REPORT OF THE ADVISORY TEAM

ON

THE GUIDLINE FOR Mt.SEMERU PROJECT

MAY 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request of the Government of the Republic of Indonesia, the Government of Japan decided to take up a study on the Mt. Semeru Volcanic Debris Control Project and entrusted the study to the Japan International Cooperation Agency (JICA).

The JICA conducted the study by dispatching to Indonesia a 6-man study team headed by Mr. Masayuki Watanabe of the Public Works Research Institute, Ministry of Construction from May 7 to May 27, 1981.

In collaboration with the staff of the Directorate of Rivers, Directorate General of Water Resources Development, Ministry of Public Works of Indonesia and Japanese Colombo Plan experts, the study team conducted the following surveys:

(1) Guidlines for the formulation of a master plan
(2) Possibility of development water resources
(3) Possibility of giving disaster warning
(4) Preliminary survey of fluvio-geomorphological classification for hazard zoning
(5) Preliminary survey of socio-economic conditions of the area

After further studies were conducted in Japan, the team has compiled the present report on the guidlines for Mt. Semeru Project.

I hope that this report will contribute to the development of the project and to the enhancement of the friendly relations between Japan and Indonesia.

I wish to express my deep appreciation to the authorities and people concerned of Indonesia for their close cooperation extended to the team, and also my sincere condolences to the bereaved families of the victims of the disaster in the Lumajang area which occurred during the survey.

June 1981

Keisuke Arita
President

Japan International Cooperation Agency

Menteri P.U : Jangan Pikirkan Uang, Selamatkan Pen

127 Orang Tewas, 170 Hilan

Surabaya, Minggu.-

Banjir besar yang disebabkan land slide akibat hujan seharian penuh yang terjadi pada tanggal 14 Mei lalu telah melanda beberapa desa dalam 5 kecamatan Kabupaten Lumajang dengan menimbulkamn korban-korban, harta benda dan manusia yang berjatuhan.

Sampai hari Sabtu petang tanggal 16 Mei pukul 17.30 secara resmi tercatat 127 orang tewas, 170 orang hilang, 39 orang luka berat, 56 orang luka ringan, 333 buah rumah rusak parah dan 423 ha tanah persawahan mengalami kerusakan tertutup endapan lumpur setebal 30 cm sampai 50 cm.

Menurut laporan Bupati Lumajang Suwandi, banjir besar itu yang dibarengi lava dingin meluncur dari kantong Gunung Semeru serta batu-batu besar pohon-pohon yang tumbang memasuki jalur-jalur yang tidak dipersiapkan, yaitu memasuki Sungai Besuksat, Sungai Tunggeng, Sungai Mujur, Sungai Lanang dan Sungai Gelapan.

Yang paling parah ialah hancurnya pengaman banjir Leces sepanjang 200 meter yang dibangun di tahun 1912 serta pengaman tanggul di Desa Kertosari.

Kedua bangunan tanggul pengaman tersebut perlu segera ditangani karena akan mengancam Kota Lumajang yang jaraknya tinggal lebih kurang 15 km saja ujarnya lagi.

Menteri PU Purnomosidi Hajisarosa bersama gubernur Sunandar pada Sabtu petang lalu langsung menuju ke lokasi tanggul Leces yang pengamanan banjirnya putus sepanjang 200 meter.

Menteri menegaskan bahwa yang terpenting untuk menanggulanginya dalam jangka pendek ialah secepatnya memperbaiki jalanan desa yang rusak memfungsikan kembali irigasi dan memperbaiki rumah rumah penduduk

duduk

MERDEKA Monday May 18, 1981

g Korban Banjir Lumajang

dengan bertujuan untuk menghilangkan kesan mengerikan di daerah ini.

Selamatkan penduduk

Jangan pikirkan uang, tetapi yang penting menyelamatkan penduduk dulu. Saya harap dalam tempo singkat 3 hari dan paling lambat tanggal 20/5 perencanaan (sketsa) sudah dilaporkan melalui Dinas PU Jatim untuk menentukan kebutuhan apa saja yang diperlukan dalam usaha normalisasinya, demikian Menteri.

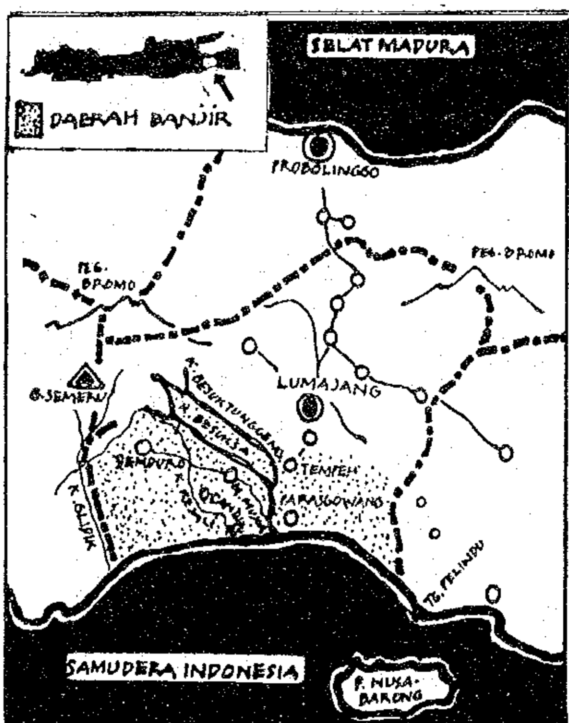
Menurut bupati Suwandi yang didampingi oleh Suparman, pimpinan Proyek Gunung Semru, dan Wiji, Kepala Dinas PU Lumajang menjelaskan bahwa perbaikan jaringan irigasi didaerah Kecamatan Candipuro dan Kecamatan Tempeh diharapkan akan menyelamatkan 5.200 Ha tahun persawahan.

Saat ini 5 buah intake tersumbat dan tidak berfungsi lagi yang terkubur oleh lumpur setinggi satumeter disamping itu juga akan dikerjakan pembersihan saluran air sepanjang 8,5 Km yang juga tersumbat oleh lumpur.

Paling cepat 10 hari jaringan irigasi didaerah kedua kecamatan tersebut harus sudah berfungsi kembali tambahnya.

Tentang pemukiman kembali penduduk yang mengalami musibah, Suwandi menjelaskan bahwa untuk setiap desa oleh Pemerintah disediakan dana Rp.6, juta.

Untuk memberikan makan sebanyak 3.500 orang pengungsi, menurut Suwandi diperlukan 1,5 ton beras dengan menempatkan dapur-dapur umum di desa-desa Penanggal Kertosari, Gondoroso, Wareng Pronojiwo dan Sumbermujur. Bantuan-bantuan pangan yang diterima sampai saat ini ialah 5 ton beras dari Kanwil Depsos Jatim, 7 ton beras dari Pemda Lumajang, 4 ton beras dari Pemda Jatim dan uang Rp.5,- juta disamping 100 potong pakaian bekas dan obat-obatan. (Stn).



Lokasi banjir lahar dingin dari Gn Semeru di daerah Kabupaten Lumajang.

Indonesian Paper reporting the disaster around Mt.Semeru

Minister of the Public Works ordered to do urgent rehab- ilitation works within 2 months specially for irrig- ation systems and road.

Conclusion and Recommendation

1 Disaster of present type can be controlled and damages thereof can be mitigated if not eliminated although occurence of the relevant natural phenomena are beyond our control.

2 Over all disaster prevention plan should be formulated imme - diately and implemented as soon as the urgent rehabilitation works have been completed.

3 Potential disaster in the whole area of the south eastern sectors of Mt. Semeru should be assessed carefully and the result thereon should be fully utilized in formulating the over all disaster prevention plan.

4 It will take long time, however, to complete structural measures necessary for disaster prevention. Therefore non structural measures including a warning and evacuation system need be provided as soon as possible. For this purpose, following items should be studied urgently :

1. Hazzard area mapping.
2. Sheltering evacuation spots finding
3. Improved warning system with a stand by network.

5 Land use regulation including the one for the inside of the fan segments must be set up and people inside have to be moved.

6 In preparing a sabo plan or design of sabo structures, particular attention should be paid on the following points :

a) Consideration of the land formation process should be reflected in making a plan of sabo works : sabo plans in the area of an active volcano can be different from those in the area of "dismantling" type.
b) Tructive force of the running water have to be utilized for fine material transportation to the sea.
c) Sabo facilities can be utilized for water resources development too.
d) Impact force must be taken into account in designing sabo dams.

7 It is advisable to take aerophotos preferrably with the 1 to 10.000 scale covering the entire area of the south eastern slope of Mt. Semeru : the result will be utilized as one of the most fundamental materials in practising the measures mentioned in the above paragraphs.

8 Observation systems and maintenance system of the Project Mt. Semeru have to be enforced

9 Training of the disaster prevention technology has to be accelerated.

1. Natural causes of the disasters

Water discharge, quantity of sediment and hydraulic features of the channel are the major factors which govern the disaster conditions.

1-1 Meteorologic conditions

Flood discharge primarily depends on the precipitation and geological conditions. The rainfall data obtained at the Proyek Tanaman Cengkeh Pencuggul Sumbermujur shows that the torrential rainfall occured just upsteam of K. Tunggeng ... But according to the data this magnitude of rainfall is not so rare.

1-2 Material supplied due to volcanic activities

Mt. Semeru is notorious for one of the most active volcanoes in the world, and we observed small scale eruption two times an hour accompanying cannon-like sounds and lava avalance that was rushing down drastically to the altitude of about 2,400 m. This lava avalance should be undesirable gift from the Mt. Semeru and just the source of evil. Unfortunately the flow direction is not forecastable though it takes the course to K. Besuk Bang in these days.

Nuee Andante deposit initially situated in the area with the altitude of 1300 m upto 2400 m is just the source of debris flow and lahar. The mountain slope formed by Nuee Andante deposit is quickly dismantled and flow type is changed to be debris flow and/or lahar. Debris flow and/or lahar rush into inhabited areas causing much damage and consequently stop the motion forming a certain spreadings which are called debris corns and/or alluvial fans. The differences between debris flow and lahar are defined in the next paragraph 1-3.

1-3 Flow Type

Four (4) types of material flows are recognized in accordance with the flow dynamics, namely

1. Nuée Andante flow
2. Debris flow
3. Lahar flow
4. Sediment flow.

In another words, Nuée Andante,Debris and some portion of lahar are classified to be mass transportation, and some portion of Lahar and Sediment flow are classified to be individual transportation. These two classifications of flow types are quite meaningfull because there is a tremendously big differences of energy and flow mechanisms between them.

Six (6) types of flows are illustrated in the Fig.1 and are difined in the relation between river-bed gradient and the co-efficient of flow conditions.

Debris flow and lahar are divided into three (3), namely

1. Boulder type debris flow
2. Muddy debris flow (mud flow)
3. Lahar.

.... /

Some criteria for the flow types classification are stated in the Table-1

TABLE-1 FLOW CHARACTERISTICS

	Boulder Type	Mud flow	Lahar
1. Material component smaller than 0.1mm	Less than 20%	More than 20%	More than 20% usually more than 40%
2. Rock material	Granite, Palaezoic	Igneous, Tertiary pyro-crastic	Pyrocrastic (ash-pumice, lava blocks)
3. Flow coefficient Vf/U*	Less than 5%	More than 5% usually 10-15%	More than 5 usually 10-15
4. Material concen-tration	More than 40%	More than 40%	Less than 40%
5. Behaviour at the dam site	Stop and forms debris lobe	Not stop but jump	
6. Material source and incipient motion	Failure of the deposit on the river-bed with the gradient of more than 15^{o}.	Landslide, eruption	Successive motion on debris flow
7. Flow charac-teristics	Run straight ahead	Run straight ahead	

Material concentration of the flows are in proportional to the river-bed gradient as shown in Fig.-2, so that the more the river-bed gradient is steep the higher the material concentration is.

Nuee Andante consists of pyrocrastic material including gas, pumice, ash and lava blocks and rushes down with high velocity accelerated by it's own weight. Other three (3) flows, on the other hands, material is drived by tractive force supplied by torrential flow. Flow types in detail are illustrated in the Fig.-4.

Material concentration just depends on the value of tan O that is the river-bed gradient as shown in the Fig.-2. The material concentration of debris flow is expressed in the equation No. 1 and the ones of lahar is shown in the equation No. 2.

$$Cd = \frac{P \tan \Theta}{(a-P)\ (\tan \Phi - \tan \Theta)} \% \qquad (1)$$

$$Cd^{1} = \frac{qs}{q} = 5.5\ (\tan \Theta)^{2}\ \% \qquad (2)$$

where P is the density of the flow
a is the specific weight of the material
Θ is the river-bed gradient
Φ is the angle of repose of the material
qs is the quantity of the sand material
q is the quantity of the water (discharge).

