Duct Design of Assembly Hall at Mandalay Technological University

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Abstract- It is intended to air-condition the internal space of the Assembly Hall at Mandalay Technological University (MTU). The main objective of air conditioning is for human comfort and the preservation of equipment. The unit thus consists of refrigeration system, the control system, electrical protection system, air circulation system and ventilation (fresh air damper) exhaust system. The most important function to install an air-conditioning system is to calculate the cooling load and duct design of the Assembly Hall at MTU. But this paper analyses duct design for required air distribution of designed space. After a series of calculation and designing the outcome was a possible solution for an optimum ducting system for our hall. The proposed design is compatible only for Assembly Hall at MTU, but the same design procedures are applicable to large ducting systems in skyscrapers and factories.

Index Terms- Air-condition, Assembly Hall, Duct design, Friction losses, Latent Heat, Sensible Heat.

I. Introduction

People appreciate the relief from discomfort afforded by a modern air conditioning system. Air conditioning, by its very name, means treating or conditioning of air to alter its temperature and moisture content to suit specific requirements [1]. Besides using in summer, it may use an air conditioning in winter for heating.

Air conditioning is used for maintaining conditions:

1) Suitable for human comfort or
2) Required by a product or process [2].

Air conditioning of office buildings, auditoriums, homes, classrooms, automobile, railway coaches, etc. is meant for maintaining comfort conditions for the occupants. In addition to the control of temperature and relative humidity, it is necessary to maintain proper air circulation and a low dust level in the conditioned space. Other typical applications of air conditioning include industrial purposes such as, watch assembly shops, telephone manufacturing, chemical industry, tool rooms, jig boring machine rooms, pharmaceutical industry, telephone exchanges, computer rooms, laboratories [3].

This paper relates the dry bulb, wet bulb and dew point temperature of air with its sensible, latent and total heats, and presents a theory of adiabatic saturation. Ducts are used in heating, ventilation, and air conditioning (HVAC) to deliver and remove air. These needed airflows include, for example, *supply air*, *return air*, and *exhaust air*. Ducts also deliver, most commonly as part of the *supply air*, *ventilation air* As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort [4].

In summer, the weather is very hot in Myanmar. In this condition, the students, guests and staffs are not comfortable being in the Assembly Hall. So it is required a comfort condition in the Assembly Hall at Mandalay Technological University.

II. Design condition of ASSEMBLY Hall

Outside condition

Dry bulb temperature = 43 $^{\circ}$C

Wet bulb temperature = 28 $^{\circ}$C
Relative humidity = 30%
Specific humidity, = 0.0175 kg/kg dry air

Inside condition

Dry bulb temperature = 25 $^{\circ}$C
Relative humidity = 50%
Specific humidity, = 0.01 kg/kg dry air

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Location	: 22° N Latitude and 96° 32' E Longitude
Side of space	: 36.5760 m × 12.1920 m × 7.9248 m
Daily range	: 30° C to 43° C = 13° C
Occupancy	: 400
Electric fluorescent	: 16 × 80W and 4 × 40W (factor=1.5)
Electric halogen light	: 4 × 1000 W (factor = 1)
Plaster on inside wall	: 1.5 cm
Outside wall construction	: 20 cm concrete block
	: 10 cm brick
Floor construction	: 60 cm concrete
Roof construction	: 0.3 cm zinc
Ceiling construction	: 0.5 cm plywood
Density; Brick	: 2000 kg/m^3
Concrete	: 1900 kg/m^3
Plaster	: 1885 kg/m^3
Asbestos board	: 520 kg/m^3
Glass	: Single glass
Doors; South	: 2 × (1.4478 m × 2.0754 m)
East	: 0.8 m × 2.0754 m
West	: 0.8 m × 2.0754 m
Bypass factor of cooling coil	: 0.15 (assume)

III. HEAT GAIN SOURCES

The interior of the building gains from a number several of sources. If the temperature and humidity of air in rooms are to be maintained at a comfortable level, heat must be extracted to offset these heat gains. The net amount of heat that is removed, is called cooling load. [2]

The components contribute to room heat gain consist of the following items.

