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ANALYSIS AND DESIGN OF VYTILA'S WATCH TOWER INTO AIR PURIFICATION SYSTEM

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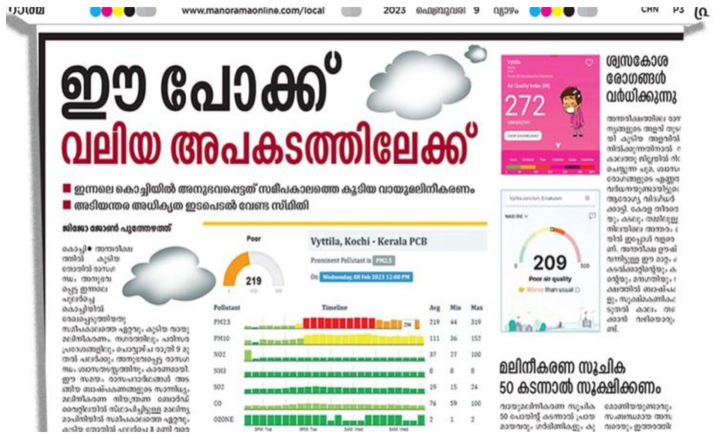
INTRODUCTION

Pollution has become one of the most debated and concerned topics of all time by global citizens. Air and water pollution are the most significant. There are also many more types of pollution like soil contamination, noise pollution, light pollution, etc. Air pollution is the largest cause of pollution death, responsible for about 6.5 million deaths according to a recent study. It refers to the contamination of the atmosphere by harmful chemicals or biological materials. Air quality is disturbed by the interaction between natural and anthropogenic environmental conditions. People exposed to poor-quality air result in major health issues. These all reflect the urge for innovations and advancements that can make the best use of science and technology. To handle the increasingly serious air pollution issue, the concept of an atmospheric air purification tower already has been proposed. The prototype of such a novel system had been built in Xian, China. A 60-meter-high chimney stands in a sea of high-rise buildings. Our project topic is inspired by China's air purification tower. Air pollution contributes to the premature deaths of 2 million Indians every year.

PROBLEM IDENTIFICATION

Outdoor air pollution issues are not commonly considered compared to indoor air pollution, nevertheless, the AQI in our city has been compromised lately. The prominent Air pollutant in Vytila is $PM_{2.5}$ which is harmful to our immune system. Due to these reasons, an air purification tower will be the best solution that can be implemented.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ഈ പോക്ക്
വലിയ അപകടത്തിലേക്ക്

Vyttila, Kochi - Kerala PCB

മലിനീകരണ സൂചിക
50 കടന്നാൽ സൂക്ഷിക്കണം

Fig. 1 Current situation of Vyttila- News reported on February 11, 2023

OBJECTIVES

The main objectives of the project are:

1. To collect the information of air quality index of Vyttila
2. To prepare a mini prototype model and check its efficiency
3. To design a 3D model of Vyttila's traffic watch tower with air purification tower using Revit Architecture
4. To design Vyttila's traffic watch tower including an air purification tower using STAAD Pro.

SCOPE

Air pollution has been a major concern throughout recent years and has proved to be fatal. The major air pollutants are from industries, dense traffics, etc. Some of the most common and dangerous pollutants are CO, CO_2, NO, NO_2, PM, ground-level ozone, etc. It is of immense importance to control and take measures for the safety of our future. So many methods are used to reduce air pollution all over the world. But most of the methods are for indoor air purification. So, we have to find new techniques to purify the outdoor air too. An air purification tower already has been proposed by China. And its prototype is already on the trial run. This project idea was inspired by China's air purification tower. The tower can be implemented in a cost-effective way and can introduce many labor opportunities.

METHODOLOGY

An air purification tower is a tower prepared to clear out pollutants and purify the air near us. The air flowing through an air purification tower passes through a filter to provide clean air coming out of it. These methods of cleaning air are scientifically well established and used widely for cleaning indoor air where the air is exchanged with the outdoors.

- Data Collection
- Mini prototype for efficiency test
- Site visit
- Study of components of air purification tower
- 3-D Modelling (Revit architecture): A detailed 3-d model of traffic watch tower with air purification tower was created using revit architecture.
- Structural designing (STAAD Pro). Using the 3-d model, structure was detailed and designed.

DATA COLLECTED

FROM CENTRAL POLLUTION CONTROL BOARD

According to the WHO, India has 14 out of the 15 most polluted cities in the world in terms of $PM_{2.5}$ concentrations.

Table 5.1 Top 13 Cities in India with the highest level of $PM_{2.5}$

Cities	$PM_{2.5}$ Levels
Delhi	153
Patna	149
Gwalior	144
Raipur	134
Ahmedabad	100
Lucknow	96
Firozabad	96
Kanpur	93
Amritsar	92
Ludhiana	91
Prayagraj	88
Agra	88
Khanna	88

In November 2016, the Great Smog of Delhi was an environmental event that saw New Delhi and adjoining areas in a dense blanket of smog, which was the worst in 17 years.

India's Central Pollution Control Board now routinely monitors four air pollutants namely sulfur dioxide (SO_2), oxides of nitrogen (NOx), suspended particulate matter (SPM), and respirable particulate matter (PM_{10}). These are target air pollutants for regular monitoring at 308 operating stations in 115 cities/towns in 25 states and 4 Union Territories of India.

These are the findings of India's central pollution control board.

- A decreasing trend has been observed in nitrogen dioxide levels in residential areas of some cities such as Bhopal and Solapur during the last few years.
- Most Indian cities greatly exceed acceptable levels of suspended particulate matter. This may be because of refuse and biomass burning, vehicles, power plant emissions, and industrial sources.
- The Indian air quality monitoring stations reported lower levels of PM_{10} and suspended particulate matter during monsoon months possibly due to wet deposition and air scrubbing by rainfall. In other words, India's air quality worsens in winter months and improves with the onset of the monsoon season.
- The average annual SOx and NOx emissions level and periodic violations in industrial areas of India were significantly and surprisingly lower than the emission and violations in residential areas of India.