These equations tell that as soon as the river-bed gradient (tan Θ) decrease Cd and Cd^{1} decrease, and this fact shows sedimentation as shown in the Fig.-5.

And it must be noted that the material size of the deposit situated upper reaches is always bigger than the one situated lower reaches because bigger sized material always needs more tractive force than smaller ones as shown in the equation (3)

$$U_{*c}^{2} = g \times H \times I = 90.8 \times d \qquad (3)$$

where d is material size
I is river-bed gradient
H is water depth
g is the gravitational acceleration

so that the bigger the material size d is the bigger the value of water depth (H) and/or riber-bed gradient (I) must be.

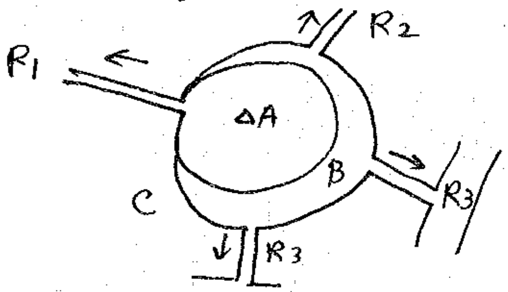
U*C is a non-dimensional tractive force due to running water. And, $H = \frac{A}{B}$ where A is the flow section, and B is the river width as shown in Fig.-6. If the river width B gets higher the water depth H, on the contrary, gets shallow.

This flow with high material concentration changes it's flow mechanisms as it passed the spots in which river-bed gradient changes and river width gets wider as illustrated in Fig.-7.

It must be noted that if material supply is continued by high material concentration flow the upper end of the deposit (sd) goes upwards quickly (Sd1 - Sd2 - Sd3 .....) so that the river-bed gets higher at this spot quickly. This phenomena should be the major cause of overtopping.

1-4 Structure of the Catchment Basin

Fundamentally speaking, every catchment basin has it's own structure based on it's geomorphologic conditions as shown in the Fig.-8, where A is the material source area from



which material supplied, B is the Buffer area in which various size deposit can be seen, C is the inhabitted area in which people live and work, R is the rivers, among the rivers in Fig.-8 R_1 is characterized by no buffer zone, R_3 is characterised, on the contrary, by sufficient area for buffer. Especially in the area of active volcano, A is the forbidden area in which ejected material primarily deposit and mountain body formation is in progress, and no river courses in this area fixed.

River couses always change in accordance with material supply due to lava flow, Nuée Andante and other pyrocrastic flows (tephra). In this sense, this area must be called the area of the God.

River couses in the area C (we call the area C the area of human) must be fixed for several tens of years or one or two hundreds years. And this is just our objectives and river improvement plans and projects must be established based on this point of view. In accordance with this concept illusttrated in Fig.-8 material has to be checked in the area A and B, and the river-bed of the rivers in the area C should be kept lower than the land surface with sufficient passing capacity. The area of material yield, transportation and sedimentation should be kept and limitted just inside of the area A and B. In this sense, the planners of the erosion control works have to recognize the boarder clearly between the areas first and then material movement must be analysed from the points of view of land formation processes including fan formation processes. From the points of view mentioned above, the structure of each catchment basin is illustrated as shown in Fig.-9. Judging from the catchment basin structure in Fig.-9, K. Glitik basin is characterized by the big buffer surrounded by old crator and fixed river course to the Indonesian ocean. In the cases of K. Rejali and K. Mujur, however, there is no obvious area recognized as the buffer, and fan-like land form is composed by lahar deposit in the case of K. Rejali and by Nuée Andante deposit and lahar depost in the case of K. Mujur. River run in the fan-like area disecting the old deposit and forming gauge with steep slope (1/10 - 1/20) and river courses show sharp bends affected by Nuée Andante deposit and this sharp bends of the thalveg were the major cause of overtopping upstream as shown in Fig.-10 in the cases of K. Mujur.

Because of the sharp bends and big mud flow discharge, K. Mujur is also characterized by big deflection of the flow and big difference of the water level between right side and left side as shown in Fig.-11.

As for the flood level difference at K. Mujur bridge the effect of the groin situated about 60m upstream at right bank must be taken into consideration.

Judging from the tremendously big tractive force shown by the boulders put on the higher river bank, water level difference and survey result in Japan velocity must exceed 15m/sec upper reaches and 5 meter/sec lower reaches. And the flow must be muddy debris flow and lahar with high viscosity.

K. Rejali is characterized by many kinds of fan formation processes. At least three (3) alluvial fans are recognized as a result of rough survey, but there are supposed to be many secondary fans in formation process. Damage conditions clearly show theflow conditions at any spots of the fan and there is a river taking another course in accordance with the flood discharge.

Primary fan spreads just lower reach of Besuk Koboan gauge, and river running on the fan begans to dissect the fan surface actively so that riverbed gets lower because of the effects of Besuk Koboan sabo dam. Small river originated from the fan head, however, shows that this river course does not have sufficient passing capacity yet. River bed have to be lower than existing level by means of additional sabo dams upper reach.

Any program intending to fix existing river bed height is not acceptable because of the reasons mentioned above. Fan formation processes are mentioned in detail in Fig.-12.

Initial fan is dissected from the head, and dismantled portion deposited lower reach. Thus the crossing point on which initial fan surface and secondary fan surface meet is called Intersection Point (I.P.) and this I.P. moves downwards when there is no material supply because of the checking effect of the sabo dams. But as soon as material began to be supplied additionally, I.P. moves upwards scattering the material from I.P. The key to analysing the stage of the fan is to find the place of I.P.

River improvement works is to keep this I.P. at the lowest place so that river bed is always lower than fan surface. In order that, material must be checked before fixing the river bed on the fan.

1-5 River-morphology - hydraulic characteristics of the river.

River courses along which disasters taken place have some troubles mentioned below :

1. Shortage of passing capacity because of small section.

2. Obstacles on the cliffs and river bed due to old Nuee Ardante stratum.

3. Bad alignment due to sharp bend.

4. Bad effects of sand bars such as point bars and single bars which increase the riverbed roughness.

5. Cross section that is too wide to concentrate the tractive force.

6. Quick and frequent change of the river bed gradient, a gradient decrease causes sedimentation.

K. Mujur has every trouble along it's course.

2. Social Causes of the Disaster

2-1 Damages always happen in the area in which people live and work so that the social reasons must be analysed precisely. There is no disaster in the area in which nobody lives and utilized the land.

From the point of this view, land use must be regulated especially in the area just situated on the iver bed and at the river banks which were damaged by overtopped flow.

In these area nobody allowed to live but only planting some tress. In order that, hazzard area must be fixed by the use of aerophotograph survey as soon as possible in order not to allow anyone to live there again.

2-2 Lack of proper warning and communication system

As long as artificial preventive measures against natural disasters are limited and destructive phenomena occur suddenly preparatory works for warning and communciation are urgently needed.

According to the hearing from the people in the damaged sites nobody heard the sounds of a kentungan that ought to be used for telling the emergency because just before lahar coming people already got into a panic so that nobody hit a kentungan and heard the sound.

And it was quite natural that the sound of kentungan was drowned by tne noise of trential rainfall hitting palm leaves and houses even if there was someone who was brave enough to hit it. And it must be also natural that the magintude of sound of kentungan is so small that it is impossible to carry warning.

It must be recognised as a measure for the signal in the time of peace and quiet.

Consequently a kentungan is of no use for emergency.

2.-3 Lack of the information to public for disaster prevention.

I saw an information board telling tourists the place of innundation area while flooding. Information and knowledge for disaster prevention have to be provided usually by means of information board, education and so on.

Engineers in charged of disaster prevention works have to be trained too.

3. Damage Conditions

Damage conditions are classified into two (2) categories such as hazzared sites and external forces which caused damages.

3-1 Hazzard sites

1. Damage cases on the riber bed.
2. Damage cases outside of the river course.
3. Damage cases at the higher places outside of the river course.

As for the damage cases on the river bed , land use must be regulated, people living on the river bed have to be migrated as long as sediment continues to be transported and river does not have sufficient passing capacity. If the river course gets stable and the quantity of sediment does not exceed the passing capacity, people are allowed to live there again.

In the cases of the damage outside of the river course, real reasons have to be analysed and river improvement works have to be done taking cost benefit ratio into consideration.

3-2 External forces

1. Lahar flooding (over topping).
2. Impact due to flow and boulders.

The real reasons of lahar flooding and impact must be analysed referring to the items mentioned in 1-5.

In the case of lahar flooding, flooded material sometimes gets into river course again in accordance with topographic conditions and discharge.

It must be noted that, especially in the cases of damage to sabo facilities, the facilities constructed upper reaches for the preventive purposes against debris and lahar must be tough enough against impact force due to debris flow and lahar.

4. Counter measures and priority

Counter measures against disasters are classified into three (3), namely :

1. Non structural measures - administrative measures.
2. Non structural measures - land use regulation.
3. Structural measures.

It is clear that non-structural measures do not need much cost compare to the structural measures, so that the administrative measures and land use regulation must be set to work as soon as possible.

4-1 Non structural measures - administrative measures.
Administrative measures include designation of hazzard area and the spots for evacuation, warning system construction, communication system building, the enforcement of observation systems and training scheme of the people for emergency. For this purposes survey result on the disaster this time must be well arranged and analysed. The best way to do is to take aerophoto as soon as possible before flooded area and flood marks will disappear.

The concept of land formation provide us useful information and careful judgement while we analysing the data and doing aerophotograph interpretation because every land form around Mt. Semeru has to be regarded as in progress stage.

4-2 Land use regulation
In the area threatened by debris and lahar people never allowed to live except planting trees and other agricultural crops.

In order to minimize the migration productivity in the remaining area have to be increased by means of irrigation and home industry promotion.

4-3 Structural measures

4-3-1 K. Glidik area

Inside of old crater especially lower reach of K. Besuk Bang and Besuk Sarat are always threatened by Nuee Ardante flow, and no structural measures seem to be successful except guide walls. Any kinds of guide walls, however, may be of no use if additional big eruption will occur so that any kinds of counter measures must be regarded as temporaly, and consequently inside of old crater in the K. Glidik basin should be big scaled sand pocket that collect the discharge from K. Glidik river systems and K. Besuk Koboan river systems. But the inside of old crater is too valuable to be abandoned completely, so that the land use for agriculture including cattle breeding is permitted.

4-3-2 K. Rejali area

Sabo dams in the Besuk Koboan basin must be enforced and increased so that the material will be checked efficiently. These sabo dams will result good and big effects to the fan areas lower reaches of Koboan gauge.

Consolidation dams in the fan area in the Rejali river systems are of no use in this stage. Guide walls and sand pockets will be good for minimizing the flooded area, but these facilities must be constructed based on the concept of fan formation and fan segment sifting. Additional sabo dams will rise the river bed of upper reaches so that two river basins, K. Glidik basin and Besuk Koboan basin, are able to be connected. Flood and almost all of the sediment can be diverted to K. Glidik basin.

4-3-3 K. Mujur area

K. Mujur area was seriously damaged by a cold lahar. As a result of the survey, every kind of trouble sources can be found along K. Besuk sat, K. Tunggeng and K. Mujur listed in 1-5.

Structural measures against next probable destructive phenomena will meet a lot of difficulties technical and financial.

It will cost too much to widen river courses upper reaches cutting Nuee Ardante terrace and old lahar deposit. Big amount of boulders kept remained on the river bed situated from the altitude of 200 m up to 400 m ranging about 8 km.
These spread of big boulders have bad effects on the hydraulic characteristics of this river, so that the sato plan intending to check these big sized material must be top priority.

In this sense, judging from the effects of Besuk Sat sabo dam, big sized material must be checked upper reaches higher than the altitude of 530 m.

As soon as new sabo dam is made inside of the reservoir to get higher so that another neighbouring area have to be prepared for next sediment trap area, such neighbouring area for sediment trap must be a fan segment and some fan segments form an alluvial fan. As long as material is continued to be supplied ceaselessly, no measures are successful without this fundamental concept of the fan segment shifting. If we succeed to check big sized material upper reaches, we can use some measures for river training aiming at stabilizing the course and bed conditions. Lower reach of K. Mujul may have enough passing capacity by the use of double section to transport the material smaller than 10 cm.

5. URGENT WORK PROPOSAL

1. Repair and enforcement.

    1. Besuk Sat No. 1 Sabo Dam
    2. Besuk Kobokan Sabo Dam
    3. Besuk Sat No. 4 Consolidation Dam apron and abutment must be enforced and carefully maintained

2. Urgent improvement works.

    1. Digging work at the sites with the altitude of 475 and 190 m in order to regulate the flow direction.
    2. Improve existing channel by means of digging works and open levees along K.Rejali.

