Application of Geosynthetics Technology for Landfill Structure Design at Pt. Toba Pulp Lestari Tbk. North Sumatera, Medan - Indonesia

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Abstract : *Modern landfill typically contain several geosynthetic and natural components integrated into a system whose primary function is the containment of waste and leachate. The physical interactions between these individual components must be carefully evaluated to ensure that the stability and performance of the liner system is provided in the long term.*

Geomembrane HDPE are gaining increasing acceptance in landfill liner systems, yet their interactions with other components in the system are often not well understood. This paper indentifies some of these interactions and suggests methods for landfill structure design.. This paper presents a design of landfill structure at PT. Toba Pulp Lestari Tbk., Medan, Nord Sumatra. The landfill dimension is 10000 m^2 and 15 m depth.

Keywords : *Direct shear, Geosynthetic, Landfill, Leachate Tank, Waste disposal,*

1. INTRODUCTION

Waste management is the collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human and industry activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is a distinct practice from resource recovery which focuses on delaying the rate of consumption of natural resources. All waste materials, whether they are solid, liquid, gaseous or radioactive fall within the remit of waste management. Waste management practices can differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management of non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator subject to local, national or international authorities.

Disposal of waste in a landfill involves burying the waste and this remains a common practice in most countries. Landfills were often established in abandoned or unused quarries, mining voids or borrow pits. A properly designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. Older, poorly designed or poorly managed landfills can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin, and generation of liquid leachate. Another common product of landfills is gas (mostly composed of methane and carbon dioxide), which is produced as organic waste and breaks down anaerobically. This gas can create odor problems, kill surface vegetation and is a greenhouse gas.

Design characteristics of a modern landfill include methods to contain waste disposal has normally landfill gas extraction systems installed to extract the landfill gas. Gas is pumped out of the landfill using perforated pipes and flared off or burnt in a gas engine to generate electricity (see Figure 1.)

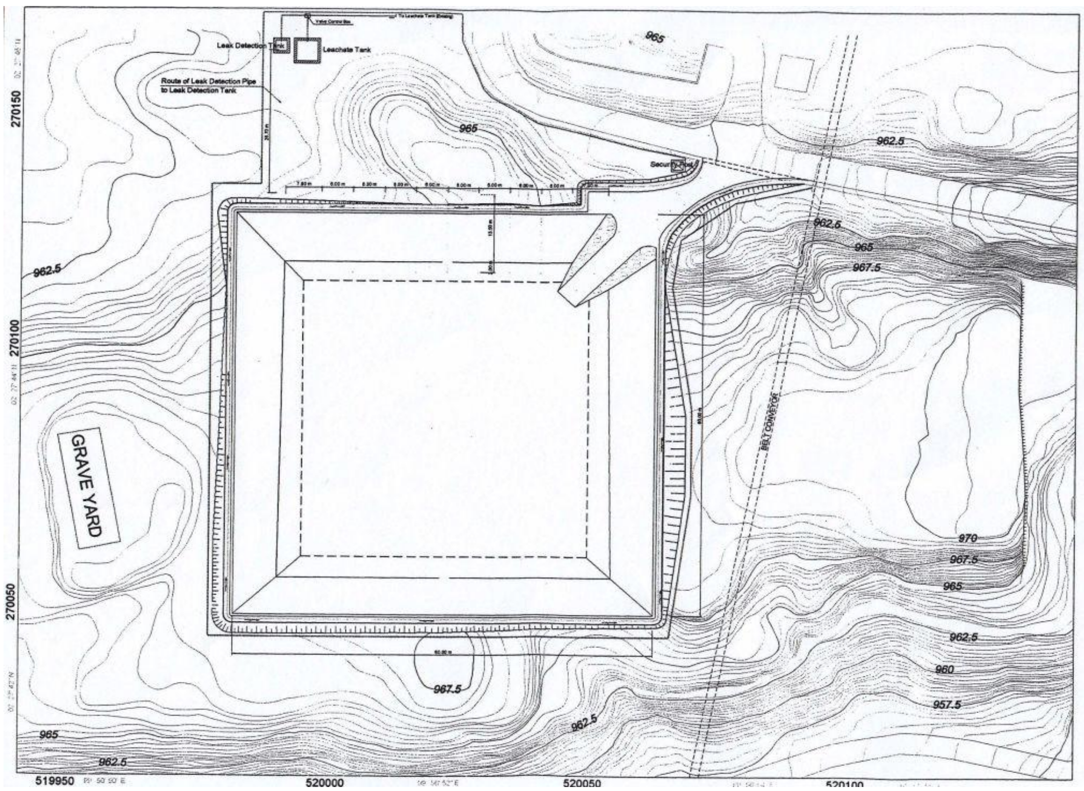

Figure 1. : Lay out of the Landfill PT.Toba Pulp Lestari Tbk.

Geomembrane High Density Polyethylene (HDPE geomembrane) is factory manufactured hydraulic barriers. Their acceptance and use has been relatively widespread, although, as with other geosynthetics, their behaviour within a multi-component liner system is not well universally understood.

HDPE geomembrane have three applications within a modern landfill liner system. The most common application is as a complete or partial replacement of a compacted clay liner. In this application, the HDPE geomembrane is located immediately above a subgrade and act to minimize leakage by isolating flow through any holes that may be present in the geomembrane itself. Another application involves the placement of the HDPE geomembrane immediately a top the geotextile. The primary purpose of the geotextile in this application is to protect the geomembrane against puncture from overlying granular drainage materials, and only to a lesser extent does the HDPE geomembrane act as a hydraulic barrier. The third application for HDPE geomembrane in landfill liners is to provide supplemental containment in areas such as leachate collection sumps or interior berms.

In recent years, the use of HDPE geomembrane for sealing measures in road construction, earthworks, hydraulic engineering and landfill construction has gained in importance.

The mobilized friction angle associated with displacement along the interface of a HDPE geomembrane and soil, a geotextile and geomembrane liner is a major factor governing the stability analysis. An upper bound solution to the interface problem would assume the interface friction angle (δ) equal to the angle of internal friction (ϕ) of the soil in contact. However, in many applications δ may be lower than ϕ and will therefore be one of the governing factors in geotechnical design where the interface represents a potential failure surface.

Laboratory testing using a direct shear test is most common method for determining the values. However, progressive failure across the interface on account of nonuniform strains and hence stresses, may result in a measured δ value considerably below the true peak value (δp). In addition, the use of multiple reversals to ascertain residual values of this angle (δr) does not simulate field conditions where large relative displacements accur without changes in direction.

