HIGH QUALITY BASEMENT ACCOMMODATION IN OLDER HOUSES

PREPARED FOR

THE PROJECT IMPLEMENTATION DIVISION
POLICY DEVELOPMENT AND RESEARCH SECTOR
CANADA MORTGAGE AND HOUSING CORPORATION

BY

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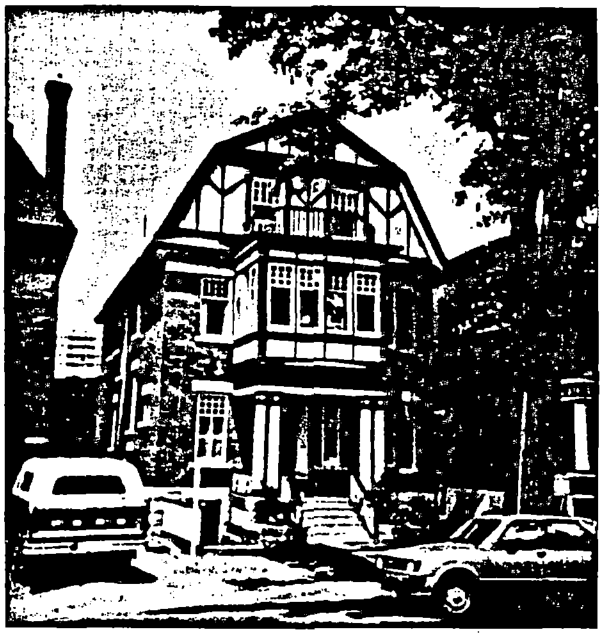

TABLE OF CONTENTS

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THIS LEGISLATION IS DESIGNED TO AID IN THE IMPROVEMENT OF HOUSING AND LIVING CONDITIONS IN CANADA. AS A RESULT, THE CORPORATION HAS INTEREST IN ALL ASPECTS OF HOUSING AND URBAN GROWTH AND DEVELOPMENT.

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DISCLAIMER

ACKNOWLEDGEMENTS

We would like to give credit to Mr. Ettore Palombo, for close supervision and concern for this construction.

ABSTRACT

This report presents the findings of a field trial of a method of retrofitting a basement to generate quality apartment accommodation. It reports on the economic and technical concerns associated with this field trial. In addition to this work Canada Mortgage & Housing Corporation is monitoring the building for a one-and-a half year period following the completion of construction to gain technical insight into the performance of this retrofit. This report addresses only the construction phase of the project.

EXECUTIVE SUMMARY

The Ottawa city centre has excellent potential for increasing population density with construction of basement apartments. Common to most basements in the Centretown area of Ottawa is a similar set of problems, some technical, some zoning related, making retrofitting such areas difficult.

A 90-year old house in the Ottawa area was retrofitted to gain insights into the problems involved in such projects. The basements in the city centre were constructed before vapour barriers, drainage tiles and damp-proofing became standard construction practice. The occasional house had a weeping tile drain system installed which has now probably deteriorated. The basements constructed in these houses were primarily storage areas. This may involve modifications to the foundation and structural support systems for the building.

The project consisted of construction and renovating an existing unfinished basement in an old centretown house. Creating a separate and self-contained dwelling unit by designing detailing using, cost-effective methods to ensure the economic viability of basement apartment retrofit.

The retrofit involved lowering of the floor slab by further excavation and adding new coincidental foundation walls as well as the application and testing of an appropriate method of sealing the foundation wall.

This report assesses the construction methodology and provides general analysis of costs of providing this type of basement accommodation. Also included is a project feasibility checklist for similar basement rehabilitation.

Conclusion for the field trial have concluded the cost per square metre were $409.75.

Canada Mortgage and Housing Corporation have access to the completed unit for a period of one and-a-half years, for the purpose of periodic monitoring of the technical performance.

1. INTRODUCTION

Within city centre areas there is potential for increasing population density with the construction of basement apartments. Common to basements there are distinct problems which typically make the quality of the living space undesirable for long term tenancy. Insufficient lighting, sewer odors, height restrictions, dampness and moisture caused by seepage, etc. are typical problems. Often these problems are such that the property owner disregards the potential. This report addresses a field test in which attempts were made to overcome some of the technical problems associated with such retrofits and in addition an analysis of the costs involved in performing such work is presented.

1.1 Retrofit of 177 Frank Street

Thorcor Holdings Limited carried out a basement retrofit on a 90 year old building located at 177 Frank Street, Ottawa, Ontario, whereby an unfinished basement of an old center-town house was finished to create a separate and self-contained dwelling unit. The construction detailing and methods utilized, attempted to ensure quality and cost-effectiveness of the basement apartment retrofit. It is hoped that the method has potential for increasing density in the older housing stock of city centres.