Of the four major Indian cities, air pollution was consistently worse in Delhi, every year over 5 years (2004–2018). Kolkata was a close second, followed by Mumbai. Chennai air pollution was the least of the four.

Table 5.2 National Ambient Air Quality Standards

S. NO.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural, and Other Area	Ecologically Sensitive Area (notified by central govt.)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), µg/m³	Annual * 24 hours**	50 80	20 80	• Improved West and Gacke • Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), µg/m³	Annual * 24 hours**	40 80	30 80	• Modified Jacob & Hqchheiser (Na-Arsenlte) • Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} µg/m³	Annual * 24 hours**	60 100	60 100	• Gravimetric • TOEM • Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m³	Annual * 24 hours**	40 60	40 60	• Gravimetric • TOEM • Beta attenuation
5	Ozone (O_3) µg/m³	8 hours** 1 hour**	100 180	100 180	• UV photometric • Chemiluminescence • Chemical Method
6	Lead (Pb) µg/m³	Annual * 24 hours**	0.50 1.0	0.50 1.0	• AAS/ICP method after sampling on EPM 2000 or equivalent filter paper • ED-XRF using Teflon filter
7	Carbon Monoxide (CO) µg/m³	8 hours** 1 hour**	02 04	02 04	• Non-Dispersive Infra-Red (NDIR) spectroscopy

* Annual arithmetic means of minimum 104 measurements in a year at a particular site taken twice a week 24 hours at uniform intervals.

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring

Note. — Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limit specified above for the respective category, it shall be considered an adequate reason to institute regular or continuous monitoring and further investigation.

5.1.1 Vehicular Exhaust

Table 5.3 Emission norms for passenger car

Norms	CO(g/km)	HC+ NOx(g/km)
1991Norms	14.3-27.1	2.0(Only HC)
1996 Norms	8.68-12.40	3.00-4.36
1998Norms	4.34-6.20	1.50-2.18
India stage 2000 norms	2.72	0.97
Bharat stage-II	2.2	0.5
Bharat Stage-III	2.3	0.35(combined)
Bharat Stage-IV	1.0	0.18(combined)

Table 5.4 Emission norms for heavy diesel vehicles

Norms	CO (g/kmhr)	HC (g/kmhr)	NOx (g/kmhr)	PM (g/kwhr)
1991 Norms	14	3.5	18	_
1996 Norms	11.2	2.4	14.4	_
India stage 2000	4.5	1.1	8.0	0.36

Norms				
Bharat stage-II	4.0	1.1	7.0	0.15
Bharat stage-III	2.1	1.6	5.0	0.10
Bharat stage-IV	1.5	0.96	3.5	0.02

Table 5.5 Emission norms for 2/3-wheeler

Norms	CO (g/km)	HC+ NOx (g/km)
1991 Norms	12-30	8-12 (only HC)
1996 Norms	4.5	3.6
India stage 2000 norms	2.0	2.0
Bharat stage-II	1.6	1.5
Bharat stage -III	1.0	1.0

5.2 FROM STATE POLLUTION CONTROL BOARD

Table 5.6 Air Quality Index of different cities in Kerala

Sl. No.	CITY	AQI
1	Kannur	151
2	Kumbalam	132
3	Kollam	125
4	Kozhikode	122
5	Trichur	119
6	Thiruvananthapuram	99
7	Elur	95

Table 5.7 Air quality details of various locations in Ernakulam

LOCATIONS	Status	AQI	$PM_{2.5}$	PM_{10}	Temp. (°C)	Humidity (%)
Kathrikadavu	Poor	139	51	94	27	79
Vyttila	Poor	174	100	125	25	89
Kochi	Poor	158	75	109	25	89

Table 5.8 Air Quality Index Range ($\mu g/m^3$)

GOOD	MODERATE	POOR	UNHEALTHY	SEVERE	HAZARDOUS
0-50	51-100	101-200	201-300	301-400	401-500(+)

Table 5.9 Vyttila's AQI (One week observation)

DATE	1/3/23	2/3/23	3/3/23	4/3/23	5/3/23	6/3/23	7/3/23
$PM_{2.5}$ ($\mu g/m^3$)	86	100	167	140	159	178	182
PM_{10} ($\mu g/m^3$)	73	52	71	70	118	150	121
O_3 ($\mu g/m^3$)	0	3	1	7	7	8	6
NO_2 ($\mu g/m^3$)	2	3	1	4	12	8	6
SO_2 ($\mu g/m^3$)	3	3	6	3	7	7	6
CO ($\mu g/m^3$)	14	14	10	9	16	17	14
TEMPERATURE (^0C)	23	23	24	27	27	30	31
HUMIDITY (%)	61	60	94	61	80	87	91
WIND (m/s)	3	2	1	1	3	3	1

5.3 AIR QUALITY ANALYSIS AND STATISTICS FOR KERALA

5.3.1 How bad are pollution levels in Kerala?

Kerala is a state in India located on the southwestern coastline. It is bordered by Tamil Nadu and Karnataka, with the region, having been a prominent spice producer and exporter going back thousands of years. Nowadays Kerala still finds itself as a large producer of goods, with items such as coconuts, tea, coffee, and spices still being exported, making its economy the 10th largest in India.

As with all cities, states, and countries that see large volumes of movement involving goods, there are always bound to be pollution-related issues arising from the large use of cars, lorries, and trucks to move these items, as well as for day-to-day commuting for people living in the state of Kerala.

Observing the data registry in years past, Kerala currently only has the city of Thiruvananthapuram on record with its pollution levels. Thiruvananthapuram, commonly called by its former name of Trivandrum, came in with $PM_{2.5}$ readings of 27.9 μg/m^3 in the year 2019.

Many of the cities besides the capital have the same infrastructure or a similar economy.

5.3.2 The main causes of pollution in Kerala

Kerala is home to a large number of factories, many of which are located not far from the coast. These factories would be major contributors to the ambient year-round pollution levels, due to them running off large amounts of fossil fuels such as diesel or coal to provide energy, as well as creating secondary pollutants as a result of their industrial processes, with chemical plants, food processing, and packaging factories as well other industrial item related production lines.