The simple shear apparatus has been used in studies by many researchers, including Rowe (1969), Oda (1975), Jewell (1980), Budhu (1984), Boulon (1991) and Gourc (1988), etc. to tests of interface friction between soil and other construction materials or inclusion/inclusion.

This paper presents the laboratory test and based on this result to design the landfill structure at PT. Toba Pulp Lestari Tbk., Medan, Nord Sumatra. The laboratory tests adopte the phenomena happen at the slope side of the landfill structure.. The landfill dimension is 10000 m^2 and 15 m depth.

2. DESIGN OF LANDFILL STRUCTURE

Geosynthetic technology concept is based on the function of geosynthetic at bottom part, slope and top of the landfill structure.

1. Collection of the waste disposal for relatively long time should be compatible with enviromental. The waste disposal must be good isoled from the out of environt areas.
2. Bottom of the landfill structure. The HDPE geomembrane should can create a condition :
   a) Barrier layer between waste disposal and soil support
   b) System of drainage can be good function for long time
   c) Add barrier layer protection (*double protection*)
   d) Ressistance from the waste disposal containts
   e) Ressistance from chemical waste disposal containt
3. Slope of the Landfill Structute. The HDPE geomembrane is capable to :
   a) Assure the water circulation to dranage system existing
   b) Reinforcement of Slope Stability
   c) Assure the slope from water disposal and gaz infuencies
   d) Ressistance from local degradation and traction force
   e) Ressistance from the ultraviolets
4. Top or Cover the Landfill structure. The HDPE geomembrane is capable to :
   a) Maintain water rainfall infiltration to waste disposal areas
   b) Maintain a capileritie from the waste disposal to the trees at above
   c) Assure a drainage system from gaz influences
   d) Assure a water rainfall drainage to out site
   e) Maintain the enough water containt at the soil for vegetable water need

From the complicities problems and function of geosynthetics at landfill structure, a technic inovation use geosynthetic material assosiated with another material (composite materials) is a idol technology to solve the waste disposal probleme. To inform more detail the geosynthetic application at landfill structure persented at Figure 2.

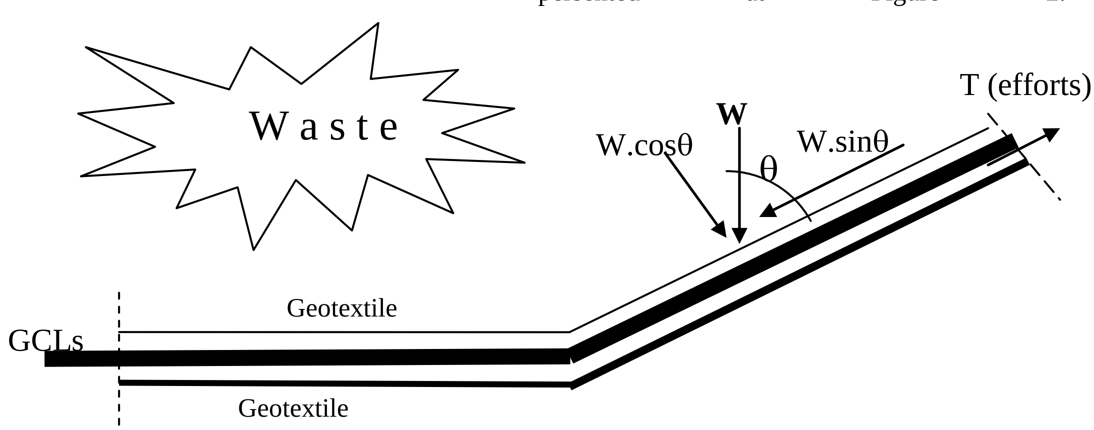

Figure 2. : Aplication of the Geosynthetic Technology at Land-Fill Slope

3. MATERIAL CHARACTERISTICS

Sandy clay is taken from the field. Prior to the start of the interface testing program, a series of tests were conducted using the direct shear apparatus (100 mm diameter) to determine the constant volume friction angle of the soil. Geomembrane HDPE is chosen for testing. in Table 1 and Table 2 presents the physical properties of the HDPE geomembrane and soil properties used.

Table 1 : Physical properties of Geomembrane used

Polymer	Thickness[a]		Mass per unit area[b]	
	mm	C.V. (%)	gr/m^2	C.V (%)
HDPE Geomembrane	0.89	7.25	1810	6.51

[a]ISO 9863 [b]ISO 9864

Table 2. : Soil properties

Type of soil	γd (kN/m^3)	ϕ peak (°)	C (kPa.)
Sandy clay	15,85	22,40	28.00

Sourch :Edy Purwanto, 2006

4. DESCRIPTION AND RESULT OF THE TEST

The sandy clay samples were prepared by pouring through the top of the apparatus. The relative density of sand is 15,85 kPa and the soil thickness is 50 mm. The experiments were conducted under normal stress levels from 50, 100 and 150 kPa. All the tests had a constant applied vertical load and at a shear speed of 3 mm/min. The results of the laboratory test is presented in Table 1.below.

Table 1. : Friction test between HDPE geomembrane and Sandy clay

Friction test	γd (kN/m^3)	H (cm)	ϕ peak (°)	C (kPa.)
HDPE – Sandy clay	15,85	5	6,30	20.00

Sourch :Edy Purwanto, 2006

Based on the results of studies in the field, laboratory test results, and a discussion with the owner of the project resulted in the design of the landfill structure as described below complete with detailed figures. Detail figures are presented in Figure 3, 4, 5, 6 and 7 as below.

5. LANDFILL STRUCTURE CONSTRUCTION

Landfill construction consists of several parts with technical specifications as below .

1. Introduction Work
2. Construction Liner
3. Construction Ditch Leak Detector
4. Construction Ditch Gatherer Lindi
5. Construction Bak Gatherer Lindi
6. Construction Bak Leak Detector
7. Construction of Roads and Waterways
8. Construction Sealants and Ventilation Gas
9. Well Monitor

5.1. WORK INTRODUCTION

Initial work in the field are:

1. Stripping soil and digging in the ground with a slope of 30 0 and the slope of the base layer 2 % from South to North .
2. Compaction basic excavation
3. Preparation of the working operations in locations
4. Perform basic soil permeability testing in the field than in the laboratory test results .

