Chapter 3 Quality Control Standard

3.1 General

The execution work methods that are selected by "Planning Manual for Road Disaster Prevention" are shown in the following. The methods that are shown in this manual are standard, but it is necessary to decide actual execution work method in consideration of the situation of the site.

3.2 Execution work Methods of Road Disaster Prevention Measures

3.2.1 Earth Work

1) Removal

The purpose of this method is to remove rock that is in danger of falling. Two typical methods are shown below.

a) Use of manpower

Loose rock that is inaccessible to large construction machinery is broken off with a breaker and falls down to the road where it can be collected and removed. As shown in Figure 3.2.1, this work is done in high places, requires traffic restrictions for safety reasons and often requires a lot of time.

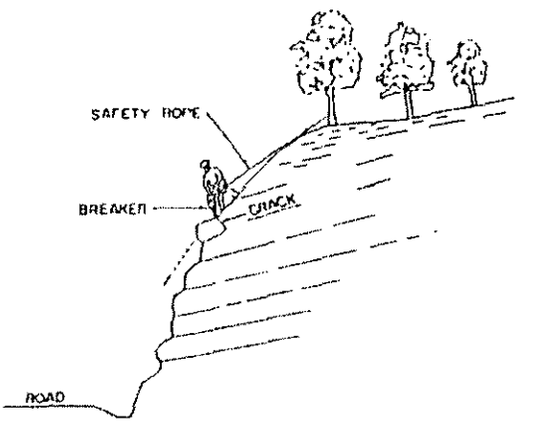


Figure 3.2.1 Removal of Loose Rock using Manpower

b) Use of construction machinery

Loose rock which is accessible to large construction machinery is removed from the slope using a back hoe (see Figure 3.2.2). This work can usually be completed in a short amount of time.

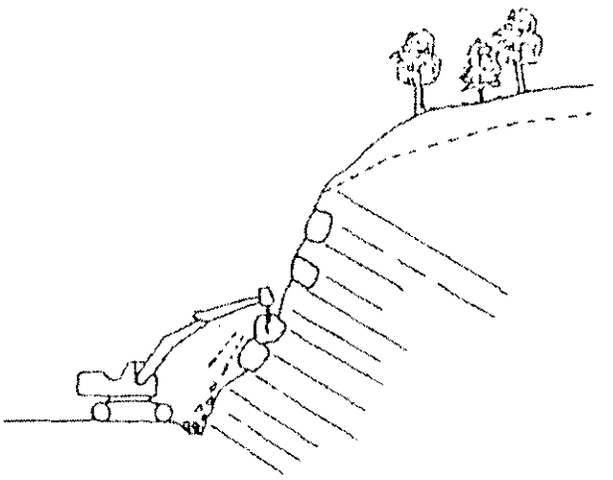


Figure 3.2.2 Removal of Loose Rock using a Back Hoe

When selecting a method to remove unstable rock, it should be based on surveys of the places experiencing rockfalls and the most suitable method for each location chosen.

2) Recutting

a) Application

Recutting is carried out to stabilize an unstable cut slope. Instability can be mainly attribute to the following factors:

i) Advanced slope erosion
ii) Landslides
iii) The existence of unstable rock on a steep slope

b) Construction Summary

i) When recutting is being executed on a stable cut slope, refer to Figure2.2.9 in Chapter2.2 to decide on the berm pitch, berm width and the slope gradient between berms.

ii) Recutting should only be done if the erosion is so advanced that the application of a drainage system, vegetation or structural work is impossible. However, when there are restraints on right of way, cribwork should be used to ensure a stable slope (see Figure 3.2.3). In this case, the cost effectiveness of construction work should be considered from the design stage. Furthermore, drainage and vegetation work should be carried out to prevent erosion.

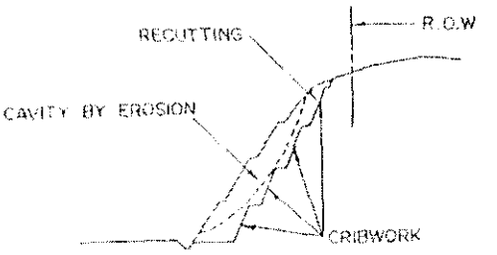


Figure 3.2.3 Cribwork

iii) For landslides, a new cut slope should be cut with a gradient gentler than that of the original cut slope. However, even if the cut slope gradient is gentler overall, it is still possible that a landslide will reoccur as a result of the recutting work by removing too much material from the foot of the original landslide (see Figure 3.2.4). For this reason, it is very important to remove the debris from the head of a landslide when recutting a cut slope with a gentler gradient

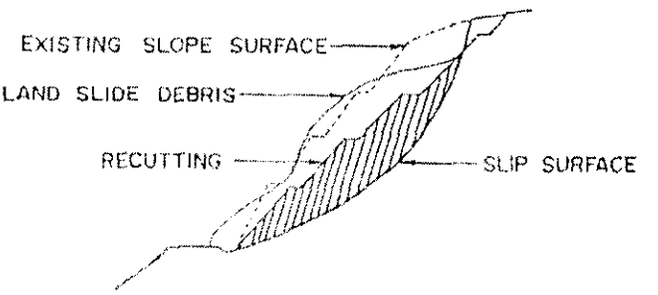


Figure 3.2.4 Trimming of Landslide Debris

iv) When recutting in unstable rock on steep ground, it is very important to decide on a stable slope gradient by considering the hardness of the rock (see Figure 3.2.5). In addition, a survey should be carried out to determine the cause of the instability. A comparison of the cost effectiveness and technical feasibility of recutting compared to other construction methods should also be carried out to select the most suitable method.

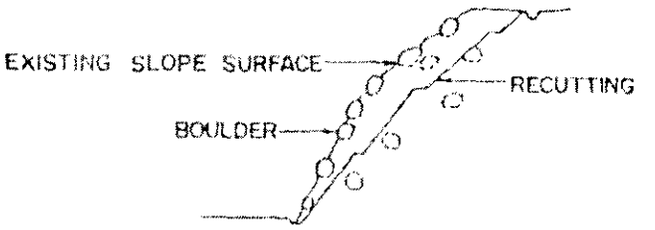


Figure 3.2.5 Recutting on Unstable Rock Slope

3) Refilling

a) Refilling of Cut Slope

i) Application

The refilling of a cut slope is carried out to eliminate the problem of extensive gully erosion caused by runoff water flowing down the slope or by spring water seeping through to the slope surface.

ii) Materials

Soil, soil cement, gabion wall, stone masonry

iii) Design and Construction Summary

(a) Rock and soil in gullies are first removed and then bench cutting is carried out. In the case of a gully having a steep slope, construction work shall be carried out in accordance with Table 3.2.1. However, if the bench cutting will cause instability in the gully, then such work should not be carried out.

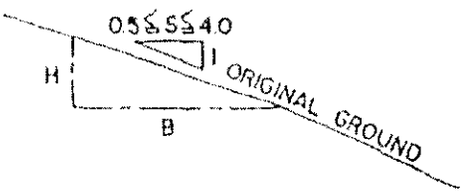


Table 3.2.1 Bench Cutting

S	B	H
0~4.0	2.5.	0.5~0.6
4.0~2.0	2.0	0.5~1.0
2.0~0.5	1.0	0.5~2.0

(b) The maximum thickness of a single refill layer should be 20 cm.

(c) From past experience, the height of a cut slope having berms should be less than 15 m. When this condition cannot be satisfied, the fill slope materials, berm width, slope gradient between berms, structural work, etc. to be applied should be reconsidered from the design stage.

(d) When filling a gully, working space is limited and so compaction equipment should consist of tampers and rammers as shown in Fig 3.2.6.

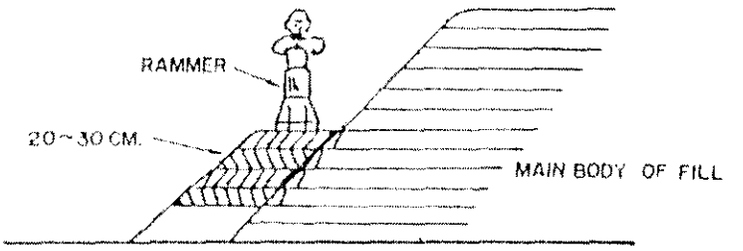


Figure 3.2.6 Slope Compaction with Tamper or Rammer

(e) When refilling is difficult to carry out due to the slope gradient, which is predetermined by the composition of the soil, then gabion wall or stone masonry will be placed on the slope's surface after refilling to prevent the refilling material from moving (see Figure 3.2.7).

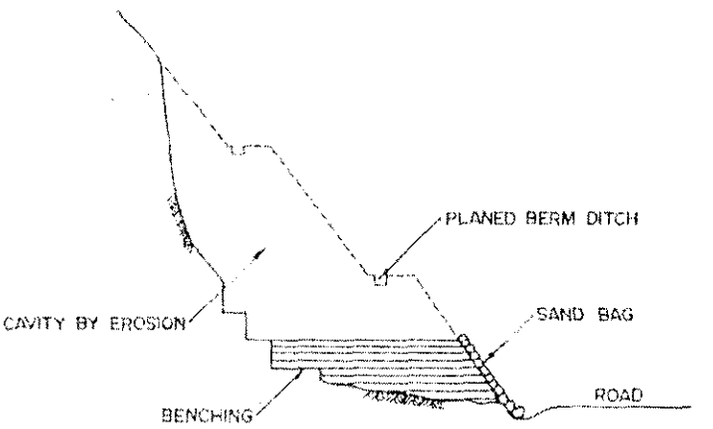


Figure 3.2.7 Protection of Refilling Material with Stone Masonry

(f) To protect a refilled cut slope from erosion and weathering, the condition of the slope should be confirmed at the design stage and a countermeasure such as surface drainage, subsurface drainage, vegetation, or structural work should be selected.

b) Refilling of Fill Slope

i) Application

The refilling of a fill slope is carried out to restore the portion of the slope that has collapsed due to scouring.

ii) Materials

Soil, soil cement, and sand.

iii) Construction Summary

(a) Benches shall be cut into the original slope to form a key between the new and the old slope works. When the collapsed portion of a slope has a steep gradient, bench cutting will be carried out in accordance with Table 3.2.1.

(b) The maximum thickness of a single refill layer will be 20 cm.

(c) Based on past experience, fill slopes with berms should be less than 30 m in height. If this condition can not be satisfied, the fill slope materials, berm width, slope gradients between berms and structural work to be used should be reconsidered from the design stage.

(d) In the case of refilling a fill slope, large-scale compaction equipment, such as that shown in Figure 3.2.8, may be used. However, where space is restricted, it is recommended that smaller equipment be used.

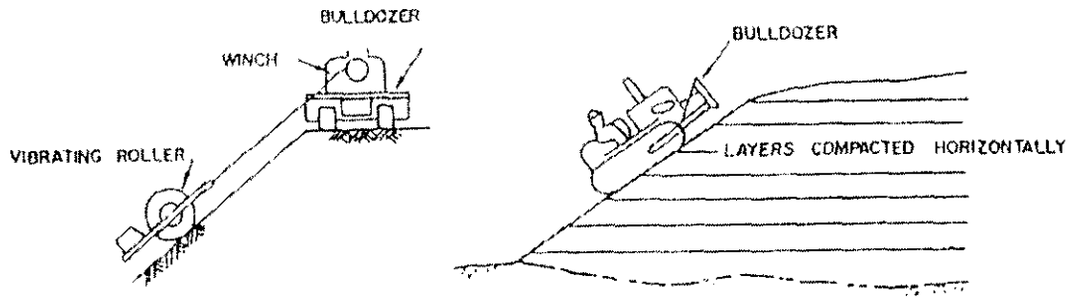


Figure 3.2.8 Slope Compaction with Vibrating Roller and Bulldozer

(e) When refilling is being executed on sloping ground which contains groundwater, drainage layers will be included in the construction of each berm as shown in Figure 3.2.9.

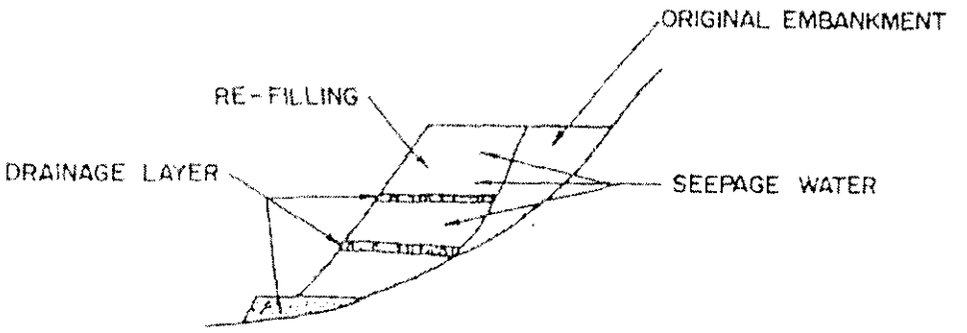


Figure 3.2.9 Berm Drainage Layer for Refilling a Fill Slope

(f) To protect a refilled fill slope from erosion and weathering, the conditions of the slope should be confirmed at the design stage and a countermeasure such as surface drainage, subsurface drainage, vegetation, or structural work should be selected.

3.2.2 Vegetation Work

1) Purpose

The purpose of vegetation work is to protect the slope surface from erosion by reducing the velocity of runoff water and to enhance the environmental quality of the area.

2) Application

i) Depending on the condition of a slope, the appropriate type of vegetation work is chosen. However, in the five situations below, vegetation work cannot be applied.

(a) Where neither sunlight nor rain can reach an area because of the adjacent structures such as bridges and viaducts.
(b) Where the acidity of soil is very strong.
(c) Where the moisture of soil is extremely limited.
(d) Where the soil is extremely hard.
(e) Where a slope is extremely steep (0.6:1 or less)

ii) In order to select the appropriate type of vegetation work, a slope survey should be carried out considering the following items:-

(a) Slope gradient

When the slope gradient is less than 1.2:1 in soft rock or clay, or less than 1.5:1 in sand or sandy soil, it is possible to prevent erosion due to runoff or the collapsing of top soil by vegetation work only.

However, if the gradients for these soil types become steeper, it is difficult to ensure slope stability using vegetation only. Therefore, measures such as cribwork and wickerwork must also be carried out.

(b) Slope rock, soil and soil hardness

Using the results of a slope survey, the types of vegetation work that are applicable for the slope can be determined by referring to Table 3.2.2.

Table 3.2.2 Applicable Vegetation Work by Soil Type

Type of Work	CUT SLOPE					FILL SLOPE		
	Sand	Sandy soil, sandy soil with gravel or rock		Clayey soil, clayey soil with gravel or rock, clay		Hard clay, weathered soft rock, Mudstone	Sandy soil, clayey soil with gravel or rock Mudstone	Sand
		Hardness of Soil		Hardness of Soil				
		≤27mm	≥27mm	≤27mm	≥27mm			
Block Sodding	A	A		A			A	A
Stripe Sodding							A	
Seed Packet Work			A		A	A		
Pick-Hole Seedling Work			A		A	A		
Seed Spraying with a Pump	B	B		B			A	C
Seed-mix Spraying with a gun	A	A	A	A	A	A		A

Note: A: Suitable
B: Suitable for fertile soil
C: Suitable for top soil

(c) Soil activity

When soil is highly acidic (pH ≤ 4), there are usually adverse effects on vegetation growth. Therefore the pH of soil should be measured and action taken when it is found to be acidic.

When material used for a fill slope is highly acidic in nature, the alkaline carbonic acidic calcium is mixed with the material to neutralize the acidity.

For cut slopes, it is generally difficult to reduce the acidity of the soil. However, there is the method where new soil is laid, which is mixed with carbonic acidic calcium and seed packet and pick-hole seedling work is carried out.

When there is spring water on either a fill slope or cut slope, a thick spray of seed-mix is effective. The seeds are mixed with binder to prevent them from being easily washed away. Cribwork can also be an effective measure that in both soil and rock.

3) Characteristics and Materials by Vegetation Work Type

The characteristics and materials for the different kinds of vegetation work are described below.

a) Block Sodding

Outline : As shown in Figure 3. 2.10, blocks of sods are laid tightly next to one another on the surface of the slope and anchored down with pins, starting from the top and going down to the toe of the slope. Sod blocks should be placed with a gap between adjacent blocks and a mixture of Fertilizer and soil is then lightly scattered over the sods filling in the gaps to encourage growth.

Characteristics: Applicable to erosion-prone soil.

Materials: Blocks of sod, sodding anchor pins, fertilizer.

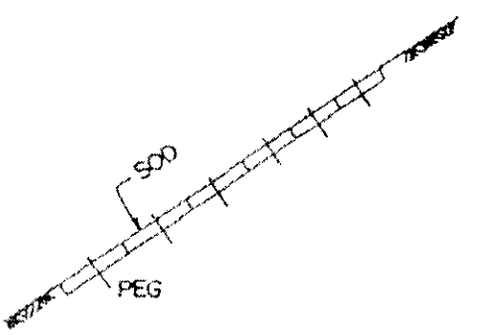


Figure 3.2.10 Block Sodding

b) Stripe Sodding

Outline: As shown in Figure 3.2.11 rectangular sod blocks are placed tightly next to each other to form a row starting from the toe of a slope. After a row of sod blocks has been laid, two-thirds of each block is covered with 30 cm of top soil and a new row begun. This results in what is called stripe sodding.

Characteristics: Stripe sodding is used for fill slopes.

Materials: Blocks of sod, top soil.

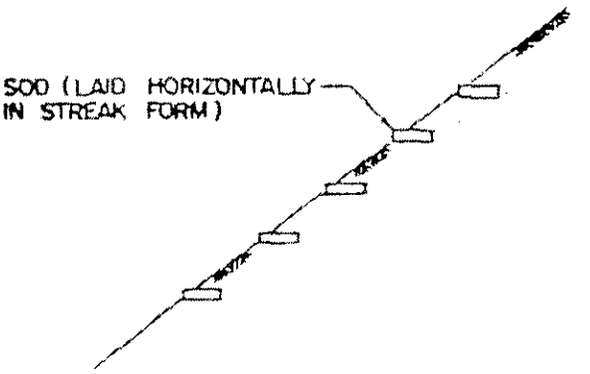


Figure 3.2.11 Stripe Sodding

c) Seed Packet Work

Outline: As shown in Figure3.2.12 holes are dug at regular intervals to form rows and a packet containing fertilizer, soil, seed and cut straw is put into each hole and fastened with an anchor pin. The distance between each hole is approximately 50 cm and about 6 packets per square metre are used.

Characteristics: Seed packet work is applied to cut slopes. As packets are used, the seed, fertilizer, and soil are not easily washed away. It is also possible to carry out seed packet work on relatively steep slopes.

Material: Polyethylene bags, seed, fertilizer, soil, anchor pins.

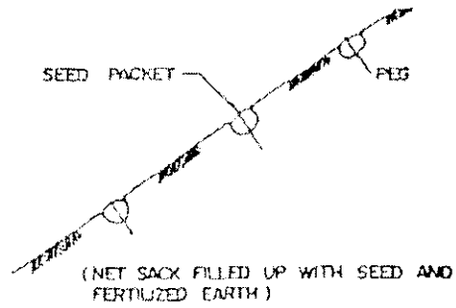


Figure 3.2.12 Seed Packet Work

d) Pick-Hole Seedling Work

Outline: As shown in Figure 3.2.13 a hole is dug, some fertilizer is put in the hole and a tree seedling is inserted together with a supporting rod.

Characteristics: Pick-hole seedling work is carried out on cut slopes, to protect the environment and improve the landscape. Other types of vegetation work would be carried out where seedlings are not planted.

Materials: Tree seedlings, fertilizer, support rods.

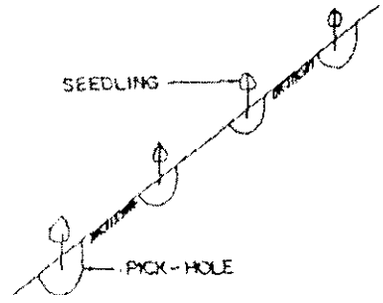


Figure 3.2.13 Pick-hole Seedling Work

e) Seed Spraying

Outline: As shown in Figure3.2.14 seed, fibre and binder is mixed with water and sprayed over the slope using a pump.
Characteristics: Seed spraying is applied to cut and fill slopes with soft soil. This method requires a vehicle or alternative spraying equipment and so is only suitable where vehicle access is available.

Materials: Seed, high quality fertilizer, fibre (pulp, woody cellulose, etc.) binder (polyvinyl alcohol, polyvinyl acetate, etc.)

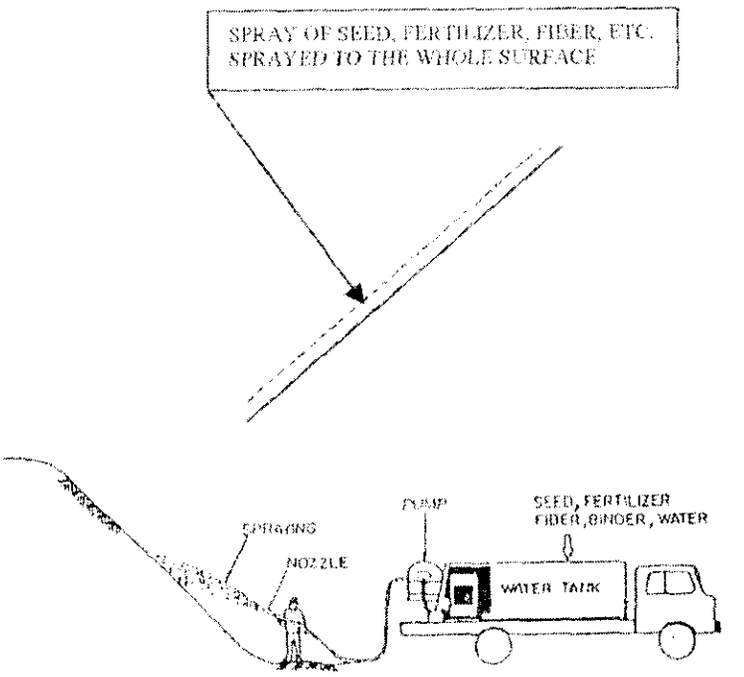


Figure 3.2.14 Seed Spraying

f) Hydroseeding

Outline: As shown in Figure 3.2.15 a mixture of seed, fertilizer, soil, and water is sprayed thickly over a slope with a mortar gun. An anti-erosion agent is then sprayed over the slope.

