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Review

A Comparison of Flood Control Standards for Reservoir Engineering for Different Countries

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Abstract: Across the globe, flood control standards for reservoir engineering appear different due to various deciding factors such as flood features, society, economy, culture, morality, politics, and technology resources, etc. This study introduces an in-depth comparison of flood control standards for reservoir engineering for different countries. After the comparison and analysis, it is concluded that the determination of flood control standards is related to engineering grade, dam type, dam height, and the hazard to downstream after dam-breaking, etc. Each country should adopt practical flood control standards according to the characteristics of local reservoir engineering. The constitutive flood control standards should retain certain flexibility in the basis of constraint force. This review could offer a reference for developing countries in the enactment of flood control standards for reservoir engineering.

Keywords: flood control standards; reservoir engineering; hydraulic structure design; reservoir classification

1. Introduction

The enactment of flood control standards for reservoir engineering is an important form of technical decision-making for the design of water resources and hydroelectric projects, which considers the safety of reservoirs, the lives, properties, and ecological environment in the areas downstream, and also directly influences the cost and completion time of projects.

Design regulations were not established in the early days following China's foundation as a country, and the flood frequency standard was generally adopted in the design of reservoir engineering projects. By the end of the 1950s, a multitude of reservoir engineering projects were rushed into quick construction; because of the lack of hydrological data etc., the practical design standard for reservoirs was generally on the low side [1,2]. The "Standard for Classification and Flood Control of Water Resources and Hydroelectric Project" (draft) was proposed in 1964, on the basis of summarizing the experience and lessons of the recent past. In this standard, it was proposed that the hydrological measured data and historical investigated data should be given more attention. At that time, some large and important reservoirs adopted the hydrometeorology method to check the design flood, this was positive for the reasonable determination of the design flood of reservoirs. After the foundation of the regulation in 1964, the "great proletarian cultural revolution" occurred in China, this regulation did not continue to be operationalized, and the status of lower design standards worsened because of the influence of man-induced factors. After the "75.8" flood dam break accident, the Chinese government significantly improved the flood control standard for reservoir engineering. This measure played a certain role in improving the attention and extent of reservoir safety, however, because of the excessive regulation of the flood control standard, the project quantities of risk mitigation and strengthening for reservoir engineering were too large, and the construction costs of new reservoirs increased. In 1978, the "Standard for Classification and Flood Control of Water Resources and Hydroelectric Project (Mountainous Area) SDJ12-78 (pilot edition)" was issued. The flood control standard for reservoir engineering in mountainous areas was properly reduced in this edition, approximately, between the 1964 standard and 1975 standard. Through practice and the soliciting of opinions across over a ten year period, most administrative departments considered the design flood control standard to be relatively high; in addition to that, the amplitude of the upper and lower limit was too large to master. Because the upper limit was usually on the high side, the construction or strengthening costs were therefore increased. For this purpose, the "additional regulation" for the "Standard for Classification and Flood Control of Water Resources and Hydroelectric Project (Mountainous Area) SDJ12-78 (pilot edition)" was formatted and issued in 1990. After some time, the current standard for the design of reservoir engineer is the "Standard for Classification and Flood Control of Water Resources and Hydroelectric Project" (SL 252-2000) issued in 2000 [3]. The new standard could be applied to mountainous areas and plain areas. The standards mentioned above played insignificant roles in the guidance of dam construction and operations, and possessed plenty of advantages [4].

Firstly, this paper introduces the determination method of the flood control standards for reservoir engineering that are adopted by several countries. Secondly, this paper analyzes the main differences of current standards among different countries. Finally, this paper proposes the key factors that should be considered when enacting standards for flood control of reservoir engineering projects, namely, the consequences and the extent of hazards related to reservoir accidents and the importance of flood-prevention objects in the downstream area should also be taken into consideration, in addition to the storage capacity, and the importance and scale of the protected engineering in the downstream area.

2. Flood Control Standards for Reservoir Engineering in China

The determination method of the flood control standards for reservoir engineering in China is comparatively systematic and rigorous [2,5–7]. It involves three steps: (1) determining the engineering classification of reservoir engineering; (2) determining the hydraulic structure grade according to the importance of hydraulic structures in reservoir engineering; (3) determining the corresponding flood control standards considering the location of hydraulic structures, the building material type, and the hydraulic structure grade.

