MECHANICAL

Engineering Student Centre

Practical Work Report 'A' Grade Exemplar

THE UNIVERSITY OF AUCKLAND

Te Whare Wānanga o Tāmaki Makaurau

NEW ZEALAND

ENGINEERING

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ENGINEERING

Practical Work Report

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Employment Period:

Date of Reporting:

Acknowledgements excluded for privacy reasons.

Summary

This summer internship with has given me the opportunity to work one of the largest commercial projects currently in New Zealand, the design for a new hotel), for which our team was involved in the HVAC (heating, ventilation and air conditioning) design. This report details some of the methodologies used in the design procedure.

a multi-disciplinary engineering consultancy working across a spectrum of industries with a large variety and complexity of projects. The largest business segment for the organization is the Buildings segment which is the combination of structural and building services (mechanical, electrical and fire) engineers. My position was as a mechanical building services engineer designing HVAC systems where I was assigned a 'buddy' (senior mechanical engineer) and we reported to the job manager. In addition, I also had to assist the fire engineering team for layouts of sprinklers and smoke/heat detectors across the building.

This position has taught me some very invaluable skills that complement my technical knowledge obtained from my university study. Mainly, my communication skills have be honed by coordinating with architects, structural and electrical engineers. Trying to fit in large ducting and piping networks within the limited ceiling space already containing beams, cable trays and sanitary and storm-water piping networks has prompted lots of discussions with other teams.

In addition, this internship with has also been an opportunity to add further skills to technical knowledge, by the use of a new CAD software (Revit MEP) for building service design and to a new discipline of engineering, fire engineering which has been very interesting. I have also had the exposure to study some of the NZS/AS standards which dictate the designs, which has been interesting as I had not had exposure to this in my study or previous work experiences.

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2.0 Office Layout and Facilities

The shown in Figure 2a, is located on
This is right on the intersection of as illustrated in Figure 2b below. The building consists of eight floors, with the ground floor containing the reception and admin areas, training and seminar rooms. The following seven floors house the teams from the various businesses lines mentioned earlier. The buildings team is located on the second floor. The building structural engineering team in located in the north block while the south block houses the building services teams. The area in the middle of the two blocks is known as 'heart space' which is the common area for the kitchen and seating area for socializing and lunch breaks.

Figure redacted.

Figure 2: (a) Auckland office building (b) office location

Every member of staff has an access pass to the building. Only the senior management can avail the parking in the two basement levels of the buildings. Lockers are also available in the basement floors. There is an online booking system which can be used to book training and meeting rooms, company cars. For site visits, the company provides full gear depending on the level of protection required. This includes access to gloves, helmets, overalls, safety vest, goggles etc. This can be booked using the company intranet.

Every staff member has a personal workstation which includes a desk, chair, filing cabinet and computer. The workstation used during my internship is shown in Figure 3. The computer has a headset attached which is used for internal and external telephonic communications. The staff also has shared access to kitchen, washrooms, printers and meeting rooms. There are two colour printers in each of the two blocks in the building. These can print upto A3 size. For larger printing such as A1 site drawings, there is one printer available for this purpose. All the basic software is pre-installed on the workstation computers, however any professional software require permission from the section manager and can only be installed by the IT team as limited licenses are available. One of the most important facility available was the access to the Australian, New Zealand and British Standards as these were often referred to during the course of the internship. Furthermore, there is a 'MyPotential' learning system available on the intranet. Every new employee in the first few days of the employment is made to go through the health and safety and induction modules to familiarize with the company's protocols and the background. The intranet also has all the other facilities such as timesheet input, payslips and other employment related services.

