GUIDELINES FOR STRUCTURAL MEASURES TO MITIGATE ADVERSE EFFECTS OF GLOF ON DAMS

Government of India

Prepared by
Design & Research Wing
Central Water Commission

JULY 2025

भारत सरकार/ GOVERNMENT OF INDIA

केन्द्रीय जल आयोग/ CENTRAL WATER COMMISSION

हिमनद झील के फटने के कारण होने वाली बाढ़ से बांधों पर पड़ने वाले प्रतिकूल प्रभावों को कम करने हेतु संरचनात्मक उपायों के संबंध में दिशानिर्देश

Guidelines for Structural Measures to mitigate adverse effects of GLOF on Dams

जुलाई/JULY-2025

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FOREWORD

In recent decades, the impacts of climate change have led to the accelerated melting of glaciers, resulting in the formation and expansion of glacial lakes in many mountainous regions. This has increased the occurrence and severity of Glacial Lake Outburst Floods (GLOFs), which can cause catastrophic damage to downstream communities, critical infrastructure, and fragile ecosystems.

The growing threat of GLOFs demands a systematic approach to risk reduction, particularly through the application of effective structural interventions. These **Guidelines for Structural Measures to Mitigate Adverse Effects of GLOFs** have been prepared to provide practical guidance for engineers, planners, disaster risk managers, and policymakers.

The guidelines emphasize the integration of structural measures with non-structural strategies, including early warning systems. They are intended to support decision-making that balances safety, environmental integrity, and the socio-economic context of vulnerable regions.

I would like to congratulate all the Committee members and officers of CWC who were involved in preparing these guidelines. I sincerely hope that these guidelines will not only serve as a technical resource but also as a catalyst for coordinated action among governments, communities, and international partners. By applying the principles and recommendations outlined herein, we can work together to reduce disaster risk, enhance resilience, and protect the fragile mountain environments that so many depend upon.

Atul Jain

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PREFACE

Glacial Lake Outburst Floods (GLOFs) pose a significant and growing threat to infrastructure, ecosystems, and communities, particularly in mountainous regions where glacial retreat has accelerated due to climate change. Among the most vulnerable infrastructures are dams, which serve as critical lifelines for water storage, hydropower generation, and flood control. The sudden and often catastrophic nature of GLOFs demands proactive and resilient engineering solutions to safeguard these essential structures.

The committee has conducted several brainstorming sessions, and the draft guidelines have been developed through an in-depth review of existing literature, case studies, and best practices from glacial and mountainous regions. The draft was widely circulated to all active stakeholders and other individual experts. Invaluable suggestions received from all have enriched these guidelines and made them more meaningful and relevant.

The report provides guidelines for structural measures to mitigate the adverse effects of GLOFs on dams, aiming to support dam designers, engineers, planners, and safety authorities in incorporating GLOF considerations into infrastructure planning and risk reduction strategies. It emphasizes the integration of scientific understanding, hydrological modeling, and robust engineering practices to enhance the resilience and safety of dam projects in GLOF-prone regions. It constitutes criteria for fixing the spillway to dams prone to GLOF along with the structural and non-structural measures to minimize the impact of GLOF on dams in various sections.

The contribution of the technical committee chaired by Shri Vijai Saran, Chief Engineer (Retd.), CWC and assisted by Shri Shiv Dutta Sharma, Chief Engineer, Designs (E&NE), Shri Vivek Tripathi, Chief Engineer, Designs (N&W) and Shri Shiv Kumar Sharma, Director CMDD (E & NE) as Member Secretary in bringing out these guidelines is duly acknowledged.

Bhopal Singh

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Contents

I. INTRODUCTION TO GLOF AND ITS SIGNIFICANCE IN DAM SAFETY 1

II. CONSTITUTION OF THE COMMITTEE 1

III. DESIGN CRITERIA FOR FIXING SPILLWAY CAPACITY BASED ON INDIAN STANDARDS 2

IV. STRUCTURAL MEASURES 5

1. New Projects 5
2. Existing Projects 6
3. Under Construction Projects 7
4. Rapid response gates/ High speed gates 7
5. Measures to minimize damages due to Debris / Boulder movement 8
6. Measures to minimize damages due to overtopping 8
7. Measures to minimize the impact of GLOF 9

V. NON-STRUCTURAL MEASURES 10

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I. INTRODUCTION TO GLOF AND ITS SIGNIFICANCE IN DAM SAFETY

Glacial Lake Outburst Floods (GLOFs) present substantial risks to projects located downstream of glacial lakes, as they involve sudden release of water triggered by events such as glacier melting or avalanches. The effects of a GLOF can vary significantly based on factors like the volume of water released, the area's topography, the distance between the glacial lake & the project, and the level of preparedness for downstream infrastructure. The GLOF magnitude at any project site is influenced by the volume of water released, which in turn, depends on the breach characteristics of the glacial lakes and their proximity to the project site.

Projects planned in the Himalayan region typically have a significant portion of their catchment area covered in snow, increasing the likelihood of glacial lake formation within the catchment. These glacial lakes pose a high risk of breaching in the future due to factors such as seismic activity, landslides into the lake, glacier calving, piping, or overtopping. Such breaches can result in a sudden and substantial discharge of water often mixed with sediment & debris carried from lakes (and/or downstream reach of river), thereby potentially threatening the safety of the downstream projects. Therefore, it is essential to consider impact of GLOF alongside the design flood when determining the spillway capacity for projects in this region.

GLOF is a very important aspect in projects located in GLOF vulnerable areas as far as dam safety is concerned. India is currently no. 3 in the world as far as numbers of large dams are concerned with more than 6000 specified dams. Out of these, more than 100 dams located in six states / UT's are susceptible to GLOF. A list of the project vulnerable to GLOF has been attached as Annexure-I.

II. CONSTITUTION OF THE COMMITTEE

A Committee was constituted for "Formulation of structural measures to be undertaken in existing and proposed dams to manage GLOF risk" vide CWC office order No. T-12074/2/2024-CMDD (E and NE) dated 29.01.2024 (Annexure-II). The list of officers involved in framing these guidelines is provided in Annexure-III.

The Committee was chaired by Shri Vijai Saran, Chief Engineer, Designs NW & S Unit, CWC and Shri Shiv Kumar Sharma, Director CMDD (E & NE) was nominated as its Member – Secretary. A number of meetings of the Committee were held in which various structural measures which can be taken in existing and proposed dams to manage GLOF risk were discussed.

Inputs from the committee members as well as consultants under the Dam Rehabilitation and Improvement Programme (DRIP) were received which were compiled in the form of draft guidelines. The draft guidelines thus prepared were shared with concerned Central Public Sector Enterprises (CPSEs) and State Government agencies (of States / UT's in which GLOF threat is prominent), inviting their feedback. Comments received from various stakeholders (Annexure – IV) were thoroughly reviewed in the subsequent meetings of the Committee.

