

CHAPTER 6

DESIGN OF SOLID WASTE MANAGEMENT SYSTEM FOR HOSUR

6.1 GENERAL

In order to improve the current solid waste management services it is essential to explore the various constraints or issues and to arrive at a suitable solution. MSWM involves a whole community and sufficient actions have to be taken to realize its full potential. Community participation is the process by which individuals and families understand responsibility for their own health and welfare of societies. The key to the success of solid waste management system in any city lies in the cooperation of citizens. This community participation requires considerable planning and management. In India, the urbanization rate was expected to increase by an average of 12.28 to 32.43% from 2007 to 2030 (hajuria et.al 2010). The Future waste prediction is done by simple linear correlation model by assuming 20% increment from the mean value of every year. The future waste prediction shown in table 6.1.

Table 6.1 Future waste prediction

| Years | Rate of waste generation (ton/day) |
|--------------|---|
| 2006 | 50 |
| 2011 | 77 |
| 2016 | 93 |
| 2021 | 112 |
| 2026 | 135 |
| 2031 | 162 |

6.2 DESIGN OF ENGINEERED SANITARY LANDFILL

The landfill is envisaged for necessary lining system, using the locally available clay after compressing, named as Engineered Sanitary Landfill.

Quantity of solid wastes/day = 77,000kgs = 77tonnes.

As per BIS

| | | |
|--|---|----------------------------------|
| Thickness of clay liner | = | 0.5 m |
| Height of the each lift | = | 3m |
| No. of lifts provided | = | 1 |
| Thickness of cover between lifts | = | 0.2 m (0.15 to 0.3m) |
| Diameter of lateral and main drains provided | = | 0.15 and 0.2 m |
| Thickness of top cover | = | 0.65m (0.6 m to 0.8m) |
| Assume total height of landfill | = | 4.5m |
| Volume of solid wastes to be dumped/day | = | Weight / Density |
| | = | 77tonnes / 0.75 t/m ³ |
| | = | 102.63m ³ |
| Area to required for daily operation per meter | = | 102.63 |
| | = | 102.63m ² |

Total area of the landfill site required = $57594.66 \text{ m}^2 = 5.75 \text{ hector}$

Life span of the site = $57594.66/102.63 = 561.81 \approx 561 \text{ days}$

The plan, longitudinal and cross sectional views of the landfill site are shown in Figures 6.1 to 6.3.

6.2.1 Landfill capacity for first five years (2006 – 2011)

Rate of solid waste generation = 77 ton/day

Out of which only 16 percent of solid waste (i.e. 12.32t/day) is to be disposed by land fill

Take density of solid waste as 0.75 t/m^3

$$\begin{aligned} \text{Volume of waste/day} &= 12.32 \text{ t/day} / 0.75 \text{ t/m}^3 \\ &= 16.42 \text{ m}^3/\text{day} \end{aligned}$$

$$\begin{aligned} \text{Volume of waste /} \\ \text{annum} &= 16.42 \text{ m}^3/\text{day} \times 365 \text{ days} = 5995.73 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Volume of liner and cover and cover systems} \\ &= 0.25 \times 5995.73 \text{ m}^3 \\ &= 1498.9 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Reduction in volume due to settlement} \\ &= 0.1 \times 5995.73 \text{ m}^3 = 599.5 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Total volume of landfill} &= 5995.73 + 1498.9 - 599.5 \\ &= 6895.13 \text{ m}^3/\text{annum} \end{aligned}$$

Assume height of landfill as 4m,

$$\begin{aligned} \text{Area required} &= 6895.13/3 \\ &= 2298.37\text{m}^2 \text{ say } 2300\text{m}^2 \end{aligned}$$

Provide size of landfill / annum as 215m length x 8m wide x 4m height.

6.2.2 Landfill capacity for next five years (2011 – 2016)

Rate of solid waste generation = 93ton/day

Out of which only 16 percent of solid waste (i.e. 14.88t/day) is to be disposed by land fill

$$\begin{aligned} \text{Take density of solid waste} &= 0.75 \text{ t/m}^3 \\ \text{Volume of waste/day} &= 14.88\text{t/day}/0.75\text{t/m}^3=19.84\text{m}^3 \\ \text{Volume of waste / annum} &= 19.84\text{m}^3/\text{day} \times 365 \text{ days} \\ &= 7241.6\text{m}^3/\text{annum} \end{aligned}$$

Volume of liner and cover and cover systems

$$\begin{aligned} &= 0.25 \times 7241.6 \text{ m}^3 \\ &= 1810.4 \text{ m}^3 \end{aligned}$$

