SELLIC: AN ENGINEERING LIBRARY

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Abstract
The intent of this paper is to present the design process which has created the new SELLIC Library for the University of Edinburgh. The design has evolved from the initial concepts completion in 1996 to a detailed design which is currently awaiting Client funding.

The building's form has arisen by the integration of the function, environmental strategy and the aesthetics. The paper will discuss the University's brief and demonstrate the application of current technology in envelope cladding and fabric energy storage.

The building's design is informed by strategic engineering decisions which were made on the environmental approach, the façade, and the type of structure. The inter-disciplinary approach between the Architects and Engineers will be reviewed and the lessons which can be learned from this approach.

INTRODUCTION

Architects Webster, Forrest, Reiach & Hall produced the winning design for the SELLIC Library in a competition run by the Royal Incorporation of Architects in Scotland. The Structural Engineers are Kirkman & Bradford and KJ Tait Engineers are the Services Engineers. The building is a new library situated within the University of Edinburgh's Kings Buildings campus. It will be completed in the summer of 2002 when the existing physical sciences, mathematics and engineering libraries will move into the new SELLIC building. Its other principal function was to act as a communication hub for students. A café, lecture theatre and computer laboratories are all to be integrated within SELLIC.

The University of Edinburgh detailed a brief which included the following points;

a) The building should be as energy efficient as possible, without a reliance on mechanical cooling. A peak internal temperature of 27'C was specified for summer conditions. This figure was based upon an anticipated internal heat gain of 50 Wm^2. This figure includes for gains from a PC located at each desk but does not address the likelihood of the book stacks being replaced by desks and PC's..
b) The layout of the Library should be able to facilitate both Book Stacks and PC's
c) The building has a briefed internal area of 5000m^2. There is a likelihood that specific areas of the building will be open 24 hours a day.

The design employs some distinctive features, including an interior glazed courtyard and roof wind towers, which will provide natural ventilation and maximise natural light throughout this energy conscious building. The design is similar in concept and methodology to the new library at Coventry University (Cook, Lomas and Eppel). Based on a square plan around the courtyard, the building presents glass facades. It links into an existing building providing complementary PC laboratory facilities, teaching and lecture accommodation and catering, all of which will be refurbished as part of the overall building project.

Figure 1: View of SELLIC within Campus

Rather than rely on sophisticated mechanical plant to control the internal environment an approach which considers the building fabric and mechanics as a single system is adopted. In essence the façade moderates the external climate, the structure absorbs the internal heat load, and the mechanical system trims the peaks and troughs.

DESIGN PROCESS

An inter-disciplinary approach was essential. It was assisted in that the members of the Design Team were familiar with each other, having worked on a number of recent projects together. The engineers were interested in the architectural approach and, as important, was the Architect's intent for the architecture to be heavily influenced by the optimum engineering solutions. For instance, the façade design was not fully realised until after the Scheme Design Report. The design process is described as follows:

Informal Regular Meetings

The Structures Engineer, Architect and ourselves all had offices in very close proximity to each other – within 5 minutes walking distance. Even with the reality of electronic communication, regular informal meetings were convened between the Engineers and Architect to resolve problems throughout the design process. Their purpose was to co-ordinate the detailed design. These meetings were not minuted, although there were formal fortnightly meetings which recorded progress.

Specialist Suppliers

In the 'spirit of Egan', specialist suppliers of cladding systems, glass and concrete were invited to attend these informal meetings to ensure the design was informed with practical solutions. Members of the Concrete Society advised on the quality of finished concrete. A glazing supplier provided samples with a variety of coatings and computed solar calculations on various glass types. The manufacturer of the pre-stressed wire brie soliel attended a serious of technical meetings and organised a technical visit to projects in Germany.

Specific samples of a ventilated heating element, and a cladding panel were constructed to test options.

Client Meetings

As with most universities, the Client was composed of a Project Manager together with representatives from the engineering, energy, security, IT and the library departments. All of these bodies had aspirations for the building which were sometimes conflicting ie. the energy department's proposal for fixed louvres in the internal courtyard, conflicted with the librarian's desire for calming views out.

