Basic Design Study for the High-Efficient Waste Incineration Power Plant Hanoi

Explanatory Report Logistics and Bunker

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1 Summary

In this explanatory report the basic concept for the plant logistics and the bunker is developed. The waste quantities and properties are specified as the basis for the design.

The site access will be provided via an internal road system, which is connected with the public highway ĐT70A at distance of nearly 800 m from the site. Three weighbridges serve to weigh the incoming and outgoing trucks.

A conventional type bunker is recommended for storing the waste. The complete bunker is divided in three sections, each serving one incineration lines. This allows sufficient stacking volume and an optimum crane operation. The waste is delivered to the bunker from an elevated tipping floor level. Dual tipping points are installed in each section.

For the waste cranes, a constellation similar to the HR-AVI Amsterdam is used which comprises of waste cranes on two different levels, which can be parked in a swallow's nest outside the working area. During the night shift when the waste is delivered, all three waste cranes have to be in operation. Therefore, the delivery period of the waste should be extended as far as possible to avoid phases where peak delivery is very distinctive. The extension has to be at least one hour per day, so that even in peak time delivery the operation of two cranes is sufficient and the third crane is then available as spare. The possibility of delivering the waste during the evening and night –Saturday and Sunday are already included for delivery - would thus alleviate logistics with crane operation. From the commercial perspective of the delivery of waste, this is even an economically attractive solution because the cycle time of the trucks used can be increased.

During the day hours, when no delivery takes place, the operation of just two cranes is quite sufficient. In the meantime, the other crane can be maintained and repaired, if necessary.

Apart from the waste bunker, a bunker to store the bottom ash from the combustion chamber for at least 3 days will be installed. The bottom-ash bunker is to be built away from the waste bunker below the horizontal pass of the boiler. For liquid consumables such as ammonia water and light fuel oil tanks and for solid consumables such as hydrated lime and activated coke silos with

at least 5 days storage time will be erected. For the boiler ash and flue gas treatment residues silos, a sufficient bottom clearance for the accessibility and filling of trucks is necessary.

2 Task

The purpose of this report is to provide an evaluation of the plant logistics with a focus on the bunker geometry and the dimensioning of the crane system in the waste and bottom ash bunkers. This report is based on the data specified for the supply and disposal logistics of the waste-to-energy plant (WtE) Hanoi. It serves for demonstrating the suitability of the chosen options and illustrates the design.

3 Design Basis

3.1 Waste

Total amount of waste, incinerated	912,500 Mg/a
Amount of waste, incinerated	2,500 Mg/d
Storage time for waste, minimum	5 d
Average incineration capacity	3 x 38.0 Mg/h

3.2 Delivery

Delivery days	365 d/a
Normal delivery	7 d/week
Duration of delivery	10 h over night

3.3 Vehicle Loading

Walking-floor trailers, per vehicle	20 Mg
Standard vehicles, per vehicle	average value 10 Mg

3.4 Other Storage Facilities

The design of all storage facilities is based on the data of the design load case (DLC) for the plant.

4 Design Data

The following data are the typical figures which have proved to be realistic in the design of comparable plants. The bunker ash quantity is calculated considering the DLC.

4.1 Waste

Bulk density of waste on delivery (high water content)	0.40 Mg/m³
Bulk density in bunker, matured and mixed (low water content)	0.35 Mg/m³

4.2 Bottom Ash

Total production of wet bottom ash	30 Mg/h
Bulk density of wet bottom ash	1.2 Mg/m³

4.3 Delivery

Peak delivery, referred to average figure	125 %
Unloading time for walking-floor trailers	15 min/vehicle
Unloading time for standard vehicles	7.5 min/vehicle

4.4 Waste Crane

Quantity	3
Grab size (hydraulic polyp)	12 m³
Compaction factor in grab	1.1
Grab filling, normally	85 %
Cycle time for loading/storage	2 min ≈ 30 cycles/h
Cycle time for clearing the tipping position	1.5 min ≈ 40 cycles/h
Grab capacity, mean:	12 m³ x 1.1 x 0.85 = 11.2 m³
Handling of waste from delivery bunker	11.2 m³ x 0.40 Mg/m³ = 4.48 Mg/cycle
Handling of matured waste from stacking bunker	11.2 m³ x 0.35 Mg/m³ = 3.92 Mg/cycle
Lifting capacity	25 Mg
Crane width	30 m
Rail length	100 m

Lifting height	40/50 m

4.5 Bottom Ash Crane

Quantity	2
Grab size (clamshell grab)	4.0 m³
Compaction factor in grab	1.0
Grab filling, normally	85 %
Cycle time	3 min
Grab capacity, mean:	4.0 m³ x 1.0 x 0.85 = 3.4 m³
Corresponding to:	3.4 m³ x 1.2 Mg/m³ = 4.08 Mg/cycle
Lifting capacity	12 Mg
Crane width	16 m
Rail length	100 m
Lifting height	15 m