Based on extensive discussions and inputs from various stakeholders, the committee finalized the guidelines of structural and non-structural measures for managing GLOF risks. The guidelines were again circulated to all the stakeholders for their inputs/comments if any. The comments received from various stakeholders are placed as Annexure-V. After due consideration of all the inputs, guidelines have been finalized which are discussed in next paras. These guidelines are applicable to all existing, under-construction, and proposed dam projects.

III. DESIGN CRITERIA FOR FIXING SPILLWAY CAPACITY BASED ON INDIAN STANDARDS

Due to high peak of GLOF hydrograph and presence of considerable debris / sediment, provision of sufficient spillway capacity / freeboard is required to minimize the risk of overtopping of Dam due to GLOF.

Presently as per IS:11223_1985 (Reaffirmed 2020) titled "Guidelines for fixing Spillway Capacity" following provisions are specified for fixing spillway capacity of dams:

As per clause 3.1.2 of IS:11223; the dams may be classified according to the size by using the static head at FRL (i.e. from FRL to minimum tail water level) and the gross storage behind the dam as given below. The overall size classification for the dam would be the greater of that indicated by either of the following two parameters (Any latest amendments/ reaffirmations of the said code shall be applicable):

Classification	***Gross Storage***	***Static Head at FRL***
Small	*Between 0.5 and 10 million m^3*	*Between 7.5m and 12m*
Intermediate	*Between 10 and 60 million m^3*	*Between 12m and 30m*
Large	*Greater than 60 million m^3*	*Greater than 30m*

As per clause 3.1.3 of IS:11223, the inflow design flood for safety of the dam would be as follows:

Size as determined above	***Inflow Design flood for safety of Dam***
Small	*100 year Flood*
Intermediate	*SPF*
Large	*PMF*

Floods of larger or smaller magnitude may be used if the hazard involved in the eventuality of a failure is particularly high or low. The relevant parameters to be considered in judging the hazard in addition to the size would be:

i) Distance to and location of the human habitations on the downstream after considering the likely future developments.

ii) Maximum hydraulic capacity of the downstream channel at a level at which catastrophic damage is not expected.

As per clause 3.1.4 of IS:11223, inflow design flood for the safety of the dam should not undermine the dam foundation and endanger its safety. Also for some dams, breaching sections or auxiliary spillways may be provided such that the breach of such sections or operation of the auxiliary spillway should not undermine the dam foundation and endanger its safety in addition to uncontrolled widening of the breach or loss of life. Under these conditions the energy dissipation arrangements for the main spillway may be designed for best efficiency for a smaller inflow flood than the inflow design flood to ensure the safety of the dam.

As per clause 3.6.1 of IS:11223; For gated spillways, the contingency of at least 10 percent of the gates with a minimum of one gate being inoperative may be considered as an emergency condition (like earthquake) for both types of design floods (see 3.1.3 and 3.1.4), for safety of the dam and for design of energy dissipation works.

As per clause 3.6.2 of IS:11223; Human failures in the operation of a high-capacity spillway may cause a downstream flood larger than the inflow flood and may endanger downstream interests. Although it is preferable to restrict the outflow capacity, if possible, to reduce this possibility, explicit consideration of such situations is not necessary.

As per clause 4.0 of IS:11223, with the two design floods (see 3.1.3 and 3.1.4), four design conditions can be summarized as below:

***Design Condition I**: Under inflow design flood for safety of dams and with inoperative gates as in 3.6.1 of IS:11223.*

***Design Condition II**: Under inflow design flood for safety of dams and with all gates operative.*

***Design Condition III**: Under inflow design flood for energy dissipation works and with inoperative gates as in 3.6.1 of IS:11223.*

***Design Condition IV**: Under inflow design flood for energy dissipation works and with all gates operative.*

As per clause 4.1 of IS:11223; Freeboard and Clearances: The freeboard as specified in relevant Indian Standards (IS:10635) should be available at FRL as also at MWL which would correspond to Design Condition II.

4.1.1 A reduced free-board may be acceptable under Design Condition I assumed as an emergency condition (like earthquake).

4.1.2 Similarly, normal clearance in the energy dissipation structure should be available for Design Condition II and lower acceptable clearances for Design Condition I.

(The above implies normal freeboard should be available for energy dissipation structure for Design Condition II and reduced freeboard may be allowed in energy dissipation structure for design condition I)

Changes to the relevant codes like IS 11223 shall be sought based on the guidelines.

Considering the unpredictability of the conditions which leads to the GLOF event and severity of its impact, it can be said that:

i. GLOF is an emergency condition.

ii. GLOF and design flood are likely to occur in same season.

iii. There are chances that peak of GLOF and peak of design flood may occur together although the probability of the same is very less.

iv. The present estimation of GLOF accounts for the volume of water only. Volume of sediment / debris which is expected to move with GLOF is currently not accounted for.

v. GLOF is a dynamic phenomenon and in view of receding of glaciers, it is likely to occur frequently. However, it is not easy to increase the spillway capacity of a dam once it is constructed.

vi. There are more than 100 existing dams likely to be affected by GLOF. But only a few projects have GLOF values higher than or equal to design flood.

Therefore, following recommendations are made for dams vulnerable to GLOF:

IV. STRUCTURAL MEASURES

1. New Projects

a. The dam spillway capacity should be designed considering Combination of updated design flood & approved GLOF as outlined below, considering the all the gates operative:

1. If GLOF is less than or equal to $1/3^{rd}$ of the design flood, project may be designed for Design Flood + GLOF.
2. If GLOF is greater than $1/3^{rd}$ of the design flood, project may be designed for the greater of the following:
   - $1\frac{1}{3}$ times of design flood
   - One lower flood than design flood + GLOF
     (Where one lower design flood shall be as follows)

Type of dam	Design flood	One lower flood
Small	100 year Flood	100 year Flood
Intermediate	SPF	100 year Flood
Large	PMF	SPF

b. The various combination of design flood hydrograph and GLOF hydrograph may be routed wherever possible to check the efficacy of the spillway capacity.

c. For concrete dams, freeboard encroachment may extend up to 0.5 meters below the top of the dam. In the case of earthen dams, the encroachment shall be restricted to 1.5 meters below the top if there is an impervious membrane (such as CFRD / ACRD / GFRD etc.) on the upstream face. For earthen dams with a central impervious core, the encroachment should be limited to 0.5 meters below the top of the central impervious core.

d. The spillway should preferably consist of a combination of a Sluice Spillway, with a minimum area of approximately 50 m^2 (for each bay) and width of at least 7 meters (each bay), and a Surface Spillway with a minimum width of 10-12 meters (each bay). Where feasible, some of the gates may be designed as fuse gates.

2. Existing Projects

For existing projects, existing spillway capacity may be compared with Combination of updated design flood & approved GLOF as stipulated at (IV) 1 (a).

For examining adequacy of spillway, following conditions may be assumed:

a. All spillway gates may be considered operational.

b. For existing concrete dams, encroachment may extend up to 0.5 meters below the top of the dam. In the case of earthen dams, the encroachment shall be restricted to 1.5 meters below the top if there is an impervious membrane (such as CFRD / ACRD / GFRD etc.) on the upstream face. For earthen dams with a central impervious core, the encroachment should be limited to 0.5 meters below the top of the central impervious core.