With a heavy export-based industry, Kerala would see large amounts of trucks taking goods to other parts of the country, as well as many cargo ships doing the same for local or global export. Ships alone give off large amounts of pollution, usually of a more dangerous nature due to a difference in fuel regulation regarding what ships can use in their engines, often containing higher contents of sulfur which ends up making its way into the atmosphere after combustion.

Cars and trucks, particularly ones that run on diesel, would give off large amounts of chemical compounds as well as fine particulate matter, with a whole host of ill health effects on those exposed, as well as having a knock-on effect on the environment.

Open burn fires are present as well, being a persistent problem in many parts of India, with a variety of materials being burnt that should instead be disposed of in a much safer manner.

5.3.3 The main pollutants found in the air in Kerala

Regarding the construction sites and road repairs, these alone would give off a huge number of dangerous particles. When a material such as various forms of rock or concrete is broken down, it can release fine silica dust, dirt particles, and other particulate matter that can make its way deep into the lungs, due to its tiny size, therefore making it past the body's natural filtration systems present in the nose or throat.

Silica dust is known as having carcinogenic properties, and when there are hundreds, if not thousands of construction or repair sites taking place across the state, then these particles can easily find their way into the atmosphere if not properly tended to, which is often the case with many construction sites improperly maintained and thus prone to massive runoff of these fine materials.

Besides the particulate matter, other pollutants would include nitrogen dioxide (NO_2) and sulfur dioxide ($S0_2$), both of which are found released from vehicles as well as factories, with nitrogen dioxide having particular prominence in the release from cars and trucks, with high volumes of it being detected via satellite or ground level readings in areas that see a larger density of traffic.

Other pollutants of note are ones such as black carbon and volatile organic compounds (VOCs), both of which are formed from the incomplete combustion of fossil fuels (as well as organic material); thus, they find their origins in factories, cars as well as open burning of refuse. Some VOCs include dangerous chemicals such as benzene and formaldehyde. Others would include carbon monoxide (CO), ozone (O_3), and dioxins, with many more being released, even from the burning of plastics alone.

5.3.5 What can Kerala do to improve its pollution levels?

Some initiatives that could be taken to see a marked improvement in pollution levels would be to find a way to reduce vehicle movement, as the state and many others throughout India saw marked improvements with the movement control orders that took place in 2020 due to the covid-19 pandemic.

Realistic ways of getting this done without causing problems would be the introduction of low emission zones, as well as incentives to get people to use their cars less, investment into public transport infrastructure as well as the issuing of fines and charges to vehicles that exceed unsafe pollution levels, with this initiative eventually being a step in the right direction to getting diesel-based engines as well as ancient or outdated vehicles off the road.

Others would be to impose similar sanctions and fines on factories that cause pollution in the surrounding air to exceed a certain level, which would lead to a better structure of industrial management by individual companies and business owners.

ANALYSIS AND DESIGN

6.1 LOAD CALCULATION

6.1.1 Load Calculation of Components of Structure

1. Floor plates:
   Material used: Mild steel
   Weight = 31.40Kg/m^2
   Area of floor = 25m^2
   Weight in kN/m^2 = 0.31kN/m^2
2. Steel plate for tower:
   Weight = 31.4Kg/m^2
   Area = 2πrh = 2*3.14*0.5*5 = 15.71m^2
   Weight in kN/m^2 = 0.31kN/m^2
3. Handrail:
   Material used: Mild steel
   Weight = 13.73Kg/m
   Length = 19.4m
   Weight in kN/m = 0.13kN/m
4. Cabin wall:
   Material used: V-Board
   Weight = 8.9 Kg/m^2
   Area = 12m^2
   Total area of 5 layers of V-board = 12*5 = 60m^2
   Weight in kN/m^2 = 0.0873kN/m^2
5. Glass:
   Dimension = 1.7*0.5
   Weight = 25.5Kg
   Area of single glass panel = 1.7*0.5 = 0.85m^2
   Weight of glass for 1m^2 = 25.5/0.85 = 30Kg
   Total area for glass panels = 19.68m^2
   Weight of glass for 19.68m^2 = 30*19.68 = 590.4Kg = 5.79kN
   Weight in kN/m^2 = 0.294kN/m^2
6. Truss work:
   Material used: Pre-fabricated aluminium truss work
   Weight = 3.75kN
   Area = 25m^2
   Weight in kN/m^2 =0.150kN/m^2
7. Stair:
   Material used: Pre-fabricated aluminium
   Height = 3m
   Width = 1m
   Weight = 349.26Kg = 3.43kN

6.1.2 Dead Load

1. For Roof Members:
   Weight of truss = 0.150kN/m^2
   Load 1 = (0.150*0.5*5)/5 = 0.075kN/m
   Load 2 = (0.150*(0.5+0.5)*1)/1 = 0.150kN/m
   Load 3 = (0.150*(0.5+0.5)*3)/3 = 0.150kN/m
2. For First Floor Members:
   Weight of floor plate = 0.31kN/m^2
   Load 1 = (0.31*0.5*5)/5 = 0.155kN/m
   Load 2 = (0.31*(0.5+0.5)*5)/5 = 0.31kN/m
   Weight of V-board = 0.0873kN/m^2
   Weight of glass = 0.294kN/m^2
   Weight of wall = 0.0873+0.294 = 1.167kN/m^2
   Load 3 = (1.167*(0.5+0.5)*3)/3 = 1.167kN/m
   Weight of tower plate = 0.31kN/m^2
   Load 4 = (0.31*(0.5+0.5)*1)/1 = 0.31kN/m
   Weight of fan = 0.44kN
   Load 5 = 0.44/4 = 0.11kN

6.1.3 Live Load

According to IS:875 part 2 imposed floor load for business and office building

a) Room for general use with separate storage:
   UDL = 2.5kN/m^2
   Load = (2.5*(0.5+0.5)*3)/3 = 2.5kN/m
b) Corridors, passages, lobbies, staircases, balconies:
   UDL = 4kN/m^2
   Load = (4*0.5*5)/5 = 2kN/m