5 Conceptual Design

5.1 Waste Delivery

The delivery is assumed to take place 7 days per week, during night for 10 hours. For the number of tipping locations and for the design of delivery bunker, it is assumed that some peaks in delivery will arise. According to the European standards, this occurs over two periods of time, each lasting approx. 2 hours. The peaks result due to the fixed starting time of the collection trucks, then they are filled at a similar time and will enter the plant even together, only depending from the distance between collection place and plant site. At all other times, a reduced amount of waste will be delivered. This trend is illustrated in the following *Figure 5.1*.

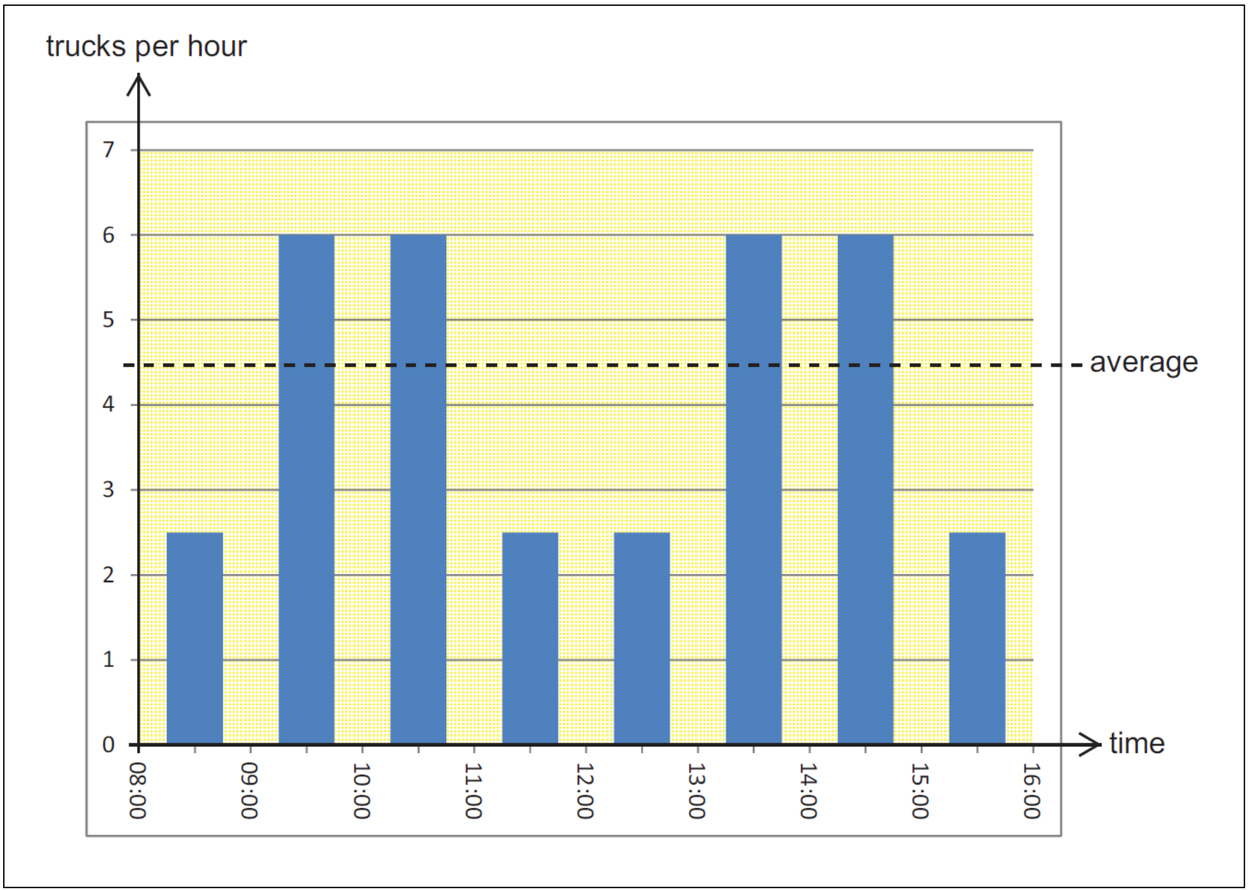

Figure 5.1: Typical waste delivery

In the future, it is necessary to consider that the plant will be supplied with waste only on 6 days/week.

The WtE Hanoi is effectively in operation for 8,760 h/a, i.e. every day of the year. The planned revisions in the order of 760 h/a take place per line, thus normally two lines are in operation as a minimum.