Table I: Sensible and Latent Heat Gains [2]

Items	Sensible heat, Q_S	Latent heat, Q_L
Heat gain through exterior structure	Yes	No
Transmission gain through interior structure	Yes	No
Infiltration and outside air	Yes	Yes
Internal gain	Yes	Yes
Miscellaneous gain	Yes	Yes
Outside air through apparatus	Yes	Yes

Grand total heat = 229948.4369 W = 65.4006 TR

Effective sensible heat factor = ERSHG/ERTHG =127525.2550/159290.9969 = 0.8

From psychometric chart,

Apparatus dew point temperature = 11˚C

Assuming; BF = 0.2

Supply $(CMM)_{min}$ $= \frac{ERSHG\ (kW)}{0.0204(t_i - t_{ADP})} = \frac{127.5253}{0.0204(25-11)}$ = 446.5172 CMM ≈ 447 CMM

Supply temperature, t_s $= \frac{ERSHG}{0.0204(CMM)} = \frac{127.5253}{0.0204(447)}$ = 13.9˚C

CMM_{supply} $= \frac{ERSHG\ (kW)}{0.0204(t_i - t_S)} = \frac{127.5253}{0.0204(25-11)}$ =563.1748 CMM ≈564 CMM

Resulting entering and leaving conditions at apparatus;

Entering temperature, t_1 $= t_i + \frac{CMM_{oa}}{CMM_{sa}}(t_o - t_i) = 25 + \frac{112}{564}(43-25)$ = 28.6 ˚ C

Leaving temperature, t_2 $= t_{ADP} + BF (t_1 - t_{ADP}) = 11 + 0.2(28.6-11) = 14.52^\circ C$

IV. DUCT DESIGN RESULTS FOR HALL

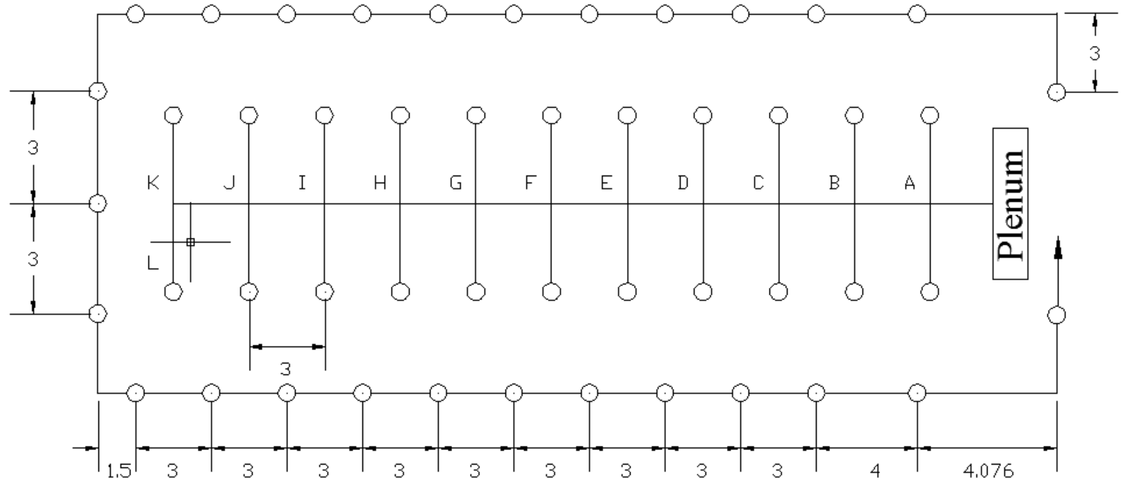


Figure 1. Duct design plan for hall

For Supply Duct,
Supply CMM = 564 CMM
Number of diffuser = 22
Capacity for each diffuser = 564/22
= 25.6364 CMM ≈ 26 CMM

By Equal Friction Method
Example: Fan to A
Supply air = 564 CMM
From Table,
Velocity = 390 m/min [5]
Duct area $= \frac{564}{390}$
$= 1.4462\ m^2$

From Table, choose a duct size (150 cm × 100 cm) for area 1.4415 m^2.[5]
Equivalent round duct diameter = 133.3 cm
Aspect ratio $= \frac{150}{100} = 1.5 : 1$

Duct sizes and lengths for the supply ducts are shown in Table 2 and 3.

