UTM
UNIVERSITI TEKNOLOGI MALAYSIA

UNDERGRADUATE PROJECT 1

Measurement of Aerodynamic Loads on the Flow Coefficient of a Natural Ventilator ”

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UTM
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- OBJECTIVES & SCOPE
- SIGNIFICANCE OF STUDY
- PRODUCT OVERVIEW
- HOW DOES IT WORK
- MEASUREMENT TECHNIQUE
- RESEARCH PLANNING

WHAT IS VENTILATION?

- Is a process of circulating air in an enclosed area with atmosphere through stack effect. (Khan et al., 2008)

Figure 1: Ventilation Process

Figure 2: Stack Effect

Source (Figure 1): https://www.windowmaster.com/solutions/natural-ventilation/passive-ventilation
Source (Figure 2): https://www.indiamart.com/proddetail/stack-effect-architectural-services-7147264930.html

BUOYANT FORCE

- Fluid with higher temperature, will have a lower density and rises up

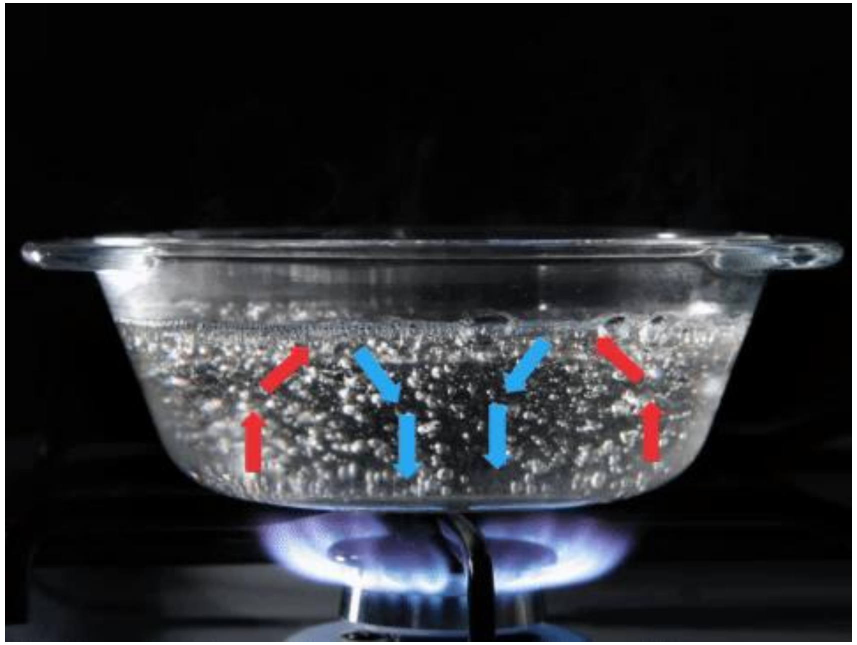


Figure 3: Buoyant Force

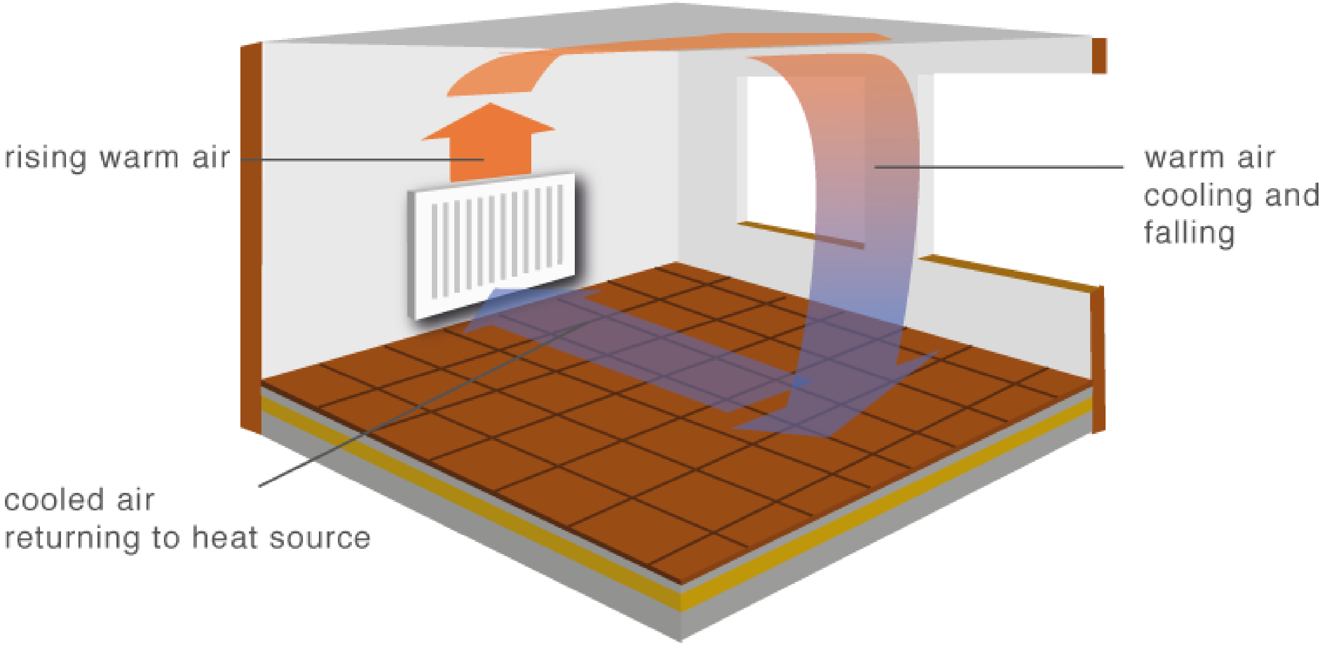
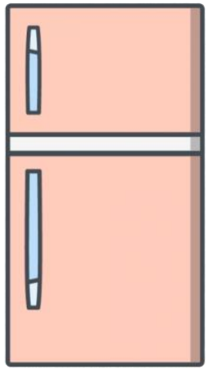


Figure 4: Convection Current in Building

HEAT SOURCES IN BUILDING

Human



Electrical Appliances

Radiation From Sun Through Windows

Cooking Appliances

OBJECTIVES

1. To design measurement techniques and further fabricate the experimental setup

2. To determine flow coefficient, Cf of the natural ventilator at different tilting angles

SCOPES

1. The experimental will be executed at 0-6 m/s of wind speed using MD UTV 24’’ fully aluminum construction spherical turbine ventilator

2. Experiment setup will be following Australian/New Zealand Standard 4720:2000

   - 5 Velocities for each testing setup (for every angle of attack)
   - Follow the experimental setup provided

WHY THIS TOPIC?

IMPORTANCE OF VENTILATION?