6.2 ANALYSIS

```
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ENGINEER DATE 22-May-23
END JOB INFORMATION
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13 0 5.2 0; 14 1 5.2 0; 17 4 5.2 0; 18 5 5.2 0; 20 1 0 1; 23 4 0 1; 25 0 3 1;
26 1 3 1; 29 4 3 1; 30 5 3 1; 31 0 5.2 1; 32 1 5.2 1; 35 4 5.2 1; 36 5 5.2 1;
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214 18 108; 215 108 103; 216 103 13; 217 7 12; 218 12 102; 219 102 97;
220 97 7;
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POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
DAMP 0.03
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END DEFINE MATERIAL
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132 TAPERED 0.3 0.0075 0.3 0.14 0.012 0.14 0.012
23 27 28 32 47 69 89 93 94 98 134 137 140 143 159 160 182 185 188 191 194 -
196 198 199 201 TO 220 TAPERED 0.2 0.0057 0.2 0.1 0.0108 0.1 0.0108
CONSTANTS
MATERIAL STEEL ALL
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LOAD 1 LOADTYPE Dead  TITLE DL
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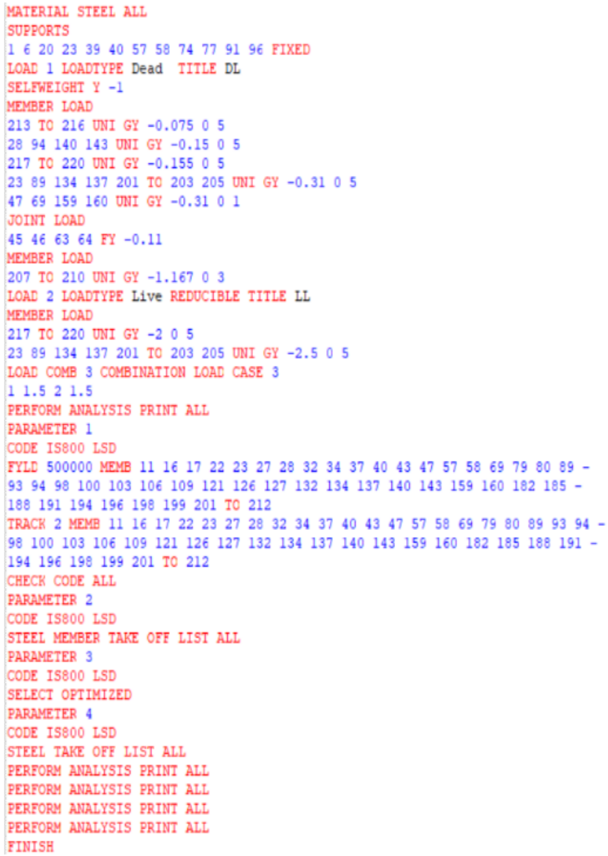

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217 TO 220 UNI GY -0.155 0 5
23 89 134 137 201 TO 203 205 UNI GY -0.31 0 5
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FYLD 500000 MEMB 11 16 17 22 23 27 28 32 34 37 40 43 47 57 58 69 79 80 89 -
93 94 98 100 103 106 109 121 126 127 132 134 137 140 143 159 160 182 185 -
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PARAMETER 3
CODE IS800 LSD
SELECT OPTIMIZED
PARAMETER 4
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STEEL TAKE OFF LIST ALL
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS PRINT ALL
PERFORM ANALYSIS PRINT ALL
FINISH
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Fig. 6.1 Snipped figure of STAAD input

The structural analysis of the tower was done using STAAD Pro software. Various loading conditions were used to analyse the tower which is acting on it. The analysis resulted to be safe and the maximum shear force, bending moment and deflection are used to design the beams and columns of the tower.