For a slope with a soil surface, the mixture is sprayed until there is a 1 to 2 cm layer. For a soft rock surface, a net is spread tightly over the rock surface to retain the mixture that is sprayed on top of the net until there is 2 to 3 cm layer. Where the surface is hard rock, this method should not generally be used. However, when for environmental reasons it is necessary that this process be carried out, the mixture is sprayed over a tightly spread net until there is a layer of 5 cm or more. Note that in this case the soil of the original mixture is replaced with binder to ensure that the mixture does not fall off the rock.

Characteristics: Hydroseeding is applied to cut slopes and uses a seed, fertilizer and soil mixture having a high soil content. As this method uses a pump and pipe system it can be used on higher slopes provided the equipment can reach, as well as on slopes with gravelly soil.

Materials: Seed, high quality fertilizer, soil (with less than 5% of its contents made up of gravel 6mm or less in diameter and mixed with compost or something similar in nature), anti-erosion agent (asphalt emulsion), binder (Portland cement, high polymer plastics), water and netting.

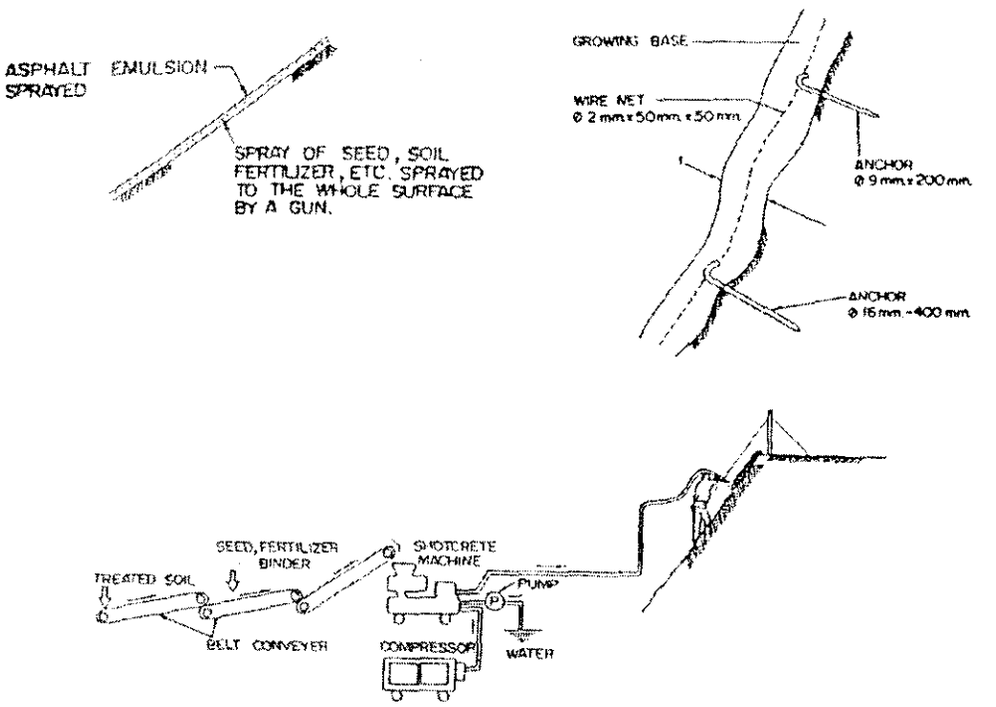


Figure 3.2.15 Hydroseeding

3.2.3 Surface Drainage

1) Crest Ditch

i) To prevent rainwater or spring water at the top of a cut slope from seeping into the slope, a crest ditch is constructed at the top of the slope. When constructing the crest ditch, it should have a large capacity as crest ditches are often difficult to reach and therefore difficult to maintain (see Figure 3.2.16) . The discharge of the water in a crest ditch must be carefully considered.

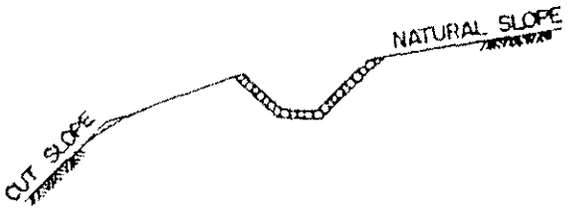


Figure 3.2.16 Crest Ditch

ii) Construction material such as stone riprap should be used.

iii) The crest ditch at the top of a cut slope should be located 1m to 3 m away from where the slope rounding was carried out.

2) Berm Ditch

i) To prevent erosion by rainfall or spring water flowing down a cut or fill slope, berm ditches are constructed on each berm of the slope.

ii) The longitudinal gradient of a berm ditch is usually the same as that of the adjacent road, but it is desirable to achieve 0.3% to 5%. As for the latitudinal gradient, as shown in Figure 3.2.17 it is 1:15 going in the opposite direction of a slope.

iii) For a berm ditch, U-shaped reinforced concrete is used. The function of a berm ditch is to connect crest and vertical ditches to assist in the disposal of rainwater or spring water. It also prevents excessive wash down from surface water on large slopes.

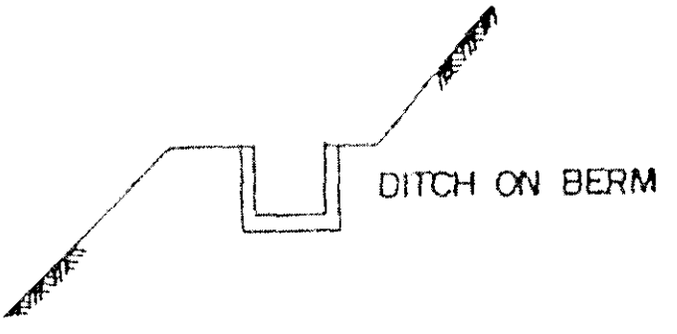


Figure 3.2.17 Berm Ditch

iv) As shown in Figure 3.2.18 to assist the flow of rainwater on a slope with hard rock, the transverse gradient on the berm is set to 5% in the direction of the slope.

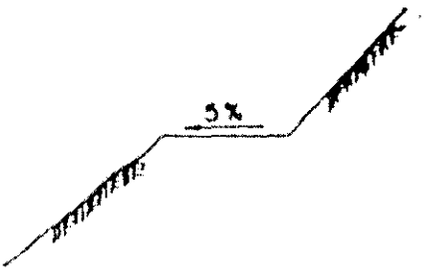


Figure 3.2.18 Gradient on Berm where the Slope is in Hard Rock

3) Toe Ditch

iii) A toe ditch is constructed to prevent the scouring of the toe of the slope by rainwater and the intrusion of rainwater onto a road pavement. Figure 3.2.19 shows a toe ditch for a cut slope. For fill slopes, the cross section is determined by the size of the fill slope.

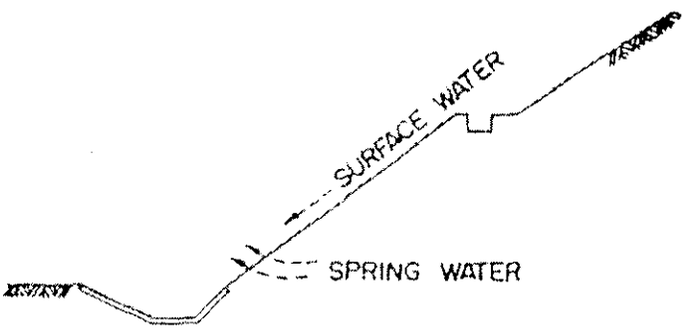


Figure 3.2.19 Toe Ditch

4) Vertical Ditch

i) Vertical ditches are constructed to channel water from the crest or berm ditches of a cut slope to the toe ditch, taking into consideration slope gradient. Vertical ditches are also constructed if the capacity of the berm ditches is insufficient or if the topography warrants it. However, even if the capacity of crest ditches, berm ditches and gutters is sufficient, if the length of berm ditch is more than 100 m, then vertical ditches are constructed every 100m or less, as shown in Figure 3.2.20. U-shaped reinforced concrete or stone riprap should be used.

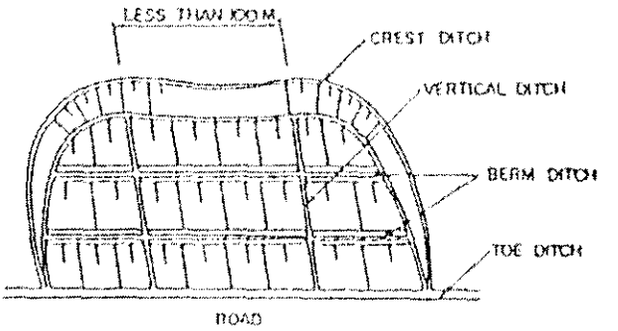


Figure 3.2.20 Vertical Ditch

5) Surface Drainage

i) Surface drainage is constructed to prevent the reoccurrence of a landslide by preventing the seepage of rainwater into previous landslide debris. This is done by collecting the rainwater in the area of a landslide and disposing of it outside that area. Wherever possible the surface water should be prevented from reaching the landslide area by using suitable cut off drainage ditches.

ii) Surface drainage is made up of numerous horizontal and vertical drains that cut up and down the entire length of the landslide debris.

iii) Stone riprap or concrete is generally used for such drainage.

iv) For horizontal drains, the interval depends on the topography but it is recommended to have one every 10m. For vertical drains, the interval should be determined by calculation of the amount of rainfall and allowing a 20% safety margin. The recommended interval for vertical drains is 100m.

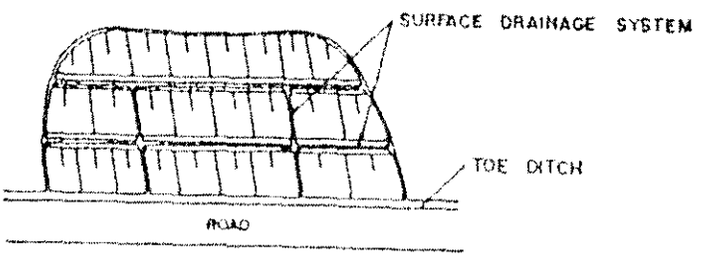


Figure 3.2.21 Surface Drainage System

3.2.4 Horizontal Drainage

1) Purpose

The purpose of a horizontal drain hole is to prevent landslides from occurring by reducing the groundwater level for unstable landslide debris and for unstable slopes predicted to have a landslide.

i) Method to Confirm Slip Surface

To properly install a horizontal drain hole for groundwater drainage, it is necessary to confirm the slip surface from a soil survey.

The boreholes for the slope survey shall be carried out in at least three spots on the potential or actual landslide surface. Sliding occurs in many cases along the boundaries between colluvium and bedrock and between severely weathered rock and lightly weathered rock. The boring is carried out to confirm these boundaries and the changes in soil types.

ii) Design of Horizontal Drain Hole

It is usual to install 4 or 5 drain holes per location. Drain holes will be 66mm in diameter and are inserted at an angle of 5° to 10° to the horizontal to assist in the drainage of groundwater(see Figure 3.2.22).

The installation is carried out using a boring machine to drill the holes, as shown in Figure 3.2.23. Where the soil is made up gravel or soil, a casing pipe is to prevent the collapse of the drill hole.

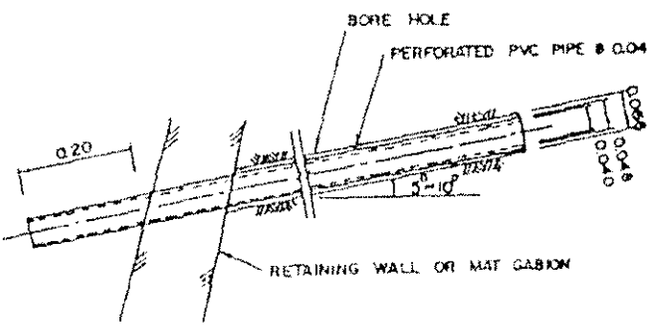


Figure 3.2.22 Angle of Drain Hole

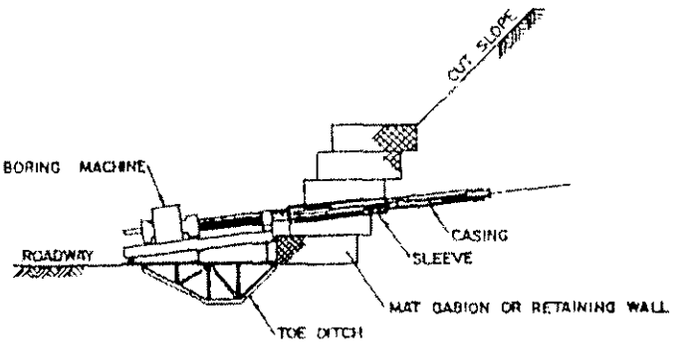
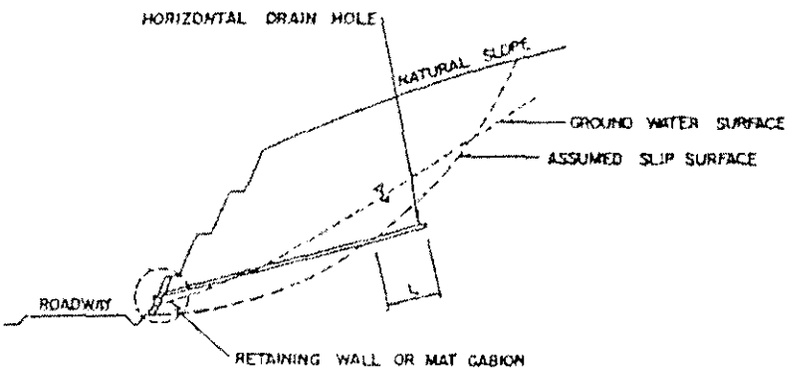


Figure 3.2.23 Boring Machine

As shown in Figure 3.2.24, the boring depth from the slip surface will 10m for soil slopes and 3m for rock slopes.



ORIGINAL GROUND CONDITION	L
SOIL	10.00
ROCK	3.00

Figure 3.2.24 Boring Depth from Slip Surface

2) Materials:

Perforated PVC pipe will be inserted in the bored holes (see Figure 3.2.25).

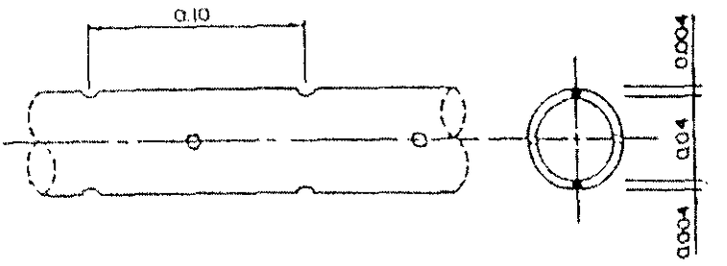


Figure 3.2.25 Perforated PVC Pipe

3) Reduction of Groundwater Level

Generally, horizontal drain holes reduce the groundwater by approximately 3m. Therefore, when carrying out stability calculations for groundwater planning where drain holes have been or will be installed, the level shall be assumed to be 3m less than the maximum groundwater level.

3.2.5 Structure

1) Cribwork

There are three types of cribwork in general use:-

i) precast concrete
ii) cast-in place
iii) sprayed concrete

The following sections cover the application, materials and design work for these three types of cribwork.

a) Precast Concrete Cribwork

i) Application

Precast concrete cribwork can be used on slopes with a gradient flatter than 1.0:1 and is effective in the following situations:-

(a) a cut slope having spring water

(b) where there is advanced erosion and weathering due to runoff from rainwater

(c) where the soil is not conducive for vegetation but vegetation is required by the surrounding conditions.

(d) where vegetation work has been carried out but there is still the fear of the slope collapsing

ii) Materials

Precast concrete cribwork blocks, concrete blocks for structures and foam.

iii) Design

(a) The span of a crib is to be 1m. The dimensions of crib members are 15cm x 15cm or 15cm x 20cm.

(b) To prevent the cribs from sliding, the spaces between the cribs are filled with mortar after 50- 100cm long anchor pins are inserted into the ground and steel wires extruding from the crib ends are tied together tightly (see Figure 3.2.26)

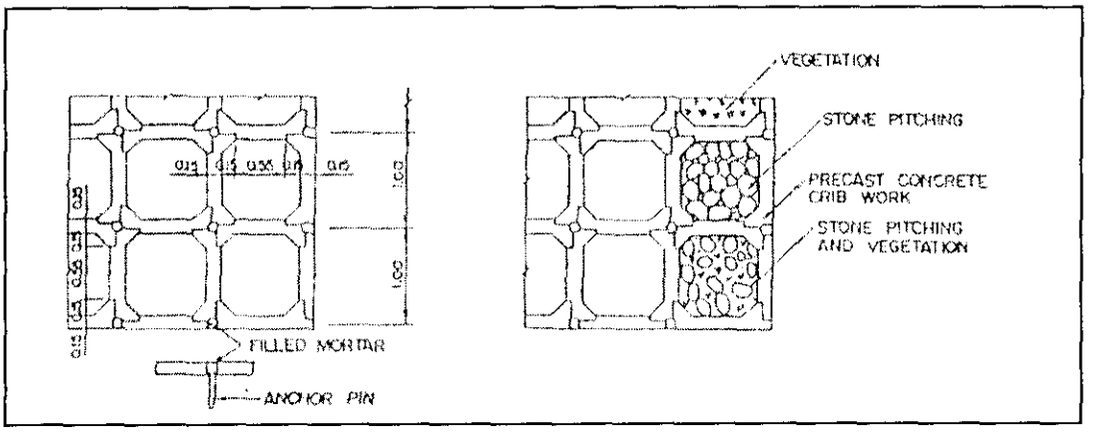


Figure 3.2.26 Sample of Precast Concrete Cribwork

(c) New soil, rich in nutrients, is placed inside the cribs to ensure that the new vegetation takes strong hold. In certain conditions, stone pitching or concrete block pitching should be used (see Figure3.2.27):-

*the gradient of the slope is steeper than 1.2:1, and

*there is a considerable amount of seepage

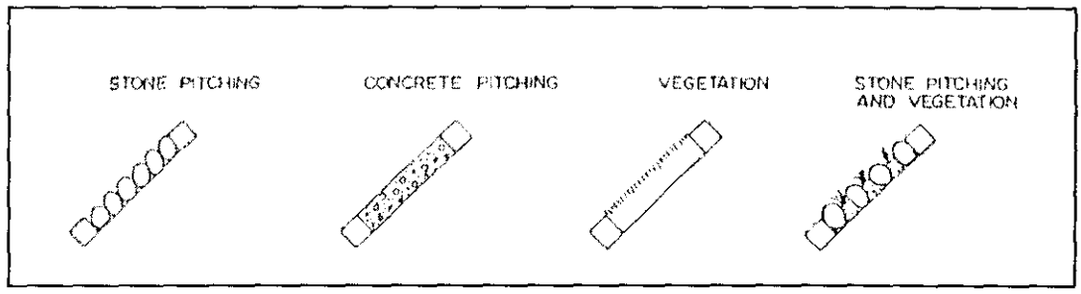


Figure 3.2.27 Examples of Work inside the Crib

(d) Where there is spring water on a slope, either a branch-like underground drainage system or water-absorption mats are put into place to prevent the soil on the slope from being washed away before precast concrete cribwork is completed.

(e) It is necessary to consider at the design stage the size and grading of the stones used to fill the cribwork the problem of weathering and small stones being washed away.

b) Cast-in-place Concrete Cribwork

i) Application

Cast-in-place concrete cribwork is used on slopes with a gradient flatter than 1.0:1 and is effective in the following situations:-

(a) when the future stability of the slope is questionable (e.g. weathered rock slope with spring water),

(b) when there is a danger that precast concrete cribwork would collapse, and

(c) when unstable rock can not be anchored to bedrock by shotcrete because of joints and cracks in the bedrock

ii) Materials:

Concrete for structures, form and reinforcing bar.

iii) Design:

(a) Cribs will be made up of cast-in-place reinforced concrete.

(b) The dimensions of crib members will be from 0.3m x 0.3m to 0.6m x 0.6m with a span of 5 to 10 times that size.

(c) The slope gradient will depend on the hardness of the soil, and anchor bars will be used at the intersections of cribs to prevent cribs from sliding (see Figure 3.2.28).

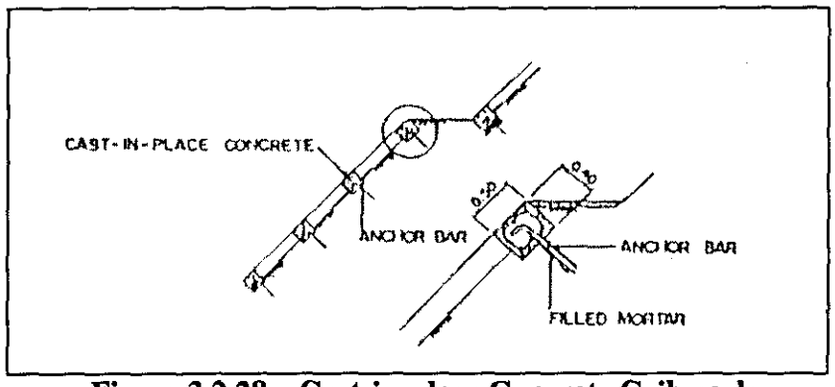


Figure 3.2.28 Cast-in-place Concrete Cribwork

(d) Depending on the condition of the slope, stone pitching, concrete pitching, stone riprap with mortar or vegetation work may be used to protect the slope.

c) Sprayed Concrete Cribwork

i) Application

(a) Sprayed concrete cribwork is used in the same situations as cast-in-place concrete cribwork but it is easier to apply and can be used on rough slopes. In addition, this type of cribwork can be made to fit the shape of a slope.

