benefit of rivers providing water for agricultural use. Their hopes were placed in the benefits of flood control projects, and on ways of reducing flood damage. A tacit social consensus to this effect developed among those living in the valleys. Flood control techniques and projects in Japan originated from this type of social background.

In recent years, the plains have been drastically changing into urbanized areas with a dense population It is therefore no longer necessary for river water to be channeled into the urbanized inland at all times, as it is in the case of farmland where the water was used for agricultural purposes Equally, there is no longer any tacit social consensus that the residents have no choice but to accept flood damage as inevitable. As is seen in the high frequency of lawsuits involving flood damage, people have come to expect that there will be flood control projects preventing flood damage.

In response to these changes in social values, flood control engineering has reached a stage at which it needs to make a switchback from arguments concerning the benefits of flood control to arguments concerning the obligatory nature of flood control Flood damage only occurs when a flood or inundation affects urban facilities, houses, industrial facilities, and farm crops. Historically, flood control measures have been aimed at doing everything possible to build flood control facilities such as levees, reservoir systems and retarding basins in order to prevent rivers from overflowing and causing damage. The flood control measures taken so far have been aimed at preventing rivers from overflowing and preventing inundation, or at minimizing damage. The principle has been one of inundation prevention.

Today, due to the progress of rapid urbanization, it is no longer possible to meet the objective of flood damage control adequately merely by attempting to prevent rivers from overflowing. The reason for this is that rapid urbanization in zones of water resources increases the flood discharge, while the urbanization process in areas in which rivers overflow has increased the number of people affected by flood damage. Flood damage takes place faster, and the numbers of those subject to it is higher; moreover, the effects of these factors are multiplied, producing a potential for devastating damage. In the river basins that have undergone rapid urbanization, measures to reduce flood damage have been studied and implemented as "comprehensive flood control measures."

In a "switchback" development, the objective of these flood control measures has therefore been broadened from preventing inundation to minimizing flood damage In the past, the objective was to prevent rivers from overflowing in order to minimize damage. In addition, complete protection of facilities and crops that are subject to flood damage has now been included in the objective. At the same time, these measures have been expanded into comprehensive ones that include measures not only for river areas but also for river basins. We call this the principle of disaster minimization

Later, following frequent breakages of levees in rivers under direct control of ministory of constractions, excess flood prevention measures were formulated as measures to avoid devastating damage from rivers running through large cities, by preventing breach disasters This allowed us to make a switchback extension from the traditional flood control measures aimed at minimizing flood damage specified in the plan, to flood control measures aimed at minimizing flood damage—including damage not specified in the plan. These comprehensive flood control and excess flood prevention measures have drastically altered the conventional system of flood control measures

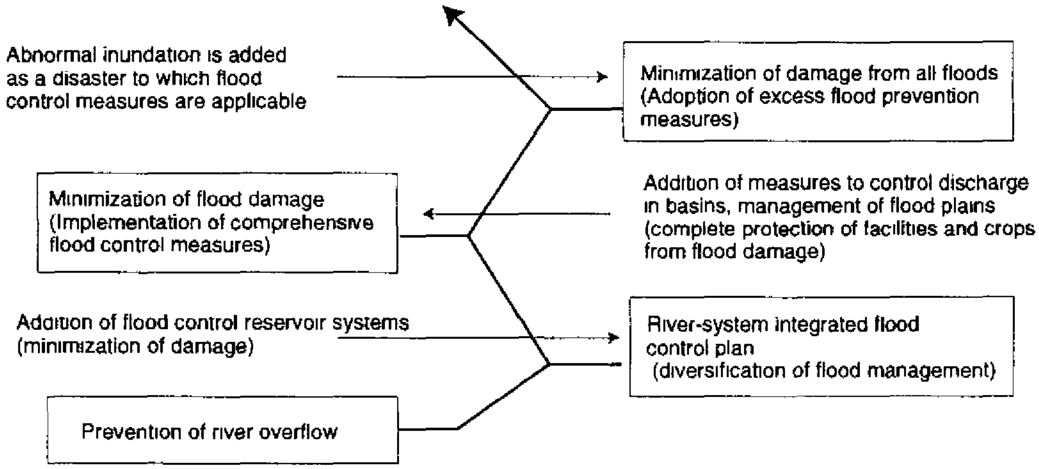

Fig. 3 Diagram of "switchback" extension of the definition of flood control measures