Problems addressed by the retrofit include aesthetic and technical problems associated with the creation of additional head room and natural lighting, control of moisture and maintenance of good air quality, the sound separation of the unit from the main house, and the re-arrangement of building supports to maximize usable living space. Noteworthy features of the retrofit included the lowering of the floor slab by further excavation and the addition of new coincidential foundation walls, as well as the application and testing of an appropriate method of sealing the foundation wall.

2.0 CHARACTERISTICS OF THE RETROFIT

2.1 Design Characteristics

Thorcor's designing staff assessed the basement unit for possible living accommodation. The basement measurements were required to determine location of existing windows, doors, water and heating pipes, load supporting columns, furnace, electrical panel, sewer and main water line and the existing height from floor to underside of the first floor joist.

There were several design constraints which had impacts on the retrofit. The design had to meet Municipal, Provincial and National Building Codes. The existing concrete floor had to be lowered by 0.5m and this required the design of a suitable and workable wall support system. Columns had to be relocated to maximize floor area.

There were design changes required to conform with municipal zoning and building departments concerns. The location of the main entrance of the apartment was changed from the side to the front of the building because of insufficient side yard. (See Figure No. 2) - Secondly, the distance of the front entrance stairway from the street was changed to allow for municipal right-of-way and set back distance.

The retrofit involved lowering of the basement floor by about 0.5m to provide more head space. The house is a 90 year old three storey brick structure supported on stone foundation walls which are about 500mm thick; the foundation walls rest on a footing which, where exposed, was about as wide as the base of the foundation walls. There were also four interior brick columns in the basement which supported a centrally located built up wood beam; these columns rested on a piece of stone which served as a footing. Three of the brick columns were removed to facilitate the lowering of the basement floor. These were replaced with 2.74m long steel posts, two jack posts per pier location. The removal and renewing of the piers is discussed later in this section.

Because an additional 0.5m of headroom was required, lowering of the floor did require excavation to be carried down below the existing footing level. It was necessary to excavate vertically next to the exterior footings adjacent to the wall leaving the supporting soil in place and to pour a reinforced concrete footing wall and stub facing wall to retain and laterally support the founding soil. One column was also excavated around the perimeter, leaving about 100mm to 150mm of soil beyond and below the pier and then a reinforced concrete supporting collar around the supporting soil. Three brick columns were removed because of the obstruction they would have created. These brick columns were replaced with steel jack posts; two posts replaced each brick pier. The one existing brick column which remains, supports the main building support beam at mid span (See Figure No. 2).

Soil conditions of the general area were indicated to consist of a discontinuous cap of sandy soil overlying on an extensive deposit of stiff silty clay soil. The foundation design chosen was assessed by a consulting engineer who determined it to be suitable for such soils.

2.2 Construction Methods

The sequence in which the excavation work was carried out was phased to minimize both the length of wall unsupported at any time and the time during which the founding soils were left exposed. This helped to minimize the potential for foundation movements undermining the house.

Excavation of the existing floor and underlying earth was carried out in the major portion of the basement area, leaving a small berm in place adjacent to the exterior walls and around the piers. The berm sloped approximately 45° from underside of footing level down to the new grade. Then, when it was time to build concrete forms, sections were assembled, the berm was removed and the facing wall poured in lengths of about 4.5m. Three concrete pours were used for the facing wall. It was possible to pour longer lengths of wall because soils were stable; this reduced time in constructing forms and placing reinforcing steel.

There were two methods which could have been used to construct basement stub walls:

1. Alternating segments of wall about 1-2m in length could be excavated and walls poured. Subsequently, at a later date, remaining berms could be excavated and concrete poured. This would provide support for building and make pouring of the perimeter facing walls a two stage operation.

2. An alternative approach would be to excavate the berm so that longer sections of the walls could be poured at one time. This requires stable soils and well coordinated construction to avoid soil settlement.