(b) It is applicable to an undulating slope.

(c) Sprayed concrete cribwork is highly useful in reinforcing prefabricated lightweight cribs.

ii) Materials

Concrete used for spraying, lightweight steel net crib, concrete sprayer.

iii) Design

(a) Cribs will be made on site of reinforced concrete via shotcrete.

(b) The members of crib will be from 0.15m x 0.15m to 0.5m x 0.5m , with span width being 5 to 10 times that size.

(c) For crib intersections and members, anchor bars will be applied to prevent cribs from sliding (see Figure 3.2.29).

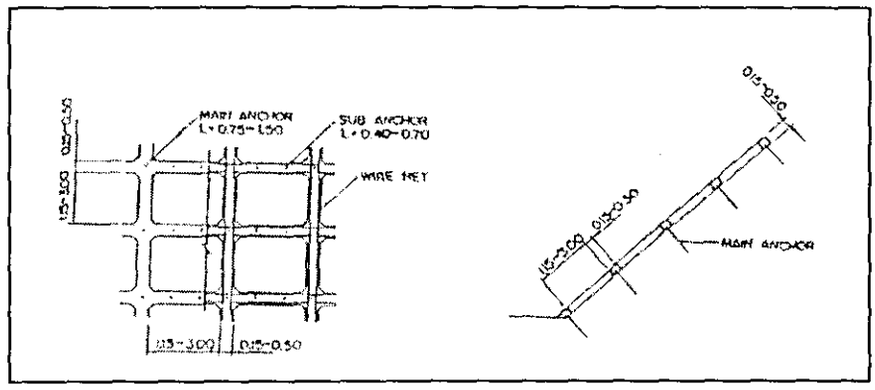


Figure 3.2.29 Sprayed Concrete Cribwork

(d) Depending on the condition of the slope, stone pitching, concrete pitching, shotcrete, stone riprap with mortar or vegetation work will be applied to protect the slope.

(e) The concrete mixture is the same as for shotcrete. The weight ratio of cement, sand and gravel is 1:3:2 and the water cement ratio is 45%.

2) Shotcrete

a) Application

i) For slopes with no spring water and rock that weathers easily

ii) For slopes with weathered rock which is about to fall

iii) For slopes with cracked and jointed rock

iv) For slopes having an overhang

v) For newly constructed, stable cut slopes where there is a danger that seepage will cause instability in the slope surface.

vi) For slopes where topsoil and vegetation work are unsuitable.

b) Materials

Spray-type concrete, diamond-shaped wire mesh (2mm x 50mm), anchor pins (16mm x 40 cm), PVC pipe (50mm) and a concrete spray gun.

c) Design

i) Generally, a concrete layer of 10 cm is sprayed on the slope. Where the surface of the slope is rock and extremely bumpy, the layer thickness should be increased to 15cm.

ii) To prevent cracking in the sprayed concrete after it has dried and to prevent the concrete from peeling off, diamond-shaped steel wire netting (2mm x 50mm) shall be used . Where necessary, steel bars can be used instead.

iii) Before spraying concrete, the steel wire netting is attached to the slope with anchor pins (16mm x 40cm) at intervals of 1 or more square metre.

iv) To construct weep holes, 50mm diameter PVC pipe is used and a weep holes are located every 2 to 4 square metres.

v) The concrete should have a weight ratio of 1:3:2 for cement, sand and gravel, with a water cement ratio of 45%.

vi) Where the area of operation is large and the slope relatively flat, concrete shrinkage and cracking may occur. To prevent the spread of cracking, a vertical expansion joint is placed every 20 metres as shown in Figure 2.2.30. Where the rock surface is very bumpy, the number of expansion joints can be reduced as temperature-induced stress will be partially absorbed.

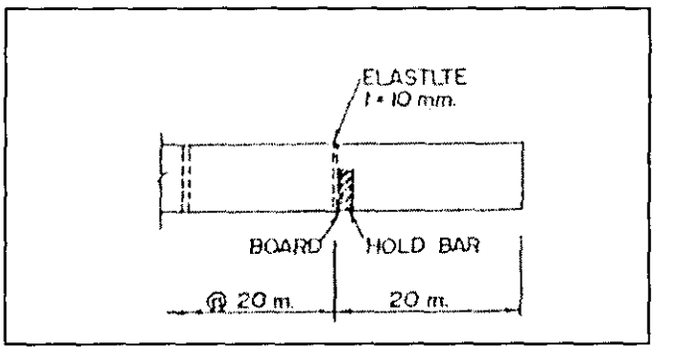


Figure 3.2.30 Vertical Expansion Joint

To prevent seepage after covering the surface of the slope with shotcrete, either the partial shotcrete method (see Figure 2.2.31), or the complete shotcrete method (which includes the use of a crest ditch) (see Figure 2.2.32) can be used.

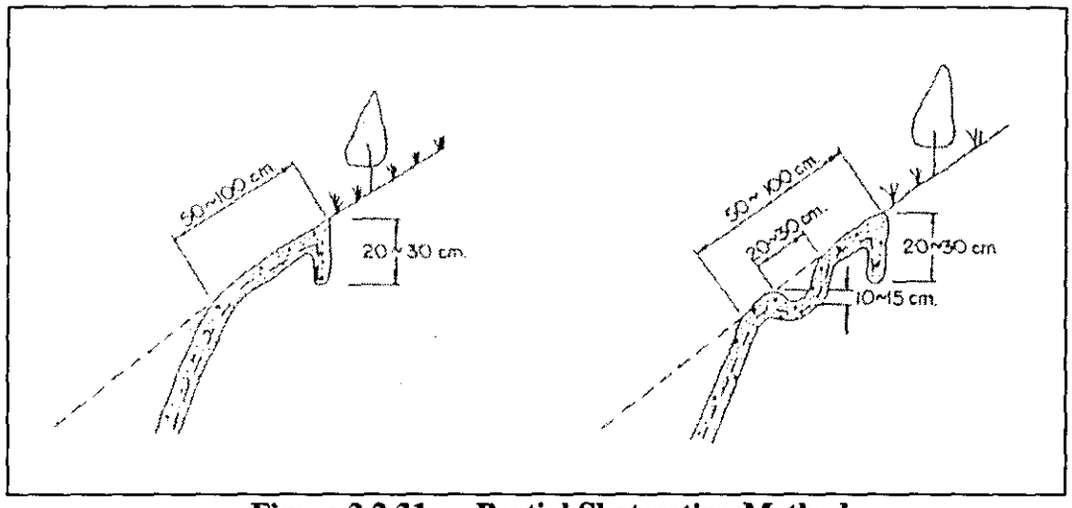


Figure 3.2.31 Partial Shotcreting Method

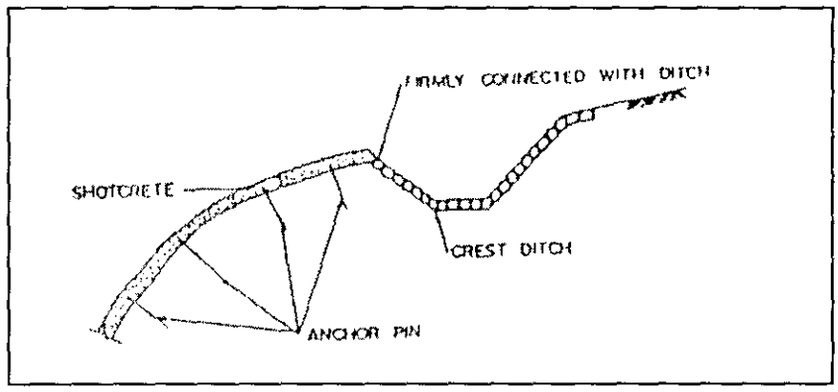


Figure 3.2.32 Complete Shotcreting Method

d) Construction

i) The surface life of the shotcrete is highly influenced by the weather at the time of construction. It is important that the timing of shotcreting be taken into consideration and shotcreting should not carried out when any one of the following conditions exists:-

ii) Pressurized water or air should be used to remove unstable rock and dust. Wire netting is then attached to the surface of the slope and the shotcreting can be sprayed onto the netting.

iii) Spraying of shotcrete should be a continuous process until a vertical expansion joint is reached.

3.2.6 Protection

1) Prevention Net

a) Application

i) A rockfall prevention net is used on cut slopes where scouring, weathering or erosion by rainfall is increasing the probability of a rockfall occurring.

ii) In addition to trying to prevent rockfalls, it is also important to prevent rocks from falling onto the road and to guide them to the toe of the slope.

iii) To prevent rocks from falling onto a road, there are two types of rockfall prevention nets (see Figure 3.2.33) :

(a) a cover-type rockfall prevention net (which is made of wire netting, wires, anchor concrete blocks and anchor bolts) that prevents rock from falling by trapping them between the cut slope and the wire netting

(b) a pocket-type rockfall prevention net (which is made of hanger wire, netting, steel supports and concrete anchor blocks) that catches falling rock in a pocket-like area by absorbing the force of the falling rock through the wire netting.

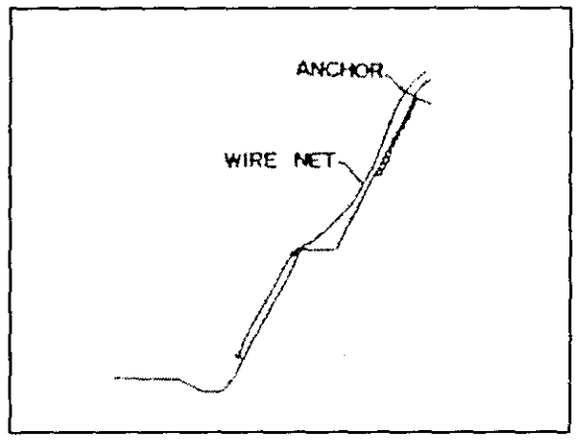


Figure 3.2.33 Prevention Nets

b) Materials

i) Wire net (wire diameter: 2.6 mm – 4.0mm, netting grid: 50mm x 50mm)

ii) Wire 3 x 7 galvanized and stranded with petroleum grease: main wire with maximum tensile strength of 12,000 kg (diameter: 16mm), sub-wire with a maximum tensile strength of 7,000 kg (diameter 12mm)

iii) Anchor bolts 1.5 m in length (diameter: 25 mm)

iv) Concrete anchor blocks (1m wide, 1.2m deep, 2.0m long in direction of rope)

v) H-shaped steel support (pocket-type rock prevention net only)

2) Prevention Fence

a) Application

A fence is effective in stopping small rocks from reaching the surface of the road. (see Figure 2.2.34) The fence can have either straight or angled supporting posts.

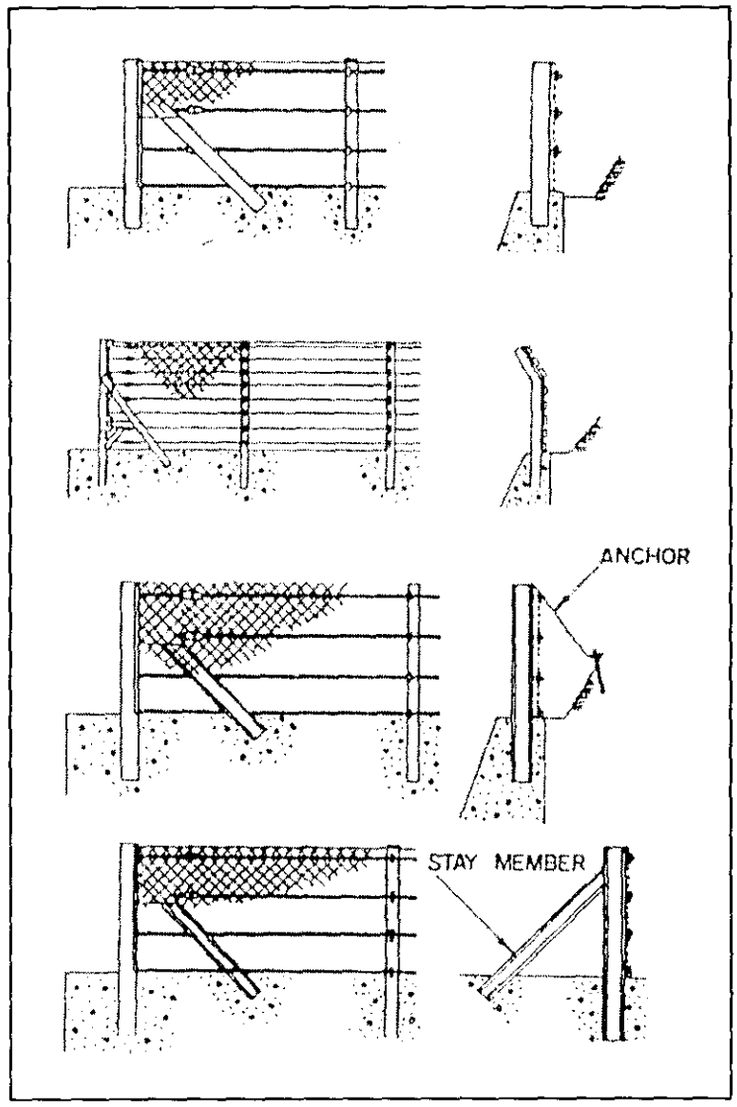


Figure 3.2.34 Wire Mesh Fence

3) Concrete Wall

a) Application

Wall barriers are relatively effective for preventing medium size rocks from reaching the surface of the road but they require a relatively wide area adjacent to the road for installation.

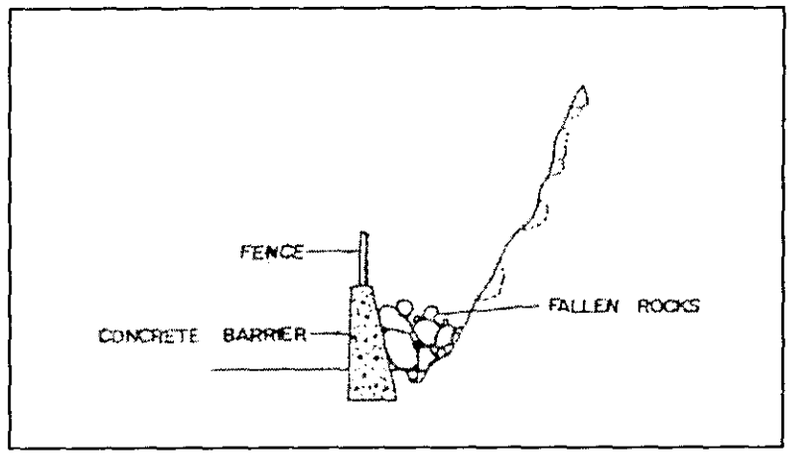


Figure 3.2.35 Concrete Wall Barrier

Chapter 4 Procurement Method of Materials

4.1 General

The law and regulation for procurement of materials are shown in this chapter.
And method of cost estimate is shown.

4.2 Procurement Condition of Materials

Usual procurement is regulated for by law 323 of TRADES LAW OF THE STATE.
In case of the materials are procured directly from the quarry site, it is regulated by "GENERAL LAW OF THE ENVIRONMENT AND NATURAL RESOURCES" and "Law No 387" of development of mines.

4.3 Cost Estimate Standard

1) Establishment of cost estimate standard

It is necessary to establish the cost estimate standard to order construction by a reasonable price in MTI. Therefore the project of the cost standardization done by Danish finance is completed and is spread immediately.

2) Cost Estimation System

The composition of the contract construction expense is following.

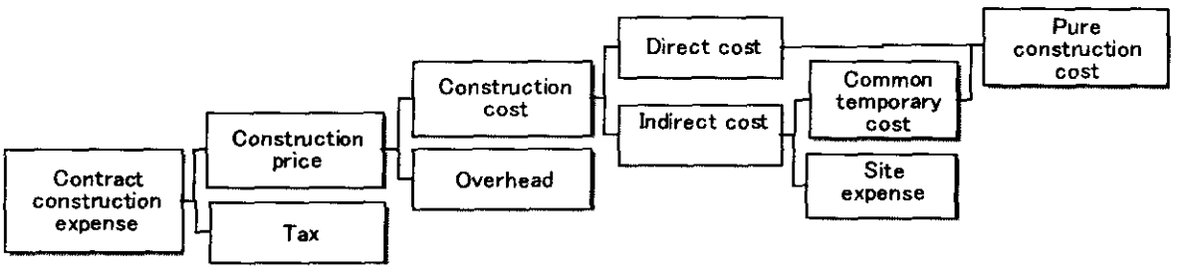


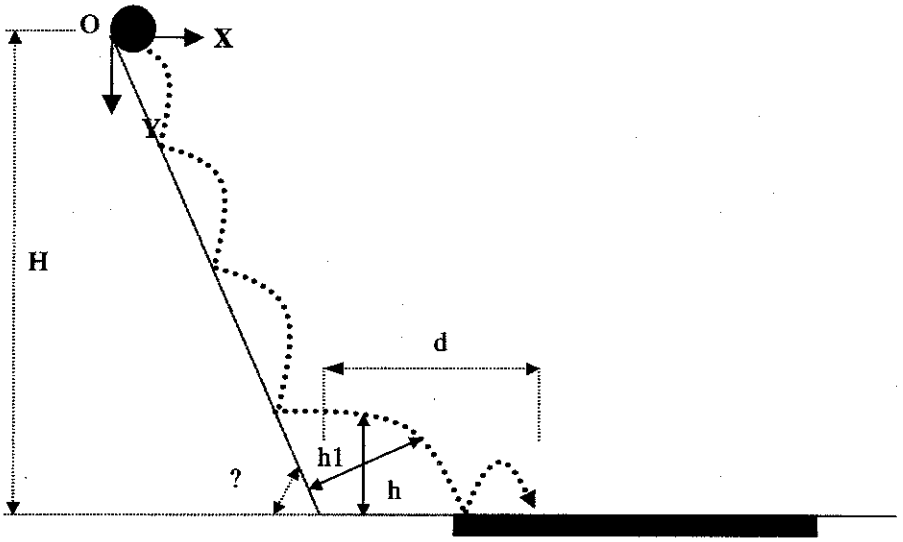
Figure 4.3.1 Cost Estimation System

3) Record of database and investigation of efficiency

It is necessary to record database of cost for reasonable estimation. The cost estimate standard is made investigating the efficiency of countermeasure works.

APPENDIX-1

◇Relation of Diameter and Jumping qt., Rolling qt.



Hmax=Bigger value of h1 and h2 is adopted

Item		Mark	Value	Remark
Rudius of Falling Boulder	m	r	-	—
Resistance Coefficient	—	Ck	0.100	Test Data
Resistance Coefficient of Air	—	ak	0.001	Doctrine Value
Coefficient of Equivarence Friction: μ	Avarage	m	0.690	Test Data (Random Number)
	Standard Deviation	ρ	0.180	
Repulsive Coefficient: e	Avarage	m	0.275	Test Data (Random Number)
	Standard Deviation	ρ	0.280	
Damping Coefficient: p	Avarage	m	0.580	Test Data (Random Number)
	Standard Deviation	ρ	0.250	
Critical Speed: Vcr	Avarage	m	4.690	Test Data (Random Number)
	Standard Deviation	ρ	2.020	

The Used Analytic Model

The Evaluation of the Impacting Force of Prevention Structure for Rock Falling in consideration of the Slope Condition Structure engineering collected paper Vol.37A.

Reference Data Except for the Above .

