3.0 ENGINEERING PRACTICE REPORT

3.1 GENERAL

Related Competencies

I have 9 years' experience within the building services industry working for an engineering consultancy. For the full 9 years I have been employed at a well establish medium sized practise BAILEYGOMM Ltd.

I joined BAILEYGOMM in August 2005 at which point I began a part time HND at London South Bank University. After completion of the HND in July 2008 I enrolled on a BEng (Hons) Degree, which I completed in the summer of 2011. I have recently graduated from an MSc in Sustainable Energy Systems at London South Bank University for which I achieved a distinction.

A1

I was also fortunate that my degree dissertation was chosen to be presented as a paper at the first Innovation & the Built Environment Academy conference which was held at South Bank University.

D1, D2

During my time at BAILEYGOMM, the knowledge I have gain has enabled me to progress from a trainee engineer to a junior engineer and now to an intermediate engineer. I have also taken on the responsibility as a line manager for the junior engineers within the mechanical department. I was involved in the interview process and I am actively involved in his career development including staff appraisals. I was able to pass on my experiences at university to ensure he has enrolled on the correct course and provided advice on the future routes he should follow.

C1, C3, E4

I have recently passed a 'Health, Safety & Environment Test for Managers & Professionals" which has enabled to me apply for a Skill Card for use on site visits.

E2

I am also committed to abiding by the CIBSE code of conduct by keeping my professional integrity and striving to broaden my knowledge, seeing every day as a learning day. Currently graded as a Licentiate member, which I achieved after completing my HND in 2008. I use the CIBSE journals to keep up to date with the most recent technology and design. In addition to attending lunchtime CPD lectures from manufacturers. During my degree I was an active member of the CIBSE Young Engineers group.

B3, E1, E4

3.2 WORK EXPERIENCE

- Heating system design using conventional radiators, air distribution & underfloor heating.
- Cooling system design using chilled water & direct expansion systems.
- Part L compliance calculations and reports.
- Hot & cold water distribution and generation design.
- Above ground drainage design.
- Creation of full and performance specifications.
- Preparation of risk assessments

E2

- Project/lead engineer

B1

- Reviewing client briefs
- Attended design and project meetings

B3, C3

- Progress reports (working for both contractor and client)
- Overseeing design and calculations carried out by junior engineers

C3, E4

- Mentoring junior engineers

C4

- Completion of QA processes, including proof reading drawings and specifications.

3.3 HIGHER EDUCATION

Degree Dissertation/Research Paper

For my degree dissertation I used a previous student facilities building which provided a D1, D2
500 seat lecture theatre, 6 seminar rooms, an exhibition space, common room and offices.

My aim was to design a low carbon building and compare my design expected energy E3
usage with benchmarks and actual metered data from the building.

The majority of standard energy saving ideas was employed such as building orientation, E3
construction & air permeability; however I was keen to try something new. I decided to use a large part of my dissertation to research the use of Phase Change Material (PCM) within the lecture theatre. PCM uses the latent heat theory, typically within a wax compound, to store high quantities of heat within a material which is then later released through night cooling. There were a few manufacturers which had experimented with small purpose made test rooms, but none had applied it to a high occupancy area.

The idea was not to propose a removal of the existing ducted cooling/heating system but to see if any useful cost effective gains could be made from the use of PCM.

I chose a particular PCM which was installed in the walls behind plasterboard as it could be retro fitted if required. I then taught myself how to use TAS dynamic modelling software after some guidance from their technical staff. TAS enables users to insert layer of the particular PCM into wall constructions therefore allowing the evaluation of energy savings.

I experimented with only night cooling to start with and then introduced various layers and positions of PCM to analyse the effects. The investigation showed peak heating load reductions of 13% and peak cooling load reductions of 17% using PCM.

Unfortunately the PCM panels were too expensive at a cost of £35 per panel and the B2, D2
payback for the cheapest solution was 33.3 years. The energy efficiency of the building as a whole also extended the payback, as the heating and cooling system was very energy efficient in the first instance. To make the PCM viable, 10 years or less payback period, they would need to be priced at £10 per panel.

The most cost effective solution was found to only employ night time cooling as there was no additional cost except from re-programming of the controls.

The final design used a biomass boiler and 230m^2 of photovoltaic panels to achieve an A1
EPC index of B and improve the existing building carbon emissions three fold.

Not long after I graduated, my dissertation tutor introduced me to the idea of writing a B2
paper for an Innovation & the Built Environment Academy conference which was held at South Bank University. I then spent some time preparing a technical paper which was subsequently selected for the symposium. In October 2012 I presented a paper titled "Review of PCM Technology for Use in Buildings - An Evaluation of the Benefits for Lecture Theatres - Case Study".