On the basis of these conditions, the following quantities can be defined for delivery (Table 5.1). Some water may separate as leachate and is collected in the sump of the bunker and is then pumped to the leachate treatment plant. The working and the processes of the leachate treatment plant are to be considered in the detail engineering phases.

Table 5.1: Quantities of waste delivered

	Mg/a	**Days/y**	**Mg/d**	**Delivery Mg/h (100 %)**	**Delivery Mg/h (125 %)**
Quantity of waste delivered	912,500	365	2,500		
Waste delivery only on 6 d/week		310	2,944	295	369
Quantity of waste incinerated			2,736	3 x 38.0	

Table 5.2: Vehicle movements

Vehicle	**Load**	**Number of trucks** average	**Number of trucks** peak, 125%
Unit	**Mg**	**Truck/h**	**Truck/h**
Standard vehicle	10	30	37
Walking-floor trailer	20	none	none

For the calculations it is assumed, that no delivery is done by walking-floor trailers, this results in a worst case scenario in terms of traffic.

5.2 Weighbridges

At the entrance of the WtE Hanoi, weighbridges are installed. The standard dimensions are 3 x 20 m and ensure the weighing of 40 feet long trailer trucks. The weighbridge works fully automatic, the identification of the trucks may happen via electronic card, register number of the truck or similar. Details have to be defined later in the engineering phase. The time span needed for a weighing procedure is under normal conditions less than 1.5 mins, normally. More than 40 trucks can therefore be weighed in an hour per weighbridge.

On an average, 30 trucks arrive for delivering waste in an hour. Adding 6 trucks (approx. 20 %) to this figure for other trucks which enter the plant to deliver additives or to collect bottom ash or residues (see chapter 5.8) results in max. 36 weighing procedures per hour. Thus, only one weighing bridge would be sufficient for incoming traffic. Taking the peak hours into consideration 37 + 6 = 43 trucks have to be weighed, which is only little more than the capacity of one weighing bridge. The installation of two weighing bridges ensures sufficient reserve capacity. This avoids queuing and waiting time for the incoming trucks.

For the outgoing traffic only one weighbridge is installed, because not all trucks have to be weighed twice, i.e. while incoming and outgoing. It is assumed, that most of the municipal waste collection trucks are only weighed as incoming trucks, as all truck data are available.

Thus, three weighbridges are proposed. Each weighbridge is equipped with a set of traffic lights and the badge reading devices.

An internal research has shown, that the availability of existing weighbridges in comparable plants is more than 99 %, thus the availability is no reason to install more than the calculated number of bridges. One of the incoming weighing bridges is equipped to be used in the outgoing direction as well. This enables maintenance in any case.

5.3 Tipping Points

The layout of the plant envisages dual tipping points at the delivery bunker, designed in standard shape. One tipping point can cater to 8 trucks per hour at the rate of 7.5 min/truck. There are 37 incoming trucks during a peak hour, i.e. 5 tipping points are required in total. This would result at least in 3 dual tipping points. As shown later, just 3 tipping points would not allow an efficient waste handling with the cranes, because the delivered material would pile up and lead to restrictions in the crane operation. Therefore, at least 9 dual tipping points are designed. This allows a better distribution of the waste as per the actual logistic within the bunker area. The number of tipping points is spread uniformly over the overall length of the bunker and results in a total of 18 tipping points. This is more than sufficient and gives the optimum in crane operation.

Each tipping point is equipped with a set of traffic lights, showing whether the tipping point is free or closed for delivery. The traffic lights are switched by the waste crane operator. Furthermore, each tipping point may be equipped with a door for odour suppression, when no delivery takes place. It is actuated by the truck driver.

Figure 5.2: Typical tipping points, with partly enclosed doors for odour suppression

5.4 Waste Bunker

5.4.1 General Bunker Design

For the bunker, separate sections are designed. The separation is achieved by means of partition walls. These partition walls provide fire protection within the bunker area. Furthermore, the construction allows installing walkways/traces between the boiler house and the delivery hall as well to the workshops, situated underneath the elevated tipping hall. The only disadvantage is that the waste transported from one section to the other has to be crane transported over this partition wall. Therefore the height of these partition walls is limited to 10 m height, in normal operation this does not lead to limitations during the logistic handlings in the bunker.

Every section of the delivery bunker is designed in a classical manner, i.e. without partition wall. The waste is delivered in the front section and will be stored and mixed in the rear section. The height the waste can be stored is sufficient, as the specified waste can be stacked with nearly vertical walls. This design enables the operator to free the delivery area easily and with a very short cycle time. This allows the maximum transfer capacity during peak hours of operation. Outside the peak hours with less frequent delivery, the stacked waste can be mixed in order to homogenize the waste.

The height of the partition wall is +10.00 m, and as such it is well below the level of the feed hoppers. In this way, a good compromise is reached between the bunker volume and accessibility by the crane.