From the point of view of the modern history of flood control, these measures not only brought about a significant change in the philosophy of flood control, but also served as a major turning point in the history of development of flood control engineering and river engineering. Thus, when we return to the basics of the philosophy of flood control and the foundations of flood control engineering, and continuously make efforts to reexamine the definitions we are using, we will be able to develop plans for new flood control techniques and achieve progress in design methods.

7. STUDY OF FACILITIES, CROPS, ETC. THAT ARE SUBJECT TO DAMAGE: RISK EVALUATION

With this change in the philosophy of flood control engineering, it is necessary to move from the principle of flood prevention to the principle of minimizing damage, and to study the facilities, crops, etc that may be subject to flood damage. Research on risk analysis is underway in various academic fields, and it is therefore necessary to advance this type of research in the field of flood control engineering on the basis of the results of such research

The Great Hanshin Earthquake, which occurred in January 1994, was an unprecedented calamity, taking a heavy toll of more than 5000 persons killed and more than 300,000 persons injured. A calamity on this scale has not occurred in the past 1000 years In terms of probability, the expected value for the number of persons killed by an earthquake per year is only five persons, and we tend to assume that this figure is apparently socially acceptable. Future social research will show what level of risk is acceptable or not. Even if the consensus of opinion is that a calamity that occurs once a year and claims five lives each time is acceptable, can we conclude that we can accept a calamity that occurs once every 1000 years and takes a death toll of 5000 each time? This type of study lies in the field of risk analysis The term "risk," which generally means danger, is defined as follows in the Rasmussen report, which is a historical study of the safety of nuclear power stations

Risk (Loss level/Unit time) = Frequency (Event/Unit time) × Scale (Loss level/Event)

This formula is interpreted as calculating the expected value of loss from disasters, injuries, loss of life, etc.

When we examine risk, we often need to examine not only the system actually causing the loss, but also various other factors, including the social environment such as the parties that suffer from a disaster, people living in and around the afflicted area, local communities, industrial activities, politics and the economy, and the natural environment. In the case of the Great Hanshin Earthquake, even if we obtain the same value from the above formula, we cannot say it is the same risk. Even if we are able to make a subjective calculation to evaluate an approximate level of danger, we cannot help carrying out objective interpretations in order to evaluate a risk.

When evaluating social risk, we are faced with the problem of determining who may be liable to suffer loss of life. If a specific group of people are exposed to a high level of risk, although the risk is not so high for a society as a whole, it means there is a lack of social justice. Arguments about risk that are based only on the expected value for society as a whole, disregarding the position of the people who suffer losses, are liable to involve injustice.

The scale of flood damage varies considerably from year to year, and it is therefore not appropriate to evaluate the risk of flood damage using only the annual average expected value. Since some people always suffer, the risk cannot be determined in terms of a macroeconomic analysis, as represented by the following formula: amount of flood damage/amount of investment in flood control.

This means that risk evaluation is a subject that requires not only formal, economic value-judgments, such as risk and cost-benefit analyses, but also ethical value-judgments concerning human beings.

When risk is evaluated, the extent of risk that is acceptable becomes an issue. The acceptable level of risk varies considerably depending on the content of the risk: it may be a pure risk, i.e., one with only the possibility of suffering damage without any benefit; a speculative risk associated with benefits; a subjective risk shared by everyone facing the risk under the same conditions, an objective risk that varies depending on the conditions of each individual; a static risk that exists in every society without exception; an active risk that varies in accordance with changes in the desires of the society and human beings, a special risk, the cause and result of which are personal; a voluntary risk that individuals take when they act of their own free will; or a passive risk that individuals take when they participate in an activity not voluntarily, but when forced to do so by their society. Flood damage can be regarded as a pure risk, a subjective risk, a static risk and a passive risk

There are also various evaluation indexes for risk, including the amount of damage, the death rate, and lost time, and these are ultimately determined by subjective value recognition. C. Starr presented a report at the National Academy of Science (NAS) in 1970 in which he carried out a quantitative evaluation of social values and deaths in accidents in relation to the social engineering system. The report concluded that the relation between the awareness of benefits on the part of the general population and the risk of being killed in an accident is linear, as indicated below.