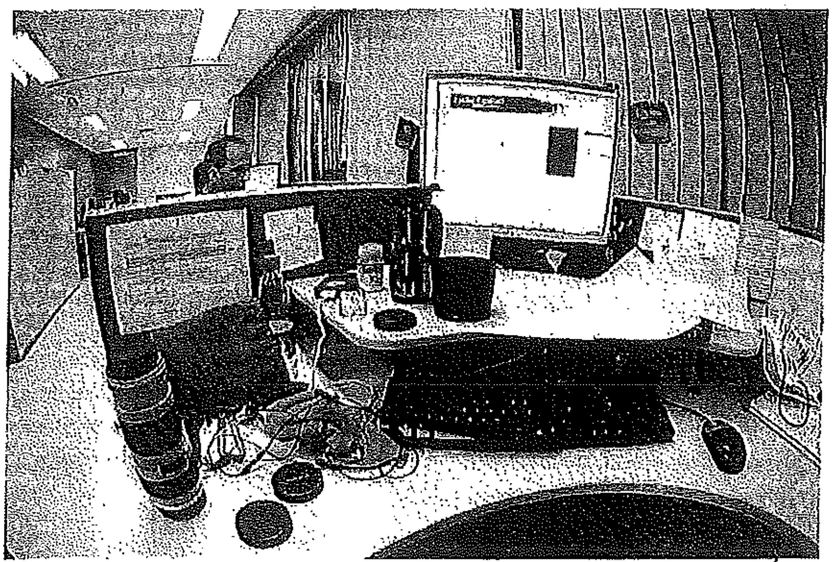

Figure 3: Workstation used during employment

3.0 Staff Organization

As mentioned earlier, the building services team consists of a combination of mechanical, electrical and fire engineers. Within the building services team, there are three sections, red, green and yellow. This sectioning of the large team separates out the nature of projects that each section carries out due to large variation in projects. The red team undertakes the larger commercial projects while the yellow team is more focused on more on residential and office buildings. The green team is focused on the business line in the Australia but are based in the Auckland head office, but are designing for a very different climate. I was placed in the red team, working on one of the largest commercial projects, the

Each of the three sections has a section manager, to which the technical directors report to. There are seven technical directors in each of the sections. Under each technical director of the respective engineering discipline (mechanical, electrical or fire) are the senior engineers and engineers, which accumulate to approximately forty engineers in each section. This structure is illustrated in Figure 4. A similar organizational structure is followed in the other business lines.

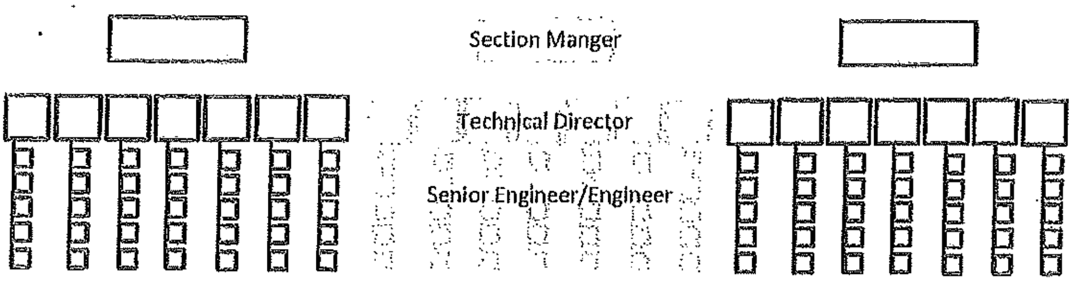

Figure 4: Organizational structure in the building services team

Apart from this there is a team of nine CAD drafters which are based in each section and carry out the major CAD related work. The Auckland office c has approximately 1000 employees in total, with a further 2000 more spread across the other 16 locations in the Asia-Pacific region. The kev figures in the senior executive team consists of the Executive Chairman, the CEO e and the Managing Director of New Zealand Operations,

Every year, employs up to 1 graduates and up to summer students nationally across a wide range of disciplines, with students from engineering, science, IT, business, science and the arts. The People and Culture team (Human Resources) of about 20 people and the supporting payroll and accounts team provide and excellent working environment with regular events and development programs. One of the ... shown in Figure 5.

Figure redacted

4.0 HVAC

The current project being undertaken by the team was looking at running all the services for a new hotel on , Upon my joining, I was given an introduction to the architectural and structural design of the hotel. Subsequently, as the preliminary design had been issued earlier in the year, I was given the current working drawing sets for the mechanical services. The senior engineer in our team ( ) had given me an introduction to the CAD software that is used by the company, AutoDesk REVIT 2016.

The next document I was introduced to was the 'Load Modelling Report'. This report is a detailed summary of the amount of hours per day there would be sunshine in each room depending on its location, maximum number of occupants expected and number of computers and other heat emitting electrical equipment. These factors eventually dictates to amount of sensible and latent heat loads in each zone and the amount of supply air that needs to be supplied, which is required to size the ducting. This load modelling is performed using a modelling software called Carrier E-20 (Hourly Analysis Program). I had been given the task of sizing and inserting the ducts in the CAD model for Level H1.

Looking at the floor plan for Level H1 (Figure 9), it can be seen the riser has been designed in the North-East corner of the building by the architects, To serve the lobby area on the floor, it seems to be ideal to have two main ducts running along the length of the building, one to serve along the North end of the building prior to the dining area (main duct 1) and second longer one along the east end of the building running to the south end before the retail stores (main duct 2). Both these main ducts will branch of to serve the respective zone/space in the lobby. These zones are shown in Table 1.