5.2. CONSTRUCTION LINER

This construction consists of :

1. Provide land to be used as a liner material
2. Preparation of the base layer of soil compacted silt kelempungan each from 0.15 to 0.20 meters at the optimum moisture content up to a thickness of 1.00 m premises permeability 10-07cm / dt . Used compactor Sheep -type non - vibratory roller .
3. Make use of leak detection layer of silt soil kepasiran up to a thickness of 0.30 m with permeability 10-4m / dt .
4. Making the trenches as channel leak detection and leachate collection pipes installed .
5. Making the barrier soil layer of silty clay soil , the thickness of 0.30 m , the permeability of 10-7 cm / sec
6. Preparation of the leachate collection layer of silt soil kepasiran , 0.60 m thick , the permeability of 10-4 m / sec , followed manufacture and installation trench leachate collection pipes .
7. Preparation of a protective layer of local soil
8. Each area of 200 m2 and a minimum thickness of 0.15 m permeability testing .

5.3. CONSTRUCTION DITCH LEAK DETECTION :

This construction consists of :

1. The slope of the trench towards the tub leak detector 2 %
2. Ditch the leak detector is made from South to North
3. The distance between the trench 6.00 meters
4. Surroundings trench leak detector installed in diameter from 0.04 to 0.05 m gravel .
5. Surroundings trench leak detection dibungkur geotextile .
6. At the end of the pipe to be installed embankment to the leachate drainage basin leak detector

5.4. CONSTRUCTION DITCH GATHERER LEACHATE

This construction consists of :

1. The slope of the trench to the leachate collection tub 2 %
2. Ditch the leachate collection from the South to the North , within 6 meters
3. Pipe Lindi hollowed out and filled with gravel placed diparit wrapped in geotextile .
4. In order leachate collected in the leachate collection pipes still flowing smoothly then leachate pipes always cleaned by flowing water through a pipe cleaner .
5. Design of the landfill is divided into 2 parts .

5.5. CONSTRUCTION BAK GATHERER LEACHATE :

This construction consists of :

1. Bak leachate collection consists of 1 unit .
2. The size of the leachate collection tub masing2 4x4x8 meters .
3. Soil excavation for leachate collection tub compacted .
4. On the basis of a given layer of gravel and sand + 10 cm thick .
5. Construction tank leachate using concrete materials and waterproof
6. Equipped with leachate pipe hole .

5.6. CONSTRUCTION LEAK DETECTION BAK :

This construction consists of :

1. The size of 1.50 x 1.50 x tub 8.00 meters
2. Construction tub leak detection using water-resistant reinforced concrete
3. In the tub wall is provided lobang2 for leachate pipes .

5.7. ROAD CONSTRUCTION AND SALURANAIR :

This construction consists of :

1. Type the path made operational on site
2. To use CBR 20 subbase layer and base layer using CBR 50
2. The drains are made simply by extracting the local soil with a layer of hardened soil
3. In the top layer of asphalt road construction use , and
4. Culverts installed at crossings with roads

5.8. CONSTRUCTION AND VENT GAS Covers

This construction consists of :

1. Excavation depth of 4 meters and 0.50 meters in diameter inner pipe filled with coral and equipped 4inchi as a gas vent pipe.
2. 4 -inch diameter pipe is given the holes that serves to remove the gas that is formed from layers of solid waste .
3. The intermediate cover soil layer of silty clay to 0.15 m thick , the permeability of 10-4 m / sec.
4. The ground layer of clay barrier hood kelempungan 0.60 m thick compacted to achieve permeability 10-7 cm / sec .
5. hood thick HDPE geomembrane be a minimum of 1 mm and max permeability of 10-7 cm / sec .
6. hood drainage layer thickness of 0.30 m with permeability 1o - 4 m / sec and at the top is installed geotextile to minimize blockage of the drainage hood lining .
7. Equipment Tire Roller compactor Ruber
8. The soil for the plants in the form of top soil land DNG thickness of 0.60 meters .

5.9. WELL MONITOR

Monitoring wells required to monitor the water quality which is located on the top and bottom landfill structure.

1. Monitoring Well at the Up - Stream :
   Quantity: 1 piece
   Depth : 25 of M.T.
2. Monitoring Well at the Down - Stream :
   Quantity: 2 pieces
   Depth : 25 of M.T.

5.10. OPERATING TIME OF LANDFILL

structure landfill is expected to collect waste and prevent pollution in groundwater. The dimensions and capacities of the building Landfill is as follows.

1. Total volume waste / day : 35.80 m3 / day
2. Volume Landfill : 100x100x10 m3 .
3. Landfill time operational : 100000 m3 / hr x 365 35.80 m3 / day = 7.65 years

6. CONCLUSION

The direct shear test is a good way to measure the bond strength parameters for design and an excellent way to study the interface friction behavior between sol-inclusion or inclusion/inclusion. However, it was found to be reliable only to obtain the coefficient of friction, not the sliding displacement at interfaces. Based on the laboratory tests, the values of shear parameters obteined are used to design the landfill structure and the landfill structure designed is presnted in figures.

7. Acknowledgement

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REFERENCES

[1} Boulon M., *Developpement d'une boite de cisaillement annulaire, Rapport Scientifique-Greco-rheologie des geomateriaux, France, 370-380. 1987.*

[2] Boulon M., *Le comportement d'interface sol-structure : aspects experimentaux et numeriques, Revue Francais Geotecnique no.54, 27-37, France, 1991.*

[3] Blondeau F and Josseaume H., *Mesure de la resistance au cisaillement residuelle en laboratoire, Bull. Liaison Lab. Ponts et Chausses special, France, 1976.*

[4] *Budhu, M., Nonunifromities imposed by simple shear apparatus, Canadien. Geotechnic J.20, 125-137,1984.*

[5] *Edy Purwanto, Etudes des interfaces geosynthetiques en geotechnique, These Doktor, Universite Joseph FOURIER – France, 1996.*

[6] Gourc J.P.,*Interaction Sol – Renforcement Geosynthetiques, Greco Geomateriaux , 284-287, 1988*

[7] Gourc J.P., *Le Stockage de Surface des Dechets: Les Centres d'Efouissement Technique, Cours G13: Geotechnique et Environnement, DEA M.M.G.E. UJF, Grenoble, France, .1992.*

[8] Garg K.G., *Evaluating Soil - Reinfrocement Friction, Earth Reinforcement Practice, Vol.1, Balkema, Rotterdam, 67-72. 1992.*

[9] Jewell, R.A., *Some Effects of Reinforcement on the Mechanical Behaviour of Soils, PhD thesis, University of Cambridge.1980.*

[10] Kishida H and Uesugi M., *Tests of Interface Between Sand and Steel in Simple Shear Apparatus ", Revue Francais Geotechnique 37, no.1, 45-52., France.1987.*

[11] Koerner R.M.et all., *Experimental Friction Evaluation of Slippage between Geomembranes, Geotextiles and Soils, International Conference on Geomembrane, Denver, USA.1990*