Table 2. Duct Sizing Calculation Results Form for Supply Duct

Duct section	Air quantity CMM	CMM Capacity (%)	Duct area (%)	Duct area (sq.m)	Equivalent round duct dia: (cm)	Rectangular duct (cm × cm)	Aspect ratio
Fan to A	564	100	100	1.4462	133.3	150 × 100	1.5 : 1
A to B	512	91	40.5	0.5857	87	85 × 75	1.13 : 1
B to C	460	82	36	0.5206	82	75 × 75	1 : 1
C to D	408	72	33	0.4772	79	75 × 70	1.1 : 1
D to E	356	63	30	0.4339	76.5	70 × 70	1 : 1
E to F	304	54	26	0.3760	71	65 × 65	1 : 1
F to G	252	45	22.5	0.3254	65.5	60 × 60	1 : 1
G to H	200	36	19	0.2748	60.3	55 ×55	1 : 1
H to I,	148	26	15	0.2169	54.8	50 × 50	1 : 1
I to J	96	17	10.5	0.1519	43.8	40 × 40	1 : 1
J to K	44	8	4.5	0.0651	32.8	30 × 30	1 : 1
K to L	26	5	3	0.0434	24.5	25 × 20	1.25 : 1

Table 3. Equivalent Length Calculation Form for Supply Duct

Duct section	Item	Length (m)	Additional equivalent length (m)
Fan to A	Duct	3.576	
A to B	Duct	3	
B to C	Duct	3	
C to D	Duct	3	
D to E	Duct	3	
E to F	Duct	3	
F to G	Duct	3	
G to H	Duct	3	
H to I	Duct	3	
I to J	Duct	3	
J to K	Duct	3	
	Elbow		3
K to L	Duct	3.5	
	Diffuser		4.5
		37.076	7.5

For Return Duct,
Supply CMM = 447 CMM
Number of diffuser = 27

Capacity for each diffuser $= \frac{447}{27} = 16.556$ CMM $\approx$ 17 CMM

By Equal Friction Method
Fan to 1

Supply air = 447 CMM
CMM capacity percent = 100%
Velocity = 330 m/min [5]

Duct area $= \frac{447}{330} = 1.3545\ m^2$

From Table, choose a duct size (145 cm × 100 cm) for area 1.3950 m^2.[5]
Equivalent round duct diameter = 131 cm

Aspect ratio $= \frac{145}{100} = 1.45:1$

Table 4 and 5 illustrate designed data for the Return Duct.

Table 4. Equivalent Length Calculation Form for Return Duct

Duct section	Item	Length (m)	Additional equivalent length (m)

Fan to 1	Duct	3	
1to 2	Duct	7.076	
	Elbow		3
2 to 3	Duct	4	
3 to 12	Duct	27	
12 to 13	Duct	4.5	
	Elbow		3
13 to 15	Duct	6	
15 to 16	Duct	4.5	
16 to 25	Duct	27	
	Elbow		3
25 to 26	Duct	4	
26 to 27	Duct	7.076	
	Elbow		3
	Diffuser		5.5
		94.152	17.5