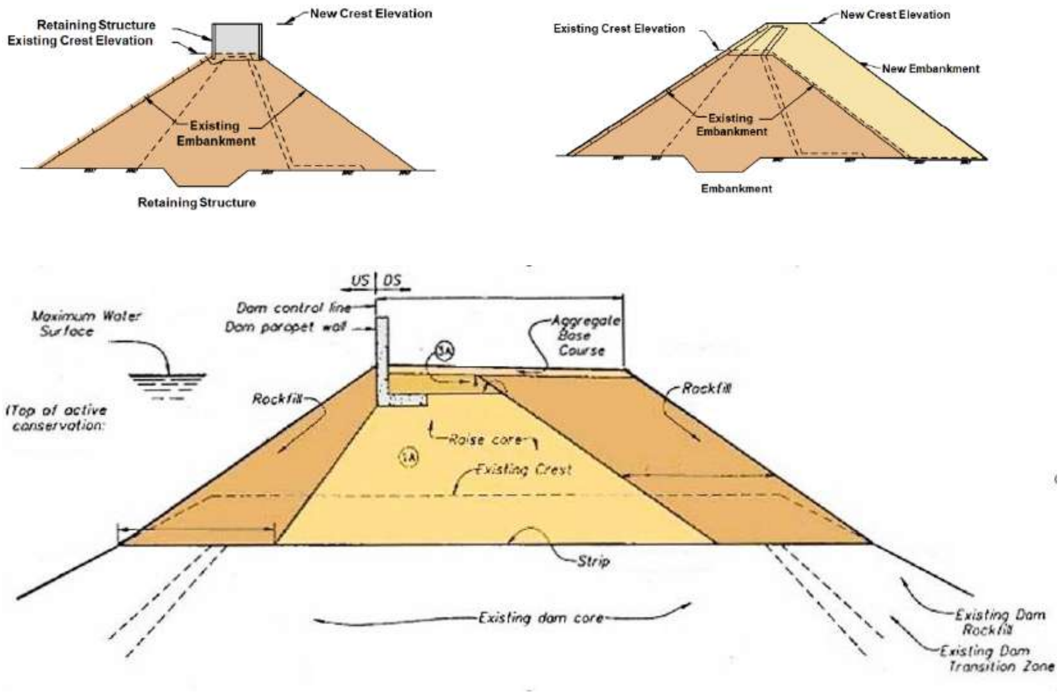
c. Flood routing may be carried out using the elevation area capacity characteristics as expected after 100 years of sedimentation (as per clause 3.4 of IS:11223) for the existing large dams to check the anticipated increase in water levels during extreme events and accordingly rule curves may be revised. For existing dams other than large dams, the latest area elevation capacity curve not older than one year may be used

If spillway capacity of the existing projects is found less than Combination of updated design flood & approved GLOF as stipulated at (IV) 1 (a), measures as mentioned below may be adopted to ensure safety of dam against overtopping:

i. Reservoir may be operated at lower level during flood period so that when the revised flood + GLOF is impinged on that lower level, it does not overtop the dam with minimum freeboard, as indicated above.

ii. Spillway capacity may be enhanced by measures such as provision of additional spillway, use of diversion tunnels as spillways, labyrinth spillway, Fuse gate, fuse plug etc. However, such measures should be based on sound engineering judgement and design practices.

iii. Increase in height of the dam may also be considered wherever feasible as shown in the following figures. All measures to increase the height / reduce freeboard shall be accompanied with rigorous calculations to ensure safety of dam under all design conditions.



<u>*Methods for increasing the height of dam*</u>

d. NOF blocks adjacent to OF blocks can be provided with profile of un-gated spillway with crest level at FRL merging with OF blocks. This may help in spilling the incoming discharge in the event of sudden rise of water beyond FRL.

3. Under Construction Projects

The stipulations for new projects as outlined above shall also be applicable for under construction projects. If any project has gone far ahead in construction such that it is difficult to incorporate the provisions applicable for new projects, in such cases, project authorities shall take necessary approval from the concerned authorities.

4. Rapid response gates/ High speed gates

Since GLOF peak occurs very quickly, it is desirable that spillway gates should open quickly to prevent overtopping of dam. Therefore, it is proposed that the gates of GLOF susceptible dams should be provided with variable speed opening mechanism with a maximum speed of 1.5-2 m/min so that these gates could be opened at higher speed in case of emergency situations. Preference to variable speed motors shall be made to achieve the above objective. In existing projects, the retrofitting of hoists for spillway gates to achieve higher opening speeds shall be evaluated in a holistic manner considering the support structures, lifting lugs & associated structures provided on gates etc. The issues of vibration, undesirable overstressing etc. may be carefully considered while adopting higher speed.

Fuse gates which operate automatically with rise in reservoir level may also be considered.

5. Measures to minimize damages due to Debris / Boulder movement

Since GLOF discharge also contains very high percentage of sediment comprising clay to boulder size, some of the following measures are required to be adopted to minimize damage due to such debris / boulders;

i. Gate size to be sufficient to allow debris to pass. For new projects, minimum size of sluice and surface spillway shall be as per clause (IV) 1 (d) of the Guidelines.

ii. Protective measures on piers and spillways should be provided to withstand boulder impacts. These measures could involve the use of High-Performance Concrete and appropriate steel liner arrangements with due precautions may also be considered after evaluating all the related project specific factors.

iii. Installing sediment traps or weirs in the river channels downstream of the glacial lakes to control the debris load carried by GLOFs, reducing damage to downstream infrastructure may also be explored wherever feasible.

6. Measures to minimize damages due to overtopping

Measures should be taken to minimize damages if dam gets overtopped due to GLOF. Some of such measures are listed below;

i. Control room to be provided away from dam top and at a higher safe location.

ii. Automatic & Remote operation of gates through SCADA based or similar systems shall be invariably provided. Considering the cyber security threats, the internet or cloud based systems for above arrangement shall be avoided. The gates shall be automatically raised/opened when the water level on upstream crosses certain threshold limit (to be specified by Project Authority). Such system shall have inbuilt manual override to prevent losses due to faulty sensors etc. Provision of automatically operating fuse gates may also be considered.

iii. Protection of vulnerable control elements such as power packs for hoist operation, trunnions etc. through suitable cover (*Applicable to existing and proposed dams).*

iv. Parapet wall may be provided on upstream side of bridge deck (*Applicable to existing and proposed dams).*

v. Roller Compacted Concrete (RCC), Continuously Reinforced Concrete Slab (CRCS), and reinforced rockfill are viable options for overtopping protection of large embankment dams. RCC, a form of concrete compacted using rollers, is known for its durability and cost-effectiveness, making it suitable for spillway and overtopping protection. CRCS, which consists of a continuously reinforced layer of concrete, offers excellent strength and crack resistance, allowing it to withstand significant hydraulic and structural stresses during overtopping events. Reinforced rockfill, which integrates rock materials with reinforcing elements, provides both stability and natural drainage, making it particularly effective in such applications.