[12] PT. Econusa Kualiva Abadi, *Construction of Leachate Tank and Leak Detection Tank, Jakarta, 2006.*

[13] Purwanto E, Gourc J.P., *Behavior of Geosynthetic Clay Liners: Laboratory Tests, Sardinia, Fifth International Landfill Symposium, Vol.2, Italy, 347-358, 1995.*

[14] Oda, M., On *Stress - Dilatancy Relation of Sand in Simple Shear Test, Soils Foundations J. 15, No.2, 17-29. .1975.*

[15] Rowe P.W., *The Relation Between the Shear Strength of Sand in Triaxial Compression, Plane Strain and Direct Shear, Geotechnique 19, no.1, 1969.*

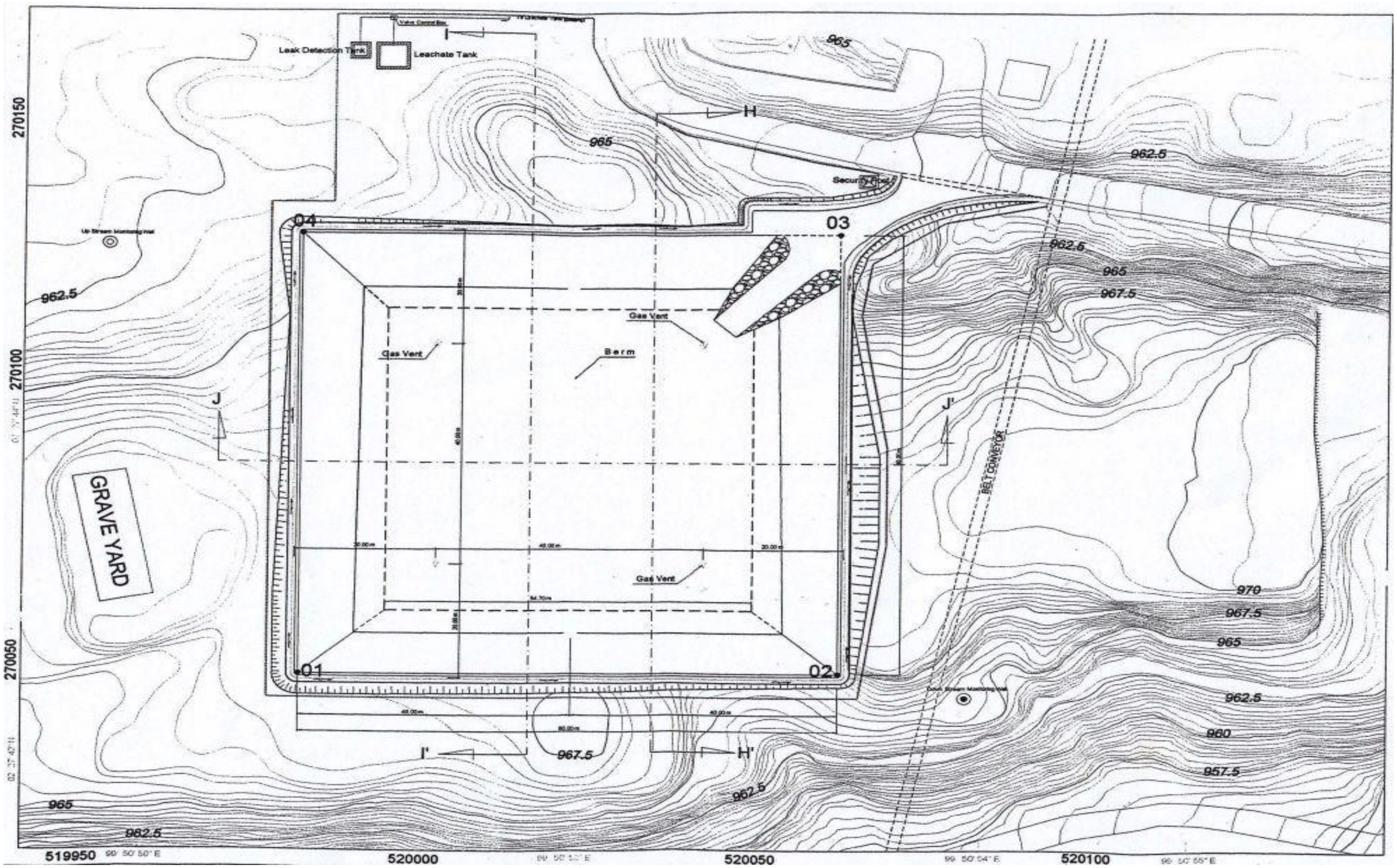
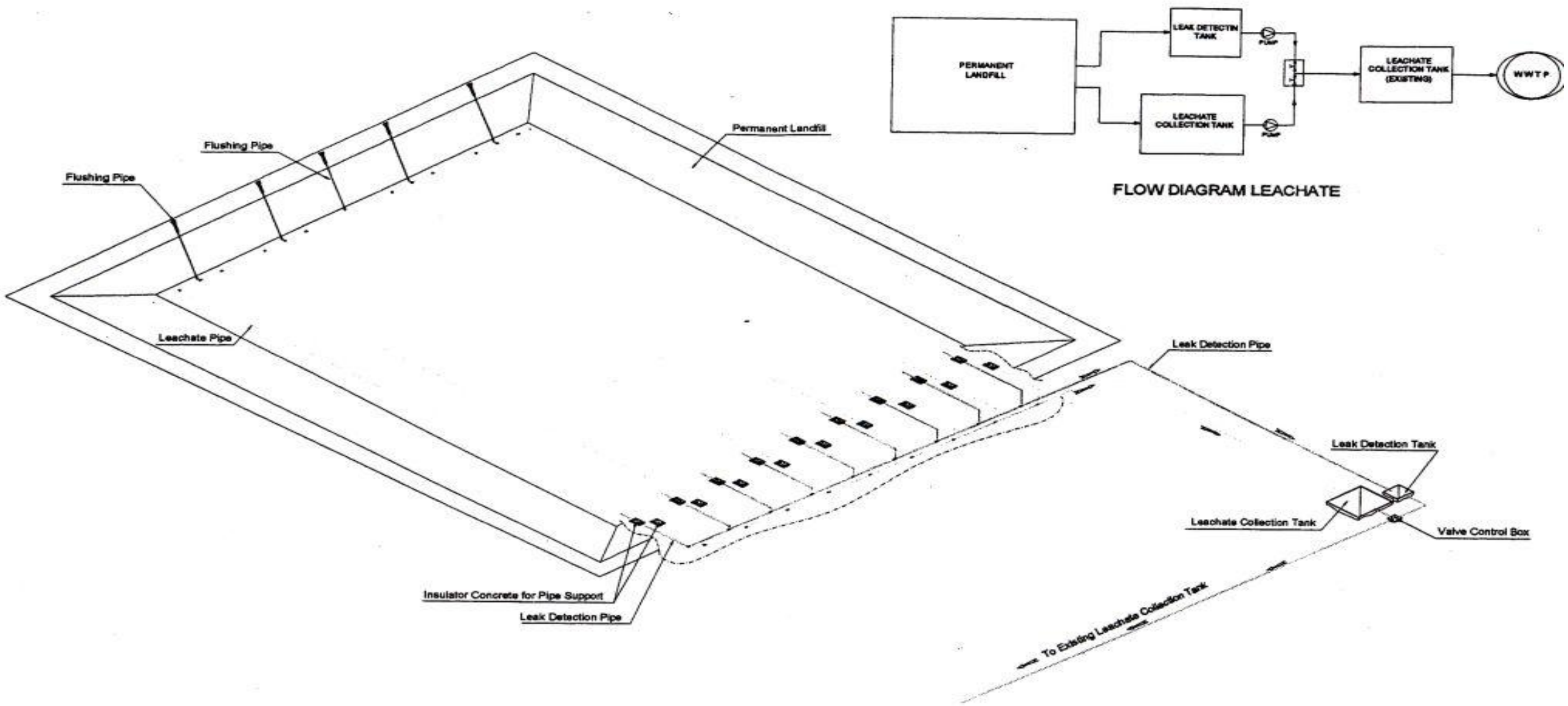