Waste cranes with 12 m^3 grabs are assumed. When the grab is open, these have a diameter of approx. 6.5 m. This means that the minimum length for the cross-section of the delivery bunker cassette needs to be 3 x 6.5 = 19.5 m; the length chosen is 22.0 m. The length of the feeding hopper level has to be 8.0 m to ensure a smooth crane operation while feeding. This results in a total bunker length of 30.0 m per section.

The bunker is divided into three sections, one section per incineration line. This allows operating the three cranes at the same time without obstructing each other. The width of each section is 24 m and gives enough space for each crane.

5.4.2 Number of Waste Cranes

Three waste cranes are assumed to operate in the bunker simultaneously. The cranes are placed on two different crane beam levels to increase the efficiency in crane operation. At the lower level two cranes are provided, at the higher level only one crane. At the sides of the bunker there are swallow nests as parking position for the waste cranes, even with two levels.

5.4.3 Delivery Bunker Area

To load the incineration with 3 x 38.0 Mg/h, a total of 114.0 Mg / 3.92 Mg/cycle = 29.1 cycles are required. As 30 cycles can be operated per hour per crane this requires 1.0 crane to feed the three incineration lines. Consequently 2.0 cranes can be used to perform all other operations in the bunker. Furthermore it means that outside delivery times only one crane is needed for operating the plant.

The waste from the delivery bunker area has to be transferred to the stacking bunker area at the rear side, where it is mixed (homogenised) and finally stapled and stored until being fed to the incinerator. On an average, a total of 295 Mg/h waste is delivered into the bunker and 369 Mg/h during the peak hours. The capacity of the waste cranes to clear the delivery bunker area is rated as follows:

2.0 cranes x 4.48 Mg/cycle x 40 cycles/h = 358.4 Mg/h.

The resulting excess capacity of approx. 60 Mg/h (approx. 20 %) is a more than sufficient margin for average delivery. Even during the peak hours there is a very small excess capacity of approx. 10 Mg/h. This means that normally no surplus of waste is left at the tipping points during peak hours.

Taking into account that one of the waste cranes is not available during delivery time, only one crane can clean the tipping points. This results in a deficit of approx. 115 Mg/h during average delivery but even 190 Mg/h during peak delivery. The volume below the tipping points has to be sufficient for this.

To simplify the crane operation, one dual tipping point should be able to receive at least four transport loads of a collection truck without having to be cleared. This is the same as two container trucks. The necessary volume is thus 2 x 20 Mg / 0.37 Mg/m³ = 108 m³. To guarantee this volume a depth of 10 m is selected for the bunker. This results in a volume of ½ (4 m x 7 m x 10 m) = 140 m³ per tipping point equal to a storage capacity of 56 Mg/tipping point. Thus, only 1.4 dual tipping points will be filled up and blocked for further delivery after one peak hour.

After the period of peak delivery (2 hours), 6 dual tipping points been filled up and cannot be used further for delivery of waste. Therefore, at least 3 additional dual tipping points should be designed to enable continuous delivery. The excess amount can be cleared easily when waste delivery is below average. By the time the second peak arises, the dumping points are once again empty in any case.

Hence, the waste cranes are the bottleneck at the assumed peak delivery times. This result is not astonishing because of the conservative figures assumed. The recommended solution to avoid this critical situation is to minimize peak delivery and/or lengthen the delivery time in practice. As shown by the calculations, 3 cranes are sufficient to operate in the bunker. Outside delivery time, even 1 crane would be sufficient to feed the hoppers. A second crane may be used to mix the delivered waste once more while the third crane is available as redundancy or is ready for inspection, maintenance or repair.

5.4.4 Stacking Bunker Area

The calculations for the stacking bunker area are based on different bulk densities, depending on the height within the stacking pile. The respective calculation rules for the structural dimensioning of the bunker specify the following compression figures for domestic waste (the elevations have been converted to the conditions prevailing at the WtE Hanoi):

Bottom, between -5.0 m to +4.5 m:	0.70 Mg/m³
Middle, between +4.5 m to +13.5 m:	0.50 Mg/m³
Top, between +13.5 m to +25.0 m:	0.35 Mg/m³

Accordingly, in the two layers bottom and middle, the average density is approx. 0.6 Mg/m³.

For the calculation of the stacking volume, the height of the feeding hopper floor is defined at +25.0 m, the base of the bunker being at a level of -5.0 m, the length is selected with 22.0 m and the width amounts to 76 m. The waste will be stacked up to the level of +20.0 m

A minimum storage of 5 days at full load (DLC with 38.0 Mg/h) is required; a storage capacity of 7 days would be appreciated. The necessary volume is thus calculated as follows:

5 d x 3 x 38.0 Mg/h x 24 h/d = 13,680 Mg.