2.1. Determination of the Reservoir Engineering Classification

According to the scale, benefit, and the importance to the national economy, reservoir engineering is classified into five levels, as Table 1 shows.

For the multiple-purpose reservoir engineering projects, the classification should take the highest level if the classification determined by different types of classification index are different.

2.2. Determination of the Hydraulic Structures Classification

According to the importance of hydraulic structure and the reservoir engineering classification, the permanent hydraulic structure is classified into five levels, as shown in Table 2.

Table 1. Classification index of reservoir engineering.

Engineering Classification	Engineering Scale	Reservoir Storage (10^8 m^3)	Flood Control		Waterlog Control	Irrigation	Water Supply	Power Generation
			Importance of the Protected Towns and Industrial, Mining Establishments	Protected Farmland Area (km^2)	Waterlog Control Area (km^2)	Irrigation Area (10^4 Mu)	Importance of Water Supplying Object	Installed Capacity (10^4 Kw)
I	Large (1)	≥10	Significantly important	≥333,333	≥133,333	≥100,000	Significantly important	≥120
II	Large (2)	10~1.0	Important	333,333~66,667	133,333~40,000	10,0000~33,333	Important	120~30
III	Medium	1.0~0.10	Moderate	66,667~20,000	40,000~10,000	33,333~3333	Moderate	30~5
IV	Small (1)	0.10~0.01	General	20,000~3333	10,000~2000	3333~333	General	5~1
V	Small (2)	0.01~0.001		<3333	<2000	<333		<1

Table 2. Permanent hydraulic structure classification.

Engineering Grades	Primary Structure	Secondary Structure
I	1	3
II	2	3
III	3	4
IV	4	5
V	5	5

2.3. Consideration of Structure Material Type and Regional Differences

Two types of structure materials are widely used in China, concrete and earth-rock. The flood resistance abilities of dams with different material types are also different. Dams without cementing materials, such as earth dams and rock-fill dams, are vulnerable to dam-break accidents caused by flood overtopping. Therefore, their flood control standards are higher than concrete dams and masonry dams, which contain cementing materials and are resistant to minor flood overtopping.

Geographically, there are plain areas, coastal areas (plain areas for short), and mountainous areas, hilly areas (mountainous areas for short), as such, there are effectively two different situations. When the height of permanent a hydraulic structure for retaining water in mountainous areas is lower than 15 m and the maximum water head difference between upstream and downstream is lower than 10 m, the flood control standards should be determined by referring to the standard of plain areas. When the height of a permanent hydraulic structure for retaining water in plain areas is higher than 15 m and the maximum water head difference between upstream and downstream is higher than 10 m, the flood control standard should be determined by referring to the standard of mountainous areas.

The rivers in mountainous areas are usually narrow, along with higher flood peaks, and larger flood volumes and time period variations, so the height of permanent hydraulic structure for retaining water is consequently higher. Generally, the reservoirs in plain areas are located in the midstream and downstream with relatively wider river widths, more gentle slopes, and lower dam heights, and the floods associated with these areas rise and fall more slowly, which is different from the floods in mountainous areas. Generally, it is easier and more important to take the emergency discharge measures for reservoirs in plain areas in the event of serious flood events. Therefore, for the hydraulic structures at the same level, the flood control standard in plain areas is lower than the one in mountainous areas.

2.4. Flood Control Standards for Reservoir Engineering in Mountainous Areas

The flood control standard for reservoir engineering in mountainous areas is shown in Table 3 [3].

Table 3. Flood control standard for permanent hydraulic structures in mountainous and hilly areas, return period (year).

Project		Classifications of Hydraulic Structures				
		1	2	3	4	5
Standard for design flood		1000~500	500~100	100~50	50~30	30~20
Standard for check flood	Earth-rock dam	PMF or 10,000~5000	5000~2000	2000~1000	1000~300	300~200
	Concrete dam; cemented masonry dam	5000~2000	2000~1000	1000~500	500~200	200~100

For earth-rock dams, if the dam-break could cause significantly serious hazard to downstream areas, the standards for check flood of hydraulic structure in level 1 should be the probable maximum flood (PMF) or the flood up to a 5000-year or 10,000-year return period; the standards for check flood of level 2 to 4 hydraulic structures could be upgraded correspondingly.

For concrete dams and cemented masonry dams, if overtopping could cause significant losses, the standard for check flood for level 1 hydraulic structures could be the PMF or a flood with up to a 10,000-year return period, which should go through a special debate process and be authorized by the responsible department.

