JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

# The Study on the Solid Waste Management Improvement for Surabaya City in The Republic of Indonesia

# FINAL REPORT

## Volume 4

# SUPPORTING REPORT II

## ( FEASIBILITY STUDY )

May 1993

Pacific Consultants International
EX Corporation

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All the Rupiah amounts including the projects costs shown in this report are indicated in 1992 price unless otherwise indicated. Those amounts are estimated partly based upon the foreign prices by applying dominant 1992 currency exchange rates, i.e.: US $ 1 = Rp 2,000 = ¥125 (¥1 = Rp 16)

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## Abbreviations & English Translations

(in alphabetical order)

| | | | |
|---|---|---|---|
| 1. | ADIPURA | : | Noble City Award, an award presented by the Central Government to the local government for their efforts in sustainable improvement of the overall urban environmental quality. |
| 2. | AMDAL | : | Environmental Impact Assessment system. |
| 3. | ANDAL | : | Environmental Impact analysis. |
| 4. | BAPEDAL | : | Environmental Impact Control Agency. |
| 5. | BAPPEDA | : | Local development Planning Agency. |
| 6. | BAPPENAS | : | National Development Planning Agency. |
| 7. | Bina Marga | : | Directorate General of Highways, a name of a directorate general under the Ministry f Public works. |
| 8. | Biro KLH | : | Provincial Bureau of KLH. |
| 9. | BPPT | : | Technology Study and Application Agency. |
| 10. | Cabang | : | Branch office for sanitary management at District Level. |
| 11. | Camat | : | Chief of District. |
| 12. | Cipta Karya | : | Directorate General of Human Settlements, a directorate general under the ministry of Public Works. |
| 13. | CBD | : | Central business District. |
| 14. | Depo | : | Waste transfer station with an administrative office. |
| 15. | Dinas Kebersihan | : | Cleansing department. |
| 16. | Dinas Marga | : | Road department. |
| 17. | IUIDP | : | Integrated Urban Infrastructure Development Project. |
| 18. | JATIM | : | East Jawa Province. |
| 19. | JKT | : | Jakarta. |
| 20. | KA ANDAL | : | Terms of Reference of ANDAL. |
| 21. | Kampung | : | Unplanned low-income residential area naturally originated from villages and inhabited by people migrated from rural areas. |
| 22. | Kecamatan | : | District, an administrative area. |
| 23. | Kelurahan | : | Sub-District, and administrative area. |
| 24. | KLH | : | Ministry of Population and Environment. |
| 25. | KMS | : | Surabaya Municipality; Surabaya Municipal Government. |
| 26. | LPA | : | Final Disposal site. |
| 27. | LPS | : | open-dumping waste transfer station without administration office (literally means temporary disposal site). |
| 28. | Lurah | : | Chief of sub-District. |

| | | | |
|---|---|---|---|
| 29. | MCK | : | Public facilities for taking shower, washing, and toilet. |
| 30. | Pasar | : | Traditional market. |
| 31. | Pasukan Kuning | : | "Yellow Troop" (waste collection workers and street sweepers). |
| 32. | PDAM | : | Water Supply Municipal Company. |
| 33. | PEL | : | Preliminary Environmental Evaluation report. |
| 34. | Perda | : | Municipal Regulations. |
| 35. | PIL | : | Preliminary Environmental Information report. |
| 36. | PLN | : | State Electric company |
| 37. | Rayon | : | Working area f each Assistant to the Mayor. |
| 38. | RT | : | Neighborhood unit. |
| 39. | RW | : | Community Unit. |
| 40. | SBY | : | Surabaya. |
| 41. | SEL | : | Environmental Evaluation Study. |
| 42. | SMA | : | Surabaya Metropolitan Area. |
| 43. | SUDP | : | Surabaya Urban Development Plan. |
| 44. | SWM | : | Solid Waste management |

# *PART 1*

# *PROCUREMENT OF VEHICLES AND CONTAINERS*

# PART 1. PROCUREMENT OF VEHICLES AND CONTAINERS

## Chapter 1 Things to be Confirmed for Determination of Types, Capacity, Number and Schedule of Trucks and Containers

### 1.1 Target Annual Haulage Amount to be Collected and Hauled by 1999

#### 1) KMS' Haulage Amount

In order to make a secure procurement plan, the total haulage amounts during rainy season as shown in Table 1.1-1 and Fig 1.1-1 are used as basis for the procurement plan. The KMS' haulage amounts are projected to be 1,117 ton/day in 1995, and 1,350 ton/day in 1999, with the following assumptions :

(1) Total waste generation amount will increase by 5% per year.

(2) Percentage of waste uncollected which is currently 15% of the total generaton will decrease to by 9% in 2000 through the construction of new Depo/LPS and placing new containers there or placing mini-containers along road sides.

(3) Waste recycled before LPA will remain to be constant (10% of the total waste generation) in terms of percentage.

(4) Waste collected by RT/RW but disposed at unidentified places will dissapear by the year 1999.

(5) Waste collected and transported by waste generators (Currently 8% of the total waste generation) will increase to 25% in 1999 by enforcing the self-transportation of waste generated from P.D. markets, small shops & offices, and large hotels whose waste amount exceed more than 2.5 $m^3$/day.

(6) Waste hauled amount by KMS' truck will remain to be constant in the future. All the incremental portion will be hauled by contractors.

**Table 1.1-1 Total Haulage Amount During Rainy Season (ton/Day)**

| Year | Waste Generated | Not Collected | Recycled before LPA | Collected by RT/RW but Disposed at Unidentified Places | Collected and Transported by Waste Generator | KMS' Haulage Amount | Hauled by KMS' Truck | Hauled by Contractor |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6)=(1)-(2)-(3)-(4)-(5) | (7) | (8)=(6)-(7) |
| 1992 | 1,748 | 263 | 180 | 186 | 130 | 989 | 691 | 298 |
| 1993 | 1,835 | 260 | 189 | 159 | 200 | 1,027 | 691 | 336 |
| 1994 | 1,927 | 257 | 198 | 132 | 270 | 1,070 | 691 | 379 |
| 1995 | 2,024 | 254 | 208 | 105 | 340 | 1,117 | 691 | 426 |
| 1996 | 2,125 | 251 | 219 | 78 | 410 | 1,167 | 691 | 476 |
| 1997 | 2,231 | 248 | 230 | 51 | 480 | 1,222 | 691 | 531 |
| 1998 | 2,342 | 245 | 241 | 24 | 550 | 1,282 | 691 | 591 |
| 1999 | 2,460 | 242 | 253 | 0 | 615 | 1,350 | 691 | 659 |

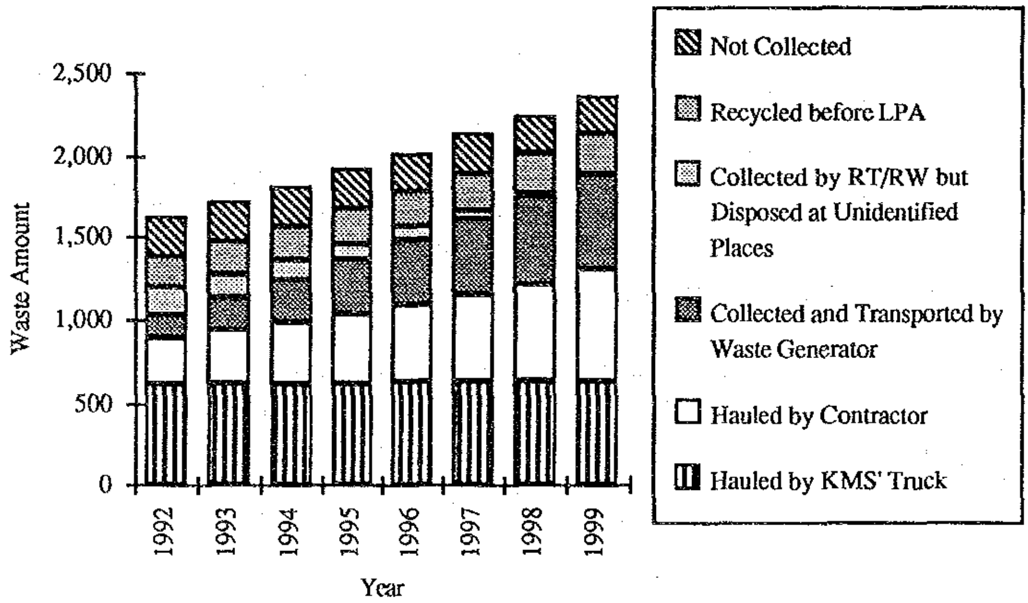



**Fig. 1.1-1 Future Amount of Waste to be Collected, Hauled and Recycled**

## 2) Haulage Amount by Type of Truck and Contractors

In the current KMS' haulage system, large containers placed in Depo/LPS are hauled by armroll trucks and mini-containers placed in streetside are hauled by compactor trucks. This systems can be highly evaluated, and should be maintained in the future.

As shown in the Table 1.1-1, waste amount hauled by KMS' trucks in the future will be maintained at the current level (691 ton/day). The incremental waste will be hauled by contractors because the use of contractors is cost-effectiveness. The waste haulage amounts by the KMS and contractors by the type of trucks as shown in Table 1.1-2 are planned with the following policy :

(1) All the open dumping practice at Depo/LPS will be eliminated by 1997, before the end of the SUDP period.

(2) The KMS will not purchase new compactor trucks. All waste of mini containers will be hauled by contractors after the existing KMS' compactor trucks are abandoned.

**Table 1.1-2 Future Amount of Waste Hauled by Type of Trucks**

Unit : Ton / day

| Year | Waste Amount to be hauled | By KMS | | | | By Contractors | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Container Truck | Compactor Truck | Open Dump Truck | KMS Total | Contractor Total | Container Truck | Compactor Truck | Open Dump Truck |
| | (1) | (2)=(5)-{(3)+(4)} | (3) | (4) | (5)=(1)+(2)+(3)+(4) | (6)=(1)-(5) | (7)=(6)-(8)-(9) | (8) | (9) |
| 1992 | 989 | 539 | 121 | 31 | 691 | 298 | - | - | - |
| 1993 | 1,027 | 617 | 60 | 14 | 691 | 336 | 217 | 69 | 50 |
| 1994 | 1,070 | 656 | 30 | 5 | 691 | 379 | 246 | 108 | 25 |
| 1995 | 1,117 | 686 | 0 | 5 | 691 | 426 | 266 | 148 | 12 |
| 1996 | 1,167 | 686 | 0 | 5 | 691 | 476 | 312 | 158 | 6 |
| 1997 | 1,222 | 686 | 0 | 5 | 691 | 531 | 362 | 169 | 0 |
| 1998 | 1,282 | 686 | 0 | 5 | 691 | 591 | 410 | 181 | 0 |
| 1999 | 1,350 | 686 | 0 | 5 | 691 | 659 | 464 | 195 | 0 |

Note : 1. All the estimated waste haulage amount are those in rainy season, based upon which required numbers of trucks and containers are estimated.

2. Annual increased waste to be hauled by contractors' compactor trucks (column 8) in 1996 and thereafter will increase by a 20% of annual incremental waste (column 1).

### 3) Haulage Amount by KMS' Truck and Contractors by 5 Sub-districts

Based upon the future waste haulage amounts by 5 Sub-districts shown in Table 1.1-3, the future haulage amounts by KMS' trucks and contractors by 5 Sub-districts as shown in Table 1.1-4 are estimated on the following policy :

(1) KMS' trucks cover mainly center and north Sub-districts and street waste of 5 Sub-districts. The waste haulage activities of the KMS in the west district will be taken over by contractors at first, and then contractors haulage service will expand to the south and the east Sub-districts.

(2) One open dump truck will be assigned to each Sub-district and haul waste irregularly generated including :

a. Bulky waste
b. Construction debris such as stones, sand and concrete
c. Pruned trees
d. Waste collected from rivers and drainage by citizens

## Table 1.1-3 Haulage Amount by 5 Sub-districts

| | Projected Waste Generation By 5 Sub-Districts (percentage) | | | | | | Projected Waste Amount to be Hauled By 5 Sub-Districts | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Center | North | East | South | West | Total | Center | North | East | South | West | Total |
| 1992 | 20.9 | 17.6 | 30.1 | 23.8 | 7.6 | 100 | 207 | 174 | 298 | 235 | 75 | 989 |
| 1993 | 20.2 | 17.5 | 30.2 | 23.9 | 8.2 | 100 | 208 | 180 | 310 | 245 | 84 | 1,027 |
| 1994 | 19.5 | 17.4 | 30.3 | 24.0 | 8.8 | 100 | 209 | 186 | 324 | 257 | 94 | 1,070 |
| 1995 | 18.8 | 17.3 | 30.4 | 24.1 | 9.4 | 100 | 210 | 193 | 340 | 269 | 105 | 1,117 |
| 1996 | 18.2 | 17.2 | 30.5 | 24.2 | 9.9 | 100 | 212 | 201 | 356 | 282 | 116 | 1,167 |
| 1997 | 17.6 | 17.1 | 30.6 | 24.4 | 10.3 | 100 | 215 | 209 | 374 | 298 | 126 | 1,222 |
| 1998 | 16.8 | 17.0 | 30.7 | 24.6 | 10.9 | 100 | 215 | 218 | 394 | 315 | 140 | 1,282 |
| 1999 | 16.2 | 16.9 | 30.8 | 24.8 | 11.3 | 100 | 219 | 228 | 415 | 335 | 153 | 1,350 |
| 2000 | 15.7 | 16.8 | 30.9 | 25.0 | 11.6 | 100 | 225 | 241 | 442 | 358 | 166 | 1,432 |
| 2001 | 15.2 | 16.7 | 31.0 | 25.2 | 11.9 | 100 | 231 | 254 | 470 | 383 | 181 | 1,519 |
| 2002 | 14.7 | 16.6 | 31.1 | 25.4 | 12.2 | 100 | 237 | 267 | 500 | 409 | 196 | 1,609 |
| 2003 | 14.2 | 16.5 | 31.1 | 25.6 | 12.6 | 100 | 242 | 281 | 530 | 436 | 215 | 1,704 |
| 2004 | 13.7 | 16.4 | 31.2 | 25.8 | 12.9 | 100 | 247 | 296 | 563 | 465 | 233 | 1,804 |
| 2005 | 13.3 | 16.3 | 31.2 | 26.0 | 13.2 | 100 | 254 | 311 | 596 | 496 | 252 | 1,909 |
| 2006 | 12.9 | 16.2 | 31.2 | 26.2 | 13.5 | 100 | 260 | 327 | 630 | 529 | 273 | 2,019 |
| 2007 | 12.5 | 16.1 | 31.3 | 26.4 | 13.7 | 100 | 267 | 343 | 668 | 563 | 292 | 2,133 |
| 2008 | 12.1 | 16.0 | 31.3 | 26.6 | 14.0 | 100 | 273 | 361 | 705 | 599 | 316 | 2,254 |
| 2009 | 11.7 | 15.9 | 31.3 | 26.8 | 14.3 | 100 | 278 | 378 | 745 | 638 | 340 | 2,379 |
| 2010 | 11.3 | 15.8 | 31.4 | 27.0 | 14.5 | 100 | 284 | 397 | 789 | 679 | 364 | 2,513 |

Note : 1. Waste haulage amounts by 5 Sub-districts in 1992 are estimated based upon the JICA Study Team's field survey.
2. Waste haulage amounts by 5 Sub-districts will be more and more proportional to the distribution of the future population by 5 Districts as a result of increasing haulage coverage in suburban areas.

**Table 1.1-4 Haulage Amount by KMs' Trucks and Contractors**

| | Projected Waste Generation Rate By 5 Sub-Districts | | | | | | Projected Waste Amount to be Hauled By 5 Sub-Districts | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Center | North | East | South | West | Sub-Total | Center | North | East | South | West | Sub-Total | Total |
| 1992 | 133 | 99 | 286 | 110 | 63 | 691 | 74 | 75 | 12 | 125 | 12 | 298 | 989 |
| 1993 | 177 | 149 | 263 | 101 | 1 | 691 | 31 | 27 | 47 | 144 | 83 | 336 | 1,027 |
| 1994 | 178 | 158 | 275 | 79 | 1 | 691 | 31 | 28 | 49 | 178 | 93 | 379 | 1,070 |
| 1995 | 178 | 164 | 289 | 59 | 1 | 691 | 32 | 29 | 51 | 210 | 104 | 426 | 1,117 |
| 1996 | 180 | 171 | 302 | 37 | 1 | 691 | 32 | 30 | 54 | 245 | 115 | 476 | 1,167 |
| 1997 | 183 | 178 | 308 | 11 | 1 | 691 | 32 | 31 | 56 | 287 | 125 | 531 | 1,222 |
| 1998 | 183 | 185 | 321 | 1 | 1 | 691 | 32 | 33 | 73 | 314 | 139 | 591 | 1,282 |
| 1999 | 186 | 194 | 309 | 1 | 1 | 691 | 33 | 34 | 106 | 334 | 152 | 659 | 1,350 |
| 2000 | 191 | 205 | 293 | 1 | 1 | 691 | 34 | 36 | 149 | 357 | 165 | 741 | 1,432 |
| 2001 | 197 | 216 | 276 | 1 | 1 | 691 | 34 | 38 | 194 | 382 | 180 | 828 | 1,519 |
| 2002 | 202 | 227 | 260 | 1 | 1 | 691 | 35 | 40 | 240 | 408 | 195 | 918 | 1,609 |
| 2003 | 206 | 239 | 244 | 1 | 1 | 691 | 36 | 42 | 286 | 435 | 214 | 1,013 | 1,704 |
| 2004 | 210 | 252 | 227 | 1 | 1 | 691 | 37 | 44 | 336 | 464 | 232 | 1,113 | 1,804 |
| 2005 | 216 | 264 | 209 | 1 | 1 | 691 | 38 | 47 | 387 | 495 | 251 | 1,218 | 1,909 |
| 2006 | 221 | 278 | 190 | 1 | 1 | 691 | 39 | 49 | 440 | 528 | 272 | 1,328 | 2,019 |
| 2007 | 227 | 289 | 173 | 1 | 1 | 691 | 40 | 51 | 495 | 562 | 291 | 1,442 | 2,133 |
| 2008 | 232 | 307 | 150 | 1 | 1 | 691 | 41 | 54 | 555 | 598 | 315 | 1,563 | 2,254 |
| 2009 | 236 | 321 | 132 | 1 | 1 | 691 | 42 | 57 | 613 | 637 | 339 | 1,688 | 2,379 |
| 2010 | 241 | 337 | 111 | 1 | 1 | 691 | 43 | 60 | 678 | 678 | 363 | 1,822 | 2,513 |

Note : 15% of projected waste haulage amounts of Surabaya are collected by mini-container trucks.

### 4) Variation of Waste Haulage Amount in Depo/LPS

#### (1) Daily Variation

Daily variation of waste amount is studied in 25 Depo/LPS in Surabaya. The result is shown in Table 1.1-5. There is no outstanding change by day in the 25 Depo/LPS. Thus, there is no need to consider the waste generation change by day.

**Table 1.1-5 Variation of Waste Volume by Day by the Total Waste Volume of 25 Depo/LPS**

| | Mon | Tue | Wed | Thu | Fri | Sat | Sun | Ave |
|---|---|---|---|---|---|---|---|---|
| Waste Volume/day | 654 $m^3$ | 658 $m^3$ | 654 $m^3$ | 652 $m^3$ | 654 $m^3$ | 659 $m^3$ | 672 $m^3$ | 658 $m^3$ |
| Ratio | 0.99 | 1.00 | 0.99 | 0.99 | 0.99 | 1.00 | 1.02 | 1.00 |

#### (2) Seasonal Variation

It is estimated that waste haulage amount in rainy season is about 15% more than that in dry season based upon the JICA Study conducted in 1992. The truck procurement plan is prepared based upon the haulage amount in rainy season.

## 1.2 Types and Capacity of Containers and Trucks

(1) Maximum loading limit is 8,000 kg/axle. (KM. 461/AJ. 403/Phb-62)

(2) Maximum total length of freight truck is 9 m.
(Section 2, Sub-section 1, KM7/AJ 005/Phb-84)

(3) Maximum total length of the rear overhang is 0.625 x wheel base.
(Section 4, Sub-section 1, KM7/AJ 005/Phb-84)

(4) For a truck which has three axles or more, maximum length of rear overhand 0.475 x wheel base.
(Section 4, Sub-section 3, KM7/AJ 005/Phb-84)

(5) Maximum width and the height of a vehicle including load is 2.5 m and 3.5 m respectively. (Section 31, Sub-section a, b, and of PPL (eraturan Pemerintah Lalu-Lintas) )

(6) Maximum exceeding length of load on the truck:
- At the back : 2 m
- In the front : not exceeding front glass
(Section 4, Sub-section 3, KM7/AJ 005/Phb-84)

(7) For a vehicle which is used for special purposes, the maximum limits issued in ths decree can be changed after the written agreemnt of the ocmmunication minister is obtained.
(Section 4, KM7/AJ 005/Phb-84)

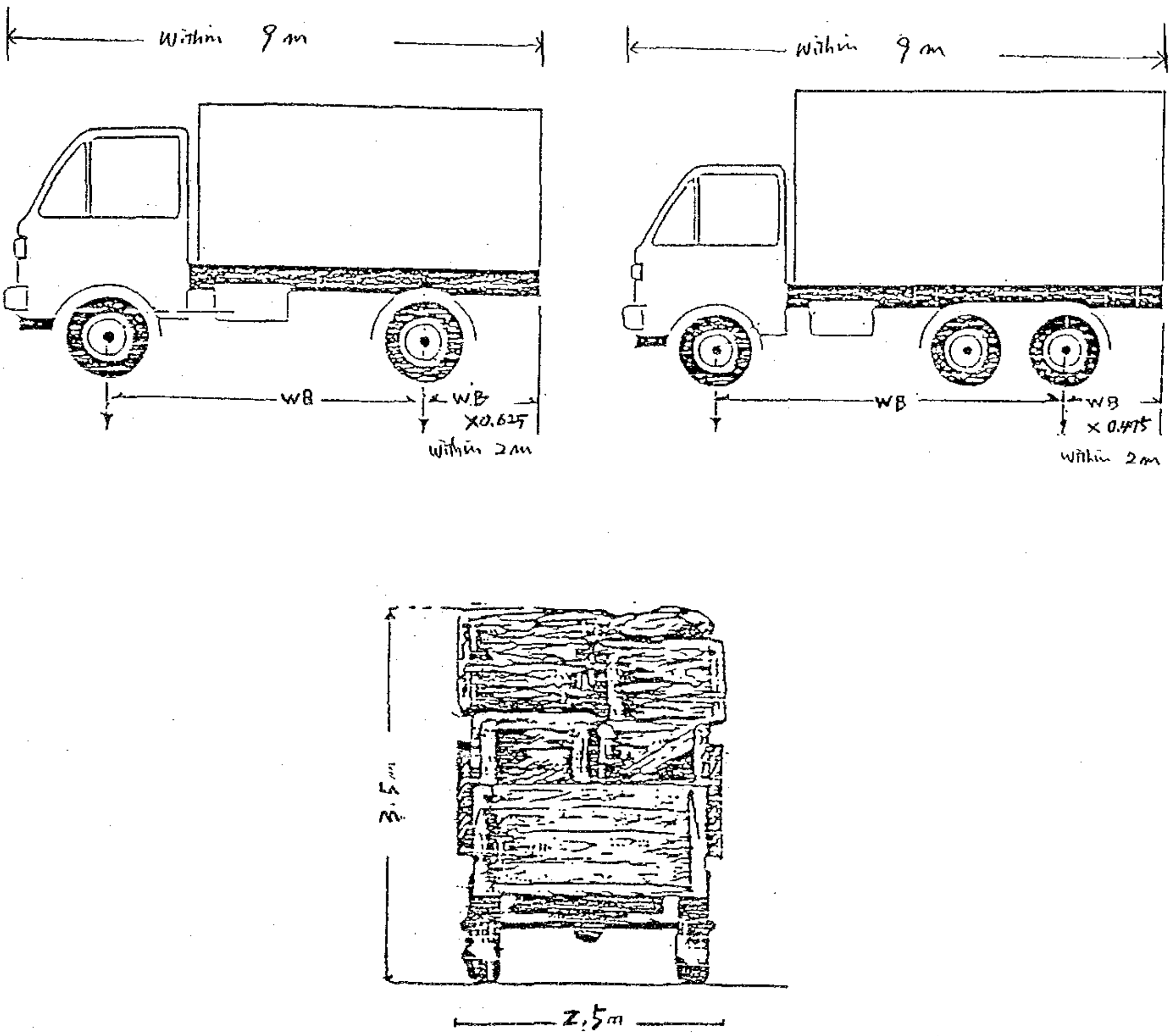



FIG. 1.1-2 **Maximum Truck Size by the Road Regulations**

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

## 2) Arm-Roll Truck

### (1) Chassie and Containers

In Indonesia, two types of chassie are available for waste collection, i.e., 7 GVW and 14 GVW. In addition, there is an idea to modify a 7 GVW to 10 GVW by using two rear axles. The appropriate container size for each type of truck is shown in Table 1.1-6.

