Client Report :

Potential for heating energy savings in prisons after Quattro Seal application

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Executive Summary

This report provides the results and findings of the energy simulation carried out on A Wing, HMP Wymott, Lancashire, chosen by the HM Prison Service as a representative block of a typical prison for England and Wales with regard to building type and airtightness conditions. The objective of this study is to estimate the potential for heating energy savings after remedial sealing carried out by The Energy Savers Ltd, utilising the Quattro Seal sealant process: a system of sealant application to improve airtightness of structures.

The geometrical model of the prison block has been created out of the information gathered at the prison on 16th November 2004. Reasonable assumptions have been made when further information, not available from this source, has been required. Key parameters for the analysis are the infiltration rate before and after the sealing process. These data have been obtained from the air leakage tests and air leakage audits carried out on two cells and one office in A Wing, HMP Wymott on that day by BRE.

We have estimated the heating energy consumption for the energy model to be 1469 and 1102 GJ per annum before and after the sealing process respectively (window sealing in the roof of the central area of the block has not been taken in account). This is a 25% potential heating energy saving. Monitored data on gas consumption for A Wing, HMP Wymott for the last three years show an average heating consumption of 1342 GJ per annum. We, therefore, estimate the heating energy savings potential that could be obtained to be 335 GJ (93064 kWh) per annum, 25% of the average heating consumption. If we take 1.034p per KWh as the mean cost of a unit of gas, this amounts to a saving of £962. With the cost of applying the sealant process estimated to be (from The Energy Savers Ltd) of the order of £3136, this would give a simple payback period of 39 months, 32.6 if we consider an increase of 20% in future energy cost

The basis of good design for ventilation provision is to make the building envelope airtight and then provide controlled ventilation; i.e. the concept of “build tight – ventilate right”. This approach reflects and addresses current concerns regarding indoor air quality, energy conservation and associated environmental issues. In naturally ventilated buildings, a tight envelope (effective in limiting uncontrolled infiltration through the building fabric) requires adequate and controlled background ventilation to meet the health requirements of the occupants.[1]

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Introduction

BRE was commissioned to estimate the potential for heating energy savings in a typical block of a standard prison after remedial sealing carried out by The Energy Savers Ltd, utilising the Quattro Seal sealant process: a system of sealant application to improve airtightness of structures.

Building energy simulation is a basic tool for the study of energy demand and performance in buildings. Computer simulation programs are effective analytical tools for building energy research and evaluation of both envelope and HVAC systems. BRE has undertaken similar works in this field by the use of appropriate simulation tools and this study is considered of particular interest in showing both the benefits in terms of energy savings achievable by an airtightness envelope in buildings and the capabilities of the energy modelling tools to evaluate when this and other energy efficiency measures are feasible to be undertaken and suitable for the environment.

For this analysis, predictions will be focused on the heating energy savings achievable after the Quattro seal process.

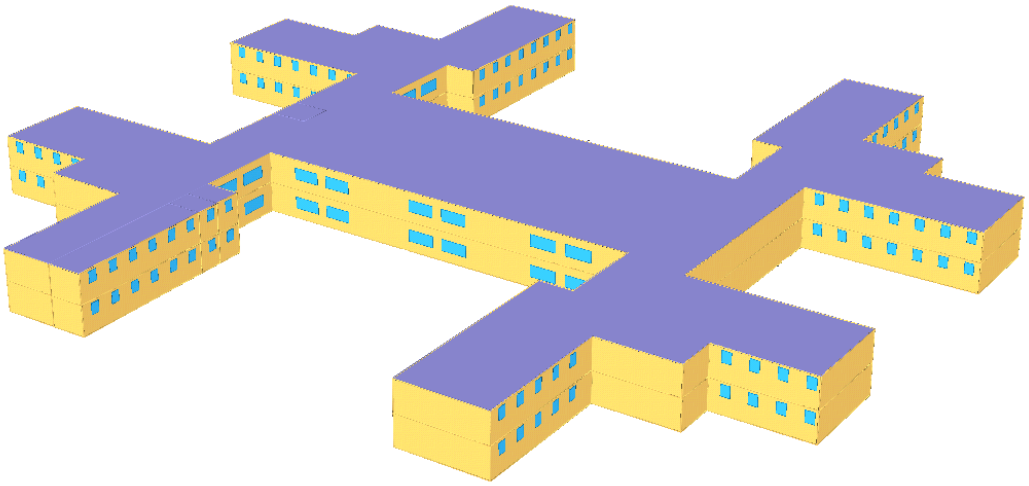
However, the analysis will take full account of the need for adequate air quality for building occupiers. Considerations about heating system controls and ventilation strategies, and their possible influence in the potential energy saving will also be taken in account.