One Approch to The Rational Design of Prevension Structure for Rock Falling
Symposium Collected Paper about The Impact Force by the Rock Falling and so on
The Impact Force Evaluation and Application of the Prevension Structure in consideration of the Slope Condition
Symposium Collected Paper about The Impact Force by the Rock Falling
The Evaluation Method that the Energy of Falling Rock From Top of the Slope
Symposium Collected Paper about The Impact Force by the Rock Falling
The Consideration about the Movement Fixed Number of the Falling Rockl and the Jumping Quantity
Civil Constitute Collected Paper NO. 581/ IV -37
The Development of the Movement Analytic Method of the Falling Rock on the Slope
Structure Engineering Collected Paper Vol.43A

Diameter (m)		Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
	T=30°·H=10m	10	1	20.13	0.52	8.65	2.81
		10	2	20.13	0.38	11.21	2.81
		10	3	17.88	0.58	17.25	0.56
		10	4	20.13	0.40	6.32	2.81
		10	5	17.41	0.25	3.67	0.08
		10	6	20.13	0.47	7.15	2.81
		10	7	17.39	0.25	17.39	0.07
		10	8	17.39	0.36	3.40	0.06
		10	9	17.40	0.35	9.89	0.08
		10	10	17.37	0.25	16.50	0.05
			Ave	18.54	0.38	10.14	1.21
	T=30°·H=20m	20	1	34.69	0.52	31.16	0.05
		20	2	34.71	0.44	22.48	0.07
		20	3	40.13	0.25	30.82	5.49
		20	4	34.72	0.35	8.13	0.08
		20	5	34.72	0.25	28.92	0.08
		20	6	34.72	0.25	28.92	0.08
		20	7	34.67	0.33	4.34	0.03
		20	8	40.13	0.85	28.38	5.49
		20	9	40.13	0.36	19.43	5.49
		20	10	34.72	0.54	8.11	0.08
			Ave	36.33	0.41	21.07	1.69
	T=30°·H=30m	30	1	52.08	0.26	3.20	0.12
		30	2	52.19	0.41	23.26	0.23
		30	3	0.12	0.00	-	0.00
		30	4	52.11	0.41	5.43	0.15
		30	5	52.34	0.41	15.95	0.38
f=0.5m		30	6	52.08	0.34	2.01	0.12
		30	7	52.09	0.45	11.76	0.13
		30	8	55.13	0.25	33.62	3.17
		30	9	52.11	0.57	17.85	0.15
		30	10	0.12	0.00	-	0.00
			Ave	42.04	0.31	14.13	0.44
	T=30°·H=40m	40	1	69.39	0.25	31.53	0.11
		40	2	69.40	0.36	6.48	0.12
		40	3	0.12	0.00	-	0.00
		40	4	69.79	0.49	11.83	0.51
		40	5	75.13	0.79	58.65	5.85
		40	6	75.13	0.62	62.22	5.85
		40	7	75.13	0.25	68.85	5.85
		40	8	69.42	0.60	7.60	0.14
		40	9	0.12	0.00	-	0.00
		40	10	69.41	0.58	56.48	0.13
			Ave	57.30	0.39	37.95	1.85
	T=30°·H=50m	50	1	86.94	0.65	71.62	0.34
		50	2	86.69	0.36	11.61	0.09
		50	3	0.12	0.00	-	0.00
		50	4	86.67	0.93	12.93	0.07
		50	5	86.69	0.38	7.04	0.08
		50	6	90.13	0.74	43.94	3.53
		50	7	86.96	0.66	35.45	0.36
		50	8	86.67	0.48	51.66	0.07
		50	9	87.30	0.85	63.97	0.69
		50	10	86.73	0.37	24.99	0.13
			Ave	78.49	0.54	35.91	0.54

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=40°·H=10m	10	1	15.17	0.25	11.97	3.25
	10	2	12.23	0.31	12.01	0.32
	10	3	15.17	0.25	3.11	3.25
	10	4	12.04	0.25	12.04	0.12
	10	5	11.99	0.25	11.99	0.08
	10	6	0.16	0.00	-	0.00
	10	7	15.17	0.25	7.04	3.25
	10	8	12.01	0.71	10.26	0.09
	10	9	15.17	0.39	4.18	3.25
	10	10	12.05	1.02	7.59	0.13
		Ave	12.12	0.37	8.91	1.38
T=40°·H=20m	20	1	30.17	0.76	11.94	6.34
	20	2	23.91	0.56	8.10	0.08
	20	3	23.89	0.25	23.34	0.06
	20	4	24.00	0.78	21.59	0.17
	20	5	23.92	0.35	4.06	0.08
	20	6	23.93	0.43	5.70	0.10
	20	7	23.92	0.25	23.92	0.09
	20	8	24.67	1.48	21.23	0.84
	20	9	0.16	0.00	-	0.00
	20	10	23.97	0.89	17.27	0.13
		Ave	22.26	0.58	15.24	0.79
T=40°·H=30m	30	1	36.07	0.90	28.14	0.32
	30	2	35.92	0.90	6.36	0.17
	30	3	0.16	0.00	-	0.00
	30	4	35.92	0.25	13.10	0.17
	30	5	35.91	0.80	33.34	0.16
	30	6	35.93	0.43	10.64	0.18
	30	7	40.17	0.52	33.24	4.42
	30	8	35.91	0.27	2.76	0.15
	30	9	35.95	0.60	5.58	0.20
	30	10	35.94	0.28	3.78	0.18
		Ave	32.79	0.49	15.22	0.60
T=40°·H=40m	40	1	48.43	1.25	45.64	0.76
	40	2	47.84	0.60	36.59	0.17
	40	3	48.29	0.90	46.36	0.62
	40	4	50.17	1.45	34.42	2.50
	40	5	47.85	0.50	41.94	0.18
	40	6	47.80	0.46	32.94	0.13
	40	7	48.06	0.86	15.65	0.39
	40	8	50.17	0.63	23.54	2.50
	40	9	47.84	0.25	46.99	0.17
	40	10	48.02	0.90	41.82	0.35
		Ave	48.45	0.78	36.59	0.78
T=40°·H=50m	50	1	65.17	0.25	59.68	5.58
	50	2	60.05	1.28	57.18	0.46
	50	3	59.73	0.35	31.16	0.14
	50	4	62.15	3.97	53.40	2.56
	50	5	0.16	0.00	-	0.00
	50	6	59.74	0.55	55.51	0.15
	50	7	59.69	0.45	36.79	0.11
	50	8	59.96	1.11	43.75	0.38
	50	9	59.93	1.14	22.61	0.35
	50	10	60.79	1.29	58.93	1.21
		Ave	54.74	1.04	46.56	1.09

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=50°·H=10m	10	1	8.82	0.81	6.60	0.42
	10	2	8.54	0.48	3.34	0.15
	10	3	10.88	2.10	9.98	2.49
	10	4	10.65	1.97	9.74	2.26
	10	5	11.22	2.30	9.88	2.83
	10	6	8.55	0.51	4.13	0.16
	10	7	8.57	0.61	2.57	0.18
	10	8	8.75	0.86	6.25	0.36
	10	9	10.72	1.41	9.41	2.33
	10	10	8.53	0.28	3.88	0.14
		Ave	9.52	1.13	6.58	1.13
T=50°·H=20m	20	1	20.21	0.36	9.55	3.43
	20	2	19.53	1.31	17.75	2.75
	20	3	16.95	1.01	4.49	0.16
	20	4	16.97	1.05	5.71	0.19
	20	5	16.97	1.35	6.84	0.19
	20	6	17.03	0.48	10.88	0.25
	20	7	17.06	1.25	13.11	0.28
	20	8	16.92	0.95	7.43	0.14
	20	9	16.94	0.29	2.91	0.15
	20	10	16.95	0.25	1.51	0.17
		Ave	17.55	0.83	8.02	0.77
T=50°·H=30m	30	1	26.28	2.34	9.69	1.11
	30	2	27.71	2.36	24.78	2.53
	30	3	25.79	1.20	23.02	0.62
	30	4	25.99	1.58	19.91	0.82
	30	5	25.47	0.49	18.00	0.29
	30	6	26.02	1.17	15.07	0.85
	30	7	30.21	1.04	15.21	5.04
	30	8	25.43	0.96	19.01	0.26
	30	9	25.64	0.72	2.79	0.46
	30	10	26.52	1.23	25.83	1.34
		Ave	26.50	1.31	17.33	1.33
T=50°·H=40m	40	1	34.65	0.78	28.38	1.08
	40	2	33.76	0.27	1.75	0.19
	40	3	33.77	0.69	3.10	0.21
	40	4	34.06	0.87	6.02	0.50
	40	5	35.27	2.18	21.92	1.70
	40	6	33.73	0.51	1.69	0.16
	40	7	34.10	1.04	16.27	0.54
	40	8	33.89	1.54	28.86	0.33
	40	9	34.85	2.08	21.13	1.29
	40	10	34.10	1.82	26.59	0.53
		Ave	34.22	1.18	15.57	0.65
T=50°·H=50m	50	1	43.04	1.91	37.54	1.08
	50	2	42.52	3.12	23.10	0.56
	50	3	42.21	1.61	22.47	0.25
	50	4	42.91	1.80	39.72	0.96
	50	5	42.13	0.81	5.39	0.18
	50	6	48.66	5.54	44.61	6.70
	50	7	42.13	0.26	1.59	0.18
	50	8	42.20	0.61	9.42	0.24
	50	9	42.61	1.36	15.36	0.65
	50	10	42.17	0.81	5.20	0.22
		Ave	43.06	1.78	20.44	1.10

Diameter (m)		Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
	T=30°·H=10m	10	1	17.54	0.50	16.77	0.22
		10	2	17.51	0.55	13.72	0.19
		10	3	17.48	0.53	8.52	0.16
		10	4	17.54	0.95	8.81	0.22
		10	5	17.48	0.69	8.21	0.16
		10	6	20.26	0.61	13.84	2.94
		10	7	17.52	0.93	12.05	0.20
		10	8	17.50	0.59	12.52	0.18
		10	9	17.45	0.62	8.56	0.12
		10	10	17.50	0.70	11.91	0.18
			Ave	17.78	0.67	11.49	0.46
	T=30°·H=20m	20	1	34.76	0.63	33.65	0.12
		20	2	34.79	0.75	11.69	0.15
		20	3	34.77	0.50	7.98	0.12
		20	4	34.85	0.50	29.04	0.20
		20	5	34.76	0.63	3.38	0.12
		20	6	34.74	0.63	31.88	0.09
		20	7	34.83	0.67	26.99	0.19
		20	8	40.26	0.80	9.05	5.62
		20	9	34.83	0.51	2.28	0.19
		20	10	34.76	0.50	34.76	0.12
			Ave	35.33	0.61	19.07	0.69
	T=30°·H=30m	30	1	55.26	0.50	43.48	3.30
		30	2	55.26	0.50	43.48	3.30
		30	3	52.22	0.75	16.44	0.26
		30	4	52.47	0.81	45.00	0.51
		30	5	52.19	0.62	38.02	0.23
f=1.0m		30	6	0.25	0.00	-	0.00
		30	7	55.26	0.50	43.48	3.30
		30	8	52.18	0.87	43.03	0.22
		30	9	55.26	0.98	48.01	3.30
		30	10	52.15	0.66	43.91	0.19
			Ave	48.25	0.62	40.54	1.46
	T=30°·H=40m	40	1	69.51	1.13	63.64	0.23
		40	2	69.45	0.57	62.44	0.17
		40	3	69.47	1.12	36.70	0.19
		40	4	75.26	0.66	35.93	5.98
		40	5	0.25	0.00		0.00
		40	6	69.46	0.57	45.96	0.18
		40	7	69.47	0.69	10.66	0.19
		40	8	69.44	0.82	29.21	0.16
		40	9	0.25	0.00		0.00
		40	10	69.49	0.74	11.99	0.21
			Ave	56.21	0.63	37.07	0.73
	T=30°·H=50m	50	1	86.78	1.02	12.71	0.18
		50	2	86.79	0.50	12.70	0.19
		50	3	86.77	0.60	68.49	0.17
		50	4	90.26	0.90	44.80	3.66
		50	5	86.83	0.50	18.62	0.23
		50	6	90.26	1.13	73.30	3.66
		50	7	86.83	0.50	18.62	0.23
		50	8	86.83	0.50	18.62	0.23
		50	9	86.78	0.81	7.97	0.17
		50	10	86.76	0.99	18.06	0.16
			Ave	87.49	0.75	29.39	0.89

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=40°·H=10m	10	1	12.27	0.70	2.20	0.35
	10	2	12.29	0.77	11.16	0.37
	10	3	12.12	0.53	9.11	0.20
	10	4	12.19	0.52	9.69	0.27
	10	5	12.14	0.50	4.01	0.22
	10	6	0.32	0.00	-	0.00
	10	7	12.09	0.71	5.31	0.17
	10	8	13.18	1.15	12.56	1.27
	10	9	12.21	0.98	7.67	0.29
	10	10	12.09	0.65	10.35	0.17
		Ave	11.09	0.65	8.01	0.33
T=40°·H=20m	20	1	24.28	1.65	20.99	0.44
	20	2	0.32	0.00	-	0.00
	20	3	24.05	0.50	5.78	0.21
	20	4	24.05	0.57	22.56	0.22
	20	5	23.99	0.72	19.21	0.15
	20	6	0.32	0.00	-	0.00
	20	7	0.32	0.00	-	0.00
	20	8	24.09	0.92	16.84	0.26
	20	9	30.34	1.07	12.92	6.51
	20	10	24.09	0.50	22.68	0.26
		Ave	17.59	0.59	17.28	0.81
T=40°·H=30m	30	1	36.07	0.90	17.43	0.31
	30	2	40.34	0.92	20.09	4.59
	30	3	35.98	0.50	13.43	0.23
	30	4	36.07	0.69	18.87	0.31
	30	5	36.04	0.73	14.18	0.29
	30	6	36.04	0.65	5.23	0.29
	30	7	36.05	0.68	29.25	0.29
	30	8	36.07	0.71	33.69	0.32
	30	9	36.03	0.68	24.92	0.27
	30	10	36.03	0.96	12.04	0.28
		Ave	36.47	0.74	18.91	0.72
T=40°·H=40m	40	1	50.34	1.30	12.05	2.67
	40	2	47.95	0.50	44.99	0.28
	40	3	47.96	0.50	42.18	0.29
	40	4	49.34	1.36	48.46	1.67
	40	5	49.62	1.54	42.31	1.95
	40	6	48.64	0.99	48.30	0.97
	40	7	47.95	0.54	3.12	0.28
	40	8	48.10	0.96	31.95	0.43
	40	9	47.91	0.79	15.67	0.24
	40	10	50.34	1.08	10.41	2.67
		Ave	48.82	0.96	29.95	1.15
T=40°·H=50m	50	1	59.83	0.50	58.24	0.24
	50	2	61.11	1.32	41.23	1.52
	50	3	59.81	0.50	57.69	0.22
	50	4	59.87	0.61	56.48	0.29
	50	5	59.83	1.17	52.78	0.24
	50	6	62.07	1.62	60.56	2.49
	50	7	59.90	0.76	17.18	0.31
	50	8	65.34	0.58	42.20	5.75
	50	9	61.07	1.91	57.98	1.48
	50	10	59.85	0.97	25.39	0.26
		Ave	60.87	1.00	46.98	1.28

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=50°·H=10m	10	1	8.68	0.50	1.36	0.29
	10	2	8.96	0.75	8.91	0.57
	10	3	8.65	0.96	6.39	0.26
	10	4	8.93	0.98	2.73	0.54
	10	5	8.91	0.69	8.82	0.52
	10	6	8.67	0.58	5.79	0.28
	10	7	8.89	0.73	4.88	0.50
	10	8	9.01	0.77	8.95	0.62
	10	9	8.65	0.77	2.31	0.26
	10	10	9.00	0.84	7.41	0.61
		Ave	8.84	0.76	5.75	0.44
T=50°·H=20m	20	1	17.92	1.11	17.35	1.14
	20	2	17.70	1.24	16.03	0.92
	20	3	17.52	0.90	16.98	0.74
	20	4	17.11	1.58	8.69	0.33
	20	5	17.13	0.88	5.84	0.35
	20	6	17.04	0.77	2.84	0.26
	20	7	18.81	1.99	17.65	2.02
	20	8	17.80	1.59	14.73	1.02
	20	9	17.12	0.95	13.13	0.34
	20	10	17.18	1.16	3.73	0.40
		Ave	17.53	1.22	11.70	0.75
T=50°·H=30m	30	1	26.12	1.40	24.06	0.95
	30	2	25.50	0.79	2.71	0.32
	30	3	27.47	2.77	23.34	2.29
	30	4	26.22	1.81	23.45	1.05
	30	5	25.52	0.80	10.47	0.34
	30	6	25.59	0.82	5.52	0.41
	30	7	25.79	0.85	9.91	0.62
	30	8	25.78	1.14	8.42	0.61
	30	9	26.49	1.34	25.91	1.31
	30	10	25.52	0.58	7.54	0.34
		Ave	26.00	1.23	14.13	0.83
T=50°·H=40m	40	1	33.85	0.82	24.38	0.28
	40	2	36.98	2.15	34.70	3.41
	40	3	34.44	1.57	22.57	0.88
	40	4	33.86	0.69	6.71	0.30
	40	5	34.22	1.56	25.31	0.66
	40	6	34.51	1.01	34.33	0.95
	40	7	34.73	2.46	21.51	1.16
	40	8	33.90	2.20	10.89	0.33
	40	9	33.84	0.81	21.30	0.28
	40	10	36.83	3.32	33.25	3.26
		Ave	34.71	1.66	23.49	1.15
T=50°·H=50m	50	1	42.28	0.80	3.95	0.32
	50	2	44.48	2.00	43.45	2.52
	50	3	42.28	1.82	17.69	0.32
	50	4	44.24	2.08	43.47	2.28
	50	5	42.39	1.20	30.98	0.43
	50	6	45.77	5.82	35.70	3.82
	50	7	42.26	1.67	7.26	0.31
	50	8	44.41	2.49	41.72	2.45
	50	9	42.28	2.44	36.31	0.32
	50	10	42.47	1.15	14.76	0.52
		Ave	43.28	2.15	27.53	1.33

Diameter (m)		Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
	T=30°·H=10m	10	1	20.39	0.77	10.48	3.07
		10	2	17.75	0.85	10.83	0.43
		10	3	18.12	1.04	17.62	0.80
		10	4	17.51	0.75	14.53	0.19
		10	5	17.51	0.88	11.46	0.18
		10	6	17.50	0.99	11.81	0.18
		10	7	17.56	1.05	7.08	0.24
		10	8	17.50	0.75	17.30	0.18
		10	9	17.61	0.89	10.30	0.29
		10	10	17.52	0.88	4.01	0.20
			Ave	17.90	0.88	11.54	0.58
	T=30°·H=20m	20	1	35.33	1.13	18.30	0.69
		20	2	34.93	1.16	28.74	0.29
		20	3	0.38	0.00	-	0.00
		20	4	34.91	0.98	20.37	0.27
		20	5	34.89	0.99	13.77	0.25
		20	6	34.89	0.80	10.80	0.25
		20	7	0.38	0.00	-	0.00
		20	8	35.05	0.82	33.49	0.41
		20	9	34.97	0.75	28.99	0.33
		20	10	0.37	0.00	-	0.00
			Ave	24.61	0.66	22.06	0.25
	T=30°·H=30m	30	1	52.31	1.27	19.65	0.35
		30	2	0.37	0.00	-	0.00
		30	3	52.20	0.86	5.86	0.24
		30	4	52.31	0.86	39.43	0.35
		30	5	52.27	1.04	26.61	0.31
f=1.5m		30	6	52.53	1.09	44.84	0.57
		30	7	52.34	0.75	43.44	0.37
		30	8	60.39	1.02	23.60	8.43
		30	9	52.23	0.75	48.29	0.27
		30	10	0.37	0.00	-	0.00
			Ave	42.73	0.76	31.47	1.09
	T=30°·H=40m	40	1	69.93	1.17	31.56	0.65
		40	2	69.55	0.75	51.80	0.26
		40	3	69.53	1.19	19.48	0.25
		40	4	0.37	0.00	-	0.00
		40	5	0.37	0.00	-	0.00
		40	6	69.64	1.15	42.14	0.36
		40	7	69.55	0.75	51.80	0.26
		40	8	69.55	0.75	51.80	0.26
		40	9	69.55	0.75	51.80	0.26
		40	10	69.57	1.29	12.83	0.29
			Ave	55.76	0.78	39.15	0.26
	T=30°·H=50m	50	1	87.47	1.38	39.22	0.87
		50	2	86.88	0.97	17.80	0.28
		50	3	86.86	0.87	36.83	0.26
		50	4	86.88	1.43	60.05	0.27
		50	5	86.96	0.88	35.53	0.36
		50	6	86.82	0.96	22.91	0.21
		50	7	86.91	1.10	71.92	0.31
		50	8	86.97	0.85	21.18	0.36
		50	9	86.80	1.17	8.11	0.20
		50	10	86.92	0.75	74.42	0.32
			Ave	86.95	1.04	38.80	0.34

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=40°·H=10m	10	1	12.36	0.75	5.37	0.44
	10	2	12.22	0.75	9.77	0.31
	10	3	12.20	0.75	11.96	0.28
	10	4	12.29	0.75	11.27	0.38
	10	5	12.25	0.75	11.28	0.34
	10	6	12.22	0.75	7.78	0.30
	10	7	12.21	0.75	4.30	0.29
	10	8	12.21	0.75	11.15	0.29
	10	9	0.48	0.00		0.00
	10	10	12.20	0.75	11.81	0.29
		Ave	11.06	0.68	9.41	0.29
T=40°·H=20m	20	1	24.13	1.14	16.05	0.30
	20	2	24.12	0.94	9.28	0.28
	20	3	24.15	0.75	7.78	0.31
	20	4	24.11	0.84	16.55	0.27
	20	5	24.20	1.27	5.82	0.36
	20	6	24.10	0.75	24.10	0.27
	20	7	24.08	1.11	20.25	0.24
	20	8	0.48	0.00		0.00
	20	9	24.14	0.90	19.36	0.31
	20	10	24.22	0.80	17.63	0.38
		Ave	21.77	0.85	15.20	0.27
T=40°·H=30m	30	1	36.09	1.14	26.21	0.34
	30	2	36.08	1.02	15.65	0.33
	30	3	36.17	0.93	30.65	0.41
	30	4	36.08	0.75	35.45	0.33
	30	5	36.14	1.21	33.31	0.39
	30	6	36.42	1.13	13.29	0.67
	30	7	36.16	0.75	31.29	0.40
	30	8	0.48	0.00		0.00
	30	9	36.08	1.90	23.52	0.32
	30	10	36.82	1.31	10.13	1.07
		Ave	32.65	1.01	24.39	0.43
T=40°·H=40m	40	1	48.26	1.03	21.86	0.59
	40	2	0.48	0.00		0.00
	40	3	48.04	1.26	32.56	0.37
	40	4	48.09	1.65	40.55	0.42
	40	5	48.08	1.00	6.61	0.41
	40	6	48.10	1.00	8.25	0.43
	40	7	47.99	0.75	28.03	0.32
	40	8	48.06	0.75	12.74	0.39
	40	9	48.45	1.20	47.60	0.78
	40	10	48.21	1.06	30.49	0.54
		Ave	43.38	0.97	25.41	0.42
T=40°·H=50m	50	1	60.82	1.76	24.59	1.23
	50	2	59.98	1.65	14.37	0.39
	50	3	59.91	0.75	47.49	0.32
	50	4	59.98	0.75	2.93	0.39
	50	5	0.48	0.00		0.00
	50	6	59.90	0.76	5.63	0.31
	50	7	59.93	1.15	51.55	0.34
	50	8	59.89	0.75	47.86	0.31
	50	9	59.90	0.75	10.11	0.31
	50	10	59.94	0.96	39.12	0.35
		Ave	54.07	0.93	27.07	0.40