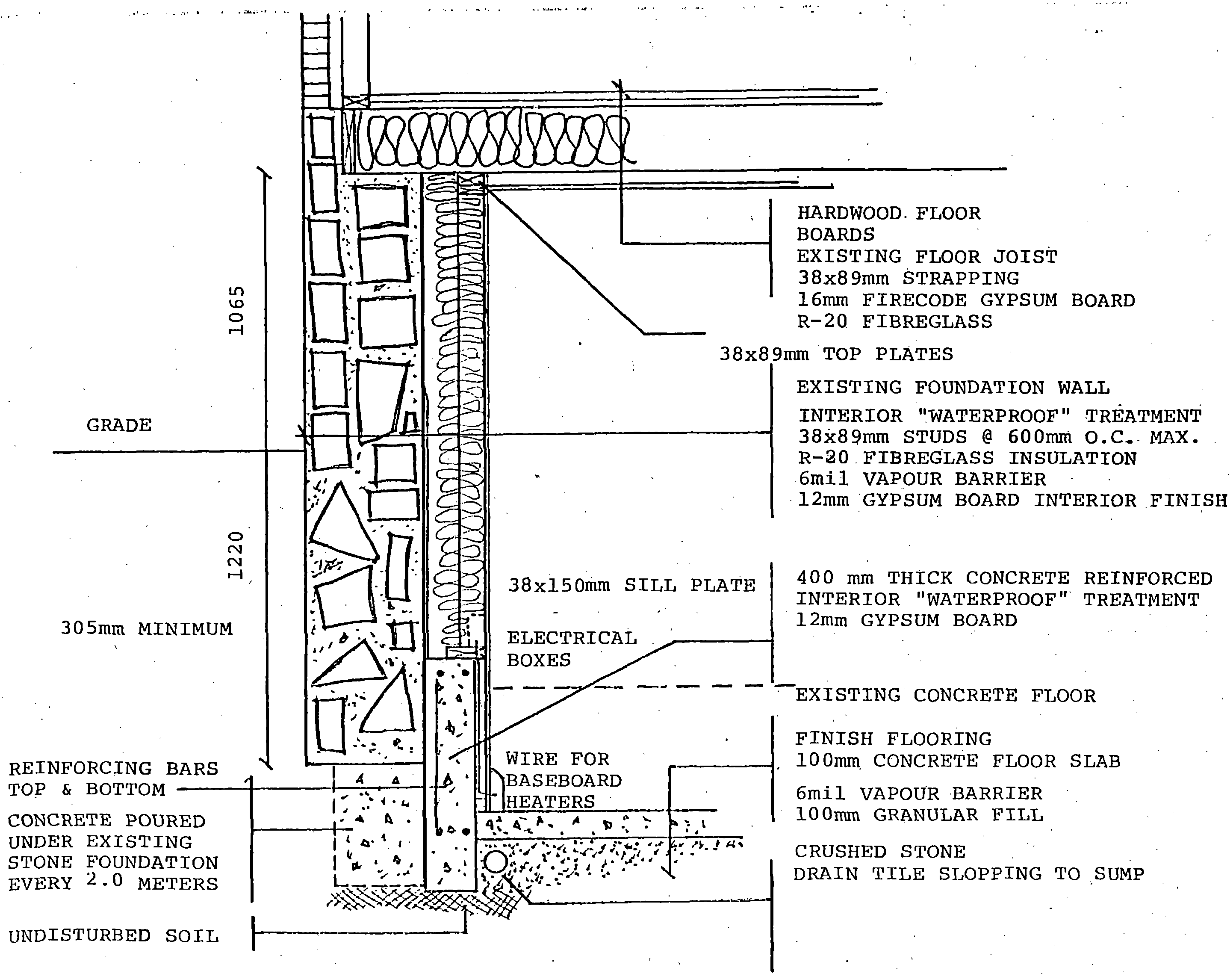
   Fortunately, the second alternative could be used. This allowed savings to be obtained on the following:

   i) Construction materials;
   ii) Construction manpower;
   iii) Pouring time;
   iv) Site readied for cement truck;
   v) Site scheduling;
   vi) Reinforcing bar installed in concrete stub wall.

Temporary steel jack posts were placed on either side of the brick columns to temporarily support the main house support beam while the three brick columns were removed. Two steel jacks/per brick column were used and replacement was carried out one column at a time. The fourth column was retained and a concrete collar was poured around its base to provide added support. In preparation for the facing wall and collar, the soil below these areas was cleaned of loosened and uncompacted materials. Care was taken to avoid undermining the existing footings and the remedial work was poured as soon as possible after excavation.

