrier is largely an educational and control problem. Training strategies will have to be developed for the needs of CMHC Technical Services, builders, manufacturers, homeowners, HUDAC, Provincial Housing Authority and municipal inspectors.

9. An individual at National Office should be assigned the responsibility to initiate and coordinate the work. It must be emphasized that this individual should be given the necessary authority and funding to carry out the work.

MOISTURE INDUCED STRUCTURAL DAMAGE IN HOUSING
TERMS OF REFERENCE FOR A RESEARCH PROGRAM

Prepared for

The Technical Research Division
of
Canada Mortgage and Housing Corporation

by
Peter A. Rowles, P.Eng.

July 1981

CMHC Project Manager: J.H. White, P.Eng.

MOISTURE INDUCED STRUCTURAL DAMAGE IN HOUSING
TERMS OF REFERENCE FOR A RESEARCH PROGRAM

1.0 INTRODUCTION

The purpose of this document is to serve as a terms of reference for a research program to investigate moisture induced structural damage in housing.

The information upon which these terms of reference are based was drawn from sources such as:

- literature currently available on the subject;
- reports produced for CMHC both internally and by consultants;
- discussions with concerned groups - Ontario Hydro, HUDAC, EMR, NRC and CEA;
- discussions with other CMHC departments;
- recommendations from Scanada Consultants Ltd. and CMHC regional offices; and
- discussions within the Technical Research Division.

The terms of reference defines the scope and potential impact of the problem. This report attempts to identify the numerous factors associated with moisture induced damage. It defines the direction of research through a set of objectives. These objectives will be satisfied by a number of outputs from various studies directed toward specific interest groups. The work plan to achieve these objectives is discussed in terms of sub-objectives, required work, phasing, cost, timing and interrelationships between studies. An estimate of the overall resource requirements is made and the involvement of others, especially those members of the committee to whom this document is directed, is discussed.

2.0 PROBLEM

There have been a number of reported cases of moisture induced structural damage in housing across Canada. Newly constructed, electrically heated houses on the east and west coast, some super-insulated houses on the prairies, recently constructed houses in the Northwest Territories and well sealed houses in less extreme climates have experienced severe moisture accumulation within the outer structure. The symptoms which indicate moisture accumulation are varied and usually unnoticeable until damage to the structure is significant. A large number of cases were discovered in Newfoundland during investigation of apparent siding malfunctions. These are discussed in some detail in the reports by R.E. Platts "Field Survey of Moisture-Troubled Walls in Newfoundland Houses" (1) which provided background information for E.P. Burnetts report "Moisture Related Problems in Houses in Newfoundland".(2)

Platts estimates that 20-30% or more of recently constructed houses in Newfoundland are suffering from sustained saturation within the walls which is resulting in the rotting of wood components.

These estimates are inconclusive as they are based on insufficient data. However, Burnett suggests that, if only 10% of the houses are affected, "there would be serious consequences for:

- the owner
- the builders
- the mortgage insurers
- the warranty program
- the regulatory authorities".

If there are 2,000 to 6,000 units affected by this problem, as suggested, the cost of repairs alone could be in the range of $40 million to $120 million.

In addition to structural damage, the accumulation of moisture can dramatically reduce thermal resistivity of insulation and result in increased energy losses from the house. This is an aspect of the problem which has not received much consideration in previous reports, but, adds to the importance of finding suitable solutions.

There are many parameters or mechanisms to be considered in this problem, none of which can be viewed in isolation. These mechanisms can be grouped under the following titles:

a) The sources of moisture;
b) The driving forces which push it into the shell structure;
c) The pathways or conductors through which moisture travels;
d) The blocking forces which inhibit its removal causing the accumulation and subsequent damage.

2.1 Moisture Sources

There are three basic sources of moisture. It can enter the shell structure from inside the house, from outside of the house or be present in the components of the shell when constructed.

Moisture is generated inside the house by the occupants themselves and their use of appliances and space conditioning systems. A family of four can produce between 10 and 24 kilograms of water per day (3). To achieve acceptable levels of indoor relative humidity most of this moisture must be removed.

Another source of moisture inside the house is the basement floors and walls. Actually moisture seeps into the foundations from outside but is evaporated by warm air and adds to the relative indoor humidity of the house. For this reason the basement is treated as an indoor source of moisture.

Moisture entering the shell from outside is usually dependent on the climate. The annual rainfall, the severity and orientation of wind, outdoor humidity levels and hours of sunshine are contributing factors to the level of moisture penetration from outside the house.

Moisture is also present in the building materials when the house is constructed. The components of the structure such as the wood framing, plywood sheathing, concrete, etc., are usually high in moisture content at the time of construction and require a period of time to dry out or cure.

2.2 Driving Forces

The driving forces are those which push moisture into the shell structure. The interrelationships between these forces can be such that they add or subtract from each other. The predominant forces which are discussed here are:

a) Air pressure differentials between the inside and outside of the house;
b) Vapour pressure differentials;
c) Outside climate.