Reduction in volume due to settlement

$$= 0.1 \times 7241.6 \text{ m}^3 = 724.16 \text{ m}^3$$

$$\begin{aligned} \text{Total volume of landfill} &= 7241.6 + 1810.4 - 724.16 \\ &= 8327.8 \text{ m}^3/\text{annum} \end{aligned}$$

Provide height of landfill as 4m,

$$\begin{aligned} \text{Area required} &= 8327.84/3 \\ &= 2775.94\text{m}^2 \text{ say } 2776\text{m}^2 \end{aligned}$$

Provide size of landfill / annum as 215m length x 9.7m wide x 4m height

6.2.3 Landfill capacity for next five years (2016 – 2021)

Rate of solid waste generation = 112ton / day

Out of which only 16 percent of solid waste (i.e. 17.92 t/day) is to be disposed by land fill

Take density of solid waste as 0.75 t/m³

$$\begin{aligned} \text{Volume of waste/day} &= 17.92 \text{ t/day} / 0.75 \text{ t/m}^3 \\ &= 23.89\text{m}^3/\text{day} \end{aligned}$$

$$\begin{aligned} \text{Volume of waste / annum} &= 23.89\text{m}^3/\text{day} \times 365 \text{ days} = \\ &8721.06\text{m}^3/\text{annum} \end{aligned}$$

$$\begin{aligned} \text{Volume of liner and cover and} \\ \text{cover systems} &= 0.25 \times 8721.06 \text{ m}^3 \\ &= 2180.2 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Reduction in volume due} \\ \text{to settlement} &= 0.1 \times 2180.2 \text{ m}^3 = 218.02 \\ &\text{m}^3/\text{annum} \end{aligned}$$

$$\begin{aligned} \text{Total volume of landfill} &= 8721.06 + 2180 - 218.02 = \\ &10683.04 \text{ m}^3/\text{annum} \end{aligned}$$

Assume height of landfill as 4m,

$$\text{Area required} = 10028.96/3 = 3342.98 \text{ m}^2 \text{ say } 3343\text{m}^2$$

Provide size of landfill / annum as 215m length x 11.7m wide x 4m height

6.2.4 Landfill capacity for next five years from (2021 – 2026)

$$\text{Rate of solid waste generation} = 135\text{ton/day}$$

Out of which only 16 percent of solid waste (i.e. 21.6t/day) is to be disposed by land fill Take density of solid waste as 0.75 t/m³

$$\begin{aligned} \text{Volume of waste/day} &= 21.1\text{t/day} / 0.75 \text{ t/m}^3 \\ &= 28.8 \text{ m}^3/\text{day} \end{aligned}$$

$$\begin{aligned} \text{Volume of waste / annum} &= 28.8 \text{ m}^3/\text{day} \times 365 \text{ days} \\ &= 10512 \text{ m}^3/\text{annum} \end{aligned}$$

Volume of liner and cover and cover systems

$$= 0.25 \times 10512 \text{ m}^3 = 2628 \text{ m}^3$$

Reduction in volume

$$\text{due to settlement} = 0.1 \times 10512 \text{ m}^3 = 1051.2 \text{ m}^3$$

$$\begin{aligned} \text{Total volume of landfill} &= 10512 + 2628 - 1051.2 = 12088.8 \\ &\text{m}^3/\text{annum} \end{aligned}$$

Assume height of landfill as 4m,

$$\text{Area required} = 12088.8/3 = 4029.43 \text{ m}^2 \text{ say } 4030\text{m}^2$$

Provide size of landfill / annum as 215m length x 14.0m wide x 4m height.

6.2.5 Landfill capacity for next five years from (2026 – 2031)

Rate of solid waste generation = 162ton/day

Out of which only 16 percent of solid waste (i.e. 25.92t/day) is to be disposed by land fill

Take density of solid waste as 0.75 t/m³

$$\text{Volume of waste/day} = 25092\text{t/day} / 0.75 \text{ t/m}^3 = 34.56 \text{ m}^3/\text{day}$$

$$\text{Volume of waste / annum} = 34.56\text{m}^3/\text{day} \times 365 \text{ days} = 12614.4\text{m}^3/\text{annum}$$

Volume of liner and cover and cover systems

$$= 0.25 \times 12614.4\text{m}^3 = 3153.6 \text{ m}^3$$

Reduction in volume due

$$\text{to settlement} = 0.1 \times 12614\text{m}^3 = 1261.44 \text{ m}^3$$

$$\text{Total volume of landfill} = 12614.4 + 3153.6 - 1261.44 = 14506.56\text{m}^3/\text{annum}$$