3. Urgent construction works based on the overall plan
    1. 1st stage construction of the dike for the sand pocket with the area of apprеximately 5 km^2 near Desa Sumbersari and the confluence of K.Tunggeng and Besuk Sat.
    2. Some guide wall along K.Tunggeng upper reach in order to prevent spreading of the flow material in the case of emergency.

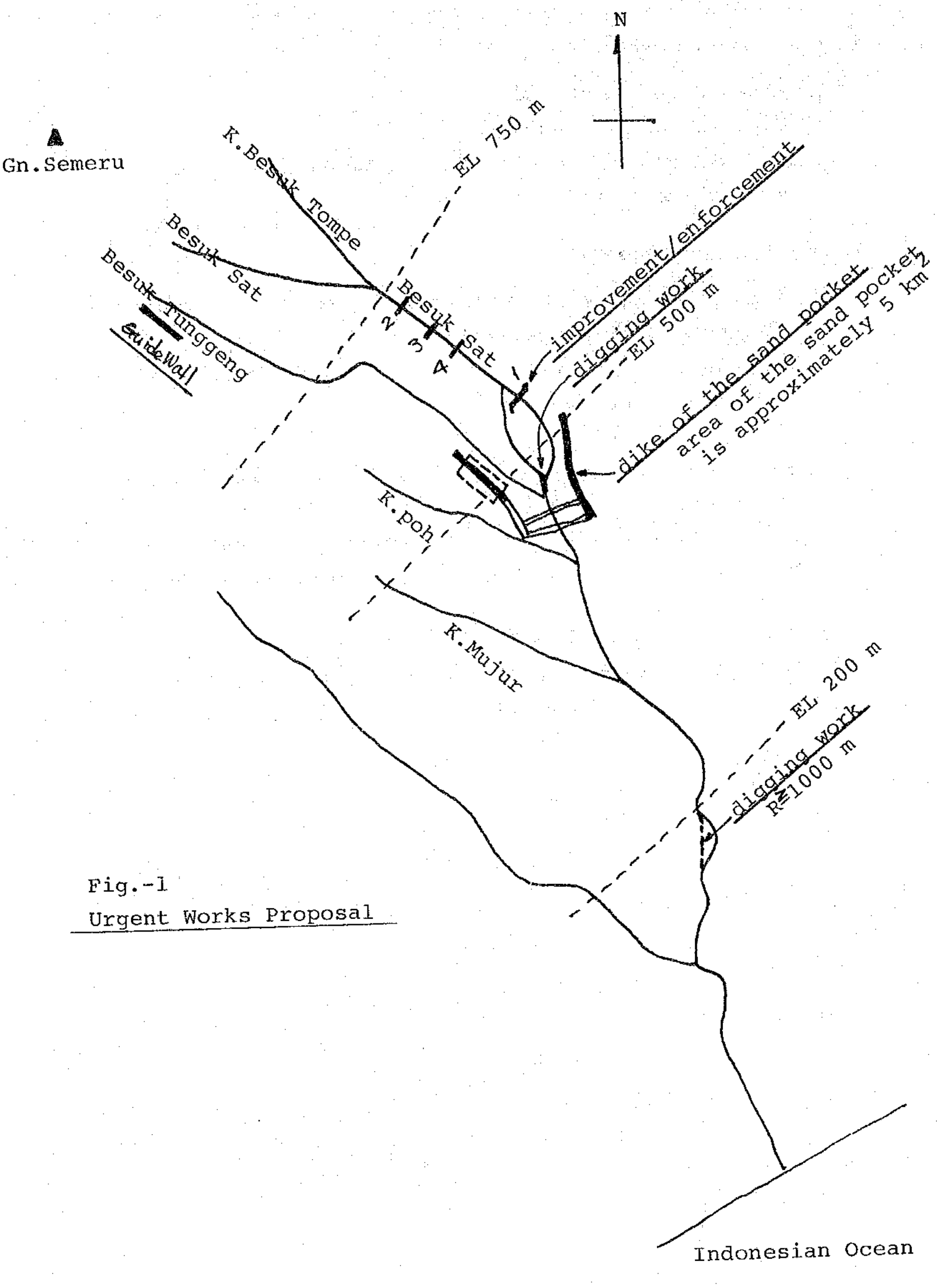
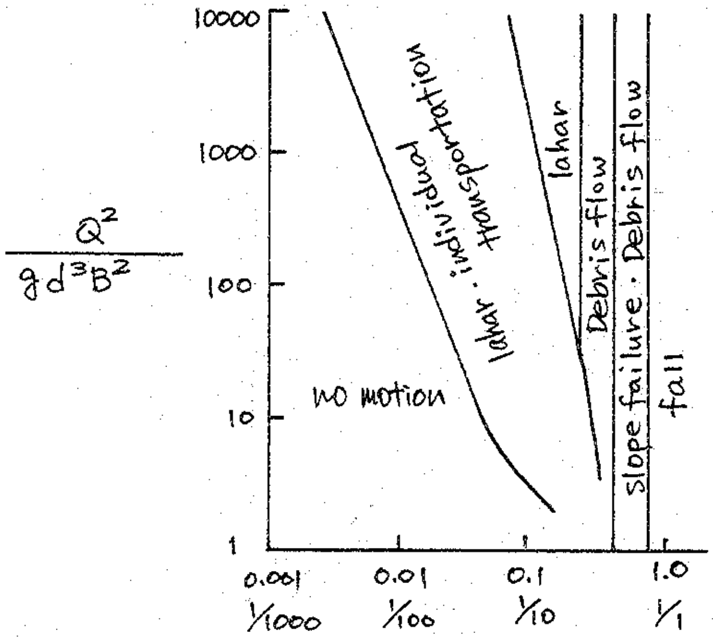


Fig.-1
Urgent Works Proposal

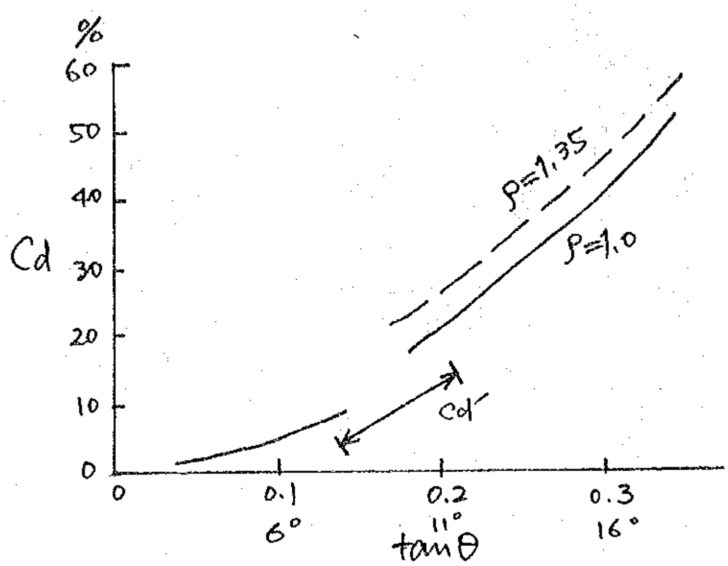


$I = \tan\theta$

Fig- 2 FLOW TYPES DEFINED BY RIVER BED GRADIENT AND FLOW CONDITIONS

Q : Flood discharge
g : gravitational acceleration
d : material size
B : river width
I : river-bed gradient

after Dr. Ashida



$$Cd = \frac{\rho \tan\theta}{(\sigma - \rho)(\tan\phi - \tan\theta)}$$

Cd:material concentration
of the flow

$$Cd' = \frac{q_s}{q} = 5.5(\tan\theta)^2$$

Fig.- 3 Material concentration versus riverbed gradient

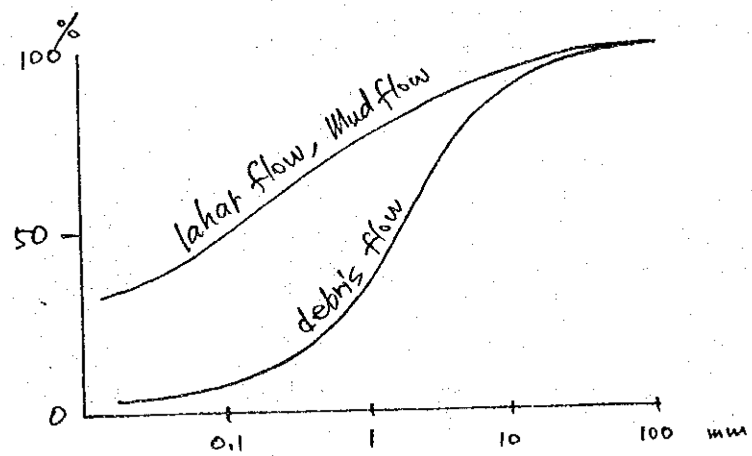
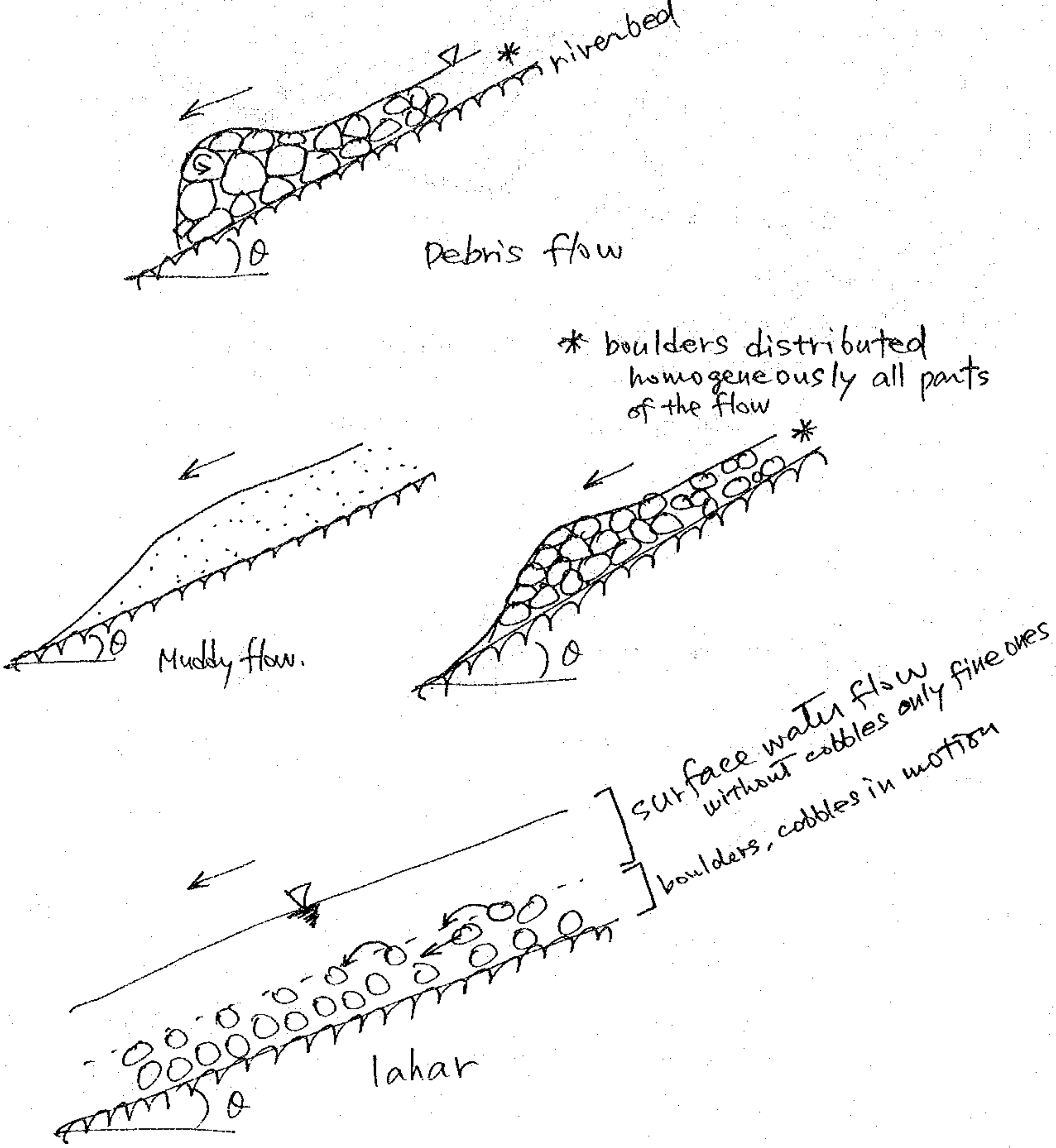
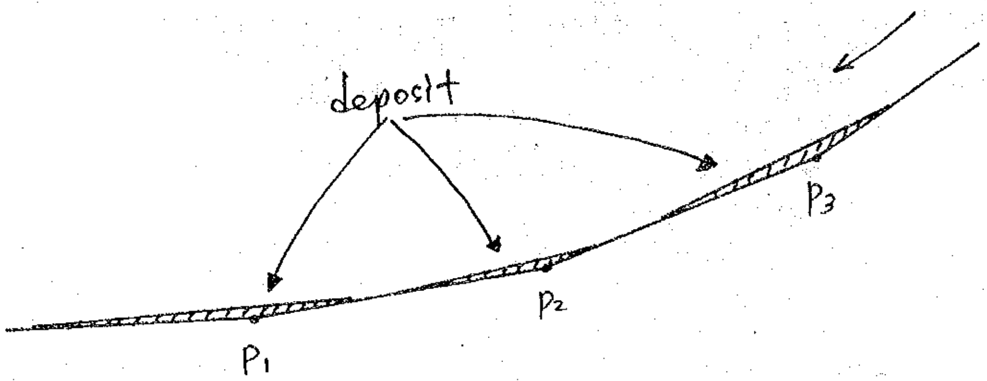


Fig.-4 Concept of the difference of the material size distribution

Fig.-5 Flow TYpes illustration





P1, P2, P3 are the gradient changing points.