The various loads acting on the beams and columns of the tower is:

- Dead loads
- Live loads
- 1.5*(Dead load + Live load)

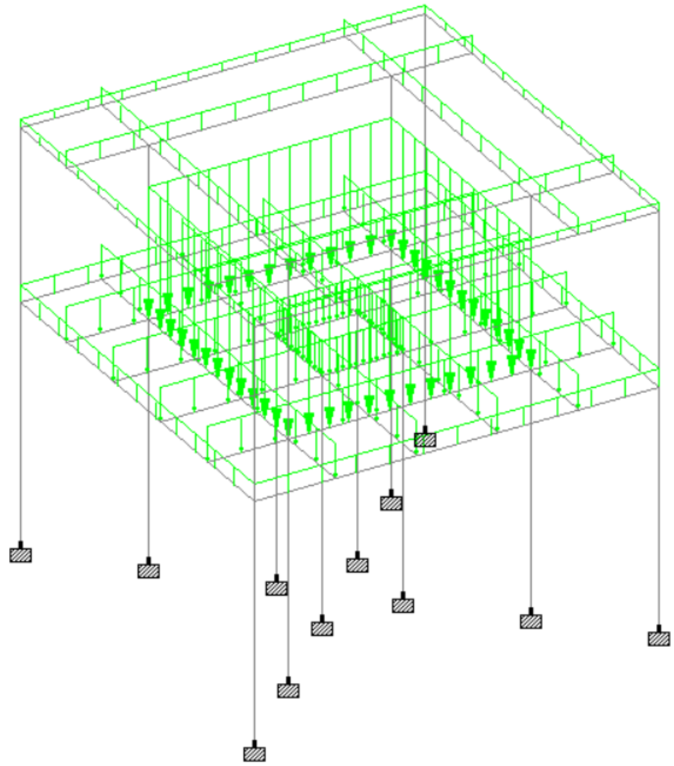

Fig. 6.2 Dead load diagram

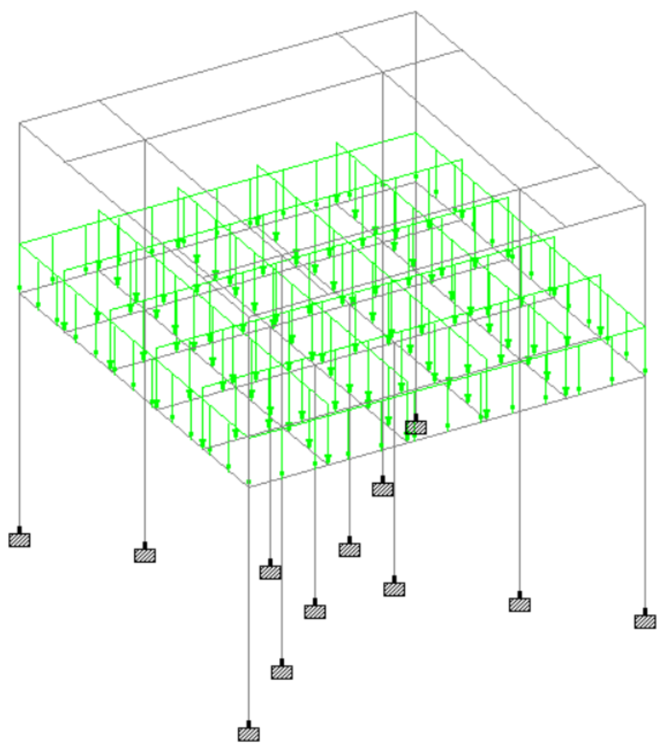

Fig. 6.3 Live load diagram

Table 6.1 Total applied load and summation of moments around the origin due to dead load

Direction of Loading	Load Values (kN/m)	Moment Values (kNm)
X	0.00	174.72
Y	-71.37	0.00
Z	0.00	-174.72

Table 6.2 Total reaction load and summation of moment around the origin due to dead load

Direction of Loading	Load Values (kN/m)	Moment Values (kNm)
X	0.00	-174.72
Y	71.37	0.00
Z	0.00	174.72

Table 6.3 Total applied load and summation of moments around the origin due to live load

Direction of Loading	Load Values (kN/m)	Moment Values (kNm)
X	0.00	150.00
Y	-70.00	0.00
Z	0.00	-150.00

Table 6.4 Total reaction load and summation of moment around the origin due to live load

Direction of Loading	Load Values (kN/m)	Moment Values (kNm)
X	0.00	-150.00
Y	70.00	0.00
Z	0.00	150.00

The Shear Force Diagram, Bending Moment Diagram and Deflection Diagram of the tower is shown in figure 6.4, 6.5 and 6.6 respectively.

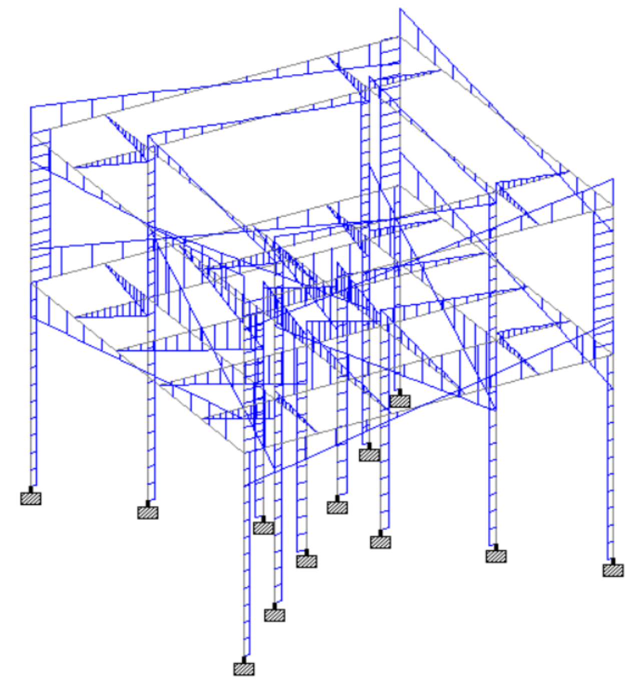

Fig. 6.4 Shear force diagram

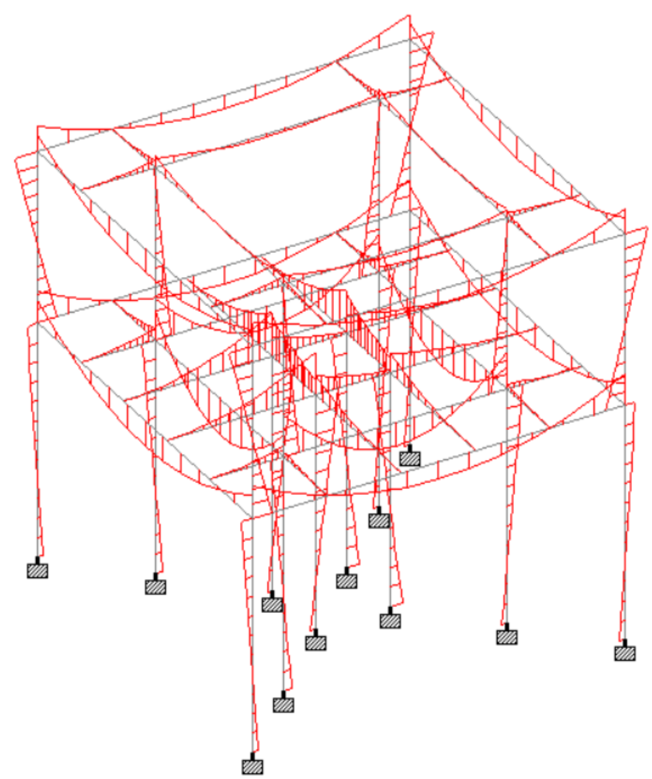

Fig. 6.5 Bending moment diagram

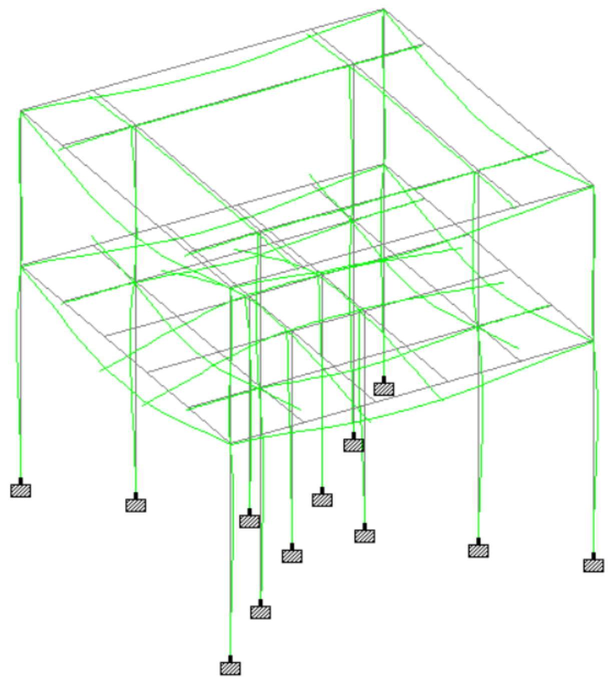

Fig. 6.6 Deflection of beams and columns

The maximum bending moment values and maximum shear Force values after the analysis of the tower are shown in table 6.5 and 6.6 respectively.

Table 6.5 Maximum bending moment values

Direction of Bending Moment	Maximum Positive BM (kNm)	Maximum Negative BM (kNm)	Load Combination
M_y	2.773	1.195	1.5*(DL + LL)
M_z	9.162	0.000	1.5*(DL + LL)

Table 6.6 Maximum shear force values

Direction of Shear Force	Maximum Positive SF (kN)	Maximum Negative SF (kN)	Load Combination