1. Important to keep enclosed breathing area with fresh and good quality air in which no known contaminants are present in harmful concentrations. (Oakley, 2002)

2. More than 8000 chemical species have been identified in the indoor environment (Dichloroethane, Formaldehyde, Nitrogen Dioxide, etc) (Awbi, 1991)

3. Without ventilation, the effects are excessive humidity, condensation, overheating and build-up of odors (Khan et al., 2008).

WAY OF INSTALLATION

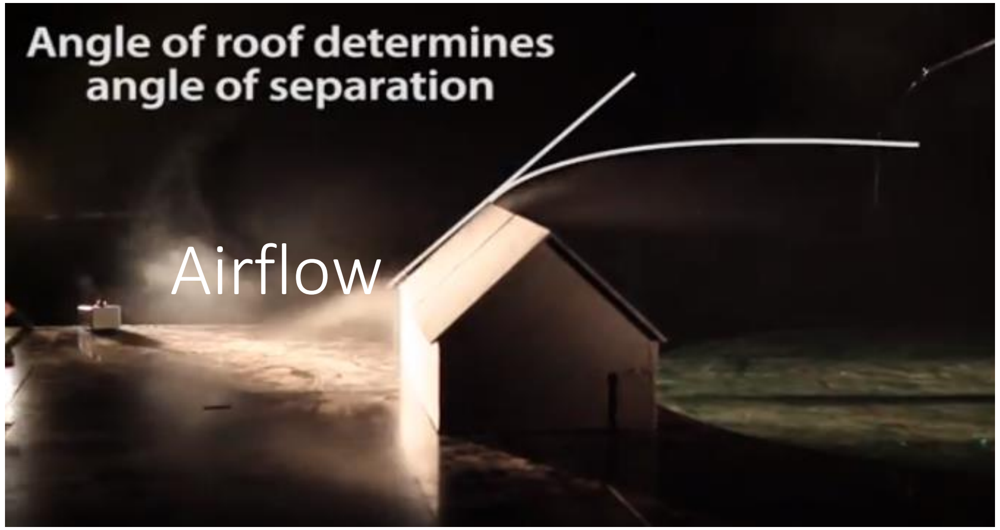
Some turbines are installed at an angle and some perpendicular to the ground

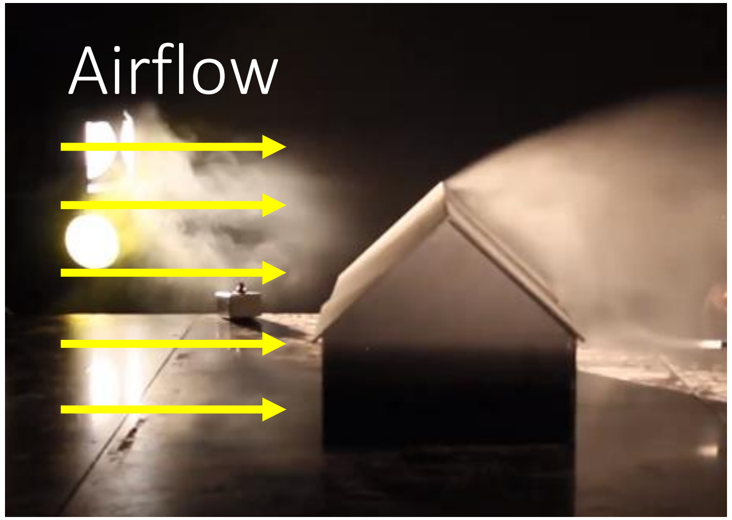
Figure 1: Ventilator Installed at an angle

Figure 2: Ventilator Installed at perpendicular to ground

Source (Figure 1): https://www.indiamart.com/proddetail/natural-turbo-air-ventilator-15801340912.html
Source (Figure 2): Australian/New Zealand Standard 4740:2000

DIFFERENT AIRFLOW BEHAVIOR

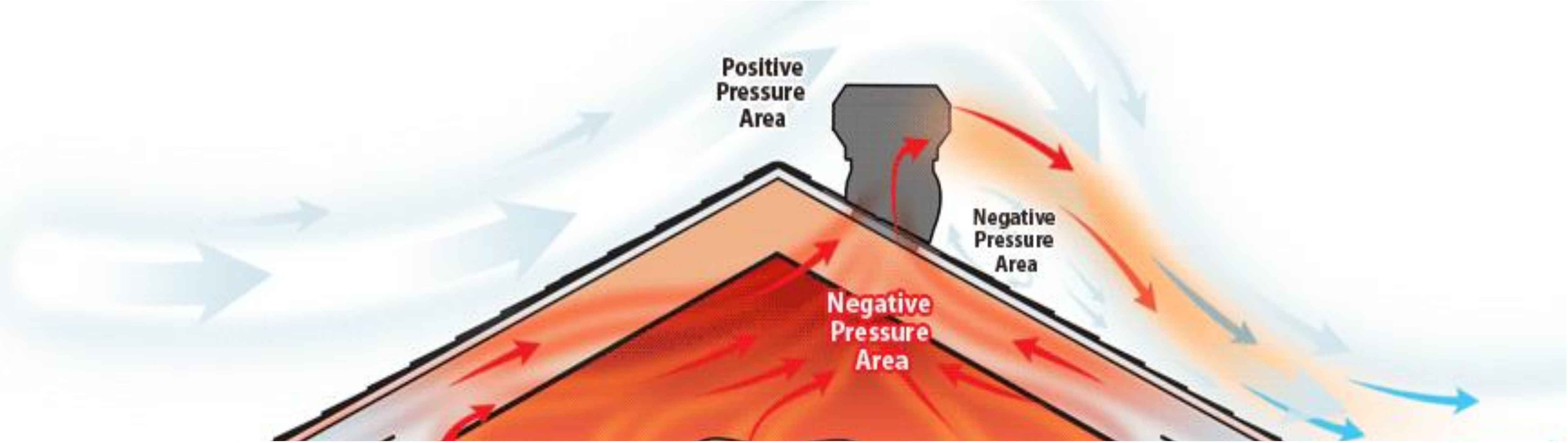




STRUCTURE OF TURBINE VENTILATOR

Image source: https://www.shirokoi.org

AIRFLOW THROUGH TURBINE VENTILATOR



HOW DOES IT WORK?