(Awareness of benefits) = (Relative level of advertisement)
× (Ratio of population involved in activities for social engineering system)
× (Usefulness and importance of such activities for individuals)

(1) The risk of being killed in an accident is the upper limit of the risk with an allowable rate of death from a disease (Approximately 10^{-2}/year.)
(2) Risk at the same level as a natural calamity (approximately 10^{-6}/year) can be almost completely ignored if it is generated by human activities. Risk at a lower level can be completely ignored.
(3) The social acceptance level for a risk rises as the benefits increase. (Relation of exponential function)
(4) Ordinary citizens tend to accept a voluntary risk willingly. A voluntary risk is about 1000 times larger than a passive risk

There are relations between risks and benefits, such as social benefits and social risks, as well as individual benefits and individual risks, and the acceptance level of personal risk created inevitably in connection with social benefits must be determined by a trade-off between the upper limit (death from a disease) and the lower limit (natural calamity)

The objective of this concept is to measure, control and evaluate risk in order to reduce the level of risk that inevitably accompanies even high reliability and safety and keep it below an appropriate level, by comparing the risk with risks in various other fields so that social consensus can be obtained from various points of view, including economic, ethical and cultural points of view. This means that there is a yardstick based on several values on a plane different from the yardstick based only on one value, i e , rationality in terms of economic efficiency and usefulness

We also need to address risk evaluation in flood control engineering, based on the results of studies of risk evaluation in other fields, without determining indexes for risk in a self-righteous way simply because we have no choice but to determine the acceptable level of risk subjectively. In this analysis, natural calamities are grouped together, but the risk of some calamities will be reduced with the progress of flood control projects. Therefore, it is assumed that the socially acceptable level of risk will be strictly determined. We need to carry out an analysis of the risk associated with the progress of disaster prevention projects in the future

8. CRISIS MANAGEMENT IN PLANNING METHODS: FROM AN EMPHASIS ON INVESTMENT EFFECT TO AN EMPHASIS ON CRISIS MANAGEMENT

The planning method for conventional flood control engineering is based on the safe flow of the design flood discharge and design flood, i.e. limited flood discharge Excess flood control measures are not based on this premise, and are formulated from the point of view of systems engineering in order to avoid devastating damage from inundations This approach introduced a historic "switchback" change in the philosophy of flood control, following the introduction of comprehensive flood control measures.

The least desirable event is assumed to be the worst possible event associated with disasters caused by the collapse of levees on large rivers, and the preceding events that contribute to cause devastating damage are examined in order to formulate measures to prevent each of these events. These measures are then systematized and included in the excess flood control measures. In this case, the fault tree analysis method used in systems engineering is applied.

The River Council held many consultation meetings in response to an inquiry from the Construction Minister, and submitted its findings in the form of "The Report on Excess Flood Control Measures and Method of Promoting Such Measures" in March 1987. According to this report, we should first "proceed with the construction of wide, high-standard levees in a specific series of sections on the large river as a main measure to avoid devastating damage from excess flooding due to breachs in large rivers in the area of large cities." At the same time, "people place a high value on waterfront spaces as valuable locations providing relaxation and recreation in the urban environment Securing disaster prevention space that can serve as a safe evacuation place as part of the disaster prevention measures in overcrowded cities is urgently required.' Therefore, "major development areas form part of the cities, and these can be expected to serve as multifunctional urban spaces that can meet such diversified demands " Thus, "we should actively work out ways of making appropriate arrangements with regard to land use, and actively promote the development of such space."

The report also suggests that we should carry out research on "a system for land use and building designed to avoid devastating damage in the closed-type flood area in which flood water does not return to the river, or does not diffuse because of the geographical features, when a levee breaks or a flood occurs," and on "the control of flood flow ... to minimize damage when levees break or floods occur." For the first time since the Meiji era, excess floods, which are termed "floods exceeding the design discharge" in contrast to "design floods" and are an external force not foreseen in the control plan, have been regarded as part of flood control measures.