In the two bottom layers, a volume of 76 m x 15 m x 18.5 m = 21,090 m³ is theoretically available (the usable length is calculated only with 15 m in place of 22 m). From this value, the unavailable volume for the two tunnels crossing the bunker has to be subtracted, i.e. ca. 2 x 4 m x 15 m x 15 m = 1,800 m³. The quantity of the two bottom layers is then 19,290 m³ x 0.6 Mg/m³ = 11,574 Mg. The volume of the top layer is 76 m x 15 m x 7.5 m = 8,550 m³ equal to 2,992 Mg of waste. This results in 14,566 Mg waste, which is enough for the required 5 days storage, but less (by approx. 4,600 Mg) for the desired 7 days storage. Additional capacity is available by increasing the stacking height up to the feeding hopper level. This gives 76 m x 10 m x 5 m = 3,800 m³ equal to 1,330 Mg (the usable length is calculated only with 10 m in place of 22 m); otherwise the stacked pile may collapse. The partial area below the tipping points accounts for further 0.5 x 76 m x 10 m x 7 m = 2,660 m³ or 1,596 Mg of waste. With this capacity of nearly 17,492 Mg, 6.4 days delivery can be stored in the bunker and enable a high flexibility in bunker logistic.

In practice, if the entire area below the tipping points is used, the storage capacity increases and offers an additional capacity of 0.6 days.

Thus, the bunker capacity will be sufficient for 7 days. The mentioned calculations are based on some simplifications, especially that the waste cannot be stored vertically, but in the form of heaps.

The figures below illustrate the bunker design:

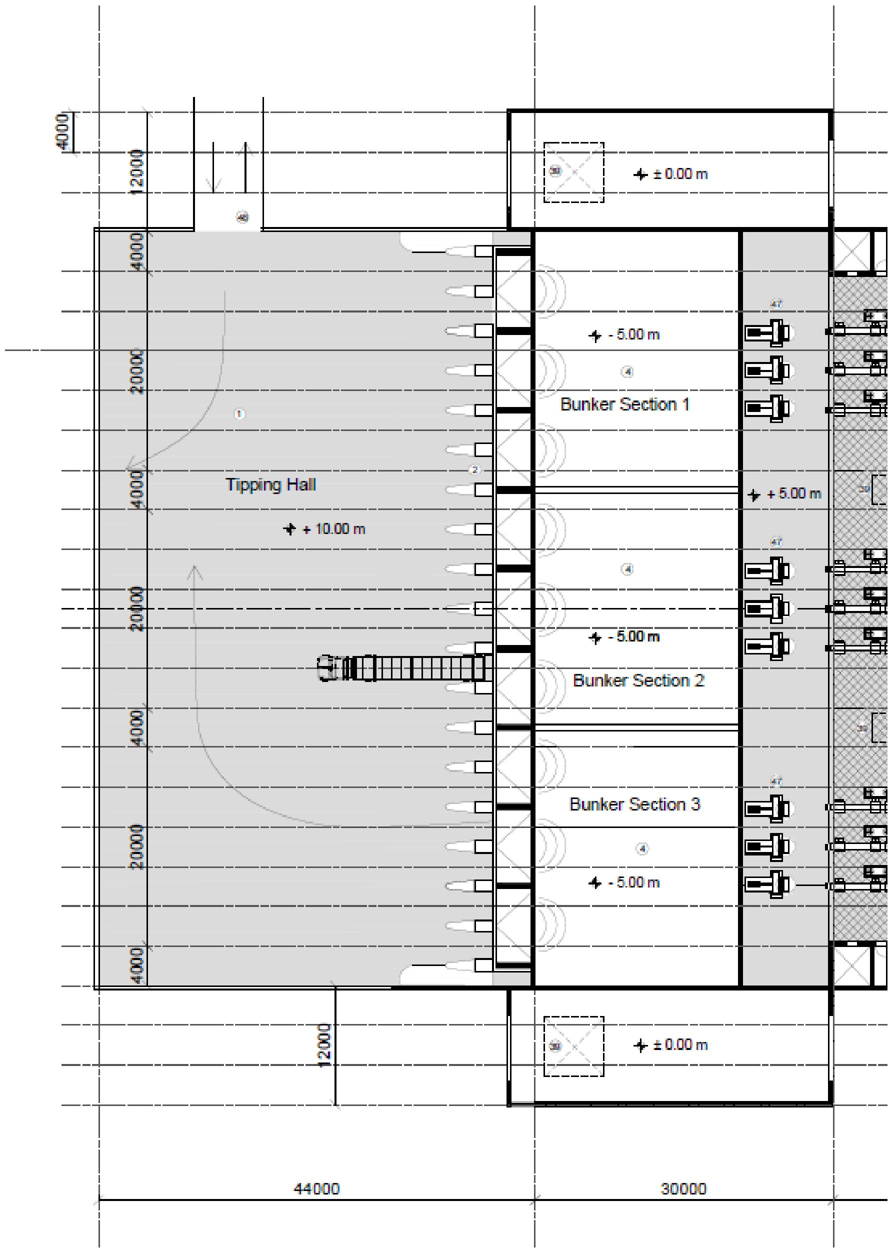

Figure 5.1: Schematic Bunker Floor Plan

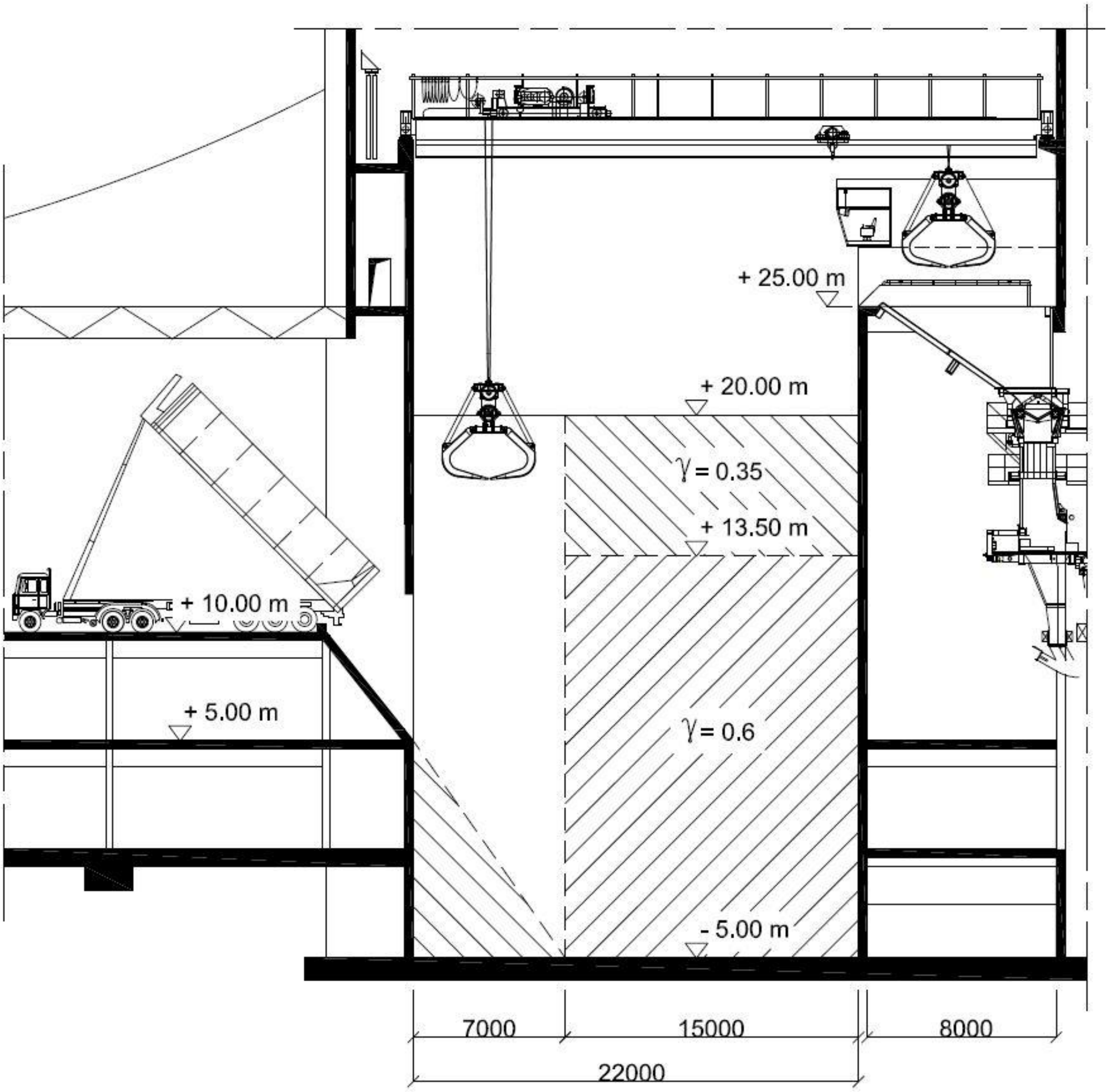

Figure 5.2: Schematic Bunker Section with Main Dimensions

5.5 Waste Cranes

A classic design with "swallow nests" situated outside the working area is designed. The necessary three cranes are distributed over two crane beam levels. This means that each crane can be used over the entire bunker area and can be parked in the swallow nests. There is no middle crane which would have to be parked on top of the partition wall, so that the crane operations of the two other cranes on the same level are obstructed.