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=50°·H=10m	10	1	9.73	1.63	8.75	1.34
	10	2	8.88	1.06	8.00	0.49
	10	3	8.83	0.90	4.89	0.44
	10	4	9.11	0.96	6.46	0.71
	10	5	10.16	1.87	9.58	1.77
	10	6	8.86	1.04	8.06	0.47
	10	7	10.99	2.31	9.99	2.60
	10	8	8.84	0.76	1.67	0.45
	10	9	9.03	1.24	4.32	0.64
	10	10	9.07	1.19	5.62	0.68
		Ave	9.35	1.30	6.73	0.96
T=50°·H=20m	20	1	20.75	3.34	19.10	3.97
	20	2	17.24	1.94	12.70	0.46
	20	3	17.20	1.05	8.01	0.41
	20	4	17.19	1.18	8.76	0.40
	20	5	17.21	1.55	12.39	0.43
	20	6	17.73	2.44	13.94	0.95
	20	7	17.16	1.31	8.29	0.38
	20	8	17.63	2.72	12.94	0.84
	20	9	17.25	1.64	7.57	0.47
	20	10	17.19	1.06	11.54	0.41
		Ave	17.65	1.82	11.52	0.87
T=50°·H=30m	30	1	27.53	2.20	26.99	2.36
	30	2	25.80	0.90	24.81	0.62
	30	3	25.57	1.35	12.65	0.40
	30	4	25.96	1.59	11.83	0.79
	30	5	25.57	0.97	7.35	0.40
	30	6	25.56	1.09	6.43	0.39
	30	7	25.92	1.13	19.80	0.75
	30	8	26.17	1.27	25.54	0.99
	30	9	25.99	1.47	4.61	0.82
	30	10	25.60	1.07	7.71	0.43
		Ave	25.97	1.30	14.73	0.79
T=50°·H=40m	40	1	36.24	2.98	33.60	2.67
	40	2	34.14	1.36	3.99	0.58
	40	3	34.35	3.62	23.52	0.78
	40	4	33.99	1.08	2.24	0.43
	40	5	34.35	1.84	30.40	0.79
	40	6	33.97	1.49	11.51	0.40
	40	7	34.47	2.44	21.84	0.90
	40	8	34.53	1.57	4.41	0.97
	40	9	34.33	1.68	24.06	0.76
	40	10	34.16	2.06	28.04	0.59
		Ave	34.45	2.01	18.36	0.89
T=50°·H=50m	50	1	42.99	2.72	24.72	1.03
	50	2	47.35	4.57	44.78	5.40
	50	3	43.48	2.38	22.53	1.52
	50	4	42.46	2.51	32.39	0.50
	50	5	42.49	2.21	9.28	0.53
	50	6	44.04	1.89	28.52	2.08
	50	7	42.46	1.05	32.41	0.50
	50	8	50.54	5.89	44.58	8.58
	50	9	42.67	1.74	6.18	0.72
	50	10	43.62	2.57	39.21	1.67
		Ave	44.21	2.75	28.46	2.25

Diameter (m): f=2.0m

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=30°·H=10m	10	1	17.61	1.15	5.39	0.29
	10	2	17.69	1.20	14.52	0.37
	10	3	17.67	1.01	15.53	0.35
	10	4	17.67	1.00	16.42	0.35
	10	5	17.66	1.06	10.33	0.34
	10	6	17.72	1.08	2.38	0.40
	10	7	17.59	1.08	9.46	0.27
	10	8	17.58	1.07	2.38	0.26
	10	9	17.72	1.10	11.54	0.40
	10	10	17.59	1.00	16.76	0.27
		Ave	17.65	1.07	10.47	0.33
T=30°·H=20m	20	1	34.90	1.00	30.21	0.26
	20	2	35.20	1.17	4.17	0.56
	20	3	34.90	1.23	27.04	0.26
	20	4	34.90	1.00	30.21	0.26
	20	5	35.21	1.17	11.29	0.57
	20	6	35.00	1.17	3.80	0.36
	20	7	34.89	1.00	14.06	0.24
	20	8	34.89	1.14	16.52	0.25
	20	9	34.91	1.28	30.03	0.26
	20	10	35.04	1.23	20.98	0.40
		Ave	34.98	1.14	18.83	0.34
T=30°·H=30m	30	1	52.31	1.00	51.13	0.35
	30	2	52.28	1.11	7.60	0.32
	30	3	52.37	1.03	37.02	0.41
	30	4	52.29	1.01	51.53	0.33
	30	5	52.28	1.20	33.32	0.32
	30	6	52.34	1.05	41.80	0.38
	30	7	52.46	1.53	41.54	0.50
	30	8	52.39	1.12	7.35	0.43
	30	9	52.29	1.12	51.31	0.33
	30	10	52.35	1.14	26.45	0.39
		Ave	52.33	1.13	34.90	0.37
T=30°·H=40m	40	1	69.69	1.11	6.44	0.41
	40	2	69.62	1.08	23.97	0.34
	40	3	69.74	1.50	12.95	0.46
	40	4	69.70	1.43	56.80	0.42
	40	5	69.62	1.27	20.79	0.34
	40	6	69.67	1.10	47.49	0.39
	40	7	69.64	1.27	36.96	0.35
	40	8	69.74	1.30	46.88	0.46
	40	9	69.63	1.10	9.05	0.35
	40	10	69.67	1.00	49.22	0.39
		Ave	69.67	1.22	31.05	0.39
T=30°·H=50m	50	1	86.97	1.07	47.21	0.37
	50	2	86.96	1.13	9.05	0.36
	50	3	86.94	1.30	79.09	0.34
	50	4	86.97	1.13	42.91	0.37
	50	5	86.95	1.11	11.04	0.35
	50	6	86.91	1.09	7.27	0.30
	50	7	86.95	1.11	21.94	0.35
	50	8	87.03	1.16	13.29	0.42
	50	9	87.07	1.32	36.06	0.47
	50	10	87.28	1.48	75.55	0.67
		Ave	87.00	1.19	34.34	0.40

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=40°·H=10m	10	1	12.30	1.00	12.30	0.38
	10	2	12.29	1.18	11.64	0.37
	10	3	12.29	1.00	11.02	0.37
	10	4	12.34	1.06	5.70	0.43
	10	5	12.85	1.80	10.69	0.93
	10	6	12.32	1.10	10.28	0.41
	10	7	12.28	1.00	6.27	0.37
	10	8	12.28	1.00	10.81	0.37
	10	9	12.40	1.30	8.40	0.48
	10	10	12.29	1.20	9.59	0.37
		Ave	12.37	1.16	9.67	0.45
T=40°·H=20m	20	1	24.52	1.38	23.61	0.68
	20	2	24.37	1.25	21.52	0.54
	20	3	24.18	1.96	18.81	0.34
	20	4	24.27	1.30	17.04	0.44
	20	5	24.27	1.25	5.47	0.44
	20	6	24.18	1.39	13.51	0.34
	20	7	24.51	1.24	14.23	0.68
	20	8	24.18	1.12	16.44	0.34
	20	9	24.53	1.42	12.23	0.69
	20	10	24.18	1.17	2.74	0.34
		Ave	24.32	1.35	14.56	0.48
T=40°·H=30m	30	1	36.37	1.55	34.60	0.62
	30	2	36.32	1.00	28.11	0.57
	30	3	36.17	1.00	35.82	0.41
	30	4	36.27	1.38	13.07	0.52
	30	5	36.24	1.65	27.53	0.48
	30	6	36.26	1.15	14.26	0.50
	30	7	36.53	1.29	17.22	0.77
	30	8	36.21	1.37	20.35	0.46
	30	9	36.75	1.59	34.79	1.00
	30	10	36.19	1.30	15.11	0.44
		Ave	36.33	1.33	24.09	0.58
T=40°·H=40m	40	1	48.16	1.19	9.62	0.49
	40	2	48.65	1.42	31.11	0.98
	40	3	48.11	1.83	45.36	0.44
	40	4	48.13	1.33	6.98	0.46
	40	5	48.37	2.02	35.52	0.70
	40	6	48.16	1.74	31.76	0.49
	40	7	48.16	1.92	23.61	0.49
	40	8	48.21	1.99	18.28	0.53
	40	9	48.71	1.72	44.13	1.04
	40	10	48.16	1.18	10.20	0.49
		Ave	48.28	1.63	25.66	0.61
T=40°·H=50m	50	1	60.15	1.79	34.30	0.56
	50	2	60.07	1.77	8.80	0.48
	50	3	60.42	3.49	29.33	0.83
	50	4	60.07	1.23	18.88	0.48
	50	5	61.12	1.86	39.63	1.53
	50	6	59.97	1.00	16.17	0.38
	50	7	60.01	1.00	20.38	0.43
	50	8	59.97	1.20	18.13	0.38
	50	9	60.07	1.74	32.83	0.48
	50	10	60.26	1.94	54.90	0.67
		Ave	60.21	1.70	27.33	0.62

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=50°·H=10m	10	1	9.37	1.38	8.70	0.98
	10	2	8.95	1.09	4.60	0.56
	10	3	8.90	1.18	7.39	0.50
	10	4	9.31	1.33	8.52	0.92
	10	5	8.98	1.25	4.74	0.59
	10	6	10.30	2.02	9.83	1.91
	10	7	9.32	1.76	7.29	0.93
	10	8	9.39	1.97	6.37	1.00
	10	9	8.95	1.56	7.06	0.56
	10	10	9.16	1.19	8.91	0.77
		Ave	9.26	1.47	7.34	0.87
T=50°·H=20m	20	1	17.36	1.02	10.59	0.58
	20	2	18.16	3.06	9.90	1.37
	20	3	17.53	2.08	9.21	0.75
	20	4	17.42	1.27	16.36	0.64
	20	5	17.30	2.16	9.39	0.51
	20	6	17.56	1.59	7.46	0.78
	20	7	19.96	2.68	17.82	3.18
	20	8	17.39	1.74	15.24	0.61
	20	9	17.98	1.61	9.54	1.19
	20	10	17.30	1.43	15.81	0.52
		Ave	17.80	1.87	12.13	1.01
T=50°·H=30m	30	1	28.12	3.22	25.60	2.95
	30	2	25.75	1.89	5.33	0.57
	30	3	26.21	1.95	9.63	1.04
	30	4	25.83	2.33	17.88	0.66
	30	5	25.69	1.69	9.44	0.52
	30	6	25.68	1.35	11.13	0.51
	30	7	26.56	2.21	10.07	1.39
	30	8	25.69	1.43	9.43	0.52
	30	9	25.68	1.40	15.96	0.51
	30	10	27.56	2.48	12.85	2.39
		Ave	26.28	1.99	12.73	1.10
T=50°·H=40m	40	1	35.64	2.04	19.00	2.08
	40	2	34.54	1.39	32.78	0.98
	40	3	34.53	2.94	23.57	0.96
	40	4	37.54	3.24	35.22	3.98
	40	5	34.21	2.03	22.91	0.65
	40	6	34.17	2.46	21.76	0.61
	40	7	34.93	1.68	34.57	1.37
	40	8	34.10	2.07	26.33	0.53
	40	9	36.02	3.04	32.01	2.46
	40	10	34.22	3.06	17.98	0.66
		Ave	34.99	2.40	26.61	1.43
T=50°·H=50m	50	1	42.89	2.15	14.21	0.94
	50	2	44.25	2.95	40.51	2.30
	50	3	42.84	1.68	22.12	0.89
	50	4	44.21	2.40	43.29	2.25
	50	5	42.85	1.44	16.64	0.89
	50	6	45.70	6.17	35.95	3.74
	50	7	42.64	1.34	13.19	0.68
	50	8	43.80	3.03	15.50	1.85
	50	9	43.38	3.26	28.82	1.43
	50	10	42.52	1.25	6.43	0.56
		Ave	43.51	2.57	23.66	1.35

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	X Co.	Rolling qt. d(m)
T=60°·H=10m	10	1	6.81	1.42	4.93	1.03
	10	2	6.35	1.09	4.85	0.57
	10	3	6.80	1.10	5.76	1.03
	10	4	5.95	0.37	3.26	0.18
	10	5	6.59	1.11	4.93	0.81
	10	6	5.98	0.41	2.26	0.21
	10	7	6.42	0.73	5.99	0.65
	10	8	7.82	2.14	6.29	2.05
	10	9	8.04	2.04	7.53	2.27
	10	10	6.30	0.83	5.14	0.52
		Ave	6.71	1.12	5.10	0.93
T=60°·H=20m	20	1	11.66	0.27	1.26	0.11
	20	2	12.18	1.08	10.81	0.64
	20	3	14.47	3.21	11.58	2.93
	20	4	11.65	0.60	1.68	0.11
	20	5	11.66	0.86	3.94	0.11
	20	6	11.66	0.77	1.86	0.11
	20	7	11.87	0.98	2.84	0.32
	20	8	11.65	1.17	7.26	0.10
	20	9	12.27	0.78	12.17	0.72
	20	10	11.66	0.27	1.96	0.11
		Ave	12.07	1.00	5.54	0.53
T=60°·H=30m	30	1	26.17	4.34	20.25	8.85
	30	2	17.52	0.49	1.38	0.20
	30	3	17.74	0.82	9.66	0.42
	30	4	20.24	2.93	17.26	2.92
	30	5	20.53	3.34	17.37	3.21
	30	6	17.46	0.69	2.40	0.14
	30	7	18.61	2.02	15.69	1.29
	30	8	23.34	4.98	19.85	6.02
	30	9	17.47	0.45	1.36	0.15
	30	10	17.43	3.08	10.71	0.11
		Ave	19.65	2.31	11.59	2.33
T=60°·H=40m	40	1	26.52	2.69	24.90	3.42
	40	2	27.08	3.17	24.93	3.99
	40	3	23.29	0.51	4.16	0.19
	40	4	24.06	1.23	13.34	0.97
	40	5	23.33	0.42	1.43	0.24
	40	6	27.06	2.98	24.89	3.97
	40	7	23.49	1.63	7.58	0.40
	40	8	23.71	0.76	5.87	0.61
	40	9	25.28	3.67	19.80	2.18
	40	10	23.85	1.51	11.38	0.76
		Ave	24.77	1.86	13.83	1.67
T=60°·H=50m	50	1	36.47	12.69	30.46	7.60
	50	2	29.29	2.60	22.47	0.42
	50	3	29.07	1.04	6.03	0.20
	50	4	29.07	0.88	18.42	0.20
	50	5	29.47	3.00	17.27	0.60
	50	6	29.30	2.56	22.04	0.43
	50	7	29.08	0.51	1.63	0.21
	50	8	29.83	1.51	8.38	0.96
	50	9	29.06	1.22	13.32	0.19
	50	10	29.05	0.46	3.72	0.18
		Ave	29.97	2.65	14.38	1.10

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	X Co.	Rolling qt. d(m)
T=70°·H=10m	10	1	5.78	1.35	4.80	2.14
	10	2	4.39	1.06	3.14	0.75
	10	3	3.97	0.76	2.89	0.33
	10	4	4.97	1.44	4.21	1.33
	10	5	5.46	1.83	4.81	1.82
	10	6	7.04	3.78	5.19	3.40
	10	7	3.97	0.59	1.57	0.33
	10	8	5.30	1.62	4.82	1.66
	10	9	5.97	1.81	4.73	2.33
	10	10	4.50	1.08	3.42	0.86
		Ave	5.14	1.53	3.96	1.50
T=70°·H=20m	20	1	8.53	2.05	5.59	1.25
	20	2	7.49	0.36	0.93	0.21
	20	3	8.55	1.79	5.88	1.27
	20	4	8.52	2.12	5.42	1.24
	20	5	9.65	2.47	7.91	2.38
	20	6	7.88	0.84	6.49	0.60
	20	7	7.91	1.16	2.52	0.63
	20	8	7.67	1.37	4.45	0.39
	20	9	11.44	3.34	9.84	4.16
	20	10	11.42	3.73	9.80	4.14
		Ave	8.91	1.92	5.88	1.63
T=70°·H=30m	30	1	14.17	3.63	11.04	3.25
	30	2	11.61	1.69	3.83	0.69
	30	3	12.98	2.20	11.73	2.06
	30	4	13.41	2.29	13.01	2.49
	30	5	11.68	2.06	7.28	0.76
	30	6	11.72	1.77	4.28	0.81
	30	7	13.16	3.51	8.57	2.25
	30	8	16.88	5.89	14.69	5.96
	30	9	12.41	1.46	12.16	1.49
	30	10	11.95	1.12	5.26	1.03
		Ave	13.00	2.56	9.18	2.08
T=70°·H=40m	40	1	17.43	2.73	17.12	2.87
	40	2	16.47	3.05	12.23	1.91
	40	3	17.71	3.31	15.57	3.15
	40	4	17.04	4.22	10.87	2.48
	40	5	15.05	2.89	7.34	0.50
	40	6	14.93	0.84	5.59	0.37
	40	7	15.49	2.13	6.01	0.93
	40	8	19.44	4.60	18.82	4.88
	40	9	19.97	4.14	18.44	5.41
	40	10	15.42	1.22	13.97	0.86
		Ave	16.90	2.91	12.60	2.34
T=70°·H=50m	50	1	18.39	0.88	2.02	0.19
	50	2	18.42	0.68	4.07	0.22
	50	3	25.82	5.41	23.10	7.62
	50	4	18.70	3.16	7.68	0.50
	50	5	26.00	8.72	20.07	7.80
	50	6	19.13	0.94	18.99	0.93
	50	7	18.36	1.24	6.02	0.16
	50	8	20.51	2.65	17.73	2.31
	50	9	21.26	5.10	20.14	3.06
	50	10	20.54	3.19	15.45	2.34
		Ave	20.71	3.20	13.53	2.51

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	X Co.	Rolling qt. d(m)
T=80°·H=10m	10	1	5.95	3.49	4.87	4.19
	10	2	3.62	1.80	3.48	1.86
	10	3	2.43	0.66	2.43	0.67
	10	4	2.03	0.51	1.17	0.26
	10	5	3.86	2.06	3.78	2.10
	10	6	4.72	2.82	4.48	2.96
	10	7	5.75	3.29	4.86	3.99
	10	8	3.95	2.15	3.83	2.19
	10	9	3.06	1.28	3.06	1.29
	10	10	5.28	3.27	4.81	3.52
		Ave	4.07	2.13	3.68	2.30
T=80°·H=20m	20	1	4.07	1.05	2.55	0.54
	20	2	7.85	9.02	5.14	4.32
	20	3	4.42	1.07	3.45	0.89
	20	4	8.18	9.41	5.04	4.65
	20	5	5.04	1.56	4.95	1.52
	20	6	4.00	0.91	2.57	0.48
	20	7	7.99	8.31	5.22	4.46
	20	8	3.88	0.99	2.26	0.35
	20	9	7.24	7.15	5.21	3.72
	20	10	8.38	9.11	5.12	4.85
		Ave	6.10	4.86	4.15	2.58
T=80°·H=30m	30	1	10.24	4.84	9.92	4.95
	30	2	9.72	4.40	9.40	4.43
	30	3	9.84	4.51	9.69	4.55
	30	4	13.18	11.24	10.03	7.89
	30	5	6.37	1.84	3.86	1.08
	30	6	10.25	4.86	9.91	4.96
	30	7	8.57	3.26	8.48	3.28
	30	8	12.14	7.75	10.04	6.85
	30	9	8.04	2.92	6.53	2.75
	30	10	9.19	3.87	8.96	3.90
		Ave	9.75	4.95	8.68	4.46
T=80°·H=40m	40	1	17.33	24.61	10.12	10.28
	40	2	15.73	22.51	10.11	8.68
	40	3	7.33	0.27	1.36	0.27
	40	4	7.60	1.96	4.08	0.54
	40	5	8.80	2.69	5.54	1.75
	40	6	9.44	3.09	6.44	2.39
	40	7	12.78	12.39	10.16	5.73
	40	8	8.24	2.08	4.99	1.19
	40	9	19.19	14.69	10.40	12.14
	40	10	17.11	22.67	10.17	10.05
		Ave	12.36	10.70	7.34	5.30
T=80°·H=50m	50	1	9.01	0.33	0.94	0.19
	50	2	17.94	30.57	10.25	9.12
	50	3	12.80	16.67	10.01	3.98
	50	4	13.51	4.74	12.17	4.69
	50	5	15.61	28.02	10.17	6.79
	50	6	20.74	21.53	15.15	11.93
	50	7	14.39	23.18	10.08	5.58
	50	8	12.17	13.98	10.18	3.36
	50	9	13.97	5.22	12.45	5.15
	50	10	12.78	15.55	10.17	3.96
		Ave	14.29	15.98	10.16	5.48