Fig.-6 Deposit at the gradient changing points

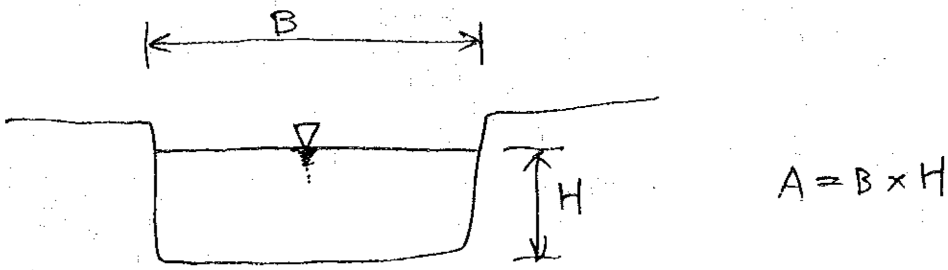


Fig.-7 Flow section

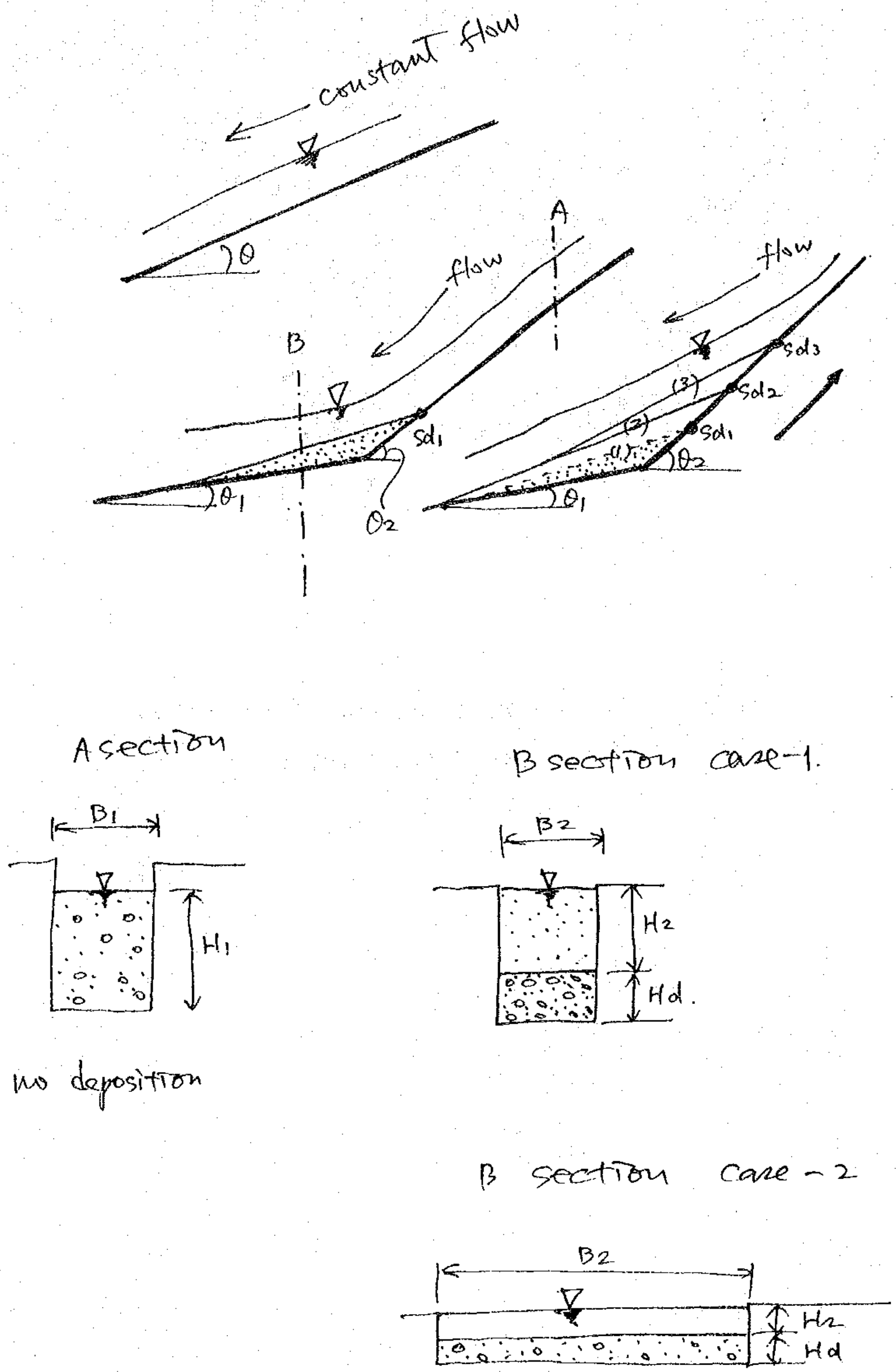

constant flow
θ
A
flow
B
sd1
θ1
θ2
flow
sd3
sd2
sd1
(3)
(2)
(1)
θ2
θ1
A section
B1
H1
no deposition
B section case-1.
B2
H2
Hd.
B section case-2
B2
H2
Hd

Fig.-8

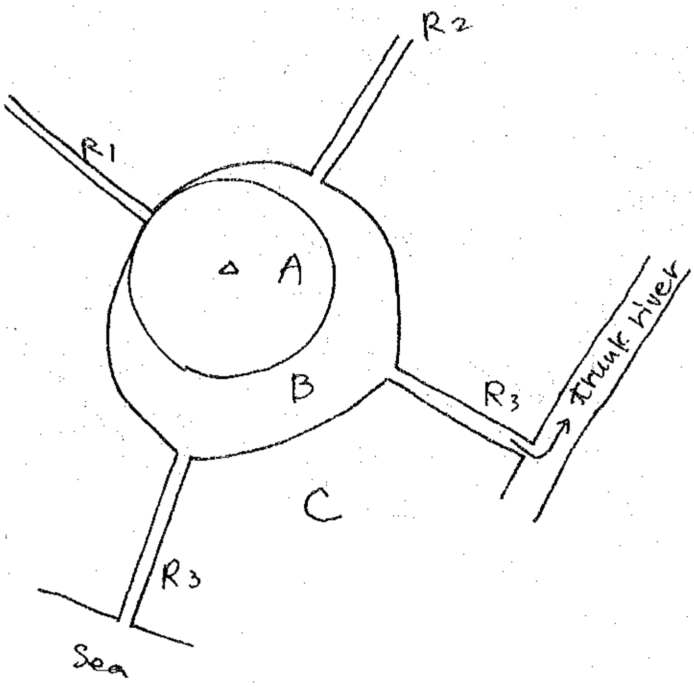
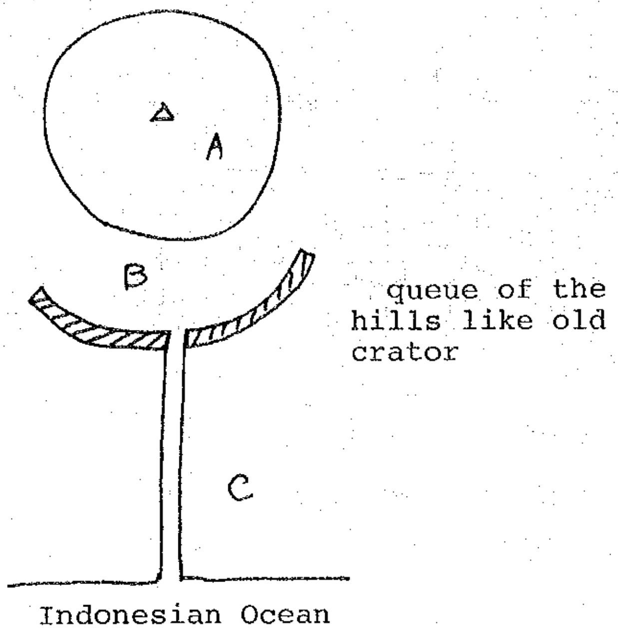
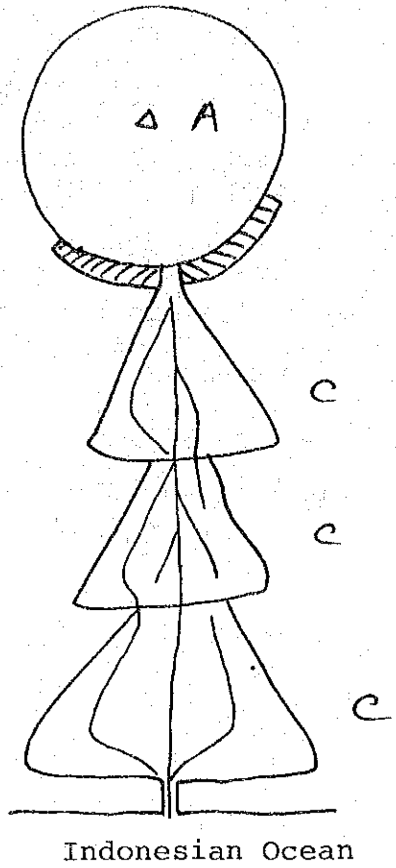


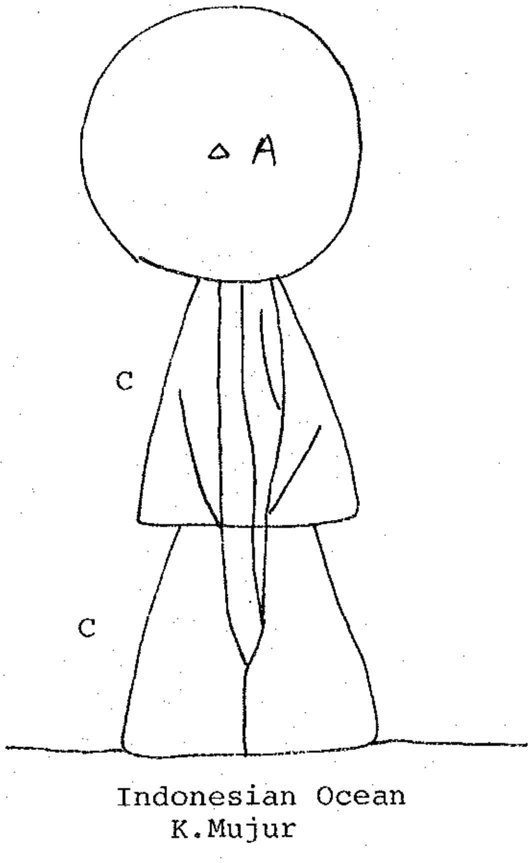
Fig.-9 Fundamental Concept of the Catchment Basin Dasin Structure