In the swallow nest, the necessary maintenance and repair is carried out. An auxiliary hoist between the roof trusses facilitates installation and removal of heavy parts on the crane and the trolley. On the floor of the swallow's nest, there is a closable hatch opening to allow the grab to be lowered to ground floor. From here it will be transported with a fork lift truck with trailer to the workshop.

A double-girder overhead crane with hydraulic grab is proposed as the crane type. Hydraulic grabs have become increasingly popular, after the 4-rope grabs had previously dominated the scene for many years.

With the hydraulic type grab, all driving mechanisms are located in the head of the grab, which means that only one supporting rope and one electric power cable are required. The lifting mechanism and the cable drum are located on the trolley. With a 4-rope grab, the two supporting and two closing ropes have to be led through a winch in such a way as to ensure that the closed grab does not open. The winch is a very complex mechanism; the wear and tear on the ropes is quite substantial, meaning that frequent replacements are necessary. The hydraulic grab has now become the preferable option in the interest of cost-effectiveness. And as this type of grab can handle more waste with a high compaction factor, it has been selected as the better option for the WtE Hanoi (note: the compaction figure in the calculations is estimated below the expected figure in practice as a worst case scenario).

The cranes are fully automated and can recognize and store the logistics of the stacking areas, so that a bunker management system can be operated. Outside delivery hours, only two cranes are in operation, mostly in automatic operation. During waste delivery, all cranes are required. These are then operated manually, as in this way it is possible to achieve higher handling capacities. Operation of all cranes in parallel is performed by only two crane operators, working in one crane cabin in between the feeding hoppers of the incineration lines. So only two crane chairs are installed, completed by a radio controlled control panel. A crane operator can operate two cranes simultaneously, i.e. one crane manually while the other is in automatic mode.

The cranes are operated from the crane cabin. The crane cockpit is placed as much as possible elevated above the feeding hopper level in the vicinity of the in-situ heavy structure on the storage side of the bunker. The elevated position means that it is possible to look into the feed hoppers, and there is also a good view of the delivery area of the bunker. Because of the length of the bunker there are some restrictions in view, but the excellent position is comparable to the position in the HR-AVI Amsterdam, which gives no problems in operation. There are many examples of waste-to-energy plants with even more restricted view, that still work perfectly. Any relevant information for the operator can be provided by installed cameras.

5.6 Bottom Ash Bunker

The bottom ash bunker is built separately, away from the waste bunker to allow the direct loading from the bottom ash into trucks. The building is pushed as a concrete structure underneath the boiler, and is equipped with two bottom-ash cranes. These operate fully automatically and keep the dumping areas clear. The solution with two cranes is necessary because of the high capacity of the plant and ensures the availability of the plant even if one crane fails.

The bottom ash bunker itself is as narrow as possible and the depth is equal to the waste bunker. The additional width is proposed at street level and higher, where the loading takes place. The street has a width that trucks can overtake. The truck rides to a position, where the loading can take place with a minimum of riding of the crane to receive the maximum of loading capacity. Baffle plates shaped in the form of a hopper and fixed on the crane bridge ensure that the contents of the open grab are emptied onto the trailer of the truck without any mess. It is assumed that the usual semi-trailers are used for transport of the bottom ash.

The bottom ash cranes are equipped with a hydraulic clamshell type grab and can be operated fully automated. Manual operation with utilization of the semi-automatic is performed with a radio controlled control panel when the bottom ash is loaded onto the trucks. The cranes are operated each by an operator who gives the enabling signal for unloading, while all other functions are performed by the crane in fully automatic operation. There is one crane cabin installed with one chair to operate one or the other crane. Normally there is no need to use the cabin.

If both of the bottom ash cranes are not available, a mobile excavator is used to clear the discharge area. These can be rented immediately.

The bottom ash needs to be stored intermediately before being transported away or treated further. An intermediate buffer of at least 3 days is required in order to bridge weekends and public holidays. The wet bottom ash discharged out of the extractors amounts to:

30 Mg/h : 1.2 Mg/m^3 x 24 h/d x 3 d = 1,800 m^3.

A width of 4 m has always to be kept clear at the discharge points of the bottom ash discharger (3 per incineration line) and cannot be used for storage, thus a width of 3 x 3 x 4 = 36 m. As the discharge points only block half of the bunker width, the other width can be used as storage volume.