In conventional flood control measures, the design flood discharge and the design flood specified in the "flood prevention plan" were regarded as the external force requiring to be dealt with, and flood control facilities were constructed one by one. If a flood exceeding the design scale occurred, the flood was studied, the design scale was expanded to deal with the flood, and then a new "flood prevention plan" was formulated. Flood control facilities were then constructed in accordance with the new plan. This is how the conventional system worked.

However, when a levee is built, it encourages urbanization of the river basin, and, as a result, the land behind the levee undergoes a heavy concentration of population and assets. In particular, the development of the large cities in which Japan's most important central control functions are sited was only possible through the construction of levees.

With the current levee technique, levees have risk of breakage at all times, although the probability of such breakage is extremely low. When a flood exceeding the design scale or an excess flood occurs, the levees are broken by overflowing or overtopping. The large cities in which population and assets are heavily concentrated suffer particularly severe damage, and this in turn is likely to cause devastating damage to the administration, economy, and every aspect of society. For this reason, we have tried to prevent devastating damage by minimizing the frequency of excess floods. When a large-scale flood occurred, it was basically dealt with by increasing the scale of the "flood prevention plan " By contrast, excess flood prevention measures are aimed at preventing devastating damage from inundations caused by breach—although there is little that can be done about some levels of inundation and flooding.

However, even continuous expansion of the design scale cannot completely eliminate the possibility of devastating damage. How to avoid this critical situation becomes an important issue when a large city develops through the extreme urbanization of a river basin

The original intention of all the systems, facilities and structures that are constructed using every available type of engineering and technology is to provide facilities that can be used Each of them is provided with a method of ensuring the safety of its users and those in the vicinity in case a load or an external force exceeding the design load or force is applied to them, or if they are not operated correctly, or if an emergency occurs.

Generally, such methods include a way of cutting off the power source and a method of releasing the abnormal external force from the system. These are relatively inexpensive in comparison with the cost of the facility as a whole, and are easily provided in many cases.

Flood control projects, however, are aimed at providing safety at a much higher level, by protecting the national land from flood damage and creating a safe country. River engineering is a variety of techniques that are used to achieve this objective. Ensuring safety is therefore a requirement to which the highest priority is given An emergency in a structural system such as a flood control system is a situation in which a load or external force, i e a flood exceeding the design flood discharge or an excess flood occurs.

The traditional method of increasing the design scale each time an excess flood occurs did not posed any specific problems at a time when the population and assets in river basins were not changing so rapidly. However, in a river valley in which urbanization has begun, the existence of a levee itself tends to speed up the urbanization process, since the levee tends to suggest that flood disasters will no longer take place, and the danger of disasters is less and less recognized socially. As a result, when a disaster occurs due to a breach, although it is caused by an excess flood, the implementation of the flood control project may be criticized as having made the damage greater than if it had not been implemented at all, because the development of infrastructure of various types, including the flood control project, is regarded as facilitating the urbanization of the land behind the levee. Of course, such criticism is merely criticism of the infrastructure for not being completely flawless, disregarding the various benefits the infrastructure provides. Since there is no question of opting to have no levee and do nothing at all, the argument that levees are not needed is unrealistic. However, the basic policy in implementing a flood control project, and specifically whether we should aim at attaining the maximum benefit with the limited investment, or at minimizing damage even under the worst possible conditions in order to attain benefit steadily, however small it may be, is an undecided issue.

In today's urban society, in which people move their residence very frequently, information regarding the worst possible situation that could be caused by a disaster does not filter down to residents. In addition, in a highly developed society, when the worst possible situation actually occurs and the community has failed to take measures to avoid it, the community is more likely to suffer from damage so devastating that the whole foundations of the society are shaken.

When we review this matter with the emphasis on investment considerations, we can highlight the advantages and economic efficiency of flood control projects in preventing the more frequent small-scale and medium-scale disasters. For this reason, it is very likely that the specific economic advantages of flood control projects will not be obvious in relation to disasters on the scale that causes devastating damage, the frequency of which is extremely low.