In order to arrive at an agreed Client Brief, a series of minuted meetings were held between members of each department and the Design Team. Although time-consuming, the process ensured that key users had an opportunity to state their requirements and understand the reasons for the ultimate design.

DESIGN SPECIFICS

This section will review three items of design which demonstrate the collaborative process between the architecture and engineering: the envelope, the structure and the wind towers.

The Structure

A complex collaborative exercise was undertaken to evolve the type of structure which would integrate with the extract ventilation holes, the book stacks and the lighting layout. The optimum arrangement had to obey several rules within each criteria.

The key strategy decision was that the building shall consume lower levels of energy than comparable buildings and that it shall avoid the requirement for air conditioning due to summer overheating. A popular aspect of low energy buildings in recent years has been the application of an exposed concrete structure to minimise peak internal temperatures in conjunction with a mechanical ventilation system.

The usefulness of the thermal mass of the building for evening out temperature variations suggested additional benefits in the use of a concrete frame, whilst the square building plan and column grid, and the need to minimise floor to floor heights, pointed to two way spanning flat slab construction. The adopted solution is on in-situ concrete flat slabs 250-225 thick on 400 dia. circular in-situ concrete columns. In-situ concrete stair and lift cores provide lateral stability. Control of the cast form of the exposed slab soffits has been given careful consideration in order that an acceptable finish can be ventilation, lighting and formwork joints.

The thermal mass of the building evens out the temperature variations in the summer, by delaying the transfer of heat into a building, the time the peak temperature is reached can be altered. By using high thermal mass elements, the building fabric can store more of the heat that reaches the internal surfaces. To make efficient use of mass, one must be able to ventilate at night to lower the concrete structure. Otherwise the heat absorbed tends to accumulate and discomfort results.

The thermal mass of the books was not taken into account, because of the likelihood of them being removed at a later date. However their initial location influenced the position of quiet areas for study, on account of their sound absorption characteristics.

The Ground Floor is served by a mechanical ventilation system, where supply air is forced through the raised floor plenum and extracted via grilles in the First Floor slab into a return air network of ducts in the First Floor's raised floor void. The First and Mezzanine Floors are ventilated by a combination of opening windows and wind towers

Figures 2 & 3, details the ventilation strategy in conjunction with the exposed structure for a typical summer's day and night.

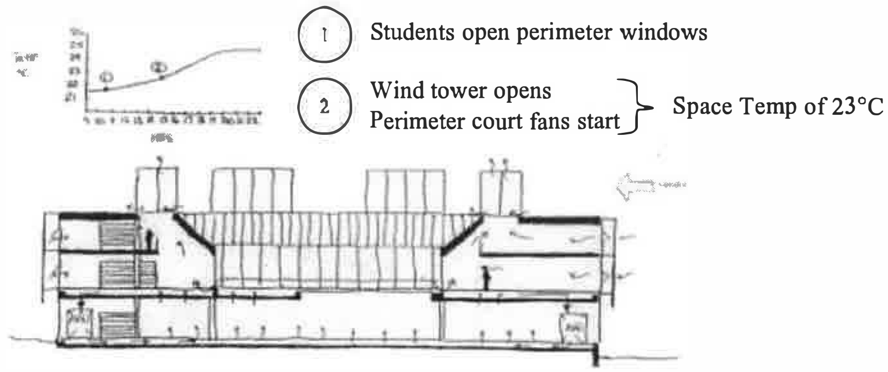

Figure 2: Summer's Day Environmental Strategy.