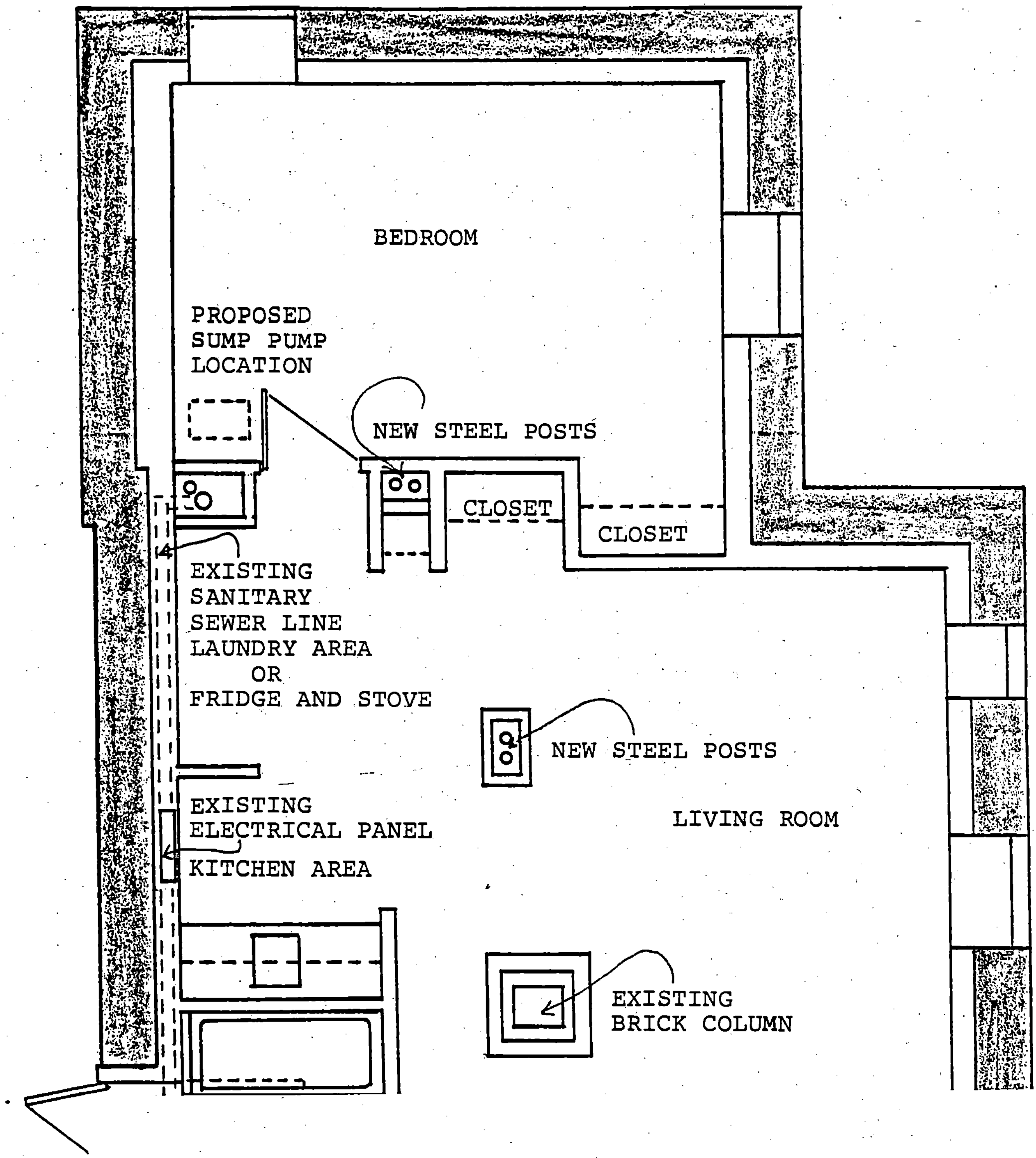
To lower the basement floor required the following tasks:

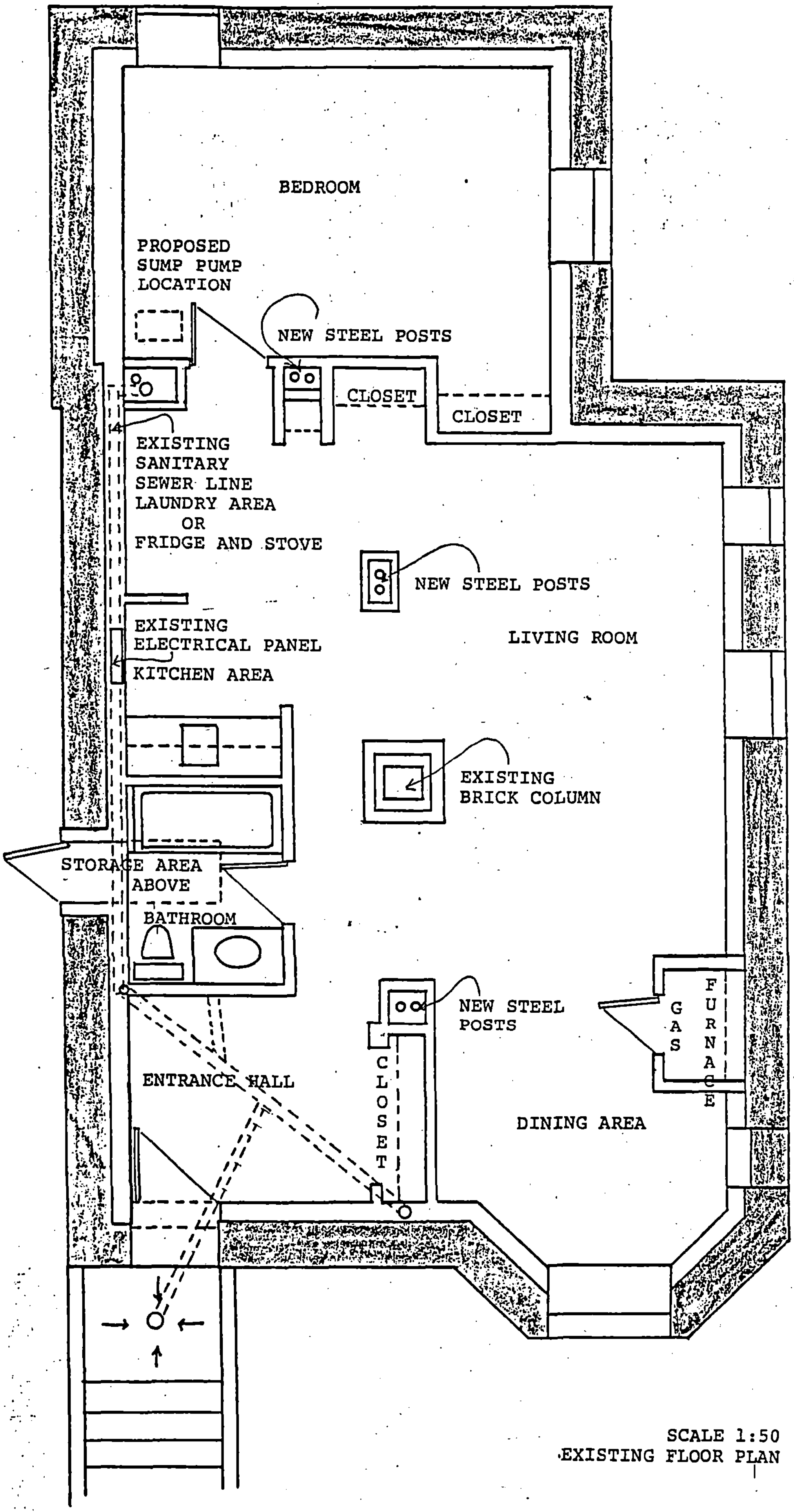
i) Breaking the existing concrete with a sledge hammer,
ii) Removing concrete and rock under concrete slab,
iii) Removing existing oil hot water furnace and oil tanks,
iv) Relocating existing electric hot water heater,
v) Removing existing basement stairway leading to the exterior and replacing it with a temporary wooden ramp to assist in removing material from basement,
vi) A suitable site for large bin to load excavated material,
vii) Relocations of sewer drain pipe in the basement area, and,
viii) Excavating of 160 cubic yards of material from the basement.



SCALE 1:20

FIGURE 1


BEDROOM
PROPOSED
SUMP PUMP
LOCATION
NEW STEEL POSTS
CLOSET
CLOSET
EXISTING
SANITARY
SEWER LINE
LAUNDRY AREA
OR
FRIDGE AND STOVE
NEW STEEL POSTS
EXISTING
ELECTRICAL PANEL
KITCHEN AREA
LIVING ROOM
EXISTING
BRICK COLUMN



SCALE 1:50
EXISTING FLOOR PLAN

3.0 OBJECTIVES AND SCOPE

3.1 Scope of the Retrofit

The retrofit activity included the following:

- Excavating basement area of 177 Frank Street, Ottawa, Ontario, by way of removing existing concrete floor to a point below existing foundation wall.
- Re-arranging supports temporarily and permanently so as to allow the above;
- Repairing and preparing wall surfaces so as to minimize moisture accumulation over time;
- Removing existing furnace;
- Pouring a new concrete floor;
- Partitioning space;
- Upgrading electrical service and installing electrical wiring;
- Plumbing a new bathroom and kitchen;
- Maximizing natural light intake;

3.2 Objectives of the Monitoring

The objectives of this study were:

1. To assess methodologies for retrofitting basements.

2. To determine a feasibility check list for considering costs/benefits associated with basement retrofits.

3. To assess questions as to the effects of the retrofit on technical questions such as moisture, mildew, air circulation and other technical problems associated with basement retrofits.

It should be noted that CMHC will be monitoring the building attempting to assess the typical problems mentioned in point 3 to determine the performance of the techniques used. Therefore this report only includes technical observations to date.