Assume height of landfill as 4m,

$$\text{Area required} = 14506.56/3$$

$$= 4835.52 \text{ m}^2 \text{ say } 4836 \text{ m}^2$$

Provide size of landfill / annum as 215m length x 16.7m wide x 3m height

6.3 LANDFILL PHASES

| | | |
|-------------------------|---|--|
| Active life of landfill | = | 25 years |
| Duration of one phase | = | 1 year |
| No. of phases | = | 25, each phase extends from base to final cover. |
| No. of cells | = | 12 / annum (since filling is done monthly once) |

6.4 LINER AND LEACHATE COLLECTION SYSTEM

(a) The liner system will comprise of the following layers below the waste.

1. 0.3m thick drainage layer comprising of coarse sand or gravel.
2. 1m thick clay layer / amended soil layer.

(b) Leachate collection pipes.

Diameter of HDPE pipes (perforated) = 15cm

Spacing of pipe required = 32m

(c) Leachate treatment plant

1. Collection sump (2.5m diameter, 3.5m depth)
2. On – line lime dosage system
3. On-line polyelectrolyte dosage system

4. Clarifier (3m diameter, 3.5m depth)
5. Clarified water sump (2.5m diameter, 3.5m depth)
6. Pressure Sand Filter (0.45m diameter, 2.15m depth)
7. Pressure Carbon Filter (0.3m diameter, 2.15m depth)
8. On-line chlorine dosage system

6.5 COVER SYSTEMS

The cover system will comprise the following layers above the waste

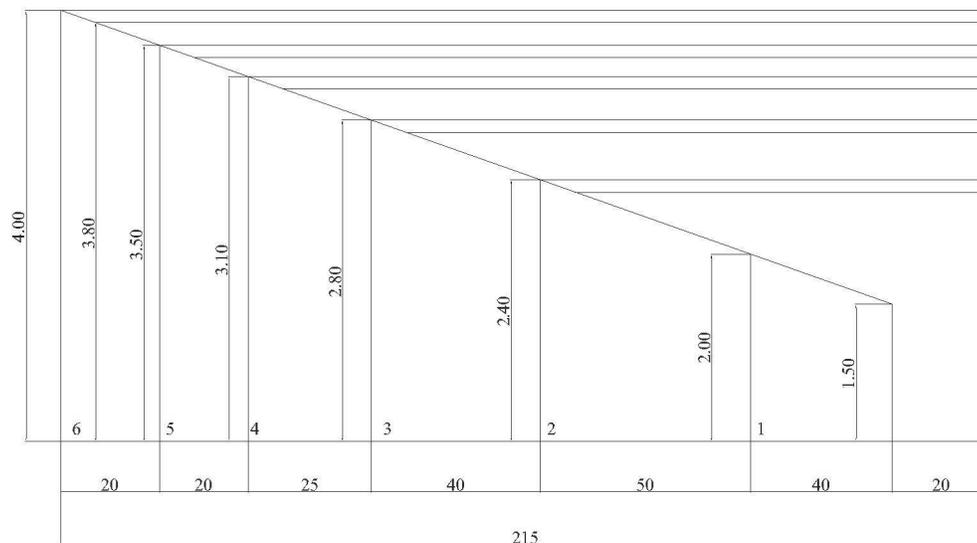
1. 0.45m thick gas collection layer comprising of gravel (stone dusts with no fines)
2. 0.6 m thick barrier layer (sandy soil + 5 percent bentonite)
3. 0.3m thick surface layer of local top soil for vegetative growth.

Passive gas vents 1m high (above GL), will be provided at a spacing of 32m x 32m.

6.5.1 Landfill Infrastructure and Layout

1. Site fencing : all around the landfill
2. Weigh bridge (computerized): 50t capacity with office
3. Administrative office : 10m x 5m building
4. Equipment workshop and garage: 30m x 20m building

5. Temporary holding area : 10m x 10m (To hold one month waste)
6. Leachate treatment facility: 20m x 10m tentative
7. Surface water drain : Adjacent to arterial road along periphery
8. Leachate collection pipe : Adjacent to arterial road along periphery
9. Access roads Main access road: 7m wide from main road to landfill area
10. Arterial road : 3.5m wide all along the periphery



ALL DIMENSIONS IN 'm'