**Table 1.1-6 Estimated Appropriate Container Capacity by Truck**

| | | 7 GVW with Single rear axle | 10 GVW Uprated from 7 GVW with Two rear axle | 14 GVW with Single rear axle |
|---|---|---|---|---|
| Weight of Chassie & Equipment (1) | | 2.7 t | 3.5 t | 5.0 t |
| Weight of empty container (2) | | 0.9 t | 1.3 t | 1.5 t |
| Dead Weight (3) = (1) + (2) | | 3.6 t | 4.8 t | 6.5 t |
| Maximum Pay Load (4) = GVW - (3) | | 3.4 t | 5.2 t | 7.5 t |
| Container Dimension (5) | | | | |
| (Inside) | L | 3.6 m | 4.2 m | 4.5 m |
| | W | 1.9 m | 2.1 m | 2.1 m |
| | H | 1.2 m | 1.4 m | 1.5 m |
| Appropriate container capacity (6) | | 8 $m^3$ | 12 $m^3$ | 14 $m^3$ |
| Maximum Waste Amount per Container (7)=(6)x0.367 | | 2.9 t | 4.4 t | 5.1 t |

Note 1. For the estimation of the body capacity, the waste bulk density 0.367 is used based on the JICA study conducted in rainy season.

Note 2. It is assumed that the two rear axle truck including arm-roll will be 30% heavier than a single rear axle truck.

Note 3. Container dimension is decided by the road regulations and safety operation ; a truck will be tumbled if the center of gravity is too high due to the high container.

### (2) Reliability of Operation

It is anticipated the use of 10 GVW truck modified from 7 GVW with two rear axle will have the following problems :

a. There is no guarantee that the uprated 10 GVW truck satisficactorily performs its function. The local manufactures have never modified a 7 GVW truck to a 10 GVW by using two rear axle.

b. Troubles may occur to a driving system such as an engine, a transmission, a clutch due to augment payload.

c. There is a question to the strength of a chassie because basic design of 7 GVW truck itself is not changed although GVW is increased to 10 ton.

Thus, the reliability of 10 GVW (uprated from 7 GVW) is so uncertain. In addition, the durability may be short, and the maintenance cost may increase. Without constructing a prototype of 10 GVW truck and making sure the reliability of operation, 10 GVW trucks cannot be recommended.

### (3) Cost of Arm-Roll Truck

The unit haulage cost per ton of waste by type of Arm-Roll truck is shown in Table 1.1-7. In view of the unit cost comparison, 14 $m^3$ container truck using 14 GVW truck is the most cost-effective, followed by 12 $m^3$ container truck of 14 GVW and 8 $m^3$ container truck of 7 GVW.

Table 1.1-7 Unit Costs of Arm-Roll Trucks and Containers per Ton of Waste Hauled

| Type of Truck | Truck Price | | | Cost of Containers Needed per Truck | | | Total Cost | Waste Amount Hauled by a Truck/year | Unit Haulage Cost per ton/year |
|---|---|---|---|---|---|---|---|---|---|
| | Chassie | Equipment | Total | Unit Price | Units | Cost for container provision | | | |
| | [1] | [2] | [3]=[1]+[2] | [4] | [5] | [6] | [7]=[3]+[6] | [8] | [9]=[7]÷[8] |
| Current 6m3 | Rp. 35,200,000 | Rp. 15,400,000 | Rp. 50,600,000 | Rp. 5,502,000 | 6 | Rp. 33,000,000 | Rp. 83,600,000 | 3,528 | 23,676 |
| Recommended 8 m3 | Rp. 35,200,000 | Rp. 15,400,000 | Rp. 50,600,000 | Rp. 6,000,000 | 6 | Rp. 36,000,000 | Rp. 86,600,000 | 4,704 | 18,410 |
| Current 10 m3 | Rp. 59,300,000 | Rp. 22,000,000 | Rp. 81,300,000 | Rp. 7,000,000 | 6 | Rp. 42,000,000 | Rp. 123,300,000 | 5,881 | 20,966 |
| Current 12 m3 | Rp. 59,300,000 | Rp. 22,000,000 | Rp. 81,300,000 | Rp. 7,500,000 | 6 | Rp. 45,000,000 | Rp. 126,300,000 | 7,057 | 17,897 |
| Recommended 14 m3 | Rp. 59,300,000 | Rp. 26,000,000 | Rp. 85,300,000 | Rp. 8,000,000 | 6 | Rp. 48,000,000 | Rp. 133,300,000 | 8,233 | 16,191 |

Note : [8] = [container capacity] x 0.33 x 0.9 x 330 days/year

## (4) Depo/LPS and Road Conditions

The possibility of the placement of 14 $m^3$ containers or 8$m^3$ containers is studied by examining the layout plan of each Depo/LPS and the data on the width of its access roads. The result of this study is shown in Table 1.1-8.

The criteria for the placement of 14 $m^3$ containers and 8 $m^3$ containers are as follows :

- Depo/LPS should have at least 13 m length and 3 m width for operation of a 14 $m^3$ container, 11 m length and 2.5 m width for a 8 $m^3$ container including access road width.
- Depo/LPS should have an entrace with a width at least about 4 m.
- Depo/LPS should be large enough that a truck can make a turning (minimum turning radius is 10 m).

Any Depo/LPS which satisfy the above criteria was judged to be able to be placed with the containers. As for Depo and LPS which did not fully satisfy the above criteria, the possibility for placement of containers in the Depo/LPS were examined by a simulation, it was found that the placement of the containers (either 14 $m^3$ or 8 $m^3$ containers) is possible at all the Depo/LPS except for the following :

A. Depo/LPS that requires either Expansion or Relocation :

1. LPS Pasar Kapasan (Kel. Sidodadi, Kec. Simokerto)
2. LPS Pasar Turi (Kel. Bubutan, Kec. Bubutan)
3. LPS Pasar Tambak Rejo (Kel. Rangkah, Kec. Tambaksari)
4. LPS Pasar Bangun Rejo (Kel. Dupak, Kec. Krembangan)
5. LPS Krembangan (Kel. Krembangan Selatan, Kec.Krembangan)
6. LPS Bak Larangan (Kel. Sukolilo, Kec. Kenjeran)

B. Depo/LPS of which Entrance Needs to be Enlarged :

7. LPS Pasar Kembang (2.7 m) (Kel. Wonorejo, Kec. Tegalsari)
8. Depo Bunguran (3.0 m) (Kel. Bongkaran, Kec. Pabean Cantikan)

With respect to the waste collection from large markets, the use of open type containers as shown in Fig. 1.1-4 is advisable because more amount of waste can be put in the open type containers than in the closed type contianers, and the waste loading into the open type containers is easier.

**Table 1.1-8 Results of Study on the Possibility to Place 14 m3 & 8 m3 Containers (1)**

| No | Sub District | Kecamatan | Kelurahan | Name of Depo/LPS | Status | Hauled by | Type of Truck Currently Used | No. of the existing Containers | Estimated Waste Amount | 14 m3 Containers to be placed | 8 m3 Containers to be placed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Central Surabaya | Bubutan | Alun Alun Contong | Sulung | Used | KMS | 10 m3 container | 1 | 3.0 t | 1 | [2] |
| 2 | Central Surabaya | Bubutan | Bubutan | Penghela | Used | KMS | 10 m3 container | 4 | 11.9 t | 3 | N.P. |
| 3 | Central Surabaya | Bubutan | Bubutan | Depo Pirngadi | Used | KMS | 10 m3 container | 4 | 10.8 t | 3 | N.P. |
| 4 | Central Surabaya | Bubutan | Bubutan | Pasar Turi | Used | KMS | Dump truck | - | 15.5 t | N.P. | N.P. |
| 5 | Central Surabaya | Bubutan | Jepara | Babadan/Dupak | Used | KMS | 10 m3 container | 2 | 5.9 t | 2 | [3] |
| 6 | Central Surabaya | Bubutan | Tembok Dukuh | Pasar Tembok | Used | KMS | 10 m3 container | 2 | 6.0 t | 2 | N.P. |
| 7 | Central Surabaya | Bubutan | Tembok Dukuh | Depo Demak | Used | KMS | 12 m3 container | 4 | 14.3 t | 4 | N.P. |
| 8 | Central Surabaya | Genteng | Embong Kaliasin | Depo Kayoon | Used | KMS | 12 m3 container | 5 | 17.8 t | 5 | N.P. |
| 9 | Central Surabaya | Genteng | Genteng | Depo Simpang Dukuh | Used | KMS | 6 m3 container | 5 | 8.9 t | N.P. | 4 |
| 10 | Central Surabaya | Genteng | Kapasari | Pecindilan | Used | KMS | 10 m3 container | 6 | 14.9 t | 4 | N.P. |
| 11 | Central Surabaya | Genteng | Peneleh | Makam Peneleh | Used | KMS | 6 m3 container | 4 | 7.1 t | 2 | [3] |
| 12 | Central Surabaya | Simokerto | Kapasan | Gembong Gas | Used | KMS | 6 m3 container | 4 | 7.1 t | 2 | [3] |
| 13 | Central Surabaya | Simokerto | Sidodadi | Pasar Kapasan | Used | Contractor | Dump truck | - | 8.9 t | N.P. | N.P. |
| 14 | Central Surabaya | Simokerto | Simokerto | Simolawang | Used | Contractor | Dump truck | - | 11.0 t | N.P. | [5] |
| 15 | Central Surabaya | Simokerto | Simolawang | Pegirian | Used | KMS | 6 m3 container | 4 | 7.9 t | N.P. | 4 |
| 16 | Central Surabaya | Simokerto | Tambakrejo | Depo Tambakrejo | Used | KMS | 10 m3 container | 4 | 14.9 t | 4 | N.P. |
| 17 | Central Surabaya | Tegalsari | Dr. Sutomo | Pandegiling | Used | KMS | 10 m3 container | 4 | 15.0 t | 4 | N.P. |
| 18 | Central Surabaya | Tegalsari | Dr. Sutomo | Pasar Kupang | Used | KMS | 6 m3 container | 1 | 1.8 t | N.P. | 1 |
| 19 | Central Surabaya | Tegalsari | Dr. Sutomo | Taman Ketampon | Used | KMS | 6 m3 container | 3 | 5.4 t | 2 | [3] |
| 20 | Central Surabaya | Tegalsari | Kedungdoro | Kedung Anyar Wetan | Used | Contractor | Dump truck | - | 11.0 t | 3 | [5] |
| 21 | Central Surabaya | Tegalsari | Keputran | Depo Keputran | Used | KMS | Dump truck | - | 18.0 t | 4 | N.P. |
| 22 | Central Surabaya | Tegalsari | Keputran | Depo Dinoyo | Used | Contractor | Dump truck | - | 12.8 t | 3 | N.P. |
| 23 | Central Surabaya | Tegalsari | Tegalsari | Kedungsari | Used | KMS | 6 m3 container | 4 | 9.4 t | 3 | [4] |
| 24 | Central Surabaya | Tegalsari | Wonorejo | Pasar Kembang | Used | Contractor | Dump truck | - | 3.6 t | N.P. | 2 |
| 25 | North Surabaya | Kenjeran | Bulak | Depo Tambak Deres | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 26 | North Surabaya | Kenjeran | Bulak Banteng | Depo Bulak Banteng | Will be used | - | - | - | - | P | P |
| 27 | North Surabaya | Kenjeran | Kenjeran | Kenjeran | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 28 | North Surabaya | Kenjeran | Kenjeran | Depo Wiratno | Used | KMS | 6 m3 container | 1 | 0.9 t | [1] | 1 |
| 29 | North Surabaya | Kenjeran | Sidotopo Wetan | Depo Sidotopo Wetan | Used | KMS | 6 m3 container | 3 | 2.8 t | 1 | [2] |
| 30 | North Surabaya | Kenjeran | Sukolilo | Bak Larangan | Used | Contractor | Dump truck | - | 2.0 t | N.P. | N.P. |
| 31 | North Surabaya | Kenjeran | Tanah Kali Kedinding | Depo Kali Kedinding | Used | KMS | 6 m3 container | 2 | 3.0 t | 1 | [2] |
| 32 | North Surabaya | Krembangan | Dupak | Pasar Bangun Rejo | Used | Contractor | Dump truck | - | 3.0 t | N.P. | N.P. |
| 33 | North Surabaya | Krembangan | Dupak | Depo Dupak Bandarejo | Used | KMS | 6 m3 container | 4 | 7.2 t | N.P. | 4 |
| 34 | North Surabaya | Krembangan | Krembangan Selatan | Krembangan Barat | Used | KMS | 10 m3 container | 4 | 11.0 t | 3 | [5] |
| 35 | North Surabaya | Krembangan | Krembangan Selatan | Krembangan | Used | KMS | 6 m3 container | 1 | 0.6 t | N.P. | 1 |
| 36 | North Surabaya | Krembangan | Moro Krembangan | Depo Gresik | Used | KMS | 12 m3 container | 4 | 14.0 t | 4 | N.P. |

**Table 1.1-8 Results of Study on the Possibility to Place 14 m3 & 8 m3 Containers (2)**

| No | Sub District | Kecamatan | Kelurahan | Name of Depo/LPS | Status | Responsible Body | Type of Truck | No. of the existing Containers | Estimated Waste Amount | 14 m3 Containers to be placed | 8 m3 Containers to be placed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | North Surabaya | Krembangan | Perak Barat | Depo Tanjung Sadari | Used | Counterpart | Dump truck | - | 9.7 t | 3 | [5] |
| 38 | North Surabaya | Pabean Cantikan | Bongkaran | Depo Bunguran | Used | KMS | 6 m3 container | 5 | 8.9 t | 3 | [4] |
| 39 | North Surabaya | Pabean Cantikan | Bongkaran | Pengampon | Used | KMS | 6 m3 container | 4 | 7.1 t | 2 | [3] |
| 40 | North Surabaya | Pabean Cantikan | Krembangan Utara | Babaan | Used | Contractor | Dump truck | - | 9.2 t | 3 | N.P. |
| 41 | North Surabaya | Pabean Cantikan | Krembangan Utara | Pesapen Pompa | Used | Counterpart | Dump truck | - | 4.8 t | [2] | 2 |
| 42 | North Surabaya | Pabean Cantikan | Nyamplungan | Gambir | Used | Contractor | Dump truck | - | 7.5 t | N.P. | 4 |
| 43 | North Surabaya | Pabean Cantikan | Nyamplungan | Dukuh Gili | Used | KMS | 10 m3 container | 2 | 3.0 t | 1 | [2] |
| 44 | North Surabaya | Pabean Cantikan | Perak Timur | Indrapura PLN | Used | Contractor | Dump truck | - | 1.0 t | [1] | 1 |
| 45 | North Surabaya | Pabean Cantikan | Perak Timur | Kalimas Barat | Used | KMS | 10 m3 container | 3 | 5.9 t | 2 | [3] |
| 46 | North Surabaya | Pabean Cantikan | Perak Utara | Depo Kalimas Baru | Used | Sea Port Authority | Dump truck | - | 2.6 t | 1 | [2] |
| 47 | North Surabaya | Pabean Cantikan | Perak Utara | Teluk Kumai | Used | Sea Port Authority | 6m3 container | 3 | 5.4 t | 2 | [3] |
| 48 | North Surabaya | Pabean Cantikan | Perak Utara | Kalianget | Used | Sea Port Authority | Dump truck | - | 1.0 t | N.P. | 1 |
| 49 | North Surabaya | Pabean Cantikan | Perak Utara | Depo Tanjung Priok | Used | Sea Port Authority | Dump truck | - | 7.0 t | 2 | [3] |
| 50 | North Surabaya | Pabean Cantikan | Perak Utara | Teluk Nibung | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 51 | North Surabaya | Pabean Cantikan | Perak Utara | Jamrut Selatan | Used | KMS | 6 m3 container | 2 | 3.6 t | 1 | [2] |
| 52 | North Surabaya | Pabean Cantikan | Perak Utara | Nilam | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 53 | North Surabaya | Pabean Cantikan | Perak Utara | Mirah | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 54 | North Surabaya | Pabean Cantikan | Perak Utara | Jakarta Lloyd | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 55 | North Surabaya | Semampir | Ampel | Pasar Pegirian | Used | KMS | 10 m3 container | 4 | 9.6 t | 3 | [4] |
| 56 | North Surabaya | Semampir | Ampel | Nyamplungan | Used | KMS | 10 m3 container | 2 | 5.0 t | 2 | [3] |
| 57 | North Surabaya | Semampir | Sidotopo | Kunti | Used | Contractor | Dump truck | - | 10.0 t | [3] | N.P. |
| 58 | North Surabaya | Semampir | Wonokusumo | Depo Wonosari Tegal | Used | Contractor | Dump truck | - | 13.8 t | 4 | N.P. |
| 59 | West Surabaya | Benowo | Benowo | Benowo | Will be used | | | | | P | P |
| 60 | West Surabaya | Lakarsantri | Lidah Kulon | Wisma Lidah Kulon | Used | KMS | 6 m3 container | 1 | 0.8 t | [1] | 1 |
| 61 | West Surabaya | Lakarsantri | Lontar | Depo Candi Lontar | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 62 | West Surabaya | Tandes | Asemrowo | Pasar Asemrowo | Used | Contractor | Dump truck | - | 0.6 t | [1] | 1 |
| 63 | West Surabaya | Tandes | Balongsari | Depo Balongsari | Used | KMS | 6 m3 container | 2 | 4.8 t | 2 | [3] |
| 64 | West Surabaya | Tandes | Buntaran | Buntaran | Will be used | | | | | P | P |
| 65 | West Surabaya | Tandes | Karang Poh | Depo Karang Poh | Used | KMS | 6 m3 container | 2 | 2.8 t | 1 | [2] |
| 66 | West Surabaya | Tandes | Manukan Kulon | Depo Manukan Kulon | Used | KMS | 6 m3 container | 4 | 8.8 t | 3 | [4] |
| 67 | West Surabaya | Tandes | Manukan Kulon | Manukan Telaga | Used | KMS | 6 m3 container | 1 | 3.4 t | N.P. | 2 |
| 68 | West Surabaya | Tandes | Manukan Wetan | Manukan Wetan | Used | KMS | 6 m3 container | 1 | 2.4 t | [1] | 1 |
| 69 | West Surabaya | Tandes | Putat Gede | Depo Kupang Indah | Used | KMS | 6 m3 container | 3 | 5.8 t | 2 | [3] |
| 70 | West Surabaya | Tandes | Simomulyo | Depo Simomulyo | Used | Contractor | Dump truck | - | 11.0 t | 3 | [5] |
| 71 | West Surabaya | Tandes | Simomulyo | Depo Simohilir | Used | KMS | 6 m3 container | 2 | 3.4 t | 1 | [2] |
| 72 | West Surabaya | Tandes | Sonokwijenan | Depo Sonokwijenan | Used | KMS | 6 m3 container | 2 | 3.0 t | 1 | [2] |