   Additionally, Articulated Concrete Block (ACB) mattresses may be used for overtopping protection. These are pre-cast concrete blocks interconnected with cables or other systems, forming a flexible yet robust protective layer that adapts to the surface and allows water to flow over safely.

   All overtopping protection systems require proper drainage or pressure relief measures. Rockfill and gabion systems naturally facilitate drainage, while others like RCC, CRCS, and ACB require specialized drainage components, such as drainage layers, collector pipes, and weep holes, to manage seepage and pressure effectively. When designing overtopping protection systems, it is essential to account for all limitations, potential failure modes, and risks associated with carrying spillway flow over the embankment. These considerations ensure the safety and stability of the dam structure under extreme conditions.

vi. In case of Concrete dams, abutments and toe of the dam should be strengthened to withstand overtopping.

vii. Stepped spillways (with irregular steps) located on the abutment groins may also be considered for provision of auxiliary spillway capacity.

viii. Mid-level tunnel spillways in case of embankment dams can also be considered.

ix. The issue of floating timber to block spillways should also be considered in defensive design measures.

7. Measures to minimize the impact of GLOF

The impact of GLOF on dams can be minimised by reducing the quantity of GLOF or by attenuating its peak or by reducing its debris load through structural measures to be carried out at the Glacier Lake or in its immediate vicinity as given below. However, these measures may not always be feasible or techno-economically possible due to difficult site conditions.

i. Lowering of Lake (siphoning or pumping)

ii. Artificial Drainage Channel

iii. River channel reinforcement by strengthening the cross-sections of rivers and by constructing erosion protection in vulnerable reaches.

iv. Constructions of weirs to trap sediment / boulders as shown below

Examples for measures of trapping sediment and debris

V. NON-STRUCTURAL MEASURES

Early Warning system (EWS) is a non-structural activity which minimizes the loss of human life and economic property and reduces the vulnerability of HEP's to GLOF risks. However, for development of EWS, following steps are required to be taken:

- Continuous intensive monitoring of lakes in the project catchment identified as threat to existing HEP's / MPP's by the concerned Project authorities themselves or by agencies hired by them.

- Development and installation of robust and effective Early Warning system (EWS)
- Establishment of a criterion for cost and data sharing frameworks regarding continuous intensive monitoring, risk reduction measures and EWS by Project authorities through an appropriate mechanism among the various Projects in a cascade.
- Preparation of Emergency Action Plan
- Fool proof communication system (e.g. Satellite phones) for vulnerable projects.
- If the first dam in a cascade system of projects on a GLOF affected river reach is found safe on design parameters for the worst GLOF scenario, the GLOF threat may thus largely be mitigated for the downstream projects. If required, the first Dam may be maintained at a low level during monsoon season i.e. Monsoon Reservoir Level (MRL), even at the cost of loss in generation of power. This loss in power generation cost may be worked out and shared by all other downstream dam projects in suitable proportion.
- Involvement of defence/military establishments that are existing in nearby areas of glacial lakes.

Annexure – I

List of Projects for which Glacial Lake Outburst Flood (GLOF) submitted to CWC

S. No.	Name of Project	State (India) /Country (Year of Approval)*	Design Flood Cumec	GLOF value Cumec (Year)*
1.	Siang Lower HEP	Arunachal Pradesh (2009)	60115	3391
2.	Demwe Lower HEP	Arunachal Pradesh (2009)	28500	3780
3.	Demwe Upper HEP		27500	3989
4.	Kalai-I HEP	Arunachal Pradesh (2011)	23128	2807
5.	Kalai-II HEP		24268	2690
6.	Hutang-II HEP		24837	2615
7.	Etalin HEP (Tangon limb)	Arunachal Pradesh (2011)	10218	2143
8.	Etalin HEP (Dri limb)		11811	1170
9.	Attunli HEP		9927	2227
10.	Nyukcharong Chu HEP	Arunachal Pradesh (2012)		1426
11.	Rho HEP			1406
12.	Raigam HEP	Arunachal Pradesh (2013)		889
13.	Gimiliang HEP	Arunachal Pradesh (2013)	5555	565
14.	New Melling HEP	Arunachal Pradesh (2013)		1130
15.	Mago Chhu HEP			1252
16.	Tsachu-I HEP	Arunachal Pradesh (2013)		1476
17.	Tsachu-I Lower HEP			1453
18.	Tsachu-II HEP			1428
19.	Tawang-I HEP	Arunachal Pradesh (2012)	4264	1378
20.	Tawang-II HEP		5000	1368
21.	Oju HEP	Arunachal Pradesh (2014)	3996	2512 (2014) 3664 (2024)
22.	Dibang HEP	Arunachal Pradesh (2016)	26230	1719
23.	Chhatru HEP	Himachal Pradesh (2013)	1400 (100 Year) 2272 (SPF)	1410

S. No.	Name of Project	State (India) /Country (Year of Approval)*	Design Flood Cumec	GLOF value Cumec (Year)*
24.	Bursar HEP	J&K (2016)	4577	371
25.	Kholongchu HEP	Bhutan (2012)		2339
26.	Chamkharchhu-I HEP	Bhutan (2012)	9406	5112
27.	Alaknanda HEP	Uttrakhand (2015)	26400	1145
28.	Goriganga IIIA HEP	Uttrakhand (2017)	3693	642
29.	Dagmara MPP	Bihar (2021)		3021
30.	Bajoli Holi HEP	Himachal Pradesh (2022)	7419	1284
31.	Sirkari Bhyol-Rupsiabagar HEP	Uttarakhand (2022)	2501	1672
32.	Tandi HEP	Himachal Pradesh(2022)		1925
33.	Rashil HEP			1902
34.	Bardang HEP		6828	1801
35.	Reoli Dugli HEP		8189	1523
36.	Purthi HEP		8877	1349
37.	Sach Khas HEP		9047	1331
38.	Upper Siang	Arunachal Pradesh (2022)		5484
39.	West Seti	Nepal (2023)	14251	1610
40.	Arakot Tuini	Uttrakhand (2023)		127
41.	Kamala	Arunachal Pradesh	17416	1663 (2024)
42.	Kishanganga	J&K	2000	2249 (2024)
43.	Pakal Dul	J&K	5890	1260 (2024)
44.	Dugar HEP	Chenab Basin	9425	2264 (2024)
45.	Kirthai II HEP		9600	2242 (2024)
46.	Kiru HEP		10196	2241 (2024)
47.	Kwar HEP		10534	2239 (2024)
48.	Dulhasti PS		8000	2233 (2024)
49.	Ratle HEP		13814	2226 (2024)
50.	Sawalkot HEP		18711	1668 (2024)
51.	Salal PS		22427	1624 (2024)
52.	Naba	Arunachal Pradesh(2024)		3357