1 - 1st MONTH FILL
 2 - 2nd MONTH FILL
 3 - 3rd MONTH FILL
 4 - 4th MONTH FILL
 5 - 5th MONTH FILL
 6 - 6th MONTH FILL

Figure 6.1 Schematic filling of waste in landfill area

The above Schematic filling is done by eight stages, First stage the entire layout is filled up to 1.5m depth further for compression. Second. Third, fourth, fifth, sixth, seventh and eighth stage filling are 1.5m – 2m ,2m – 2.4m, 2.4m – 2.8m, 2.8 – 3.1m, 3.1m – 3.5m, 3.5m – 3.8m and 3.8m – 4m respectively. The stages represent the month at which the filling is done from the starting of solid waste disposal. For every month/stage the cover is given up to 0.15m.

6.6 DESIGN OF COMPOSTING YARD

A detailed exclusive windrow composting yard with all plant component is designed.

Rate of waste generation = 77 t/day, in which 27 percent of solid waste is to be disposed by composting.

$$\text{i.e., } 77\text{t/day} \times 0.27 = 20.79 \text{ t/day}$$

Take density of waste as 0.385t/m^3

$$\text{Volume of waste} = 20.70 \text{ t/day} / 0.385\text{t/m}^3 = 54 \text{ m}^3/\text{day}$$

$$\text{Volume of waste per week} = 54 \text{ m}^3/\text{day} \times 7 \text{ days} = 378\text{m}^3/\text{week}$$

6.7 WINDROW PILES

Provide one windrow for one week of waste

Provide windrow of 2m wide and 1.5m height

$$\begin{aligned} \text{Therefore, required length of windrow} &= 378 \text{ of waste} / ((3.14/4) \\ &\quad \times 2\text{m} \times 1.5\text{m}) = 160.5\text{m} \end{aligned}$$

Provide the size of windrow per week as 160.5m length x 2m wide x 1.5m height

For four weeks of active phase, provide 4 no. of windrows of same size.

6.8 CURING PILES

$$\text{Volume to be cured} = 378/\text{week} \times 50 \text{ percent of shrinkage} = 189 \text{ m}^3/\text{week}$$

$$\text{Volume to be cured/month} = 189 \times 4 = 756 \text{ m}^3/\text{month}$$

As 50 percent shrinkage occurs, provide the length of curing piles as half of the length of the windrow piles.

Provide 4 nos. of curing piles of size 80.25m x 2m x 1.5m each

6.9 RUNOFF COLLECTION BASIN

Assumptions

- i The maximum precipitation during the rainy season is assumed as 644mm.
- ii 100 percent of precipitations falling on the hard surface will runoff .
- iii About 25 percent of the precipitation falling on the windrows and other piles will runoff.

$$\begin{aligned}
 \text{Runoff hard surface} &= 160.5\text{m} \times 2\text{m} \times 4\text{nos.} \times 5.5 \text{ times} \\
 &= 7062 \text{ m}^2 \times 644\text{mm} \times 100 \text{ percent} = 4547.92 \text{ m}^3 \\
 \text{Runoff from piles} &= 80.25\text{m} \times 2\text{m} \times 4\text{nos} \times 3\text{times} \\
 &= 1926\text{m}^2 \times 644\text{mm} \times 25 \text{ percent} = 310.08 \text{ m}^3 \\
 \text{Total} &= 4547.92+310.08 = 4858.006\text{m}^3 \text{ say } 4868\text{m}^3
 \end{aligned}$$

Therefore, provide collection basin of size 240m length x 24m wide x 2m depth.

The provided collection basin can hold 850m^3 of runoff plus 1152 m^3 of precipitation that will fall directly into the basin during the rainy season. The runoff holding basin is constructed of concrete leak proof basin so that the collected runoff can let to evaporate.