1. Hot air are accumulated in the attic

2. Hot air from attic flows through the turbine blades to outside of the house and rotates ventilator even with absence of breeze air

3. Presence of breeze air which pass through the turbine ventilator will rotate the turbine blades even faster

4. Negative pressure will be generated inside the turbine ventilator hence increase the flow rate of ventilation

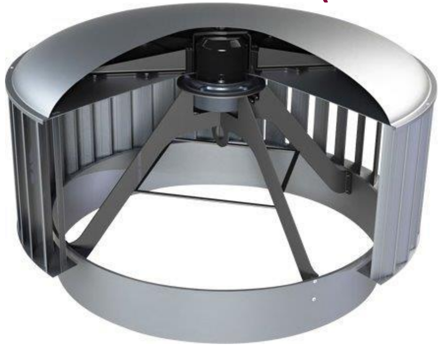
TURBINE VENTILATORS (ACTIVE & PASSIVE)

ROTATING CHIMENY COWL (PASSIVE)

WIND DRIVEN VENTILATOR

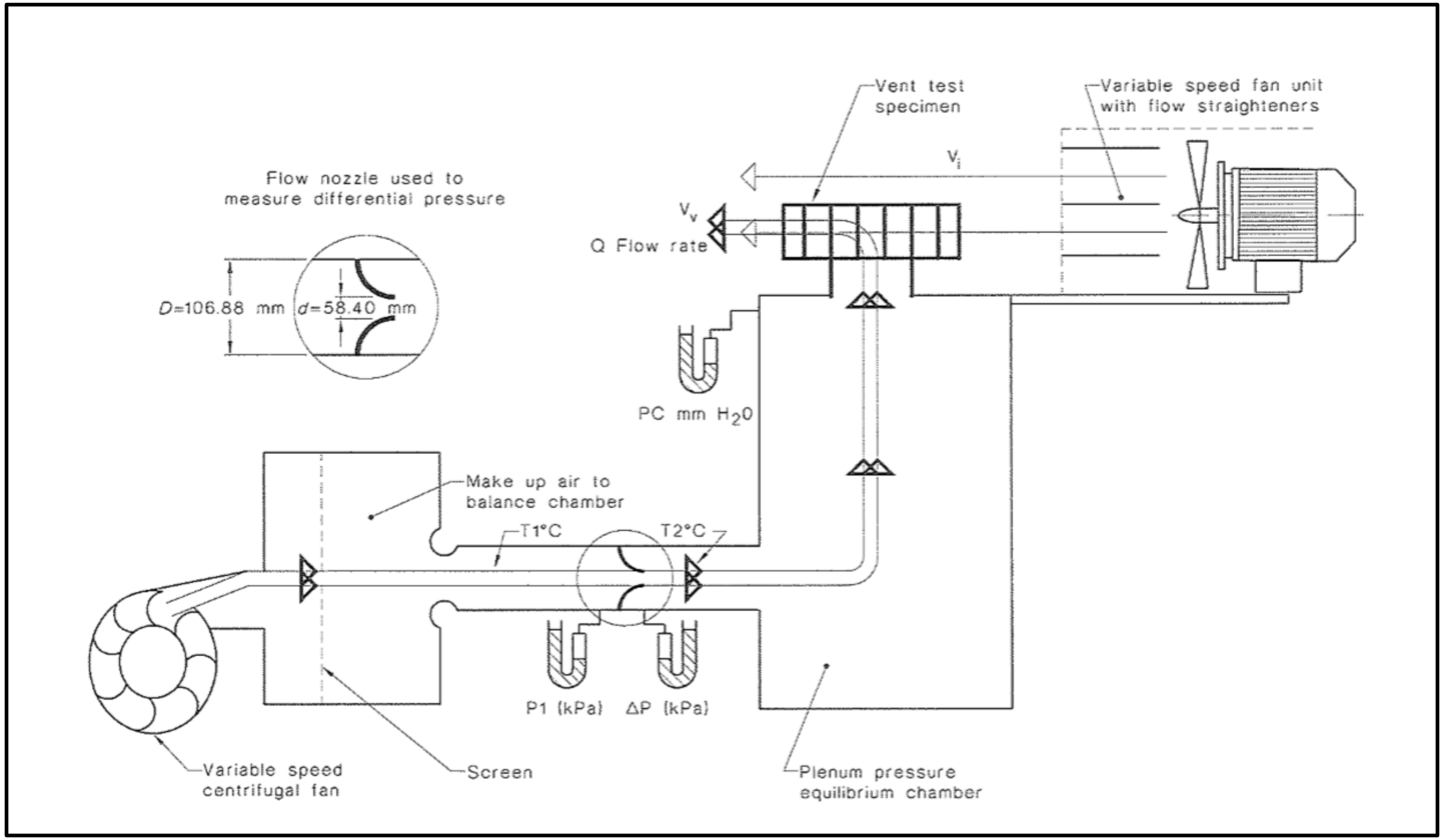
VERTICAL AXIS WIND EXTRACTOR (VAWTEX) (ACTIVE & PASSIVE)

ECO POWER (ACTIVE)