K.Glidik



K.Rejali



K.Mujur

Fig.-10Catchment Basin Structure of K.Glidik, K.Rejali and K.Mujur

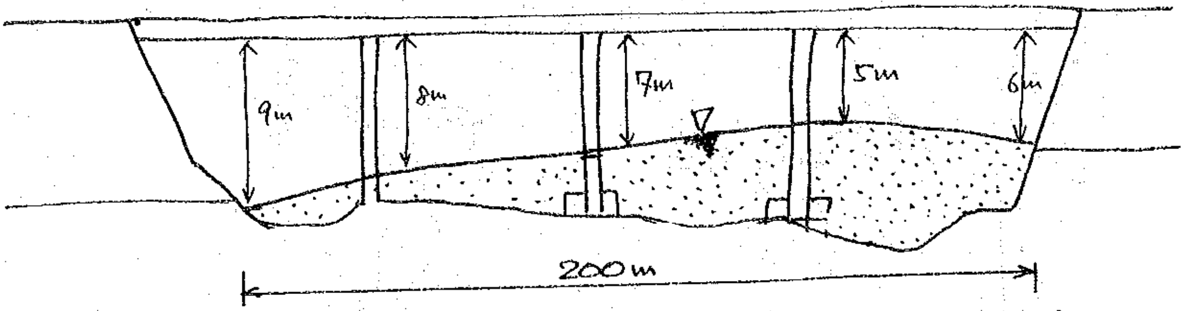
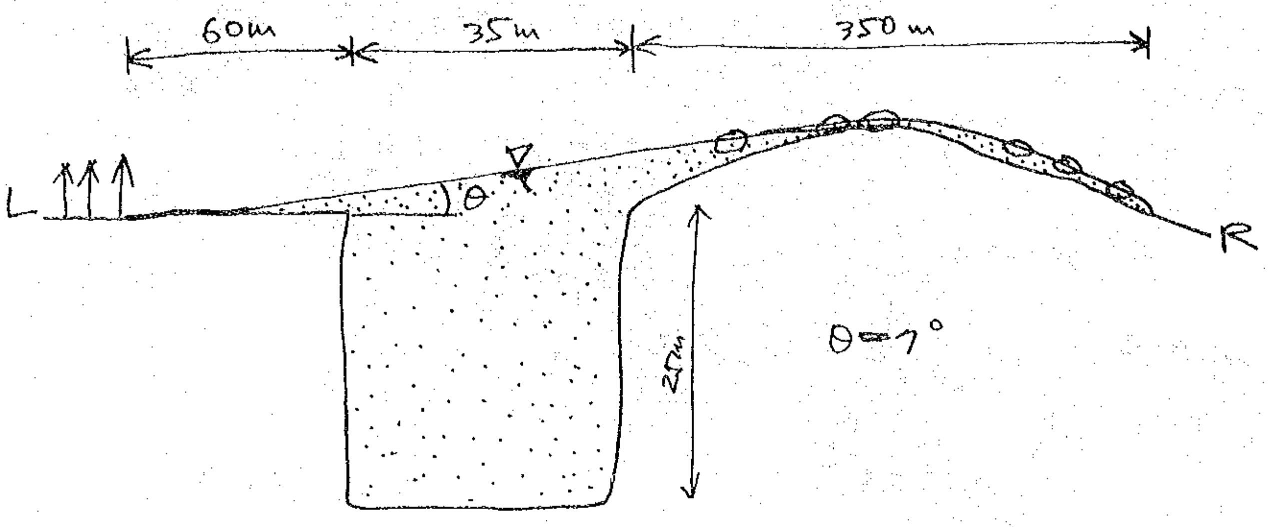
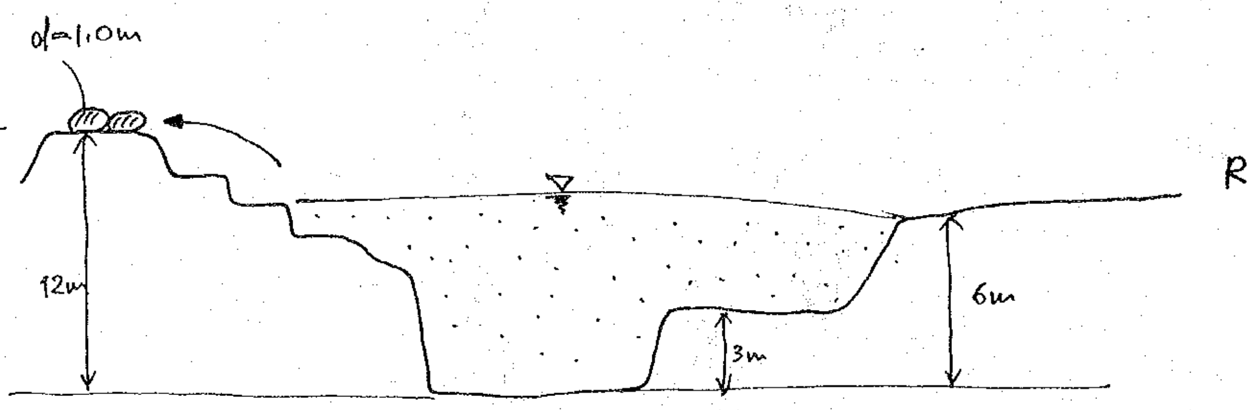


Fig.-11 Flood mark of the mudflow remained on the surface of the piers of K.Mujur Bridge



Case-1 K.Tunggeng at the altitude of about 950m

Maximum diameter of boulders is approximately 2.0 m, riverbed gradient is 6 degree, that is equivalent to 1/10.



Case- 2 K.Besuk Sat

1.5 km upstream of No.1 Sabo Dam

Fig.- 12 Difference of the Flood Level

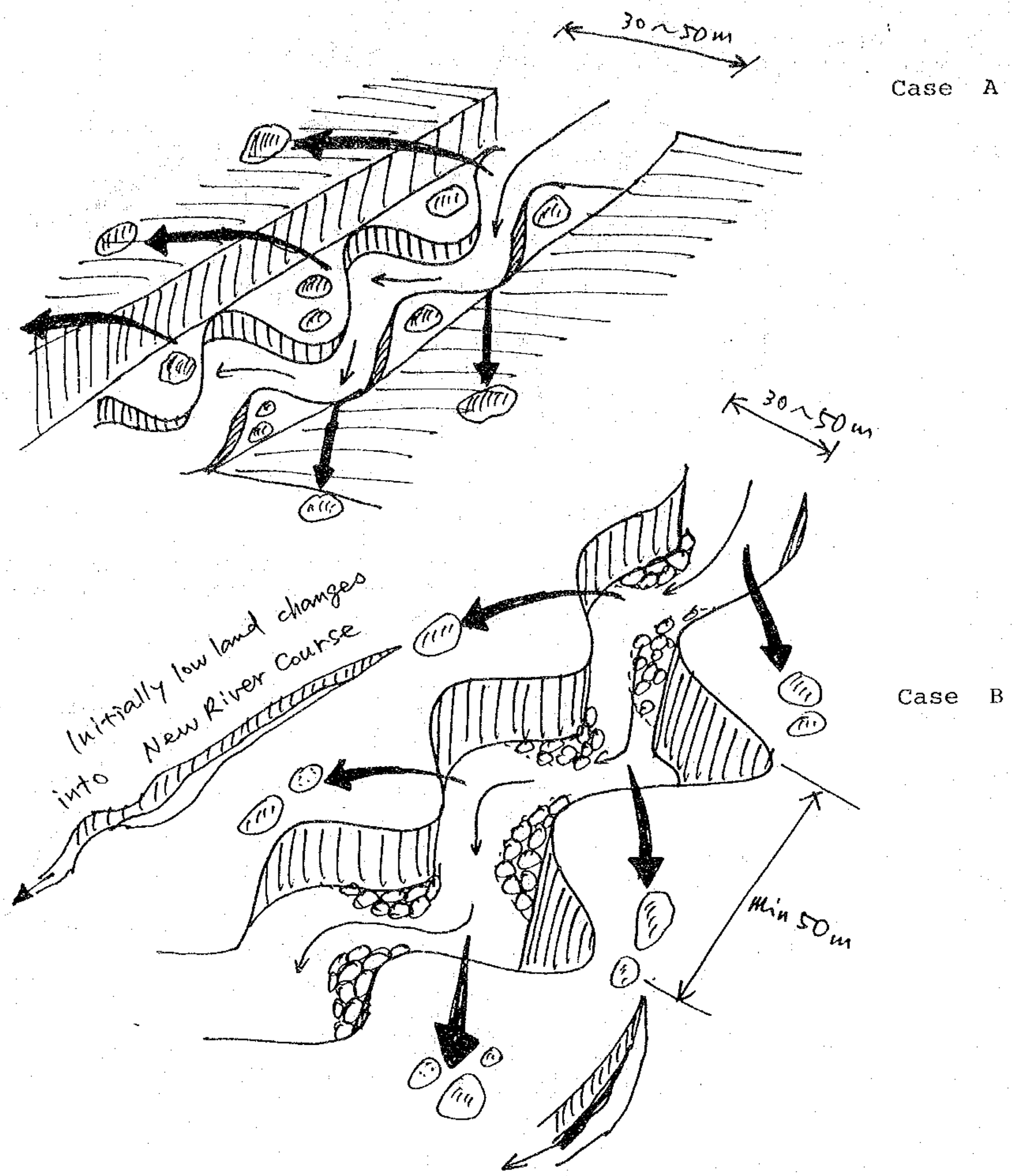


Fig.- 13 Sketch of the Sharp Bends

Riverbed gradient is approximately 1/15--1/20
If the gradient of the land surface is minus, overtopped material spreaded tremendously wide and sometimes made new river course.

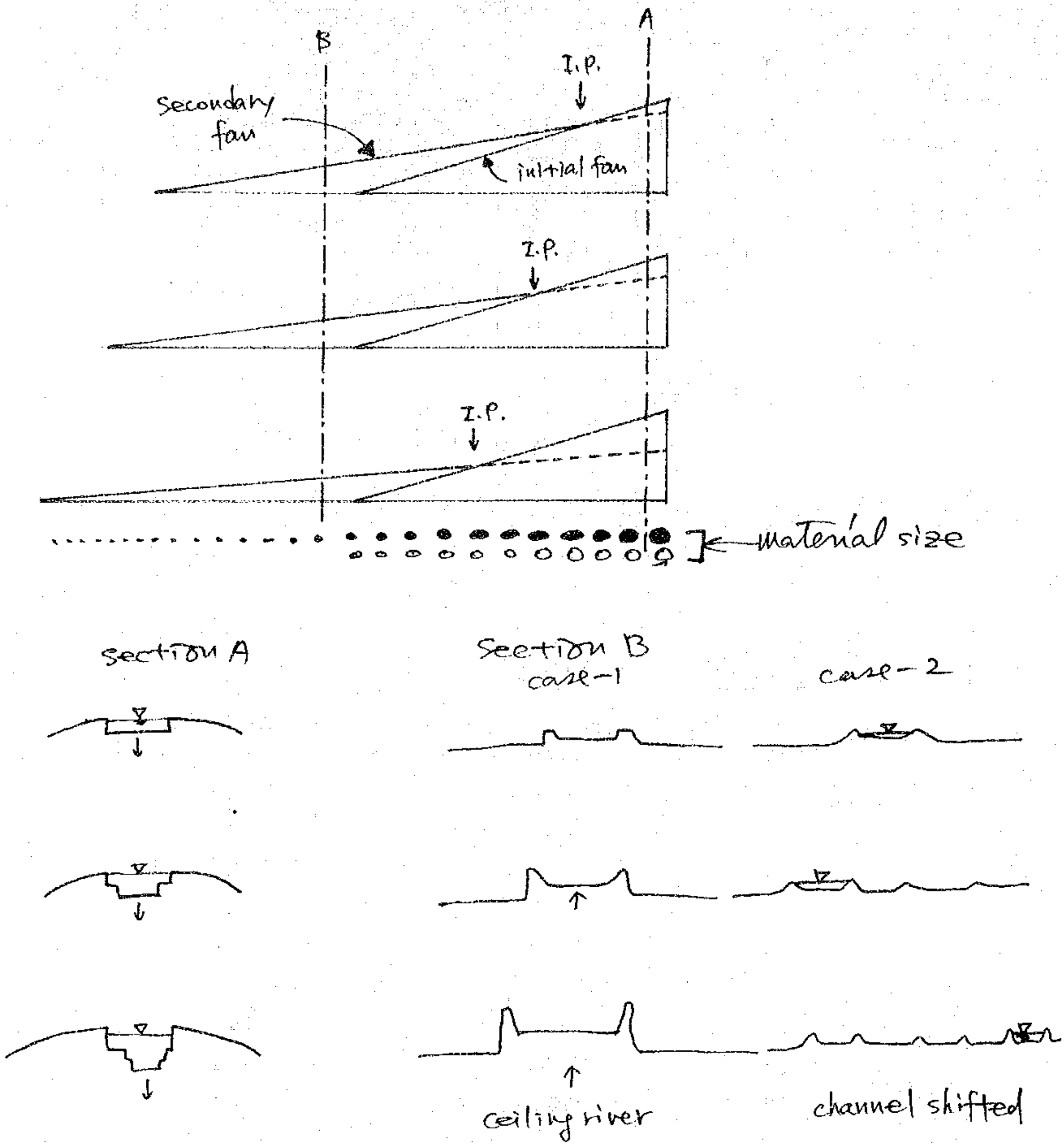


Fig.- 14 Fan Formation Process

Table-2 RAINFALL DATA AT THE PROYEK TANAMAN CENGKEH PENANGGEL SEMBER MUJUR (EL 740 M)

	Day	mm	
May	6	38.5	
	7	74.5	
	8	32.5	
	9		
	10	14.5	
	11	3.5	
	12	24.5	
	13	36.5	
	14	200.0	(16.00-18.00)
	15	30.0	
	16	15	
	17	15	