**Table 1.1-8 Result of Study on the Possibility to Place 14 m3 & 8 m3 Containers (3)**

| No | Sub District | Kecamatan | Kelurahan | Name of Depo/LPS | Status | Responsible Body | Type of Truck | No. of the existing Containers | Estimated Waste Amount | 14 m3 Containers to be placed | 8 m3 Containers to be placed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 73 | West Surabaya | Tandes | Sukomanunggal | Sukomanunggal | Used | KMS | 6 m3 container | 1 | 0.6 t | [1] | 1 |
| 74 | West Surabaya | Tandes | Tandes Kidul | Darmo Indah | Stop | | | - | - | P | P |
| 75 | West Surabaya | Tandes | Tandes Lor | Sentong | Stop | | | - | - | P | P |
| 76 | West Surabaya | Tandes | Tubanan | Depo Tubanan | Used | KMS | 10 m3 container | 1 | 3.2 t | 1 | [2] |
| 77 | South Surabaya | Karang Pilang | Babatan | Depo Babatan | Used | KMS | 6 m3 compactor | [3] | 0.5 t | [1] | 1 |
| 78 | South Surabaya | Karang Pilang | Balas Klumprik | Balas Klumprik | Stopped | - | - | - | - | - | - |
| 79 | South Surabaya | Karang Pilang | Dukuh Kupang | Dukuh Kupang Barat (Sel) | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 80 | South Surabaya | Karang Pilang | Dukuh Kupang | Dukuh Kupang Barat (Utara) | Used | KMS | 10 m3 compactor | 1 | 1.8 t | [1] | 1 |
| 81 | South Surabaya | Karang Pilang | Gunungsari | Yani Golf | Used | KMS | 6 m3 container | 1 | 1.0 t | [1] | 1 |
| 82 | South Surabaya | Karang Pilang | Jajar Tunggal | Jajar Tunggal | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 83 | South Surabaya | Karang Pilang | Karang Pilang | Karang Pilang | Used | KMS | 6 m3 container | 1 | 1.7 t | [1] | 1 |
| 84 | South Surabaya | Karang Pilang | Kebraon | Kemlaten | Used | KMS | 6 m3 container | 1 | 1.7 t | [1] | 1 |
| 85 | South Surabaya | Karang Pilang | Kebraon | Kebraon | Used | KMS | 6 m3 container | 2 | 4.0 t | 1 | [2] |
| 86 | South Surabaya | Karang Pilang | Kedurus | Kedurus | Used | KMS | 6 m3 container | 2 | 3.6 t | 1 | [2] |
| 87 | South Surabaya | Karang Pilang | Waru Gunung | Waru Gunung | Used | KMS | 6 m3 container | 1 | 1.5 t | [1] | 1 |
| 88 | South Surabaya | Karang Pilang | Wiyung | Wiyung | Used | KMS | 6 m3 container | 1 | 1.6 t | [1] | 1 |
| 89 | South Surabaya | Karang Pilang | Wiyung | Depo Gunung Sari Indah | Used | KMS | 6 m3 container | 1 | 1.7 t | [1] | 1 |
| 90 | South Surabaya | Sawahan | Banyu Urip | Pasar Simo | Used | Contractor | Dump truck | - | 5.4 t | 2 | [3] |
| 91 | South Surabaya | Sawahan | Banyu Urip | Simo Katrungan | Used | KMS | 6 m3 container | 2 | 1.8 t | [1] | 1 |
| 92 | South Surabaya | Sawahan | Pakis | Bintang Diponggo | Used | KMS | 12 m3 container | 2 | 5.0 t | 2 | [3] |
| 93 | South Surabaya | Sawahan | Pakis | Depo Dukuh Kupang Timur | Used | KMS | 12 m3 container | 3 | 7.5 t | 2 | [4] |
| 94 | South Surabaya | Sawahan | Pakis | Depo Kembang Kuning | Used | Contractor | Dump truck | - | 33.0 t | 8 | N.P. |
| 95 | South Surabaya | Sawahan | Petemon | Depo Bukit Barisan | Used | Contractor | Dump truck | - | 16.7 t | 4 | N.P. |
| 96 | South Surabaya | Sawahan | Putat Jaya | Pasar Kupang Gunung | Used | Contractor | Dump truck | - | 1.2 t | [1] | 1 |
| 97 | South Surabaya | Sawahan | Sawahan | Widodaren | Used | KMS | 6 m3 container | 2 | 2.4 t | [1] | 1 |
| 98 | South Surabaya | Sawahan | Sawahan | Merapi | Used | KMS | 6 m3 container | 2 | 1.6 t | N.P. | 1 |
| 99 | South Surabaya | Wonocolo | Bendul Merisi | Depo Bendul Merisi | Used | KMS | 6 m3 container | 3 | 4.1 t | 1 | [2] |
| 100 | South Surabaya | Wonocolo | Gayungan | Gayungan Pring | Used | KMS | 6 m3 container | 1 | 1.5 t | N.P. | 1 |
| 101 | South Surabaya | Wonocolo | Gayungan | Depo Gayungsari | Used | KMS | 6 m3 container | 2 | 3.6 t | 1 | [2] |
| 102 | South Surabaya | Wonocolo | Gayungan | Gayungsari Pasar | Will be used | | | - | - | N.P. | P |
| 103 | South Surabaya | Wonocolo | Jambangan | Kebon Agung | Used | Contractor | Dump truck | - | 2.2 t | [1] | 1 |
| 104 | South Surabaya | Wonocolo | Jemur Wonosari | Jemur Woonosari | Used | KMS | 6 m3 container | 3 | 5.4 t | 2 | [3] |
| 105 | South Surabaya | Wonocolo | Jemur Wonosari | Jemur Ngawinan | Used | KMS | 6 m3 container | 1 | 1.8 t | [1] | 1 |
| 106 | South Surabaya | Wonocolo | Karah | Depo Karah | Will be used | | | | - | P | P |
| 107 | South Surabaya | Wonocolo | Ketintang | Ketintang LPN | Used | Contractor | Dump truck | - | 1.8 t | N.P. | 1 |
| 108 | South Surabaya | Wonocolo | Ketintang | Ketintang Sekolahan | Will be used | | | - | - | N.P. | P |

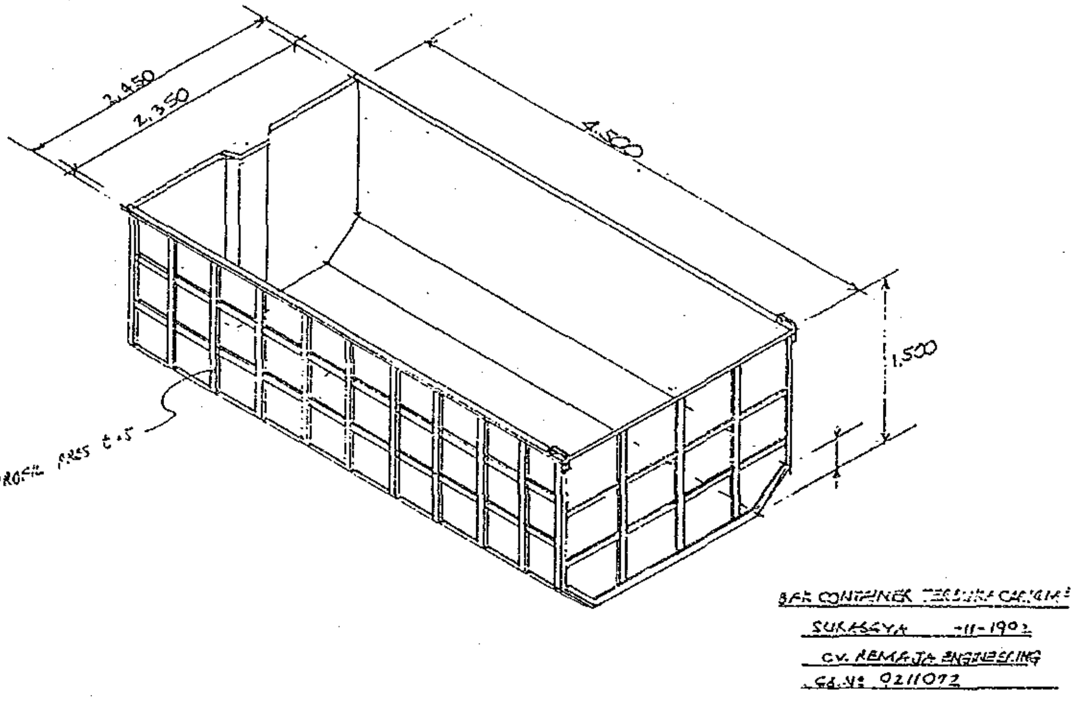
**Table 1.1-8 Result of Study on the Possibility to Place 14 m3 & 8 m3 Containers (4)**

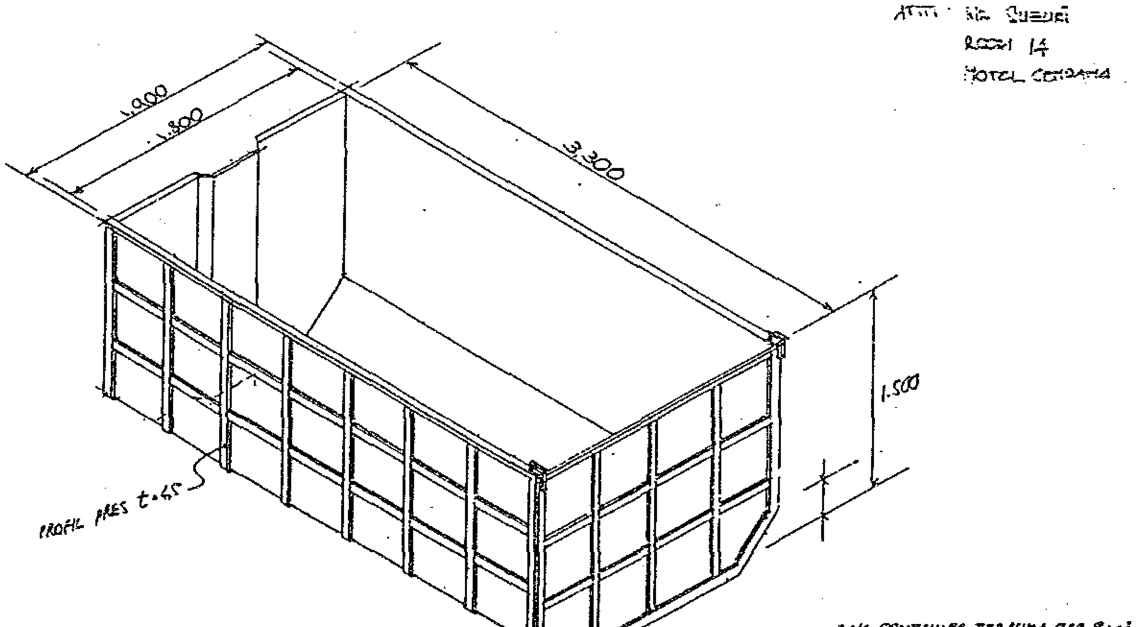
| No | Sub District | Kecamatan | Kelurahan | Name of Depo/LPS | Status | Responsible Body | Type of Truck | No. of the existing Containers | Estimated Waste Amount | 14 m3 Containers to be placed | 8 m3 Containers to be placed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 109 | South Surabaya | Wonocolo | Ketintang | Ketintang Baru | Used | Contractor | Dump truck | - | 1.4 t | N.P. | 1 |
| 110 | South Surabaya | Wonocolo | Menanggal | Perum. BBD Ahmad Yani | Used | KMS | 6 m3 compactor | 1 | 0.3 t | [1] | 1 |
| 111 | South Surabaya | Wonocolo | Menanggal | Depo Menanggal | Used | KMS | 6 m3 container | 2 | 2.5 t | 1 | [2] |
| 112 | South Surabaya | Wonocolo | Pagesangan | Depo Pagesangan | Used | Contractor | Dump truck | - | 2.7 t | 1 | [2] |
| 113 | South Surabaya | Wonocolo | Pagesangan | Kebonsari | Used | Contractor | Dump truck | - | 1.8 t | N.P. | 1 |
| 114 | South Surabaya | Wonocolo | Siwalan Kerto | Siwalan Kerto | Used | KMS | 6 m3 container | 1 | 1.6 t | [1] | 1 |
| 115 | South Surabaya | Wonokromo | Darmo | Opak | Used | KMS | 6 m3 container | 1 | 0.4 t | N.P. | N.P. |
| 116 | South Surabaya | Wonokromo | Jagir | Bendul Merisi | Used | Contractor | Dump truck | - | 12.1 t | 3 | [5] |
| 117 | South Surabaya | Wonokromo | Jagir | Pasar Wonokromo | Used | Contractor | Dump truck | - | 16.2 t | 4 | N.P. |
| 118 | South Surabaya | Wonokromo | Ngagel | Ngagel | Used | Contractor | Dump truck | - | 3.6 t | 1 | [2] |
| 119 | South Surabaya | Wonokromo | Ngagel Rejo | Depo Bratang Lapangan | Used | KMS | 6 m3 container | 4 | 5.4 t | 2 | [3] |
| 120 | South Surabaya | Wonokromo | Ngagel Rejo | Depo Ngagel Dadi III | Used | KMS | 6 m3 container | 4 | 4.3 t | [2] | 2 |
| 121 | South Surabaya | Wonokromo | Ngagel Rejo | Pasar Krukah | Used | KMS | 6 m3 container | 1 | 1.5 t | [1] | 1 |
| 122 | South Surabaya | Wonokromo | Sawunggaling | Wonoboyo | Used | KMS | 6 m3 container | 2 | 1.8 t | [1] | 1 |
| 123 | South Surabaya | Wonokromo | Sawunggaling | Pasar Wonokitri | Used | Contractor | Dump truck | - | 0.4 t | [1] | 1 |
| 124 | South Surabaya | Wonokromo | Sawunggaling | Pasar Wonokitri | Used | KMS | 6 m3 container | 3 | 6.0 t | 2 | [3] |
| 125 | South Surabaya | Wonokromo | Sawungggaling | Joyoboyo | Used | KMS | 6 m3 container | 1 | 1.5 t | [1] | 1 |
| 126 | South Surabaya | Wonokromo | Wonokromo | Depo Kintamani | Used | KMS | 6 m3 container | 5 | 11.2 t | 3 | [5] |
| 127 | South Surabaya | Wonokromo | Wonokromo | Jetis | Used | KMS | 6 m3 container | 1 | 2.2 t | [1] | 1 |
| 128 | East Surabaya | Gubeng | Airlangga | Srikana | Used | KMS | 12 m3 container | 3 | 14.0 t | 4 | [6] |
| 129 | East Surabaya | Gubeng | Barata Jaya | Bratang Binangun | Used | KMS | 10 m3 container | 3 | 9.0 t | 3 | [4] |
| 130 | East Surabaya | Gubeng | Baratajaya | Baratajaya | Used | KMS | 10 m3 container | 1 | 4.5 t | [2] | 2 |
| 131 | East Surabaya | Gubeng | Gubeng | Depo Kangean | Used | KMS | 10 m3 container | 3 | 12.6 t | 3 | N.P. |
| 132 | East Surabaya | Gubeng | Kertajaya | Pasar Pucang Anom | Used | Contractor | Dump truck | - | 2.0 t | [1] | 1 |
| 133 | East Surabaya | Gubeng | Mojo | Mojoarum | Used | KMS | 10 m3 container | 1 | 9.0 t | 3 | [4] |
| 134 | East Surabaya | Gubeng | Mojo | Depo Kaliwaron | Used | KMS | 6 m3 container | 2 | 3.8 t | 1 | [2] |
| 135 | East Surabaya | Gubeng | Mojo | Mojo | Used | KMS | 6 m3 container | 2 | 3.5 t | 1 | [2] |
| 136 | East Surabaya | Gubeng | Pucang Sewu | Depo Kalibokor | Used | KMS | 6 m3 container | 4 | 8.1 t | 2 | [4] |
| 137 | East Surabaya | Rungkut | Kali Rungkut | Raya Rungkut | Used | KMS | 6 m3 container | 2 | 3.0 t | 1 | [2] |
| 138 | East Surabaya | Rungkut | Kali Rungkut | Rungkut Harapan | Used | KMS | 6 m3 container | 1 | 1.2 t | [1] | 1 |
| 139 | East Surabaya | Rungkut | Kali Rungkut | Depo Rungkut Alang Alang | Used | Contractor | Dump truck | 1 | 8.1 t | 2 | [4] |
| 140 | East Surabaya | Rungkut | Kali Rungkut | Raya Kali Rungkut | Stopped | - | - | - | - | P | P |
| 141 | East Surabaya | Rungkut | Kedung Baruk | Kedung Asem | Stopped | | | - | - | P | P |
| 142 | East Surabaya | Rungkut | Kendang Sari | Raya Kendang Sari Industry | Used | KMS | 6 m3 container | 2 | 2.8 t | [1] | 1 |
| 143 | East Surabaya | Rungkut | Kendangsari | Depo Kendangsari Block C | Used | KMS | 6 m3 container | 1 | 1.7 t | [1] | 1 |
| 144 | East Surabaya | Rungkut | Kendangsari | Prapen | Used | KMS | 6 m3 container | 1 | 0.8 t | [1] | 1 |

**Table 1.1-8 Results of Study on the Possibility to Place 14 m3 & 8 m3 Containers (5)**

| No | Sub District | Kecamatan | Kelurahan | Name of Depo/LPS | Status | Responsible Body | Type of Truck | No. of the existing Containers | Estimated Waste Amount | 14 m3 Containers to be placed | 8 m3 Containers to be placed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 145 | East Surabaya | Rungkut | Kendangsari | Kendangsari Telkom | Used | KMS | 6 m3 container | 2 | 2.2 t | [1] | 1 |
| 146 | East Surabaya | Rungkut | Kutisari | Kutisari Indah | Used | KMS | 6 m3 container | 3 | 4.6 t | [2] | 2 |
| 147 | East Surabaya | Rungkut | Panjaringan Sari | Panjaringan Sari | Used | KMS | 6 m3 container | 1 | 1.2 t | [1] | 1 |
| 148 | East Surabaya | Rungkut | Rungkut Kidul | Depo Rungkut Kidul | Used | KMS | 6 m3 container | 5 | 9.6 t | 3 | [4] |
| 149 | East Surabaya | Rungkut | Rungkut Menanggal | Depo Rungkut Menanggal | Used | KMS | 6 m3 container | 2 | 3.6 t | 1 | [2] |
| 150 | East Surabaya | Rungkut | Rungkut Menanggal | Rungkut Barata | Stopped | - | - | - | - | P | P |
| 151 | East Surabaya | Rungkut | Tenggilis Mejoyo | Tenggilis Tengah | Will be used | - | - | - | - | P | P |
| 152 | East Surabaya | Rungkut | Tenggilis Mejoyo | Depo Tenggilis Mejoyo | Used | KMS | 6 m3 container | 2 | 3.2 t | 1 | [2] |
| 153 | East Surabaya | Tambak Sari | Ploso | Depo Karang Gayam | Used | KMS | 6 m3 container | 3 | 6.0 t | 2 | [3] |
| 154 | East Surabaya | Tambak Sari | Rangkah | Pasar Tambak Rejo | Used | Contractor | Dump Truck | - | 3.6 t | N.P. | N.P. |
| 155 | East Surabaya | Tambak Sari | Rangkah | Sarangan Tuwowo | Used | KMS | 6 m3 container | [3] | 0.8 t | N.P. | 1 |
| 156 | East Surabaya | Tambak Sari | Tambak Sari | Depo Bogen | Used | KMS | 6 m3 container | 4 | 6.6 t | 2 | [3] |
| 157 | East Surabaya | Sukolilo | Dukuh Sutorejo | Sutorejo I | Used | Contractor | Dump truck | - | 0.6 t | [1] | 1 |
| 158 | East Surabaya | Sukolilo | Dukuh Sutorejo | Sutorejo II | Used | Contractor | Dump truck | - | 0.6 t | [1] | 1 |
| 159 | East Surabaya | Sukolilo | Kalisari | Mulyosari | Used | KMS | 12 m3 Container | 1 | 4.3 t | [2] | 2 |
| 160 | East Surabaya | Sukolilo | Manyar Sabrangan | Manyar Kertoadi | Used | KMS | 10 m3 container | 2 | 5.9 t | 2 | [3] |
| 161 | East Surabaya | Sukolilo | Manyar Sabrangan | Depo Manyar | Used | KMS | 10 m3 containers | 4 | 16.o t | 4 | N.P. |
| 162 | East Surabaya | Sukolilo | Menur Pumpungan | Sarangan Arif Rahman Hakim | Stopped | | | | - | P | P |
| 163 | East Surabaya | Sukolilo | Menur Pumpungan | Arif Rahman Hakim | Used | KMS | 10 m3 container | 2 | 7.0 t | 2 | [3] |
| 164 | East Surabaya | Sukolilo | Mulyorejo | Depo Wisma Permai | Used | KMS | 6 m3 container | 1 | 1.5 t | [1] | 1 |
| 165 | East Surabaya | Sukolilo | Semolowaru | Semolowaru Elok | Used | KMS | 6 m3 container | 2 | 1.7 t | [1] | 1 |
| 166 | East Surabaya | Sukolilo | Semolowaru | Depo Semolowaru | Used | KMS | 6 m3 container | 2 | 3.6 t | 1 | [2] |
| 167 | East Surabaya | Tambak Sari | Gading | Putro Agung Wetan | Used | KMS | 10 m3 container | 3 | 10.0 t | 3 | [4] |
| 168 | East Surabaya | Tambak Sari | Pacar Keling | Tambangboyo | Used | KMS | 6 m3 container | 2 | 3.7 t | 1 | [2] |
| 169 | East Surabaya | Tambak Sari | Pacar Keling | Depo Pacar Keling | Used | KMS | 6 m3 container | 3 | 4.4 t | [2] | 2 |
| 170 | East Surabaya | Tambak Sari | Pacar Keling | Pasar Gubeng Masjid | Used | KMS | 6 m3 container | 1 | 1.4 t | [1] | 1 |
| 171 | East Surabaya | Tambak Sari | Pacar Keling | Pacar keling | Used | KMS | 10 m3 container | 1 | 4.0 t | 1 | [2] |
| 172 | East Surabaya | Tambak Sari | Pacar Keling | Petojo | Used | KMS | 6 m3 container | 1 | 1.9 t | [1] | 1 |
| 173 | East Surabaya | Tambak Sari | Pacar Keling | Gubeng Masjid | Used | KMS | 6 m3 container | 1 | 1.9 t | [1] | 1 |
| 174 | East Surabaya | Tambak Sari | Pacar Kembang | Sarangan Pacar kembang | Used | KMS | Dump truck | - | 0.3 t | [1] | 1 |
| 175 | East Surabaya | Tambak Sari | Ploso | Ploso Baru | Stopped | | | - | - | P | P |

Note : 1. Figures in parenthesis [ ] indicate numbers of optional containers that can be possibly be placed, but not advisable mainly because waste amount is not large enough, or not cost-effective.
2. "N.P." means not possible or difficult to place containers because the spaced or access to Depo/LPS is inadequate.
3. "P" means possible to place containers. But the marked Depo/LPS are not used currently.




**Source : CV. REMAJA ENGINEERING**

**FIG. 1.1-3** Examples of a 8 $m^3$ and and 14 $m^3$ Open Containers

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### 3) Mini-Container Truck

It is planned that the future waste haulage service with mini-container trucks will be contracted out to contractors. Therefore, the KMS will not purchase mini-container trucks. It is advised that the KMS will either sell or lease the existing mini-container trucks to contractors by 1995 if they are still usable.

It is expected that the contractors will choose the most cost-effective type of trucks. (The JICA Study Team recommend 14 $m^3$ REL trucks so far as mini-container trucks due to the reason shown in Appendix).

### 4) Conclusion

The following two container truck system are recommended :

1. 14 GVW Arm-Roll truck with 14 $m^3$ container.
2. 7 GVW Arm-Roll truck with 8 $m^3$ container.

12 $m^3$ container trucks with 10 GVW uprated from 7 GVW by using two rear axle, are not recommended because its operational reliability has not been confirmed. KMS should make a prototype of 12 $m^3$ container truck to study the reliability of operation for at least one year if the KMS wishes to introduce the 10 GVW trucks.

The examples of a 8 $m^3$ container truck and a 14 $m^3$ container truck is shown in Fig. 1.1-3 and Fig. 1.1-4 respectively.