2.5. Flood Control Standard for Reservoir Engineering in Plain Areas

The flood control standard for reservoir engineering in plain areas is shown in Table 4 (Ministry of Water Resources of P.R.C 2000).

Table 4. Flood control standards for permanent hydraulic structures in plain areas, return period (year).

Items		Classification of Permanent Hydraulic Structures				
		1	2	3	4	5
Reservoir engineer	Design	300~100	100~50	50~20	20~10	10
	Check	2000~1000	1000~300	300~100	100~50	50~20
Sluice gate	Design	100~50	50~30	30~20	20~10	10
	Check	300~200	200~100	100~50	50~30	30~20

3. Flood Control Standard for Reservoir Engineering in Other Countries

3.1. The United States of America (US)

There is no general flood control standard for each government sector, state, and private enterprise [8]. Before the 1930s, the method of frequency analysis had been generally adopted for large- and medium-sized reservoir engineering projects in the US [9,10], and method of hydrometeorology has been gradually adopted since 1938 [11]. The flood control standard was proposed in "Reservoir safety inspection reference guide (manual)" by The Army Corps of Engineers (USACE) in 1974 [12]. The standard classified dams in terms of their height, their storage capacity, and the dam breaking risk. Different flood control standards for spillway are shown in Table 5 (USACE 1974) and the classification of dam risks by USACE is shown in Table 6 (USACE 1974).

Table 5. Flood control standard for spillway by The Army Corps of Engineers (USACE).

Engineering Scale			Standard for Flood Control of Spillway (Recurrence Interval or PMF)		
Classification	Storage (10^4 m^3)	Dam Height (m)	High Risk	Medium Risk	Low Risk
Large	>6170	>30	PMF	PMF	1/2 PMF~PMF
Medium	123~3170	12~30	PMF	1/2 PMF~PMF	100 years~1/2 PMF
Small	6~123	8~12	1/2 PMF~PMF	100~1/2 PMF	50 years~100 years

Table 6. Classification of dam risks by USACE.

Classification	Degree of Human Casualty	Economic Losses
High risk	More than a small number of casualties	Large (large amount of public facilities, industrial or agriculture)
Medium risk	Small number of human casualties (undeveloped city, less residential buildings)	Obvious (obvious agriculture, industrial or other buildings)
Low risk	No human casualty (no permanent residential buildings)	Very small (undeveloped regions, temporary buildings or agriculture)

3.2. Russia

The Building Acts of the former Soviet Union confirmed the flood control standard for reservoir engineering according to dam height, the geologic condition of the dam foundation, dam materials, and the dam breaking consequences, which is shown in Table 7 (Council of Ministers of Former Soviet Union 1974). If there are cities in the downstream area of reservoirs, the flood control standard in level II, III, and IV could be upgraded one to two levels.

Table 7. Flood control standard for reservoir engineering of former Soviet Union.

Classifications	Dam Foundation	Dam Height (m)		Flood Control Standard Return Period (Year)
		Earth Dam	Concrete Dam	
I	Rock Gravel soil and hard clay Plastic clay	>100 >75 >50	>100 >50 >25	1000
II	Rock Gravel soil and hard clay Plastic clay	70~100 35~75 25~50	60~100 25~50 20~25	100
III	Rock Gravel soil and hard clay Plastic clay	25~70 15~35 15~25	25~60 10~25 10~20	33
IV	Rock Gravel soil and hard clay Plastic clay	<25 <15 <15	<25 <10 <10	20

Spring floods of the rivers in Russia (former Soviet Union) mostly result from snowmelt [13], therefore, the frequency calculation method has been adopted to determine the flood control standard before the issue of the "Construction Standard" (33-01-2003) in 2004. Afterwards, the PMF method has been used more widely. Also, in this "Construction Standard", the PMF method is recommended to estimate the check flood in the designing work of reservoir engineering in the areas with cyclone activity.

3.3. Japan

The determination of design flood control standards for reservoir engineering in Japan is mainly based on the frequency statistic method. However, the highest design flood control standard is the flood with 100- to 200-years return period. The check flood control standard is determined by an additional method. The "Regulation for the design of dam engineering" issued by the Ministry of International Trade and Industry (MITI) in 1957 and the revised version issued by the Minister of Agriculture, Fisheries and Food (MAFF) in 1965 are shown in Table 8 [14,15].