Table 1: Zones with required air flow and duct sizes and parameters

Zone/Space Name	Air Flow (L/s)	Circular Duct Diameter (mm)	Rectangular Duct Width (mm)	Rectangular Duct Height (mm)	Velocity (m/s)	Pressure Loss (Pa/m)
MAIN DUCT 1	1078	500	380	720	5.3	0.6
Servery Bar	195	250	190	380	4	0.8
Hearth Area	291	315	240	480	3.6	0.55
Pre-function	240	315	240	480	3	0.35
Lobby-circulation	69	200	150	300	2.2	0.37
Stairs	63	160	120	240	3	0.85
Corridor 2	220	250	190	380	4.5	1
MAIN DUCT 2	3104	800	600	1200	8.5	0.8
Luggage Store	267	315	240	480	3	0.35
Reception	250	315	240	480	3.2	0.4
Entry East	302	315	240	480	3.75	0.55
Espresso Bar	405	315	240	480	5	0.9
Bar Perimeter 2	324	315	240	480	4.2	0.7
Bar-C	101	160	120	240	3.2	0.7
Corridor 1	298	315	240	480	3.7	0.56
Lift Lobby	105	160	120	240	3.2	0.7
Bar Perimeter 1	720	400	300	600	5.8	0.9
Entry South	332	315	240	480	4.2	0.7
RISER	4182	800	600	1200	8.5	0.8

Next, the duct sizing procedure is carried out. Using "[redacted] Best Practice for Duct Sizing" guidelines, it can be seen that for this project (hotel) would be classified as a commercial/public type based on Table 2. Using this, the indicative values for the air velocity and maximum pressure loss per unit length of pipe can be determined, which using the duct sizing wheel can be used to find the required duct diameter (circular duct) or the dimensions of a rectangular duct (height and width).

Table 2: [redacted] best practice for duct sizing

Duct Type		Residential		Commercial/Public		Industrial	
		m/s	Max Pa/m	m/s	Max Pa/m	m/s	Max Pa/m
Fan Discharge		5.0 - 8.0	-	6.5 - 11	-	8.0 - 14	
Main Riser		4.0 - 7.0	1.0	6.0 - 9.0	1.2	7.0 - 12	1.5
Main Duct		3.5 - 6.0	1.0	5.0 - 8.0	1.0		1.2
Branch Duct		3.0 - 5.0	0.8	3.0 - 6.5	0.8	4.0 - 9.0	1.0
	Rigid	2.0 - 4.0	1.0	2.5 - 4.5	1.0	2.5 - 4.5	1.0
	Semi-rigid	2.0 - 4.0	1.0	2.0 - 4.0	1.0	2.0 - 4.5	1.2
Runout Duct	Flexible	1.5 - 2.7	1.0	1.5 - 2.7	1.0	1.8 - 3.0	1.2

The use of the duct sizing wheel is a very quick and accurate procedure for sizing ducts. In our university courses, a much more tedious procedure is used to find the duct sizes using a chart from the ASHRAE charts but the amount of times ducts need to be sized on a daily basis makes the wheel a very reliable tool. Firstly, knowing the amount of air flowrate for the respective zone from Table 1, the maximum permissible pressure loss found from Table 2 can be equated by the blue band on the top of Figure 6. Next, the red band on the right is checked to make sure the velocity at this pressure loss does not exceed that recommended from Table 2 for the duct type. This is to ensure that the air flow does not become too noisy and disturb the occupants. Next the dial on the left side of the wheel points to the required circular diameter or if a rectangular duct is being used, the green band gives the dimensions. These vary from a square sized duct to a rectangular duct with a high aspect ratio.

The above mentioned procedure was used and the duct sizes are recorded in Table 1. When the final duct sizes were obtained the actual velocity and pressure drop values were also recorded in Table 1.