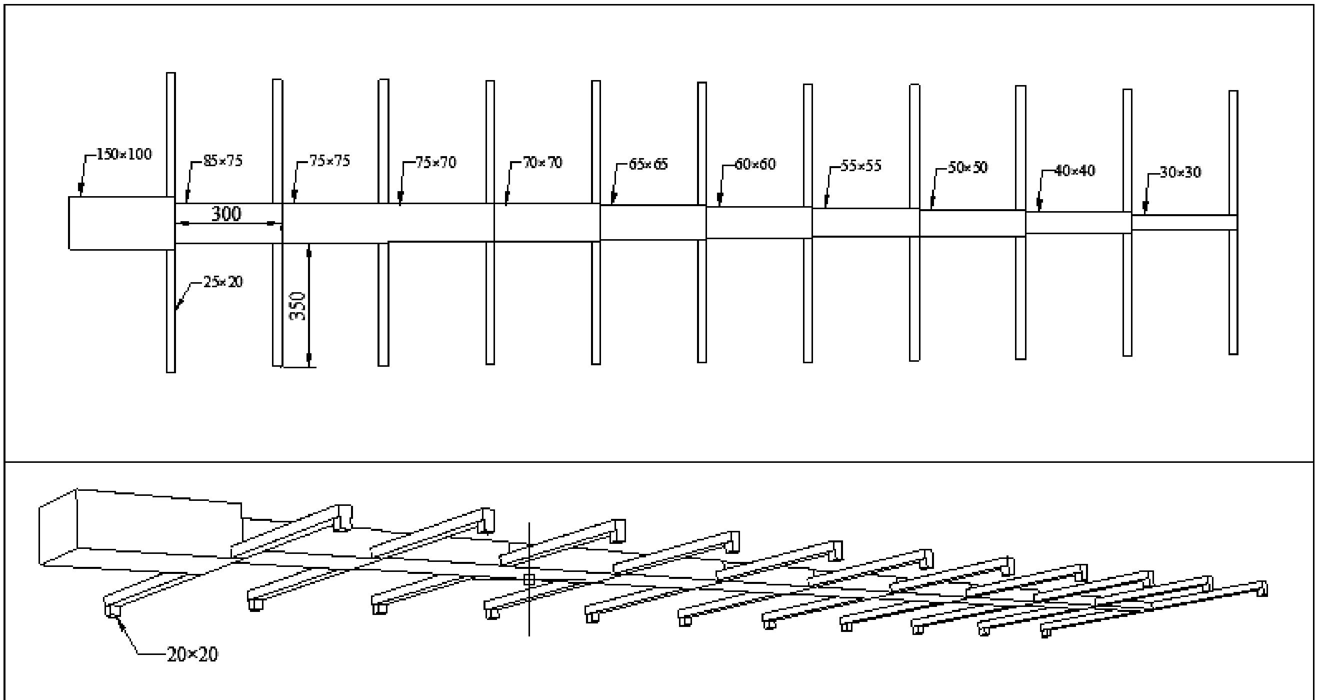
Table 5. Duct Sizing Calculation Results Form for Return Duct

Duct section	Air quantity CMM	CMM Capacity (%)	Duct area (%)	Duct area (sq.m)	Equivalent round duct dia: (cm)	Rectangular duct (cm × cm)	Aspect ratio
Fan to 1	447	100	100	1.3545	131	145 × 100	1.45 : 1
1 to 2	430	96	42	0.5689	84.5	80 × 75	1.07 : 1
2 to 3	413	92	40.5	0.5486	84.5	80 × 34	1.07 : 1
3 to 4	396	89	39	0.5283	82	75 × 75	1 : 1
4 to 5	379	85	37.5	0.5079	79	75 × 70	1.07 : 1
5 to 6	362	81	36	0.4876	79	75 × 70	1.07: 1
6 to 7	345	77	35	0.4741	76.5	70 × 70	1 : 1
7 to 8	328	74	33.5	0.4538	76.5	70 ×70	1 : 1
8 to 9	311	70	32	0.4334	73.8	70 × 65	1.08 : 1
9 to 10	294	66	30.5	0.4131	73.8	70 × 65	1.08 : 1
10 to 11	277	62	29.5	0.3996	71	65 × 65	1 : 1
11 to 12	260	58	27.5	0.3725	68	65 × 60	1.08 : 1
12 to 13	243	54	26.5	0.3589	68	65 × 60	1.08 : 1
13 to 14	226	51	25	0.3386	65.5	60 × 60	1 : 1
14 to 15	209	47	23.5	0.3183	62.8	60 × 55	1.09 : 1
15 to 16	192	43	22	0.2980	62.8	60 × 55	1.09 : 1
16 to 17	175	39	20.5	0.2777	60.3	55 × 55	1 : 1
17 to 18	158	35	19	0.2573	57.3	55 × 50	1.1 : 1
18 to 19	141	32	17.5	0.2370	54.8	50 × 50	1 : 1
19 to 20	124	28	15	0.2032	51.8	50 × 45	1.1 : 1
20 to 21	107	24	14	0.1896	49.3	45 × 45	1 : 1
21 to 22	90	20	12	0.1625	46.3	45 × 40	1.12 : 1
22 to 23	73	16	10.5	0.1422	43.8	40 × 40	1 : 1
23 to 24	56	13	8	0.1084	38.3	35 × 35	1 : 1
24 to 25	39	9	6	0.0813	32.8	30 × 30	1 : 1
25 to 26	22	5	3	0.0406	24.5	25 × 20	1.25 : 1
26 to 27	17	4	2.5	0.0339	24.5	25 × 20	1.25 : 1