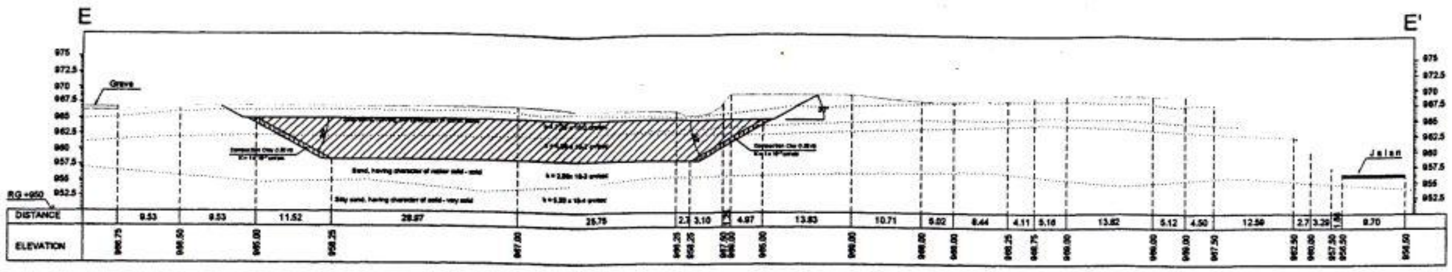
Figure 3.: Layu Out of Leak Detection Pipe and Access Road



QUANTITY OF PIPE AND PIPE FITTING

	Ø 6" PVC PIPE (M)	Ø 2.5" PVC PIPE (M)	PVC PIPE Ø 2" (M)	TEE Ø 6" (pcs)	TEE Ø 2.5" (pcs)	ELBOW Ø 6" (pcs)	ELBOW Ø 2.5" (pcs)	30" ELBOW Ø 2" (pcs)	REDUCER 6"-2" (pcs)	VALVE (pcs)
LEACHATE COLLECTION PIPE	810	-	-	12	-	18	-	-	-	-
LEAK DETECTION PIPE	226	-	-	8	-	10	-	-	-	-
FLUSHING PIPE	-	-	65	-	-	-	-	5	5	-
DISCHARGE PIPE	-	409.4	-	-	1	-	5	-	-	2

Figure 4. : Isometric For Piping Layout



SECTION E - E'
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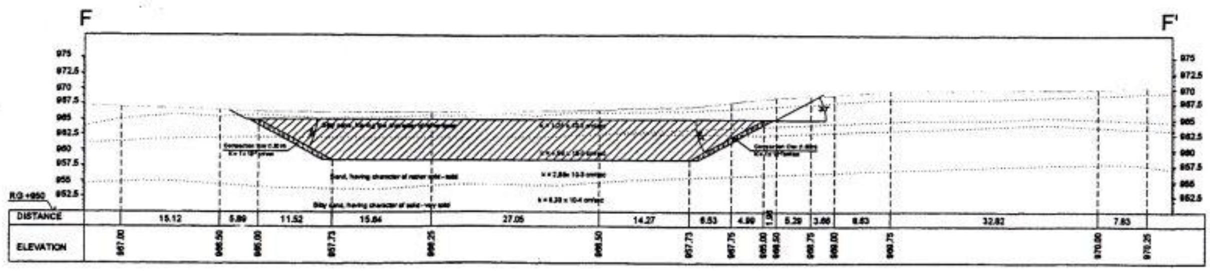

SECTION F - F'
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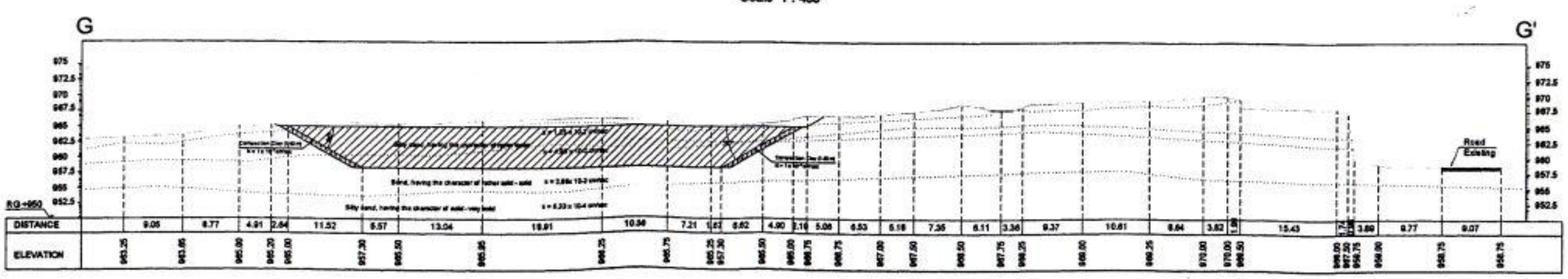