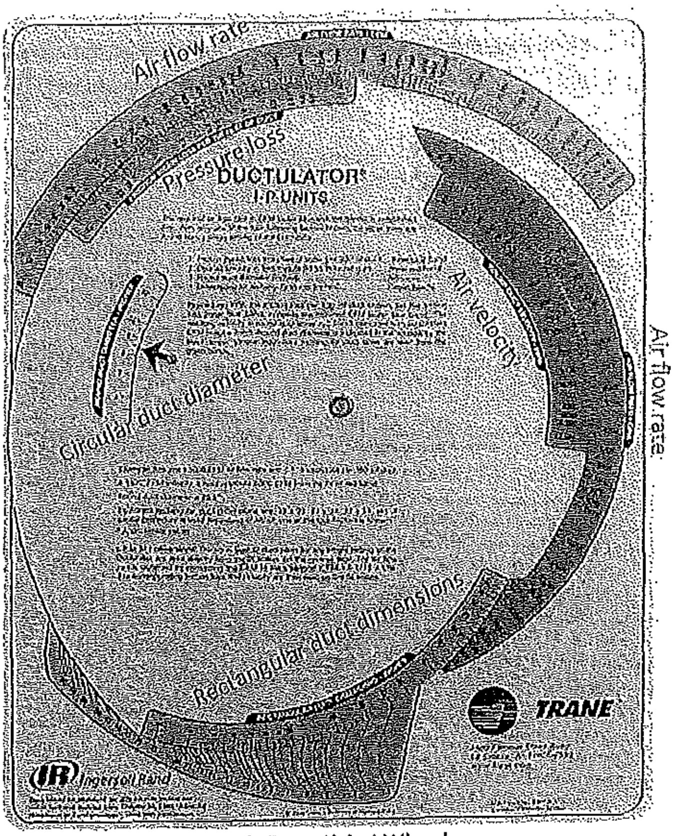

Figure 6: Duct Sizing Wheel

Sizing the ducts was a very straightforward procedure and doesn't require much critical thinking. However, when these ducts need to be placed in the CAD model with all the other services running, this is the major task and requires coordination with the other engineering disciplines trying to fit the equipment in the limited size ceiling void.

For a simple first pass analysis, a section along level H1 was cut to investigate the space and positioning of all the services. This is shown in Figure 7. What can be seen is that in this preliminary design, the pluming pipes are running through the I beam in the lobby zone. In the corridor space, the cable trays running through the concrete column and the newly added supply air duct is clashing with the ceiling tiles.

Using the measure tool the dimensions were determined. After consulting with the senior engineers, it was mentioned that the current layout had to be revised and I was told to do some sketches to find possible solutions. It was clear that the stormwater and sanitary waste pipes could not be moved as they are gravity driven and require that space. However, all the other fixtures were flexible, but had to keep in mind that the more bends and turns that are included in the pipes and ducts, more fan/pump power would be needed to drive the flow.

Figure 8 below shows the optimal solution from the many sketches which were drawn. What can be seen is that the supply air ducting has been shifted to the lobby zone and has been rotated by 90°. The plumbing pipes, hot/chilled water pipes and cable trays have been translated down and room for crossovers has been left if required.