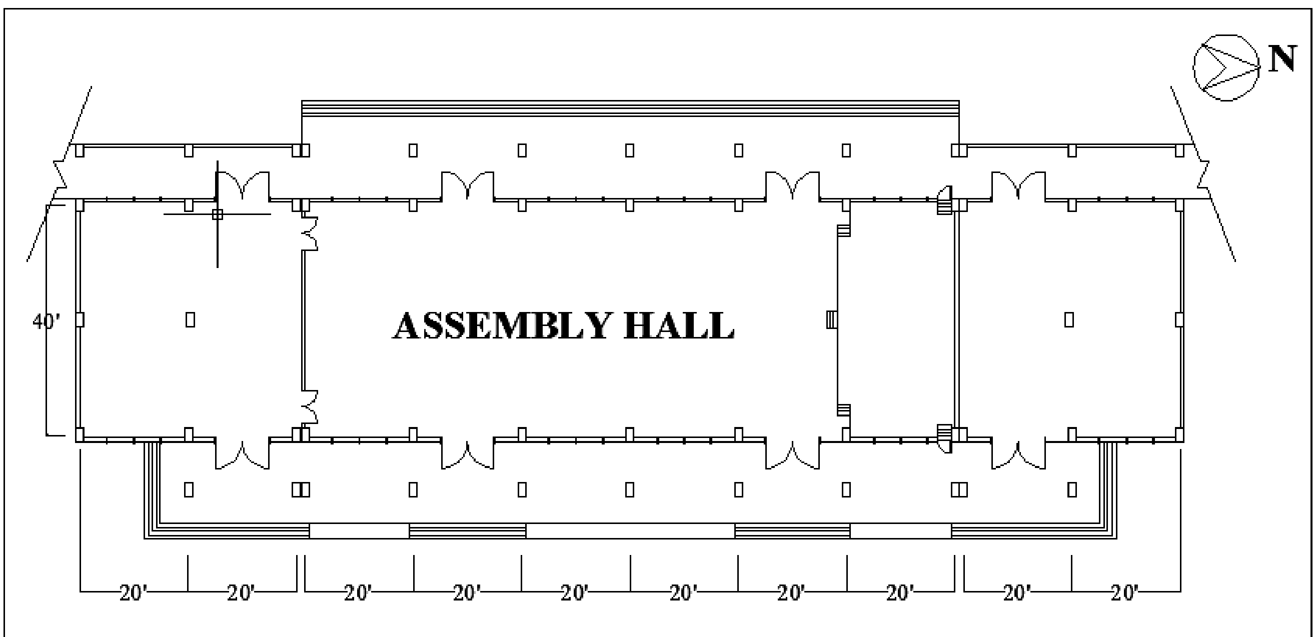
V. CONCLUSION

Design of duct for Assembly Hall at MTU was presented in this paper. Cooling load capacity of this hall was found to be 65 tons, supply air 564 CMM, entering temperature was 28.6˚C, and leaving temperature was 14.52˚C. For duct design, equal friction method was used for supply duct design and return duct design. The supply air for each duct section and duct layout was calculated. To achieve adequate supply air distribution, the supply air CMM for outlet was divided by area proportions method. The reduction of duct section should be carefully designed. In this particular design, return duct was necessary because the fan was not located adjacent to the space to be cooled and doors are closed throughout. In conclusion, this duct design can be applied in the implementation of air-conditioning system in MTU's Assembly Hall.