SECTION G - G'
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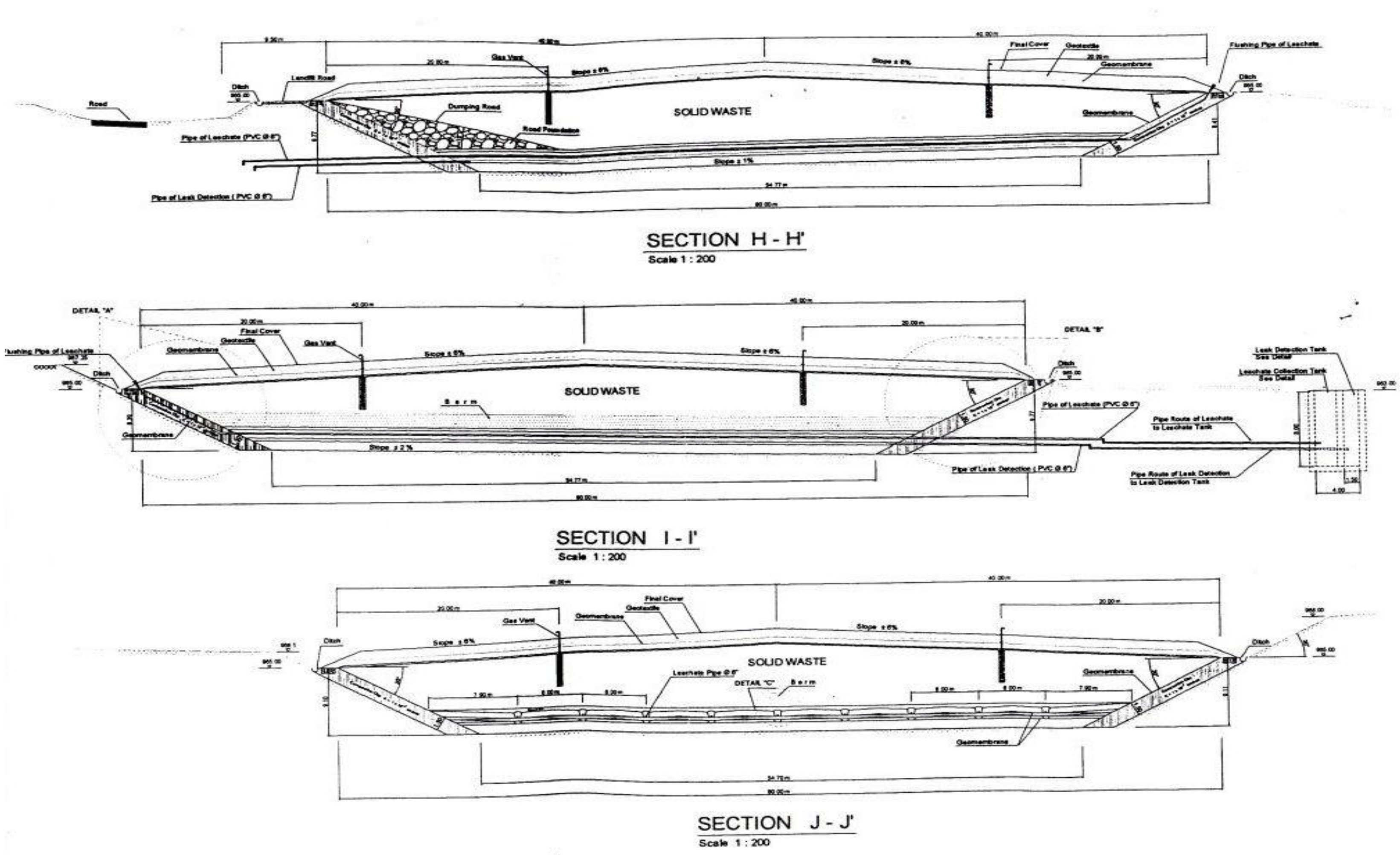