Table 8. Flood control standard for reservoir engineering in Japan. MITI, Ministry of International Trade and Industry; MAFF, Minister of Agriculture, Fisheries and Food.

Classification	Standard of MITI in 1957		Standard of MAFF in 1965	
	Concrete Dam	Earth-Rock Dam	Concrete Dam	Earth-Rock Dam
Design flood (return period (year))	100	200	100	120
Check flood	return period of design flood multiplied by 120%			

The "Regulation for the design of dam engineering" issued in 1978 specified a modification of the flood control design standard for reservoir engineering in that the concrete dam should be designed according to floods with 200-year return periods or the largest flood in historical record; the design flood of earth dams and rock-fill dams should be 20% larger than concrete dams.

3.4. Britain

Reservoir engineering projects in Britain are classified into four categories [16]. The flood control design standard is regulated according to dam breaking risk and the initial state of reservoir discharging, as Table 9 (Institute of Civil Engineers 1978) shows.

Table 9. Flood control design standard for reservoir engineering in Britain.

Classification		Initial State of Reservoir	Flood Control Designed Standard for Reservoir		
Grades	**Dam Breaking Risk**		**General Standard**	**Minimum Standard (Overtopping of Rare Flood Is Allowed)**	**Alternative Standard (Economically Reasonable)**
A	Large amount of lives	Discharge the daily average inflow	PMF	0.5 PMF or flood with 10,000-year return period (choose the larger one)	Not allowed
B	(1) No serious casualties; (2) Large economic losses.	Just fully stored (no overflow)	0.5 PMF or flood with 10,000-year return period (choose the larger one)	0.3 PMF or flood with 1000-year return period (choose the larger one)	Equal to the design flood with the minimum sum which contains the spillway cost and the sum of all losses
C	Little threat to lives; Limited economic losses.	Just fully stored (no overflow)	0.3 PMF or flood with 1000-year return period (choose the larger one)	0.2 PMF or flood with 150-year return period (choose the larger one)	the reservoir inflow should not be less than the minimum standard but could exceed the general standard
D	No hazard to lives; Limited economic losses.	Discharge the daily average inflow	0.2 PMF or flood with 150-year return period (choose the larger one)	Not allowed	Not allowed

3.5. Germany

The flood control standards for reservoir engineering in Germany issued in 1986 are shown in Table 10 (Federal Ministry for the Environment 1986).

Table 10. Flood control standard for reservoir engineering in Germany.

Loading Condition	Return Period (Year)	
	Small-Sized Reservoir	Large and Medium-Sized Reservoir
Normal loading condition	100	200
Abnormal loading condition	1000	1000

3.6. Canada

Most flood control reservoir engineering in Canada considers floods with 100- year return periods (Canadian Dam Association 1999). Some provinces take the measured maximum flood or floods with 200- to 500-year return period as the flood control standard [17].

When determining the design flood control standard for reservoir engineering, the calculating guideline for design discharge of spillway, which is recommended by the American Society of Civil Engineers (ASCE), is generally followed in Canada, as Table 11 (ASCE 1995) shows.

Table 11. Design flood control standard for spillway in Canada.

Classifications	Storage and Height		Dam Breaking Risk		Design Flood of Spillway
	Storage (10^6 m^3)	Height (m)	Casualty	Losses	
Large (no dam breaking is allowed)	>56.6	>18.3	Large amount	Significant losses or political influence	PMF; the probable most serious flood according to the basin conditions
Medium	1.4~56.6	12.2~30.5	Maybe some, but less amount	Within the bearable scope of all the financial resources	Flood with design standard; the typical flood based on the most severe rainstorm or meteorological conditions
Small	<1.4	<1.52	None	Equal to a certain quantity of damming expenses	Calculated by frequency method; with 50- to 100-year return period

3.7. Sweden

Most of the reservoir engineering projects in Sweden were constructed in the 1950s and 1960s when there was not yet a systematic design standard for the determination of various design flood water levels [18]. In fact, the design flood water level was determined by highest water level on record multiplied by a security coefficient. In the past several decades, through observations taken over the operational periods of dams, the deficiency of the above-mentioned methods was verified.