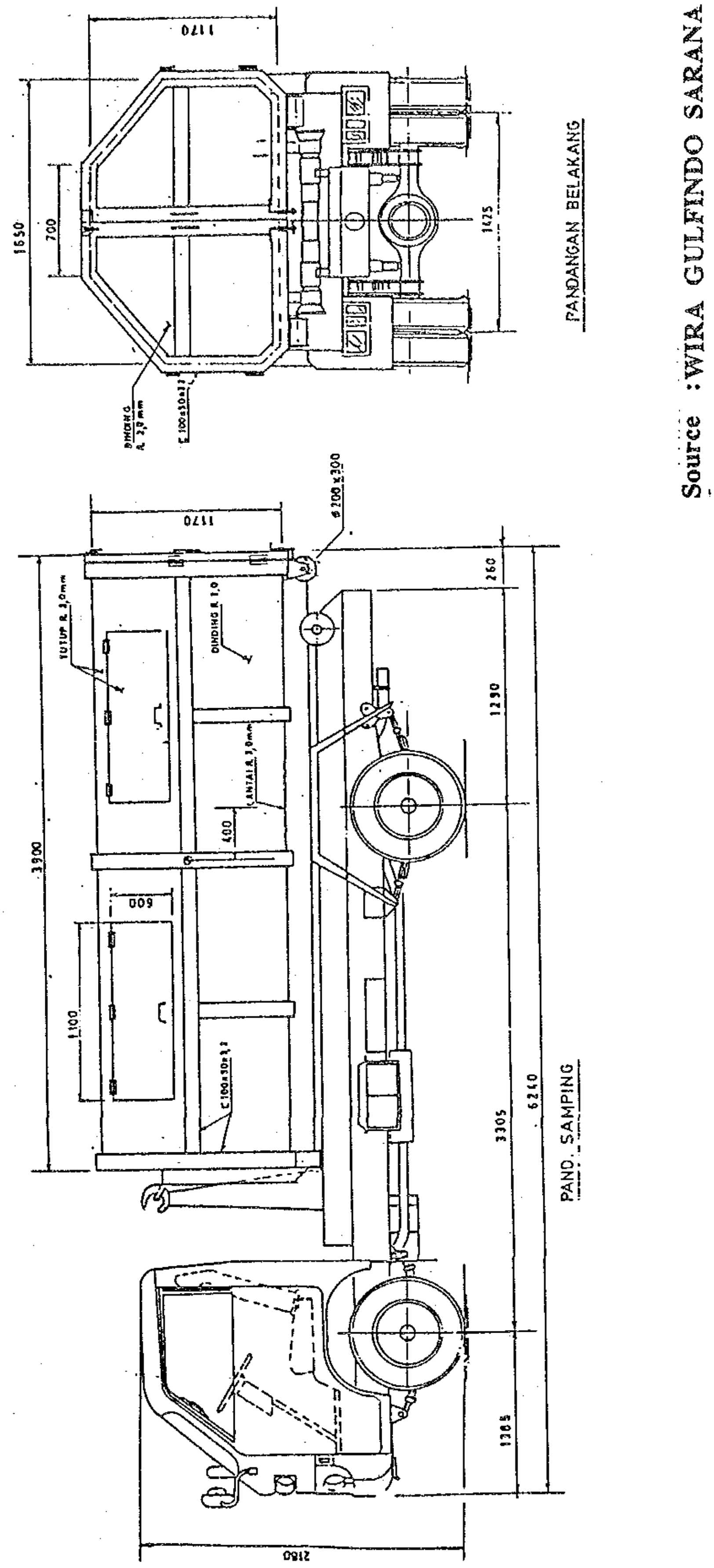


**FIG. 1.1-4** Example of 7 GVW Arm-Roll Truck with 8 $M^3$ Container

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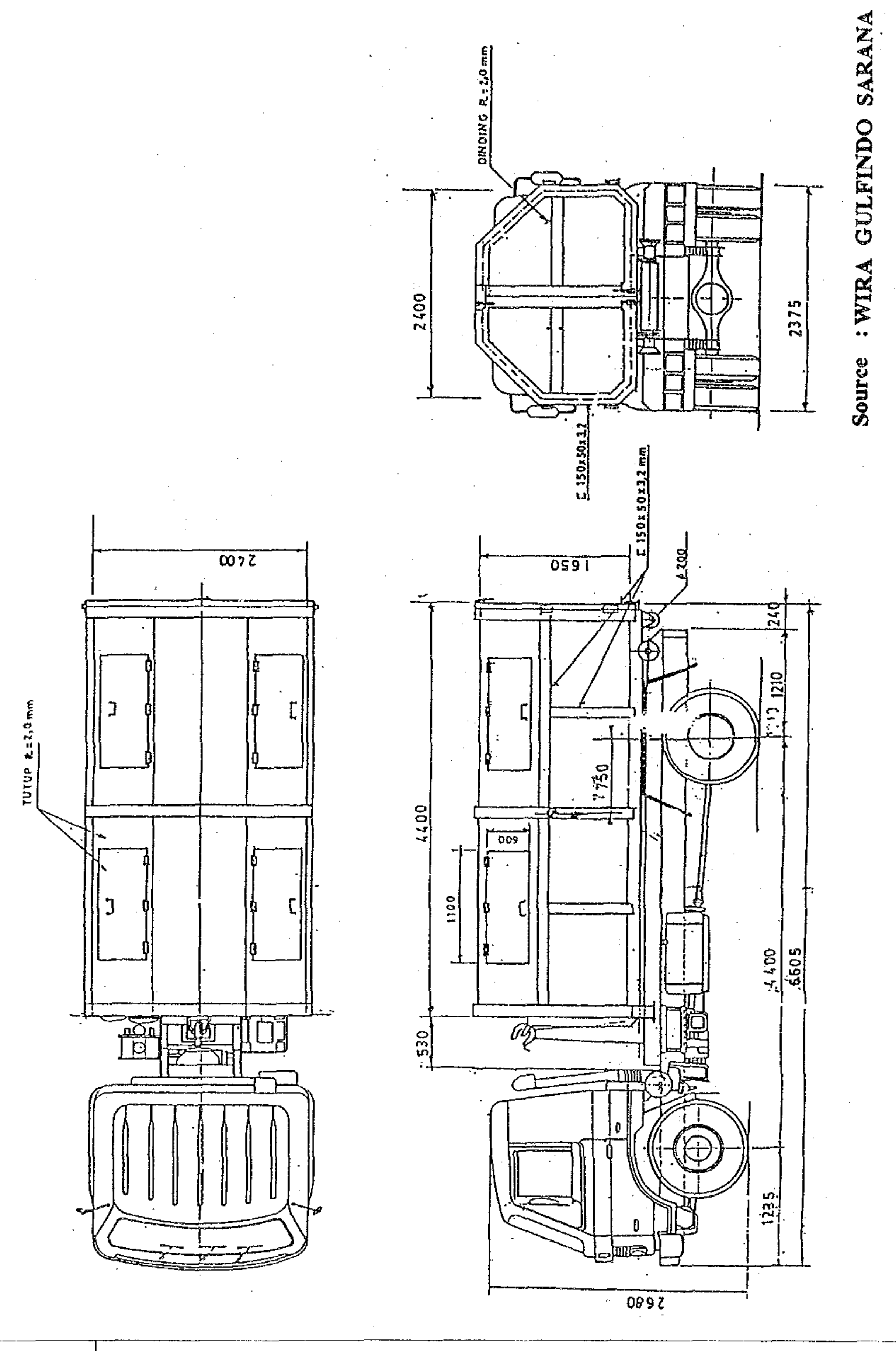



FIG. 1.1-5 Example of 14 GVW Arm-Roll Truck with 14 $M^3$ Container

## 1.3 Location of LPA and Haulage Distance and Time up to 1988

### 1) Location of LPA

It is expected that two LPA can be secured both in the east and in the west of Surabaya. In the disposal plan, the new east LPA is planned to be constructed and will be opened in 1997. However, this plan is still uncertain since the LPA location has not yet been decided. Thus, the use of the new east LPA is not considered in the preparation of vehicle procurement plan for SUDP period. Lakarsantri LPA can be used until 1996. Thereafter Benowo LPA will takeover Lakarsantri LPA. Keputih LPA will be used until 1997. Benowo LPA is expected to open in 1996. The future destination (LPA) of waste haulage trucks by sub-district is shown in Table 1.1-9.

**Table 1.1-9 Future Destination (LPA) of Waste Haulage Trucks by Sub-districts**

| Year | Sub - District | | | | |
|---|---|---|---|---|---|
| | Center | North | East | South | West |
| 1993 | Keputih | Keputih | Keputih | Lakarsantri | Lakarsantri |
| 1994 | Keputih | Keputih | Keputih | Lakarsantri | Lakarsantri |
| 1995 | Keputih | Keputih | Keputih | Lakarsantri | Lakarsantri |
| 1996 | Benowo | Benowo | Keputih | Benowo | Lakarsantri |
| 1997 | Benowo | Benowo | Keputih | Benowo | Benowo |
| 1998 | Benowo | Benowo | Benowo | Benowo | Benowo |
| 1999 | Benowo | Benowo | Benowo | Benowo | Benowo |

### 2) Haulage Distance and Time to LPS.

Table 1.1-10 shows the haulage distance and time to LPA from the centers of Sub-district estimated based upon the field survey of the JICA Study Team.

**Table 1.1-10 Haulage Distance and Time to Disposal Site (LPA) from the Centers of 5 Sub-Districts**

| Sub-District | Trip from the Center of Sub-District to Disposal Site | | | | | |
|---|---|---|---|---|---|---|
| | Eastern Part | | Western Part | | | |
| | Keputih | | Lakarsantri | | Benowo | |
| | Distance (km) | One Way Trip Time | Distance (km) | One Way Trip Time | Distance (km) | One Way Trip Time |
| Surabaya : Center | 11 km | 18 min | 17 km | 35 min | 23 km | 45 min |
| North | 16 km | 33 min | - | - | 21 km | 45 min |
| East | 3 km | 10 min | - | - | 28 km | 65 min |
| South | - | - | 12 km | 30 min | 24 km | 50 min |
| West | - | - | 2 km | 10 min | 17 km | 35 min |

### 3) Transfer Station

### a. Conclusion

The planned future LPA in Benowo is located further than the existing LPA in Keputih or Lakarsantri. The JICA Study Team has made a comparative study of the haulage costs with or without a large transfer station in order to know whether or not a transfer station is necessary.

As a result of the comparative study it is concluded that :

1. Under the existing haulage system of Surabaya where there are many Depo and LPS, a large transfer station is not necessary if a final disposal site (LPA) is located within 40 km from collection areas.

2. The above conclusion means that construction of any large transfer station is not feasible, and therefore not advisable if a LPA is located in Surabaya.

3. A transfer station might be necessary if a LPA is constructed outside Surabaya such as Sidoarjo.

4. The KMS's existing haulage system with Depo and LPS is efficient as Depo and LPS serve as mini-transfer stations.

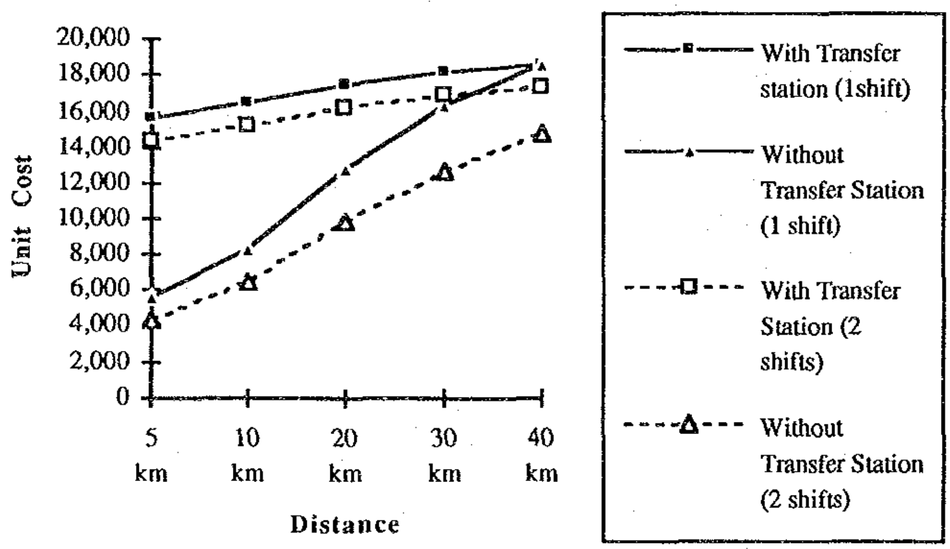



**Fig. 1.1-6 Unit Cost Comparison between Haulage with Transfer Station and Direct Haulage**

**Table 1.1-11 Cost Comparison between With and Without Transfer Station by Using 1 Shift Collection**

(Unit. Rp/ton)

| Distance / Unit Cost | 5 km | 10 km | 20 km | 30 km | 40 km |
|---|---|---|---|---|---|
| Collection Cost | - | 5,674 | 5,674 | 5,674 | 5,674 |
| Transfer Station Cost | - | 9,731 | 9,731 | 9,731 | 9,731 |
| Haulage Cost | - | 1,057 | 2,025 | 2,743 | 3,234 |
| Total Haulage Cost with a Transfer Station | - | 16,462 | 17,430 | 18,148 | 18,639 |
| Total Haulage Cost without a Transfer Station | 5,674 | 8,285 | 12,759 | 16,313 | 18,641 |

**Table 1.1-12 Cost Comparison between With and Without Transfer Station by Using 2 Shifts Collection**

(Unit. Rp/ton)

| Distance / Unit Cost | 5 km | 10 km | 20 km | 30 km | 40 km |
|---|---|---|---|---|---|
| Collection Cost | - | 4,418 | 4,418 | 4,418 | 4,418 |
| Transfer Station Cost | - | 9,731 | 9,731 | 9,731 | 9,731 |
| Haulage Cost | - | 1,057 | 2,025 | 2,743 | 3,234 |
| Total Haulage Cost with a Transfer Station | - | 15,206 | 16,174 | 16,892 | 17,383 |
| Total Haulage Cost without a Transfer Station | 4,418 | 6,401 | 9,914 | 12,702 | 14,780 |

### b. Assumptions Used and Cost Estimation

The above conclusions were drawn based upon the assumptions and cost estimation as shown below :

#### (1) Type of a Transfer Station

For the purpose of the comparative study, cost estimation was made for the case where type with the transfer capacity of 1,000 ton/day is applied. The reasons for choosing the compaction type is as follows :

i) Among Compaction type, Non Compaction type, Mix type of both Compaction and Non Compaction type, and Silo type, unit cost of compaction type is estimated to be the cheapest although the unit costs of the said four type is close each other according to another JICA study for Sunter transfer station in Jakarta.

ii) Shovel loader system which dump waste on the floor (the most simple transfer station) is cheaper than the compaction type, but not recommended because it is not sanitary. The people surrounding the station site may complain about bad smell, etc.

### (2) Transfer Station

Unit cost of a transfer station is estimated at Rp. 9,731/t as shown in Table 1.1-13.

**Table 1.1-13 Unit Cost of a Transfer Station (1,000 ton/day)**

| | | | |
|---|---|---|---|
| 1) | Investment cost | | Rp. 14,704 million |
| | a. Main facility | Rp. 9,293 million | |
| | b. Waste water treatment | Rp. 1,093 million | |
| | c. Building | Rp. 2,457 million | |
| | d. building facility | Rp. 682 million | |
| | e. Civil work | Rp. 1,179 million | |
| 2) | Depreciation | | Rp. 883.4 million |
| | a. 15 years | Rp. 619.5 million | |
| | b. 15 years | Rp. 72.8 million | |
| | c. 25 years | Rp. 98.3 million | |
| | d. 15 years | Rp. 45.5 million | |
| | e. 25 years | Rp. 47.2 million | |
| 3) | Interest | | Rp. 1,323.4 million |
| 4) | Operation and maintenance | | Rp. 1,244.9 million |
| | a. Personal (50 person) | Rp. 75.0 million | |
| | b. Maintenance (2.5% investment ) | Rp. 367.6 million | |
| | c. Power | Rp. 648.0 million | |
| | d. Consumable | Rp. 254.3 million | |
| 5) | Total Cost | | Rp. 3,551.7 million |
| 6) | Unit Cost | | Rp. 9,731 million |

Note : The above costs were calculated based upon the study of SUNTER Transfer Station, Jakarta.

## (3) Haulage Cost Without a Transfer Station

Unit haulage cost without a transfer station is estimated at as shown in Table 1.1-14 based upon the following assumptions :

a. The type of truck is 10 $m^3$ Arm-Roll trucks, which is considered as a medium capacity of the KMS' major haulage trucks (8 $m^3$ and 14 $m^3$ Arm-Roll trucks).

b. Net working hour is 400 minutes for 1 shift, 800 minutes for 2 shifts. The number of working days are 330 days/year..

c. Trip speed by 5 different distances are assumed as follows :

| The distance to a dumping site from a collection area | Trip speed |
|---|---|
| 5 km | 21 km/hour |
| 10 km | 25 km/hour |
| 20 km | 29 km/hour |
| 30 km | 33 kmhour |
| 40 km | 37 km/hour |

d. Time for a container exchange and waste dumping 15 minutes/trip

e. Number of trips

| Distance | 1 shift | 2 shifts |
|---|---|---|
| 5 km | 9.2 trips/day | 18.4 trips/day |
| 10 km | 6.3 trips/day | 12.7 trips/day |
| 20 km | 4.1 trips/day | 8.2 trips/day |
| 30 km | 3.2 trips/day | 6.4 trips/day |
| 40 km | 2.8 trips/day | 5.5 trips/day |

f. Waste amount of 10 $m^3$ container is assumed to be 3.2 ton.

g. Arm-Roll operation costs of 10 $m^3$ container truck are estimated to be Rp. 55,120,000 for 1 shift working, and Rp. 85,842,000 for 2 shifts.

| | | 1 shift | 2 shifts |
|---|---|---|---|
| 1. | Depreciation | Rp. 11,614,000 | Rp. 11,614,000 |
| 2. | Loan Interest | Rp. 8,536,000 | Rp . 8, 536,000 |
| 3. | Operation & Maintenance | | |
| | 3.1 Fuel | Rp. 6,081,000 | Rp. 12,162,000 |
| | 3.2 Salary of drivers & assistants | Rp. 4,260,000 | Rp. 8,520,000 |
| | 3.3 Tax and Insurance | Rp. 2,030,000 | Rp. 2,030,000 |
| 4. | Maintenance (12.5% of truck purchase cost) | Rp. 10,163,000 | Rp. 20 326,000 |
| 5. | Cost of containers | | |
| | 5.1 Depreciation of containers per truck | Rp. 6,600,000 | Rp. 13,200,000 |
| | 5.2 Maintenance of containers per truck | Rp. 825,000 | Rp. 1,650,000 |
| 6. | Total cost (1+2+3+4+5) | Rp. 50,109,000 | Rp. 78,038,000 |
| 7. | Indirect Management Cost (10% of item 6) | Rp. 5,011,000 | Rp. 7,804,000 |
| 8. | Grand total (6+7) | Rp. 55,120,000 | Rp. 85,842,000 |

**Table 1.1-14 Unit haulage Cost without a Transfer Station by 5 Different Distances from collection Site to LPA**

| | 1 shift | | 2 shifts | |
|---|---|---|---|---|
| | Amount of waste collection per truck | Unit cost | Amount of waste collection per truck | Unit cost |
| 5 km | 9,715 t | Rp. 5,674/t | 19,430 t | Rp. 4,418/t |
| 10 km | 6,653 t | Rp. 8,285/t | 13,411 t | Rp. 6,401/t |
| 20 km | 4,320 t | Rp. 12,759/t | 8,659 t | Rp. 9,914/t |
| 30 km | 3,379 t | Rp. 16,313/t | 6,758 t | Rp. 12,702/t |
| 40 km | 2,957 t | Rp. 18,641/t | 5,808 t | Rp. 14,780/t |

### (4) Haulage Cost from a Transfer Station to LPA

Unit haulage costs from a transfer station to a LPA are estimated as shown in Table 1.1-15 by using the following assumptions :

a. Type of truck is 40 $m^3$ trailer truck.

b. The site of transfer station is located 5 km from a collection area, and the disposal site is set four cases : 5 km, 15 km, 25 km, and 35 km from the transfer station.

c. Waste haulage amount per truck 20 ton/truck/trip

d. Trip speed by 4 different distances from the transfer station

| Distance from the transfer station to LPA | Trip speed |
|---|---|
| 5 km | 25 km |
| 15 km | 30 km |
| 25 km | 35 km |
| 35 km | 40 km |

e. Time needed for exchange container and waste dumping time
15 minutes/trip

f. Number of working shift — 2 shifts

g. Net working time — 800 minutes for 2 shifts

h. Working days — 330 days/year

i. Number of trip

| | |
|---|---|
| 5 km | 20.5 times/day |
| 15 km | 10.7 times/day |
| 25 km | 7.9 times/day |
| 35 km | 6.7 times/day |

j. Annual operation cost of 40 $m^3$ trailer truck

| | |
|---|---|
| 1) Depreciation of truck (7 years) | Rp. 42,857,000 |
| 2) Loan interest | Rp. 31,499,000 |
| 3) Container provision | Rp. 15,000,000 |
| 4) Maintenance (12.5% of Truck Purchase Cost) | Rp. 37,500,000 |
| 5) Labor | Rp. 3,000,000 |
| 6) Fuel | Rp. 6,904,000 |
| 7) Tax | Rp. 250,000 |
| 8) Insurance | Rp. 6,000,000 |
| 9) Total | Rp. 143,010,000 |

**Table 1.1-15 Unit Haulage Cost from a Transfer Station to LPA by 4 Different Distances**

| | Waste amount per truck | Unit Haulage Cost |
|---|---|---|
| 5 km | 135,300 t/year | Rp. 1,057/t |
| 15 km | 70,620 t/year | Rp. 2,025/t |
| 25 km | 52,140 t/year | Rp. 2,743/t |
| 35 km | 44,220 t/year | Rp. 2,234/t |

## 1.4 Average Haulage Amount per Truck per Day

### 1) Target Trips to be made per day

The average target number of trip made per day of an arm-roll truck to be made is shown in Table 1.1-16.

One may be worried that the traffic congestion may get worse in the future due to increases of number of cars, and it may cause the trip number to decrease in the future. However, it is considered possible to maintain the target trip number in the future in view of the following :

(1) It is possible to avoid traffic congestions by starting the haulage operation earlier than 7:30 am. (the current KMS' trucks leave the garage around 7:30 ~ 8:30).

(2) The KMS has a plan to construct a ring road, and highway during the SUDP period. It is expected to mitigate the traffic.

**Table 1.1-16 Average Target Number of Trip per day for Arm-Roll Trucks**

| Sub-district | Keputih, New East LPA | Lakarsantri LPA | Benowo LPA |
|---|---|---|---|
| Surabaya | | | |
| Center | 7.8 | -- | 3.8 |
| North | 4.9 | -- | 3.8 |
| East | 11.4 | -- | 2.8 |
| South | -- | 5.3 | 3.5 |
| West | -- | 11.4 | 4.7 |

Assumptions used : (1) 15 minutes spent for haulage and dumping
(2) Net working time is 400 minutes

### 2) Number of Operation Days

The average operation days are assumed to be 330 day/year.

## 1.5 Abandonment or Sales Schedule of the Existing Trucks and Containers

It is proposed that the KMS will sell used trucks to contractors if contractors accept them. The sales of the used trucks is beneficial to KMS because contractors may be able to reduce contract prices if cheap used trucks are made available to them.

The abandonment or sales schedule of the existing trucks and containers are shown in Tables 1.1-17 and 1.1-18 respectively.

The following policy is proposed for abandonment or sales of trucks and containers.

(1) Trucks that have been operated more than 7 years should be abandoned or saled.

(2) Containers that have been operated more than 5 years should be abandoned or sold.

(3) Containers that have been operated less than 5 years should be sold if the corresponding trucks are abandoned or sold.