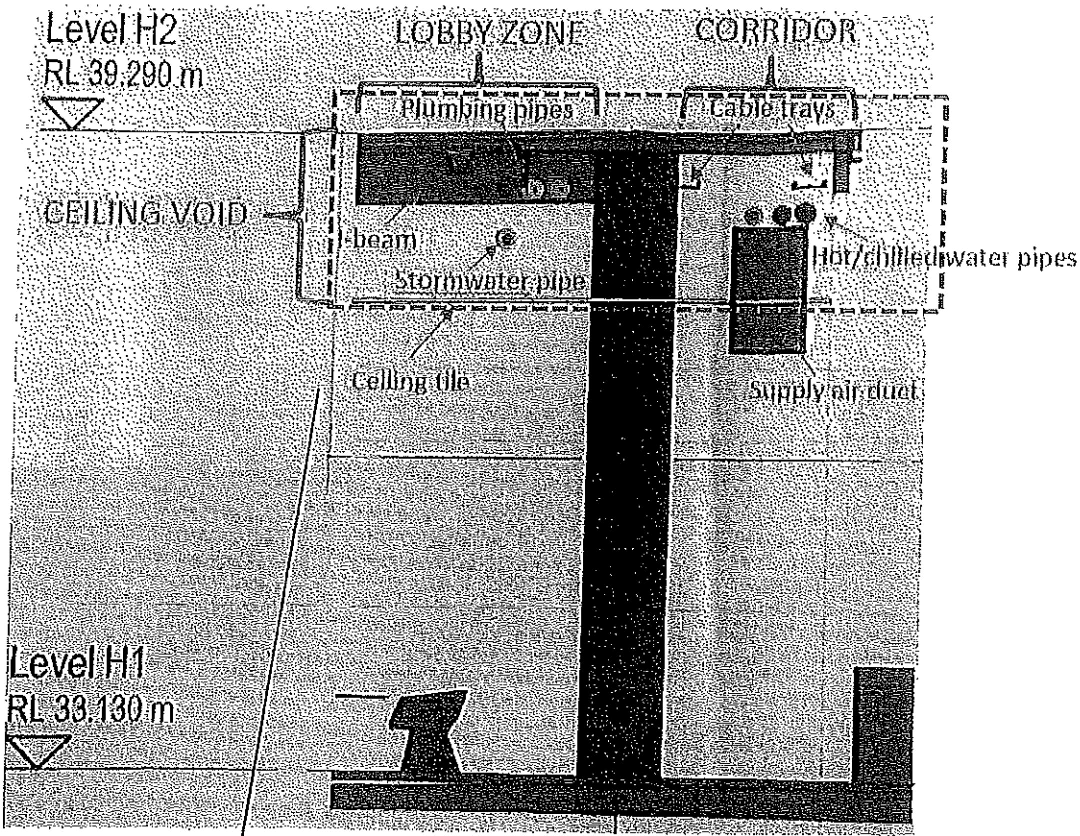

Figure 8: Typical corridor/lobby cross-section

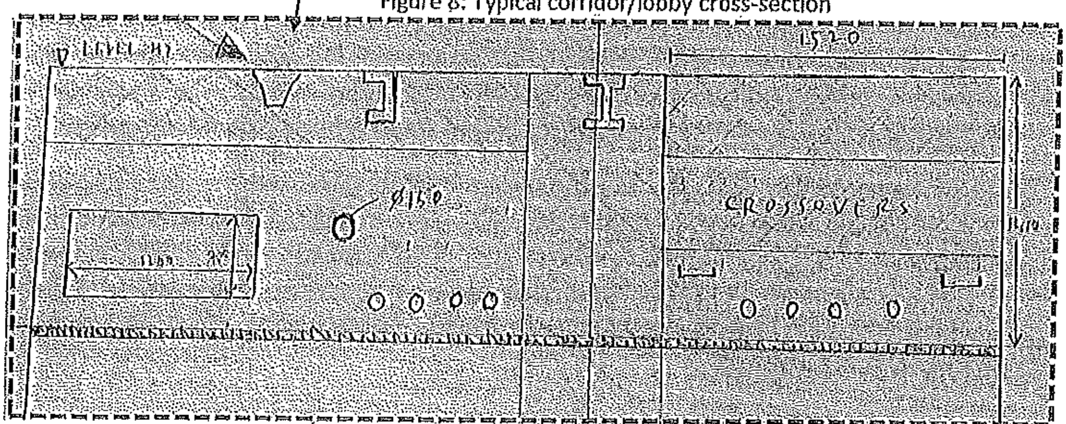

Figure 7: Optimal solution for placing all services in the ceiling void

Figure redacted

... showing the position of the new supply duct

Next, after placing the duct, I was told to size the fan that needs to be selected for driving in the supply air into these areas. This selection first required to determine the amount of pressure drop in the ducts due to both major and minor losses. For example, there is a 60° elbow in the duct, to determine the pressure loss for this fitting, we refer to the ASHRAE duct design database which has been extracted in Figure 10. For the 240x480 duct the H/W ratio is 0.5, hence the loss coefficient for this fitting will be 0.59.

CR3-6 Elbow, Mitered

	C_o Values										
	H/W										
θ	0.25	0.50	0.75	1.00	1.50	2.0	3.0	4.0	5.0	6.0	8.0
20	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.05	0.05	0.05
30	0.18	0.17	0.17	0.16	0.15	0.15	0.13	0.13	0.12	0.12	0.11
45	0.38	0.37	0.36	0.34	0.33	0.31	0.28	0.27	0.26	0.25	0.24
60	0.60	0.59	0.57	0.55	0.52	0.49	0.46	0.43	0.41	0.39	0.38
75	0.89	0.87	0.84	0.81	0.77	0.73	0.67	0.63	0.61	0.58	0.57
90	1.30	1.27	1.23	1.18	1.13	1.07	0.98	0.92	0.89	0.85	0.83

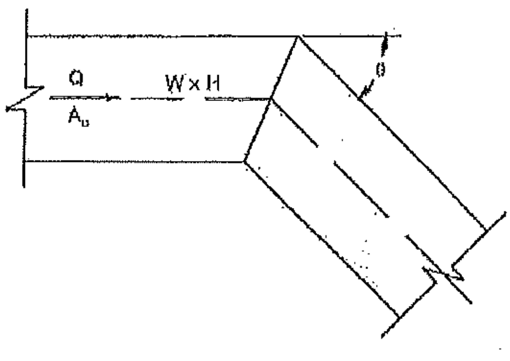

Figure 10: 60° elbow loss coefficient

The same procedure was used to determine all the pressure drop across all the fittings and the major losses due to the roughness of the ducts. This is summarized in Table 3 below. What can be seen is that the total pressure loss with the addition of a 10% safety factor results in a 246.5 Pa pressure drop at a rate of 4182 L/s. Now referring to the company preferred manufacturer catalogue from FanTech, the FanTech HC 0804 Axial fan is selected as shown in Figure 11. Finally this selected fan and the supporting attenuators, after consulting the acoustic engineers was selected and added to the CAD model. Subsequently, this entire procedure was repeated multiple times to do the supply air on the other floors.