This is because there is an assumption that the damaged area will always have been repaired by the time the next disaster occurs. However, this assumption is not necessarily valid, as is evident from previous examples in history of communities that have ruined by flood disasters. It is therefore necessary to adopt the method of assuming disasters caused by breach as the least desirable event in terms of systems engineering and to carry out a fault tree analysis and minimize the damage from inundations even during an excess flood, in order to improve the reliability and systems safety of flood control facilities.

The results of a fault tree analysis of excess flooding are shown in Fig. 4.

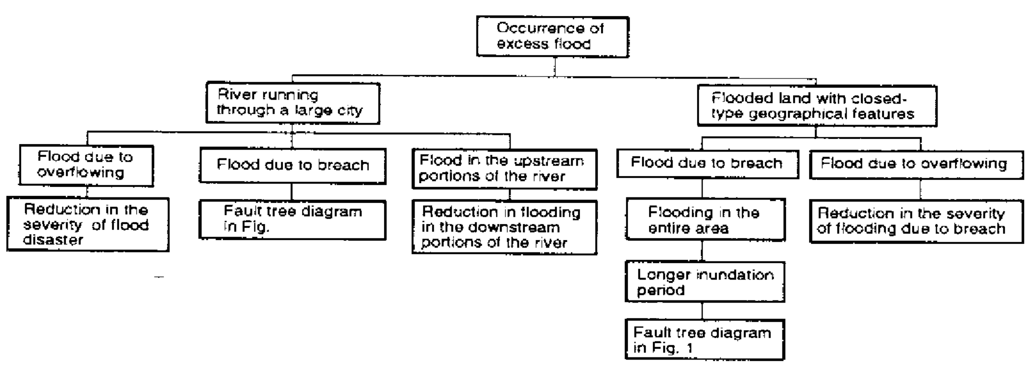

Fig. 4 Fault tree analysis for excess flood control measures

The difference between Fig. 4 and Fig. 1 is that the levee will not break even if a flood exceeding the design high water level occurs; in particular, this is designed to prevent breach due to overtopping The likelihood of a flood in the upstream portions of the river and the adoption of the planning method are therefore subjects of study. Excess flood control measures are measures formulated for crisis management in flood control. Even when an excess flood occurs, these measures are aimed at avoiding devastating damage by 1) preventing the disaster of breach, and 2) minimizing the area that can be flooded. In particular, they are designed to prevent breach due to overtopping.

1. Construction of high-standard levees .... A way of preventing disastrous breach

These levees will have a structure that provides sufficient safety in relation to the destructive mechanisms of overtopping, overflowing, water penetration, and leakage, by increasing the reference section of the levee from the present 2-in-1 gradient to a 30-in-1 gradient.

Where L = the external force of the flood, $f(L)$ = the probability density of occurrence, Q = flood control capacity at the time when the "flood protection plan" is completed, such as the flow capacity of the river and the retarding capacity of the retarding basin, $S(L)$ = the amount of flood and potential flooded area that is currently protected by levees, but is likely to be inundated by the external force L of the flood if the levees are broken, $W(t)$ = assets per $S(L)$ that are likely to be damaged (disaster potential). The time when the river project was initiated is set as the origin $t = 0$, and the current point of time is $t = t$. The expected value for the annual amount of damage from disasters D is obtained from the following formula:

$$D(t) = \int_0^{\infty} S(L)W(t)f(L)dL$$

Where D' = the expected value for the annual amount of damage in connection with disasters caused by breach when a flood occurs that exceeds the flood control capacity of the conventional flood control method, as well as disasters caused by breach that occur with a very low probability even if the flood does not exceed the flood control capacity, or so-called breach without overtopping. The expected value for the annual reduction in the amount of damage D-D' is calculated as follows, where $b(L)$ is the probability of breach that occurs when a flood does not exceed the flood control capacity or $L<Q$, and this is assumed to be in the acceptable range, since the probability is normally very low.

$$D'(t) = \int_Q^{\infty} S(L)W(t)\,f(L)dL + \int_0^{Q} S(L)W(t)\,b(L)\,f(L)dL$$

$$D(t) - D'(t) = \int_0^{Q} S(L)W(L)\,\{1 - b(L)\}\,f(L)\,dL$$

However, although there was a social consensus at the time when the project was initiated that the disaster was within the acceptable range, the levee was constructed while the urbanization of the basin was taking place, and as a result, a social perception has arisen that there is no longer any potential for damage from flooding in the land behind the levee As a result, population and assets have concentrated excessively, and the scale of the potential damage from excess flooding has grown to such an extent that it can no longer be ignored In other words, the figure for $W(t)$ will be very large.