## Table 1.1-17 Abandonment or Sales Schedule of the Existing Trucks

| YEAR | TRUCKS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 m3 Arm-Roll Truck | | 10 m3 Arm-Roll Truck | | 12 m3 Arm-Roll Truck | | Open Truck | | 6 m3 REL | | 10 m3 REL | |
| 1992 | 26 | | 13 | | 4 | | 6 | | 5 | | 10 | |
| | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining |
| 1993 | 14 | 12 | 8 | 5 | 0 | 4 | 0 | 6 | 0 | 5 | 0 | 10 |
| 1994 | 0 | 12 | 13 | 0 | 4 | 0 | 4 | 2 | 2 | 3 | 5 | 5 |
| 1995 | 10 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 5 | 0 |
| 1996 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

## Table 1.1-18 Abandonment or Sales Schedule of the Existing Containers

| YEAR | CONTAINERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.6 m3 Container | | 1.0 m3 Container | | 6 m3 container | | 10 m3 Container | | 12 m3 Container | |
| 1992 | 38 | | 550 | | 161 | | 79 | | 19 | |
| | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining | To be Hauled or Sold | Remaining |
| 1993 | 0 | 38 | 80 | 470 | 79 | 82 | 72 | 7 | 11 | 8 |
| 1994 | 38 | 0 | 99 | 371 | 76 | 6 | 7 | 0 | 8 | 0 |
| 1995 | 0 | 0 | 371 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |

## 1.6 *Spare Trucks Requirement*

In the preparation of a vehicle procurement plan, requirements for spare trucks are considered in the following manner :

1. Number of trucks needed for waste haulage from each Sub-district are calculated by rounding up fractions (Example : Necessary number of trucks is estimated to be 6 by rounding up 5.2 trucks).

2. Requirement for 8 $m^3$ Arm-Roll trucks will gradually decrease after the year 1997, and will be redundent because 8 $m^3$ containers will be replaced by 14 $m^3$ containers as waste amounts increase in the future. Redundent trucks can be then used as spare trucks.

It is advised that the KMS will apply two shift working system if a vehicle shortage occur.

## 1.7 Duration of Trucks and Containers

Duration of trucks and containers are assumed to be 7 years and 5 years respectively.

## 1.8 Procurement Schedule

Based upon the assumptions and proposed policy explained in the previous sections, a vehicle procurement plan is prepared as shown in Tables 1.1-19, 1.1-20 and 1.1-21. Total units of trucks to be purchased are as follows :

Total Unit of Trucks to be Purchased by the KMS During 1992-1998

| | | | |
|---|---|---|---|
| 1) | 8 $m^3$ Arm-Roll Trucks | : | 24 |
| 2) | 14 $m^3$ Arm-Roll trucks | : | 39 |
| 3) | Open dump Trucks | : | 5 |
| 4) | Compactor trucks (FEL or REL) | : | 0 |

## Table 1.1-19 Procurement Plan of 8 $m^3$ Arm-Roll Trucks

| Year | Total Amount of Waste to be Hauled by 8 m3 Arm-Roll Truck | Surabaya Center | | Surabaya North | | Surabaya East | | Surabaya South | | No. of 8 m3 Arm-Roll Trucks Required for the Next Year | No. of 8 m3 Arm-Roll Trucks to be Procured | Abandonment of New Trucks | Total No. of 8 m3 Arm-Roll Trucks to be Procured |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Amount of Waste | No. of 8 m3 Arm-Roll Truck Needed | Amount of Waste | No. of 8 m3 Arm-Roll Truck Needed | Amount of Waste | No. of 8 m3 Arm-Roll Truck Needed | Amount of Waste | No. of 8 m3 Arm-Roll Truck Needed | | | | |
| | (1) | (2) | (3) | (4) | (3) | (6) | (7) | (8) | (9) | (10)=(3)+(5)+(7)+(9) | (11) | (12) | (13)=(11)+(12) |
| 1992 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 |
| 1993 | 72 | 19 | 2 | 16 | 2 | 27 | 1 | 10 | 1 | 7 | 7 | 0 | 7 |
| 1994 | 86 | 22 | 2 | 19 | 2 | 35 | 2 | 10 | 1 | 11 | 4 | 0 | 4 |
| 1995 | 186 | 48 | 3 | 44 | 4 | 78 | 3 | 16 | 1 | 17 | 6 | 0 | 6 |
| 1996 | 199 | 52 | 6 | 49 | 6 | 88 | 4 | 10 | 1 | 17 | 0 | 0 | 0 |
| 1997 | 192 | 51 | 6 | 50 | 6 | 88 | 4 | 3 | 1 | 26 | 7 | 0 | 7 |
| 1998 | 185 | 49 | 6 | 49 | 6 | 87 | 14 | 0 | 0 | 25 | -1 | 0 | 0 |
| 1999 | 178 | 48 | 6 | 50 | 6 | 80 | 13 | 0 | 0 | 23 | -2 | 0 | 0 |
| 2000 | 171 | 18 | 6 | 51 | 6 | 72 | 11 | 0 | 0 | 22 | -1 | 0 | 0 |
| 2001 | 165 | 48 | 6 | 52 | 6 | 65 | 10 | 0 | 0 | 21 | -1 | 7 | 4 |
| 2002 | 158 | 47 | 6 | 52 | 6 | 59 | 9 | 0 | 0 | 20 | -1 | 4 | 3 |
| 2003 | 151 | 45 | 5 | 52 | 6 | 54 | 9 | 0 | 0 | 19 | -1 | 6 | 5 |
| 2004 | 144 | 44 | 5 | 53 | 6 | 47 | 8 | 0 | 0 | 18 | -1 | 0 | 0 |
| 2005 | 137 | 43 | 5 | 53 | 6 | 42 | 7 | 0 | 0 | 17 | -1 | 7 | 5 |
| 2006 | 129 | 41 | 5 | 52 | 6 | 36 | 6 | 0 | 0 | 16 | -1 | 0 | 0 |
| 2007 | 123 | 41 | 5 | 51 | 6 | 31 | 5 | 0 | 0 | 15 | -1 | 0 | 0 |
| 2008 | 117 | 40 | 5 | 52 | 6 | 25 | 4 | 0 | 0 | 15 | 0 | 0 | 0 |
| 2009 | 110 | 38 | 5 | 51 | 6 | 21 | 4 | 0 | 0 | 13 | 2 | 4 | 1 |
| 2010 | 103 | 36 | 4 | 50 | 6 | 17 | 3 | 0 | 0 | 13 | 0 | 3 | 3 |

## Table 1.1-20 Procurement Plan of 14 $m^3$ Arm-Roll Trucks

| Year | Total Amount of Waste to be Hauled by 14m3 truck | Surabaya Center | | Surabaya North | | Surabaya East | | Surabaya South | | No. of 14 m3 Trucks Required in the Next year | No. of 14m3 Trucks to be Procured | Abandonment of New Trucks | Total No. of 14 m3 Trucks to be Procured |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Amount of Waste | No. of 14 m3 Truck Needed | Amount of Waste | No. of 14 m3 Truck Needed | Amount of Waste | No. of 14 m3 Truck Needed | Amount of Waste | No. of 14 m3 Truck Needed | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10)=(3)+(5)+(7)+(9) | (11) | (12) | (13)=(11)+(12) |
| 1992 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| 1993 | 303 | 78 | 3 | 65 | 4 | 116 | 3 | 44 | 2 | 18 | 18 | 0 | 18 |
| 1994 | 480 | 124 | 4 | 110 | 6 | 191 | 5 | 55 | 3 | 17 | 0 | 0 | 0 |
| 1995 | 480 | 124 | 4 | 114 | 6 | 202 | 5 | 40 | 2 | 24 | 6 | 0 | 6 |
| 1996 | 488 | 127 | 9 | 121 | 8 | 214 | 5 | 26 | 2 | 24 | 0 | 0 | 0 |
| 1997 | 494 | 131 | 9 | 127 | 9 | 229 | 5 | 7 | 1 | 39 | 15 | 0 | 15 |
| 1998 | 501 | 133 | 9 | 134 | 9 | 234 | 21 | 0 | 0 | 39 | 0 | 0 | 0 |
| 1999 | 508 | 137 | 9 | 143 | 10 | 228 | 20 | 0 | 0 | 39 | 0 | 0 | 0 |
| 2000 | 515 | 143 | 10 | 153 | 10 | 219 | 19 | 0 | 0 | 39 | 0 | 0 | 0 |
| 2001 | 521 | 149 | 10 | 163 | 11 | 209 | 18 | 0 | 0 | 39 | 0 | 18 | 18 |
| 2002 | 528 | 155 | 10 | 174 | 11 | 199 | 18 | 0 | 0 | 40 | 1 | 0 | 1 |
| 2003 | 535 | 160 | 11 | 186 | 12 | 189 | 17 | 0 | 0 | 40 | 0 | 6 | 6 |
| 2004 | 542 | 165 | 11 | 198 | 13 | 179 | 16 | 0 | 0 | 40 | 0 | 0 | 0 |
| 2005 | 549 | 173 | 11 | 210 | 14 | 166 | 15 | 0 | 0 | 41 | 1 | 15 | 16 |
| 2006 | 557 | 179 | 12 | 225 | 15 | 153 | 14 | 0 | 0 | 40 | 0 | 0 | 0 |
| 2007 | 563 | 185 | 12 | 237 | 15 | 141 | 13 | 0 | 0 | 41 | 0 | 0 | 0 |
| 2008 | 569 | 192 | 13 | 253 | 17 | 124 | 11 | 0 | 0 | 41 | 0 | 0 | 0 |
| 2009 | 576 | 197 | 13 | 269 | 18 | 110 | 10 | 0 | 0 | 41 | 0 | 18 | 18 |
| 2010 | 583 | 204 | 13 | 285 | 19 | 94 | 9 | 0 | 0 | 42 | 1 | 1 | 2 |

## Table 1.1-21 Procurement Plan of Open Dump Trucks

| Year | Total Amount of Waste to be Hauled by Open Dump Truck | Surabaya Center | | Surabaya North | | Surabaya East | | Surabaya South | | Surabaya West | | No. of Open Dump Trucks Required for the Next Year | No. of Open Dump Trucks to be Procured | Abandonment of New Trucks | Total No. of Open Dump Trucks to be Procured |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Amount of Waste | No. of Open Dump Truck Needed | Amount of Waste | No. of Open Dump Truck Needed | Amount of Waste | No. of Open Dump Truck Needed | Amount of Waste | No. of Open Dump Truck Needed | Amount of Waste | No. of Open Dump Truck Needed | | | | |
| | (1) | (2) | (3) | (4) | (3) | (6) | (7) | (8) | (9) | (10) | (11) | (12)=(3)+(5)+(7)+(9)+(11) | (13) | (14) | (15) |
| 1992 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 3 |
| 1994 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 1 |
| 1995 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 4 | 0 | 0 | 0 |
| 1996 | 4 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 1 | 0 | 0 | 5 | 1 | 0 | 1 |
| 1997 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 1998 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 1999 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2000 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2001 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2002 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2003 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2004 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 3 | 3 |
| 2005 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 1 | 1 |
| 2006 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2007 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 1 | 1 |
| 2008 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2009 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |
| 2010 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 0 | 0 | 0 |

## Chapter 2 Things to be Confirmed for Estimation of Manpower Requirement and Working Shifts

### 2.1 Number of Drivers and Assistants Required

For an arm-roll truck of 8 $m^3$ and 14 $m^3$, 1 driver and 1 assitant are required. For an open dump truck, 1 driver is enough (assistants for waste collection will be provided by each Rayon depending on the need).

In 1998, all 8 $m^3$ arm-roll trucks and 54% of 14 $m^3$ arm-roll trucks are assumed to conduct one-man operation as to save manpower.

The annual manpower requirement for 8 $m^3$ and 14 $m^3$ arm-roll trucks and the open dump trucks are shown in Table 1.2-1.

It is estimated that required number of manpower will decrease from 146 persons in 1992 to 92 persons in 1995. 54 persons will be made redundent. Some of them will retire, while the others may be transfered to other sections in the Cleansing Department.

### 2.2 Working shift

The vehicle procurement plan is prepared based upon 1 shift working system due to the following reasons :

1. Although the cost of haulage with two working shift is lower than that with one shift, the difference is not so large (about 10%).

2. Night shift work may cause th efollowing problems :
   a. Safety problem
   b. Operational problem
   c. Noise and other environmental problems to the residents

3. Responsibility problem between two drivers (one day time, the other in night time) may occur if some damages to the truck occured.

**Table 1.2-1 Future Manpower Requirement for all Trucks**

| Year | Current Trucks | | | | | | | | | | | | | | New Trucks to be Procured | | | | | | | | Spare Person | | Total | | | Surplus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 m3 Container | | 10 m3 Container | | 12 m3 Container | | Open Dump Truck | | 6 m3 REL Compactor | | 10 m3 REL Compactor | | Sub-Total | | 8 m3 Container | | 14 m3 Container | | Open Dump Truck | | Sub-total | | | | | | | |
| | D | A | D | A | D | A | D | A | D | A | D | A | D | A | D | A | D | A | D | A | D | A | D | A | A | D | Total | |
| 1992 | 26 | 26 | 13 | 13 | 4 | 4 | 6 | 0 | 5 | 5 | 10 | 20 | 64 | 68 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 9 | 69 | 77 | 146 | 0 |
| 1993 | 12 | 12 | 5 | 5 | 4 | 4 | 2 | 0 | 5 | 5 | 10 | 20 | 38 | 46 | 6 | 6 | 12 | 12 | 3 | 0 | 21 | 18 | 4 | 5 | 63 | 69 | 132 | -14 |
| 1994 | 12 | 12 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 | 5 | 10 | 21 | 25 | 7 | 7 | 18 | 18 | 4 | 0 | 29 | 25 | 8 | 8 | 58 | 58 | 116 | -16 |
| 1995 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 11 | 11 | 17 | 17 | 5 | 0 | 32 | 28 | 14 | 13 | 49 | 43 | 92 | -24 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 17 | 24 | 24 | 5 | 0 | 46 | 41 | 3 | 2 | 49 | 43 | 92 | 0 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 17 | 24 | 24 | 5 | 0 | 46 | 41 | 3 | 2 | 49 | 43 | 92 | 0 |
| 1998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 39 | 18 | 5 | 0 | 70 | 18 | 4 | 0 | 74 | 18 | 92 | 0 |

Note : D = Driver
A = Assistant

# Chapter 3 Things to be Confirmed for Estimation of Costs of Procurement, Operation and Maintenance

## 3.1 Procurement Cost

### 1) Depreciation

The purchase costs of a 14 $m^3$ arm-roll truck, a 8 $m^3$ arm-roll truck and a container for each type of the truck and an open dump truck are estimated in Table 1.3-1.

Table 1.3-2 shows the depreciation of each truck type, assuming the durability of arm-roll trucks are 7 yearss and open dump trucks are 10 years.

Table 1.3-1 Unit Price of Chassie, Equipment, Body, and Container

| | Type of Chassie | Truck Price | | | | Cost of Containers Needed per Truck | | | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | | Chassie | Equipment | Body | Total | Unit Price | Units | Cost for Container Provision | |
| | | (1) | (2) | (3) | (4)=(1)+(2)+(3) | (5) | (6) | (7) | (8)=(4)+(7) |
| 8 $m^3$ Container Truck | 7 GVW | Rp. 35,200,000 | Rp. 15,400,000 | 0 | Rp. 50,600,000 | Rp. 6,000,000 | 6 | Rp. 36,000,000 | Rp. 86,600,000 |
| 14 $m^3$ Container Truck | 14 GVW | Rp. 59,300,000 | Rp. 26,000,000 | 0 | Rp. 85,300,000 | Rp.8,000,000 | 6 | Rp. 48,000,000 | Rp. 133,300,000 |
| Open Dump Truck | 7 GVW | Rp. 35,200,000 | Rp. 13,200,000 | Rp. 2,300,000 | Rp. 50,700,000 | - | - | - | Rp. 50,700,000 |

Note : 1. The above prices inlude PPN the government tax (10%).

2. The above prices are those offered by the company o fthe second highest prices. (The price quatations were offered by 6 local agents for truck chassies in Surabaya, and by 5 manufactures of truck body, equipment and containers (2 manufactures are in Jakarta)).

Table 1.3-2 Depreciation of Trucks by Type

| | 8 $m^3$ Arm-Roll Truck | 14 $m^3$ Arm-Roll Truck | Open Dump Truck |
|---|---|---|---|
| Purchase Cost | Rp. 50,600,000 | Rp. 85,300,000 | Rp. 50,700,000 |
| Durability | 7 years | 7 years | 10 years |
| Depreciation/year | Rp. 7,229,000 | Rp. 12,186,000 | Rp. 5,070,000 |

Table 1.3-3 Capital Investment Program for 8 m³ Container Trucks System

| Year | Total Amount of Waste to be Hauled | Total No. of 8 m³ Trucks to be Procured (Million Rupiah) | Cost of Procurement of 8 m³ Trucks | Number of 8 m³ Container to be procured | | | | | | Cost of Procurement of Containers (Million Rupiah) | Total Cost (Million Rupiah) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Required Number of Containers | No of Spare Container | Total No.of Containers Required | Procured Number of Containers | Abandonment of New Containers | Total No. of Containers | | |
| | (1) | (2) | (3) | (4) | (5) | (6)=(4)+(5) | (7) | (8) | (9)=(7)+(8) | (10)=(9) x 6.0 | (11)=(3)+(10) |
| 1993 | 72 | 7 | 354.2 | 31 | 2 | 33 | 39 | 0 | 39 | 234 | 588.2 |
| 1994 | 86 | 4 | 202.4 | 37 | 2 | 39 | 44 | 0 | 44 | 264 | 466.4 |
| 1995 | 186 | 6 | 303.6 | 79 | 4 | 83 | 6 | 0 | 6 | 36 | 339.6 |
| 1996 | 199 | 0 | 0 | 84 | 5 | 89 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 192 | 7 | 354.2 | 81 | 5 | 86 | 0 | 0 | 0 | 0 | 354.2 |
| 1998 | 185 | 0 | 0 | 78 | 4 | 82 | 0 | 0 | 0 | 0 | 0 |
| 1999 | 178 | 0 | 0 | 75 | 4 | 79 | 0 | 39 | 26 | 156 | 156.0 |
| 2000 | 171 | 0 | 0 | 72 | 4 | 76 | 0 | 44 | 42 | 252 | 252.0 |
| 2001 | 165 | 4 | 202.4 | 70 | 4 | 74 | 0 | 6 | 3 | 18 | 220.4 |
| 2002 | 158 | 3 | 151.8 | 67 | 4 | 71 | 0 | 0 | 0 | 0 | 151.8 |
| 2003 | 151 | 5 | 253.0 | 64 | 4 | 68 | 0 | 0 | 0 | 0 | 253.0 |
| 2004 | 144 | 0 | 0 | 61 | 4 | 65 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 137 | 5 | 253.0 | 58 | 3 | 61 | 0 | 26 | 13 | 78 | 331.0 |
| 2006 | 129 | 0 | 0 | 55 | 3 | 58 | 0 | 42 | 39 | 234 | 234.0 |
| 2007 | 123 | 0 | 0 | 52 | 3 | 55 | 0 | 3 | 1 | 6 | 6.0 |
| 2008 | 117 | 0 | 0 | 50 | 3 | 53 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 110 | 1 | 50.6 | 47 | 3 | 50 | 0 | 0 | 0 | 0 | 50.6 |
| 2010 | 103 | 3 | 51.8 | 44 | 3 | 47 | 0 | 0 | 0 | 0 | 151.8 |

**Table 1.3-4 Capital Investment Program for 14 m³ Container Trucks System**

(Unit : Rp. Million)

| Year | Total Amount of Waste to be Hauled | Total No. of 14 m³ Trucks to be Procured | Cost of Procurement of 14 m³ Trucks (Million Rupiah) | Number of 14 m³ Container to be procured | | | | | | Cost of Procurement of Containers (Million Rupiah) | Total Cost (Million Rupiah) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Required Number of Containers | No of Spare Container | Total No.of Containers Required | Procured Number of Containers | Abandonment of New Containers | Total No. of Containers | | |
| | (1) | (2) | (3) | (4) | (5) | (6)=(4)+(5) | (7) | (8) | (9)=(7)+(8) | (10)=(9) x 8.0 | (11)=(3)+(10) |
| 1993 | 303 | 18 | 1,535.4 | 73 | 4 | 77 | 122 | 0 | 122 | 976 | 2,511.4 |
| 1994 | 480 | 0 | 0 | 116 | 6 | 122 | 0 | 0 | 0 | 0 | 0 |
| 1995 | 480 | 6 | 511.8 | 116 | 6 | 122 | 2 | 0 | 2 | 16 | 527.8 |
| 1996 | 488 | 0 | 0 | 118 | 6 | 124 | 1 | 0 | 1 | 8 | 8.0 |
| 1997 | 494 | 15 | 1,279.5 | 119 | 7 | 125 | 3 | 0 | 3 | 24 | 1,303.5 |
| 1998 | 501 | 0 | 0 | 121 | 7 | 128 | 2 | 0 | 2 | 16 | 16.0 |
| 1999 | 508 | 0 | 0 | 123 | 7 | 130 | 1 | 122 | 123 | 984 | 984.0 |
| 2000 | 515 | 0 | 0 | 124 | 7 | 131 | 2 | 0 | 0 | 0 | 0 |
| 2001 | 521 | 18 | 1,535.4 | 126 | 7 | 133 | 1 | 2 | 3 | 24 | 1,559.4 |
| 2002 | 528 | 1 | 85.3 | 127 | 7 | 134 | 2 | 1 | 3 | 24 | 109.3 |
| 2003 | 535 | 6 | 511.8 | 129 | 7 | 136 | 2 | 3 | 5 | 40 | 551.8 |
| 2004 | 542 | 0 | 0 | 131 | 7 | 138 | 2 | 2 | 4 | 32 | 32.0 |
| 2005 | 549 | 16 | 1,364.8 | 133 | 7 | 140 | 1 | 123 | 124 | 992 | 2,356.8 |
| 2006 | 557 | 0 | 0 | 134 | 7 | 141 | 2 | 0 | 2 | 16 | 16.0 |
| 2007 | 563 | 0 | 0 | 136 | 7 | 143 | 1 | 3 | 4 | 32 | 32.0 |
| 2008 | 569 | 0 | 0 | 137 | 7 | 144 | 2 | 3 | 5 | 40 | 40.0 |
| 2009 | 576 | 18 | 1,535.4 | 139 | 7 | 146 | 3 | 5 | 8 | 64 | 1,599.4 |
| 2010 | 583 | 2 | 170.6 | 141 | 8 | 147 | 2 | 4 | 6 | 48 | 218.6 |

**Table 1.3-5 Capital Investment Program for Open Dump Trucks System**

| Year | Total Amount of Waste to be Hauled (ton/day) | Total No. of Open Dump Trucks to be Procured | Cost of Procurement of Open Dump Truck (Million Rupiah) |
|---|---|---|---|
| | (1) | (2) | (3)=(2) x 50.7 |
| 1993 | 0 | 0 | 0 |
| 1994 | 3 | 3 | 152.1 |
| 1995 | 4 | 1 | 50.7 |
| 1996 | 4 | 0 | 0 |
| 1997 | 5 | 1 | 50.7 |
| 1998 | 5 | 0 | 0 |
| 1999 | 5 | 0 | 0 |
| 2000 | 5 | 0 | 0 |
| 2001 | 5 | 0 | 0 |
| 2002 | 5 | 0 | 0 |
| 2003 | 5 | 0 | 0 |
| 2004 | 5 | 3 | 152.1 |
| 2005 | 5 | 1 | 50.7 |
| 2006 | 5 | 0 | 0 |
| 2007 | 5 | 1 | 50.7 |
| 2008 | 5 | 0 | 0 |
| 2009 | 5 | 0 | 0 |
| 2010 | 5 | 0 | 0 |

## 2) Loan Interest

Loan interest for each type of truck is estimated at as follows :

| | | |
|---|---|---|
| (1) | 8 $m^3$ container truck | Rp. 5,313,000 |
| (2) | 14 $m^3$ container truck | Rp. 8,957,000 |
| (3) | Open dump truck | Rp. 3,900,000 |

Note : Annual average interest after discount is estimated at by the following formula.