Figure 4. : Cross Section of Topography of Landfill Location

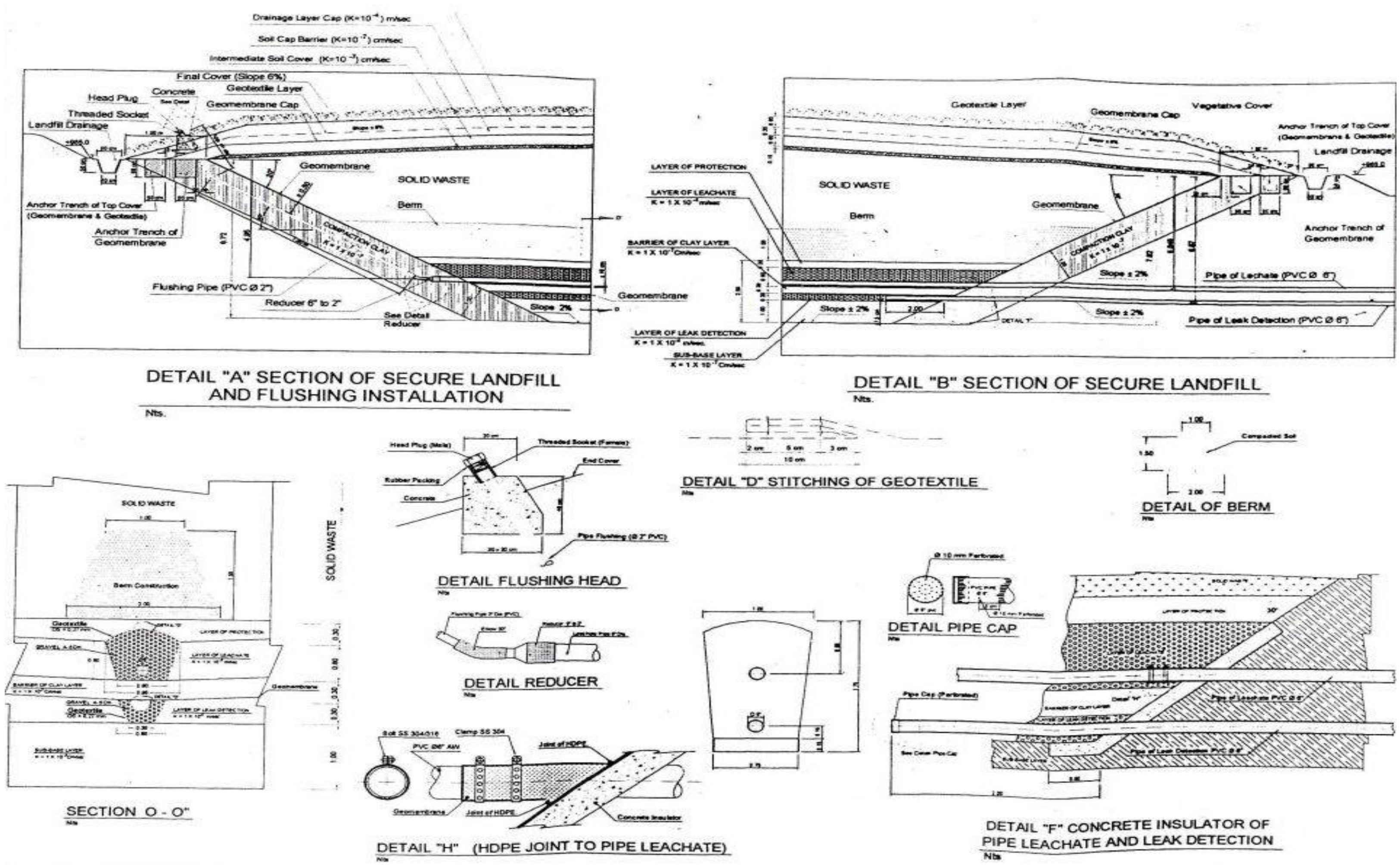

Figure 5. : Detail of Secure Landfill and Flushing Installation

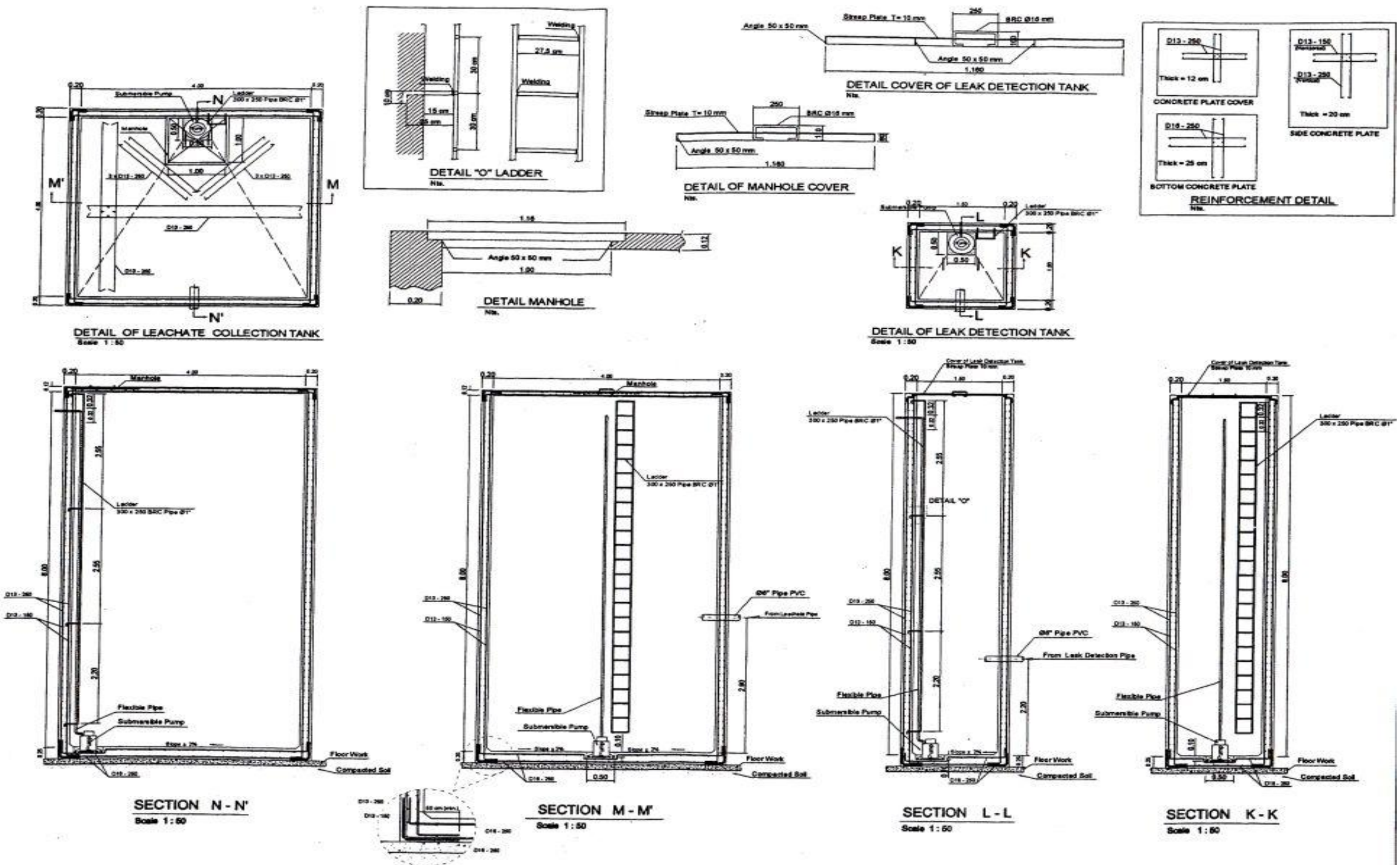

Figure 6. : Detail of Leachate Collection and Leak Detection Tank