M_y	3.814	2.536	1.5*(DL + LL)
M_z	1.804	1.804	1.5*(DL + LL)

6.3 DESIGN

6.3.1 Section Identification

- For Roof:
  Total load = 3.75kN
  Intensity of udl = 3.75/5 = 0.75kN/m
  Assume self-weight = 0.8kN/m
  Total load = 0.75+0.8 = 1.55kN/m
  Total factored load = 1.55*1.5 = 2.325kN/m
  Max. BM = $(Wl^2)/8 = (2.325*5^2)/8$
  = 7.26kNm
  $(Z_p)_{req} = M/f_y*\gamma_{mo}$
  = $(7.26*10^6)/250*1.1$
  = 31944mm² = 31.944cm²
- For First Floor:
  Total udl = 5.762kN/m
  Weight of tower = 4.84kN
  Factored udl = 5.762*1.5 = 8.642kN/m
  Factored point load = 4.84*1.5 = 7.26kN
  Max. BM = $(Wl^2)/8 + (Wl/4)$
  = $(8.642*5^2)/8 + (7.26*5)/4$
  = 36.085kNm
  $(Z_p)_{req} = M/f_y*\gamma_{mo}$
  = $(36.085*10^6)/250*1.1$
  = $158774mm^2 = 158.774cm^2$

As per IS:875 part 2 and SP 6, we choose the section according to the calculation above. The selected section has a greater Z_p value. ISMB 300 @ 44.2kg/m for columns and ISMB 200 @ 25.4kg/m for beams.

6.3.2 Properties of The Selected Section

- ISMB 300
  Weight per Meter (w) = 44.20 Kg/m
  Sectional Area (a) = 56.26 cm2
  Depth of Section (h) = 300 mm
  Width of Flange (b) = 140 mm
  Thickness of Flange (tf) = 12.40 mm
  Thickness of Web (tw) = 7.50 mm
  Moment of Inertia (lxx) = 8603.60 cm4
  Moment of Inertia (lyy) = 453.90 cm4
  Radius of Gyration (rxx) = 12.37 cm
  Radius of Gyration (ryy) = 2.84 cm
- ISMB 200
  Weight per Meter (w) = 25.40 Kg/m
  Sectional Area (a) = 32.33 cm2
  Depth of Section (h) = 200 mm
  Width of Flange (b) = 100 mm
  Thickness of Flange (tf) = 10.80 mm
  Thickness of Web (tw) = 5.70 mm
  Moment of Inertia (lxx) = 2235.40 cm4
  Moment of Inertia (lyy) = 150.00 cm4
  Radius of Gyration (rxx) = 8.32 cm
  Radius of Gyration (ryy) = 2.15 cm

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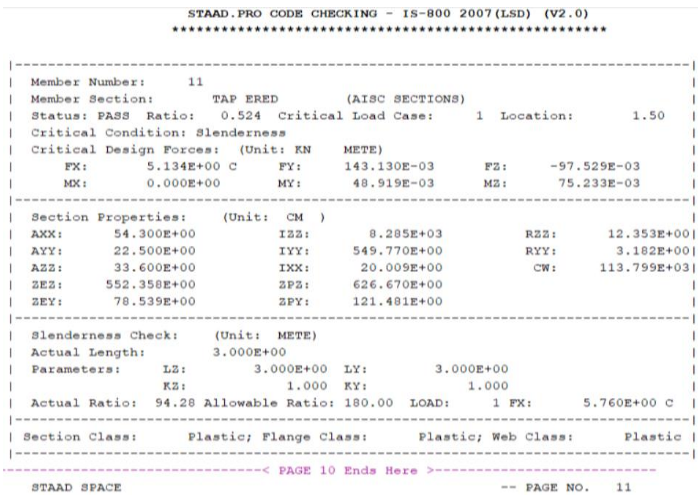
Table 6.7 Steel Take-Off

PROFILE	Member No:	LENGTH (Meter)	WEIGHT (kN)
Tapered	11	53.60	22.358
Tapered	23	100.00	24.405
Total			46.763