Source : https://www.breezsol.com/product-category/ventilation/roof-ventilation/

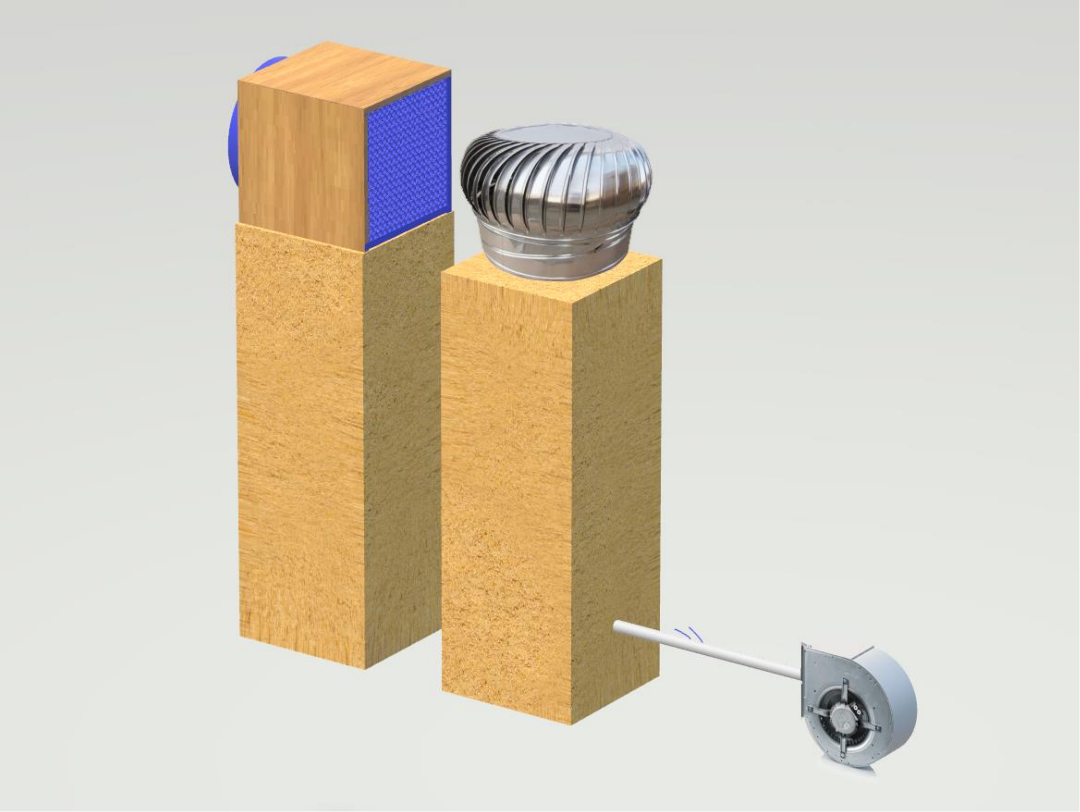
EXPERIMENTAL SETUP

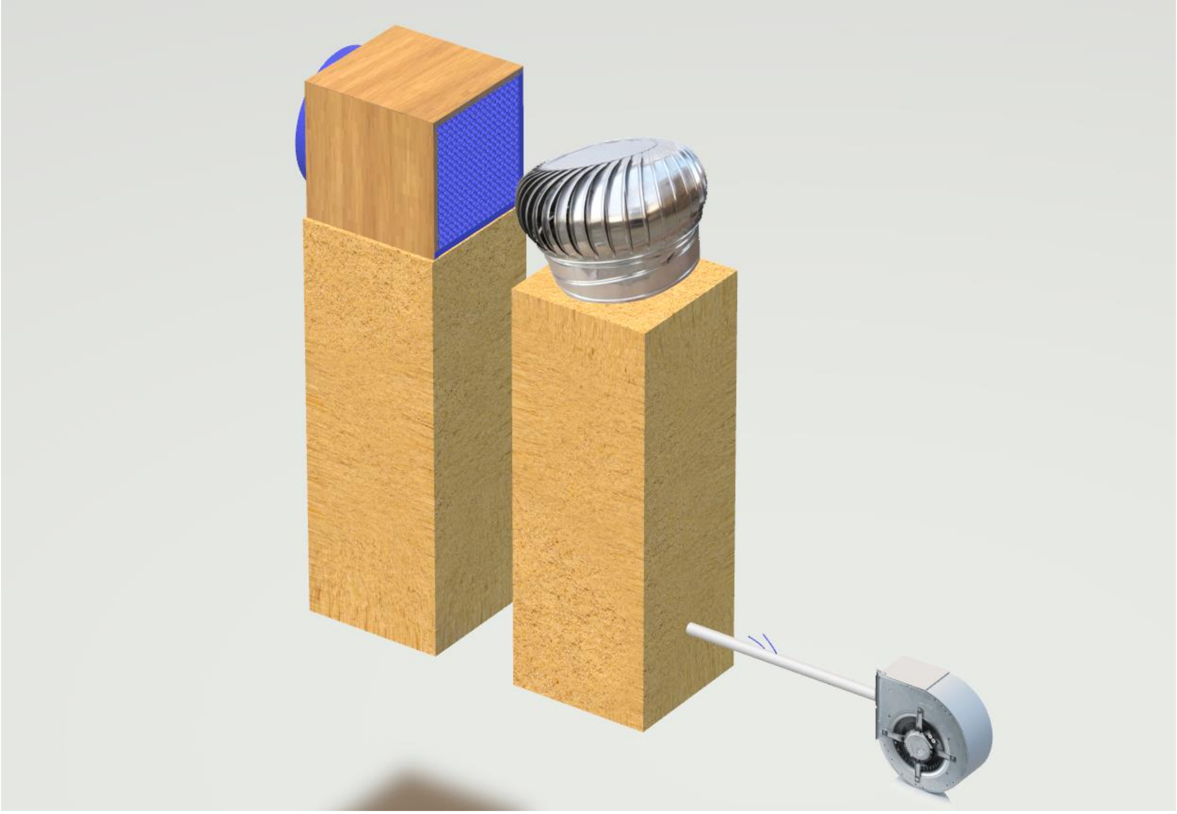


Source: Australian/New Zealand Standard 4740:2000

EXPERIMENTAL SETUP

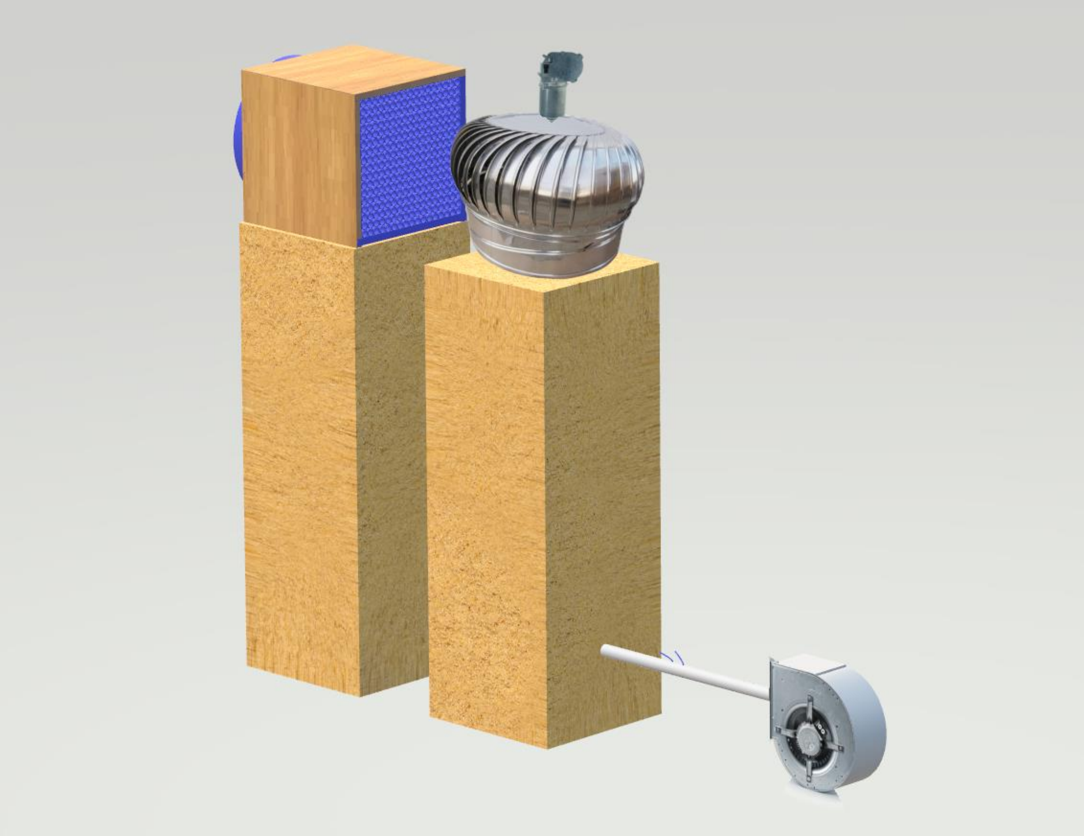
Experiment 1



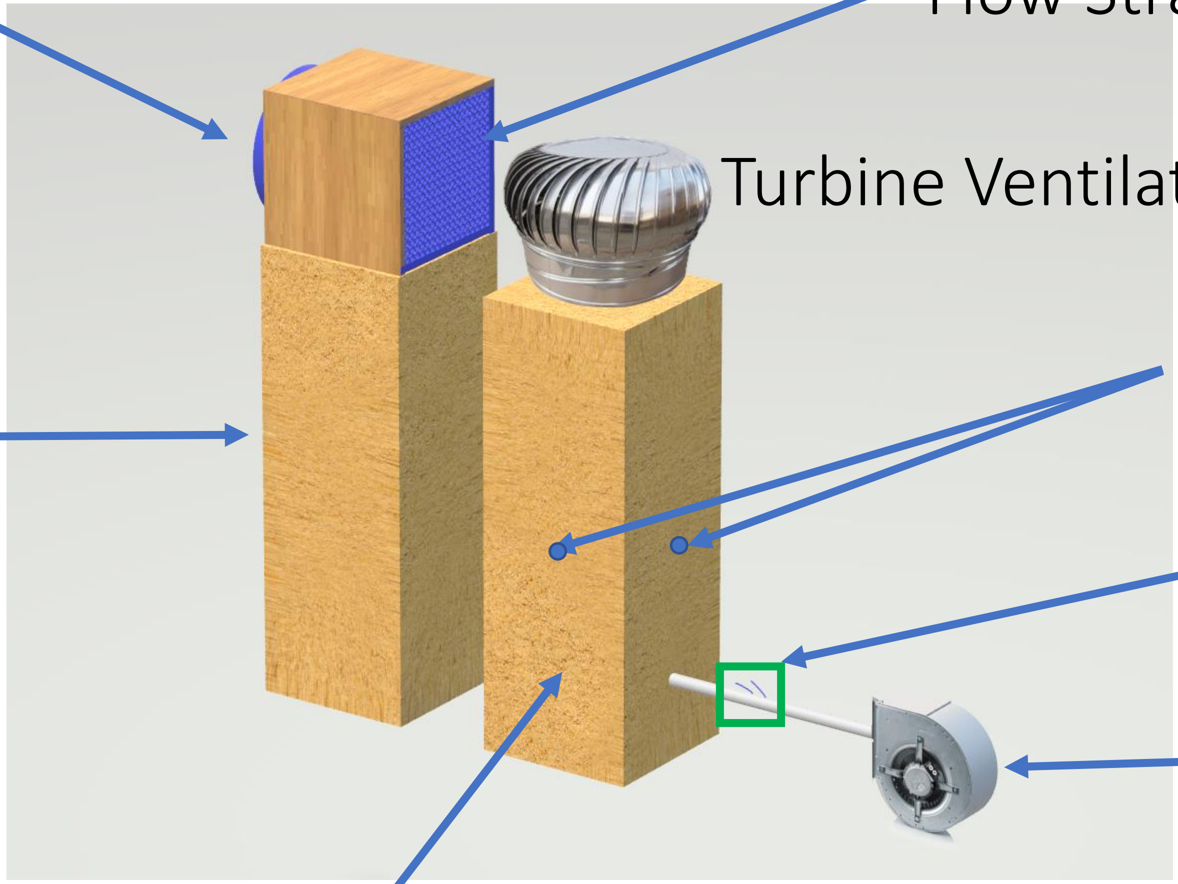


EXPERIMENTAL SETUP

Experiment 2



PARTS & COMPONENT



PARTS & COMPONENT

Variable Speed Fan

- Act as breeze air to drive turbine ventilator and should able to produce 5 different velocity

Optical Tachometer

- Used to measure the rotational speeds of the turbine ventilator

Centrifugal Fan

- Act as intake air from ambient into planum chamber

PARTS & COMPONENT