Air pressure differentials between the inside and outside of a house will determine the direction of air flow through the shell. When indoor air pressure is negative, relative to outdoors, the direction of air flow will be into the house. This is known as infiltration. When the indoor air pressure is positive, relative to outside, the direction of air flow will be out of the house. This condition is known as exfiltration.

Traditionally houses have operated at a negative pressure during the heating season and the shell has been subjected to, predominantly, infiltration forces. The negative pressure has been induced as a result of the requirement for combustion air by the heating system which has usually been fossil-fuel fired. The combustion air which is taken from the inside of the house and exhausted through the flue must be replaced. When all doors and windows are closed this usually occurs by infiltration through the structure.

When infiltration occurs in winter, dry outside air, relative to inside the house, will pass through the shell. As this air is heated, it is able to retain a higher absolute moisture content. Therefore this air is able to absorb moisture as it passes through the shell and, in effect, dries out the internal components. This has possibly been the major force inhibiting the development of this problem in the past.

In the past ten to fifteen years there have been some changes to the basic design and operation of the house structure. Houses have become better insulated, air and vapour tightened and there have been increasing trends towards electric heating and external combustion furnaces. These factors have combined to create a new condition within the house. A condition where, over a proportion of the shell during the winter, the pressure differential between inside and outside is positive and the flow of air is towards the outside. In

this exfiltration mode, warm, moist inside air passes through openings in the shell. As this air is cooled, its ability to hold water is reduced. If the temperature gradient across the shell passes through the dew point of the air, water will condense inside the structure.

The degree of infiltration or exfiltration is related to the location of the neutral pressure plane. The neutral pressure plane is defined by the set of points around the perimeter of a house, where the pressure differential between inside and outside is effectively zero. Typically above the neutral plane, there is an exfiltration of air and below the plane there is infiltration. The location of the neutral plane is a function of internal and external temperatures, the air tightness of the structure and the locations of air leakage. Houses with furnaces, which take combustion air from inside the house and exhaust air through a flue, tend to have higher neutral planes. Electrically heated houses or those with effectively external combustion tend to have lower neutral planes and are more susceptible to the exfiltration - condensation condition.

The conditions which are discussed here exist during the heating season only. These conditions could be reversed during the summer months. In some climatic regions, there may be a significant number of hot humid days where houses, especially air conditioned ones, will experience an infiltration-condensation condition.

The second driving force is vapour pressure differences. Water vapour will migrate from areas of high vapour concentration to areas of low vapour concentration. In the usual situation, during the heating season, the absolute concentration of moisture is greater inside the house than outside. Therefore the tendency is for moisture to move from the inside to the outside, irrespective of air flow direction. It can therefore add, or subtract, from moisture transported by air flow. This condition can also be reversed during the summer months.

Climate plays a significant role as a driving force. It affects the other driving forces by varying the outside air and vapour pressure dramatically. The climate pushes moisture into the structure through rain, wind and high humidity. The outer claddings of houses are designed to ensure adequate screening against these forces. However, the climate in certain regions of Canada is quite severe and the design requirements for cladding materials in certain areas may require special considerations.

All of these forces can be found at work to some degree in any structure. Their relative magnitudes fluctuate daily, monthly, seasonally and annually. Based on the reports of problem cases, it appears that moisture transport through exfiltration is the most dominant mechanism causing damage. However, the information available to date is inconclusive and consideration of all factors is required to thoroughly understand the moisture problem.

2.3 The Conductors

Given that the driving forces exist, there still have to be avenues or pathways for the moisture to enter the structure. These pathways act as conductors and can be designed and constructed in such a way to be more or less resistive to the flow of moisture. These conductors include:

a) the gaps and discontinuities in the internal and external cladding which allow air transport of moisture.

b) the permeability of building materials.

c) other physical properties of building materials such as surface tension.

Gaps and discontinuities can exist in walls, ceilings, floors, basements, air/vapour barriers, sheathing, siding, and around doors, windows, pipes and heaters and the list goes on. Attempts to tighten houses will reduce the number and size of gaps but in all likelihood they will continue to exist.

These discontinuities provide pathways for air to transport moisture. The sign of the pressure differential determines the direction of air flow and the number, size and nature of the discontinuities determines the quantity of air and moisture flow.

The material components which form the shell structure are also conductors of moisture. Under given vapour pressure differentials they conduct moisture or allow it to diffuse at rates based on the materials characteristic permeability. The positioning of materials in certain sequences in the shell is an important consideration for promoting or impeding the migration of moisture.

Building materials can also transport water by way of surface tension when water wets the materials within narrow gaps. This can occur in the overlaps and spacings of external siding.

2.4 Blocking Forces

These blocking forces include:

a) inadvertent and unintended vapour barriers;
b) external climate;
c) absorption and storage characteristics of materials;
d) thermal characteristics of the shell and the location of dew point.

The use of certain building materials and the manner in which they are applied to the structure can create inadvertent or unintentional vapour barriers. This pertains specifically to the application of sheathings, building papers, sidings and paints, both internal and external. The existance of an external air vapour barrier will impede the drying out process of the shell structure.