S. No.	Name of Project	State (India) /Country (Year of Approval)*	Design Flood Cumec	GLOF value Cumec (Year)*
53.	Nihare	Arunachal Pradesh (2024)		3464
54.	Nalo	Arunachal Pradesh (2024)		3097
55.	Dengser	Arunachal Pradesh (2024)		2974
56.	Anjaw	Arunachal Pradesh		3445 (2024)
57.	Subansari Lower	Arunachal Pradesh	37500	765 (2024)
58.	Subansari Upper	Arunachal Pradesh	13097	1817 (2024)
59.	Teesta III	Sikkim	7000	12946 (2024)
60.	Rangit III	Sikkim (2024)		1996 1814
61.	Rangit IV		5616	
62.	SR 6 HEP	Nepal		1103 (2024)
63.	Teesta-IV	Sikkim	13000	12676 (2024)
64.	Teesta-V		14596	12045 (2024)
65.	Teesta-VI		11462	11157 (2024)
66.	TLDP-III		10430	6717 (2024)
67.	TLDP-IV		15400	6154 (2024)
68.	Chutak	Indus Basin (2024)	980	713
69.	Lakhwar-Vyasi	Uttrakhand	8850	32 (2024)
70.	Joshiyara Barrage MB II	Uttrakhand	8368	879 (2024)
71.	Punatsangchu-I HEP	Bhutan (2006)	11500	4300 - Consultancy
72.	Amochu HEP	Bhutan (2011)		1138 - Consultancy
73.	Wangchu HEP	Bhutan (2013)		1741 - Consultancy
74.	Arun-3 HEP	Nepal (2012)		6830 – Consultancy
	Total 74 Projects			

Year Mentioned in Column 3 & Column 5 represents the assessment year of GLOF

Annexure-II

File No.T-12074/2/2024-CMDD(E and NE)

भारत सरकार Government of India

केन्द्रीय जल आयोग Central Water Commission

पूर्व एवं उत्तर पूर्व संगठन East and North-East Organization

कंक्रीट और चिनाई बांध अभिकल्प निदेशालय

CMDD (E&NE) Directorate

सत्यमेव जयते

ORDER

Subject: Committee for formulation of structural measures to be undertaken in existing and proposed dams to manage GLOF risk – reg.

With the approval of competent authority, a committee under the chairmanship of Chief Engineer, Design(NW&S), CWC is hereby constituted for formulation of structural measures to be undertaken in existing and proposed dams to manage GLOF risk.

1. Chief Engineer, Designs (NW&S)	Chairman
2. Chief Engineer, Designs (N&W)	Member
3. Chief Engineer, Designs (E&NE)	Member
4. Director, CMDD (N&W)	Member
5. Director, Gates (E&NE)	Member
6. Director, Gates (N&W)	Member
7. Director, Hydrology (NE)	Member
8. Director, Instrumentation	Member
9. Director, FE&SA	Member
10. Director, CMDD (E&NE)	Member Secretary

Terms of Reference of Committee:

1. Formulation of structural measures to be undertaken in existing and proposed dams to manage GLOF risk such as Dam type; Spillway type and capacity; safety features for Gates, control room, Hydraulic cylinders etc; Instrumentation required and other similar measures.
2. The committee is expected to complete its evaluation and submit the final report within a stipulated timeframe of two months.
3. Committee may co-opt any other member as per requirement.

Signed by Shiv Kumar Sharma
Date: 29-01-2024 10:48:46
Reason: Approved

(S. K. Sharma)
Director

Copy to committee members:

i. Chief Engineer, Designs (NW&S), CWC, Sewa Bhawan, New Delhi
ii. Chief Engineer, Designs (N&W), CWC, Sewa Bhawan, New Delhi
iii. Chief Engineer, Designs (E&NE), CWC, Sewa Bhawan, New Delhi
iv. Director, CMDD (E&NE), CWC, Sewa Bhawan, New Delhi
v. Director, CMDD (N&W), CWC, Sewa Bhawan, New Delhi
vi. Director, Gates (E&NE), CWC, Sewa Bhawan, New Delhi
vii. Director, Gates (N&W), CWC, Sewa Bhawan, New Delhi
viii. Director, Hydrology (NE), CWC, Sewa Bhawan, New Delhi
ix. Director, Instrumentation, CWC, Sewa Bhawan, New Delhi
x. Director, FE&SA, CWC, Sewa Bhawan, New Delhi

Copy for kind information to:

i. PPS to Chairman, CWC, Sewa Bhawan, New Delhi
ii. PPS to Member, D&R, CWC, Sewa Bhawan, New Delhi

Annexure-III

PERSONS INVOLVED

To frame the guidelines for Structural Measures to mitigate adverse effects of GLOF on Dams, the following officers of CWC were associated at different points of time:

1. Shri Vijai Saran, Chief Engineer (Retd.), Central Water Commission
2. Shri Vivek Tripathi, Chief Engineer, Design (N&W)
3. Shri Shiv Dutta Sharma, Chief Engineer, Design (E&NE)
4. Shri Nitya Nand Rai, Chief Engineer, CWC
5. Shri S.K. Kamboj, Director, Gates (N&W)
6. Shri Shiv Kumar Sharma, Director, CMDD (E&NE)
7. Shri S.K. Shukla, Director, FE&SA
8. Shri Rahul Kumar Singh, Director, Gates (NW&S)
9. Shri Amit Ranjan, Director, Gates (E&NE)
10. Shri Somesh Kumar, Director, Embankment (N&W)
11. Shri Ashish Kumar, Director, Instrumentation
12. Shri Samarth Agarwal, Director, CMDD (N&W)
13. Shri Randhir Kumar Choudhary, Deputy Director, CMDD (N&W)
14. Shri Ankit Kumar, Deputy Director, FE&SA
15. Shri Adepu Raghavendra, Deputy Director, Embankment (E&NE)
16. Shri Akshat Jain, Deputy Director, Hydrology (NE)
17. Shri Arun Pratap Singh, Deputy Director, CMDD (NW&S)
18. Shri Madhukant Goyal, Deputy Director, CMDD (E&NE)
19. Shri Cherupalli Sanjeev, Assistant Director, CMDD (E&NE)

Annexure-IV

1. Comments received from NHPC:

Para No.	Statement as per Draft report	Suggestion / Comments
Para 1 (A.1)	As per clause 3.1.2 of IS 11223, the dams may be classified according to size by using the hydraulic head (from normal or annual average flood level on the downstream to the maximum water level) and the gross storage behind the dam.	As per clause 3.1.2 of IS:11223-1985 (Reaffirmed 2000), Amendment No. 2, Sept. 1991; the dams may be classified according to size by using the static head at FRL (from FRL to minimum tail water level) and the gross storage behind the dam.
Page 3: New Projects	The dam spillway capacity should be designed for design flood + GLOF. All gates may be considered operative.	In the higher reaches of the Himalayan region, the topography is characterized by steep slopes and narrow valleys, which present significant space constraints. Constructing additional spillways in such challenging terrain often requires extensive abutment cutting, leading to serious stability concerns as well as technical and construction challenges, all of which have significant financial implications. Both PMF (Design Flood) and GLOF represent rare and severe hydrological events, and their concurrent occurrence would lead to extreme design condition. Therefore, it will be appropriate to apply the condition of GLOF combined with lower return period flood for spillway capacity. A balanced approach that takes into account both technical feasibility and cost-effectiveness, while maintaining safety standards, is crucial for sustainable project development. This approach helps to avoid over-design, which can lead to unnecessary complexity and increased costs without delivering proportional benefits.
Page 3 : Existing Projects :	Existing spillway capacity may be compared with updated design flood +vetted/revised GLOF	The construction of additional spillways in existing or under-construction dams to manage higher floods may not always be possible due to various constraints, including technical and spatial limitations. The probability of two extreme events occurring simultaneously is exceedingly rare, therefore instead of design flood, GLOF may be combined with lower floods such as 1 in 100-year flood for capacity.