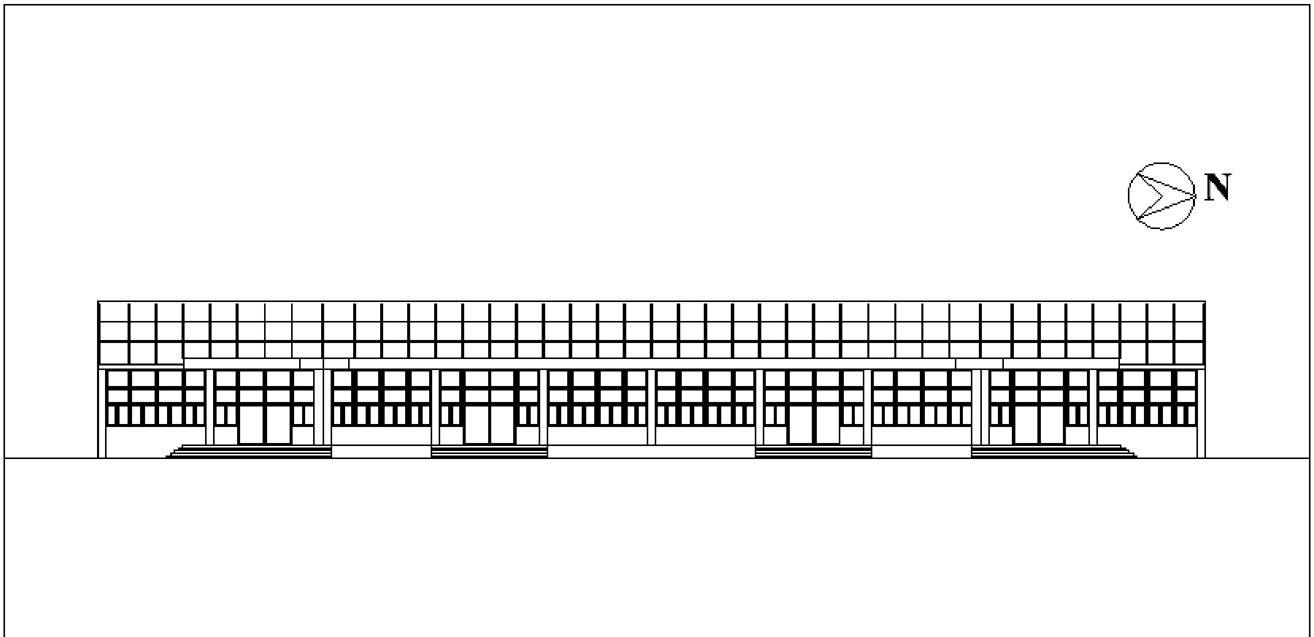
APPENDIX



DRAWING NAME:	TOP AND PERSEPCTIVE VIEW OF DUCT LAYOUT	DEPARTMENT OF MECHANICAL ENGINEERING	
DRAWN BY:	LWIN MYO	MANDALAY TECHNOLOGICAL UNIVERSITY	
		SCALE : 1:15	UNIT : cm



DRAWING NAME	PLAN VIEW OF ASSEMBLY HALL AT M.T.U	M.T.U
DRAWN BY	LWIN MYO	SCALE : 1:300
DEPARTMENT	DEPARTMENT OF MECHANICAL ENGINEERING	UNIT : inch



DRAWING NAME	FRONT VIEW OF ASSEMBLY HALL AT M.T.U	M.T.U
DRAWN BY	LWIN MYO	SCALE : 1:300
DEPARTMENT	DEPARTMENT OF MECHANICAL ENGINEERING	UNIT : inch

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