Table 3: Minor and major losses in the duct

Description	Duct Length (m)	Loss Coefficient	Friction Loss (Pa/m)	Pressure Drop (Pa)
1200x700 duct	22.1		0.8	17.68
90° bend		0.11		3.23
60° bend		0.59		17.35
30° bend		0.17		5.00
Transition		1.18		34.70
1200x600 duct	32.4		0.8	25.92
90° bend		0.11		4.22
45° bend		0.37		14.21
90° bend		0.11		4.22
90° bend		0.11		4.22
90° bend		0.11		4.22
Intake		1.21		46.46
Discharge		1.11		42.62
TOTAL				246.5 (incl 10% SF)

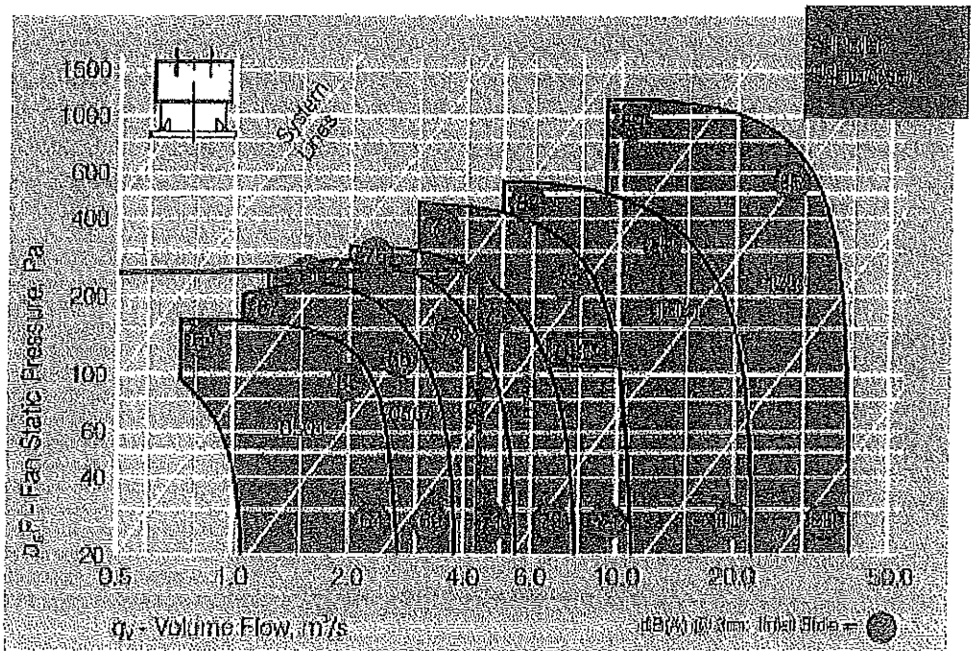

Figure 11: FanTech axial fan selection

5.0 Fire Protection Engineering

Fire protection system within buildings are driven by the application of NZS/AS standards for the design of fire detection (fire alarm), fire suppression (sprinklers, extinguishers, and smoke barriers), and escape facilities. The two main standards which dictate the design of these devices are NZS 4512:2010 (sprinklers) and NZS 4541:2013 (detectors) which were used during the tenure with the company.

The CAD model containing the building model (architecture), structural elements, and all the other services placed within the building was completed. The final elements were the fire protection systems. This had to be added to the CAD model before drawings of the RCP (reflected ceiling plans) could be printed and issued to the clients. The methodology used for the positioning of the two types of fire protection systems is described below.

Firstly, for a first pass analysis, smoke detectors are normally placed in all the required spaces within the building. To minimize the chance of false alarms arisen due to activation of smoke detectors, these are replaced by heat detectors in the following areas;

- Top of stairways, lift shafts, service ducts and skylights.
- Under loading dock canopies, covered balconies and under external building appendages.
- In-built storage enclosures (eg. Cleaners cupboards, understair cupboards)
- Toilet/bathroom spaces or other wet areas where steam is likely to be generated.
- Within 5m horizontally of any cooking apparatus.