The following formulas apply to disasters that are likely to occur in the land behind the levee before and after the external force of the flood exceeds the flood control capacity, such as the design flow capacity or the flow capacity of the river and the retarding capacity of the retarding basin

$$\Delta D_{L\text{-}0} = S(L)\ b\ (L), \quad \Delta D_{L+0} = S(L)$$

The moment the flood exceeds the design flood capacity, the levee is broken, and the floodwater starts to flow into the hinterland, producing the same result obtained when there is no river improvement. Consequently, in large cities in which population and properties are highly concentrated, the disaster level reaches a stage at which the disaster of a breach cannot be tolerated.

The excess flood control measures allow us to construct high-standard levees and to prevent the levee from collapsing even if it is overtopped or the river overflows it.

In this case:

$$D'(t) = \int_{Q}^{\infty} S(L-Q) W(t) f(L)\, dL$$

$$D(t) - D'(t) = \int_{0}^{\infty} S(L) W(t) f(L)\, dL - \int_{Q}^{\infty} S(L-Q) W(t) f(L)\, dL$$

As a result, even if a flood exceeds the flood control capacity, the disaster caused by the inundation in the hinterland of the levee is:

$$\Delta D_{L+\Delta L} = S(L + \Delta L - Q) W(t) = S(\Delta L) W(t)$$

These relations are shown in Fig. 5.

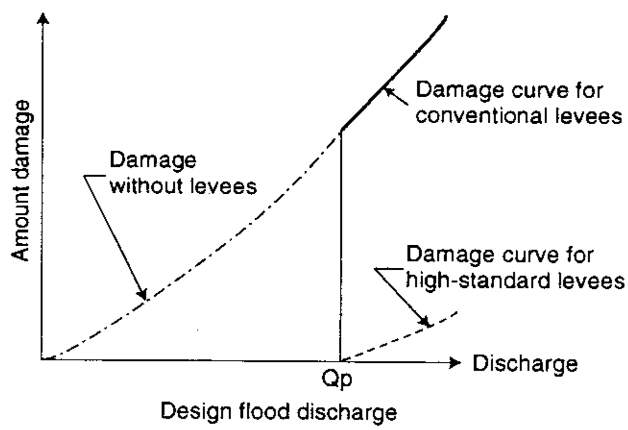

Fig. 5 Effect of projects for conventional levees and high-standard levees

A diagram comparing the high-standard levee and the conventional levee is given in Fig. 6.