In 1985, the ad hoc committee called "Flödeskommittén" was established in Sweden, and its main task was to draw up new guidelines for design flood determination and recommend flood risk classification for each reservoir engineering project. In the new guideline, reservoir engineering projects were classified into two types: high-risk dams (level I) and low-risk dams (level II). A conceptual hydrological model was proposed in the new flood guideline, and the design flood water level was obtained by considering the extreme climate and hydrological changes which were obtained by the conceptual hydrological model, i.e., HBV model. The comparison of new and formal design flood water level of partial reservoir engineering in five rivers in Sweden is showed in Table 12.

The dams in Table 12 are all with high risk, and built in 1944~1983. The new design flood water level obviously increased 20%~45%.

Table 12. The higher design flood water level in the new flood guideline.

(1)	(2)	(3)	(4)	(5)	(6)	
Name of Dam	Type	River	Built Year	Dam Height(m)	Design Flood for Spillway	
					Initial (m^3/s)	Updated (Increased Percent)
Ajaure	R	Ume älv	1967	45	950	40%
Stornorrfors	B/R		1958	20	3300	35%
Midskog	G/E	Indalsälven	1944,1956	27	2300	35%
Bergeforsen	E		1955,1959	29	2300	45%
Stenkulla	E	Ångermanälven	1983	30	1250	40%
Gallejaur	R/E	Skellefte älv	1964	55	700	20%
Letsi	R	Lule älv	1967,1970	85	1500	25%
Porsi	E		1962	40	2700	15%
Vittjärv	G		1974	15	2200	50%
Boden	E		1971	21	2800	20%

Note: * R is rock-fill dam; E is earth-fill dam; G is gravity dam; B is buttress dam.

3.8. Norway

Previously the design flood for each reservoir engineering project that was managed by the government was set as Q_{1000}, and the security check flood for all dams was set as a PMP flood. In the new clause issued in 2003, the flood classification was required to be determined according to the influenced size of dam-breaking, as illustrated in Table 13. The new guideline introduced the methods used for calculating design floods and security check floods.

Table 13. Design flood and security check flood in terms of dam classification.

Consequence Grade	Design Flood	Security Check Flood
3 (serious)	Q_{1000}	PMF
2 (moderate)	Q_{1000}	PMF or $1.5 \times Q_{1000}$
1 (slight)	Q_{500}	—

The datam used for the flood calculation should proceed quality control. Any adopted flood calculation in the dam design or safety assessment must be submitted to NVE (Norwegian Water Resources and Energy Directorate) for check and approval.

3.9. France

There are no formal standards of flood control for reservoir engineering in France. They do the flood control work according to the experience and acknowledged method formed in the past, and revise and correct the flood control work in terms of the specific status based on factual work.

Accompanied with the issue of n°2077-1735 order in 2007 [19], the management ordinance regarding hydraulic structure was changed and a new order related to dam safety was proposed in France. Each hydraulic structure was classified according to four types [20], A, B, C, D respectively, based upon its characteristics. For dams, the considering factors were dam height (H, unit is m) above ground level and reservoir volume (V, unit is m^3). The classification of dams in French regulation is shown in Table 14.

In the above-mentioned n°2077-1735 order, proprietors were required to provide the security reports for dams of A type and B type. The acting government would analyze the security report, and decide whether the report could pass the approval.

Table 14. Classification of dams in French regulation.

Type	Threshold Value Parameters
A	H ≥ 20 m
B	Not type A, $H^2 \times \sqrt{V} \geq 200$ and H ≥ 10 m
C	Not A, B type, $H^2 \times \sqrt{V} \geq 20$ and H ≥ 5 m
D	Not A, B, C type, H ≥ 2 m

3.10. India

The standard of design flood in India is mainly determined by the hydrometeorology method [21,22]. Earth-rock dams are required to be designed according to PMF, and other types of dams are required to be designed according to design standard floods. The flood control standard for reservoir engineering (112233-1995BIS) issued in the year 1995 in India is shown in Table 15.

Table 15. Design flood control standard for reservoir engineering in India.

Classifications	Total Storage (10^6 m^3)	Water Head (m)	Design Flood
Small	0.5~10	7.5~12	Flood with 100 return period
Medium	10~60	12~30	Normal design flood
Large	>60	>30	PMF

3.11. Brazil

In Brazil, for important dams, if dam break could bring serious loss (including life security) to downstream areas, the design flood standards for spillway adopt PMF [22]; for unimportant small dams and public construction, the design flood standards consider the floods with a 150~300 return period; for private construction, the design flood standards consider the floods with a 75~150 return period.