4.0 TECHNICAL PROBLEMS AND REMEDIES: CONSTRUCTION METHODS

4.1 Additional Head Room

Additional head room was achieved by removing the existing concrete floor and relocating a water line in the ceiling. Strapping the ceiling with 38x89mm wood studs helped to overcome the protrusion of several sized heating pipes located in the ceiling. In some locations heating pipes were boxed into a chase in the ceiling.

The floor to ceiling height before excavation was 1.98m. After unit completion with flooring and finished ceiling, it was 2.43m in most areas.

4.2 Natural Lighting

Before the basement was renovated it was dark and had very little means of indirect light penetration from the sides of the window frames or wall panels. After the renovation, this basement had five window openings with larger glazing areas and access to more indirect light penetration. Light penetration into the living unit was achieved by placing angled walls and light coloured wall coverings next to the window wells.

4.3 Reduction and Control of Moisture

Prior to excavation of the basement floor and repair to the walls, the basement had a much higher moisture presence than at present. Moisture seeped through the stone masonry wall and from the concrete floor. After the new concrete floor was installed, the level of moisture was reduced considerably. Under the new concrete slab there was 100mm of crushed stone along with a sheet of 6mil polyethylene moisture barrier.

The new concrete facing wall was coated with a sealer. This sealer was painted onto the concrete and stone foundation up to the outside grade line.

Prior to the sealer being applied, the stone foundation had to be wire brushed loosening deteriorated mortar and debris. Filling of cracks in the wall was achieved by parging the interior surface of the wall. This provided a consistent surface for application of sealer on the interior of the stone wall.

Next to the facing concrete wall, a 100mm drain tile was installed around the interior perimeter to intercept any water or moisture flowing from the exterior. This drain tile lead to a sump hole in the basement floor. Adequate space for installation of a sump pump has been provided in the event of significant accumulation of seepage water.

4.4 Air Quality

Prior to the work being done, there were several odors which were present in the basement. It was a space that was not vented. It had two odorous oil tanks and there were musty odours from damp conditions of the basement. The plumbing system was such that sewer gases were being allowed into the space. And finally, insects appeared to be a significant problem.

After the oil tanks and oil boiler were removed, the smell of oil was also removed. Plumbing problems were rectified reducing the problems with sewer gas. Damp conditions were reduced which had similar effects on the presence of musty odours. Windows were replaced with a new operating type allowing fresh air to enter the unit. The presence of insects were reduced significantly.

4.5 Sound Separation

The sound separation of the unit consisted of installing fibreglass insulation R.S.I 3.5 batts between the floor joist of the first level or ceiling of the basement unit. The ceiling was strapped with 38x89 wood framing and then 12mm drywall. Some sections of the ceiling were lowered more than others to accommodate pipes and supporting beams. (The sound transmission class (STC) rating is a minimum of 45 based on section II table IIB of Residential Standards.) The unit was also given a separate entrance at the front of the building.

4.6 Sewer and Water Lines

A new sewer line was installed rerouting sewer drainage from below the existing floor to a location concealed behind new drywall and flooring materials. This new ABS sewer line was given a small slope and was placed on top of the new stub wall around the perimeter of the building. It was under the concrete floor in the location of the new bathroom and kitchen areas, to allow for drainage and connection to the existing sewer main at the front of the building.

4.7 Wood Framing

Exterior walls were framed with 38x89mm wood framing, with R.S.I. 3.5 batt installation, vapor barrier and 12mm painted drywall. (See Figure No. 1.)

Interior partitions 12mm drywall an 38x89 wall studs at 400mm centres.

4.8 Windows

Four vinyl sliders were used in the retrofit and one fixed thermopane window.

4.9 Doors

Interior doors were hollow core type and exterior doors were solid wood panelled type. installed as all conventional systems would be.

The main entrance had to be broken out with a hammer and chisel from the foundation wall to accommodate the entrance at the front of the building. The entrance stairway was built in front of the building to allow for extra floor area in the main living area.

5.0 RATIONALE FOR THE PARTICULAR CONSTRUCTION DETAILS USED

From the new concrete floor to the first floor joist, the method was similar to other construction. From the first floor joist (ceiling of basement) to the top of the new concrete face wall, used were 38x89mm wood framing spaced out from the existing stone foundation. The top plates were 38x89mm wood and the bottom plates were 38x89mm wood, set on the concrete face wall. Anchor bolts were not necessary in this procedure, so concrete nails were used instead. The concrete face wall was strapped with plywood-cut strips as furring between the concrete and drywall.

Electrical boxes were fastened to the 38x89 wood frame above the concrete face wall. These receptacle boxes were set 300mm higher than normal practice. Electrical baseboard heater wires were installed in metal conduit between the concrete face wall and drywall. This also allowed work crews to finish the drywall walls without cutting most drywall sheets. This allowed more usable floor area because the wood frame wall was located above the concrete face wall. The wood frame wall was insulated with R.S.I. 3.5 fibreglass insulation batts. Air Barrier (6mil polyethelene) was behind the drywall and a moisture barrier, such as a concrete sealer applied onto the new concrete face wall and existing stone foundation up to existing grade elevation.