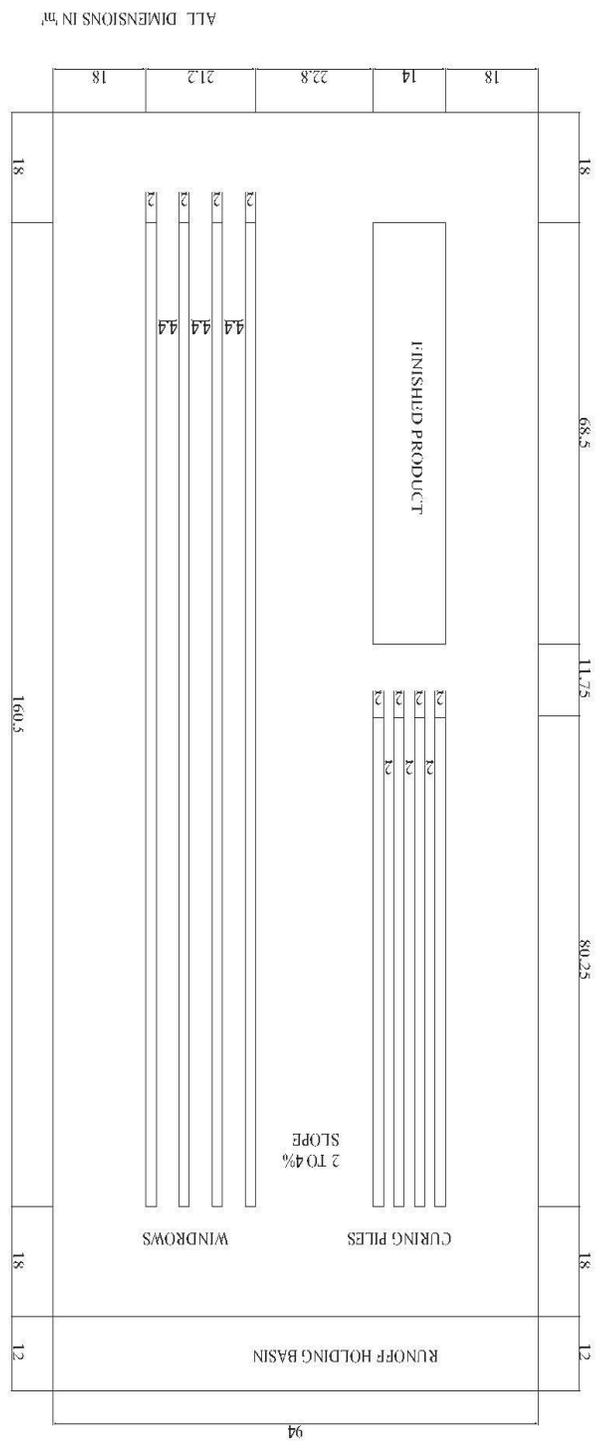


Figure 6.2 Layout of composting facility

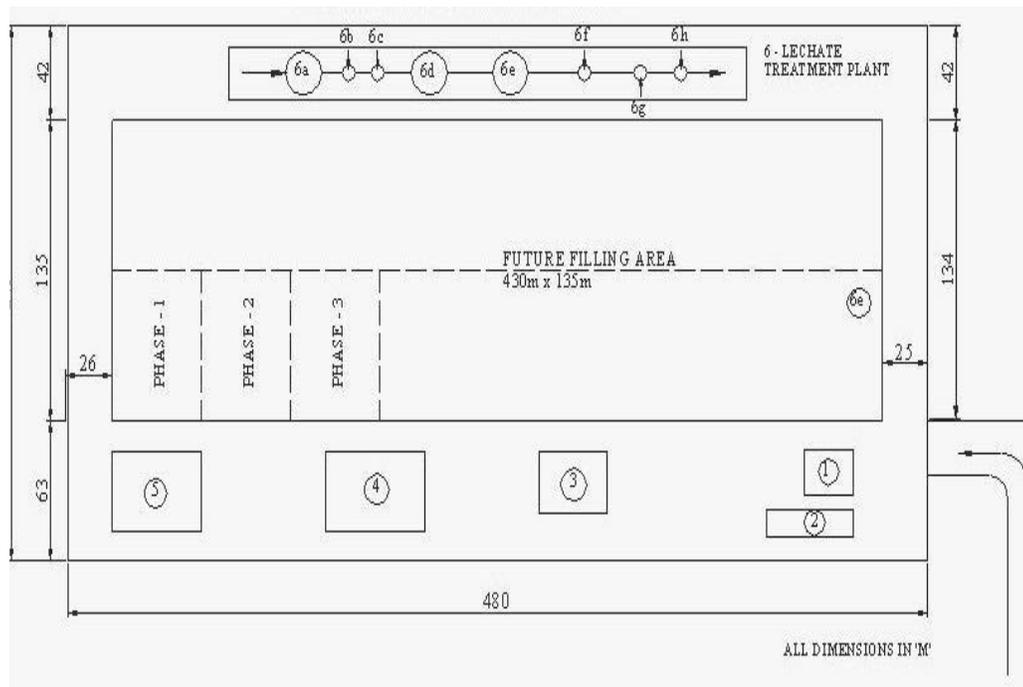


Figure 6.3 Layout of engineered sanitary landfill

1. Weigh bridge (10m x 10m), 2. Office room (10m x 5m), 3. Inspection / screening facility (10m x 10m), 4. Equipment workshop (30m x 30m), 5. Temporary holding area (15m x 15m), 6. Effluent treatment plant, 6a-Collection sump (5m dia, 7m depth), 6b-on-line lime dosage system, 6c-online polyelectrolytic dosage system, 6d-clarifier (6m dia, 7m depth) 6e-clarified water sump (5m dia, 7m depth), 6f-pressure sand filter (0.90m dia, 4.3m depth) 6g-pressure carbon filter (0.60m dia, 4.3m depth), 6h-on-line chlorine dosage system, 7. Phase I, Phase II etc. – landfill area / annum (year 1st 190m x 10m).

6.10 Design of Multiple-Chamber Incinerator

A small incinerator for ultimate thermal destruction of infectious and cotton waste is envisaged so as to serve the Hosur town municipality

which includes Bio medical wastes and conveniences of people from housing units.

The incinerator is multiple chambers, retort type, which can have 600-700°C of temperature in the primary combustion chamber and 900-1100°C in the secondary combustion chamber.

Basic Data

| | | |
|------------------|---|--|
| Waste type | : | Non – biodegradable |
| Moisture content | : | 10 percent |
| Combustion rate | : | 2.5t/hr. (assuming 12hrs. working hour, and 57 percent be non -Biodegradable substances, (therefore, 28.5 t/day) |

Composition of refuse

| | | |
|-----------------|---|------------------------------|
| Dry combustible | : | 2.5 t/hr. x 0.9 = 2.25 t/hr. |
| Moisture | : | 2.5 t/hr. x 0.1 = 0.25 t/hr. |

Heat combustion

Assume the heating value of garbage as 8820Btu/lb or 20580 kJ/kg or 4939 kC/kg

$$\begin{aligned}