4. Comparison of Flood Control Standards for Reservoir Engineering between Different Countries

Basic conditions and water regime factors are likely to be different in different countries [22–25], therefore, the regulation of flood control standards and the calculation method for design floods are also different.

In the US, Canada, India, and China, the reservoir storage and dam height are taken as the main factors for the determination of flood control standards. In the US, Britain, Canada, Brazil, etc., the probable hazard losses and the probable number of potential casualties resulting from a dam breaking are also taken as the main factors, in addition to the storage capacity and dam height, when determining the flood control standard for reservoir projects. In China, the importance and scale of the protected engineering projects in downstream areas is considered when determining the flood control standard for reservoir engineering.

There are two primary methods for expressing the flood control standard of reservoir engineering [26,27]: one is the flood frequency analysis method, the other one is the hydrometeorology method. In the US, India, Canada, etc., the main method is the hydrometeorology method. In Japan, Russia, China, etc., the main method is the flood frequency analysis method.

In China and the US, there are upper and lower limits of the standards of each level, and they are consecutive. The highest level of the flood control standard is PMF or floods with a 10,000-year return period, and the lowest level is floods with a 20- to 50-year return period. However, in Russia, Britain, Japan, and the other countries, the classifications of the flood control standard are not consecutive, which appears instead as stepping changes.

The reservoir engineering projects are divided into large, medium, and small types by the storage capacity and dam height in the US, Germany, and Canada, and the flood control standard is classified into three categories. However, in China, the reservoir engineering projects are divided into five types (i.e., large (1); large (2); medium, small (1) and small (2) types) by storage capacity and the importance of protected projects. Additionally, the hydraulic structures are also divided into five levels, corresponding to five classifications of the flood control standard.

The design flood is exclusively taken into account in the determination of the flood control standard in the US, Canada, and Britain. However, in China, Russia, Japan, and Germany, the design flood and check flood are both considered.

The probability distributions used by the countries who use the return period as an index in their classification are mainly based on practical and applicable experience or statistical test comparison. The choice of distribution usually requires a sufficient theoretical foundation, an easy application, flexible form, and qualities that are receptive to users. The distribution line type adopted for frequency analysis of design flood (rainstorm) of countries in the world [28] are showed in Table 16.

Table 16. Flood (rainstorm) probability distribution line type for the countries who use the return period as an index in their classification.

Distributions Line Type	Country
Pearson Type III Distribution (P-III)	China, Russia, Switzerland
Logarithmic Pearson Type III Distribution (LP-III)	The US, Canada, India
Generalized Extreme Value Distribution (GEV)	Britain, France
Extreme Value Type II, Type III Distribution (EV2, EV3)	Britain, France
Two/Three Parameters Logarithmic-Normal Distribution	Japan
Extreme Value Type I Distribution	Germany, Sweden, Norway
K-M Distribution	The Former Soviet Union

5. Conclusions

By comparing the determination methods of flood-control standards for reservoir engineering projects of different countries, it reveals that the determination method in each country is relatively systemic, rigorous, and basically reasonable. Overall, the flood control standard of reservoir engineering in China is a little lower than the standards of Britain, Canada, Brazil, and India etc. countries, but farther lower than the standard of the US, and higher than the standards of Russia, Germany, Japan, Norway, France, and other countries.

From the comparison and analysis, we can learn that: in some countries, the importance and scale of the protected engineering projects in downstream areas is considered when determining the flood control standard for reservoir engineering, however, the consequence of dam breaking is not taken as an important impacting factor when determining the classification of reservoir engineering. In fact, with the increasing development of society and economy, the consequence of dam breaking is increasingly serious. Therefore, dam breaking risk and the consequence of reservoir accident should be taken into consideration when determining the flood control standard for reservoir engineering.

Therefore, one suggestion or potential policy to propose for some countries is as follows: risk analysis should be included as one of the determining methods of the flood control standard, the flood control standard should be determined according to engineering scale and the hazard extent of dam breaking. Of course, the storage capacity, dam height, dam type, dam materials, as well as the importance and scale of the protected engineering projects in downstream areas should also be comprehensively considered.

The determination of flood control standards of other nations could be found based on the corresponding methods in the various types of determinations for the flood control standards. This review could provide technical support for the determination of flood control standards for reservoir engineering in developing countries, and could help in making the determination both more rational and more operable. Furthermore, it can offer reference material to consider for reformulating relevant specification of safety standards for reservoir engineering.

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