For 8 $m^3$ and 14 $m^3$ container truck = (purchase cost ) x (10.5% interest) x 20 years ÷ 2 ÷ 10 years.

For open dump truck = (purchase cost) x (10.5% interest) x 20 years ÷ 2 ÷ 13 years

## 3.2 Operation and Maintenance Cost

Operation and Maintenance cost is estimated at as follows :

| | 8 $m^3$ Container Truck | 14 $m^3$ Container Truck | Open Dump Truck |
|---|---|---|---|
| (1) Fuel | Rp. 5,900,000 | Rp. 6,500,000 | Rp. 2,000,000 |
| (2) Salary for drivers and assistants | Rp. 4,260,000 | Rp. 4,260,000 | Rp. 2,760,000 |
| (3) Tax and Insurance | Rp. 2,030,000 | Rp. 2,030,000 | Rp. 2,030,000 |
| (4) Maintenance (12.5% of truck purchase cost) | Rp. 6,325,000 | Rp. 10,663,000 | Rp. 6,338,000 |
| (5) Total operation and Maintenance cost | Rp. 18,515,000 | Rp. 23,453,000 | Rp. 13,128,000 |

## 3.3 Cost of Containers

Cost of Containers are estimated at as follows :

| | 8 $m^3$ Container Truck | 14 $m^3$ Container Truck |
|---|---|---|
| (1) Depreciation of 6 Containers per truck | Rp. 7,200,000 | Rp. 9,600,000 |
| (2) Maintenance of Containers per truck | Rp. 900,000 | Rp. 1,200,000 |
| (3) Total | Rp. 8,100,000 | Rp. 10,800,000 |

Note : (1) Depreciation period of container is assumed to be 5 years.

(2) Maintenance cost of a container is assumed to be 2.5% of containers' purchase cost.

### 3.4 Cost per truck per year

Cost per truck per year is estimated at Rp. 39,157,000/year for a 8 $m^3$ container truck, Rp. 55,396,000 for a 14 $m^3$ container truck, and Rp. 22,098,000 for an open dump truck as follows :

| | | 8 $m^3$ Container Truck | 14 $m^3$ Container Truck | Open Dump Truck |
|---|---|---|---|---|
| (1) | Depreciation | Rp. 7,229,000 | Rp. 12,186,000 | Rp. 5,070,000 |
| (2) | Loan interest | Rp. 5,313,000 | Rp. 8,957,000 | Rp. 3,900,000 |
| (3) | Operation and Maintenance | Rp. 18,515,000 | Rp. 23,453,000 | Rp. 13,128,000 |
| (4) | Cost of containers | Rp. 8,100,000 | Rp. 10,800,000 | - |
| (5) | Total cost | Rp. 39,157,000 | Rp. 55,396,000 | Rp. 22,098,000 |

### 3.5 Capital Investment Cost

It is estimated a sum of Rp. 6, 368,000 is required to the procurement of all the necessary trucks and containers during 6 years from 1993-1998. A cot summary is shown in the Table below. Yearly procurement costs are shown in Table 1.3-4 and 1.3-6.

**Table 1.3-3** ***Summary of Procurement Costs of Trucks and Containers***

(Unit : Million Rupiah)

| | Unit Cost | Quantity | Total Cost |
|---|---|---|---|
| | (1) | (2) | (1) x (2) = (3) |
| 1. 8 m3 Arm-Roll Trucks | Rp. 50.6 m | 24 | Rp. 1,214.4 m |
| 2. 14 m3 Arm-Roll Trucks | Rp. 85.3 m | 39 | Rp. 3,326.7 m |
| 3. Open Dump Trucks | Rp. 50.7 m | 5 | Rp. 253.5 m |
| 4. 8 m3 Containers | Rp. 6.0 m | 89 | Rp. 534.0 m |
| 5. 14 m3 Containers | Rp. 8.0 m | 130 | Rp. 1,040.0 m |
| 6. Total | - | - | Rp. 6,368.6 m |

## Chapter 4 Comparison of Haulage Costs With and Without New Final Disposal Site (LPA) in the East of Sarabaya

### 4.1 Definition of Two Cases

This chapter studies the following two cases:

Case A : 2 LPA are available: one in the west (Benowo) and the other in the east part of Surabaya.

Case B : Only one LPA is available in the west (Benowo)

### 4.2 Results of the Comparison

A summary of the comparison is shown in the table below :

**Table 1.4-1 Summary of the Comparison of the Two Cases**

| | Case A | Case B | Difference between the 2 Cases |
|---|---|---|---|
| 1. Average Trips to be made per truck per day | 7.7 trips/truck/d | 3.5 trips/truck/d | 4.2 trips/truck/d |
| 2. Estimated Average Unit Haulage Cost per Ton | Rp 10,000/ton | Rp 22,000/ton | Rp 12,000 |
| 3. Annual Average Haulage Cost throughout Years 1992 -2010 | Rp 5,355 million | Rp11,780 million | Rp 6,425 million |
| 4. Cost Index (Case A=100) | 100 | 220 | 120 |

Notes:

1. The average trips shown in the table are the grand average trips of container (arm-roll) trucks collecting from each parts of Surabaya (east, west, center, north and south). The average trips were obtained from the field survey conducted by JICA Study Team, of which results are shown in the following table :

| Sub-Districts | Average Daily Trips to be made under Case A | Average Daily Trips to be Made under Case B | Percentages of Waste Haulage Amount |
|---|---|---|---|
| 1. Center | 7.8 trips/truck/d | 3.8 trips/truck/d | 20.9 % |
| 2 North | 4.9 trips/truck/d | 3.8 trips/truck/d | 17.6 % |
| 3 East | 11.4 trips/truck/d | 2.8 trips/truck/d | 30.1 % |
| 4 south | 6.0 trips/truck/d | 3.5 trips/truck/d | 23.8 % |
| 5 West | 4.7 trips/truck/d | 4.7 trips/truck/d | 7.6 % |
| Weighted Average | 7.7 trips/truck/d | 3.5 trips/truck/d | (Total) 100 % |

2. It is assumed that the average unit haulage cost per ton (Item 2) is inversely proportional to the average number of trips (Item 1). This assumption is appropriate because the unit cost of haulage per ton per truck is inversely proportional to amount of waste hauled per truck, which in trun is proportional to number of trips made per truck.

3. The average unit hualage cost (Rp 10,000/ton) is estimated on the base of weighted average of 1) the existing KMS' grand average cost (Rp 12,000/ton) of haulage with arm-roll trucks and compactor trucks, 2) and the estimated corresponding average cost of the future contractors (Rp 8,000/ton) assuming further that ratio of waste haulage of KMS and constrctors is 50 to 50.

4. Annual average haulage costs (Item 4) are estimated by using future annual average waste amount to be hauled under KMS' responsibility during 1992 - 2010.(Average 1,467 ton/day x 365 days/year = 535,455 ton/year).

## 4.3 Conclusion

As can be seen from the table above, Case B with one LPA in Benowo is 2.2 times costly than the Case A. Annual average cost difference (possible KMS' saving by having LPA in the east part of Suraba) is estimated to be Rp 6,425 million/year. throughout the years 1992 -2010. Such difference is too large to be ignored.

Furtherfore, due to the future development in the east part of Surabaya, it is expected that the waste generation amount will increase faster in the east part of Surabaya than in the rest of Surabaya. Then, the real difference in the future will be greater than estimated Rp 6,425 million.

It is very strongly recommended that KMS should make all efforts to obtain a land in the east part of Surabaya, and construct a LPA before closing the existing LPA in Keputih, which will happen in 1997 at the latest.

# *PART 2*

# *CONSTRUCTION OF SANITARY LANDFILLI IN BENOWO*

# PART 2 CONSTRUCTION OF SANITARY LANDFILL IN BENOWO

## Chapter 1 Key Factors of Design

### 1.1 Site Conditions

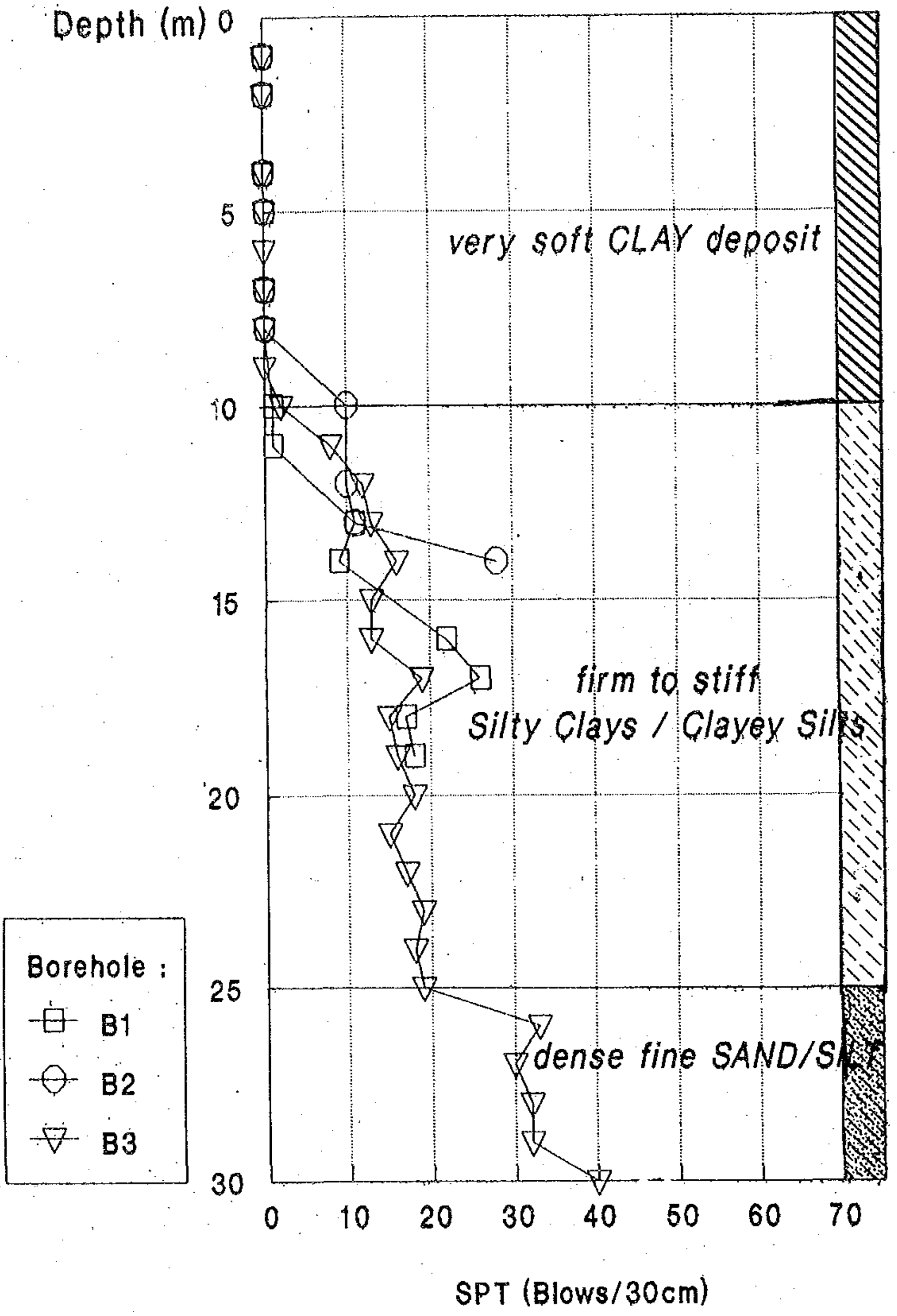
#### 1) Geology

Surface soil consists of soft silty clay which classified as alluvium deposit. The depth of this soft clay was confirmed by the boring test at around 10 m at the site, whereas it is about 20 m at the project site of Tandes Interchange of Surabaya-Gresik Toll Road. This soft clay disappears in opposite side of the River Lamong in Gresik which is located in the opposite direction of Tandes Interchange. Below this soft clay, there distribute stiff clay and silt layer with the thickness of about 15 m which has already been consolidated and dense fine sand/silt as shown in Fig. 2.1-1.

The clay is generally used for water proof linig material for the footpath and the partition of salt farms here. Then it is considered that the surface soil has enough impermeability under the small head not more than 1 meter. According to the result of laboratory test, the coefficient of permeability distributes in the range from 0.8 to 5 x $10^{-5}$ cm/s.

The surface soil causes many cracks when dried up, however, it is considered to beimpermeable if it is kept in wet condition.

The whole layer of alluvium deposit with a depth of about 10 m still has a possibility of consolidation. According to the result of laboratory test, the pre-compression stress is measured to be from 3 to 4 t/$m^2$.This means the subsoil stays in normal consolidation status.




| FIG. 2.1-1 | GEOLOGICAL PROFILE OF THE SITE |
|---|---|

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## 2) Existing Land Use

Most part of coastal plane is occupied by salt farm around the planning landfill site, and remaining part such as canal, dredged pond are used for fishery or fish breeding. Bigger sized canal or tributary of the River Lamong are used for water transportation of salt or salt production materials.

Small villages are located in the marginal area of coastal plane or along the river in isolated position each other. The nearest residences with about 20 houses are located on AMD road, 300 m away from the proposed connection point between AMD road and the access road of the landfill site. There are four villages that are located on the downstream of tribultaries that flow through the planning landfill site. The nearest village from the whole candidate landfill site for future expansion is located about 1 km below along the stream. In these villages no piped waster is available, so people use river water for laundry and bathing. Drinking water is supplied by PDAM tank lorry and stored in a communal reservoir installed in each village.

Amid the salt farm, there is no permanent residence, however, some temporary huts for seasonal laborers of salt farm are scattered with a distribution one in several hectare. These huts are only used during the dry season when the salt production is executed, therefore there are no inhabitants during the rainy season in the planning landfill site.

Along the western boundary of the planning landfill site, there locate two lines of high tension electricity lines, one has the potential of 500 KV and the other has 150 KV. The high tension lines are owned by PLN (National Electricity Enterprise) and has a restriction on the land use of the neighboring area. If someone intends to build some structure with a height of 10 m beside the high tension line, he is obliged to keep the structure away from the center of the line by at least 50 m as shown in Fig. 2.1-2. Besides this restriction, any kind of road crossing the high tension line should be installed a special protection structure made of metal wire just beneath the line.

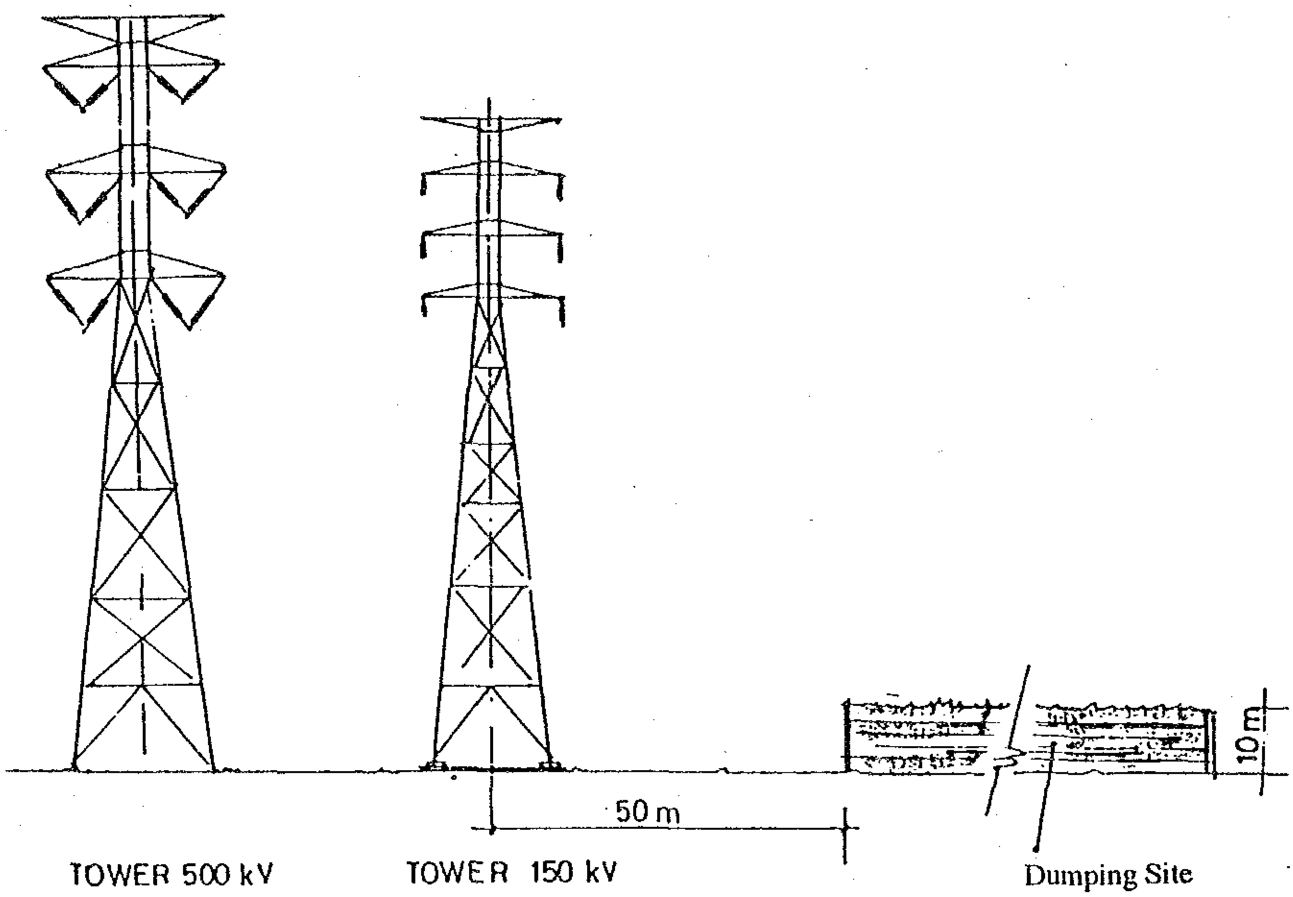


FIG. 2.1-2 RESTRICTION ON SPACE UTILIZATION BESIDE THE HIGH TENSION LINE IN BENOWO

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

## 1.2 Design Concept

### 1) Environmental Protection

To design a landfill site, the technical guideline issued by Directorate of Environmental Sanitation, CIPTA KARYA, is to be referred to. The guideline raises several negative impacts taht may be caused by landfull operation, and at the same time suggests mitigation measures against each impact. The general expression of the impacts and the countermeasures are summarized in Table 2.1-1

### 2) Future Land Use

The planning site is involved in a comprehensive development plan called "Rencana Detail Tata Ruang Kota Tambak Osowilangon". The planned land use around the planning landfill site is supposed to be green area. The site and the neighboring area for future expansion is bounded by two high tension electricity line in the west side and also bounded by planned toll road Surabaya Gresik in the north side. The south side is connected with planned residential area or golf course.

The future land use of the planning landfill site is not clearly decided yet. If the land use is decided as green area, it is possible to change the site with less care after completion of landfill operation.

If there is any other land use plan, the adaptability of ex-landfill site should be considered according to its purpose of land use. Table 2.1-2 shows an example of consideration for this choice. Table 2.1-3 also shows some example of conversion of ex-landfill site in Japan.

According to these experience, after 15 years since the end of landfill operation, it can be converted into various types of land use with some mitigation measures attached to the site and the building. If the type of land use has less requirements like park, green belt and golf course, it can be converted sooner than 15 years.

