



**CANADA'S GREEN PLAN  
LE PLAN VERT DU CANADA**

**MONITORING AND INVESTIGATION OF A MULTI-SUITE  
RESIDENTIAL COMPLEX IN WHITEHORSE, YUKON,  
FROM 1988 To 1992**

**PREPARED FOR:**

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The goal of this study reported here was to advance our understanding of multi-residential buildings. Closeleigh Manor is EMR's first involvement in building and monitoring a multi-residential dwelling to the equivalence of the R-2000 performance standard for houses.

This work was performed for CANMET's Buildings Group as part of its commercial-buildings research activities. These activities are distinct from but complementary to the Buildings Group's Advanced Commercial Buildings Program (C-2000).

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## **Executive Summary**

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Closeleigh Manor is a 3-storey, 3140 m<sup>2</sup>, 30-suite apartment building with 340 m<sup>2</sup> of commercial space. It is located in Whitehorse, Yukon, situated at latitude 60.7°North at an elevation of 637 m. Whitehorse has a 97½% design temperature of -41°C and 6988 Celsius heating degree-days. The complex, which opened in 1988, was designed for senior citizens and represents the first building of its kind to be constructed to the equivalence of the R-2000 performance standard developed for houses. Energy efficient features incorporated into Closeleigh Manor include increased wall and ceiling insulation levels, upgraded windows, a vapour diffusion retarder and continuous air barrier system, and a ventilation system with heat recovery.

The purpose of this project was to learn more about the cold climate operation of a multi-suite residential complex that had been built using R-2000 standards. The results and findings were to be used to assist in providing answers to common questions and concerns about large buildings in the areas of design, envelope durability, the operation, effectiveness and efficiency of mechanical systems, and indoor air quality. The project's conclusions and recommendations were to provide guidelines for the design and operation of future buildings of this type. This report documents information relating to:

- the monitoring investigation which commenced in the fall of 1988;
- the original building design;
- the issues which arose and the problems which occurred in the ensuing years;
- the manner in which issues and problems were addressed and resolved;
- system changes which were implemented and their effect on building performance;
- recommendations for further system changes;
- the use of building energy analysis tools such as the DOE2 computer program; and
- guidelines and recommendations for the design and operation of future buildings.

To evaluate the performance of Closeleigh Manor and to analyse the applicability of R-2000 standards to apartment buildings of this type, a study of the building was initiated in the fall of 1988. A computer monitoring system was installed to continuously gather the data required to assess actual building performance and to determine the effectiveness of the energy efficient features. The system consisted of approximately 120 sensors located throughout the building and measured heating fluid flow rates and temperatures, supply and exhaust air flow rates and temperatures, energy consumption, interior space conditions and weather. In addition to the computerized monitoring, a series of ventilation related manual measurements were conducted to gather detailed information on the air distribution system and the indoor environment and an independent engineering evaluation of the building was carried out.

A detailed analysis of the computerized and manually measured monitored data from Closeleigh Manor was carried out in the following areas:

- the building envelope;
- the design heating requirement;
- the envelope air leakage;
- the heat recovery system;
- the ventilation air distribution system;
- the boiler system
- the space heating system;
- the domestic hot water system;
- the cooling system; and
- the electrical system.

The findings showed that the main factors which impacted on Closeleigh Manor's heating requirement were the ventilation rate, the envelope air leakage, the overall heat recovery effectiveness and the windows. The effect of these factors on the building's energy performance was studied using a calibrated energy analysis model. The analysis included Closeleigh Manor as it was originally constructed, the building after numerous changes were implemented, and the building's potential if it were being constructed today. The following annual space and ventilation requirements were determined.

- The original building configuration required 68.5 kJ/m<sup>2</sup>/HDD or 1503 GJ;
- After numerous changes, the current requirement is 49.0 kJ/m<sup>2</sup>/HDD or 1075 GJ/yr;
- With the technology advances in recent years, if Closeleigh Manor was constructed today, it would be possible to attain an annual space and ventilation load as low as 23.6 kJ/m<sup>2</sup>/HDD or 574 GJ.