		For existing dams, under all gate operating conditions, increasing the dam height by constructing parapet walls may be considered as a viable solution. This should be undertaken in accordance with comprehensive engineering assessments to ensure the modification adheres to all relevant safety and stability criteria, thereby maintaining both dam safety and operational reliability. Further, controlled overtopping of the dam, with appropriate safety measures as outlined in Para-A4, may also be permitted, subject to evaluation on a case-by-case basis. The guidelines applicable to existing dams may also be extended to under-construction projects.
Page-4 (last para)	Flood routing may be carried out using the elevation area capacity characteristics as expected after 100 years of sedimentation (as per clause 3.4 of IS 11223) for the existing dams to check the anticipated increase in water levels during extreme events and accordingly rule curves may be revised.	For small reservoirs of Run off the river projects, determination of elevation area capacity characteristics as expected after 100 years of sedimentation using Empirical Area method as given in IS: 5477 part-2 (referred in clause 3.4 of IS 11223) is not in practice. To ensure sustainability and to maintain storage capacity of these reservoirs sediment management strategy such as sluicing and flushing are generally adopted. If such practices are not adopted and reservoir is kept at FRL throughout the year, the entire reservoir capacity is lost within 5 to 30 years depending upon reservoir size, inflow, sediment load and trap efficiency etc. Hence for Run off the river projects, it is suggested that flood routing studies may be carried out as per initial reservoir elevation area capacity curve and for existing hydro project reservoirs using the latest reservoir survey capacity, if pseudo equilibrium has been achieved.
Para A.5	Reduction of GLOF hazards	The activities mentioned at A.5 (i), (ii), (iii) & (iv) may be taken up by national level agencies such as NDMA / SDMA, CWC or concerned State Governments authorities in association with dam owners.
Para B	Non-Structural Measures	The glacial lakes are located in far flung / remote areas far away from even most upstream hydropower projects. Hence it is difficult to monitor all the lakes by project authority. In some basins, defence / military establishments are existing in nearby area of glacial lakes. Hence the establishment / monitoring of identified potentially dangerous glacial lakes for early warning can be done through

		such establishments by a central agency of the country. The cost of monitoring and implementation of Early Warning System (EWS) can be shared among the all downstream projects on the basis of few parameters like; proximity to glacial lakes, plant generation capacity, type of dam, spillway capacity, size of reservoir, free board and reservoir operation criteria etc. Keeping reservoir at lower level during monsoon months is as per existing CWC guidelines for sediment and flood management for all the ROR projects. Also ROR projects have very less capacity to contain GLOF volume, except for some reaction time, if reservoir is kept at lower level. Hence sharing of cost does not seems justified. It is submitted that a safety cost may be incorporated to account for the cost of additional outlet/spillway for negotiating GOLF. It may be similar to the cost component considering flood moderation is kept and separate budgetary support is provisioned to moderate tariff structure.

2. Comments received from NEEPCO:

A. Structural Measures:

1. Quick acting Gates: It would be beneficial to provide detailed specifications on the required response time for quick-acting gates to efficiently handle GLOF peaks, especially for larger dams.

2. Measures to minimize damages due to overtopping: A Risk-cost analysis describing when overtopping protection measures are necessary despite their costs, and when operational controls (like lowering reservoir levels) might work, may be incorporated.

B. Non-structural Measures:

1. Protocols for timely data sharing between upstream and downstream project authorities may be incorporated.

2. With climate change accelerating glacier melting and increasing the frequency of extreme weather events, advanced technologies such as radar, satellite imagery, robust sensors for continuous glacier lake level monitoring, seismic activity tracking, and machine learning algorithms may be employed to improve the accuracy of GLOF event prediction. In view of the specialised expertise required and the financial investment involved in these activities, it is desired that central agency(s) with proficiency in GLOF monitoring be engaged for continuous observation. The costs associated with comprehensive GLOF management may be borne by the concerned hydropower developers, as necessary.

3. Comments received from UJVNL:

❖ Additional Structural Measures to Mitigate the Adverse Effects of GLOF on Hydroelectric Projects:

1. Gates should be equipped with variable-speed mechanisms that allow rapid opening in response to emergency situations. Speed of gates should be designed such that gates are fully opened before reaching the peak flood.

2. Early warning system & real time monitoring of Glacial lake formation/development may be done at government of India level and noticeable information be shared to SDMA/DDMA/SDSO/Dam owners.

3. Funds for catchment area treatment should be utilized in the treatment of upstream vulnerable slide zones in consultation with competent authority including G.S.I.

4. **Design for Combined Floods:** The spillway capacity should be designed for both design flood and potential GLOF to accommodate extreme discharge events. This ensures that the spillway can handle unexpected surges of water without overtopping the dam.

5. **Enhanced Freeboard Requirements:** Dams should have increased freeboard, particularly in vulnerable areas, for safety against overtopping. This may involve raising the dam height or providing parapet wall on the dam crest to handle exceptional flood levels.

6. **Sediment and Boulder Control Structures:** Installing sediment traps or weirs in the river channels downstream of the glacial lakes can help control the debris load carried by GLOFs, reducing damage to downstream infrastructure.

7. **River Channel Reinforcement**: Strengthening the cross-sections of rivers and constructing erosion protection measures can help to maintain channel stability and reduce the destructive force of a GLOF.

8. Reliable power supply systems including power back up should be established to prevent operational failure during emergency events.

9. NOF blocks adjacent to OF blocks can be provided with profile of ungated spillway with crest level at FRL merging with OF blocks. This may help in case of sudden rise of water which may start functioning at FRL. The possibility of providing spillway profile in NOF blocks may be explored.

10. **Stepped Spillways:** Installing stepped spillways on the abutment groins can provide additional energy dissipation and reduce the velocity of water entering the downstream system.

11. **Diversion Tunnels**: Wherever possible, diversion tunnel can be used as emergency spillways, providing an additional route for water discharge during extreme events.

12. **Retrofitting and Upgrades**: Existing dams that do not meet current standards for GLOF resilience should be retrofitted with increased spillway capacity, additional spillways, or enhanced freeboard. Additionally, real-time flood routing models can help optimize operations during extreme events.

13. **Guideline A3.ii** Provision of Steel liner may also be added.