3.4 SPECIFIC PROJECT EXPERIENCE

Student Accommodation Canterbury (£9m)

After spending around 5 years working for other senior engineers on their projects I was given a 240 bedroom student accommodation and student facilities development to develop myself as a project engineer.

The university required an energy efficient building and emphasised this objective by asking for a BREEAM rating of excellent. There was also a requirement for a facility to B1
charge students extra if they exceeded a set energy consumption limit. To meet this objective I designed and developed a central boiler system and each 'flat' of 5-8 bedrooms had its own local satellite heating unit with an integral hot water storage vessel.

Each satellite unit is fitted with a heat meter and water meter along with a local temperature control system. In addition the electrical supply to each flat was also fitted B2
with a meter. All of the meters and control systems communicate with a central computer within the warden's office which enables the university to use a monitoring and targeting system. The controls can also be limited so if an energy limit is reached the unit functionality can be decreased. This particular function was used to charge students additional fees if they exceeded pre-set energy consumptions targets.

During the construction phase we A2, D1
worked closely with the manufacturer and was able to offer a new add on system. The extra equipment gave the ability of the central computer to be accessed off site via a web based system. The university took up the offer as it allowed their facilities management team, who were not based on site, to be alerted of any faults within the centralised system.

We also specified a high heat recovery 'whole house' system for each flat. These were selected with low specific fan powers to provided constant ventilation to each bedroom and kitchen. The building services design and general building construction enabled us to A1
achieve an EPC index under Part L 2006 of 32. This is against a newly built building of similar use having a benchmark of 42.

Being my first entire project as project engineer, I was involved in preparing the C1, C2
necessary BREEAM documentation and witness testing to enable its successful hand over and occupation in September 2012.

We have since revisited site to take peak meter readings for each cluster flat to allow us A1
to take due cognisance of the actual consumption figures for future designs of similar projects.

120 Bedroom Hotel (£6m)

Due to the success of the student accommodation project above we were selected by the same developer to work on another project also located in Canterbury. This involved the same design team as the previously mentioned student accommodation.

Once again as project engineer I was involved from the initiation of the project. This includes producing an initial sketch scheme and attending preliminary meetings with the design team and client. From these initial meetings the design was developed into a full design which was tendered and constructed.

There is a generic specification for the majority of the building services systems which promotes energy efficiency and good design practise. In addition to the guidance we were required to meet 3 energy targets.

1. 30% reduction in energy consumption – specified by the client.
2. EPC index of 28 (Part L 2006) – Specified through BREEAM
3. CO_2 reduction of 15% using renewables – Specified through BREEAM

To achieve the three targets I designed a pre-heat domestic hot water system served by a 43 kW external air source heat pump (ASHP). The manufacturer of the heat pump has a full working system installed at the HQ and I was invited to speak to their technical team and see the system in in operation. B3

To ensure a standalone ASHP was the most suitable solution I calculated the predicted energy savings from other systems which showed the standalone ASHP was the optimal solution. B2

To further my design and obtain the most accurate energy savings I created a spreadsheet which models the thermal storage system coupled to the ASHP. I then adjust the storage size, ASHP output temperature and seasonal coefficient of performance (SCOP) to find the most energy efficient solution. B1, B2, E3

My figures were also checked by an independent consultant working for the client. This involved creating a presentable graph, table and a written description of the calculations. One of the main reasons for the check was the hotel chain (and the clients consultant) had not managed to meet all of their energy targets with only an air source heat pump. A1, A2

The pre heat ASHP system exceeded all three targets showing an energy reduction of 54%, a CO2 reduction of 18% in comparison to a modern gas fired system and also achieved an EPC index of 29.

Another energy savings solution which I design was a grey water harvesting system. Two thirds of the baths within the hotel are connected to an underground grey water system which holds and filters the water. This water is fed into a 'water manager' in the plantroom which pumps the water to serve all WCs and urinals within the hotel. The grey water system is sized to meet 100% of the total connected load.

At the end of the project I had the responsibility of witness testing all of the mechanical systems and gathering construction data for BREEAM credits. C2

The project was completed successfully, handed over and occupied in November last year.

University of East Anglia – HVAC System Redesign (£600k)

This was my one of my first major projects in which I was heavily involved in the design and coordination of the services. A design brief was created and then I was tasked with rectifying the existing system to ensure it operated effectively.

The building is located on the outskirts of Norwich; it consisted of 4 floors of laboratories of which we were working mainly on the top floor. It operated with full fresh air plant utilising an air handling unit on a lower floor which provided tempered air to terminal heater batteries above the ceiling. All main plant had a run and standby capacity to allow the building to operate continuously in the occurrence of any plant failures.

The main issue to solve was the rooms could not hold a constant humidity, 55% +/- 10%. Due to this, parts of the building were not operational as they needed a consistent reading before they could be occupied.