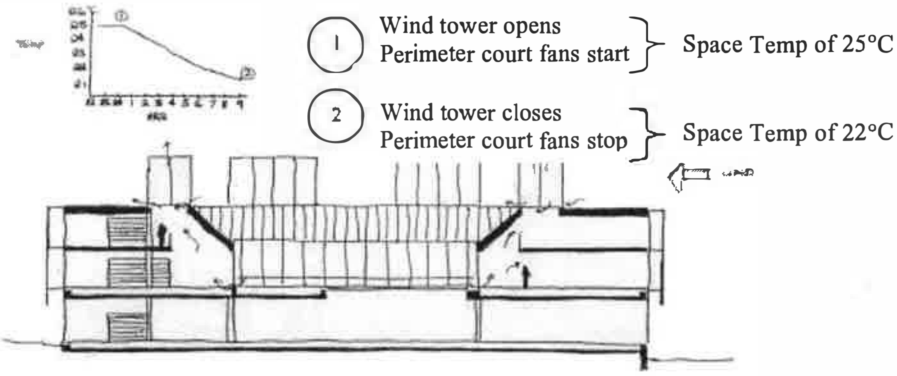

Figure 3: Summer's Night Environmental Strategy.

Figure 4 details a typical 6m x 6m bay with book stacks, lighting and ventilation holes. Various patterns of lighting were tested on the following rules:

i) Achieve an illuminance of 150W at low level in the book stack.
ii) Achieve an illuminance of 300W at a reading table
iii) Be applicable for partitioned rooms in addition to the open-plan areas.

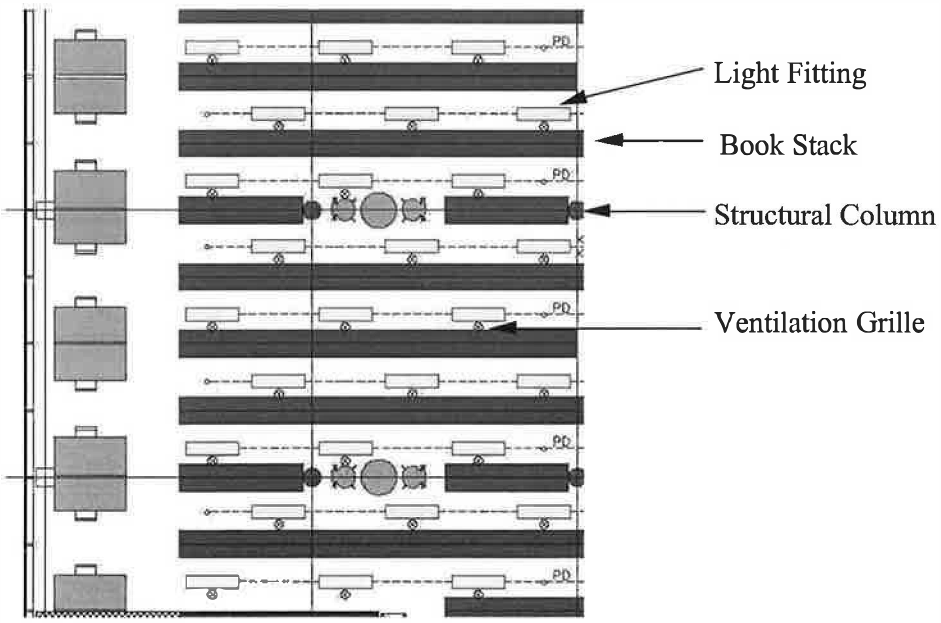

Figure 4: Typical Array of Stacks, Lights & Extract Grilles.

Virtual computer simulations were run for the various lighting options, using the program Radiance, to produce accurate representations of illuminances, glare and aesthetics.

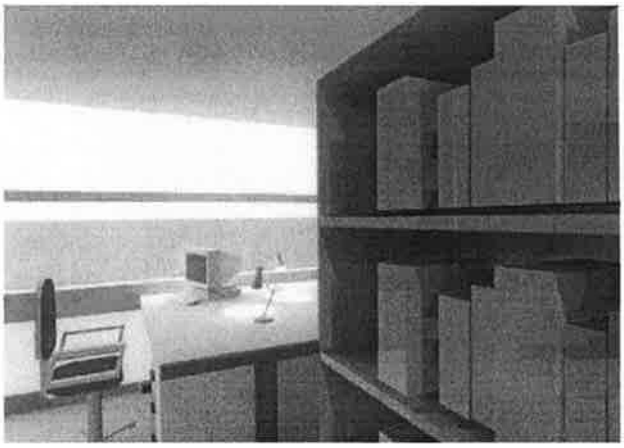

Figure 5: First Floor Reading Room Simulation taken at 2pm, May 15.