14. **B. non-structural measures**- It may be considered to provide additional ungated spillway with crest at FRL over and above present codal provision for the first dam in the river Valley where GLOF is expected. Also, additional freeboard over and above the present codal provision may also be considered for first in the river Valley project with GLOF risk, in view of climate change and possible upward revision of design flood. Cost can be distributed to other downstream projects

Correction in Annexure – A:

1. In point 84, Joshiyara Barrage MB-II design flood is 8368 not 5000.

4. <u>Comments received from THDC:</u>

1. *<u>Point no. B at page 4 (Combination of Sluice and Surface Spillways)</u>*

   The configuration and combination of spillway is finalized taking into account the various factors such as hydrological, topological (width of the gorge), type of dam, sedimentation characteristics. The spillway arrangement is checked for safely passing the inflow design flood by simulating flow pattern of the discharges, workability of the energy dissipation arrangement. Therefore, the condition of combination of sluice and surface spillway may limit the improvisation of the spilling arrangement and in some cases may prove to be impractical.

   Regarding minimum 10-12 m with of Surface Spillways, it is submitted that the width of spillways is depended on many factors and in case of narrow and steep hill sites, the surface spillway of 10-12m in addition to sluices may be difficult/ impractical to accommodate.

2. *<u>Point no. A3 at page 6 (Minimum area and width of Sluice Spillway)</u>*

   For measures to minimize damages due to Debris / Boulder movement, the size of Sluice Spillway is recommended with a minimum area of 50 m^2 and a width of at least 7 meters and a Surface Spillway with a minimum size of 10-12 meters in width. As stated in above points, the size of Spillway is depended on various hydrological and topological factors, therefore, accommodating the minimum recommended size of spillway in dams may be difficult and impractical.

5. Comments received from NDSA:

2. The aforesaid guidelines have been reviewed, and the observations/comments of NDSA are provided below:

3. The guidelines state that "for new dam projects, spillway capacity should be designed for the design flood plus GLOF" ; while "for existing projects, the existing spillway capacity may be compared with the updated design flood plus vetted/revised GLOF." In this regard, it is suggested that both GLOF and PMF/SPF events are independent hence the probability of both these events occurring simultaneously should be worked out based on joint probability concept or something similar. If probability of occurring of both these events simultaneously is quite high; then only they should be added.

4. Regarding recommendation of casting the piers in M75 concrete in the projects likely to be affected by the GLOF appears to be highly impractical considering sizes of piers in such projects due to cost, as well as casting issues. It is suggested that project location with respect to the project should be given due weightage. In the recent GLOF event of south Lohnak, Teesta - V project, which is about 75 km d/s of the glacial lake, it successfully bear the impact of silt laden GLOF. Such event are rare and the amount of damage it did to the structure should be acceptable for such rare events. In view of the above this recommendation may be reviewed.

5. There is a recommendation on automatic gate operation by sensors. In this regard it is to mention due to cyber security reasons, automated gate operation are not advised. In view of this, the recommendation can be reviewed.

6. Comments received from Damodar Valley Corporation

NIL

7. Comments received from PHE Department, Meghalaya

NIL

8. Comments received from SDSO, Bihar

NIL

Annexure-V

1. Comments received from NHPC:

Clause & page No. of Draft Report	Existing statement	Comments / Change proposed by NHPC
(III), Page-2	IS:11223_1985 (Reaffirmed 2000)	IS:11223_1985 (Reaffirmed 2020)
(III), Page-2	Hydraulic head	The hydraulic Head in column 3 of table be replaced with Static Head at FRL.
(IV) 1 (a), Page-4	The dam spillway capacity should be designed as follows considering the all the gates operative:	The dam spillway capacity should be designed considering Combination of updated design flood & approved GLOF as outlined below, considering all the gates operative:
(IV) 1 (b), Page-5	Routing of the flood shall be carried out wherever possible and provision for spillway capacity shall be provided accordingly.	Routing of the Combination of updated design flood & approved GLOF as stipulated at (IV) 1 (a), shall be carried out wherever possible and provision for spillway capacity shall be provided accordingly.
(IV) 2, Page-5	For existing projects, existing spillway capacity may be compared with updated design flood + approved GLOF................	For existing projects, existing spillway capacity may be compared with Combination of updated design flood & approved GLOF as stipulated at (IV) 1 (a). ....
(IV) 2(b) , Page-6	For concrete dams, encroachment may extend up to 0.5 meters below the top of the dam.	For existing concrete dams, encroachment may extend up to 0.5 meters below the top of the dam. In addition, encroachment may extend up to dam top by constructing solid parapet wall at dam top as a viable solution on case to case basis. This should be undertaken in accordance with comprehensive engineering assessments to ensure the modification adheres to all relevant safety and stability criteria, thereby maintaining both dam safety and operational reliability.
(IV) 2(c) , Page-6	Flood routing may be carried out using the elevation area capacity characteristics as expected after 100 years of sedimentation (as per clause 3.4 of IS: 11223) for the existing large dams to check the anticipated increase in water levels during extreme events and accordingly rule curves may be revised.	For small reservoirs of Run off the river projects, determination of elevation area capacity characteristics as expected after 100 years of sedimentation using Empirical Area method as given in IS: 5477 part-2 (referred in clause 3.4 of IS 11223) is not in practice. To ensure sustainability and to maintain storage capacity of these reservoirs sediment management strategy such as sluicing and flushing are generally adopted. If such practices are not

		adopted and reservoir is kept at FRL throughout the year, the entire reservoir capacity is lost within 5 to 30 years depending upon reservoir size, inflow, sediment load and trap efficiency etc. For Runoff the river projects it is suggested that flood routing studies may be carried out as per initial reservoir elevation area capacity curve and for existing hydro projects reservoir routing studies may be carried out using latest reservoir survey capacity if pseudo equilibrium have been achieved. Detail comment of NHPC already in report (Annexure-III, 1- comments received from NHPC).
(IV) 2(c) , Page-6	If spillway capacity of the existing projects is found less than updated design flood + approved GLOF, measures as mentioned below may be adopted to ensure safety of dam against overtopping:	If spillway capacity of the existing projects is found less than <u>Combination of updated design flood & approved GLOF as stipulated at (IV) 1 (a),</u> measures as mentioned below may be adopted to ensure safety of dam against overtopping:
(IV) 4 , Page-7	The gates of GLOF susceptible dams should be provided with variable speed opening mechanism with a maximum speed of 1.5 – 2 m/min so that these gates could be opened at higher speed in case of emergency situations.	The speed of Spillway Radial gates is mentioned as 1.5 – 2 m/min in cl. no. 4 in draft guidelines. which shall result in additional power requirement and considerable changes in the motor-pump sizes of the power packs. The capacity of DG sets shall also require to be increased 3-4 times. In the existing power stations of NHPC, the opening speed of Radial gates is typically 0.5 m/min except in Kishanganga Power Station where the same is 1.0 m/min. Accordingly, it is suggested to keep the maximum speed of Radial gates as 1.0m/min.
(IV) 5(ii) , Page-8	Protection measures on piers and spillways should be provided to withstand boulder impacts. These measures could involve the use of High-Performance Concrete.	Protection measures on piers and spillways should be provided to withstand boulder impacts. These measures could involve the use of High-Performance Concrete and Steel liner along with standard concrete.
(IV) 7 , Page-9 & 10	Measures to minimize the impact of GLOF	The activities mentioned at (IV) 7(i), (ii), (iii) & (iv) may be taken up by National level agencies such as NDMA / SDMA, CWC or other concerned State Government authorities in association with dam owners.