The concrete face wall was poured in front of the old stone foundation footing and existing earth. To help stabilize the old stone foundation wall and footing, sections of earth 254mm by 500mm wide were removed. The concrete face wall had this extended support every 2.0m along the face wall. This was done to prevent any future movement of the old stone wall.

Below is an exterior way of stopping leaks in a stone basement wall:

General poor drainage around the outside of basement walls is usually best dealt with by trenching and backfilling with self-draining fill after installing a drain next to the footing. Insulation can be fitted to the outside of walls and this job can be done at the same time as the drainage trenching.

When trenching around buildings take care that trenches are adequately braced and that foundations are not undermined. Trenching is best done in short sections so that there is no risk of the stone basement walls being subjected to massive changes of soil support which could result in the walls falling into the trench.

5.1 Stages in Excavation of Soils Next to Stone Foundation (Exterior)

1. Excavate short sections next to the stone foundation.
2. Add 6mil polyethylene sheet folded back until excavated trench is refilled.
3. Place perimeter drain of perforated pipe, laid to fall to soakaway or connect to storm sewer.
4. Install crushed stone over drain.
5. Barge on, cast or repair stone foundation.
6. Install rigid sheet insulation of glass fibre or foam plastic say 5cm thick.
7. Back fill with clean, self-draining fill of stones and gravel. If original soil is put back in trench instead of installing new material a filter layer of mineral wool should be placed over the crushed stone which covers the drain tile.
8. The 6mil polyethylene sheet is folded back over excavated trench and fill.
9. Topsoil is replaced over polyethylene which should be deep enough to avoid normal gardening.

5.2 Anticipated Technical Performance of the Foundation Seal

One of the novel features of the retrofit was the foundation seal. The cement-base sealer used on basement walls is packaged in dry-power form and is a heavy-duty coating for all masonry and concrete. It fills and seals pores, the manufacturer assures complete protection against moisture penetration. Unlike a paint film it permits walls to breathe - prevents damaging accummulation of moisture vapour which peels paint. This product is recommended for all types of masonry, interior, exterior, above grade and below. It provides the benefit of ease of application and improved performance, when compared to applying paint.

5.2.1 Sealer Application

Preliminary surface preparation surface to be coated must be clean. Chip, sandblast or grind off all defective materials and foreign matter (paint, dirt, whitewash, grease, oils, etc.). Remove efflorescence, mineral salts, scum or fungus.

To apply the sealer product it is necessary to repair all cracks, joints or holes and stop running water with water plug and relieve all excess water pressure by tapping out weep holes at base of wall. The work area is left open at least 24 hours until the sealer sets firmly.

Two applications of the product are required:

A. Base coat, minimum 2 lbs. per sq. yd. (1 kg/m^2) to fill and seal surface and a second coat, minimum 1 lb. per sq. yd. (1/2 kg/m^2).

5.2.2 Benefits of using a sealer

The benefits of using a sealer on concrete or stone foundation walls can prevent moisture, dust and rot behind wood frame walls.

1. the use of a tough, well-sealed sealer or membrane on the walls helps keep moisture out.
2. protection from water accumulation in the soil.
3. to prevent leaks if minor cracks develop in joints or between stones.
4. to make the wall watertight against ordinary seepage, as may occur after a rainstorm.

6.0 PROJECT FEASIBILITY CHECKLIST FOR PROSPECTIVE BUILDERS IN CONSIDERING COST BENEFITS WITH BASEMENT CONSTRUCTION

A contractor or home owner should check thoroughly before proceeding:
Because of the high costs of performing such a retrofit the homeowner would be wise to thoroughly check the following before proceeding.

Features of the Basement:

1. survey plan, for side yard, rear yard and front set back allowances;
2. measure basement, (showing windows, doors, sewer and water line entries through foundation wall). Also check and locate building supports on drawings accurately before construction and planning their design for a particular use;
3. determine the depth of the sewer line in the main road and the depth where it penetrates the foundation wall;
4. check with soils expert or engineering person to the nature of the soils and conditions;
5. the condition of the foundation may determine further investigation;
6. the location of the water line, power, sewage, gas, etc.;
7. the location of the entrance to the space. Exterior or interior entrance. It would be preferably to establish a front entrance to the new unit. Front entrances are much more desirable to most people who may rent or establish an office or commercial space;
8. Investigate the adequacy of the DHW and heating system. Options include:

    i) leave in the same location;
    ii) replace the unit;
    iii) change the location; this will depend on type of fuel used;
    iv) install separate systems for each unit.