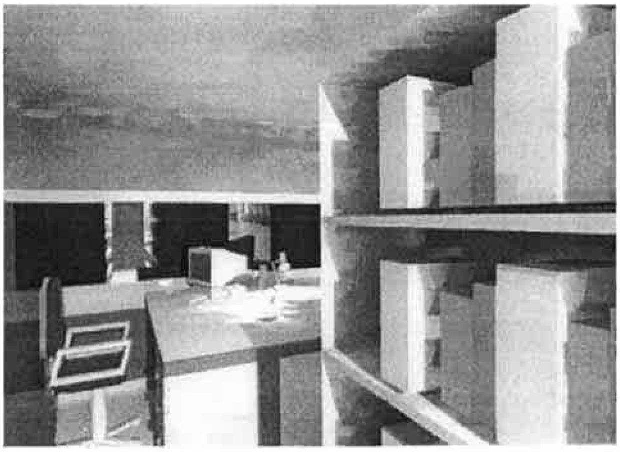

Figure 6: First Floor Reading Room Simulation taken at 9pm, May 15

The Envelope

Although the Architect had a desire for a highly transparent façade, he deemed that its form should be driven by the optimum engineering solutions.

Integral to the environment strategy was that the façade should reflect the vast majority of the sun's rays. Even by reducing the glazing to 30% of the building's envelope, it could not achieve the required level of solar reflection. A brie soliel would be required.

Various manufacturer's products were considered in terms of weight, cost, solar performance and aesthetics. Detailed discussions with manufacturers were required to properly evaluate the construction details. The optimum solution was a pre-stressed wire mesh which would be suspended 1500mm off the curtain wall. The wire mesh design was initially used in industrial sewage applications, but it has recently been applied to skin a small number of buildings in Europe.

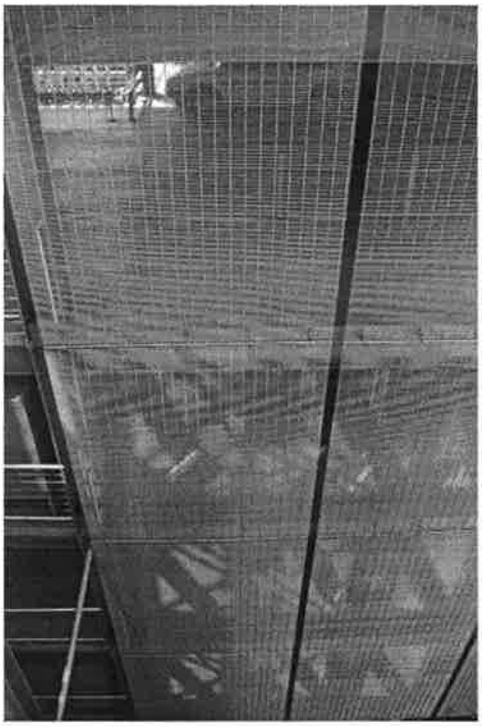

Figure 7: Pre-stressed mesh used in German application.

As the angle of the sun varied throughout the day one had to calculate the solar transmission through the wire mesh for each hour and on each façade. This proved to be an extremely complicated calculation. The results then being fed into the thermal model for the resultant internal temperature profiles.

For areas of the envelope which would not be covered by the brie soliel, ie. the courtyard elevations, there remained the challenge to evolve a façade which remained transparent, yet which reflected a large proportion of the peak solar gain. Advanced glazing materials which incorporated the latest reflective coatings in a variety of combinations were all evaluated using computer simulations of the building's thermal model.