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=60°·H=10m	10	1	7.70	2.77	6.70	1.92
	10	2	6.26	0.91	2.17	0.49
	10	3	6.13	0.80	4.24	0.36
	10	4	6.12	0.55	2.93	0.34
	10	5	7.53	2.29	6.63	1.76
	10	6	6.79	1.13	6.17	1.01
	10	7	9.70	3.52	6.90	3.93
	10	8	6.36	1.61	3.86	0.59
	10	9	6.27	1.06	2.68	0.50
	10	10	6.31	0.79	4.78	0.53
		Ave	6.92	1.54	4.71	1.14
T=60°·H=20m	20	1	12.05	1.04	4.63	0.51
	20	2	12.09	1.38	9.66	0.55
	20	3	13.88	2.43	12.37	2.33
	20	4	14.24	2.50	12.36	2.70
	20	5	13.61	3.26	9.25	2.06
	20	6	14.44	2.79	13.84	2.89
	20	7	11.90	0.89	5.40	0.35
	20	8	12.19	1.01	6.50	0.65
	20	9	12.03	1.10	4.52	0.48
	20	10	11.84	1.00	8.88	0.29
		Ave	12.83	1.74	8.74	1.28
T=60°·H=30m	30	1	17.61	2.14	8.48	0.29
	30	2	17.59	1.18	3.73	0.27
	30	3	21.12	4.33	16.67	3.80
	30	4	17.73	2.05	5.47	0.41
	30	5	21.03	3.91	18.30	3.71
	30	6	17.70	0.91	9.33	0.38
	30	7	19.20	2.01	7.16	1.88
	30	8	18.61	2.96	13.32	1.29
	30	9	19.54	2.30	8.27	2.22
	30	10	17.61	1.08	12.26	0.29
		Ave	18.77	2.29	10.30	1.45
T=60°·H=40m	40	1	24.83	2.92	20.84	1.74
	40	2	23.72	2.00	5.71	0.63
	40	3	23.42	2.60	18.38	0.33
	40	4	26.97	3.80	25.28	3.88
	40	5	25.95	2.51	24.80	2.85
	40	6	25.09	3.06	20.87	2.00
	40	7	26.06	4.78	18.62	2.96
	40	8	25.12	2.67	21.99	2.02
	40	9	23.74	2.17	7.01	0.65
	40	10	23.42	0.91	5.10	0.32
		Ave	24.83	2.74	16.86	1.74
T=60°·H=50m	50	1	29.19	1.49	6.31	0.33
	50	2	33.04	4.97	26.66	4.18
	50	3	29.21	0.97	3.88	0.34
	50	4	32.35	3.69	29.60	3.48
	50	5	33.32	4.68	30.10	4.45
	50	6	29.42	1.10	2.37	0.56
	50	7	32.47	3.43	30.73	3.60
	50	8	29.27	1.73	18.74	0.40
	50	9	31.68	4.59	23.67	2.82
	50	10	29.50	1.10	4.83	0.63
		Ave	30.95	2.78	17.69	2.08

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=70°·H=10m	10	1	6.34	2.41	5.04	2.70
	10	2	7.25	2.94	5.28	3.61
	10	3	4.17	0.67	3.35	0.53
	10	4	3.98	0.64	1.66	0.34
	10	5	4.26	1.37	2.61	0.62
	10	6	5.69	2.37	5.06	2.05
	10	7	4.12	0.81	3.43	0.48
	10	8	6.24	2.36	5.01	2.60
	10	9	5.13	1.48	4.95	1.49
	10	10	4.21	0.98	2.56	0.57
		Ave	5.14	1.60	3.90	1.50
T=70°·H=20m	20	1	7.68	0.73	1.65	0.40
	20	2	8.58	2.09	5.62	1.30
	20	3	9.75	2.69	7.92	2.47
	20	4	9.13	2.46	6.52	1.85
	20	5	8.98	1.98	7.16	1.70
	20	6	7.95	1.13	6.72	0.67
	20	7	8.82	2.14	6.24	1.54
	20	8	9.89	2.88	8.12	2.61
	20	9	9.95	2.85	8.28	2.68
	20	10	7.68	0.95	1.92	0.40
		Ave	8.84	1.99	6.02	1.56
T=70°·H=30m	30	1	11.80	1.51	10.34	0.88
	30	2	13.10	2.19	12.83	2.18
	30	3	11.32	0.50	1.40	0.40
	30	4	11.25	1.35	2.61	0.34
	30	5	15.61	4.39	14.64	4.69
	30	6	15.52	5.10	11.86	4.60
	30	7	11.68	2.32	6.20	0.76
	30	8	12.80	3.45	8.17	1.88
	30	9	12.16	2.66	7.68	1.24
	30	10	11.41	1.36	8.18	0.49
		Ave	12.67	2.48	8.39	1.75
T=70°·H=40m	40	1	21.14	5.57	19.68	6.58
	40	2	15.86	1.79	5.38	1.30
	40	3	15.08	1.46	11.12	0.52
	40	4	16.38	2.58	6.37	1.82
	40	5	17.27	4.27	11.29	2.71
	40	6	15.03	0.53	2.80	0.47
	40	7	14.96	1.55	3.11	0.40
	40	8	19.91	6.10	14.92	5.35
	40	9	15.08	2.26	4.96	0.53
	40	10	15.30	2.15	11.25	0.74
		Ave	16.60	2.83	9.09	2.04
T=70°·H=50m	50	1	19.59	1.48	19.40	1.39
	50	2	19.00	3.10	7.03	0.80
	50	3	18.80	1.99	4.30	0.60
	50	4	23.86	8.72	20.06	5.66
	50	5	22.20	5.21	20.02	4.00
	50	6	18.80	2.76	5.96	0.60
	50	7	22.04	7.61	20.05	3.84
	50	8	18.81	2.62	6.41	0.61
	50	9	22.49	7.11	20.10	4.29
	50	10	18.58	2.66	8.71	0.38
		Ave	20.42	4.33	13.20	2.22

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=80°·H=10m	10	1	3.43	1.70	3.43	1.67
	10	2	5.45	3.40	4.92	3.69
	10	3	2.72	0.99	2.60	0.95
	10	4	4.54	2.78	4.54	2.77
	10	5	4.67	2.85	4.53	2.91
	10	6	2.57	0.97	1.92	0.80
	10	7	4.60	2.80	4.47	2.83
	10	8	2.92	1.23	2.42	1.15
	10	9	3.74	2.00	3.74	1.97
	10	10	4.40	2.65	4.40	2.64
		Ave	3.90	2.14	3.70	2.14
T=80°·H=20m	20	1	7.72	10.82	5.17	4.19
	20	2	6.15	6.84	5.01	2.62
	20	3	3.95	0.56	0.92	0.42
	20	4	4.71	1.38	3.74	1.19
	20	5	9.09	10.93	5.03	5.57
	20	6	6.12	6.32	5.05	2.60
	20	7	5.38	2.91	5.00	1.86
	20	8	4.03	0.79	2.66	0.50
	20	9	7.43	10.58	5.10	3.91
	20	10	5.32	1.89	4.97	1.80
		Ave	5.99	5.30	4.27	2.46
T=80°·H=30m	30	1	6.40	1.49	4.62	1.11
	30	2	5.70	1.08	2.65	0.41
	30	3	7.72	2.69	6.00	2.43
	30	4	7.48	2.23	7.48	2.19
	30	5	5.86	1.31	3.05	0.57
	30	6	14.53	13.39	10.06	9.24
	30	7	10.47	5.15	9.99	5.18
	30	8	9.20	3.94	8.55	3.91
	30	9	7.10	2.29	4.98	1.81
	30	10	7.25	2.56	4.94	1.96
		Ave	8.17	3.61	6.23	2.88
T=80°·H=40m	40	1	15.42	16.60	10.16	8.36
	40	2	9.19	2.88	6.24	2.14
	40	3	8.34	2.55	4.94	1.29
	40	4	13.81	10.23	10.21	6.76
	40	5	10.80	4.88	10.15	3.75
	40	6	9.15	3.04	5.98	2.10
	40	7	11.57	6.91	10.03	4.51
	40	8	9.52	2.80	7.22	2.47
	40	9	14.92	20.53	10.11	7.86
	40	10	10.82	5.36	10.14	3.77
		Ave	11.35	7.58	8.52	4.30
T=80°·H=50m	50	1	12.44	16.74	10.17	3.62
	50	2	11.04	8.22	10.09	2.22
	50	3	19.67	35.29	10.05	10.86
	50	4	10.78	6.53	10.06	1.96
	50	5	10.98	3.34	10.08	2.16
	50	6	9.68	1.25	3.86	0.86
	50	7	17.89	32.31	10.03	9.07
	50	8	16.41	27.53	10.11	7.59
	50	9	14.76	25.24	10.17	5.94
	50	10	9.31	1.05	2.06	0.50
		Ave	13.29	15.75	8.67	4.48

	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=60°·H=10m	10	1	8.74	2.78	7.97	2.97
	10	2	6.36	1.16	4.16	0.59
	10	3	8.50	2.75	7.86	2.73
	10	4	8.57	2.49	7.77	2.80
	10	5	6.73	1.23	6.03	0.95
	10	6	7.24	1.62	7.09	1.47
	10	7	8.03	2.23	7.57	2.26
	10	8	8.93	3.04	8.20	3.15
	10	9	6.71	1.22	3.77	0.94
	10	10	6.67	1.13	6.67	0.90
		Ave	7.65	1.97	6.71	1.88
T=60°·H=20m	20	1	16.05	4.33	14.90	4.50
	20	2	13.94	2.42	13.37	2.39
	20	3	13.36	2.38	10.84	1.82
	20	4	13.69	2.61	11.56	2.14
	20	5	12.03	1.46	9.40	0.49
	20	6	12.41	2.19	7.54	0.86
	20	7	11.95	1.16	5.71	0.40
	20	8	11.97	1.57	6.37	0.42
	20	9	14.59	3.27	12.55	3.04
	20	10	11.94	1.67	9.24	0.39
		Ave	13.19	2.31	10.15	1.65
T=60°·H=30m	30	1	18.34	3.56	10.77	1.02
	30	2	18.96	2.11	16.84	1.64
	30	3	17.73	0.85	2.01	0.41
	30	4	17.96	1.27	10.51	0.64
	30	5	17.78	1.52	10.42	0.46
	30	6	19.01	2.07	17.63	1.69
	30	7	19.12	1.95	18.80	1.80
	30	8	19.37	2.23	18.74	2.05
	30	9	17.83	3.35	11.53	0.51
	30	10	18.58	1.78	4.07	1.26
		Ave	18.47	2.07	12.13	1.15
T=60°·H=40m	40	1	24.42	3.78	11.16	1.32
	40	2	27.10	4.45	22.80	4.00
	40	3	23.54	1.93	11.76	0.45
	40	4	23.54	1.28	7.09	0.45
	40	5	24.00	3.23	8.82	0.90
	40	6	25.94	2.63	25.21	2.84
	40	7	24.30	1.62	11.61	1.21
	40	8	26.30	3.19	25.50	3.20
	40	9	23.77	3.10	15.51	0.67
	40	10	23.57	1.95	18.52	0.48
		Ave	24.65	2.72	15.80	1.55
T=60°·H=50m	50	1	29.81	3.13	20.83	0.94
	50	2	31.71	2.98	30.30	2.84
	50	3	29.62	5.05	17.35	0.75
	50	4	31.80	5.21	23.33	2.93
	50	5	29.56	1.31	25.81	0.69
	50	6	29.40	1.38	3.37	0.53
	50	7	31.30	2.85	30.11	2.44
	50	8	33.90	4.48	30.40	5.03
	50	9	34.88	11.00	30.07	6.01
	50	10	31.34	2.46	30.11	2.47
		Ave	31.33	3.98	24.17	2.46

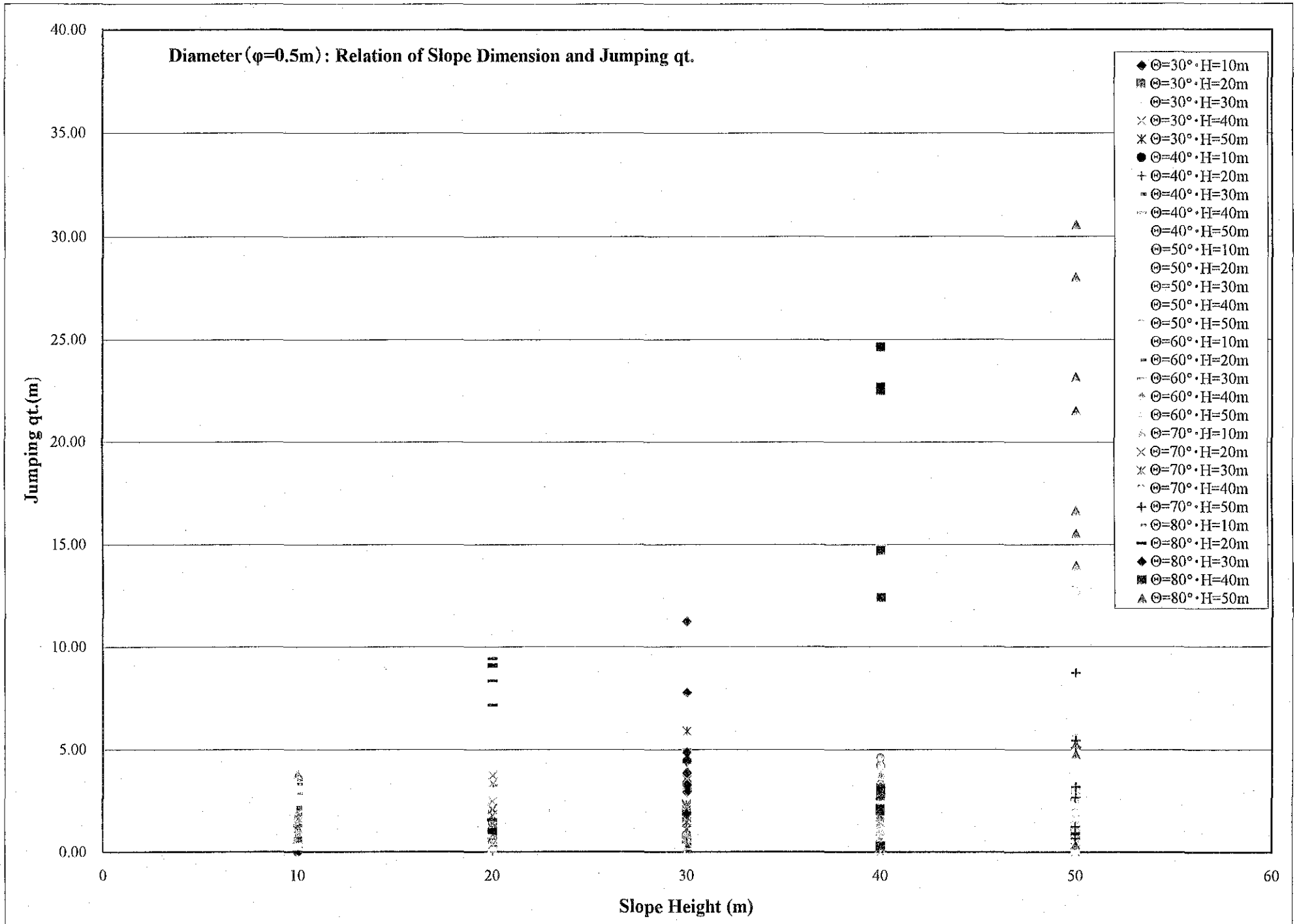
	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=70°·H=10m	10	1	8.36	4.44	7.75	4.72
	10	2	8.62	4.21	7.52	4.98
	10	3	5.61	2.14	5.61	1.97
	10	4	6.01	2.46	5.84	2.37
	10	5	4.14	0.89	2.47	0.50
	10	6	6.58	2.99	6.37	2.94
	10	7	5.71	2.25	5.43	2.07
	10	8	5.65	2.24	4.91	2.01
	10	9	4.45	1.45	3.01	0.81
	10	10	7.73	4.00	7.26	4.09
		Ave	6.28	2.71	5.62	2.65
T=70°·H=20m	20	1	10.47	3.40	8.75	3.19
	20	2	8.11	1.83	5.20	0.83
	20	3	8.01	2.12	4.50	0.73
	20	4	12.05	5.08	10.27	4.77
	20	5	8.64	1.98	6.19	1.36
	20	6	8.80	1.67	8.80	1.52
	20	7	12.40	6.14	10.08	5.12
	20	8	10.49	2.98	9.98	3.21
	20	9	9.65	2.65	7.84	2.37
	20	10	9.95	2.83	8.63	2.67
		Ave	9.86	3.07	8.02	2.58
T=70°·H=30m	30	1	13.64	3.13	11.60	2.72
	30	2	11.54	1.54	2.83	0.62
	30	3	14.99	4.48	12.03	4.07
	30	4	13.33	2.42	13.10	2.41
	30	5	17.80	6.09	14.98	6.88
	30	6	12.57	1.98	5.35	1.66
	30	7	18.71	7.70	15.36	7.80
	30	8	11.55	2.87	6.65	0.63
	30	9	17.69	6.31	15.21	6.77
	30	10	11.44	1.75	7.79	0.52
		Ave	14.33	3.83	10.49	3.41
T=70°·H=40m	40	1	28.73	14.56	20.12	14.17
	40	2	17.25	3.71	13.18	2.69
	40	3	16.38	2.25	7.82	1.82
	40	4	15.98	1.57	15.69	1.42
	40	5	17.43	2.91	17.09	2.88
	40	6	16.59	3.76	10.69	2.03
	40	7	15.61	2.45	6.88	1.05
	40	8	21.99	6.77	19.91	7.43
	40	9	19.90	6.18	14.78	5.34
	40	10	19.54	6.16	13.94	4.98
		Ave	18.94	5.03	14.01	4.38
T=70°·H=50m	50	1	25.16	10.82	20.09	6.97
	50	2	19.14	3.31	10.94	0.94
	50	3	18.87	3.07	13.36	0.67
	50	4	30.33	14.65	20.31	12.13
	50	5	18.76	1.89	7.77	0.56
	50	6	19.17	4.84	10.68	0.97
	50	7	22.28	9.09	20.28	4.08
	50	8	20.54	2.98	7.13	2.35
	50	9	21.30	2.51	20.01	3.10
	50	10	18.82	2.04	4.29	0.62
		Ave	21.44	5.52	13.49	3.24

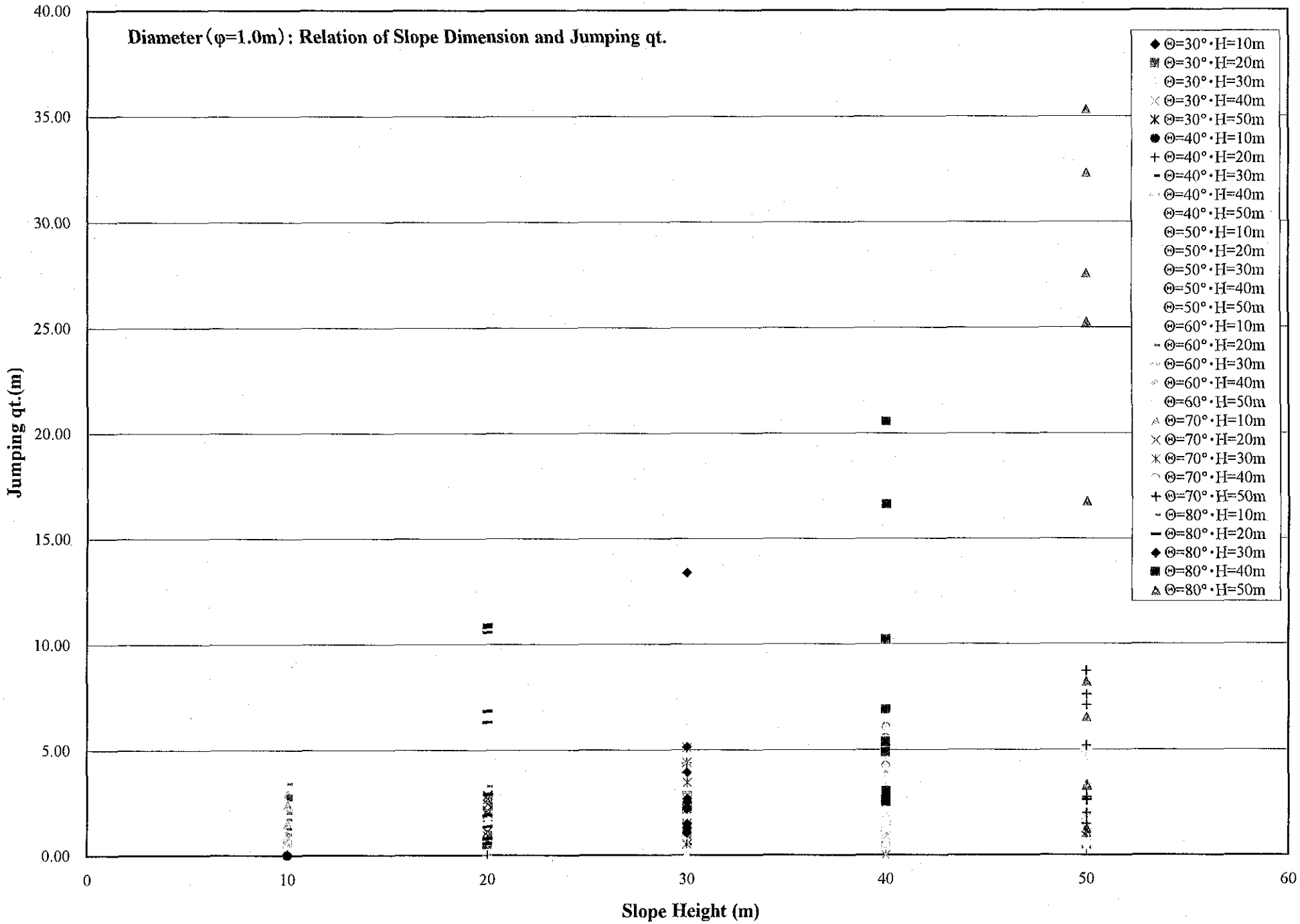
	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=80°·H=10m	10	1	4.23	2.52	4.23	2.46
	10	2	5.89	3.29	4.71	4.13
	10	3	5.98	3.62	4.95	4.22
	10	4	2.46	0.76	1.79	0.70
	10	5	3.64	1.94	3.64	1.87
	10	6	4.73	3.01	4.73	2.96
	10	7	3.60	1.91	3.56	1.84
	10	8	2.86	1.19	2.55	1.10
	10	9	4.59	2.88	4.59	2.83
	10	10	3.69	1.99	3.69	1.93
		Ave	4.17	2.31	3.84	2.40
T=80°·H=20m	20	1	8.89	5.07	5.12	5.36
	20	2	11.19	13.42	5.03	7.66
	20	3	5.25	2.09	3.90	1.72
	20	4	6.60	7.23	5.00	3.07
	20	5	8.01	9.32	5.18	4.48
	20	6	10.47	11.59	5.30	6.95
	20	7	8.03	12.06	5.01	4.50
	20	8	8.13	9.47	5.11	4.60
	20	9	11.78	12.68	5.22	8.25
	20	10	10.47	11.59	5.30	6.95
		Ave	8.88	9.45	5.02	5.35
T=80°·H=30m	30	1	10.85	5.38	9.99	5.56
	30	2	6.13	1.75	3.29	0.84
	30	3	9.86	4.58	9.70	4.58
	30	4	10.32	5.05	9.81	5.03
	30	5	7.71	2.50	7.71	2.42
	30	6	5.95	1.82	3.35	0.66
	30	7	10.16	4.92	9.84	4.87
	30	8	7.32	2.70	4.99	2.03
	30	9	11.46	6.07	10.01	6.17
	30	10	13.30	11.88	10.19	8.01
		Ave	9.31	4.67	7.89	4.02
T=80°·H=40m	40	1	18.59	25.46	10.28	11.54
	40	2	7.83	1.33	2.43	0.77
	40	3	8.04	1.70	3.54	0.99
	40	4	7.78	1.27	3.52	0.73
	40	5	15.50	22.69	10.19	8.45
	40	6	10.99	6.40	10.09	3.94
	40	7	12.67	12.86	10.17	5.61
	40	8	9.87	3.27	7.42	2.81
	40	9	7.82	1.66	3.51	0.77
	40	10	11.93	11.09	10.06	4.88
		Ave	11.10	8.77	7.12	4.05
T=80°·H=50m	50	1	16.30	29.84	10.17	7.48
	50	2	17.11	29.74	10.00	8.29
	50	3	15.55	8.31	10.14	6.73
	50	4	21.28	32.42	10.18	12.46
	50	5	9.48	1.62	2.96	0.67
	50	6	9.46	1.74	5.26	0.64
	50	7	14.83	24.53	10.23	6.02
	50	8	13.79	12.91	10.12	4.98
	50	9	15.57	17.87	10.05	6.75
	50	10	12.20	14.97	10.13	3.39
		Ave	14.56	17.39	8.92	5.74