**Table 2.1-1 General Expression on the Risk and Countermeasure in Lanfill Design**

| Supposed Risk | Countermeasure |
|---|---|
| Surface Water Population | a. Limit run off from outside by diversionary ditch arround site.<br>b. Avoid contact berween run off and waste by intermediate soil cover with regular slope.<br>c. Reduce working face by controlling the range for daily dumping.<br>d. Protect spring or low-flow stream in the site by piping or ther mean which meets the maximum flow volume. |
| Groundwater Pollution<br>1. Leachate production<br><br><br>2. Leachate Percolation | a. Limit run off<br>b. Limit infiltration during operation<br>c. Limit infiltration by impermeable final cover<br>d. Limit working face<br>e. Apply bottom liner in case natural impermeability is insufficient<br>f. Collect and treat leachate water by means of landfill bottom gradient, drainage network and leachate treatment facility. |
| Air Pollution<br>1. Airborne litter<br><br><br>2. Airborne dust<br><br>3. Gas concentration | a. Keep the size of working face as small as possible<br>b. Use portable litter screen to prevent litter being blown off the site<br>c. Spread water on surface during long dry periods<br>d. Control gas movement in a landfill layer by installing vents made of more permeable material than the surrounding soil. |
| Morphologic Deformation<br>1. Landslide<br>2. Settlements<br>3. Erosion | a. Establish necessary preliminary works based on the geotechnical survey and assessment |
| Influence on Traffic<br>1. Damage of road<br><br><br><br>2. Littering | a. Provide solid access road enough to support vehicle weight and axle weight under a predicted haulage frequency<br>b. Cover waste with net during haulage |

Source : Technical Guideline for Soil Waste Management, CIPTA KARYA

**Table 2.1-2 Adaptability of Ex-landfill Site**

| Land use / Check point | Park / Green belt | Golf / Course | Road / Canal | Parking lot / Athletic field | Low building / Wood house | High / Building | Simple / Pipeworks |
|---|---|---|---|---|---|---|---|
| Subsidence | - | - | m | m | S | S | m |
| Bearing Capacity | - | - | m | m | S | m | m |
| Gas generation | m | m | m | m | S | S | m |
| Leachate | S | S | S | S | S | S | m |
| Erosion of metal and concrete | - | - | - | - | - | S | m |
| Forestration | S | S | - | m | S | S | - |
| Size of dumped waste | - | - | - | - | - | S | - |
| Permeability of dumped waste | m | m | m | m | S | m | - |
| Treatment of dumped waste | m | m | S | S | S | S | S |

Note : Rating basis is S : Strictly requested countermeasure
m : Medium
- : Negligible Influence

Source : "Investigation on Utilization of ex-final disposal site" Obayasigumi Co. Ltd. 1989

**Table 2.1-3 Example of Land Use Conversion from Ex-landfill Site**

| Facility | Owner | Location | Size (ha) | Completion of new facility | End of landfill operation | Elapsed time (Year) | Countermeasure adopted |
|---|---|---|---|---|---|---|---|
| 1. Sports Park | Koto Municipality | Tokyo | 4.5 | 1967 | Dec, 1962 | 5 | a. Pile foundation<br>b. Gas vent<br>c. Polyethylene covered underground cable |
| 2. Garage and workshop of Garbage Truck | Metropolitan Govt. Cleansing Dept. | Tokyo | 2.0 | Apr. 1959 | 1939 | 20 | a. Pile foundation<br>b. Gas vent gallary below ground floor |
| 3. Office and workshop of Garbage Truck | Autonmous Entprs. of Cleansing | Tokyo | 0.4 | 1974 | Dec. 1962 | 12 | a. Pile foundation<br>b. Flexible joint for pipe connection |
| 4. Warehouse | San'yo Commercial Co.Ltd. | Tokyo | 2.3 | May 1981 | Dec. 1962 | 19 | a. Upheaved floor<br>b. Gas vent gallery |
| 5. Vegetable Storage | Govenmental Fund for Stabilization of Vegetable Supply | Tokyo | 0.6 | Oct. 1978 | Dec. 1962 | 16 | a. Pile foundation<br>b. Upheaved floor |
| 6. Warehouse | Metropolitan Govt. Welfare Dept. | Tokyo | 0.1 | Mar. 1980 | Dec. 1962 | 18 | a. Pile foundation<br>b. Gas ven gallery |
| 7. Sports Park | Koto Municipality | Tokyo | 10.8 | May 1977 | Mar. 1967 | 10 | a. Gas vent for drain pit<br>b. Distributed gas vent<br>c. Ventilation window<br>d. Gravel basis below the ground floor |
| 8. Park | Metropolitan Govt. | Tokyo | 8.7 | Oct. 1978 | Mar. 1967 | 11 | a. Underdrain network<br>b. No closed room<br>c. Upheaved ground floor with gas vent gallery<br>d. Expose surface layer of garbage to promote aerobic decomposition<br>e. Replace surface layer for roadbed |
| 9. Gymnasium | Metropolitan Govt. | Tokyo | 2.7 | Sep. 1976 | Mar. 1967 | 9 | a. Pile foundation with floor beam<br>b. No closed room<br>c. Forced ventilation for indoor with automatic starter controled by gas detector<br>d. Distributed gas vent for outdoor<br>e. Flexible joint for underground pipe |

| Facility | Owner | Location | Size (ha) | Completion of new facility | End of landfill operation | Elapsed time (Year) | Countermeasure adopted |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 10. Viaduct | Metropolitan Exp. Way Authority | Tokyo | - | Dec. 1979 | Dec. 1962 | 17 | No particular measure |
| 11. Incineration Plant | Metropolitan Govt. Cleansing Dept. | Tokyo | 9.7 | Apr. 1973 | Mar. 1967 | 6 | a. Increment thickness against corrosion of steel pipe for foundation<br>b. Underground trough for pipe line<br>c. Use of volcanic pebble for back fill<br>d. Upheaved ground floor with ventilation gallery<br>e. Distributed gas vent outdoor<br>f. Replace the roadbed<br>g. Spray cement mortar on the slope during the basement excavation<br>h. Dry and dispose removed waste<br>i. Gas detection and use of gas mask during construction<br>j. Flexible joint of pipe line |
| 12. Botanical Park | - | Tokyo | 3.0 | Nov. 1988 | Mar. 1967 | 21 | a. Double slab floor<br>b. Forced ventilation controled by automatic gas detector |

## Chapter 2 Structure and Function of Facility

### 2.1 Access Road

The standard structure of access road is planned in the form as shown in Fig. 2.2-1. The bearing capacity is planned to be 10 ton of axle load according to the regulation of DPU (Ministry of Public Works) : Decree of Minister No. 378, 1987. The pavement specification will be decided in order to satisfy the above regulation and referring to the standard enacted by DPU : Decree of Minister No.378, 1987. The width of the access road is set at 30 m considering the mitigation of influence caused by garbage hauling vehicles to the neighboring area. The road side space of 8 m in width is expected to perform as a buffer zone.

On-site road A which is constructed along the boundary of the site in direct connection with the access road will be applied the similar standard to the access road.

As for the crossing point with the high tension line of PLN, it is necessary to adapt a special protection work in accordance with the regulation on the electricity supply. The requirement of protection work is specified by PLN as shown in Fig. 2.2-2. Concerning this matter, PLN actually expressed the protection work should be adapted to both AMD road and the access road of the planing landfill site, however, the former is not considered to be included in the project of landfill site construction. Therefore, the work for the access road alone is included in this plan.

This protection work for AMD road against the high tension line will be treated by Dinas PU, KMS (Public Works Department of Surabaya City) in the course of implementation of this project.

The similar item related to AMD road can be pointed out, namely the railway crossing improvement. It will be also necessary to be solved by Dinas PU by the time the construction of landfill site is started.

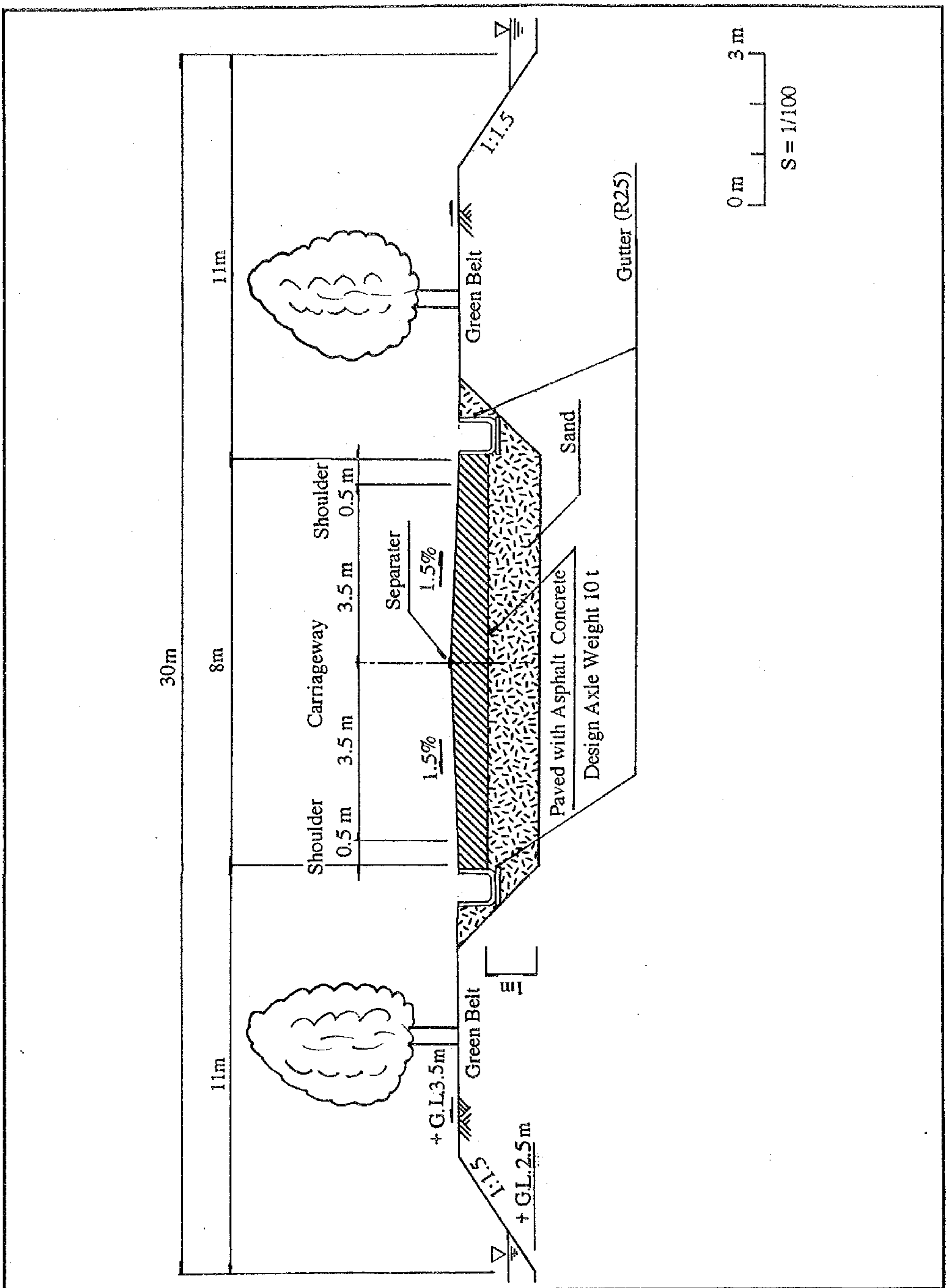


FIG. 2.2-1 **STANDARD STRUCTURE OF ACCESS ROAD**

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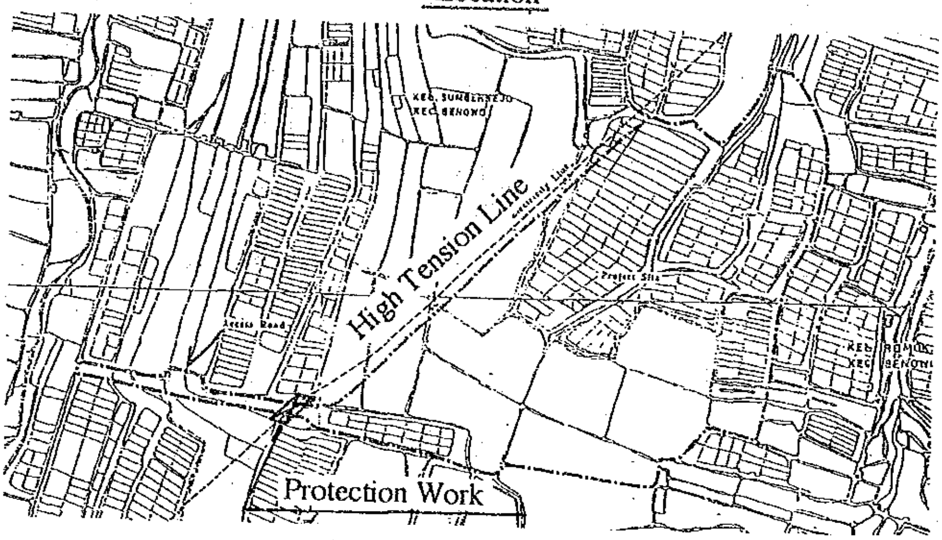
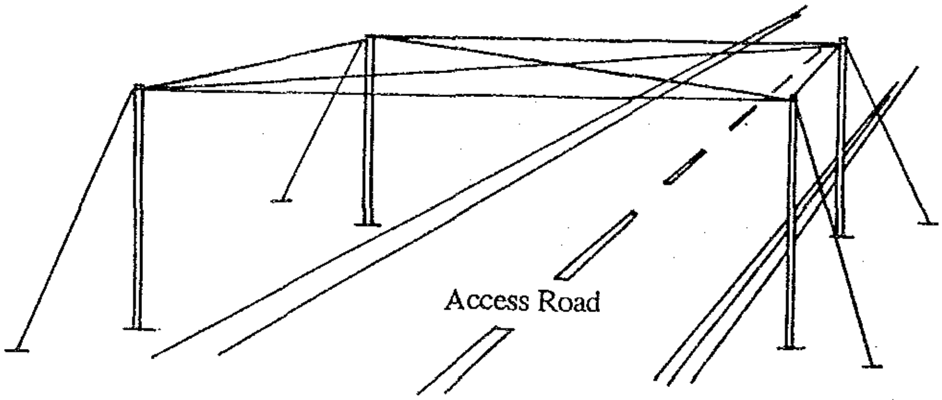
Location




Protection Work




Plan S=1/300

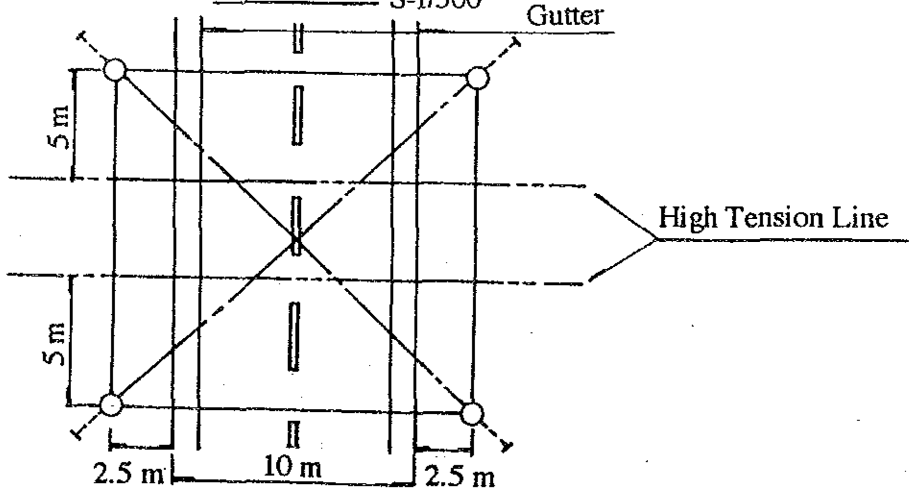



**FIG. 2.2-2** STRUCTURE OF PROTECTION WORK AGAINST HIGH TENSION LINE

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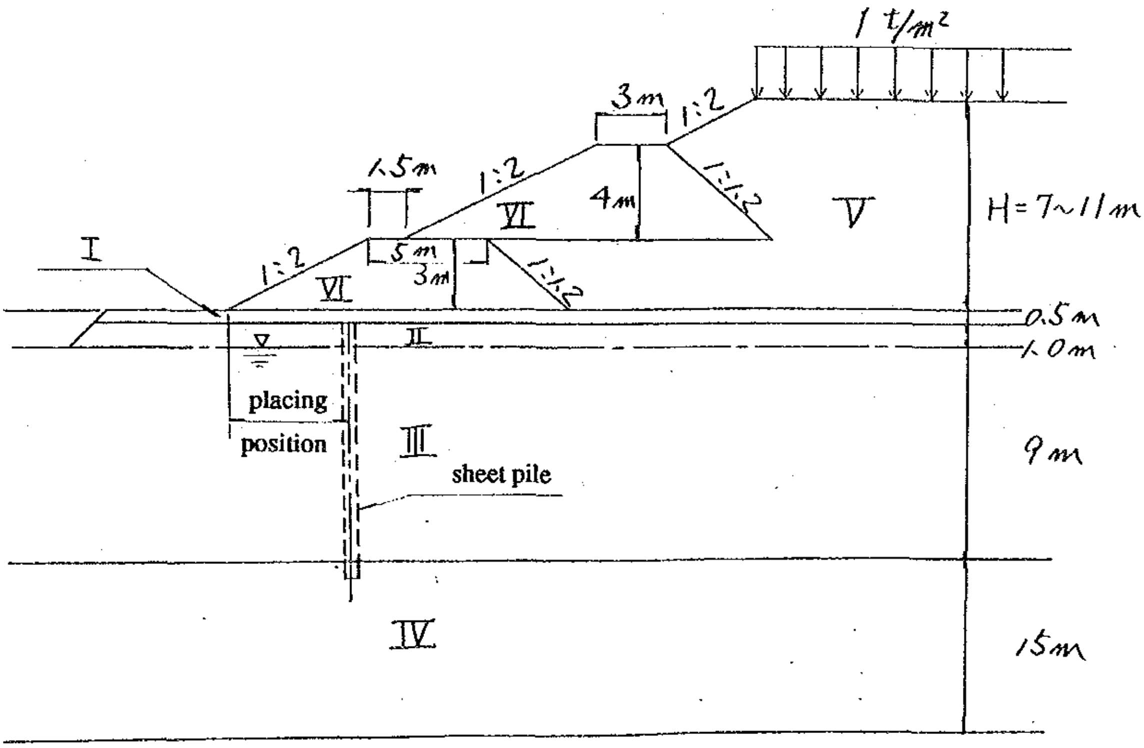
## 2.2 Stability of Dike and Base Ground

### 1) Objectives

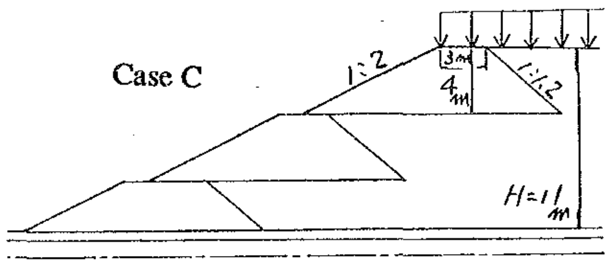
Under the conditions illustrated below, the height of landfill (H), type and length of sheet piles and their placing positions are to be determined.




Following 3 cases are considered for the height of landfill.

| | |
|---|---|
| Case A | H = 7m |
| Case B | H = 9m |
| Case C | H = 11m |

Case C



2) **Required Safety Factor**

$$Fs = \frac{\text{resistance moment}}{\text{sliding moment}} \geq 1.2$$

Note : Eathquake is not considered.

3) **Soil Characteristic Parameters**

| Layer | Depth (m) | Unit weight *5 r(t/m³) | Unit weight in the water r' (t/m³) | Internal friction angle ø | Cohesion C (t/m²) |
|---|---|---|---|---|---|
| I | 0.5 | 1.80 *1 | - | 0 | 4.0 *2 |
| II | 1.0 | 1.45 *3 | - | 0 | 0.3 *3 |
| III | 9.0 | 1.45 *3 | 0.45 | 0 | 0.3 *3 |
| IV | 15.0 | 1.74 *3 | 0.74 | 0 | 4.5 *4 |
| V (waste) | 7 - 11 | 1.00 *7 | - | 10 *6 | 1.5 *6 |
| VI | dike | 1.80 *1 | - | 0 | 4.0 *2 |

*1 Refer to cohesive soil of banking in Table 2.1-1.

*2 Calculated by assuming : N value of banking = 6 - 7, C = (0.6 ~ 0.65) Nt/m²

*3 Refer to the soil survey report

*4 Estimated from the N value in the soil survey report

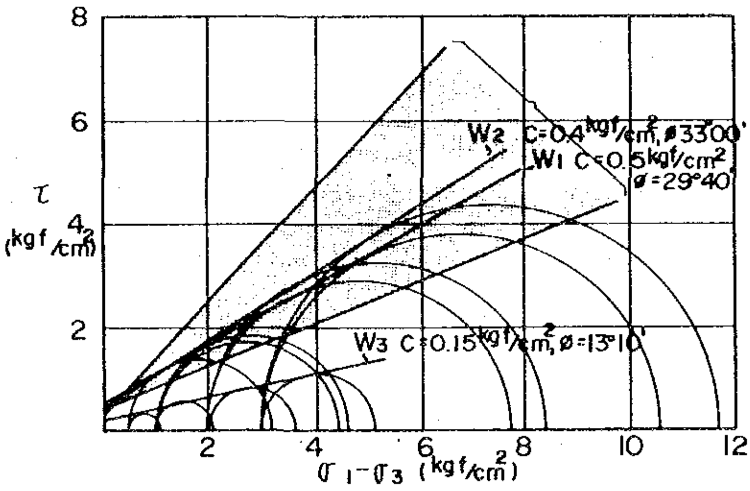
*5 r' = r -1

*6 Refer to Fig. 2.1-1

*7 Assumed

**Unit Weight of Soil**

| | Type | State | Unit weight above water table (t/m$^3$) |
|---|---|---|---|
| Banking | Sand mixed with gravel | Compacted | 2.0 |
| | Sand | Compacted — Good grading | 2.0 |
| | | Compacted — Poor grading | 1.9 |
| | Sandy soil | Compacted | 1.9 |
| | Cohesive soil | Compacted | 1.8 |
| Natural Soil Layer | Gravel | Firm or good grading | 2.0 |
| | | Not firm or poor grading | 1.8 |
| | Sand mixed with gravel | Firm | 2.1 |
| | | Not firm | 1.9 |
| | Sand | Firm or good grading | 2.0 |
| | | Not firm or poor grading | 1.8 |
| | Sandy soil | Firm | 1.9 |
| | | Not firm | 1.7 |
| | Cohesive soil | Hard : Deformed by strong push of finger, N = 8 - 15 | 1.8 |
| | | Slightly soft : Finger interpenetrates by medium force, N = 4 - 5 | 1.7 |
| | | Soft : Finger easily interpenetrates, N = 2 - 4 | 1.6 |
| | Clay and silt | Hard | 1.7 |
| | | Slightly soft | 1.6 |
| | | Soft | 1.4 |




W3 : Mainly of vinyl and domestic wastes
C = 0.15 kgf/cm$^2$
= 1.5 tf/m$^2$
ø = 13°10' (10° adopted)

**Result of Triaxial Compression Test**

Source : Miura, et al., "Mechanical Characteristics of Solid Waste Landfill", Lecture Book at the 5th Meeting of Japan Urban Sanitation Conference, Feb. 1984

## 4) Allowable Shearing Stress for Sheet Pile

$$\tau = S\ (kgf/cm^2) \times \frac{\text{Cross sectional area } (cm^2)}{\text{pile width } (m/m)} \times \frac{1}{1000} + 1m^2 \quad (tf/m^2)$$

| Type | With (m) | Cross Sectional area ($cm^2$) | S Allowable shearing stress for steel (kgf/cm2) | Allowable shearing stress for sheet pile (tf/m2) |
|---|---|---|---|---|
| I | 0.4 | 45.21 | 800 | 90.42 |
| II | 0.4 | 61.18 | 800 | 122.36 |
| III | 0.4 | 76.42 | 800 | 152.84 |
| IV | 0.4 | 96.99 | 800 | 193.98 |
| V | 0.5 | 133.8 | 800 | 214.08 |

## 5) Distributed Load (L)

L = 1 $t/m^2$ (assumed)

## 6) Computation Method

Total stress analysis method is used because values of the UU test are used for the soil characteristic parameters.

## 7) Result of Soil Stability Computation

| CASE | Configulation | Type of Sheet pile | Length | Placing position (from bottom of slope) | Safety factor Fs |
|---|---|---|---|---|---|
| CASE-A | 2-stage dike | II type | 12.5m | 3.0m | 1.285 |
| CASE-B | 2-stage dike plus 2m filling | II type | 14.5m | 3.0m | 1.296 |
| CASE-C | *3-stage dike | II type | 12.0m | 14.6m | 1.209 |
| | | IIItype | 12.0m | 0.0m | |

* For 3-stage dike, two rows of piles are required.