The Wind Towers

The University was concerned that the creation of SELLIC may create wind funnelling in the adjoining pedestrian routes. Due to cost and timescale constraints, it was deemed that the best approach to judge this would be to commission a computer fluid dynamic (CFD) analysis of the site with the impact of the mean wind speed.

The University's Meteorological Department has an excellent database of wind data for the site, which detailed the mean wind speed and its direction. The resultant CFD model detailed expectant wind speeds in the pedestrian routes and the wind pressure co-efficients around the Towers.

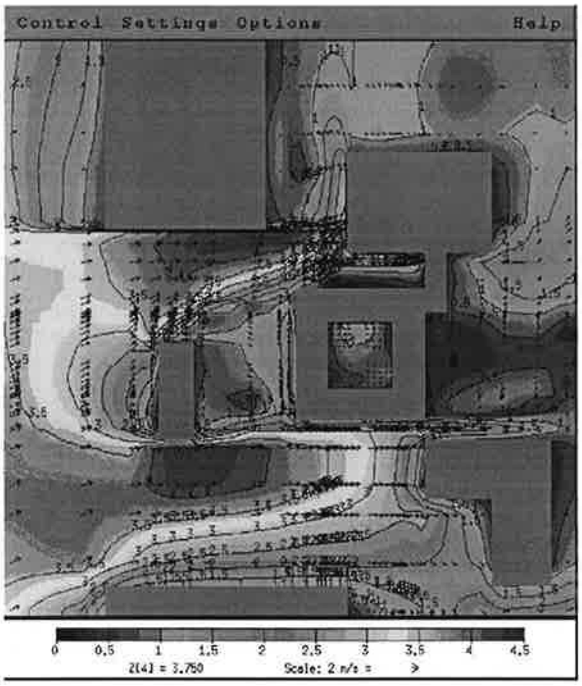

Figure 8: View of the site with air velocity cut.

The Wind Towers evolved from the initial design as a means to increase the ventilation levels in the Second Floor. However, the performance of the Tower in terms of generating air movement had to be balanced against the Architect's aesthetic desires.

The natural driving forces for ventilation are the wind and stack effect. These are, of course, variable and less easy to control than the forces associated with mechanical systems. Although at the initial concept stage the building was to be wholly naturally ventilated, but a number of issues dictated the design to be a combination of naturally and mechanically ventilated.

The Librarian's preference was that the Ground Floor windows be sealed due to the likelihood of book theft. With the Ground Floor depth being over 50m it was not suitable for natural ventilation. However the narrow floor plans on the First and Second Floors are naturally ventilated through open windows.

The BRE had previously carried out research work on the optimum form of wind cowl with many of the options originating from Victorian chimney design (Welsh). Three designs were short-listed for detailed evaluation. We constructed 1:20 scale models of each option, which were then to be analysed in a Wind Tunnel test. Figure 9 is the photograph of model under test.

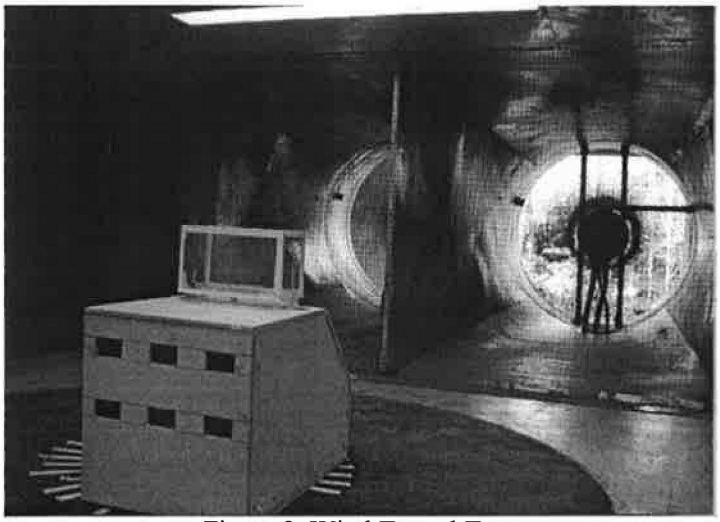

Figure 9: Wind Tunnel Test.