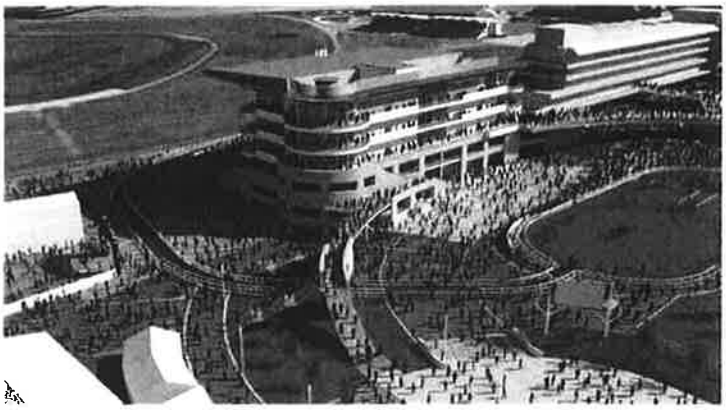
After some investigation the reason for this problem was the location of the steam injection. The system was designed to inject all the required steam into one relatively small section of ductwork, directly after the air handling unit (AHU). In the winter there was a high demand for steam injection due to the low moisture content in the air. When D1 the high steam loads were injected into the air it was wetting out (reaching dew point) before all the steam could be absorbed. Another factor which contributed to the low humidity readings were the small absorption distance allowed for after the steam humidifiers. D2

To solve the problem we replaced the steam lances close to the AHU with lower capacity units and also simplified the duct runs to create longer absorption distances. We then introduced an extra 2 sets of humidification lances within the ceiling distribution system to make up for the deficit in the new smaller units after the AHU. The extra lances were also coupled with heater batteries to ensure the air had sufficient moisture carrying capacity and to ensure the water was fully absorbed.

Due to the nature of the building, the conditions of all rooms were closely monitored post construction. In all only one room required re balancing as it was over heating. The facility is now in full operation without any issues.

Racecourse Redevelopment including a new Grandstand (£45m)

As part of a term consultancy with a large racecourse-owning company we were employed to design services for the redevelopment of a racecourse. The project involved the refurbishment and extension of two existing ancillary buildings, the creation of a new bar and betting shop plus the demolition and construction of a new 8,600m² grandstand.



I was engaged in the position of lead mechanical engineer, working with a lead electrical, overseeing Director and with the assistance of junior and intermediate engineers. This involved attending numerous design team meetings and workshops with the other consultants, presenting ideas and solutions to the design of the building and liaising directly with manufacturers to ensure their involvement from the beginning of the project. B2, C3, D1, D2, D3

One of the main challenges for the development was its usage pattern. For around 300 days of the year the buildings would be vacant as the racecourse is only used for winter racing. In addition, some of the areas (Premium Dining, Royal Box and main betting area) could be hired out for events throughout the year. The building therefore needed to be extremely flexible in its operation but with the minimum amount of plant to ensure the capital costs were not inflated to accommodate its intermittent usage. B1

During times when no events are taking place the building will be left in setback mode. This will reduce the building temperature and therefore the energy demand whilst still ensuring the building is protected against frost. After reviewing all of the available heat sources and due to the relatively low and steady plant load the decision was made to use a Ground Source Heat Pump (GSHP). An Air Source Heat Pump was deemed not to be suitable as the Coefficient of Performance (COP) would be unfavourable during the period of operation. Before this solution was taken further, a borehole specialist company was employed to drill a borehole for a thermal response test. This then allowed us to make an allowance within the tender for the number and depth of boreholes. A1, E3,
The ground source option provides a relatively steady source temperature throughout the year.

The large (1500m²) betting area on the ground floor is heated via a passive underfloor heating system. This removes the need to actively run air handling units to heat the space whilst unoccupied. As underfloor heating uses low flow and return temperatures, we are also able to connect the GSHP directly to the underfloor system. The remainder of the building is heated via radiators. To allow fast heat up of the building prior to a race day, the radiator system is also coupled to a heat exchanger fed from the boiler system. By feeding the radiators from the boiler the flow and return temperatures can be raised to increase the heat output of the radiators. The removal of the radiators from the GHSP circuit also allows the GSHP to solely feed the betting area to allow a greater heat output from the underfloor heating.

To improve the seasonal COP of the GSHP I have also linked the underfloor heating system directly to the ground source loop via a plate heat exchanger. This allows heat to be drawn from the large open space during the warmer summer months and pumped around the borehole system to recharge the ground for a small carbon penalty of E3 operating a pump.

I undertook all of the thermal load calculations for the heat pump using dynamic simulation within IES. This involved creating bespoke profiles for the building usage and then ensuring the control strategies (setback/normal) did not overlap when running on race days. To guarantee only the heat pump output was summated, I created a A1, B1, spreadsheet which allowed the input of a heat pump size and then only counted values B2, C1 below this input. This allowed an analysis of the optimum heat pump size to be made using capital costs and running costs. These calculations were also used to give the client an idea of running costs and to allow budgeting for the building operation.