ANNUAL RAINFALL DATA

	precipitation	Number of days
1970	1576 mm	110
71	1624	80
72	1331	81
73	3691	87
74	3259	154
75	2042	135
76	1506	92
77	2888	145
78	5004	234
79	3771	164

Monthly Rainfall

Jan	1981	394 mm
Feb		
Mar		262.8
Apr		209.5

Table-3 RAINFALL DATA ON MAY 14 and 16, 1981

BESUK SAT OBSERVATORY

	Day			Day	
May	3	0 mm	May	10	13 mm
	4	0		11	4
	5	3		12	17
	6	53		13	26
	7	11		14	164
	8	26		15	3
	9	0		16	124.5

May 14th from 14.00 up to 19.30

Time		Time	
14.00	0 mm	17.30	40 mm
14.30	4	18.00	35
15.00	16	18.30	5
15.30	4	19.00	18
16.00	7	19.30	2
16.30	13		
17.00	20		

Total 164

May 16th from 0.00 up to 20.00

Time	Hourly	Accltd	Time	Hourly	Accltd
0			11	0.0	93.5
1	0.5	0.5	12	0.0	93.5
2	10	0.5	13	0.0	93.5
3	10	10.5	14	2.5	96.0
4	10	20.5	15	0.5	96.5
5	16	36.5	16	19.5	116.0
6	20	56.5	17	5.5	121.5
7	14	70.5	18	1.1.5	123.0
8	21	91.5	19	0.5	123.5
9	0	91.5	20	0.5	124.0
10	2	93.5			

Table-4 **DAILY RAINFALL RECORDS**

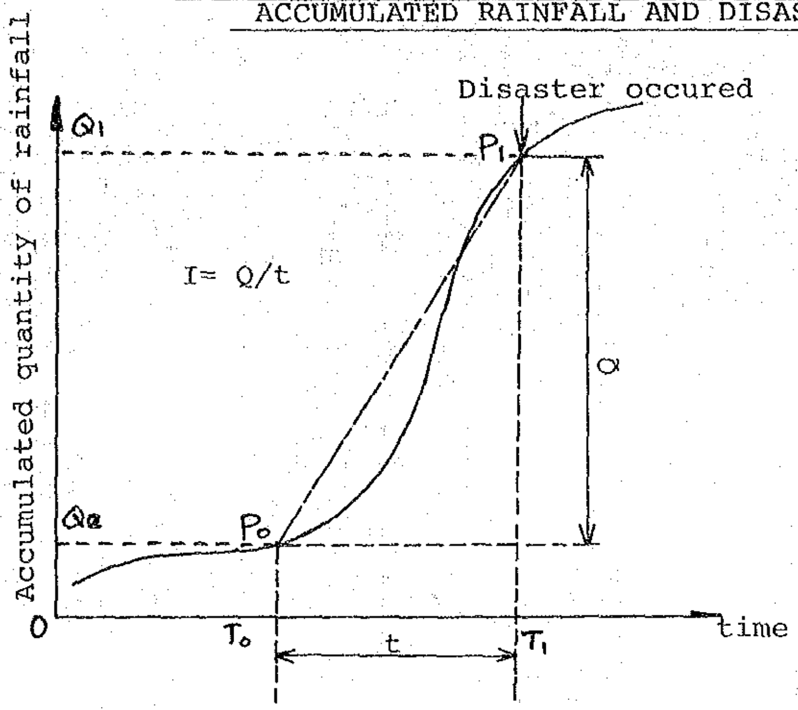
NO.	STATION	ELVASION (m)	YEAR	number of days in which rainfall exceed 100 mm	
1.	BESUK SAT (B. SAT)	795	1979	100	6 days
	"	"	1980	"	0 "
2.	CURAH KOBOAN (B. KOBOAN)	734	1979	"	5 "
	"	"	1980	"	2 days
3.	SUPIT URAKG (K.GLIDIK)	675	1979	"	4 days
	"	"	1980	"	0 "
4.	GUNUNG SAWUR (B. SEMUT)	682	1979	"	2 "
	"	"	1980	"	1 day
5.	PRONOJIWA (K. GLIDIK)	600	1979	"	3 days
	"	"	1980	"	0 "
6.	BENDO (B. TUNGGENG)	510	1979	"	2 "
	"	"	1980	"	0 "

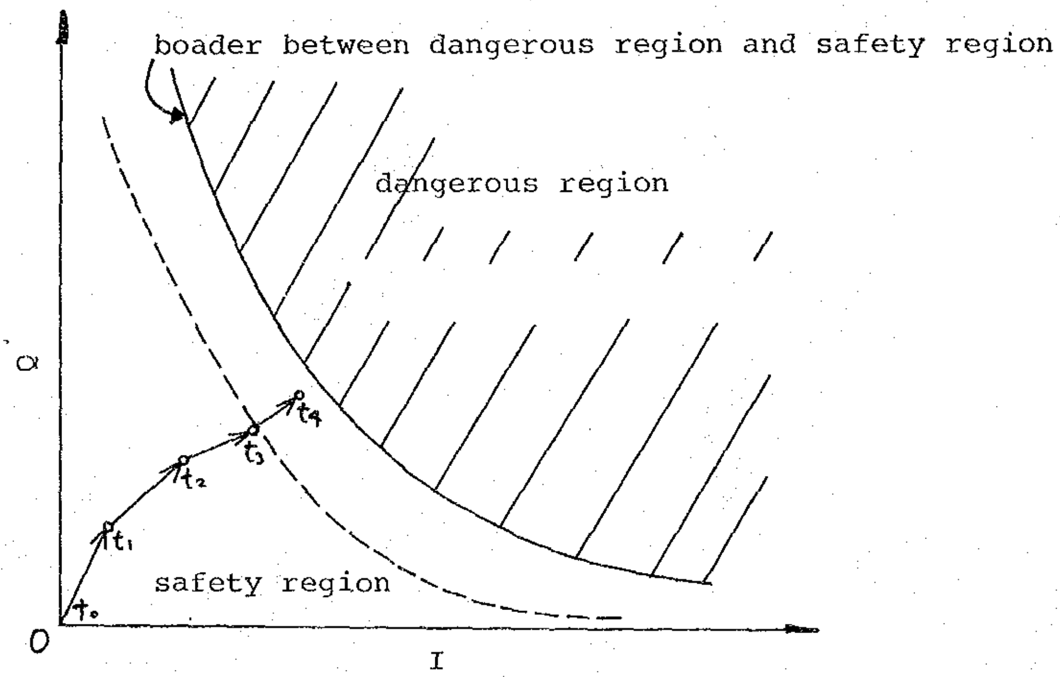
Table-5 DAILY RAINFALL EXCEEDING 100 mm

NO.	STATION	ELEVASION	YEAR	MONTH	DAY	rainfall(mm)
1.	BESUK SAT	795	1979	NOV	18	194
	"	"	"	AUG	7	100
	"	"	"	JUN	30	138
	"	"	"	AUG	8	111
	"	"	"	FEB	16	108
	"	"	"	JUN	28	107
2.	CURAH KOBOAN	734	1979	JUN	30	390
	"	"	"	AUG	7	173
	"	"	"	NOV	18	160
	"	"	"	JUN	2	142
	"	"	"	"	28	102
	"	"	1980	AUG	7	175
	"	"	"	JAN	30	150
3.	SUPIT URAKG	675	1979	JUN	30	235
	"	"	"	NOV	18	224
	"	"	"	FEB	16	128
	"	"	"	MAY	30	124
4.	GUNUNG SAWUR	682	1979	AUG	7	149
	"	"	"	JUN	30	130
	"	"	1980	AUG	7	104
5.	PRONOJIWA	600	1979	JUN	30	265
	"	"	"	NOV	18	220
	"	"	"	FEB	16	162
6.	BENDO	510	1979	JUN	28	105
	"	"	"	NOV	18	100

Fig.-15

CONCEPT OF THE CORRELATION BETWEEN ACCUMULATED RAINFALL AND DISASTER OCCURANCE





- - - - - line showing the timing of "STAND BY"

———→ accumulation curve of rainfall in real time

CORRELATION BETWEEN ACCUMULATED RAINFALL AND DISASTER OCCURANCE

-----For the timely designation of STAND BY and EVACUATION ready for emergencies due to heavy rainfall-----

The line expressing the accumulation of rainfall on an orthogonal coodinate with the accumulatted quantity of rainfall as the vertical axis and the time as the horizontal axis stands suddenly at the point P_0, and the gradient of the line get suddenly gentle at the point P_1.

The value of the accumulated amount of rainfall indicated by the point P_1 sometimes coincides with the time of the disaster occurance.

In this state, Q and I are defined as follows;

$$Q = Q_1 - Q_0$$

$$t = T_1 - T_0$$

$$I = Q/t$$

In this case, Q is considered to be the accumulated amount of rainfall that causes a slope failure and debris flow, and I is the average intensity of the rainfall.

It must be noticed, however, the value of Q highly depends on local conditions such as geology, topography, vegitation, landuse and so on. And that is why we need much data concerning the correlation between rainfall and disaster occurance.

The correlation between Q and I obtained through the process mentioned above, dangerous region and safety region can be designated on the coodinate with I axis and Qaxis.

On the Q-I coodinate the boader line between dangerous region and safety region can be set empirically,and the line indicating the time for STAND BY also can be set taking local conditions into consideration.

The point at the time of t , t , t ,...... coresponding to the value of Q and I must be recorded, and as soon as the line gets touch the lines designated on the coodinete necessary actiones must be taken by the officials concered.

The real meaning of this system must be commonly recognized by the community people in advance. And this must be the key to success of this warning systems.

Fig.-16

RAINFALL AND THE LEVEL OF LAHAR FLOW AT BESUK SAT OBSERVATORY

rainfall station: Besuk Sat 158A
flow level : Besuk Sat No.1 Sabo Dam

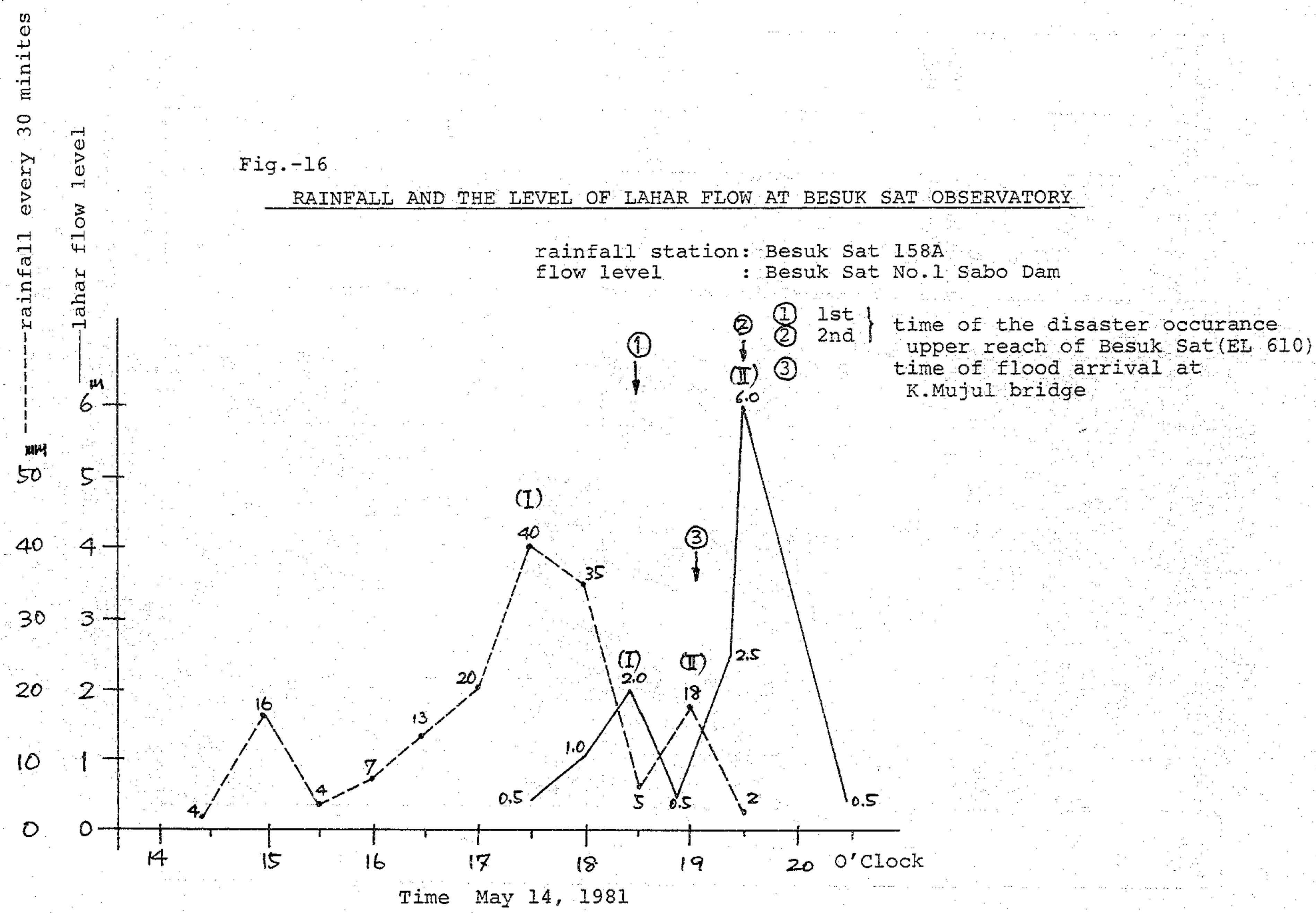
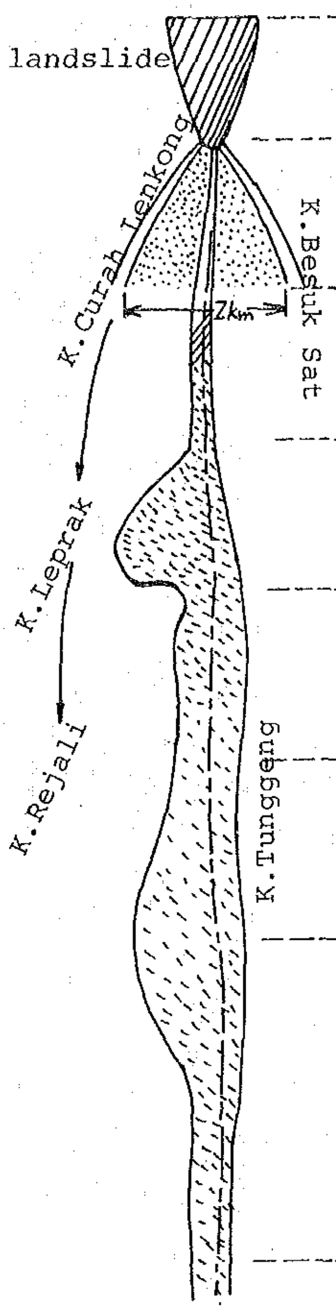