Heriot Watt University provided their wind tunnel, which was then scaled for our model. Air velocities were measured within various areas of the Tower and Library in order to appraise which Tower design was the most effective in generating natural ventilation through the Library.

In conjunction with Wind Tunnel Tests, we undertook computer bulk airflow calculations for each option and compared the results with the physical model. The bulk airflow model utilised the wind pressure coefficients obtained from the CFD exercise. The bulk airflow model predicted volume flow rates within internal zones, which were linked into the thermal model. We were able to predict internal space temperatures for each Wind Tower option.

The purpose of the physical models was to have a better understanding of the likely impact of each Tower's design in ventilating the First and Second Floors. The selected physical model appeared to predict greater levels of ventilation than the computer model. Detailed in Figure 10 is a sketch of the optimum Wind Tower Design.

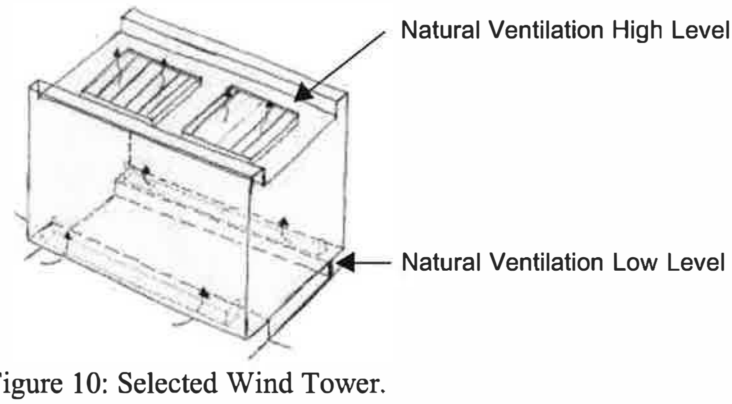

Figure 10: Selected Wind Tower.

OVERVIEW

The SELLIC project represents a good example of the application of environmental engineering, cladding and structures technology as an integral part of the architecture, which meets the University's briefing requirements. Although the building is not due for occupation until 2002, there are a number of themes in SELLIC which are worth highlighting.

Post-Completion Analysis

A common occurrence with mixed mode buildings, ie. innovative naturally and mechanically ventilated, its that insufficient time is allowed in the construction contract to fine-tune the controls once the building is occupied. Control software needs to be amended to ensure comfort conditions are achieved, particularly in the peak of summer and winter. Also plant needs to be analysed to ensure energy is not needlessly wasted.

The process agreed with the University is to arrange a series of performance tests in the summer and winter, when all parties will be in attendance. An electronic link from the site to our office will allow us to monitor the building's systems on a daily basis.

Life Cycle Costing

The University's desire for a low energy building, meant that the Team had to evolve an architecture which avoided the costly air conditioning route. The building also had to perform in comfort terms during the summer months. The heat gains are potentially considerable. For a glass façade and the move from books to PC learning will generate a lot of heat from the sun and internal gains respectively. The building envelope, structure and wind towers all have to perform in an environmental mode and therefore monies which would be apportioned to air conditioning were transferred into the building fabric.

Where we could demonstrate payback periods of less then 5 years for energy saving features, we were able to attract further monies from a distinct energy budget from the University. For instance automatic lighting controls, variable speed drives for fans were funded from a distinct budget.

The Engineer' s Influence

Throughout the design process the engineers undertook considerable research into ways of providing a mechanically simple building with low energy use. There was detailed analysis of facades, structures and air movement patterns all which have inter-linking relationships. These new generation of low energy and low running cost buildings suggests that engineering will continue to be a major influence of the architecture of the new millennium.

References

M.J.Cook, K.J.Lomas and H.Eppel ' Design and Operating Concept For An Innovative Naturally Ventilated Library' 1999 CIBSE Conference

P.Welsh 'The Testing and Ventilating of Terminals used on Ventilation Systems' 15th AIVC Conference 27-30th September 1994