## 8) Filling Height and Filling Cost

(8) Filling Height and Filling Cost

| CASE | Configulation | Filling area ($m^2$) | Filling height (m) | Sheet pile | | | | | | Total Construction Cost (10^6Rp) | Unit landfill cost ($Rp/m^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Filling Volume ($m^3$) | Lateral length (m) | Pile length (m) | Total pile length (m) | Pile weight (t/m) | Pile placing cost (10^6Rp) | | |
| CASE-A | 2-stage dike | 322,000 | 7 | 2,250,000 | 2,750 | 12.5 | 85,938 | 0.048 | 7,665 | 22,057 | 9,803 |
| CASE-B | 2-stage dike plus 2m filling | 322,000 | 9 | 2,900,000 | 2,750 | 14.5 | 99,688 | 0.048 | 8,892 | 23,284 | 8,029 |
| CASE-C | *3-stage dike | 322,000 | 11 | 3,540,000 | 2,750 | 27.0 | 185,625 | 0.055 | 18,701 | 37,630 | 10,630 |

* In Case-C, since two rows of piles with type II and type III are required, the pile weight (t/m) was Calculated as follows:

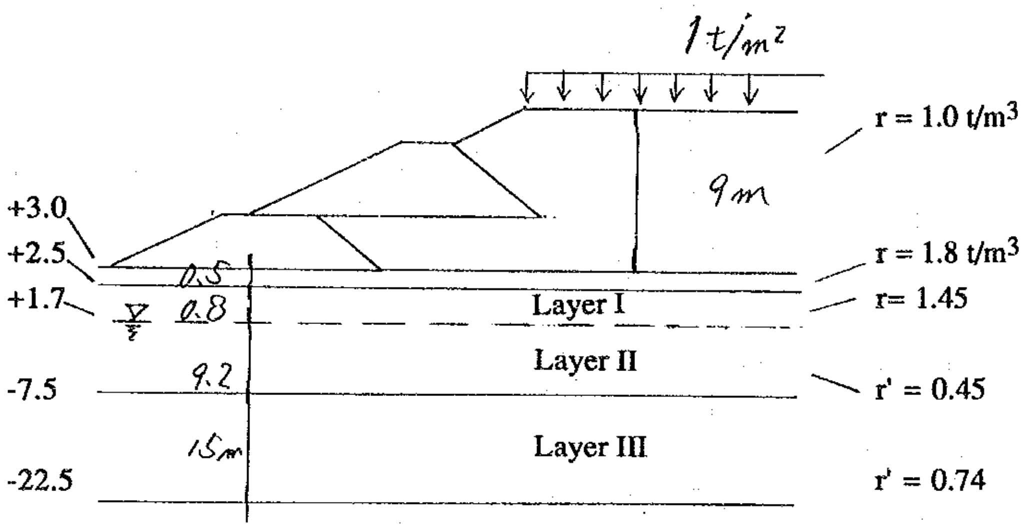
Pile weight (t/m) = (15.0m x 0.06 + 12m x 0.048)/(15m + 12m)

From the above table, Case-C is selected because of the lowest unit landfill cost.

## 2.3 Consolidation Settling of the Base Ground

Amount of consolidation settling of the base ground will be calculated from the soil survey data such as the e-log P curve in the soil survey report.

### 1) Basic Conditions




### 2) Computation Formula

$$S = \frac{eo - e1}{1 + eo} H$$

S : Settling amount (m)
eo : Initial void ratio when the overburden presure is ro
e1 : Ultimate void ratio when the internal stress of the gorund = po + Δp
po : Overburden pressure, at Z = 0.5H, before loading (t/m²)
Δp : Stress increase within the ground, at Z = 0.5H, due to loading (t/m²)
H : Thickness of the soft soil layer (m)

### 3) Compulation of Settling Amount

$$\boxed{S = \frac{eo - e1}{1 + eo} H}$$

| Layer | r (t/m³) | H (m) | Z*1 (m) | rH (t/m²) | rZ (t/m²) | po*2 (t/m²) | I *3 | Δp*4 (t/m²) | po+Δp (t/m²) | eo *5 | e1 *5 | S (m) | ΣS (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 1.45 | 0.8 | 0.4 | 1.16 | 0.58 | 0.58 | 1.00 | 10.9 | 11.48 | 3.35 | 2.42 | 0.17 | 0.17 |
| II | 0.45 | 9.2 | 4.6 | 4.14 | 2.07 | 3.23 | 1.00 | 10.9 | 14.13 | 3.19 | 2.26 | 2.04 | 2.21 |
| III | 0.74 | 15 | 7.5 | 11.1 | 5.55 | 10.85 | 1.00 | 10.9 | 21.75 | 0.79 | 0.74 | 0.42 | 2.63 |

*1 : Z = H/2

*2 : Layer I : po = (rZ)I

Layer II : po = (rH)I + (rZ)II

Layer III : p3 = (rH)I + (rH)II + (rZ)III

*3 : Influence factor on vertical stress by filling load (from the Osterbery diagram)

Layer I : a/Z = 17.5/1 = 17.5, b/Z = 100/1 = 100 } I = 0.50 x 2 = 1.00

Layer II : a/Z = 17.5/9 = 1.9, b/Z = 100/9 = 11.1 } I = 0.50 x 2 = 1.00

Layer III : a/Z = 17.5/15 = 1.1, b/Z = 100/15 = 6.7 } I = 0.50 x 2 = 1.00

*4 : Δp = Ip = I x rH = 1.0 x 1.0 x 9 + 0.5 x 1.8 + 1 = 10.9

*5 : Computed from the e-log p curves in the soil survey report.
B3 : 5.50 - 6.0 m, 11.50 m - 12.0 m

## 4) Countermeasure

Countermeasures against consolidation settling will be those that mitigate influences on the surroundings rather than complete prevention of the settling because of the following reasons:

- The complete prevention requires a huge cost
- Settling brings about increase of filling capacity.

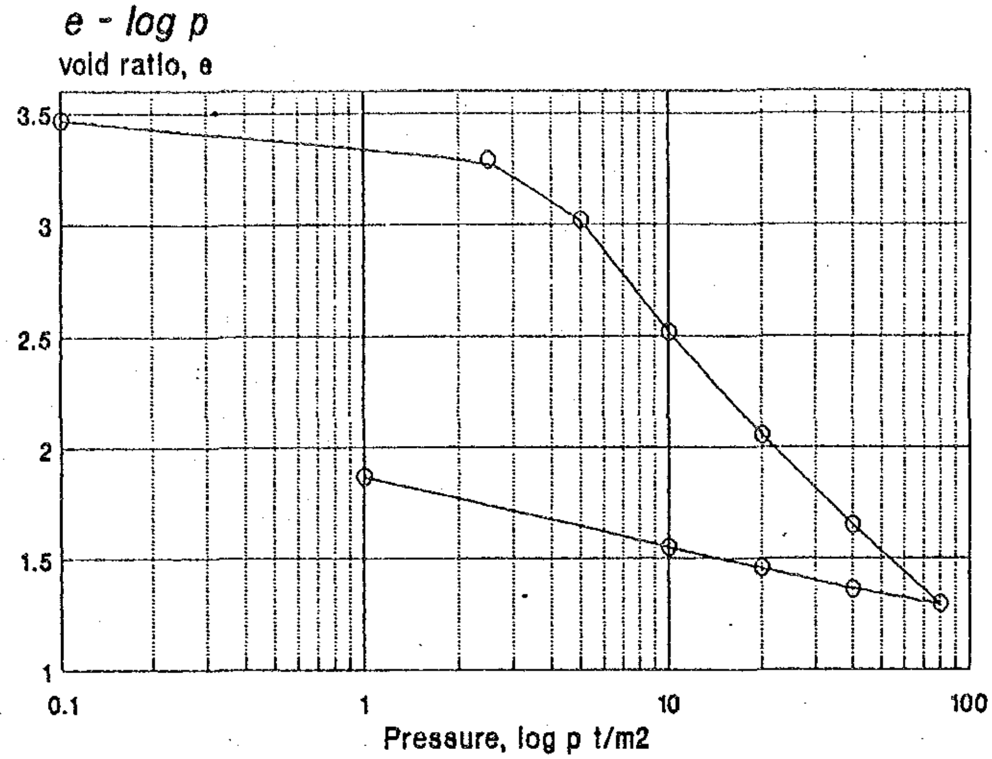
The following measures are proposed:

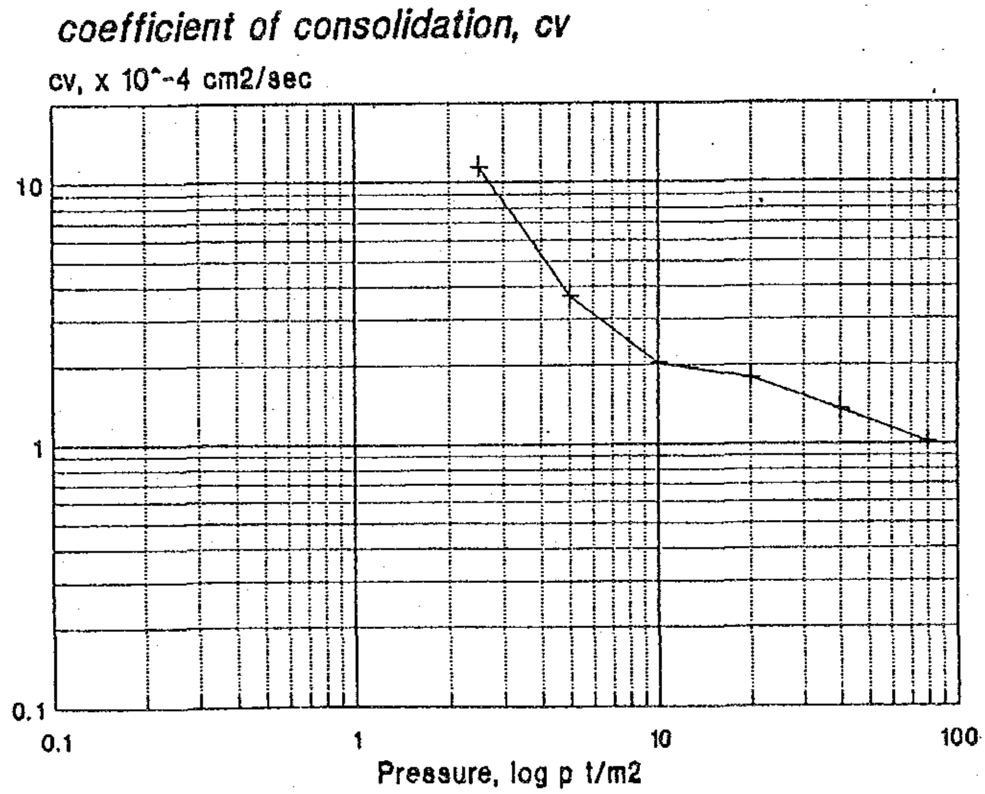
(1) Countermeasures against elevation of surrounding ground.
Sheet piles for stabilizing the base ground are to be placed outside of the dike continuously, thereby separating the filling ground from the outer soil layers.

(2) Use of cohesive soil for the dike

The dike entirely made of cohesive soil (permeability coefficient is in an order of $10^{-5}$ cm/s or less) has adaptability to differential settlement maintaining its seepage control ability.

BENOWO, Surabaya



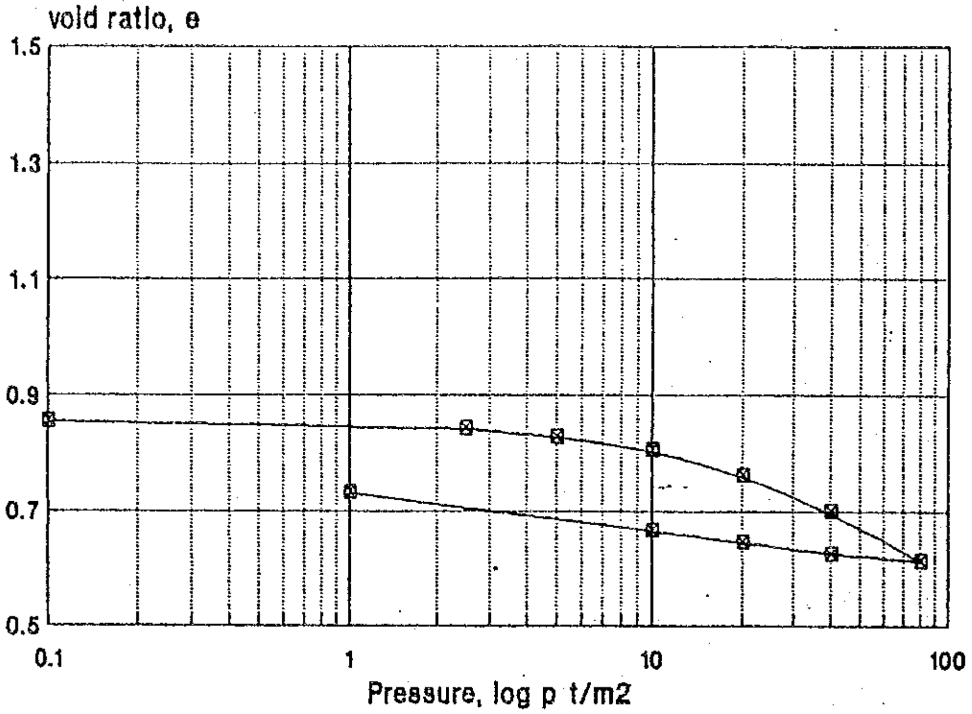

B3 : 5.50-6.0m

FIG.

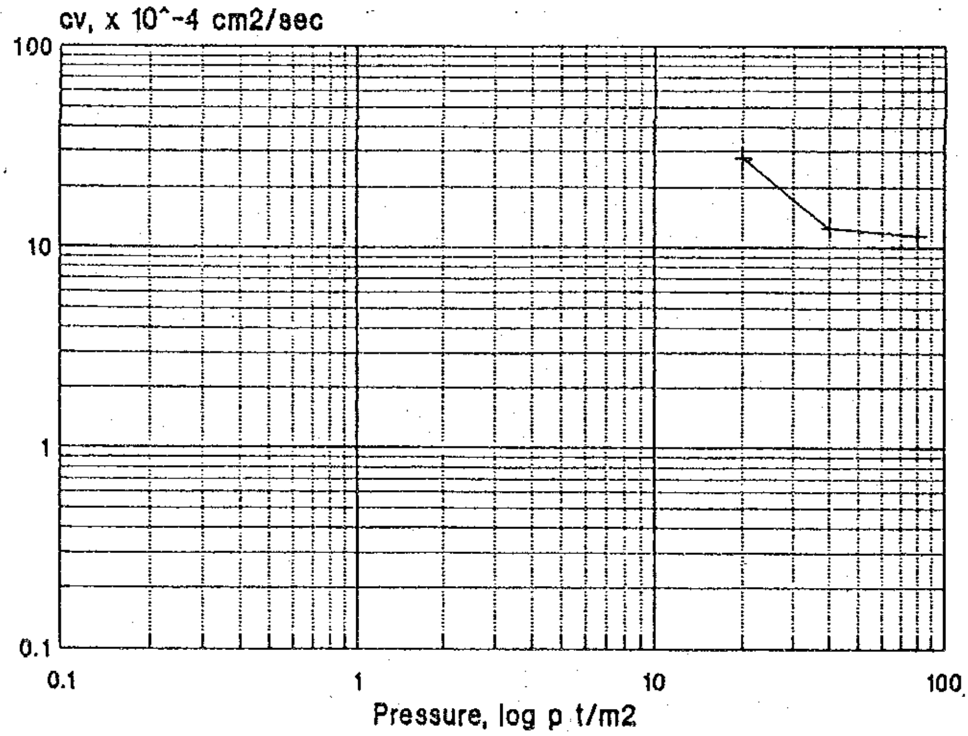
THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

BENOWO, Surabaya

*e - log p*




*coefficient of consolidation, cv*




B3 : 11.50-12m

FIG.

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

## 2.4 Leachate Control Facility

### 2.4.1 Leachate Collection Facility

#### 1) Collection Pipes

#### a. Purposes of Installing Collection Pipe

(1) To collect and transport landfill leachate
(2) To supply sufficient air into the landfill

#### b. Size and Quantity of Pipes

(1) For the purpose of leachate collection and transport

- Maximum discharge rate of leachate: Q

$$Q = \frac{\text{Maximum daily precipitation during 1979-1988}}{\text{Draining time (hr)}} \times \frac{\text{Landfill area } (m^2)}{\text{Number of pipes}} \times \text{Seepage coefficient} \times \frac{1}{3{,}600}$$

For main pipe

$$Q = \frac{0.1 \text{ m}}{\text{Draining hour}} \times \frac{320{,}000 \text{ m}^2}{\text{Number of pipes}} \times 0.6 \times \frac{1}{3{,}600}$$

For branch pipe

$$Q = \frac{0.1 \text{ m}}{\text{Draining hour}} \times \frac{60\text{m} \times 60\text{m}}{1} \times 0.6 \times \frac{1}{3{,}600}$$

- Effective cross sectional area of the pipe: $P_A$
- Roughness coefficient of the pipe: $n = 0.009$
- Slope of the pipe: I
- Diameter of the pipe: D

By Manning equation,

When $P_A = 50\%$

$$D = \left(\frac{0.009Q}{0.155^{1/2}}\right)^{3/8}$$

When $P_A = 100\%$

$$D = \left(\frac{0.009Q}{0.3117^{1/2}}\right)^{3/8}$$

(2) For the purpose of air supply

Landfill area : 32 ha

Required void volume: V

$V = 320{,}000\ (m^2) \times 0.001\ (m^3/m^2)) = 320\ m^3$

0.001 is a typical value recommended by the Japan Urban Sanitation Conference.

Main pipes length: 20,742 m

Branch pipes length: 21,243

(3) Computation Result

Pipe Diameter

| Pipe location | | Draining time (hr) | Number of main pipes | Discharge rate ($m^3/s$) | Flow ratio in pipe | Pipe slope | Required pipe diameter (m) | Pipe diameter adopted (mm) |
|---|---|---|---|---|---|---|---|---|
| 1st stage | Main | 12 | 18 | 0.0247 | 100% | 0.001 | 0.241 | 300 |
| | Branch | 12 | - | 0.0050 | 100% | 0.001 | 0.133 | 150 |
| 2nd stage | Main | 12 | 18 | 0.0247 | 50% | 0.002 | 0.275 | 300 |
| | Branch | 12 | - | 0.0050 | 50% | 0.002 | 0.151 | 150 |

The 1st-stage leachate collection pipes, for which 100% flow ratio are assumed, may subside below the base ground due to consolidation settling resulting in full of water at all time. Therefore, to maintain required void, the gas pipes with the same diameter as that of the collection pipes are to be installed.

Void Volume

| Pipe location | | Pipe length (m) | Pipe void ($m^3$) | Total void ($m^3$) | Required void ($m^3$) |
|---|---|---|---|---|---|
| 1st stage | Main | 7,104 | 502 | 631 | 320 |
| | Branch | 7,273 | 129 | | |
| 2nd stage | Main | 6,762 | 277 | 335 | 320 |
| | Branch | 6,697 | 58 | | |

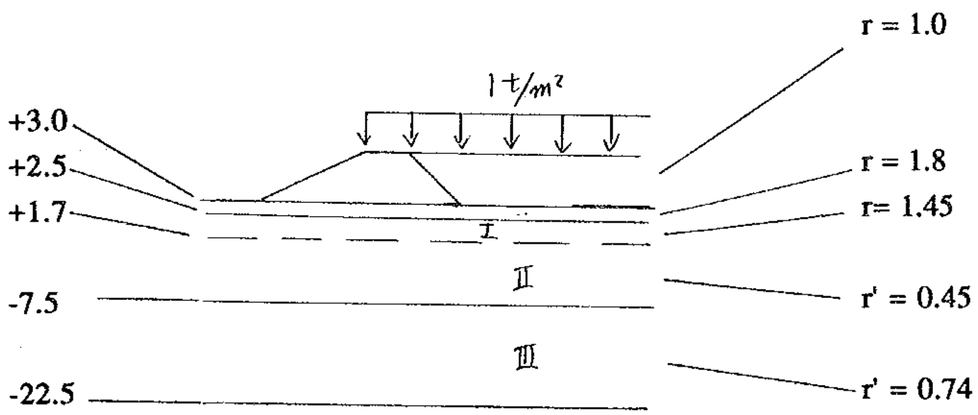
## 2) Measures Against Pipe Settling

Since the leachate collection pipes may be submerged in the groundwater correspoinding to the land subsidence, the countermeasures are considered as follows:

- Elevation of the height of broken stone pile

- Installation of gas pipes at higher elevation to be used for the multi purposes of gas collection and leachate collection after subsidence of the original pipes.

Amount of consolidation Settling (s) and Height of Broken Stone Pile (Hc)



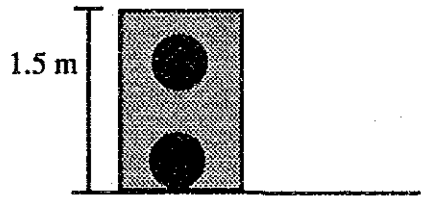

$$S = \frac{e_0 - e_1}{1 + e_0} \cdot H$$

From the e-log p curves (B3: 5.5-6m, 11.5-12m) of the soil report, the amount of consolidation settling are calculated as follows.

| Layer | Po ($t/m^3$) | ΔP ($t/m^2$) | Po+ΔP ($t/m^2$) | $e_o$ | $e_1$ | H (m) | S (m) | ΣS (m) |
|---|---|---|---|---|---|---|---|---|
| I | 0.58 | 4.9 | 5.48 | 3.37 | 2.97 | 0.8 | 0.07 | 0.07 |
| II | 3.23 | 4.9 | 8.13 | 3.19 | 2.7 | 9.2 | 1.07 | 1.14 |
| III | 10.85 | 4.9 | 15.75 | 0.78 | 0.76 | 15 | 0.17 | 1.31 |

Note: $\Delta P = 1.0 \times 3 \times 1 + 0.5 \times 1.8 + 1 = 4.9t$

The height of the broken stone pile (Hc) is determined to be 1.5 m.



### 2.4.2 Design of Recirculation System

Recirculation system consists of :

a. Retention Pond
b. Pumping Unit
c. Delivery Equipment

These equipment are designed under the consideration on both natural condition and structural condition of the landfill site.

#### 1) Retention Pond

Retention pond is designed to reserve leachate water and direct run-off to the pond and its superficial catchment area. This facility is expected to enable the leachate confinement even in rainy season. Therefore the size of retention pond should be determined to have enough capacity to contain the leachate without discharging the leachate. The characteristics of precipitation in Surabaya is summarized in Table 2.2–1. Based on this statistics, there seems to be two different seasons. From May to November, the evaporation intensity exceed the precipitation and during the rest of the year the relation becomes opposite. The most intensive rain happens in January in average.

Depth of retention pond is related to the meteorological parameters as described in the following equations.

$$D_0 = 0$$

$$D_n = D_{n-1} + (P_n - E_n)\left(1 + \frac{1-r}{r} e\right) \;\; \ldots\ldots\ldots\ldots \;\; (P_n > E_n)$$

$$\quad\; D_{n-1} + P_n - E_n \;\; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \;\; (P_n < E_n)$$

Where n: n - th month from the beginning of rainy season
Dn: Depth of the reserved leachate in the pond at the end of n - th month
Pn: Precipitation intensity during the n - th month
En: Evaporation intensity during the n - th month
r: Rate of the area of retention pond to the whole catchment area
e: Leachate production rate out of rainfall
= 1 - R,
R: Run-off coefficient, which is set at 0.4 according to the Design Guideline of Final Disposal Site of Japan.