 \text{The heating value for dry garbage} &= 2.25 \text{ t/hr.} \times 20580 \text{ kJ/kg} \\
 &= 2.25 \times 10^3 \times 20580 \\
 &= 46305000 \text{ kJ/hr.}
 \end{aligned}$$

Weight of products of combustion with 200 percent excess air

Assume that 20.85kg of products of combustion result from the combustion of 1t of garbage with 200 percent excess air

$$\begin{aligned} \text{Dry garbage} &= 2.5 \text{ t/hr.} \times 20.85 &= 51.45 \text{ t/hr.} \\ \text{Moisture} &= 0.25 \text{ t/hr} &= 0.25 \text{ t/hr.} \\ &= 51.70 \text{ t/hr.} \end{aligned}$$

Average gas temperature

The specific heat of products of combustion is 0.26 Btu/ lb F i.e. 0.606 kJ/kg.

$$\text{Temperature} = 46305000 / (0.606 \times 51.7 \times 10^3) = 1477.96^\circ\text{F} \approx 1478^\circ\text{F} = 804^\circ\text{C}$$

Combustion air Requirements

Use 200 percent excess air, 100 percent excess air is admitted through open charging door and leakage around doors, ports, expansion joints etc.

Assume that 85.72 cf i.e. 5.39 m³ of air theoretically necessary to burn 1kg of garbage

$$\begin{aligned} \text{Dry garbage} &= 2.25 \times 10^3 \text{ kg/hr.} \times 5.39 \text{ m}^3 / \text{kg} \times 2 \\ &= 24255 \text{ m}^3 / \text{hr.} = 6.8 \text{ m}^3 / \text{sec.} \end{aligned}$$

Volume of products of Combustion

Assume that 267.72 ft³/lb i.e. 16.6 m³/kg of products of combustion is formed from the combustion of 1kg of garbage with 200 percent excess air.

$$\begin{aligned}
 \text{Dry garbage} &= 2.25 \times 10^3 \text{ kg/hr.} \times 16.6 \text{ m}^3/\text{kg} \\
 &= 37350 \text{ m}^3/\text{hr.} \\
 \text{Moisture} &= 0.25 \times 10^3 \text{ kg/hr.} \times 23.58 \text{ m}^3/\text{kg mol} / 8 \text{ kg mol} \\
 &= 728 \text{ m}^3/\text{hr.} \\
 \text{Total} &= 38078 \text{ m}^3/\text{hr} \\
 &= 10.58 \text{ m}^3/\text{sec.}
 \end{aligned}$$