On the basis of the findings of this project, the principal conclusions were:

- If systems in energy efficient buildings are to be properly sized and their performance is to be optimized, more sophisticated energy analysis tools must be used during the design process. Standards and guidelines which have served as accepted practices for a number of years may no longer apply to energy efficient buildings. Optimization must include the full range of operating conditions and not just design conditions.
- Buildings of this nature must be commissioned over a full range of operating conditions if their performance and operation are to be optimized. This will require monitoring the energy performance of the whole building and the HVAC components. The more complex the building, the more important the commissioning process becomes. Annual system operation specifications and maintenance schedules must be developed and fully documented as part of the commissioning.
- Every attempt should be made to keep building systems as simple as possible. This is especially true in the north due to the harshness of the climate, the remoteness of the location and the lack of skilled service people required to maintain these systems.
- Building operators must be trained to properly operate the building and make the seasonal adjustments required to optimize performance. The building operator must then educate the occupants so that they do not operate their suites in a manner that will undermine the efforts to optimize building performance throughout the year.

The report includes recommendations and guidelines for additional changes at Closeleigh Manor which will improve the energy performance and ensure that the building is operated in a manner that will maximize its performance.

Recommendations are also presented which will serve as guidelines for the design, specification and operation of building systems in future buildings of this type.



## **Résumé**

Closeleigh Manor est un immeuble de trois étages mesurant 3140 m<sup>2</sup>. Il abrite 30 appartements et contient 340 m<sup>2</sup> d'espace à bureaux. Il est situé à Whitehorse, au Yukon, à une latitude de 60,7° nord et à une altitude de 637 m. Dans 971/2% des cas, Whitehorse a une température de calcul de -41° et il y a 6 988 degrés-jours de chauffage Celsius. L'immeuble, qui a été ouvert en 1988, a été conçu pour les personnes âgées et c'est le premier du genre à être construit selon des normes de rendement équivalentes à celles élaborées pour les maisons R-2000. Des niveaux d'isolation plus élevés pour les murs et les plafonds, des fenêtres plus étanches, un retardateur de diffusion de la vapeur, un pare-air en continu et un ventilateur récupérateur de chaleur sont parmi les éléments qui contribuent à accroître l'efficacité énergétique de Closeleigh Manor.

Ce projet devait nous permettre d'en savoir plus sur l'entretien en climat froid d'un immeuble d'habitation de plusieurs appartements construit selon les normes R-2000. Les résultats nous ont fourni des réponses et des solutions aux questions et aux problèmes que posent habituellement la conception, la durabilité de l'enveloppe, l'entretien, l'efficacité et l'efficience des systèmes mécaniques et la qualité de l'air, lorsqu'il s'agit de grands bâtiments.

Les conclusions et les recommandations émises à l'issue du projet devaient servir à établir des lignes directrices pour la conception et l'entretien des bâtiments du même genre qui seraient construits par la suite. Ce rapport inclut des données sur les points suivants :

- surveillance commencée en automne 1988;
- conception originale du bâtiment;
- questions et problèmes qui se sont posés dans les années qui ont suivi;
- manière dont les questions et les problèmes ont été étudiés et réglés;
- modifications apportées au système et incidence sur le rendement de l'immeuble;
- recommandations de nouveaux changements à apporter au système;
- utilisation d'outils d'analyse énergétique, tels que le programme informatisé DOE2;
- directives et recommandations pour la conception et l'entretien des bâtiments qui seront construits dans l'avenir.

Pour évaluer le rendement de Closeleigh Manor et analyser l'applicabilité des normes R-2000 aux bâtiments de ce genre, on a entrepris une étude du bâtiment à l'automne 1988. On a installé un système de surveillance informatisé afin de recueillir en permanence les données nécessaires pour évaluer le rendement réel du bâtiment et pour déterminer l'efficacité des équipements qui influent sur son rendement énergétique. Le système de surveillance - environ 120 détecteurs installés partout dans le bâtiment - mesurait le débit et la température du liquide calorifère, le débit d'air en circulation, la consommation énergétique, les conditions intérieures et la température extérieure. En plus de ce moyen de surveillance informatisé, on a mesuré manuellement la ventilation pour obtenir de l'information précise sur le système de distribution de l'air et le milieu intérieur. Enfin, une évaluation technique du bâtiment a été effectuée par une entreprise indépendante de génie-conseil.