The required spacing for smoke and heat detectors is shown in Figure 12 below. What can be seen is that a maximum distance of 10m can be placed between two adjacent smoke detectors with 5m maximum horizontal distance from a wall or 7m radially from the corner as shown in Figure 12a. A similar criterion applies for heat detectors as shown in Figure 12b.

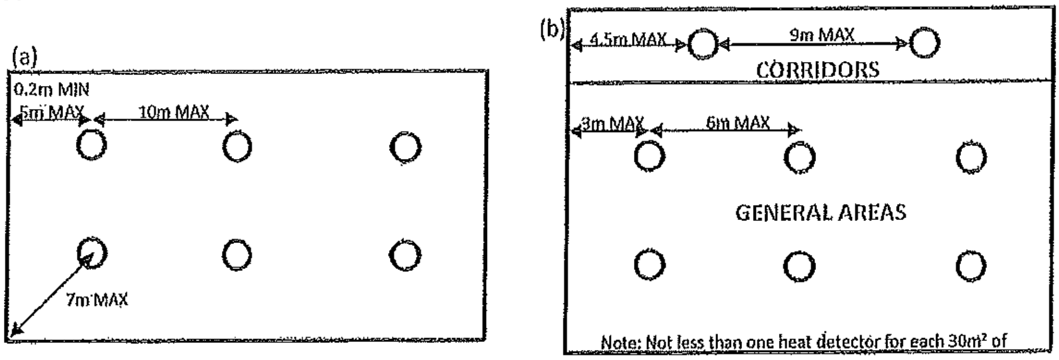

Figure 12: Spacing requirements for (a) smoke detectors (b) heat detectors

The spacing requirements for fire sprinklers are much more stringent and have many more things to consider. For instance, if a fire sprinkler is placed in close proximity of a suspended fixture as shown in Figure 13, the stream of water hits this suspended fitting and drops straight down (solid blue line). Instead where the dashed blue line shows the actual expected coverage. Hence if a fire was to ignite in the hatched area, the sprinkler would not be effective. To overcome this limitation accounted in practice a 'beam rule' has been devised in NZS 4512:2010 shown in Figure 14.

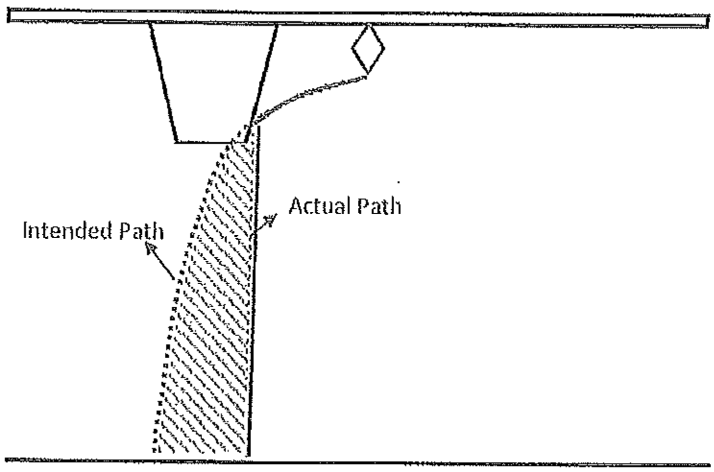

Figure 13: Obstruction hindering coverage of sprinkler

For a situation encountered in current project, a light fixture was suspended of the ceiling by 134mm, and the sprinkler has a height of 84mm, hence the distance between the tip of the sprinkler to the bottom of the light fixture is 50mm. Hence going along the 50mm line on the y-axis of Figure 14 till the curve is met, it is seen the minimum horizontal spacing required will be 234mm between the centerline of the sprinkler and the edge of the light fixture.