Volume of products of combustion through flame port

$$\text{Total volume} - \text{secondary air} = 10.58 \text{ m}^3/\text{sec} - 6.8 \text{ m}^3/\text{sec} = 3.78 \text{ m}^3/\text{sec}$$

Flame port area

Assume the velocity as 55ft/sec i.e. 16.76 m/sec

Ambient temperature as 27°C i.e. 540 deg R

$$\begin{aligned}
 \text{Required area} &= \frac{3.78 \text{ m}^3/\text{s} \times 2095 \text{ deg R}}{16.76 \text{ m/sec} \times 540 \text{ deg R}} \\
 &= 0.879 \text{ m}^2
 \end{aligned}$$

Mixing chamber area

Assume the velocity as 25ft/sec i.e. 7.62 m/sec

$$\text{Required area} = \frac{10.58 \text{ m}^3/\text{sec} \times 1095 \text{ deg R}}{7.62 \text{ m/sec} \times 540 \text{ deg R}} = 2.82 \text{ m}^2$$

Curtain wall port area

Assume the velocity as 20 ft /sec i.e. 6.09m/sec

$$\begin{aligned} \text{Required area} &= \frac{10.58\text{m}^3/\text{sec} \times 1050 \text{ deg R}}{6.09 \text{ m/sec} \times 540 \text{ deg R}} \\ &= 3.38 \text{ m}^2 \end{aligned}$$

Combustion Chamber Area

Assume the velocity as 8 ft /sec i.e. 2.43m/sec

$$\begin{aligned} \text{Required area} &= \frac{10.58\text{m}^3/\text{sec} \times 1000 \text{ deg R}}{2.43 \text{ m/sec} \times 540 \text{ deg R}} \\ &= 8.06 \text{ m}^2 \end{aligned}$$

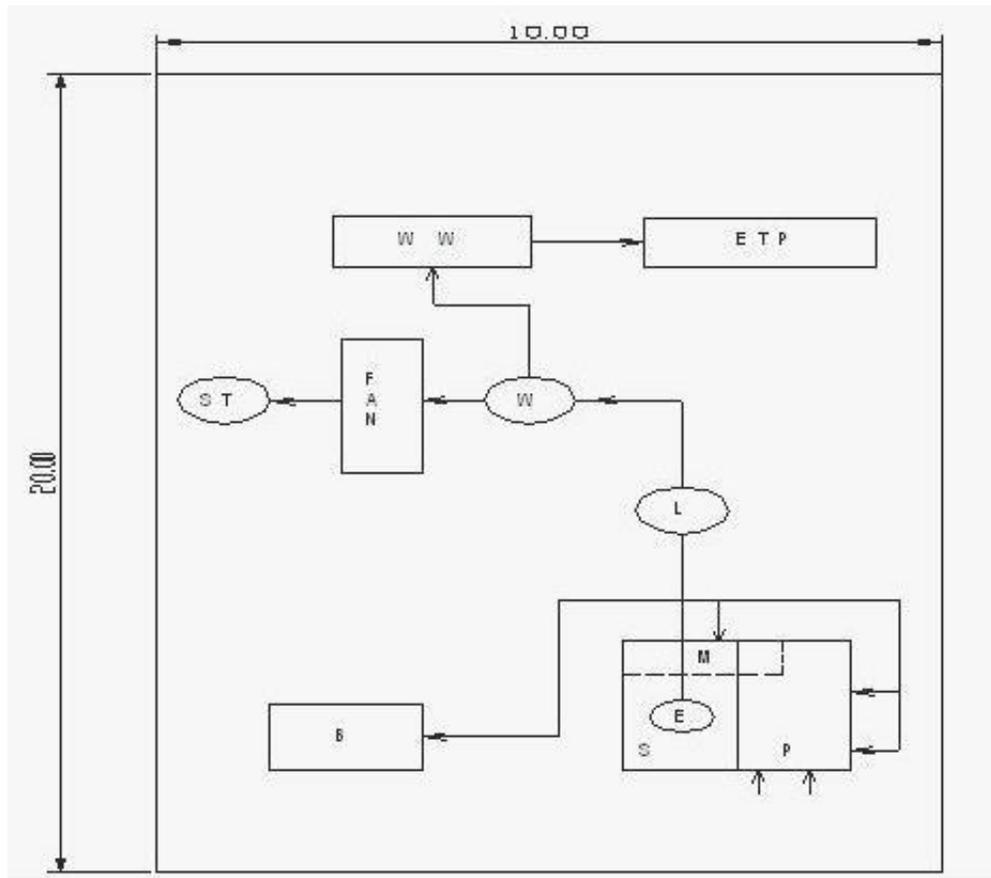
Stack area

Assume the velocity as 25 ft /sec i.e. 7.62m/sec

$$\begin{aligned} \text{Required area} &= \frac{10.58\text{m}^3/\text{sec} \times 1000 \text{ deg R}}{7.62 \text{ m/sec} \times 540 \text{ deg R}} \\ &= 2.60 \text{ m}^2 \end{aligned}$$

Grate area and arch height can be fixed by referring the relationship of grate loading to combustion rate and arch height to grate area for multiple chamber incinerators.