9. Investigate the state and adequacy of the following:
    i) windows;
    ii) doors;
    iii) electrical system.

10. Investigate all codes, bylaws and ordinances as they apply to the use of the space. This alone may determine the feasibility of this project.

11. Obtain cost estimates for work involved.

7.0 MATERIAL COSTS AND LABOUR

This step in the exercise is very important in assessing your cash flow for the project and knowing what you require to complete the job.

A contractor's cost will be higher should he have to excavate the basement floor. The existing design of the building will determine whether or not this will be necessary. If most contractors have not ventured into this type of work before, you could expect the cost estimates to be higher.

In order to protect themselves from the unknown, the contractor should boost his estimate cost.

7.1

The idea of insulating the stone foundation on the exterior was explored. (To install a rigid fibreglass or foam board in front of the stone foundation.) Materials that could be used include a rigid insulation board and regular plywood above grade and pressure treated plywood below grade and a wire lathe and stucco coating as finish.

Below is a general estimate as it related to the subject building. This estimate is only approximate as it was not performed at this site.

- Labour for excavating trench around building;
- Rental of ram set gun and shots
- Pavement repair in driveway and side of building;
- Replacement of flowers and shrubs;
- Porch removal, front and rear of building;
- Back fill (crushed stone);
- Carpenter labour;
- Purchase of regular plywood;
- Pressure treated plywood;
- Rigid fibreglass insulation;
- Glue and nails;
- Mason to install wire lathe and stucco

- Installation of flashing at the top of the foundation and plywood;
- Hauling materials away from site.

TOTAL APPROXIMATE COST OF INSTALLING INSULATION ON THE EXTERIOR OF THE STONE FOUNDATION **$4,100.00**

GENERAL COST OF MATERIALS AND LABOUR **TABLE 1**
ANALYSIS OF COSTS

Design and printing	790.01
Building permit	154.00
Rental equipment	97.04
Electrical supplies and fixtures	710.91
Electrical (labour)	1,704.00
Plumbing supplies and fixtures	1,340.72
Lumber and building supplies	5,720.52
Painting supplies	541.21
Concrete and crushed gravel	2,004.05
Removal of concrete rock and earth from basement and new front entrance stairway	2,208.00
Installing and purchase of carpeting and ceramic tiles	1,288.93
Windows and doors	534.58
Plumbing	1,000.00
Rough carpentry, finish carpentry	4,500.00
Gyproc and crack fill	2,000.00
Miscellaneous masonry	500.00
General labour and painting	560.00
Subtotal	**25,653.97**
Management fee 15%	**3,848.09**
TOTAL LABOUR AND MATERIALS	**$29,502.06**

The new unit has a 72 square meter interior gross floor area.

$29,502.06 / 72 square meters or 775 square feet = **409.75** per square meter or **$38.06** per square foot.

8.0 PROBLEMS ASSOCIATED WITH CREATING BASEMENT UNITS IN CENTRE TOWN OTTAWA, ONTARIO

According to the City of Ottawa building and zoning personnel. If a new residential unit is created on any existing lot or in buildings the developer must pay 5% of the present day square metre cost in lieu of Parkland that was not deeded over by the developer some 90 years ago. This 5% cost to provide one unit has been set to the large sum of three thousand nine hundred dollars ($3,900.00) to provide one (1) additional unit in the basement.

Many existing apartment accommodations are being deleted due to renovations occurring in the centre town area. The way they have their guide lines set up, a developer could build a new building and pay 5% in lieu of land for public purposes. And if a builder was to add more units, particularly a basement unit, this would discourage future additions to basements.

9. CONCLUSIONS AND RECOMMENDATIONS

The feasibility of the retrofit concludes the price per square meter of floor area can compete in the renovation market in creating extra useable floor area to most living units.

The project costs as shown in the materials and labour section can be adjusted to compensate for cost overruns as related to the excavation and removal of earth from the basement.

It is recommended, when material such as earth, rock or concrete is required to be removed from basements, it would be advisable to use a conveyor belt machine to assist in removal of excavated material. Also the use of jack hammer would ease excavation of material. The addition of useable floor area in most dwelling units is a welcome benefit for most households. The new-found liveable space can become space for an additional bedroom, apartment, office, games room or a commercial shop or restaurant, should zoning and planning departments allow.

The success of the project has encouraged our company to venture into similar projects due to the low cost per square meter. The creation of additional rental units can be provided to tenants at a lower cost than units built in new construction projects. The higher costs per square meter determines higher rents by the developer. The developer cannot provide living accommodations unless the rents are subsidized by various levels of government.