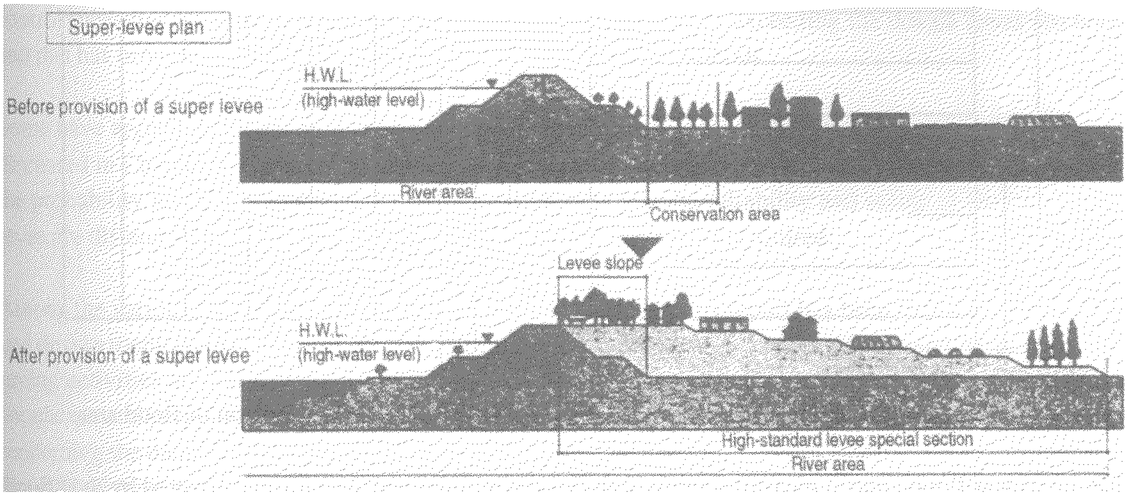

Fig. 6 Diagram of the reference cross-section of the high-standard levee

The use of land behind conventional levees has been prohibited, because it increases the risk of breach. By contrast, the technical design standard for the high-standard levee is such that normal use of the land does not increase the risk of breach.

The standard gradient for the slope is set at 30-in-1, which provides sufficient safety with regard to breach due to overflowing, which is the most dangerous type of breach when the upper side of the levee is available for normal land use

The establishment of this technical standard allows the upper side of the levee to be made available for urban and agricultural use, excluding the cultivation of rice, which is likely to cause breach due to water penetration and leakage Therefore there is no need to acquire land. This makes it possible to create an attractive new urban space close to the water beside a river.

2. Control of flooding flow / Leaving the ring levee / Construct secondary levee

Measures are required to minimize the flooded area behind the levee when the geographical features are those of a closed-type flood area. In this situation, if a breach occurs, many houses and properties are flooded up to a large height for a very long period of time, resulting in a very severe disaster. To prevent this, the hinterland of the levee, which is a closed-type flood area, is divided by ring levee and secondary levee .If the conventional method is used, the flood area is totally inundated if a breach occurs. By contrast, if the secondary levee method is employed, only the divided section of the flood area adjoining the broken part of the levee is inundated, while the other sections can escape inundation.

The results of a study of potential disasters in the divided hinterland, as shown in Figs. 7a and 7b, indicate that the expected value for the annual amount of damage can be reduced.

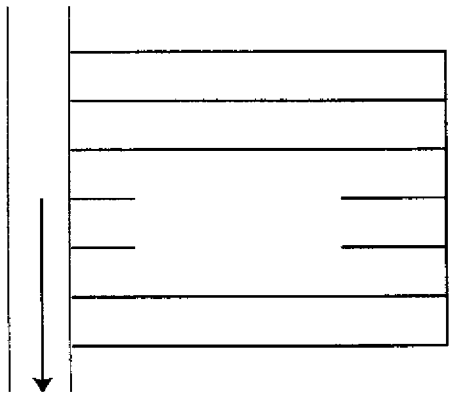

Fig -7a Parallel division of flood area

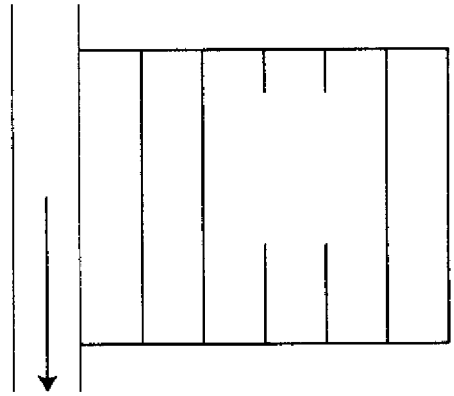

Fig.-7b. Serial division of flood area

Since the excess flood control measures apply to floods exceeding the external force covered by the "flood protection plan," some people think that we should start to implement these measures once we complete the conventional flood control measures. However, if we implement the excess flood control measures at a stage at which the flood control capacity has not reached the design flood discharge specified in the "flood protection plan," we will be able to avoid the disaster of breach and reduce the damage when a flood exceeding the flood control capacity at that stage occurs As a result, we will be able to minimize damage

In other words, the high-standard levee requires a long period of time before it is completed. Even if an excess flood occurs during that period, there is no risk of breach in the completed section, and therefore we are required to take flood-fighting measures only in the section in which the measures are not implemented. Thus, even during the implementation of the project, the objective of the crisis management measures is achieved. There is therefore sufficient need and validity for the implementation of the excess flood control measures even at a stage at which the conventional flood control measures have not been completely implemented.