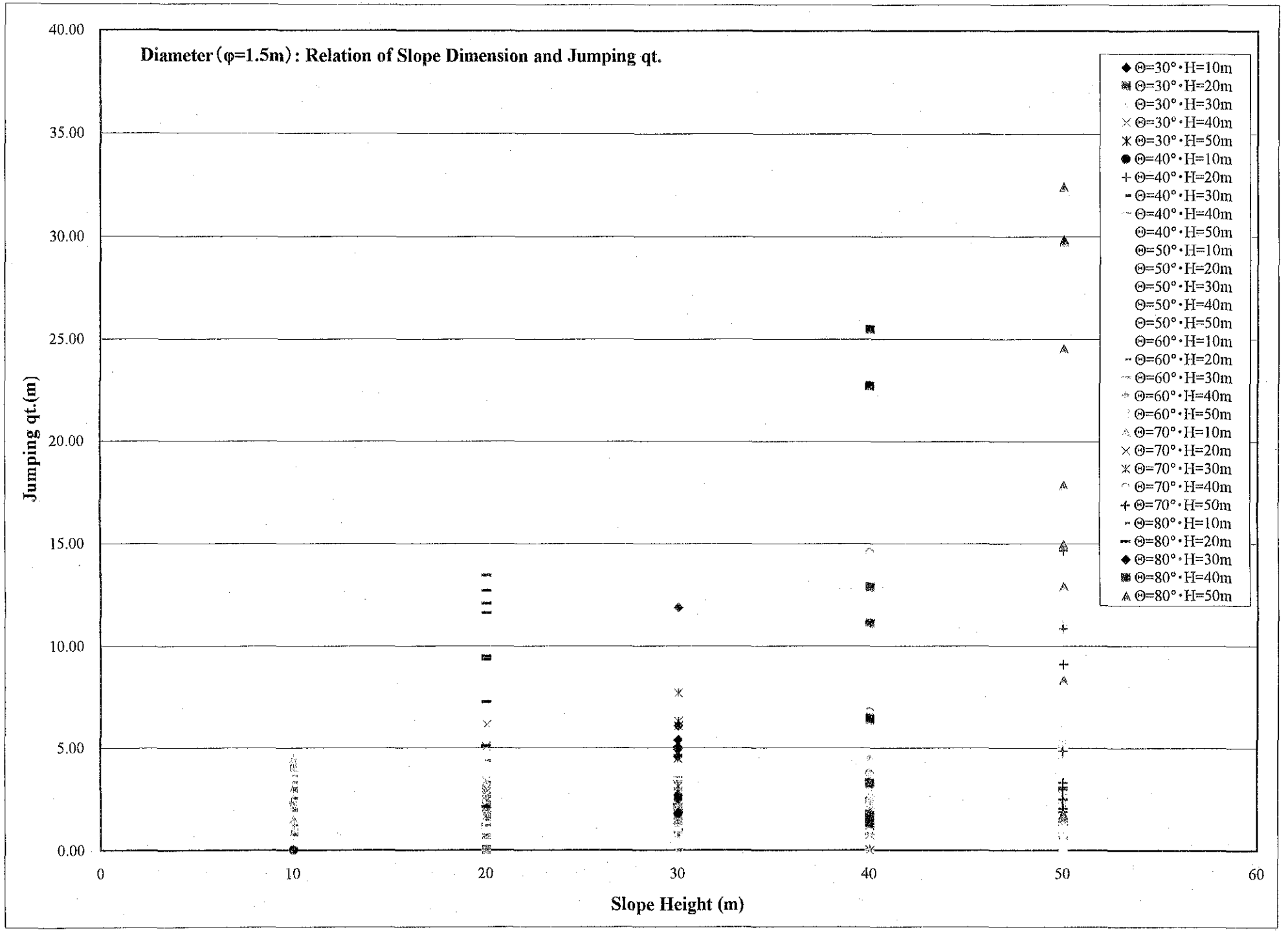
	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=60°·H=10m	10	1	6.98	1.53	6.78	1.20
	10	2	7.11	1.64	7.11	1.34
	10	3	6.65	1.56	2.80	0.88
	10	4	7.68	2.10	7.42	1.90
	10	5	6.39	1.00	4.12	0.62
	10	6	6.64	1.33	5.02	0.86
	10	7	9.56	3.54	8.66	3.79
	10	8	7.75	2.39	6.34	1.98
	10	9	7.42	2.31	5.63	1.64
	10	10	6.97	1.51	6.97	1.20
		Ave	7.31	1.89	6.09	1.54
T=60°·H=20m	20	1	12.22	1.17	5.04	0.68
	20	2	12.12	1.12	3.27	0.57
	20	3	14.08	3.69	12.97	2.53
	20	4	12.68	1.58	11.94	1.13
	20	5	13.65	2.35	13.53	2.10
	20	6	14.65	3.80	11.28	3.11
	20	7	12.10	1.79	6.96	0.56
	20	8	14.08	2.53	13.57	2.54
	20	9	13.38	2.49	11.33	1.84
	20	10	12.23	1.44	6.19	0.68
		Ave	13.12	2.20	9.61	1.57
T=60°·H=30m	30	1	24.42	7.76	19.15	7.10
	30	2	18.05	1.52	15.31	0.73
	30	3	18.73	3.18	13.96	1.41
	30	4	18.20	3.35	12.43	0.88
	30	5	20.13	4.73	18.65	2.81
	30	6	17.93	1.38	13.03	0.61
	30	7	18.24	2.94	13.86	0.92
	30	8	18.26	1.51	8.43	0.94
	30	9	18.99	2.74	16.00	1.67
	30	10	18.14	3.21	8.98	0.82
		Ave	19.11	3.23	13.98	1.79
T=60°·H=40m	40	1	23.68	2.48	6.14	0.59
	40	2	23.79	1.61	10.34	0.70
	40	3	27.19	5.94	25.04	4.10
	40	4	23.95	3.61	9.34	0.86
	40	5	23.73	2.20	4.72	0.64
	40	6	29.80	9.72	25.06	6.71
	40	7	24.93	4.48	18.17	1.84
	40	8	24.25	4.47	12.11	1.15
	40	9	28.26	3.44	16.08	5.16
	40	10	23.86	2.17	13.30	0.76
		Ave	25.34	4.01	14.03	2.25
T=60°·H=50m	50	1	33.75	5.35	26.62	4.88
	50	2	29.81	3.01	23.26	0.94
	50	3	32.05	5.39	21.77	3.19
	50	4	29.52	1.62	5.78	0.65
	50	5	33.57	4.54	28.05	4.71
	50	6	29.48	1.18	3.49	0.61
	50	7	37.84	6.61	34.72	8.98
	50	8	34.02	4.14	33.12	5.15
	50	9	31.29	2.67	22.19	2.43
	50	10	31.67	2.34	30.35	2.80
		Ave	32.30	3.68	22.94	3.43

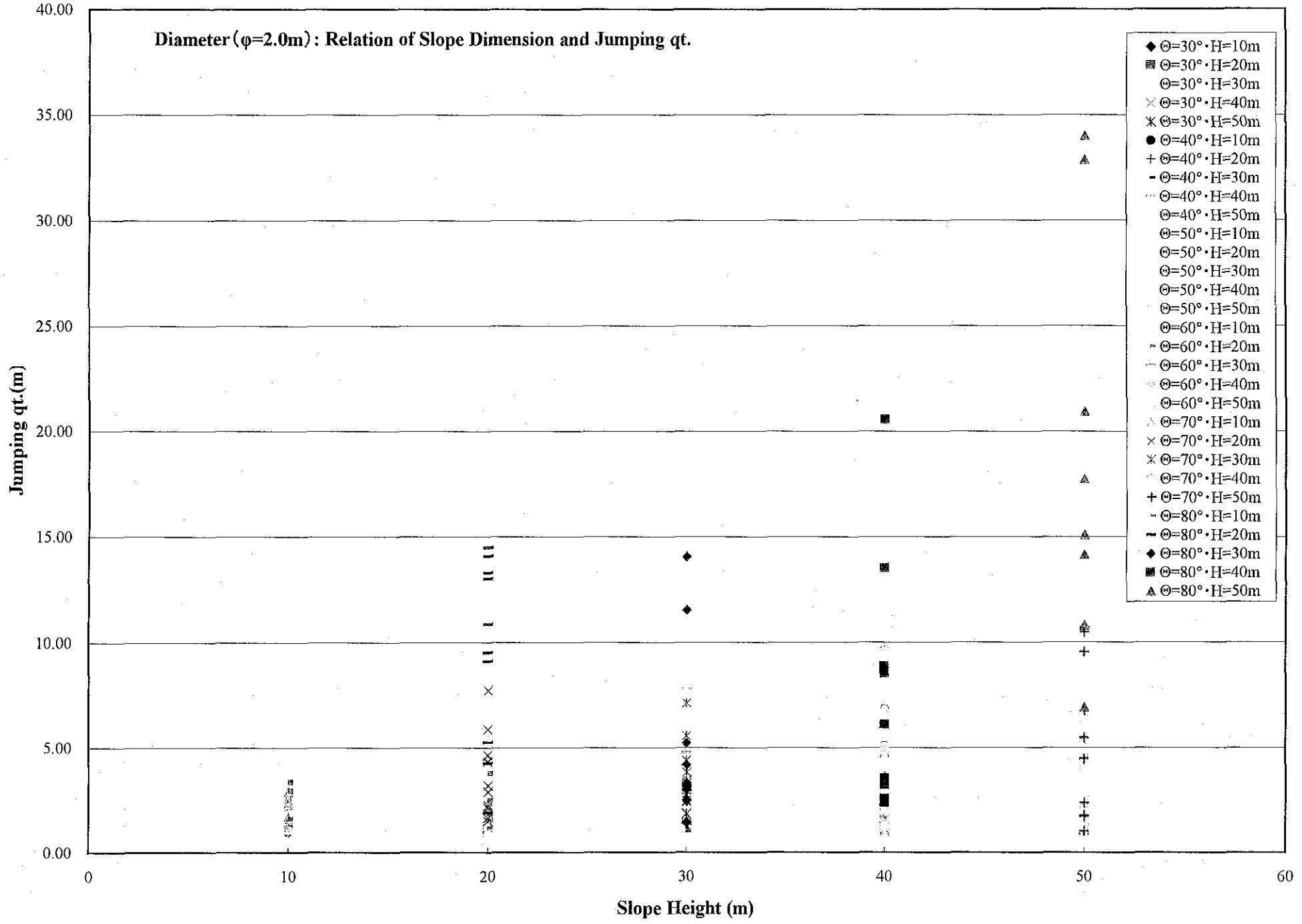
	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=70°·H=10m	10	1	4.46	1.33	2.19	0.82
	10	2	6.09	2.41	5.01	2.45
	10	3	5.70	2.28	5.10	2.06
	10	4	5.67	2.60	5.09	2.03
	10	5	4.51	1.66	3.06	0.87
	10	6	5.31	2.13	4.27	1.67
	10	7	4.82	1.49	4.82	1.18
	10	8	6.47	2.89	5.18	2.83
	10	9	4.44	1.15	3.80	0.80
	10	10	4.52	1.62	2.72	0.88
		Ave	5.20	1.96	4.12	1.56
T=70°·H=20m	20	1	11.25	4.32	10.08	3.97
	20	2	8.47	2.24	4.33	1.19
	20	3	11.72	4.64	10.28	4.44
	20	4	13.26	7.72	10.25	5.98
	20	5	8.33	1.65	2.74	1.05
	20	6	9.56	3.20	6.69	2.28
	20	7	8.05	1.49	5.87	0.77
	20	8	9.90	2.89	8.46	2.62
	20	9	9.19	2.12	9.19	1.91
	20	10	12.22	5.86	10.18	4.94
		Ave	10.19	3.61	7.81	2.91
T=70°·H=30m	30	1	12.47	3.11	8.12	1.55
	30	2	14.61	3.81	14.40	3.70
	30	3	13.72	3.31	11.64	2.80
	30	4	12.12	1.83	5.47	1.20
	30	5	18.68	7.10	15.34	7.76
	30	6	11.74	2.43	6.49	0.82
	30	7	16.51	5.54	14.82	5.59
	30	8	11.72	2.82	6.29	0.80
	30	9	12.87	3.44	8.37	1.95
	30	10	14.50	4.37	10.78	3.58
		Ave	13.89	3.78	10.17	2.98
T=70°·H=40m	40	1	17.09	4.84	10.60	2.53
	40	2	17.31	3.37	13.93	2.75
	40	3	16.07	2.14	10.44	1.51
	40	4	19.58	5.00	19.29	5.02
	40	5	15.37	1.23	2.07	0.81
	40	6	18.28	4.56	14.70	3.72
	40	7	20.59	6.86	15.44	6.03
	40	8	15.48	2.08	12.53	0.92
	40	9	16.24	3.02	11.76	1.69
	40	10	19.86	5.09	19.26	5.30
		Ave	17.59	3.82	13.00	3.03
T=70°·H=50m	50	1	18.90	2.37	8.53	0.71
	50	2	24.45	6.75	20.63	6.26
	50	3	18.92	1.72	2.90	0.72
	50	4	21.36	5.45	20.07	3.16
	50	5	19.41	4.46	11.12	1.21
	50	6	19.25	1.76	3.42	1.06
	50	7	22.10	9.52	20.03	3.90
	50	8	23.17	10.45	20.39	4.97
	50	9	33.45	10.71	25.26	15.25
	50	10	18.92	1.01	2.53	0.72
		Ave	21.99	5.42	13.49	3.79

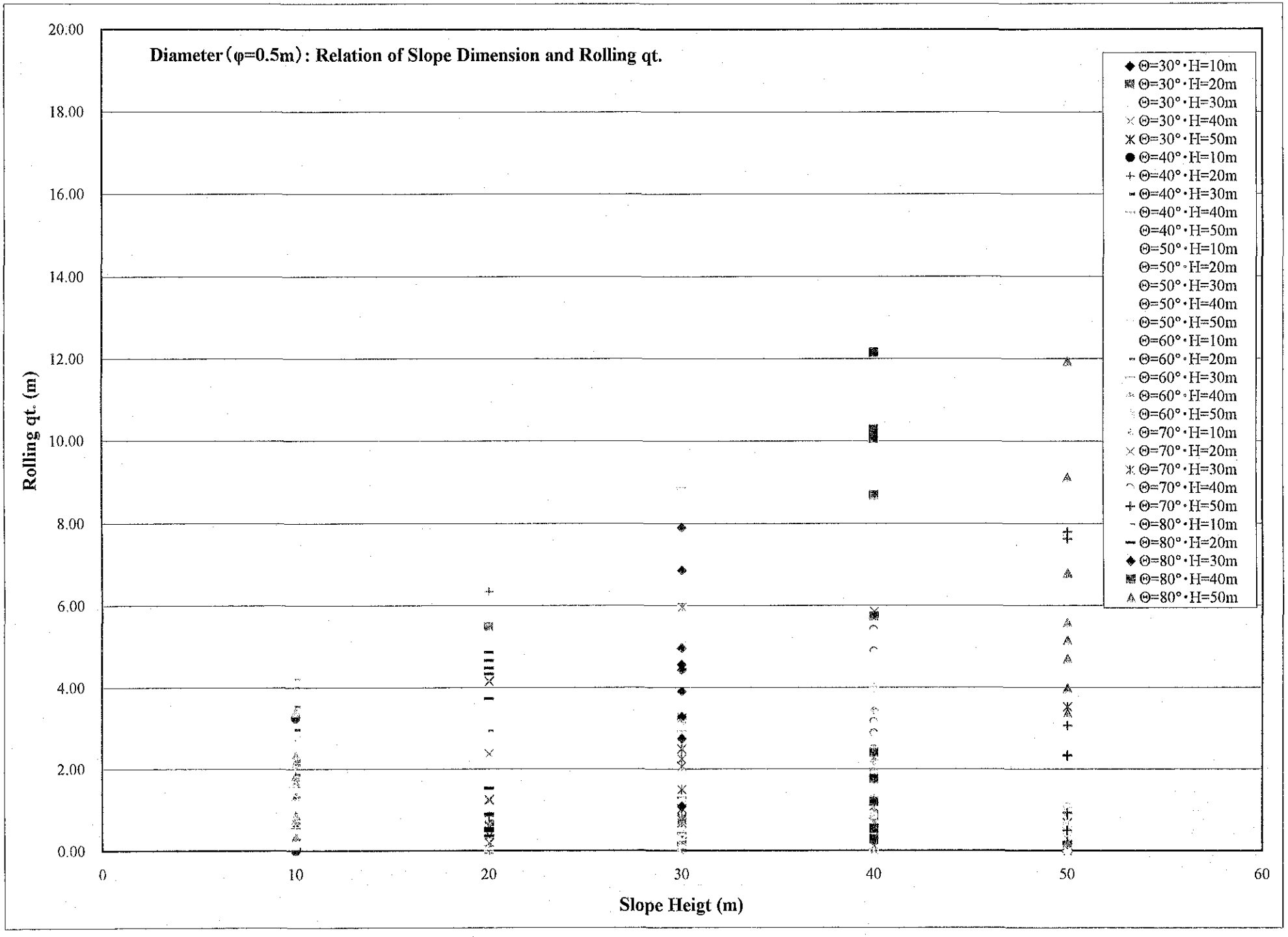
	Height (m)	N	Position Xend(m)	Max. Jumping qt. Hmax(m)	Max. Jumping qt. X Co.	Rolling qt. d(m)
T=80°·H=10m	10	1	3.29	1.64	3.29	1.53
	10	2	5.26	3.37	4.95	3.49
	10	3	4.94	3.26	4.91	3.18
	10	4	2.85	1.25	2.34	1.09
	10	5	5.40	3.42	4.86	3.64
	10	6	3.06	1.51	2.45	1.30
	10	7	4.50	2.83	4.50	2.73
	10	8	5.34	3.40	4.90	3.57
	10	9	4.64	2.97	4.64	2.88
	10	10	5.06	3.35	4.99	3.29
		Ave	4.43	2.70	4.18	2.67
T=80°·H=20m	20	1	9.75	14.48	5.05	6.23
	20	2	5.86	5.24	5.13	2.33
	20	3	6.78	9.51	5.04	3.25
	20	4	8.31	13.29	5.14	4.78
	20	5	6.39	9.11	5.02	2.86
	20	6	5.47	4.25	5.01	1.95
	20	7	12.49	14.07	5.23	8.96
	20	8	8.67	13.00	5.12	5.15
	20	9	4.78	1.88	3.21	1.25
	20	10	8.93	10.85	5.06	5.40
		Ave	7.74	9.57	4.90	4.22
T=80°·H=30m	30	1	10.47	5.22	9.79	5.18
	30	2	14.74	14.06	10.18	9.45
	30	3	7.91	3.17	5.82	2.62
	30	4	7.35	2.50	5.54	2.06
	30	5	8.04	3.18	6.12	2.75
	30	6	6.32	1.46	3.67	1.04
	30	7	7.70	3.01	5.57	2.41
	30	8	13.23	11.52	10.27	7.94
	30	9	9.38	4.19	9.37	4.09
	30	10	8.07	3.29	6.05	2.78
		Ave	9.32	5.16	7.24	4.03
T=80°·H=40m	40	1	8.89	2.54	6.10	1.83
	40	2	16.28	8.86	14.98	9.23
	40	3	15.87	8.52	14.73	8.82
	40	4	9.81	3.36	7.05	2.76
	40	5	10.04	3.24	8.56	2.98
	40	6	9.27	2.38	8.58	2.22
	40	7	13.13	6.09	13.03	6.08
	40	8	14.60	20.55	10.06	7.55
	40	9	15.24	13.52	10.20	8.18
	40	10	10.48	3.51	9.91	3.43
		Ave	12.36	7.26	10.32	5.31
T=80°·H=50m	50	1	14.01	15.11	10.18	5.19
	50	2	15.29	17.73	10.16	6.47
	50	3	20.00	20.93	15.17	11.18
	50	4	11.33	10.75	10.06	2.51
	50	5	18.00	32.87	10.15	9.19
	50	6	18.49	15.09	15.28	9.67
	50	7	15.50	6.91	13.57	6.68
	50	8	11.79	14.15	10.57	2.97
	50	9	18.19	34.00	10.29	9.37
	50	10	11.43	10.81	10.17	2.61
		Ave	15.40	17.84	11.52	6.59