This report is for The Energy Savers Ltd, and contains an independent estimation of the potential for heating energy savings in a typical block of a standard prison after applying their sealant process.

Description of the project

The building object of study is A Wing, HMP Wymott, Lancashire. The geometrical model of the prison block has been created out of the information gathered at the prison on 16th November 2004. Reasonable assumptions have been made when further information, not available from this source, has been required. For security reasons we will not include in this report any drawing of the building (building layout) or sensitive information used to develop the model.

Next figure shows a 3D view of the model used to perform the simulation.



Key parameters for the analysis are the infiltration rate before and after the sealing process. These data have been obtained from the air leakage tests and air leakage audits carried out on two cells and one office in A Wing, HMP Wymott on that day by BRE.

The average air changes per hour @ 50 Pascal in cells before and after the sealing process considered for the simulation was 14 and 4 ach/hr respectively. For offices, the only values available from tests are 32.82 and 5.5 ach/hr, also before and after the sealing respectively.

These values have been processed in order to obtain suitable parameters used by the energy modelling tool. We have used DOE-2 for this analysis. DOE-2 can consider a large amount of technical features and control strategies used nowadays in HVAC and it

has plenty of capability to simulate the infiltration rate of the building and the energy saving achievable by improving the airtightness of the building envelope.

Thermal Model

DOE-2 is a set of computer programs that provide an up-to-date, unbiased analysis of a building's energy consumption. DOE-2 predicts the hourly energy use and energy cost of a building given hourly weather information and a description of the building and its HVAC equipment and utility rate structure. Using the program, designers can determine the choice of building parameters that improve energy efficiency while maintaining thermal comfort and cost-effectiveness. The purpose of the program is to aid in the analysis of energy usage and thermal conditions in buildings.

Validation

DOE-2 has been validated by comparing its results with thermal and energy use measurements on actual buildings and with calculations. Detailed information on some of the DOE-2 program validation efforts may be found in the following reports (available from the National Technical Information Service in USA, 5285 Port Royal Road, Springfield, VA 22161):

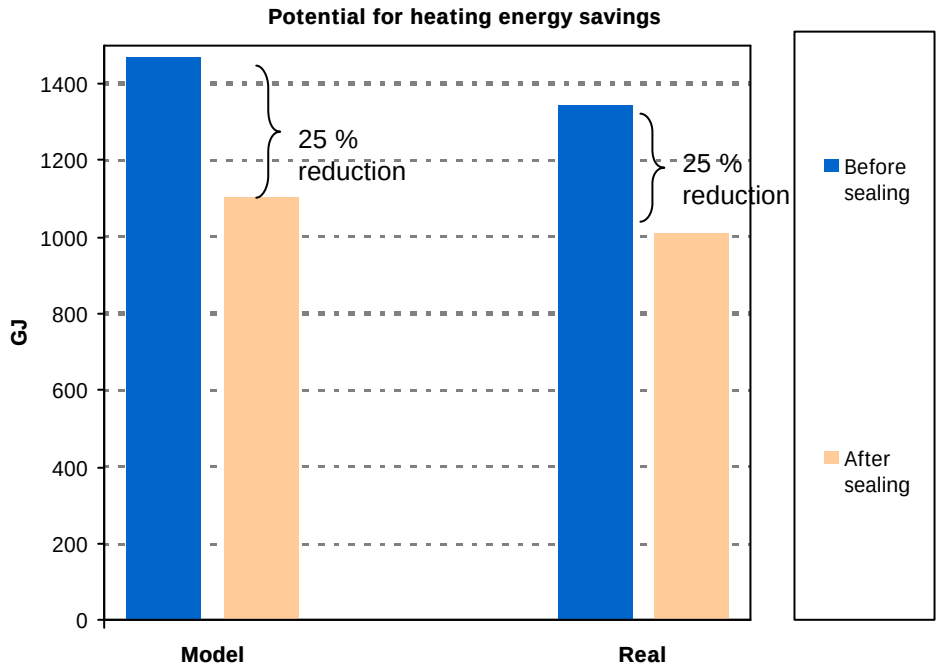
- Comparison of DOE-2 with Measurements in the Pala Test Houses. Lawrence Berkeley Laboratory, Report No. LBL-37979, 1995.
- DOE-2 Verification Project, Phase 1, Final Report. Los Alamos National Laboratory, Report No. LA-10649-MS, 1986.
- DOE-2 Verification Project, Phase 1, Interim Report. Los Alamos National Laboratory, Report No. LA-8295-MS, 1981.