The detailed loads produced from the modelling software were also passed onto a A1 specialist borehole designer to final construction design of the boreholes and the primary heat pump system.

It was also apparent it would not be feasible to recover heat from the Air Handling Units (AHU) as the payback would be extended due to the intermittent building use.

Due to the very short operating times and high loads (1.5MW) for the AHUs these are not fed from the GSHP system, instead these are fed from the gas fired boiler system. The original scheme for the gas supply comprised of a new connection into the medium pressure main in the highway with a meter at the boundary. A 650m service pipe was then to be laid around the racecourse to the new grandstand. This was a very expensive option so post tender I implemented a complete survey of the existing gas load around the site. This coupled with some existing meter data allowed me to assess the existing gas supply to the site. After speaking with the meter provider and service provider I was able to confirm the existing site supply was adequate so the construction design is to lay 40m of gas pipe from the existing main within the site, saving a considerable sum of money.

In total four AHUs serve the entire grandstand. All the systems have a system of shut off A2, B2 dampers on each floor so areas which may be hired outside the racing calendar can be 'switched on' individually. Owing to the system design I also designed the system with terminal heater batteries for each area so all areas have the option of free cooling due to the low external temperatures during the racing season.

In general, there is no provision for cooling the grandstand except from the premium dining and royal box, as these are likely to be occupied outside the racing calendar. However, due to the high occupancy levels and low sun path (winter) during operation, the rooms are susceptible to overheating. So, using dynamic simulation I evaluated the overheating for each floor using. This included the free cooling available throughout all spaces owing to the operational season.

Overall most of the floor passed partially due to the solar control glass employed to meet Part L of the building regulations. Nevertheless, Level 1 of the grandstand is the most densely occupied floor and this was the only floor to overheat during the calculations. To mitigate the issue, I employed open able windows around the entire front of house A2, B1 façade of Level 1. I was able to model the open able windows using IES to guarantee the system would work. Brise Solei was not an option as this would block the view of the racing, in addition to the majority of the heat coming from people within the space not the solar gains.

An important part of the racecourse operation is to be able to easily monitor the operation of all of the plant to allow fast reaction time to any failures. To accommodate this request all ancillary buildings included in the project and the new grandstand will be fitted with a new BMS system which controls all items of equipment and is linked back to a central supervisor within the facilities managers' office. This also allows monitoring of energy consumption in accordance with CIBSE TM39.

This is a current project under construction. Although it is not a soft landings project C2
under BRE, I will be offering my continued support to ensure the handover and operation of the building is successful. My post completion involvement will also be to monitor the energy consumption of the building in its early life and compare it to expect consumption. I will also be involved in witness testing of all buildings to confirm the building performs as designed and as efficiently as possible.

Low Humidity Packaging Room (£120k)

My position on this project was a Mechanical Design Engineer. The brief was to design a ventilation system to serve a bulk packaging room. As the product was hygroscopic in nature it was imperative the area was keep very dry. Therefore the parameters were B1 that the room had to be kept at 21°C and 25% RH with an air change rate of 15 Air Changes an Hour (ACH); it also had to remain at pressure of –15 Pa in relation to the adjoining corridor.

The was already an air handling unit developed for a similar project at the same site so my air handling unit would be based on this platform and there was an existing dehumidifier that had to be utilised so this was the base of my calculations.

I began by sketching out the system working out the air flow rates required for supply and extract air to meet the design parameters. Due to the room having to be under negative pressure more air had to be extracted than supplied, which meant some air would need to be bled of the system somewhere along the line.

My original design was to extract air from the room, add some fresh air, pass roughly half of the air through the dehumidifier, then mix the non de humidified air with the dehumidified air and ducting it through a cooling coil and then last of all bleeding off a small amount of air to allow the room the stay at a negative pressure.

After completing some calculation to work out the moisture content of the air at different points, I established the existing dehumidifier did not have the capacity to process all the required air.

My solution to this problem was the air bled at the end of the process would need to be A2 bled at the beginning therefore leaving less overall moisture for the dehumidifier to cope with.

I amended my design and passed a smaller volume of air through the dehumidifier then went through the process working out all the moisture content. All my calculations worked out on paper and the system will work with my adjusted airflows. However there was a knock on effect of the new design, due to air being bled at the beginning and the arrangement of the AHU the section where the air would be bled would be under negative pressure so the air would not be forced to bleed out of the system. This meant B2 a separate fan had to be added to extract the air. It then bleeds part of it off and ducted the rest through the air handling unit.

The project was successfully constructed and is now in operation.