Orifice

- To measure the velocity of airflow from the centrifugal fan into the planum chamber refer to ISO 5801 for conical inlet arrangement & AS2360.1.1 for orifice arrangement

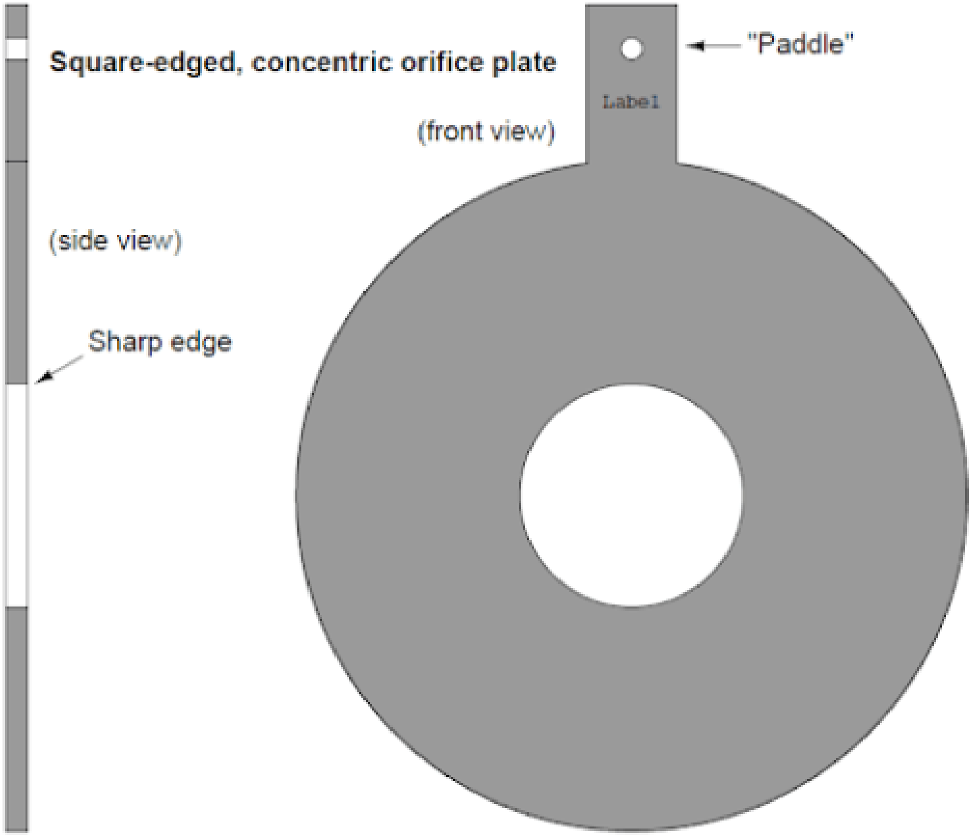
Plenum Chamber

- To force fresh air from atmosphere into a chamber to be ventilated, in which the pressure in chamber is slightly higher than atmospheric pressure [4]

Pressure Tappings

- To measure the average pressure inside the plenum and balancing chamber

ORIFICE PLATE SELECTION



CONCENTRIC PLATE

- Minimize contact with the fast-moving moving fluid stream going through the hole
- RE = 20,000 – 10^7 (for pipes under six inches)
- May be installed in either direction

Source: [6]