Although no emission cleaning systems are designed, it is proposed to install a dry scrubber followed by packed bed wet tower for ensuring complete removal of solids and odour.



Dimensions are in metre

Figure 6.4 Layout of Multiple Chamber Incinerators

P – Primary chamber, M – Mixing chamber, S - Secondary chamber, B – Air Blower, E – Effluent Duct line, L – Cyclone, W – Wet Scrubber, WW – Waste water collection sump, ETP – Effluent Treatment Plant

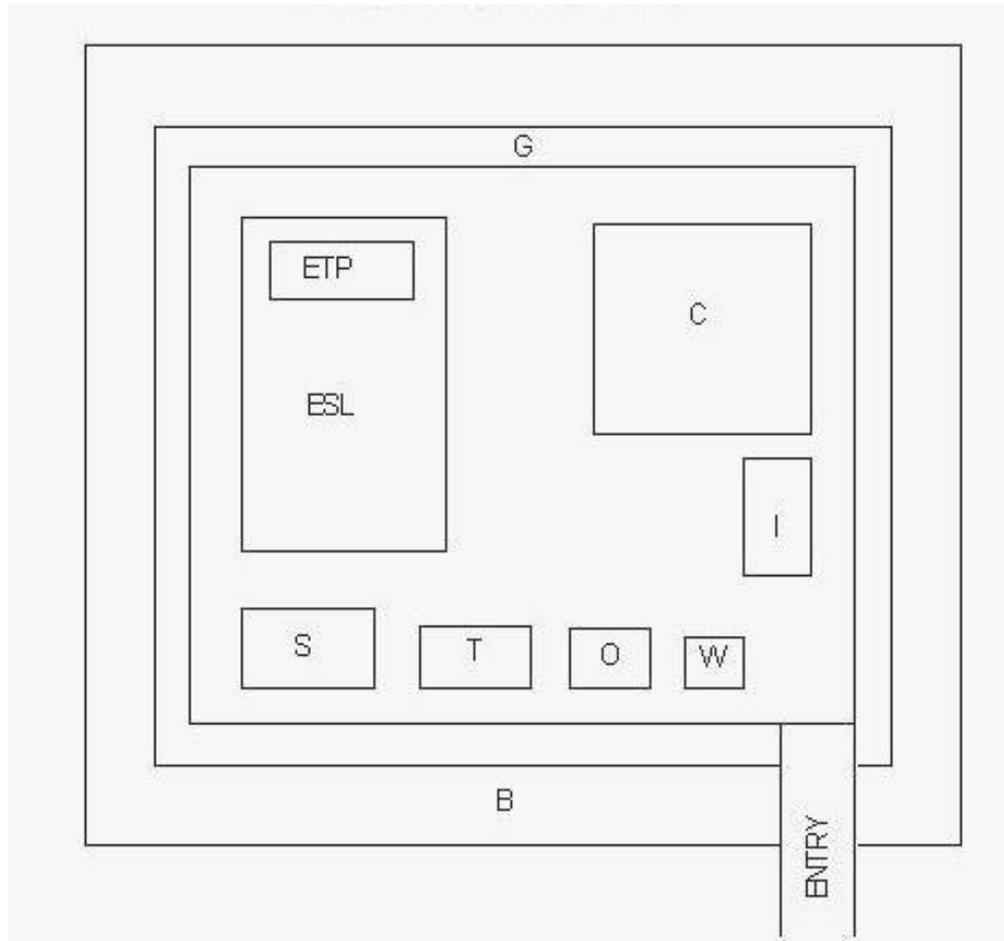


Figure 6.5 Layout of proposed facility

W – Weigh Bridge (50t), O – Office building, T – Temporary holding area, S – Waste Segregation yard, ESL – Engineered sanitary landfill, ETP – Effluent treatment plant, C- Composting yard, I – Incinerator, G- green belt, B – Buffer zone.