Une analyse précise des données obtenues à l'aide des outils informatisés ou manuels a été effectuée sur les aspects suivants :

- enveloppe du bâtiment;
- besoins théoriques en chauffage;
- chaudière;
- système de chauffage des locaux;

- infiltration d'air dans l'enveloppe;
- système de récupération de la chaleur;
- système de distribution de l'air de ventilation;
- système de chauffage de l'eau;
- système de refroidissement;
- système électrique.

D'après les résultats obtenus, on a découvert que c'était surtout la ventilation, les fuites d'air dans l'enveloppe, l'efficacité de l'ensemble du système de récupération de la chaleur et l'étanchéité des fenêtres qui influent sur les besoins en chauffage. On a étudié la façon dont ces facteurs intervenaient dans le rendement énergétique du bâtiment au moyen d'un modèle étalonné d'analyse de l'énergie. L'analyse portait sur le bâtiment tel qu'il avait été construit à l'origine, sur le bâtiment après ses nombreuses modifications et sur les capacités du bâtiment s'il avait été construit aujourd'hui. Les besoins annuels en espace et en ventilation ont été déterminés :

- pour le bâtiment tel qu'il était configuré à l'origine, il fallait 68,5 kJ/m<sup>2</sup>/degrés-jours de chauffage ou 1 503 GJ;
- après les nombreux changements, les besoins actuels sont de 49,0 kJ/m<sup>2</sup>/degrés-jours de chauffage ou 1 075 GJ/année;
- Si Closeleigh Manor était construit aujourd'hui, avec les progrès technologiques réalisés au cours des dernières années, aussi peu que 23,6kJ/m<sup>2</sup>/degrés-jours de chauffage ou 574 GJ suffiraient pour le chauffage et la ventilation.

Le projet a permis de tirer les conclusions suivantes :

- dans les bâtiments à haut rendement énergétique, pour installer des équipements de taille adéquate et optimiser leur rendement dans, il faut utiliser des outils d'analyse énergétique plus sophistiqués durant la phase de la conception. Les normes et les directives utilisées depuis de nombreuses années peuvent ne plus s'appliquer aux bâtiments à haut rendement énergétique. Si l'on veut optimiser le rendement, on ne doit pas tenir compte seulement des conditions théoriques mais de toute la gamme des conditions réelles de fonctionnement.
- Pour la mise en service de bâtiments de ce genre, on doit tenir compte de toutes les conditions de fonctionnement. Il faudra pour cela surveiller le rendement énergétique de tout le bâtiment et des éléments du système CVC. Plus le bâtiment est complexe, plus le processus de mise en service devient important. Il faut fixer les spécifications annuelles pour l'exploitation du système et les dates d'entretien, puis documenter toutes les mesures prises.
- Il faut tout faire pour que les systèmes demeurent aussi simples que possible, et c'est encore plus nécessaire pour les bâtiments construits dans le Nord en raison de la rigueur du climat, de l'éloignement et du manque de personnel d'entretien qualifié sur place.
- Les responsables des bâtiments doivent recevoir la formation nécessaire pour faire fonctionner adéquatement le bâtiment et faire les ajustements saisonniers nécessaires afin d'optimiser son rendement. Le responsable doit ensuite montrer aux occupants comment bien utiliser l'équipement de façon à ne pas nuire aux efforts déployés durant une année pour optimiser le rendement du bâtiment.

Le rapport comprend des recommandations et des lignes directrices relatives aux changements supplémentaires à apporter pour améliorer le rendement énergétique de Closeleigh Manor et utiliser le bâtiment de manière à optimiser son rendement.

**On présente aussi des recommandations qui serviront de directives pour la conception, les spécifications et l'entretien de l'équipement dans des bâtiments du même type qui seront construits par la suite.**