EXPERIMENT 1 SETTINGS

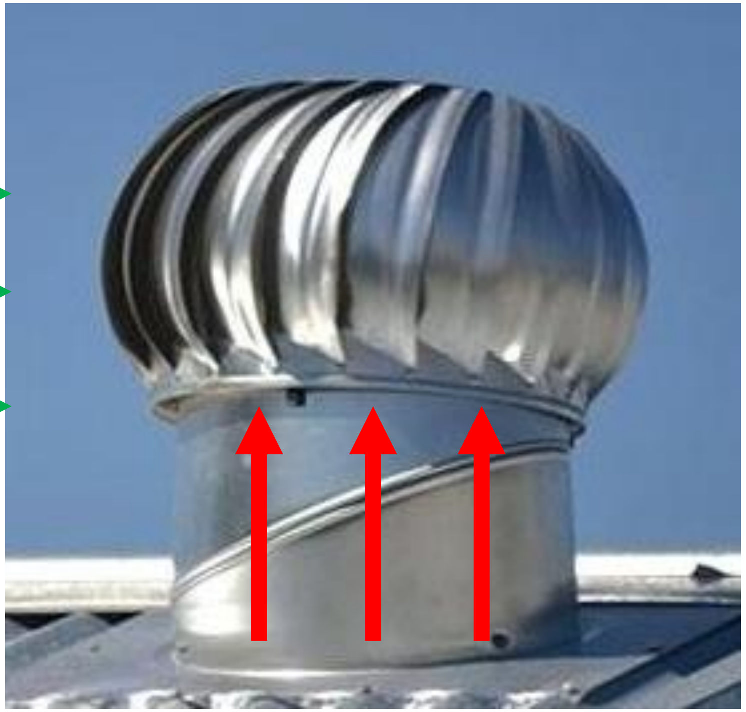
Parameter	Settings
Wind Speed	(0, 1, 2, 3, 4, 5, 6) m/s
Orifice	Concentratic Plate
Tilting Angle	0, 5, 10, 15, 20
Source of Turbine Rotation	Air Breeze

EXPERIMENT 2 SETTINGS

Parameter	Settings
Wind Speed	(0, 1, 2, 3, 4, 5, 6) m/s
Orifice	Concentratic Plate
Tilting Angle	0
Source of Turbine Rotation	Motor Driven

FLOW COEFFICIENT

V_i, Velocity of free field Incident on ventilator



V_v, Velocity through test specimen

$$\text{Flow Coefficient} = \frac{V_v, \text{Velocity through ventilator throat}}{V_i, \text{wind speed acting on ventilator}}$$

$$\text{Where } V_v = \frac{Q, \text{measured rate through ventilator}}{A_t, \text{ventilator geometric throat area}}$$

CALCULATION VOLUME FLOW RATE

$$Q = C_f A_o \sqrt{\frac{2\Delta P}{\rho}}$$

Where:

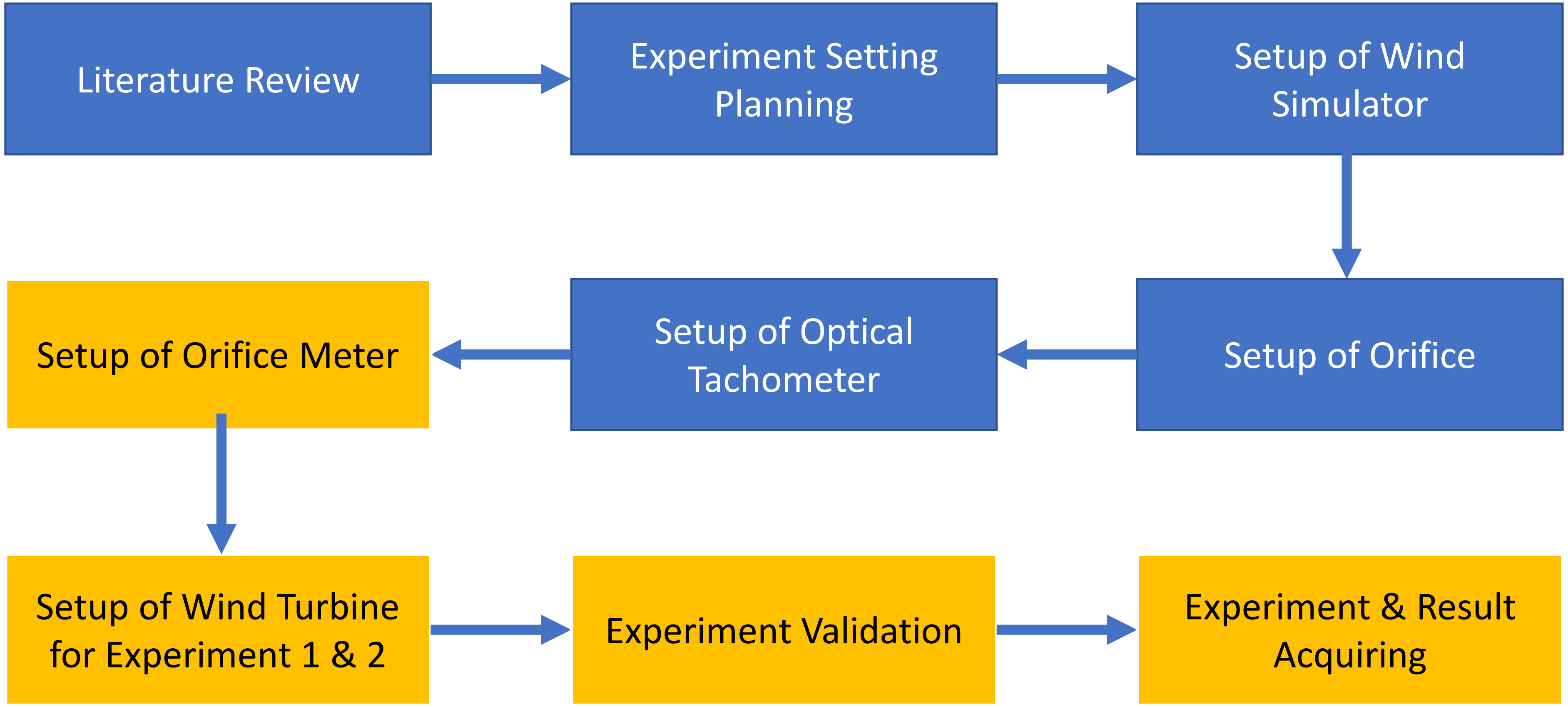
C_f = Obtained from experiments and is tabulated in reference books; it ranges from 0.6 to 0.9 for most orifices / ß ratio