(V) , Page-10 & 11	Non-Structural Measures	The glacial lakes are located in far flung / remote areas far away from even most upstream hydropower projects. Hence it is difficult to monitor all the lakes by project authority. In some basins, defence / military establishments are existing in nearby area of glacial lakes. Hence the establishment / monitoring of identified potentially dangerous glacial lakes for early warning can be done through such establishments by a central agency of the country. The cost of monitoring and implementation of Early Warning System (EWS) can be shared among the all downstream projects on the basis of few parameters like; proximity to glacial lakes, plant generation capacity, type of dam, spillway capacity, size of reservoir, free board and reservoir operation criteria, etc. Keeping reservoir at lower level during monsoon months is as per existing CWC guidelines for sediment and flood management for all the ROR projects. Also ROR projects have very less capacity to contain GLOF volume, except for some reaction time, if reservoir is kept at lower level. Hence sharing of cost does not seems justified. It is submitted that a safety cost may be incorporated to account for the cost of additional outlet / spillway for negotiating GLOF. It may be similar to the cost component considering flood moderation is kept and separate budgetary support is provisioned to moderate tariff structure.

2. Comments received from NTPC:

Sl. No.	Clause Ref	Clause	NTPC's Comments/ Observations
1.	IV, 1 & 2	**1. *New Projects*:** *a) The dam spillway capacity should be designed as follows considering the all the gates operative-------.* **2. *Existing Projects*:** *For existing projects, existing spillway capacity may be compared with updated design flood + approved GLOF ---------.*	For intermediate and large dams extreme events of SPF and PMF are considered for spillway design. If above recommendations will be considered, it will result in uneconomical design of the project. Therefore, it is better to adopt the one single criteria for new as well as exiting projects: One lower flood than design flood + GLOF
2.	IV, 1	**1. *New Projects*:** d. *The spillway should preferably consist of a combination of a Sluice Spillway, with a minimum area of approximately 50 m² (for each bay) and width of at least 7 meters (each bay), and a Surface Spillway with a minimum width of 10-12 meters (each bay). Where feasible, some of the gates may be designed as fuse gates.*	This clause may be specified for 'Intermediate and Large dams' only. Further, size of sluice depends on head and discharge, therefore, minimum size may not be specified in the guidelines and shall be decided based on design requirements. For barrages, sluice spillway is not applicable.
3.	IV, 2	**2. *Existing Projects:*** *i. Reservoir may be operated at lower level during flood period so that when the revised flood + GLOF is impinged on that lower level, it does not overtop the dam with minimum freeboard, as given above.*	For this clause following may be added: "Numerical or physical model study may be done to fix the reservoir operation level during flood period."
3.	IV, 4	**4. *Rapid response gates/ High speed gates:*** *….Therefore, it is proposed that the gates of GLOF susceptible dams should be provided with variable speed opening mechanism with a maximum speed of 1.5-2m/min so that these gates could be opened at higher speed in case of emergency situations.* *Preference to variable speed motors shall be made to achieve the above objective.*	Speed of gate may be kept as 1-1.5 m/min, based on the height of gate to open fully within 10-15 min. based on the available warning time. Preference to variable speed motors shall be made to achieve the above objective for mechanically operate gate. In case of hydraulically operated gate provision shall be made in power pack and hydraulic systems for operation of gate at different speed. Provision shall be made in power pack to open gate at higher speed with the flood signal from water level sensor/EWS.

4.	IV, 5	*5. Measures to minimize damages due to Debris/ Boulder movement:* *ii. Protective measures on piers and spillways should be provided to withstand boulder impacts. These measures could involve the use of High-Performance Concrete.*	Provision for steel liner on pier may also be mentioned in this clause.
5.	IV, 6	*6. Measures to minimize damages due to overtopping:* *ii. Protection of vulnerable control elements such as power packs for hoist operation, trunnions etc. through suitable cover (Applicable to existing and proposed dams)*	The power pack is generally placed inside the control room covering of the same may not be required. The cover may be provided for drive arrangement of mechanically operated gate. The gate is rotating on the trunnion during opening and closing and covering of the trunnion may not be possible.

3. Comments of Jaypee Vishnuprayag Hydro-Electric Plant forwarded by SDSO, Uttarakhand:

Fwd: Fwd: Draft Guidelines on Structural Measures to mitigate adverse effects of Glacier Lake Outburst Flood (GLOF) on Hydroelectric Projects - reg.

< sdsouttarakhand@gmail.com >
Wed, 05 Mar 2025 4:24:23 PM +0530

To "cmddene"<cmddene@cwc.delhi.nic.in>

महोदय,
कृपया विषयगत अग्रसारित ई-मेल का अवलोकन करने का कष्ट करें, जिसके द्वारा विष्णुप्रयाग हाइड्रो इलेक्ट्रिक प्रोजेक्ट से प्राप्त **comments** आपको आवश्यक कार्यवाही हेतु प्रेषित है।
O/o
SDSO, Uttarakhand

---------- Forwarded message ---------
From: **nagaraj.t** <nagaraj.t@jalindia.co.in>
Date: Tue, Mar 4, 2025 at 6:24 PM
Subject: Re: Fwd: Draft Guidelines on Structural Measures to mitigate adverse effects of Glacier Lake Outburst Flood (GLOF) on Hydroelectric Projects - reg.
To: State Dam Safety Organisation Uttarakhand <sdsouttarakhand@gmail.com>
Cc: mkvr.rao <mkvr.rao@jalindia.co.in>, amit.jauhari <amit.jauhari@jalindia.co.in>, pankaj.chouhan <pankaj.chouhan@jalindia.co.in>, vs.yadav <vs.yadav@jalindia.co.in>, shivpuram.barrage <shivpuram.barrage@jalindia.co.in>

Dear Sir,

Please refer Trailing mail,

We have examined the draft report . Our observations are given in succeeding paragraphs.

4. Rapid Response Gates/High Speed Gates.

In this regard, It is brought to your kind consideration that the hoisting speed of the Gates as per the relevant Indian standard code is ranging from 0.3 m/min to 0.70 m/min. The hoisting speed of Radial Gate of VPHEP Barrage has been kept to the maximum extent possible at 0.6 m/min keeping in view of 140 T weight Gate having size of 14 m X 14.4 m, and need to avoid undesirable vibrations and overstressing of the Gate. Increase of hoisting speed of heavy Gates, like ours, does not presently seem to be technically viable.

V. Non-structural Measures

The draft guidelines recommends that, "Continuous intensive monitoring of lakes in the project catchment identified as threat to existing HEP's by the concerned project authorities themselves or by agencies hired by them."
In this regard, it is submitted that all glacial lakes are generally located in inhospitable high altitude terrain. While EW System are being installed along the rivers, it may not be practical to install such ground based devices to monitor glacial lakes. It is humbly submitted that monitoring of glacial lakes should be taken up centrally by remote sensing means by a suitable Government institution.

With Regards,

Design & Research Wing

Central Water Commission