For example, in the area along the Arakawa River buildings with three or more stories account for 2 7% of the total buildings, as of 1988 By contrast, buildings with four or more stories account for 19.9% in the central Tokyo area, as of 1991 Thus, since the number of taller buildings will also increase sooner or later in the area along the Arakawa River, it is necessary to formulate a construction plan for high-standard levees in advance, and to implement the project in a timely manner

In the 120th ordinary session of the Diet in 1991, a bill for the revision of the River Law calling for the addition of provisions for high-standard levees was passed, and the use of the high-standard levee was officially established. The law provides that a special area for the construction of a high-standard levee should be provided in a river zone, structures with specific requirements must be newly constructed in the special area for the high-standard levee, and drilling does not require permission

Since ordinary land use is permitted on the upper side of the high-standard levee, river construction firms are not required to buy land, but only required to compensate for losses to landowners needed to raise the ground. For this reason, since they can easily obtain the consent of landowners, there are relatively fewer restrictions on the implementation of a project

While the conventional method applied to floods not exceeding the design flood discharge excess flood control measures are aimed at minimizing damage even from floods exceeding the design flood discharge, and this has brought about a substantial change in flood control methods

Some have argued that we would not need high-standard levees if we constructed the composite-type levee discussed in Chapter 6 However, it is not a case of a choice between two alternatives, because this study of the probability level of breach and the risk level indicates that the reliability and safety of the two types of levee are different. In some cases, construction of both levees may be required.

Among the various techniques for flood control, the objective in this report has been to discuss the planning and design methods. Measures such as flood-fighting activities, evacuation activities and first-aid and life-saving activities are not covered here Because the urbanization of the hinterland and the concentration of population and properties are facilitated after the completion of construction of levees, public announcements concerning the danger of flooding will also need to be studied; this aspect is not discussed in this report either. Since all of these measures are already implemented as "comprehensive flood control measures," they are not included in this report

9. CONCLUSION

Crisis management is defined as all of the efforts made to avoid the worst scenario that has been assumed within a specific time, using the limited resources, manpower and equipment that are available The worst scenario is generally assumed subjectively by the personnel in charge. Since preventive measures are implemented under many restrictive conditions, they cannot eliminate all possible disasters. They are therefore evaluated on the basis of how much they can reduce the fatal effects of disasters. Among the various techniques of flood control, the planning and design aspects are regarded as preparatory measures; however, when these are based on the concept of crisis management, they can be classified as equivalent to crisis management if they can reduce the severity and fatal effects of a disaster even when a critical situation has already developed. Due to the status of land use in Japan, the worst situation in the field of flood control engineering is brought about by disasters caused by collapse of levees on large rivers running through cities An analysis of the present methods of flood control engineering shows that the study of levee design techniques is a priority requirement. Among levee design techniques, the design policy for revetment structures is not at present clear An analysis of a case in which breach is given as the least desirable event, using the fault tree analysis method, indicates that it is necessary to clarify the function of levee reinforcement structures such as revetment structures, to divide the structures into impervious structures, drainage structures and structures designed to prevent scouring, and to construct structures that serve the required purposes

In addition, crisis management measures, including planning methods, required a change in the objective of the plan from the traditional principle of preventing inundation to the principle of minimizing damage, and a change from an emphasis on investment effects to an emphasis on crisis management. As a result of such changes, research has begun to take into account excess floods beyond the level of the design flood discharge.

In this case, even if we tolerate inundations from overflowing water by providing high-standard levees that will not collapse in these conditions, there are still important topics to investigate, including the best method of avoiding inundation due to breach, and the best method of dividing the hinterland of the levee in a closed flood area in order to prevent a situation in which the entire area is flooded for a long period of time.

Priorities for protection need to be established in areas that are subject to damage, and it will be necessary to carry out sociological studies with risk evaluations regarding areas that may suffer damage.