Although simulation modelling does not necessarily predict absolute energy consumption values, validation tests confirm that they do predict more accurately the marginal improvement to be expected from particular energy efficiency measures.

Findings

We have estimated the heating energy consumption for the energy model to be 1469 and 1102 GJ per annum before and after the sealing process respectively (window sealing in the roof of the central area of the block have not been taken in account). This is a 25% of potential heating energy savings. Monitored data on gas consumption for A Wing, HMP Wymott for the last three years show an average heating consumption of 1342 GJ per annum. We, therefore, estimate the heating energy savings potential that could be obtained to be 335 GJ (93064 kWh) per annum, 25% of the average heating consumption. If we take 1.034p per KWh as the mean cost of a unit of gas, this amounts to a saving of £962. With the cost of applying the sealant process estimated to be (from The Energy Savers Ltd) of the order of £3136, this would give a simple payback period of 39 months, 32.6 if we consider an increase of 20% in future energy cost.

Next figure shows graphically the potential saving analysis:



The analysis has been focused on the air leakiness of the building so the unique difference in the model for each case considered has been the infiltration rate due to the sealing system. It is assumed that there is no other significant changes in the structure, envelope or use of the building (i.e. profiles or load applied to the building, occupants

behaviour in terms of their interaction with devices that could modify building energy demand such as window opening). Otherwise the potential for heating energy savings could vary and further studies should be carried out to estimate the new percentage for savings.

The basis of good design for ventilation provision is to make the building envelope airtight and then provide controlled ventilation; i.e. the concept of “build tight – ventilate right”. The sealant process provided by The Energy Savers Ltd is a capable system to achieve the first statement of this premise. In naturally ventilated buildings, a tight envelope (effective in limiting uncontrolled infiltration through the building fabric) requires adequate and controlled background ventilation to meet the health requirements of the occupants. An adequate ventilation strategy for the building should be considered as part of the environmental and health and safety policy of the prison. BRE has the right skills and capabilities to advise HM Prison services on which means are appropriate to guarantee suitable levels of ventilation to achieve adequate indoor air quality.

Conclusion and recommendations

When the airtightness performance of the building is significantly improved after the air leakage paths around the windows are sealed, the heating energy demand is potentially reduced by 25%.

If other conditions remain the same (before and after the sealing process) and the heating system is controlled to properly respond to the new situation, this potential could be achieved.

Improving the airtightness of the envelope of the building is therefore a recommendable energy efficient measure to achieve energy savings.

The basis of good design for ventilation provision is to make the building envelope airtight and then provide controlled ventilation; i.e. the concept of “build tight – ventilate right”. The ventilation strategy for the prison should be revised in order to ensure adequate quality for the indoor air.

References

[1] Perera, E. “Ventilation for Energy Efficiency and Optimum Indoor Air Quality” Nice, IEA Proceedings, September 1993 pp 34.