```
STAAD.PRO CODE CHECKING - IS-800 2007(LSD) (V2.0)
*****************************************************

|-----------------------------------------------------------------------------|
| Member Number:      11                                                      |
| Member Section:        TAP ERED          (AISC SECTIONS)                    |
| Status: PASS  Ratio:   0.524  Critical Load Case:    1  Location:     1.50  |
| Critical Condition: Slenderness                                             |
| Critical Design Forces:  (Unit: KN    METE)                                 |
|     FX:        5.134E+00 C     FY:     143.130E-03      FZ:    -97.529E-03  |
|     MX:        0.000E+00       MY:      48.919E-03      MZ:     75.233E-03  |
|-----------------------------------------------------------------------------|
| Section Properties:     (Unit:   CM  )                                      |
| AXX:      54.300E+00          IZZ:      8.285E+03           RZZ:   12.353E+00|
| AYY:      22.500E+00          IYY:    549.770E+00           RYY:    3.182E+00|
| AZZ:      33.600E+00          IXX:     20.009E+00            CW:  113.799E+03|
| ZEZ:     552.358E+00          ZPZ:    626.670E+00                           |
| ZEY:      78.539E+00          ZPY:    121.481E+00                           |
|-----------------------------------------------------------------------------|
| Slenderness Check:      (Unit:  METE)                                       |
| Actual Length:          3.000E+00                                           |
| Parameters:       LZ:         3.000E+00  LY:         3.000E+00              |
|                   KZ:             1.000  KY:             1.000              |
| Actual Ratio:  94.28 Allowable Ratio: 180.00  LOAD:     1 FX:     5.760E+00 C |
|-----------------------------------------------------------------------------|
| Section Class:       Plastic; Flange Class:      Plastic; Web Class:    Plastic |
|-----------------------------------------------------------------------------|
----------------------------< PAGE 10 Ends Here >---------------------------
  STAAD SPACE                                                 -- PAGE NO.   11
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Fig. 6.7 Steel design sample from STAAD

6.3.3 Connection Design

Connection design is done for a critical member having high shear force. ISMB 200 beam is connected to the web of ISMB 300 column.

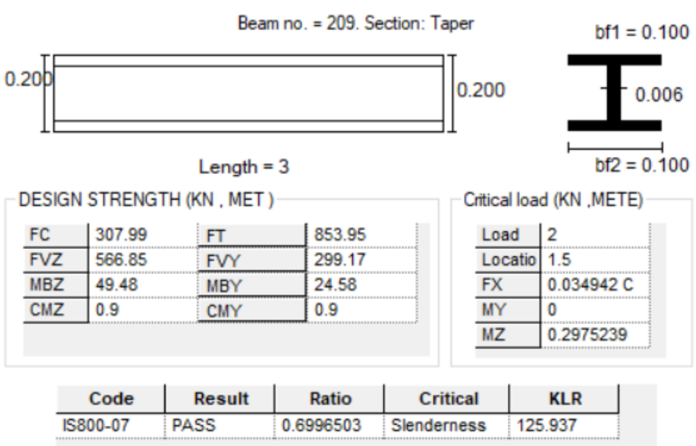


Fig. 6.8 Design details of ISMB 200

Step 1: Connection of cleat angle with the web of secondary beam.

Strength of M20 bolts in double shear = $(f_{ub}*(1+0.78)*\pi*d^2)/(\sqrt{3}*\gamma_{mb}*4)$

$= (400*(1+0.078)*\pi*20^2)/\sqrt{3}*1.25*4$

$=103314N = 103.314kN$

Strength in bearing over flange of ISMB 200

Providing an edge distance $e = 40mm$ amd pitch $p = 60mm$, find

k_b is the minimum of 40/3*22, (60/3*22)-0.25, 400/410, 1.0

$k_b = 0.606$, and $t = t_f = 10.8mm$

Strength in bearing = $(2.5*k_b*dtf_u)/\gamma_{mb}$

$= (2.5*0.606*20*10.8*410)/1.25$

$= 10733472N = 107.33kN$

Bolt value = 103.314kN

Factored reaction = 300kN

The number of bolts required = 300/103.31 = 2.90

Provide 4 bolts on two sides

Step 2: Connection of angel with web of ISMB 300.

Thickness of web of ISMB 300, $t_w = 7.5mm$

Strength of bolt in single shear = $(f_{ub}*0.78*\pi*d^2)/(\sqrt{3}*\gamma_{mb}*4)$

$= (400*0.078*\pi*20^2)/\sqrt{3}*1.25*4 = 45272N = 45.272kN$

Strength in bearing is more than it.

The bolt value = 45.272kN

The number of bolts required = 300/45.27 = 6.6

Provide 4 bolts in each angle in 2 rows at 50mm spacing.

Step 3: Design of cleat angle.

To keep the bearing strength on cleat angle greater than the strength in single shear, the thickness of cleat angle is given by,

$(2.5*k_b*dtf_u)/\gamma_{mb} = (f_{ub}*0.78*\pi*d^2)/(\sqrt{3}*\gamma_{mb}*4)$

$(2.5*0.606*20*t*410)/1.25 = (400*0.078*\pi*20^2)/\sqrt{3}*1.25*4$

$t = 4.56mm$

Use 6mm thick angle.

Provide ISA 10075,6mm angle with 100mm leg on ISMB 200

Depth of angle required on ISMB 200 = 25 + 50 + 25 = 100mm

Depth of angle required on ISMB 300 = 25 + 50 + 25 = 100mm

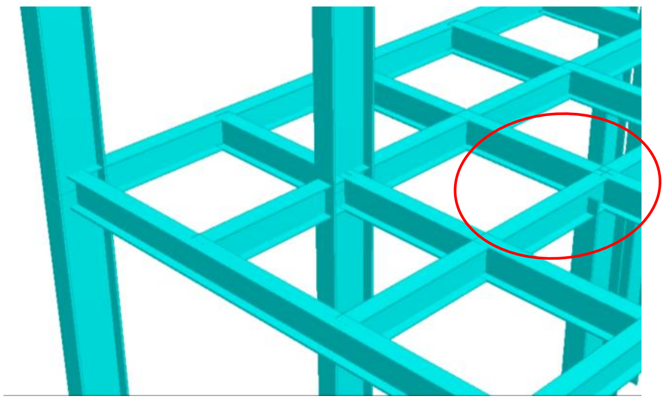


Fig. 6.9 3D figure of connection joint

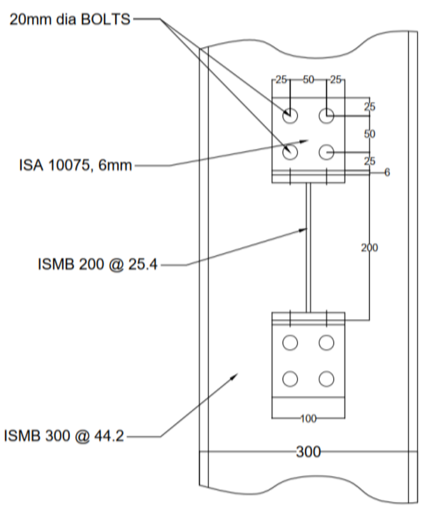
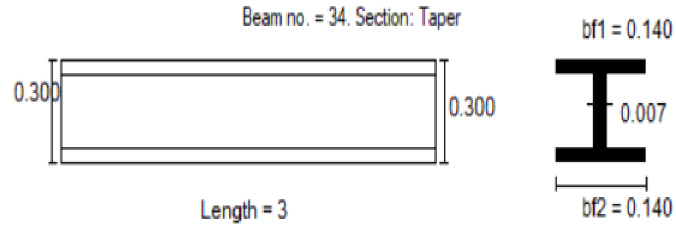