Fig.-17

BALANCE OF THE LAHAR FLOW MATERIAL on MAY 14, 1981



slope °	distance km		situation	altit. m	wid. m	eroded area m^2	eroded vol. m^3	deposit area m^2	deposit vol. m^3
				2000					
17	1.3		landslide				200×10^3		
		1.3		1600					
13	1.3								
		2.6		1300		$1.3\ 10^6$	650×10^3 (H=0.5)	1.3×10^6	400×10^3 (H=0.3)
	2.5				200				
		5.1		1100					
10	1.0				800	200 (40×5)	1000×10^3		
8		6.1		935	150		450×10^3	0.6×10^6	
	1.5							0.3×10^6	450×10^3 (H=0.5)
3		7.6		750	250				
	5.5							1.7×10^6	
				500	370	40 (40×1)	480×10^3		1900×10^3 (H=0.5)
3		13.1					1000×10^3	2.0×10^6	
	6.5								
3		19.6		300	250				
Total							3780×10^3		2750×10^3

$$\text{Total Volume} = 3780\times10^3 - 2750\times10^3 = 1000\times10^3\ m^3$$

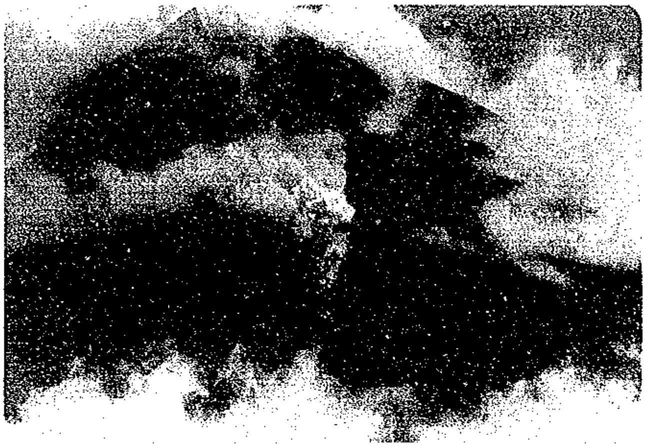


Photo-1 Lava Avalance
Occurs every thirty minutes, this is the biggest material source at this moment

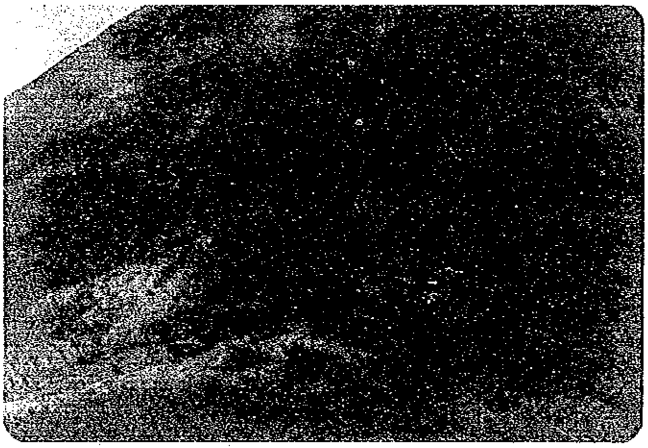


Photo-2 Deposit of Lava Avalance and Nuee Ardante
Small scale N.A. does not reach the cone area, however, this deposit is powerful enough to change the torrent courses frequently. As soon as accumulated amount exceed the critical one, material begins to move downwards periodically. (K.Glidik)

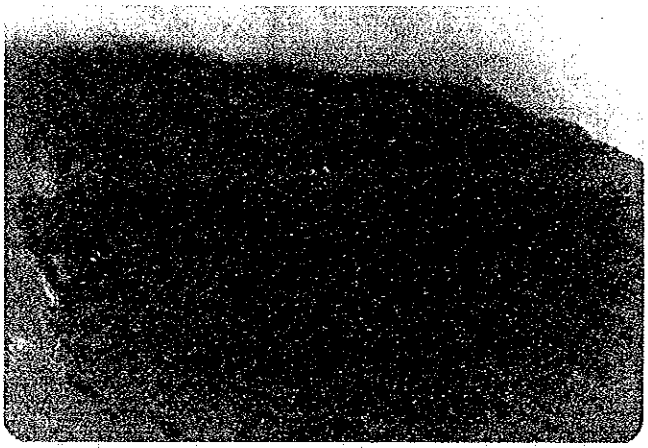


Photo-3 N.A. deposit upper reaches of K.Besuk Koboan and Besuk Semut
Not only K.B.Bang is threatened but other area in the S-E area also dangerous because of active material accumulation and dissection.

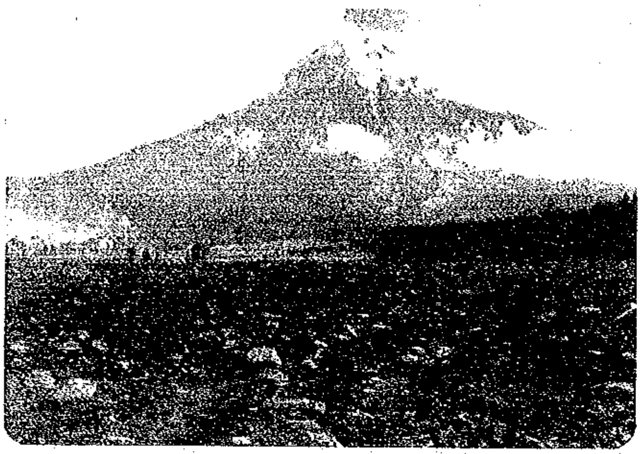


Photo-4 Lower reach of K.Besuk Kember
Two third of Desa Oro Oro Ombo that had been situated here was disappeared. Along the path of N.A., trees are burnt. White cloud shows the steam eruption due to remaining heat of N.A. deposit.

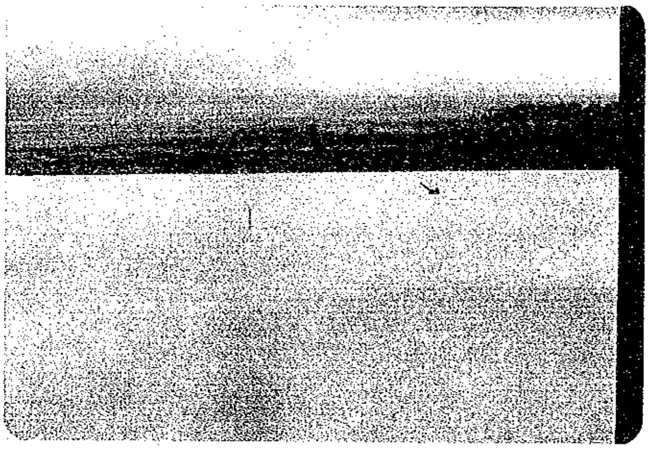


Photo-5 K.Lenkong area
Inside of so-called old crater is inundated due to the deposit that dams up the flow of K.Lenkong.

Photo-6 White cloud due to steam eruption
(K.Besuk Bang)

Photo-7 Steam blew up from the inside of N.A. deposit
Temperature exceeds 90 degree below the surface.

Photo-8 Water source area of K.Tunggeng
Flow formed typical U shaped section

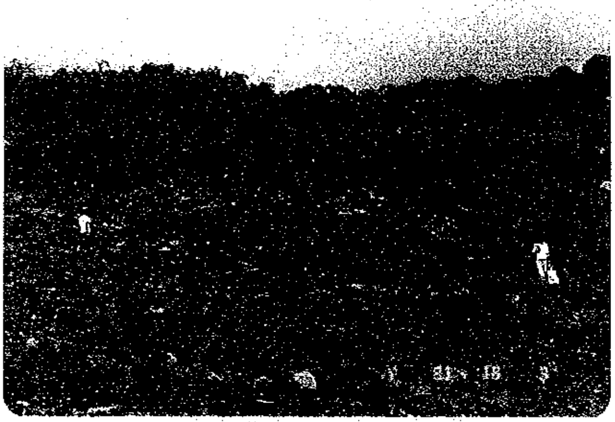


Photo-9 Water source area of K.Tunggeng (EL 1000 m)
Little boulders can be seen in the overtopped material

Photo-10 Water Source Area of K.Tunggeng
Rapid flow eroded the riverbed considerably.
The balance of the material deeply depends on the eroded depth. Old N.A. deposit looks quite tough and it makes the river course sharp bending.

Photo-11 Nobody allowed to live in the area that is threatened by overtopping.
And scattered material consists of much top soil.

Photo-12 Middle reach of K.Besuk Sat
Almost of all big boulders are left in the middle reach in which riverbed gradient is gentle and river width is big.

Photo-13 K.Mujur trunk river
No boulders can be seen because all of them are left in the middle reach of this river.

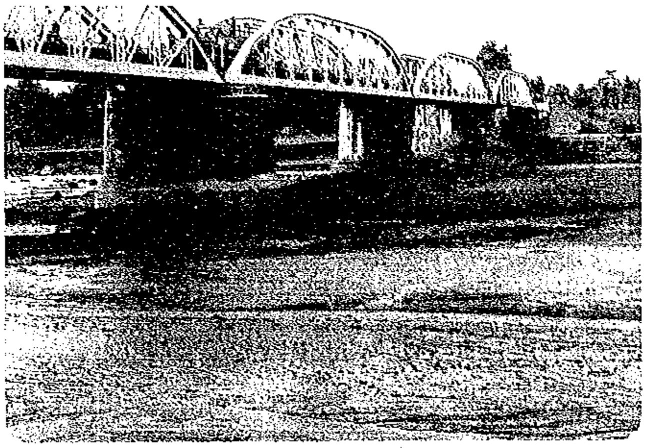


Photo-14 Flood marks remained on the piers show the big difference of the flood level because of the bending of the river course and high flow velocity.

Photo-15 Lower reach of K.Besuk Sat No.1 Sabo Dam before the disaster on May 14th.
This dam is situated quite important point from where Besuk Sat Lama is diverted. And this dam showed its big effects this time stopping the Lavar to Lumajang.