The total width of the bottom ash bunker is defined by the width of the boiler house on top of the bunker, i.e. 76.0 m. The bottom ash bunker has an effective volume of (76 - 36) m x 6 m x 5 m = 1,200 m^3. This volume, calculated as water volume, is not sufficient. The required amount can be made up by stacking in partial areas of the bunker, in particular around the loading area. The possible additional stacking height is at least 3.0 m and does not lead to any obstructions for crane operation. Under consideration of the storage angle, this gives an additional volume of (76 - 36) m x 4 m x 3 m = 480 m^3. Further some additional volume is available at the discharge points, as half of the bunker width can be used without blocking the discharge. This gives a volume of 36 m x 4 m x 4 m x 0.5 = 288 m^3. Thus nearly 1,200 m^3 + 800 m^3 = 2,000 m^3 are available as storage volume. This is equal to a storage capacity of 3.3 days.

Considering the conservative figure of bottom ash amount, the volume of the bunker is sufficient in any case.

The bottom ash crane operates slowly. The cycle time to clean the discharge points is estimated with the high figure of 3 min, the cycle time to load a truck is estimated with only 2 min because there is nearly any crane riding required. The loading of one truck with 20 Mg capacity requires only 20 Mg / 4.08 Mg/cycle = 4.9 cycles and will be finished within 10 minutes. As the next truck may wait at another position the loading time for one truck is calculated with 15 min.

The clearance of the discharge points of one incineration line requires 10 Mg/h / 4.08 Mg/cycle = 2.45 cycles/h equal 9 min. The clearance time for all three lines is thus 27 min. During this time the crane is blocked and not available to load the trucks.

The bottom ash of one week incineration (5,040 Mg) has to be loaded within the day shift of 6 working days (840 Mg/d). This results in 42 trucks/d. These will arrive at the WTE plant within 8 hours and a peak load of 125 %, i.e. 6 trucks/h. Thus one bottom ash crane is needed completely for loading purposes without any reserve for other activities during peak hours. Considering the required clearance time of only approx. 20 min for the other crane there is sufficient reserve capacity available – even in peak hours. During average hours there would be even additional reserve in capacity. During night shift only one crane is required, this gives enough time for repair and maintenance. Thus, two bottom ash cranes are sufficient.

5.7 Storage Facilities for Consumables and Residues

Various reagents and additives that are delivered for the operation of the WtE Hanoi are transferred to intermediate storages. These consumables are listed in Table 5.3, with details of the amounts involved:

Table 5.3: Properties of consumables and necessary storage capacity

Consumables	**Quantity** (kg/h)	**Bulk density** (Mg/m³)	**Storage quantity** (day)	**Means of storage**	**Required storage volume** (m³)	**Selected volume** (m³)
Ammonia water	300	1.0	20	tank	2 x 25	2 x 28
Activated coke	90	0.5	1.25 truck	silo	2 x 25	2 x 32
Hydrated lime	2,400	0.5	5	silo	6 x 96	6 x 106
Light fuel oil	-/-	0.9	1.25 truck	tank	1 x 25	1 x 50

For the two liquid reagents, tank storage is provided far enough away from the building. Unloading is carried out via a catch pit covering the rear end of the vehicle. A pipeline bridge running over the roads joins the store to the incineration plant.

The tanks or silos are at least dimensioned to take approx. 125 % of the vehicle volume. This ensures that entire vehicle loads can be filled up, which means that favourable cost prices can be obtained.

The remaining solid additives are delivered to a “central” point by silo vehicles using on-board equipment to dump and pump the material into the respective silo.

The residues shown in Table 5.4 below are produced in the WtE Hanoi:

Table 5.4: Properties of residues and necessary storage capacity

Residue	**Quantity** (kg/h)	**Bulk density** (Mg/m³)	**Storage quantity** (day)	**Means of storage**	**Required storage volume** (m³)	**Selected volume** (m³)
Boiler ash	720	0.5	5	silo	2 x 87	2 x 97
FGT Residue	3,900	0.5	5	silo	2 x 468	2 x 468

The residues are stored centrally in silos that are grouped together and placed in a way so that the silo vehicles can drive under the silo for loading. Depending on the chamber to be filled, the vehicle must advance forwards. Loading is carried out dust-free by means of appropriate loading facilities.

5.8 Number of Trucks

The number of trucks delivering the required consumables, transporting residues and boiler ash is roughly calculated on the basis of the above mentioned quantities. This sums up to 7.5 Mg/h or 1,260 Mg/week. This gives approx. 63 trucks/week equal 11 trucks/d or in average 2 trucks/h.

The number of trucks carrying off the bottom ash was calculated with 6 per hour. That means that apart from the trucks for the waste delivery approx. 8 trucks/h will enter the plant for other purposes. With some reserve this gives a calculation figure of 10 trucks/h on an average.

Thus, an average figure of 40 trucks per hour is to be expected entering the plant consisting of 30 trucks for the delivery of waste and 10 trucks for the delivery of consumables, and the disposal of residues and ash.

Hamburg, in June 2018

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