A_o = Area of orifice

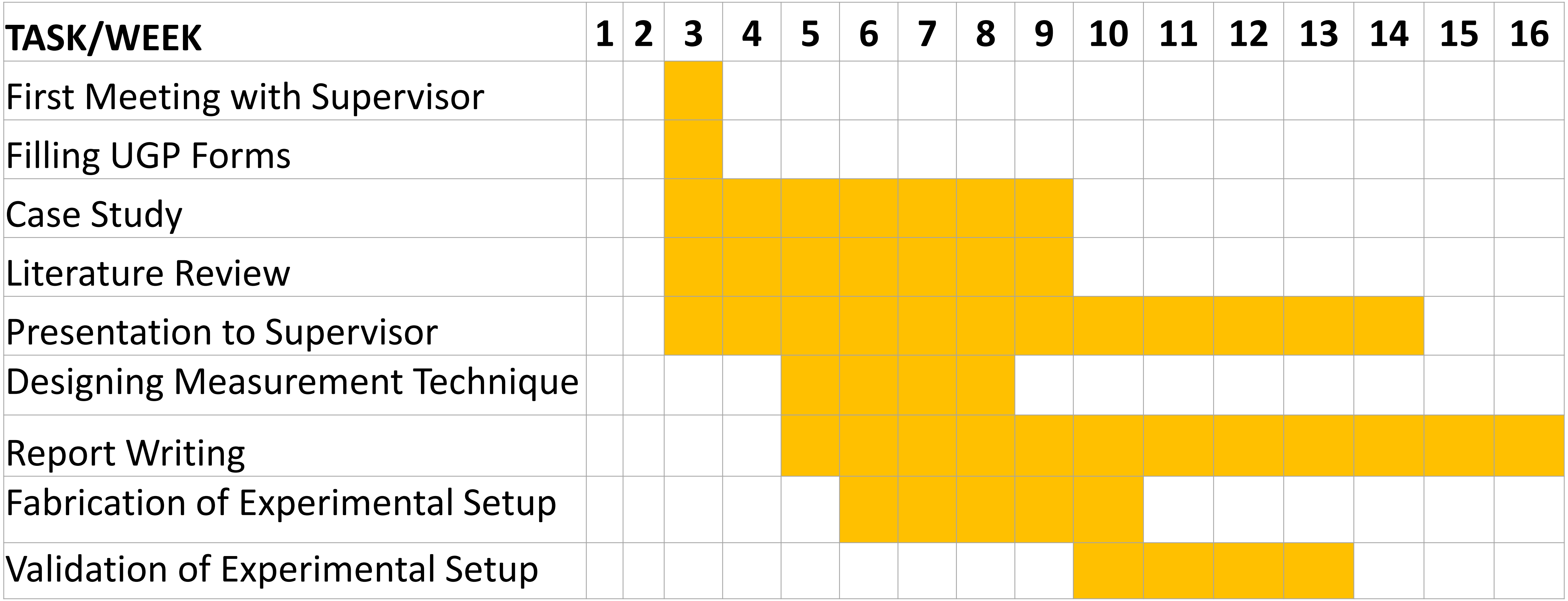
ΔP = Pressure difference between two locations before and after orifice

ρ = Density of fluid

Research Flow Chart



Gantt Chart


TASK/WEEK
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
First Meeting with Supervisor
Filling UGP Forms
Case Study
Literature Review
Presentation to Supervisor
Designing Measurement Technique
Report Writing
Fabrication of Experimental Setup
Validation of Experimental Setup

TASK/WEEK	14	15	16	17	18	19	20
Preparation for Seminar Presentation	■	■	■	■	■		
Print Report				■			
Seminar Presentation						■	
Submission of Log Book						■	
Report Submission to Supervisor						■	
Repairing Report						■	
Report Submission to Faculty						■	■

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Q&A SESSION

APPENDIX

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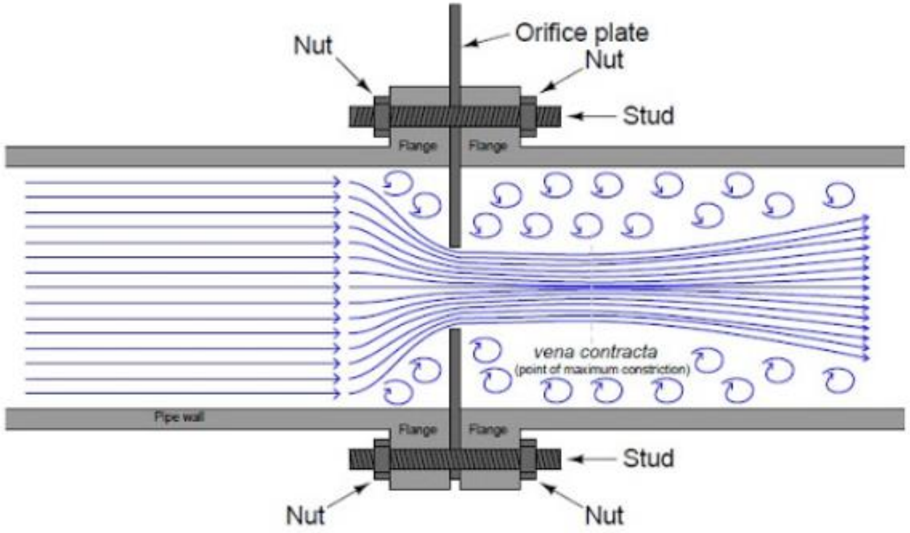
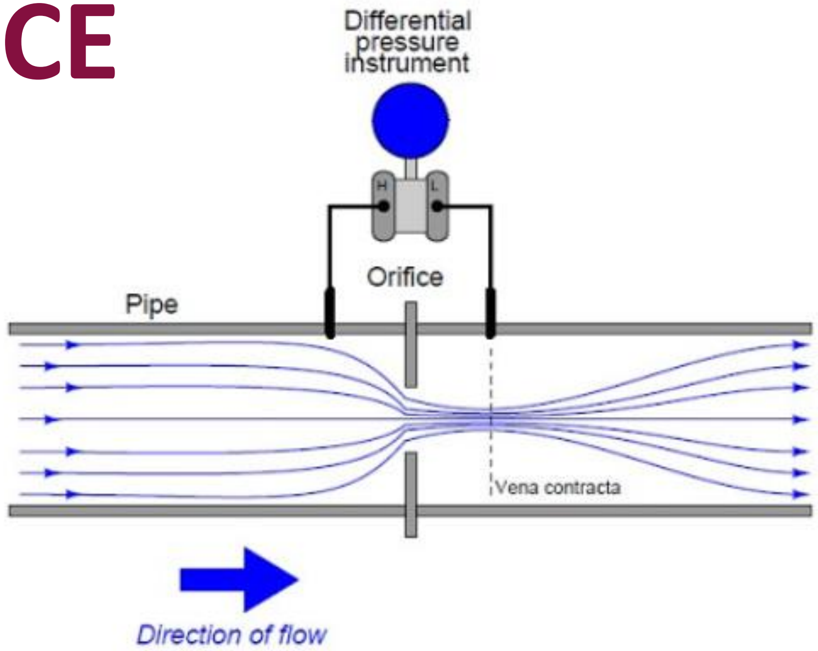
ORIFICE





1. Fluid will increase in pressure a little bit when closer to orifice and will drop suddenly when pass through the orifice