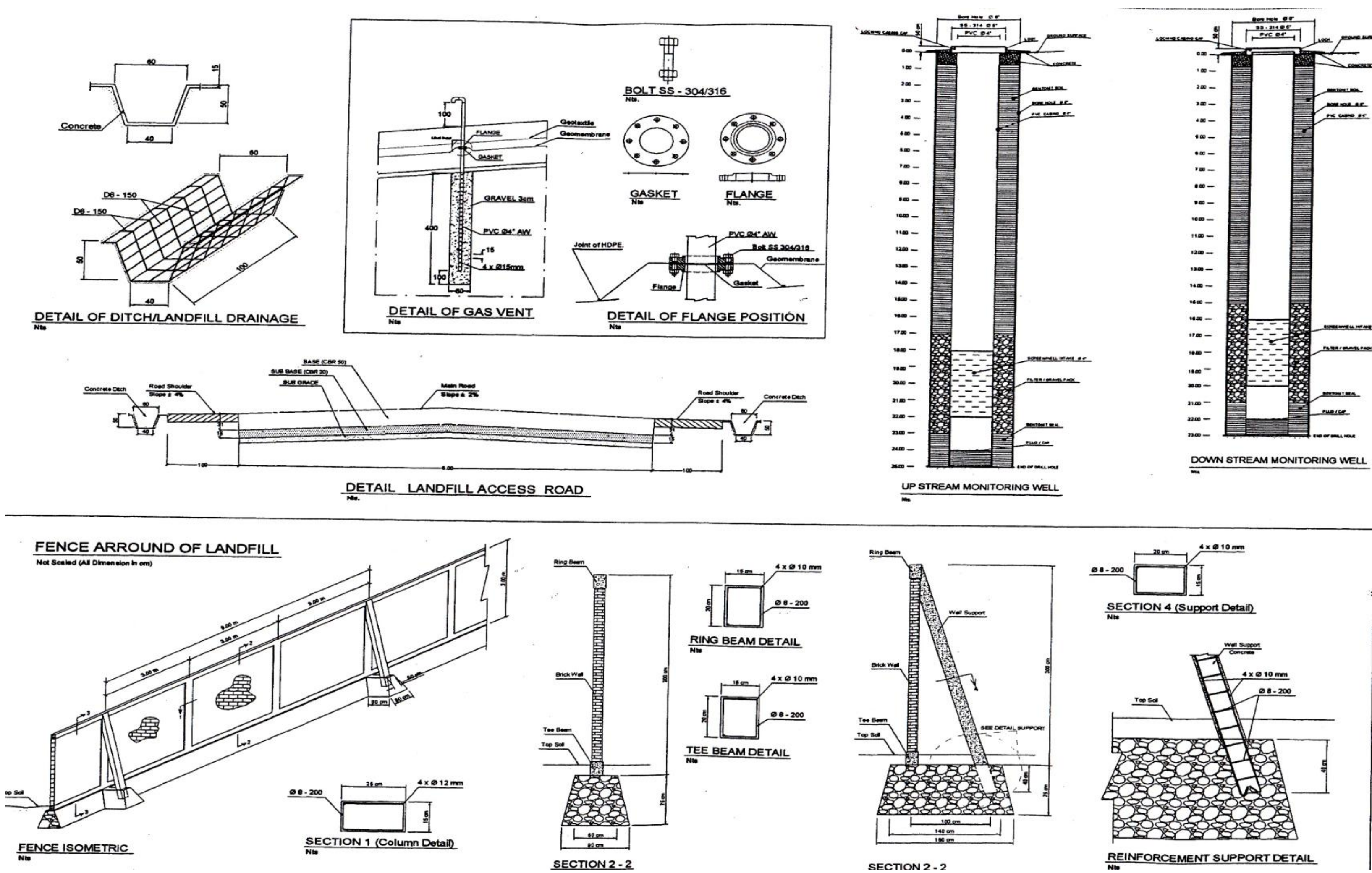

Figure 6.: Detail of Ditch Drainage, Gas Vent, Monitoring Well and Fence Arround of Landfill

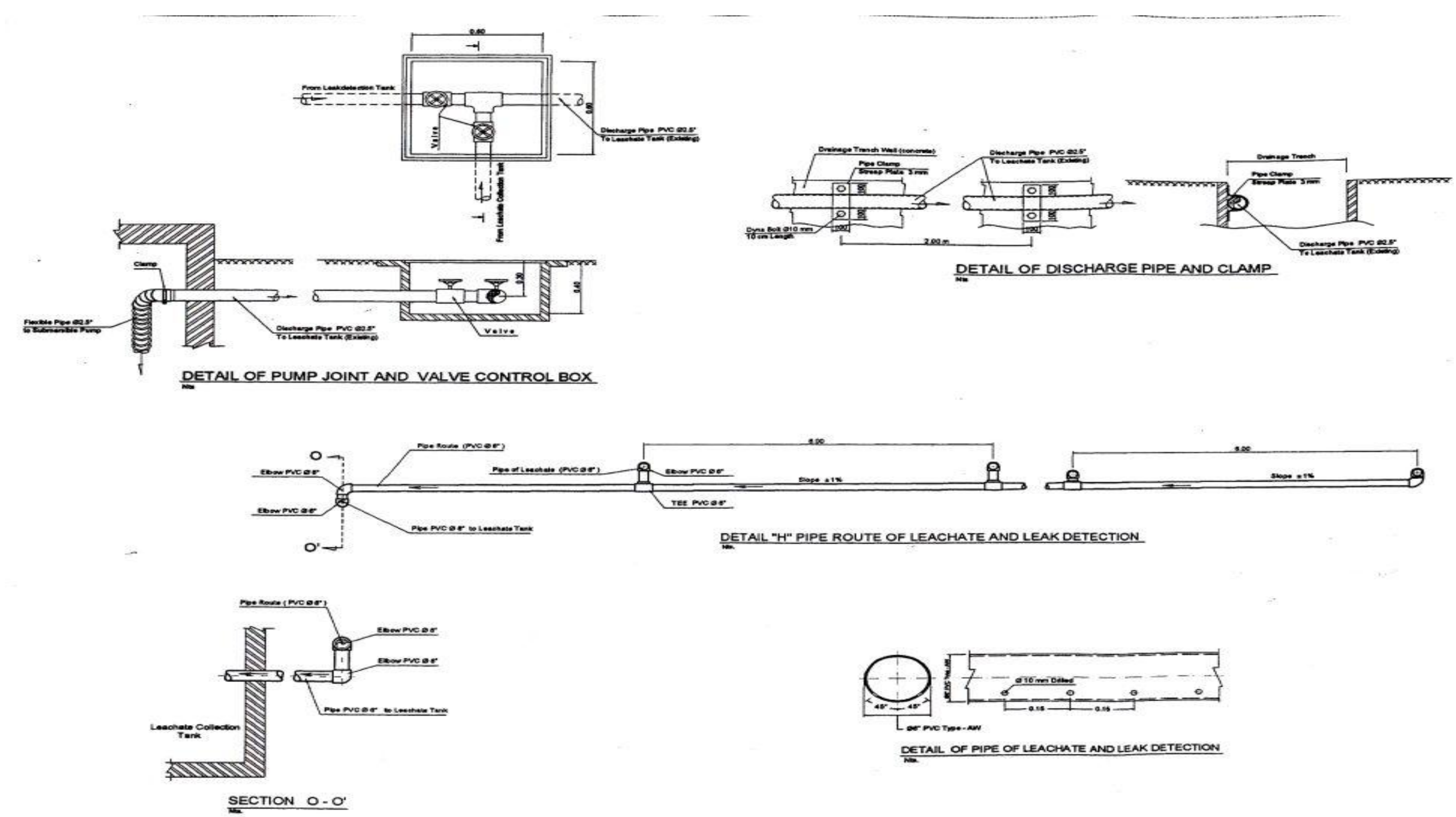

Figure 7. : Discharge Pipe and Clamp Detail, Leachate Pipe and Valve Control Box For Pump Joint.