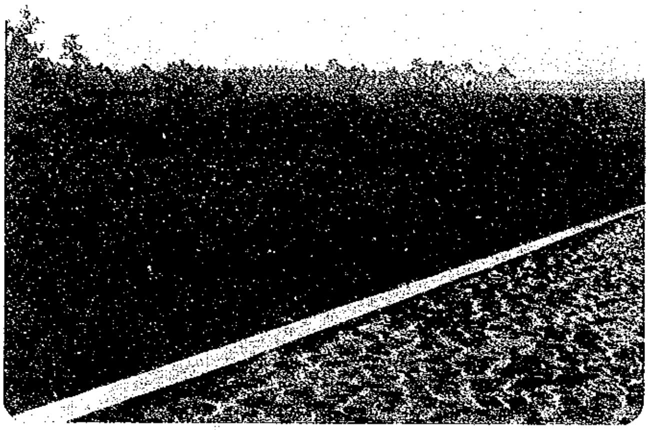


Photo-16 Besuk Sat Lama on May 16, 1981

Photo-17 Situation of K.Besuk Sat Lama
Sharp bend of the river course causes overtopping.

Photo-18 K.Besuk Sat trunk river
Before the disaster on May 14, 1981

Photo-19 K.Besuk Sat trunk river after the diaster (May 16, 1981)

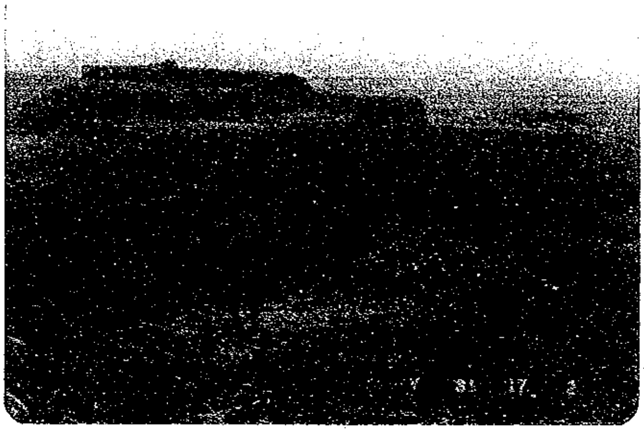


Photo-20 Besuk Sat No.1 Sabo Dam
This dam was made of gabion with concrete covering, and showed big effects this time. A few boulders attacked the dam so that the damaged was not so serious, however, dams suffering from the attack due to boulders have to be designed taking impact force into consideration.

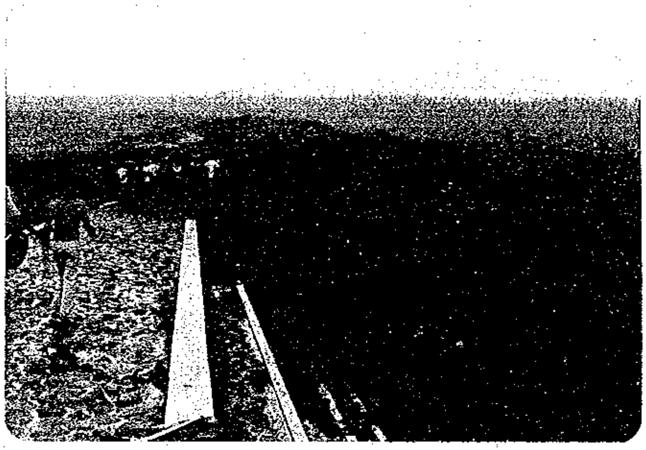


Photo-21 Situation of Besuk Sat trunk river
This photo shows that the dam checked the material to Lumajang effectively and regulated the flow effectively.

Photo-22 Crest of the Dam
The crest of the right side was about to be broken due to attack by boulders and scouring. This part must be rehabilitated and enforced.

Photo-23

Besuk Sat Lama
Small part of lavar flew into this diverted course.

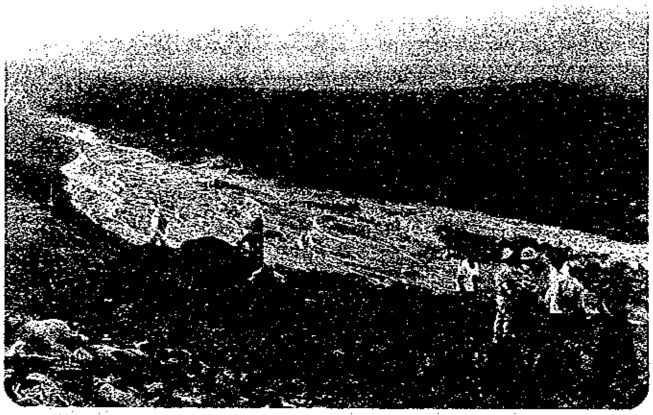


Photo-24

Besuk Sat Lama
Overtopping occurred because of small passing capacity due to narrow width of the channel. Revetment work was completed in order to prevent a flood to Lumajang. But flooded. This part must be widen urgently.

Photo-25 Breaking point just the spot of the revetment works.
Dikes made of cobbles was completely broken.

Photo-26 Breaking point of K.Besuk Sat left bank near Desa Kertosari

Photo-27 Damage situation at Desa Kertosari

Photo-28 Big boulder carried by lavar
Desa Kertosari. Weight is supported to be 20t.

before flood on May 14, 1981

Photo-29 and 30 K.Besuk Koboan at the gouge
No remarkable change took place at the fan head of K.Rejali because of the big effects of the SABO DAM situated upstream.

after flood (May 15, 1981)

Photo-31 K.Lepla flooded Second Fan
Fan formation processes are actively going.
Villages and paddy field are situated just on the riverbed and seriously damaged.

Photo-32 Riverbed gets lower because of the effects of Besuk Koboan Sabo Dams.

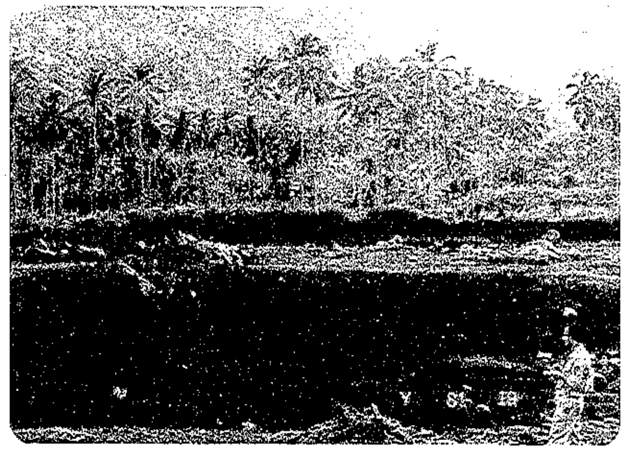


Photo-33

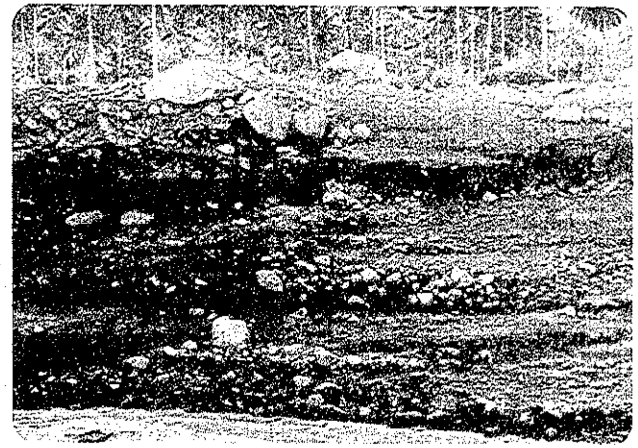


Photo-34

Alluvial Fan of K.Rejali---Fan Head area

Situation of dissection
Judging from the position of the boulders debris flow with typical front rushed down several times.

Flow takes different courses when discharge gets bigger exceeding the former level.

Photo-35,36,37 Condition of the Fan

1. Fan Head

2. Mid Fan

3. Fan End

Nobody allowed to live on the river bed

Photo-38 Disasters on the fan of K.Rejali (secondary fan)
fan head-mid fan fan head

Photo-39 Disasters on the fan of K.Rejali (secondary fan)
fan head-mid fan

Photo-40 fan head-mid fan

Annex - 1

SCHEDULE OF THE TEAM

May	7	Thu	Arrive at Jakarta from Tokyo	
	8	Fri	Courtesy call on DGWRD	
	9	Sat	Courtesy call on DGWRD	9.00
			Schedule making	9.30-11.00
			Courtesy call on JICA	11.30
			Leave Jakarta for Surabaya	Stay in SBY
	10	Sun	Surabaya-Kediri	Stay in Kediri
	11	Mon	Kediri- Lumajang	Stay in Lumajang
	12	Tue	Meeting on the schedule,data and maps available and general information	
	13	Wed	Field Survey............K.Rejari	
	14	Thu	Field Survey............K.Mujur	
	15	Fri	Field Survey............K.Glidik	
	16	Sat	Field Survey............K.Mujur	
	17	Sun	Report Making Mr.Tokuhiro and Mr.Ogasawara left for Jakarta, Mr.Fujita for Yogyakarta.	
	18	Mon	Field Survey.............K.Tunggeng Mr.Tokuhiro and Mr.Ogasawara report on the progress of the survey to DGWRD.	
	19	Tue	Field Survey............K.Rejari	
	20	Wed	Report Making Mr.Tokuhiro and Mr.Ogasawara left Jakarta for Tokyo	
	21	Thu	Hydraulic Model Test on the Flow Mechanism of lahar Discussion Left Lumajang for Surabaya and Jakarta	
	22	Fri	Report Making	
	23	Sat	Report Making	
	24	Sun	Free	
	25	Mon	Discussion at DGWRD	
	26	Tue	Submitted Final Report to DGWRD	
	27	Wed	Left Jakarta for Tokyo	

Annex-2

MEMBER LIST OF THE TEAM

1.	Leader	Master Plan	Masayuki Watanabe
2.		Water Resources	Kaoru Yoshida
3.		Warning System	Motoo Sakai
4.		Hazards Zoning	Katsumi Seno
5.		Socio Economy	Kenichi Ogasawara
6.	Advisor	General	Hideo Tokuhiro
7.	Assistant member	General	Akira Fujita

Indonesian Counterparts

1.	Project Manager	Suparman BIE
2.	Chief of Ope.Sec.	Achmadi
3.	Planning Sec.	Amran
4.		Tahar
5.	Volunteer	Robert Monc

Annex-3

LIST OF THE PARTICIPANTS OF THE MEETING ON MAY 22,1981

Mr. Masayuki Watanabe	Ir.Putra Duarsa
Mr. Katsumi Seno	Ir.Amir Muryadi
Mr. Motoo Sakai	Ir.Puramudo
Mr. Kaoru Yoshida	Ir.Djoko Legowo
	Djoko Sasongko MSc.
	Mr.I.Suryo
	Mr.Amran Sinegar
	Mr.Sukiyoto BE
	Mr.Atsushi Hamamori
	Mr.Atsuyuki Sakai

ON MAY 25,1981

Mr. Masayuki Watanabe	Ir.Amir Muryadi
Mr. Katsumi Seno	Ir.Puramudo
Mr. Motoo Sakai	Ir.Soetrisno
Mr. Kaoru Yoshida	Ir.Djoko Legowo
	Mr.Djoko Sasongko MSc.
	Mr.I.Suryo
	Mr.Sukiyoto BE
	Mr.Amran Sinegar
	Mr.Atsushi Hamamori
	Mr.Atsuyuki Sakai

Annex-4

ATTACHED SHEET (A-1 Form)

1. Background information

Mt. Semeru is the most active volcanos in Indonesia. Therefore, Lumajang area in the east-southern slope of Mt. Semeru has often suffered damages from volcanic debris flows, even though this area is regarded as the most productive in rice and other crops in East Jawa.

It is just 1977 after the serious mud flow disaster attached Lumajang area that Mt. Semeru Project was launched by the Government . Since then, activities have been concentrated to rehabilitate the destructed facilities and implemented emergency works for prevention of disasters.

On the other hand, Mt. Semeru Project Office has initiated to formulate a master plan for mitigation of disasters and improvement of living environment around Mt. Semeru as a comprehensive project.

In this connection, it is requested for the Government of Japan to provide its assistance in the from of expert service in preparing a guide line for the master plan formulation and more elaborate technical guidance on specific subjects of importance.

2. Specification for the post :

a. Survey team on the around Mt. Semeru Debris Flow disasters.

b. 1. Guide line for a master plan formulation
   2. Possibility water resources development including of ground water.
   3. Possibility of disaster warning.
   4. Preliminary survey of fluvio-geomorphological classification as a basis for harzard zoning.
   5. Preliminary survey for socio-economic evaluation.

c. Directorate General of Water Resources Development.

d. Team Leader : Sabo engineer with at least 15 years experience in planning and implementation of debris control, water resources development and related works.

   Hydrologist with experience in river regime analysis, water budget study, and sediment balance study.

Geological engineer with experience in fluvio-geomorphological study, foundation survey, geophysical survey and general geological survey.

Sabo engineer with experience in designing debris control and river training facilities.

Forecasting engineer with experience in debris and flood forecasting.

Socio-economic analyst with experience in planning and evaluating regional development project.

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