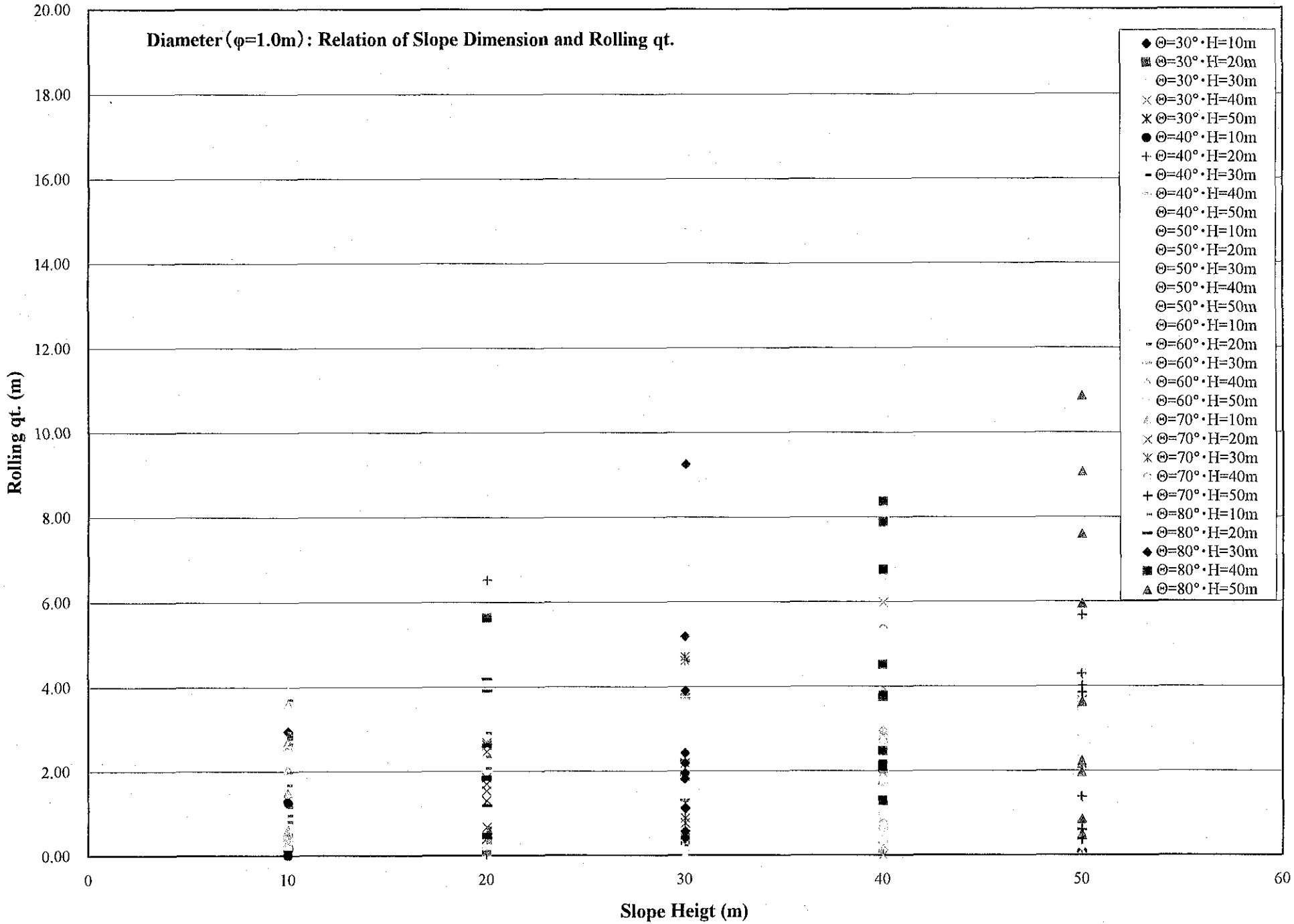

Diameter（φ=0.5m）: Relation of Slope Dimension and Jumping qt.
Jumping qt.(m)
Slope Height (m)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
Θ=40°・H=40m
Θ=40°・H=50m
Θ=50°・H=10m
Θ=50°・H=20m
Θ=50°・H=30m
Θ=50°・H=40m
Θ=50°・H=50m
Θ=60°・H=10m
Θ=60°・H=20m
Θ=60°・H=30m
Θ=60°・H=40m
Θ=60°・H=50m
Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m

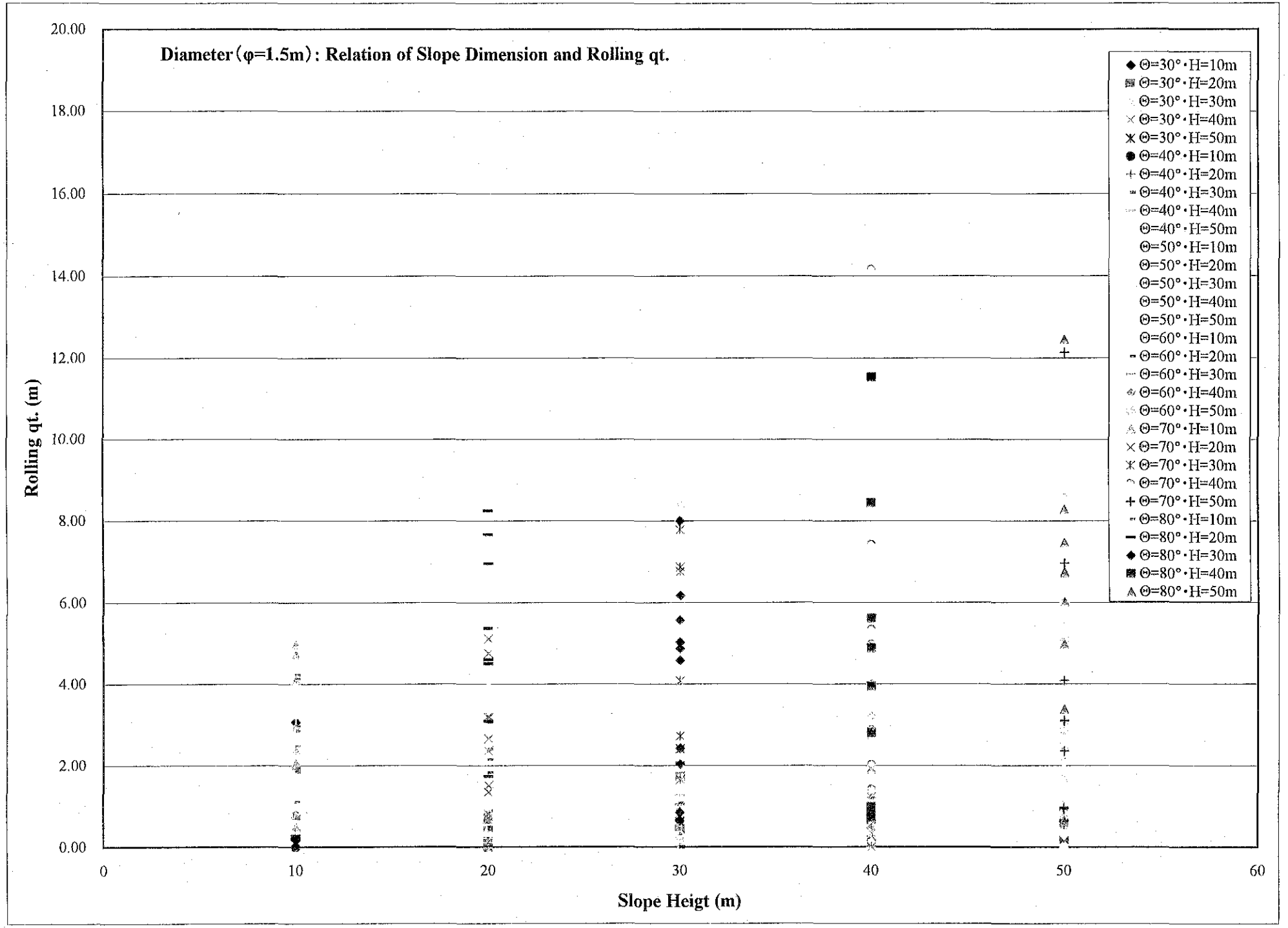

Diameter (φ=1.0m) : Relation of Slope Dimension and Jumping qt.
Jumping qt.(m)
Slope Height (m)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
Θ=40°・H=40m
Θ=40°・H=50m
Θ=50°・H=10m
Θ=50°・H=20m
Θ=50°・H=30m
Θ=50°・H=40m
Θ=50°・H=50m
Θ=60°・H=10m
Θ=60°・H=20m
Θ=60°・H=30m
Θ=60°・H=40m
Θ=60°・H=50m
Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m


Diameter (φ=1.5m) : Relation of Slope Dimension and Jumping qt.
Jumping qt.(m)
Slope Height (m)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
Θ=40°・H=40m
Θ=40°・H=50m
Θ=50°・H=10m
Θ=50°・H=20m
Θ=50°・H=30m
Θ=50°・H=40m
Θ=50°・H=50m
Θ=60°・H=10m
Θ=60°・H=20m
Θ=60°・H=30m
Θ=60°・H=40m
Θ=60°・H=50m
Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m


Diameter（φ=2.0m）: Relation of Slope Dimension and Jumping qt.
Jumping qt.(m)
Slope Height (m)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
Θ=40°・H=40m
Θ=40°・H=50m
Θ=50°・H=10m
Θ=50°・H=20m
Θ=50°・H=30m
Θ=50°・H=40m
Θ=50°・H=50m
Θ=60°・H=10m
Θ=60°・H=20m
Θ=60°・H=30m
Θ=60°・H=40m
Θ=60°・H=50m
Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m


Diameter（φ=0.5m）: Relation of Slope Dimension and Rolling qt.
Rolling qt. (m)
Slope Heigt (m)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
Θ=40°・H=40m
Θ=40°・H=50m
Θ=50°・H=10m
Θ=50°・H=20m
Θ=50°・H=30m
Θ=50°・H=40m
Θ=50°・H=50m
Θ=60°・H=10m
Θ=60°・H=20m
Θ=60°・H=30m
Θ=60°・H=40m
Θ=60°・H=50m
Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m


Diameter（φ=1.0m）: Relation of Slope Dimension and Rolling qt.
Rolling qt. (m)
Slope Heigt (m)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
Θ=40°・H=40m
Θ=40°・H=50m
Θ=50°・H=10m
Θ=50°・H=20m
Θ=50°・H=30m
Θ=50°・H=40m
Θ=50°・H=50m
Θ=60°・H=10m
Θ=60°・H=20m
Θ=60°・H=30m
Θ=60°・H=40m
Θ=60°・H=50m
Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m


Diameter (φ=1.5m) : Relation of Slope Dimension and Rolling qt.
Rolling qt. (m)
Slope Heigt (m)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
Θ=40°・H=40m
Θ=40°・H=50m
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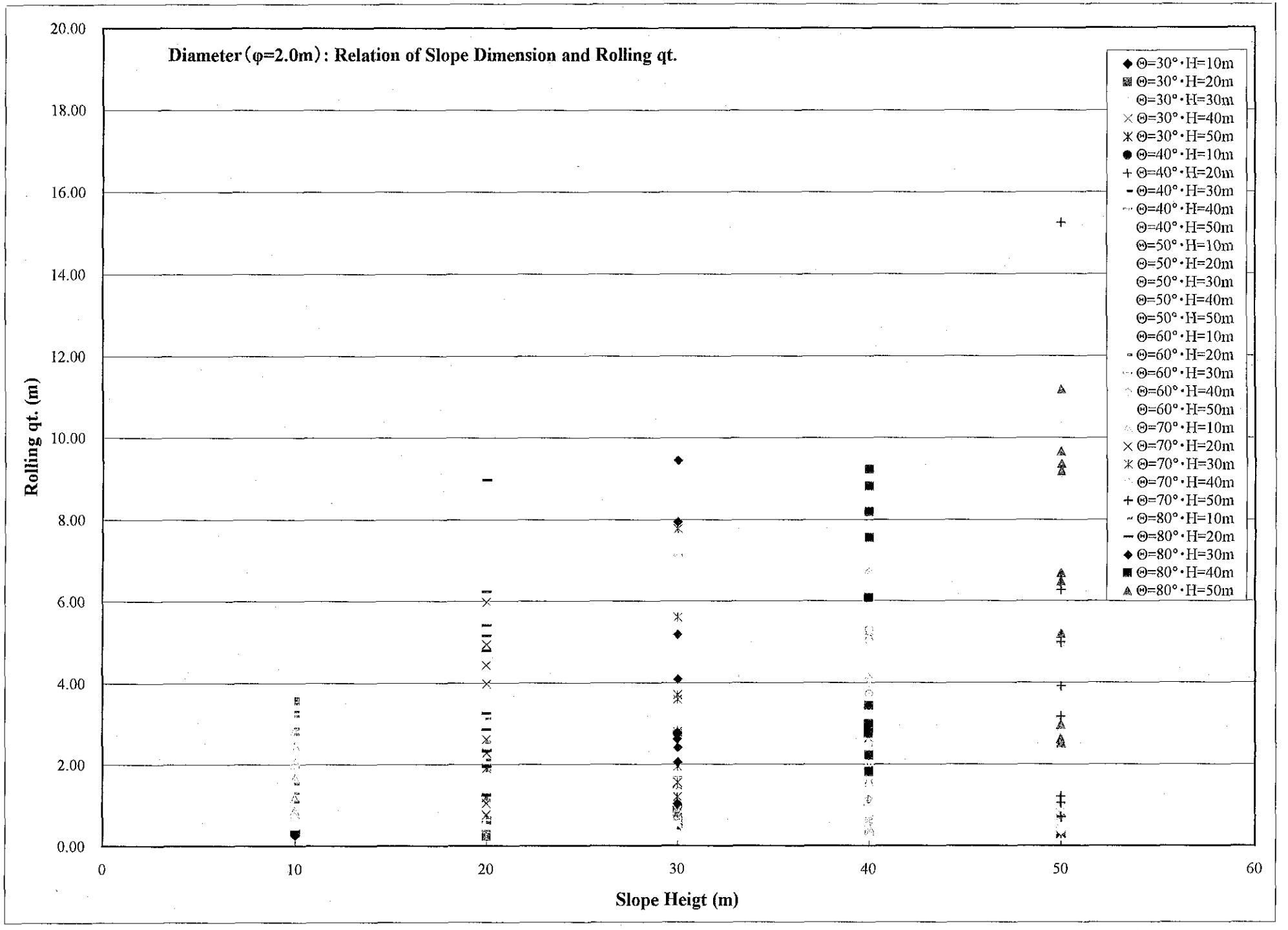
Θ=60°・H=30m
Θ=60°・H=40m
Θ=60°・H=50m
Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m


Diameter（φ=2.0m）: Relation of Slope Dimension and Rolling qt.
Rolling qt. (m)
Slope Heigt (m)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
10
20
30
40
50
60
Θ=30°・H=10m
Θ=30°・H=20m
Θ=30°・H=30m
Θ=30°・H=40m
Θ=30°・H=50m
Θ=40°・H=10m
Θ=40°・H=20m
Θ=40°・H=30m
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Θ=70°・H=10m
Θ=70°・H=20m
Θ=70°・H=30m
Θ=70°・H=40m
Θ=70°・H=50m
Θ=80°・H=10m
Θ=80°・H=20m
Θ=80°・H=30m
Θ=80°・H=40m
Θ=80°・H=50m

APPENDIX-2

Input Data for Concrete Prevention Wall

Dimension of Concrete Wall

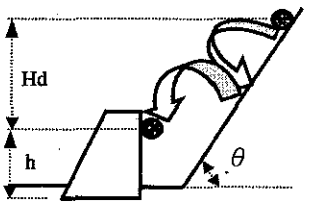
Item	Mark	Unit	Input Data	Remark
Wall Height	H	m	-	
Crown Width	b 1	m	-	
Sole Plate Width	b 2	m	-	
Grade of Front Face	1:Nf	—	-	
Effective Resisting Length	L	m	10.000	
Unit Weight	γ c	kN/m^3	23.0	

Data for Coefficient of Subgrade Reaction

Item	Mark	Unit	Input Data	Remark
Coefficient of Deformation	E_0	kN/m^2	-	
Coefficient of Reaction Force	a	-	-	
N Value	N	-	30.0	

Data of Falling Rock

Item	Mark	Unit	Input Data	Remark
Boulde Weight	W	kN	-	D=26KN/m3
Falling Height	H d	m	-	
Coefficient of Equivarence Friction	μ	—	0.18	
Slope Grade	θ	degree	-	
Appulse Heigt	h'	m	-	0.9h



Data for Stability Analysis

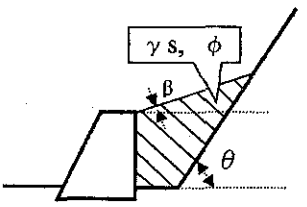
Item		Mark	Unit	Input Data	Remark
Modulus of Friction of Sole		μs	—	0.60	
Allowable Bearing Capacity	Ordinary	q a	kN/m^2	700	
	Sedimentation	q as	kN/m^2	600	
	Earthquake	q ae	kN/m^2	450	

Allowable Max. Value of Gyrarion Angle for Concrete Wall

Item	Mark	Unit	Input Data	Remark
Allowable Max. Value of Gyrarion Angl	θa	degree	2.0	2 ~ 3
Allowable Plastic Ratio	μ	—	5.0	4 ~ 6

Data for Sedimentation Level

Item	Mark	Unit	Input Data	Remark
Unit Weight of Sedimentation Soil	γ s	kN/m^3	20.0	
Internal Friction Angle	ϕ	degree	35.0	
Angle of Sedimentation Soil	β	degree	30.0	β < f



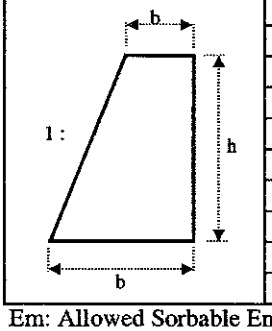
Data for Earthquake Level

Item	Mark	Unit	Input Data	Remark
Design Seismic Coefficient	k h	-	0.14	

Result of Bearing Force Check for Concrete Prevention Wall

Boulder Weight	Slope Heigh	Slope Grade (degree)					
(kN)	(m)	30	40	50	60	70	80
1.7 (f =0.5m)	10						
	20						
	30						
	40						
	50						
(kN)	(m)	30	40	50	60	70	80
13.6 (f =1.0m)	10						
	20						
	30						
	40						
	50						
(kN)	(m)	30	40	50	60	70	80
45.9 (f =1.5m)	10						
	20						
	30						
	40						
	50						
(kN)	(m)	30	40	50	60	70	80
108.9 (f =2.0m)	10						
	20						
	30						
	40						
	50						

Type of Concrete Prevention Wall



Type	Size (m)				
	h	b1	b2	Nf	Em (KJ)
A	2.00	0.50	1.50	0.50	8.94
B	2.50	0.75	2.00	0.50	21.01
C	3.00	1.00	2.50	0.50	40.90
D	3.50	1.25	3.00	0.50	70.21
E	4.00	1.50	3.50	0.50	110.41
F	4.50	1.75	4.00	0.50	163.21
G	5.00	2.00	4.50	0.50	229.76
H	5.50	2.25	5.00	0.50	310.77
I	6.00	2.50	5.50	0.50	406.73
J	6.50	2.75	6.00	0.50	518.11

Em: Allowed Sorbable Energy

APPENDIX-3 STANDARD DRAWINGS	No
Countermeasures for Slope (e.g.N026A060)	1/16
Countermeasures for Slope (e.g.N001B170)	2/16
Countermeasures for Slope (e.g.N026B160)	3/16
Countermeasures for Slope (e.g.N026B140)	4/16
Countermeasures for Slope (e.g.N003E160)	5/16
Typical Cross Section of Slops	6/16
General Layout of Concrete Cribwork	7/16
General Layout of Simple Dam	8/16
General Layout of Shotcrete	9/16
General Layout of Prevention Net	10/16
General Layout of Drainage Work (1/2)	11/16
General Layout of Drainage Work (2/2)	12/16
Countermeasures for Bridge Scoring (e.g.Tapacali Bridge)	13/16
General Layout of Protection for Scouring	14/16
General Layout of Protection for Scouring around Pier	15/16
General Layout of Protection for Scouring by Gabion Mat	16/16