The outside climate can block the migration of moisture in a number of ways. High outdoor humidity can make the vapour pressure differential so small that little effective drying of the wet structure takes place. Hours of sunshine and the accompanying solar heating on the outside of the structure can reverse the flow of moisture in the structure and result in condensation on the outside of the vapour barrier.

Building materials also have the ability to absorb and store moisture. In some cases, such as with insulation, their ability to store water can inhibit the migration of water out of the structure. The nature of these characteristics and impact on moisture accumulation in the structures is not well understood.

Increasing the amount of insulation can affect the thermal gradient across the shell and the location of the dew point. If the thermal characteristics of the shell are such that the dew point occurs inside the insulation, moisture will condense on the inside surface of the sheathing. When the moisture condenses and accumulates it can be easily absorbed by the insulation and the structural members.

2.5 Other Considerations

After reviewing the reports and listening to the large number of diverse professional opinions on the subject, it appears the actual interrelationships between the parameters and the real cause of damage are not clear. The preliminary assessment of this problem in Newfoundland indicates the potential for moisture induced structural damage is increased in:

- homes with flueless heating systems;
- air tight and highly insulated homes;
- houses which are retrofitted with increased insulation, air barriers and/or flueless heating;

Especially if these houses are located in coastal regions.

Since trends in housing are towards air tight and flueless types of construction, which is a radical change based on the age old traditions of construction, there is an immediate need to develop a thorough understanding of the moisture problem. The scope of studies should not be restricted to Newfoundland where the problem has surfaced. Conditions in that province may be conducive to speedy

development of problems. There is no conclusive evidence to say the problem cannot exist in other parts of the country, taking longer periods to surface.

Based on the involvement of insulation, air tightness and flueless heating as potentially major parameters clearly energy and energy conservation are related issues to the moisture problem. By association with these same parameters, it can also be argued that air quality inside the home is also related to the moisture issue. Therefore the study of any of these separate issues - increased energy conservation, moisture damage and air quality - must include adequate consideration of the relationships which exist between them.

There are other issues which must be considered in coming to an adequate solution to the problem. They are not discussed further in these terms of references as they are outside the scope of technical research. However they are listed here to serve as flags to those responsible for their consideration.

1. What are the political implications?
2. What are the social aspects?
3. What will be the economic impact?
4. What are the legal implications?
5. If a technical solution is found, what will be the strategy for implementation?

3.0 OBJECTIVES

Research of moisture induced structural damage in housing should be geared to meet the following basic objectives:

1. To determine the extent of the problem in existing houses across Canada.

2. To identify and analyse the major mechanisms involved in the problem.

3. To verify the cost effective of technical solutions to the problem.

4.0 END PRODUCTS

The end products of this research will be a number of technical reports presenting the extent and nature of the problem as well as practical cost-effective solutions. The findings of research will be used by CMHC to initiate demonstrations, produce Builders' Bulletins, Advisory Documents and new housing standards. Other groups, such as NRC, HUDAC, EMR, CEA, etc., will be able to incorporate the findings of research into their programs and communicate the results through their information channels. The costs presented in this research program cover only the production of technical reports and do not reflect costs for demonstration, advisory documents, etc.

5.0 WORK PLAN

The studies outlined in this work plan are divided into three main streams which are designed to meet each of the objectives. Stream A should satisfy the requirements of objective 1, Stream B - objective 2 and Stream C - objective 3. Structuring of the work plan in this manner allows a fair amount of the work, required to meet the three objectives, to be done in parallel.

The projects associated with each stream or objective are listed here. More detailed descriptions of the projects are presented in Appendix 1.

Stream A - Determine extent of the problem in existing housing across Canada.

Project 1 - Survey Design.
Project 2 - Conduct Survey of NHA Housing.
Project 3 - Analyze and Report Results.
Project 4 - Conduct Survey of all Housing in Canada.

Stream B - Identify and analyze the major mechanisms involved in the problem.

Project 1 - Preliminary analysis of mechanisms.
Project 2 - Validate preliminary analysis through field monitoring, lab modelling and field investigation of trouble houses.
Project 3 - Document mechanisms and interrelationships.

Stream C - To verify the cost effectiveness of technical solutions.

Project 1 - Postulate and design possible corrective measures.
Project 2 - Field test and monitor alternative solutions.
Project 3 - Cost benefit analysis and comparison of alternative solutions.
Project 4 - Make recommendations, based on results of studies for existing housing, new housing and retrofit cases.

5.1 Newfoundland Interim Solution

Due to the extent of the problem as it is reported in Newfoundland, there is a need to provide an interim solution for the many potentially troubled houses in that province. To satisfy this requirement it is recommended that work start on the design of a venting stack which can be retrofitted into endangered houses.

This venting stack or dummy flue will ensure that the neutral pressure plane is safely above the structure thus creating the conventional situation of negative pressure throughout the house relative to outside conditions. This should prevent further accumulation of moisture due to exfiltration-condensation and promote the drying out of structural components. Raising the neutral plane may result in greater energy losses due to infiltration, however, this can be reduced by proper air tightening of the house. An