Fig. 6.10 Connection details

6.3.4 Column Base Design

Column base design is done for a critical column member having high axial force. ISMB 300 column is connected to M20 concrete foundation.



DESIGN STRENGTH (KN , MET)

FC	861.12	FT	1459.58
FVZ	881.77	FVY	590.47
MBZ	155.11	MBY	53.55
CMZ	0.9	CMY	0.9

Critical load (KN ,METE)

Load	1
Locatio	1.5
FX	8.534652 C
MY	0.04728538
MZ	0.0732094

Code	Result	Ratio	Critical	KLR
IS800-07	PASS	0.523791	Slenderness	94.28238

Fig. 6.11 Design details of ISMB 300 column

Step 1: Size of base plate

Bearing strength of concrete = $0.45f_{ck}$

= 0.45*20 = 9N/mm^2

Factored load, Pu = 590.5kN

Area of base plate required = 590.5*10^3/9 = 65611.11mm^2

Let ‘L’ and ‘B’ be the length and width of base plate and take projection a=b

(L+2a)*(B+2b) = A

(300+2a)*(140+2a) = 65611.11

4a^2+880a-23611.11 = 0

a = 24.17mm ~ 30mm

a = b = 30mm

Width of plate = 140+(2*30) = 200mm

Length of plate = 300+(2*30) = 360

Therefore, provide 360*200 size plate

Area provided = 360*200 = 72000mm^2

Step 2: Thickness of base plate

Intensity of pressure, ω = Pu/Area

ω = 590.5*10^3/72000 = 8.201N/mm^2

$8.201 N/mm^2 < 9 N/mm^2$, hence it is safe

Minimum required thickness, $t_s = (2.5\omega*(a^2-0.3b^2)\gamma_{mo}/f_y)^{0.5} > t_f$

$(2.5*8.201*(30^2-0.3*30^2)*1.1) > 12.4$

7.538mm > 12.4mm

Hence provide 12mm thick plate

Step 3: Design of connection

Use 4 bolts of 20mm diameter 300mm long to anchor the plate to foundation. Let us provide a welded connection between column and base plate.

Total length available for welding = 2*((140+140-7.5)+(300-2*12.4)) = 1095.4mm

As per IS 800, cl.10.5.7

Strength of weld required = $(f_u/\sqrt{3}\gamma_{mw})*(L_w*t_t)$

Assume thickness of weld, s = 6mm

$t_t = 0.7s = 4.2mm$

$590.5*10^3 = (410/\sqrt{3}*1.25)*(L_w*4.2)$

$L_w = 742.433mm$

Length of weld required < Length of weld available

Hence it is safe

So, let us provide 6mm size of weld for connecting column to base.

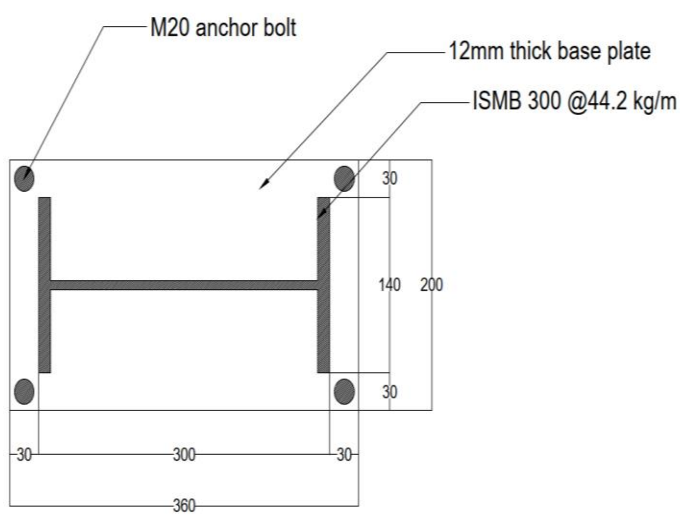


Fig. 6.12 Column base design details

6.3.5 Volume of Air Purified

In this tower, centrifugal fans are used to purify the air.

Maximum air flow rate of the fan = 34300 m^3/hour
Minimum air flow rate of the fan = 5600 m^3/hour
The maximum air flow rate per day = 34300*24 = 823200 m^3
The minimum air flow rate per day = 5600*24 = 134400 m^3
The HEPA filter traps 99.97% airborne particles above 0.3 microns from the air passes through it.

CONCLUSION

Pollution caused by $PM_{2.5}$ can cause 600 premature deaths and economic losses of about 500 crores. To control this, an air purification tower is very necessary in the high pollutant emitting zones of the country. As studied the pollution in our state Kerala throughout, and the highest pollution is among three cities, which is Ernakulam, Trivandrum and Kollam. In Ernakulam the most polluted area is Vyttila. The pollution index in this place is found to be PM_{10} and $PM_{2.5}$. Therefore, to improve the air quality of this place, designed a structure called air purification tower. The purification tower was inspired by air purifying tower in Xian China. HEPA filter and centrifugal fan is the air purification components used. The tower will be designed to incorporate with traffic watch tower. This structure has the ability to purify the air from 134400 m^3 to 823200 m^3 per day.

In addition to this air purification is also helpful for reducing global warming, and acid rain. Some other benefits are also provided to the government in other highly polluted areas that will help in the strengthening human health. All together by reducing pollution we can achieve a balanced ecosystem and develop a great vision for future generations.

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