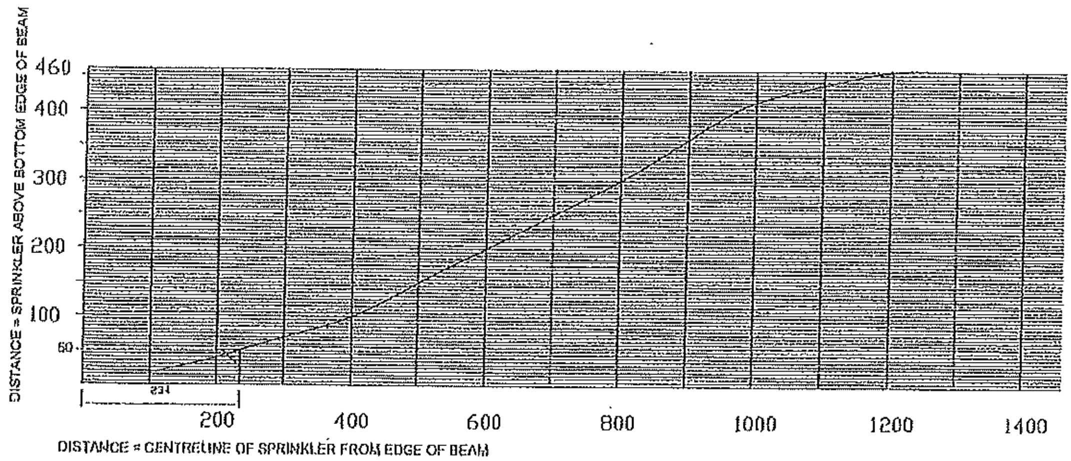

Figure 14: Beam rule for sprinkler spacing

6.0 Reflective Appraisal

Working with an organization that is widely regarded as a leader with its par-excellence approach has been an amazing experience. In some aspects it has been an opportunity to understand the challenges professional engineers face and the skills that I need to develop to fit in an organization of such kind. Although the academic abilities that I possess as a student are something I am very confident about but the chance to work in large multi-disciplinary groups like in our systems papers (ENGGEN 204,303 and 403) have been the most useful when it comes to a working environment. Communication and team work skills are the most important when it comes to an organization and am glad I could develop these through the various team based project at university.

During the week prior to the Christmas break, the 50% developed design had to be issued to the client. Both my Technical Director and the senior engineers were on an important site visit for a previous project. During this time I had the responsibility to gather the relevant drawing sets from the electrical, fire protection, plumbing, security and mechanical teams and go through the drawings for any errors which normally a senior engineer would do. This task was an excellent experience for me as I had to use communication and coordination skills to communicate to the different teams and highlight any errors hours before the drawings had to be issued.

Very early on in my employment, my section manager recognized my willingness to learn. Subsequently, he approached me to assist the fire engineering team as they were under staffed and deliverables were due in following week. At first I was very hesitant to do something which I had no academic background in, however I took this opportunity to learn a new field of engineering. In hindsight, this was one of the most enjoyable tasks I completed during by employment tenure.

Overall, what I have found is that I need to work on paying more attention to detail in my work. There were numerous times during my internship where I found I was not paying attention to the specifics of the building design and what activities would be taking place in the room. This step has a great impact on whether a smoke detector is replaced by a heat detector to prevent false alarms.

Throughout my employment, I made the conscious effort to socialize and familiarize myself with my colleagues. I was fortunate that upon my joining, there were various Christmas celebrations from which I could get a chance to mingle with other employees. Through these events I got the opportunity to network and get some advice from recent graduates and very senior staff on my future engineering career. This was one of the highlights of my internship.

7.0 Conclusions

HVAC design is a very large and broad field. However, as a summer intern, I was given the responsibility of sizing a very large network of ducts on floor H1 serving the lobby in the

Although the actual sizing procedure is very linear and straightforward, the main challenge was trying to find space in the small ceiling void to run the duct containing all the other services. This is a problem that is not encountered in the building services course at university but requires basic engineering knowledge to minimize the number of bends to minimize frictional losses.

Secondly, fire protection engineering is a relatively new but an important field immerging in building services engineering. The specifications in the standards are sometime not full-proof as some peculiar building designs are encountered in reality, differing from the simplified geometries considered in the standards. This proves a great challenge when positioning fire protection devices (sprinklers and detectors) but a conservative approach is taken using basic engineering knowledge so the design can be commissioned.

This internship with . has been one of the most enriching experiences as part of my professional career. The main skills I learnt as part of my internship are as follows:

- Negotiation and coordination skills with other services teams, trying to manage all the building facilities in the limited ceiling void. The key element here was trying to communicate with each of the other teams, some of which were outside the company like the acoustics engineers.
- I had the exposure to two very important softwares, AutoCAD and Revit MEP. Both of these are industry standard software and will be very beneficial for me in my future engineering career.
- The familiarization with Australian, British and New Zealand standards has been a very knowledgeable skill I have acquired. The constant cross-checking with these codes during the design processes is an important step. This step was never considered during the course of the study at the university.
- Working on both the mechanical design and fire protection engineering work simultaneously, I have gained great time management skills. Coordinating deliverables with the senior engineers and technical directors for both disciplines keeping in mind the other team members waiting for my work, time management has been a great skill I have developed.

Overall, I can conclude from this internship that I have been able to gain some very practical skills in a professional consultancy. There are many real-world problems that are commonly seen in applications which are ignored in an educational environment. The skills listed above will very beneficial in my future engineering career in addition to the skills I have acquired in the course of study at university.

Very well done!