2. The pressure continue to decrease until it reach “vena contracta” then starts to increase gradually

3. Beta Ratio for gas fall between 0.2 - 0.7 (best result 0.4 – 0.6)

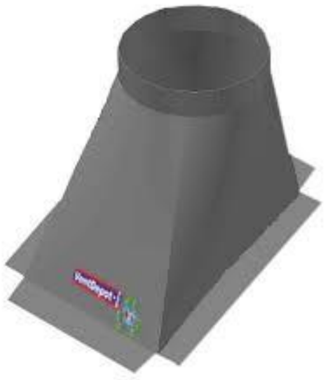
Source: [5]

TABLE 20.* DISCHARGE COEFFICIENTS FOR VENA CONTRACTA TAPS

2 INCH LINE

β	Reynolds Number									
	10,000	15,000	25,000	35,000	50,000	75,000	100,000	150,000	250,000	500,000
0.100	0.6195	0.6148	0.6106	0.6083	0.6061	0.6041	0.6031	...	...	...
0.150	0.6133	0.6097	0.6059	0.6039	0.6022	0.6004	0.5995	...	...	...
0.200	0.6098	0.6067	0.6035	0.6020	0.6004	0.5989	0.5981	0.5971	...	...
0.250	0.6090	0.6062	0.6035	0.6020	0.6007	0.5995	0.5988	0.5978	...	...
0.300	0.6109	0.6082	0.6056	0.6041	0.6029	0.6018	0.6016	0.6001	0.5993	...
0.350	0.6150	0.6123	0.6096	0.6081	0.6068	0.6055	0.6048	0.6039	0.6030	...
0.400	0.6214	0.6185	0.6154	0.6138	0.6125	0.6111	0.6103	0.6093	0.6084	0.6074
0.450	...	0.6261	0.6229	0.6212	0.6197	0.6182	0.6173	0.6165	0.6155	0.6144
0.500	...	0.6361	0.6327	0.6308	0.6293	0.6277	0.6268	0.6257	0.6247	0.6236
0.550	...	...	0.6454	0.6433	0.6418	0.6401	0.6390	0.6379	0.6368	0.6357
0.600	...	...	...	0.6601	0.6582	0.6565	0.6553	0.6541	0.6530	0.6516
0.625	...	...	...	...	0.6684	0.6666	0.6654	0.6639	0.6628	0.6613
0.650	...	...	...	...	0.6802	0.6782	0.6768	0.6753	0.6740	0.6724
0.675	...	...	...	...	0.6938	0.6916	0.6900	0.6884	0.6870	0.6852
0.700	...	...	...	...	0.7095	0.7070	0.7054	0.7034	0.7018	0.7000
0.725	...	...	...	...	0.7280	0.7250	0.7233	0.7212	0.7191	0.7169
0.750	...	...	...	...	0.7496	0.7460	0.7440	0.7417	0.7392	0.7368
0.775	...	...	...	...	...	0.7709	0.7687	0.7661	0.7634	0.7607
0.800	...	...	...	...	...	0.8012	0.7988	0.7960	0.7930	0.7900
0.825	...	...	...	...	...	0.8395	0.8370	0.8340	0.8306	0.8273

NECK OF TURBINE VENTILATOR

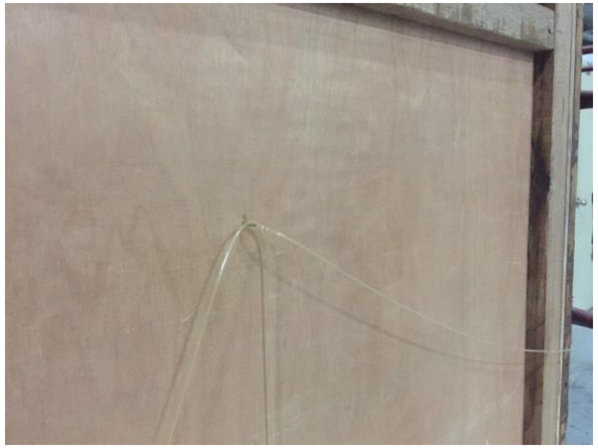


Slope Roof Mounted Base
Can be used for small, medium and large area

Flexible Adaptable Throat
Better Water resistance and customized for specific tilting angle

Cylindrical Adjustable Base
Easily adjusted to fit roof angle

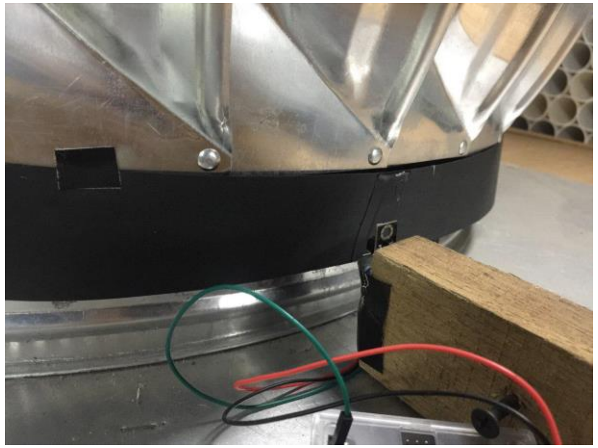
EXPERIMENTAL SETUP ON PROGRESS



PRESSURE TAPPINGS

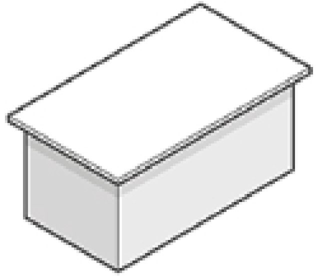
ORIFICE SETUP

TURBINE VENTILATOR WITH MOTOR

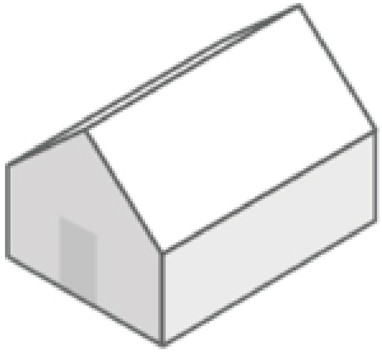


OPTICAL TACHOMETER

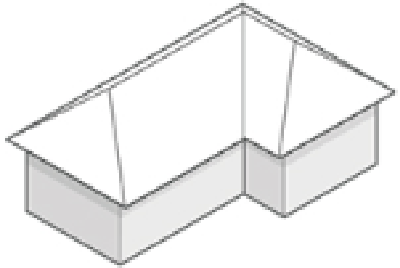
TYPES OF ROOF



Flat Roof



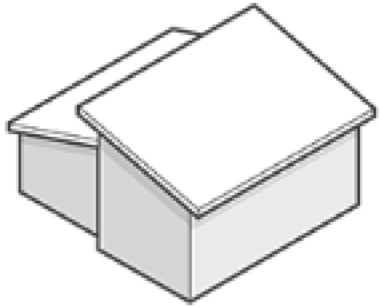
Front Gable



Cross Hipped Roof

Bonnet Roof

Box Gable Roof



Clerestory Roof