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Environmental Problems Related to Dams in India

Problèmes écologiques créés par les barrages en Inde

Umweltprobleme indischer Talsperren

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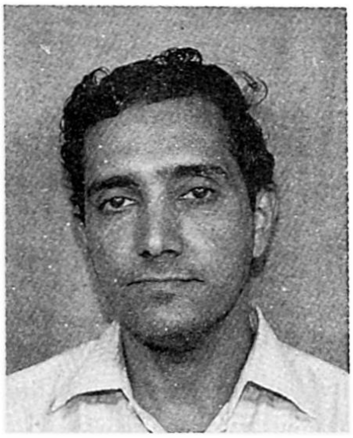

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SUMMARY

Dams are key structures in water resource projects which have contributed immensely in the development of the Indian economy. However, the construction of dams and their subsequent operation have in many cases resulted in negative environmental impacts which had to be controlled to maintain environmental equilibrium. The article discusses certain important issues concerning sizing of low level outlets in dams for evacuation, conducting dam failure analysis and seismic resistant design of dams which are being given due importance from the environmental point of view.

RÉSUMÉ

Les barrages représentent des ouvrages ayant eu une grande importance dans le développement de l'économie indienne. Cependant, aussi bien leur construction que leur fonctionnement ont eu bien souvent des conséquences fatales sur l'environnement; il a fallu revoir et reprendre la situation en main pour en assurer l'équilibre écologique. Sous l'angle de la protection de l'environnement, l'article développe certains points cruciaux relatifs à la section des orifices de décharge prévus pour la vidange de la retenue, à l'analyse du point de rupture des barrages et au calcul de leur résistance aux secousses sismiques.

ZUSAMMENFASSUNG

Talsperren sind von zentraler Bedeutung für Wasserwirtschaftsprojekte, die gewaltig zum Aufschwung der indischen Ökonomie beigetragen haben. Ihr Bau und Betrieb hatten jedoch in vielen Fällen negative Folgen auf die Umwelt, die man zur Wahrung des ökologischen Gleichgewichts in den Griff bekommen musste. Der Beitrag diskutiert als wichtige Punkte die Grösse der Grundablässe zwecks Leerung sowie Untersuchungen der Breschenbildung und der Erdbebensicherheit unter dem Blickwinkel des Umweltschutzes.

1. INTRODUCTION

The development of the Indian economy and the process of its industrialisation has been dependent upon the utilisation of the country's water resources. The demand for enhancing the agricultural produce through irrigation and to provide power to the industries have resulted in the construction of water resource projects and their importance in this respect can be gauged from the fact that from a mere 250 such projects before independence, they have grown to about 2600 by now and many more are presently under construction. Within water resource projects; dams are key structures placed at suitable location across rivers for impounding reservoirs with facilities for controlled release of water from the reservoir for the purpose of irrigation, hydropower, flood control, navigation, domestic and industrial water supply etc. Whereas dams have been responsible for the all round development of the country by fulfilling the purposes mentioned above, their construction and subsequent operation have led to certain negative environmental impact, which unless managed to maintain environmental equilibrium could lead to erosion of benefits. The problems need to be identified in detail for undertaking remedial action. This article describes specific problems related to dams in India and elaborates only on those technical issues that are presently receiving attention.

2. ENVIRONMENTAL PROBLEMS

The environmental problems created by dams in India are the same as those reported globally inkind, though their intensity may differ. These relate to the effect of submergence which is quite huge in a thickly populated country like India requiring enormous effort & resources for the rehabilitation of displaced humans, animals, birds and aquatic tauna. A culturally rich country like India had often to relocate its archaeological and anthropological relics to preserve its cultural identity. The near stagnant water in the reservoir and the marginal water systems around the dam turned into breeding ground for the insects and flies that carried many dreaded diseases which had to be combated. The entry of agriculture, domestic and industrial wastes having plant nutrient properties into the reservoir led to eutrophication and degradation of water quality which also had to be combated. Aforestation has been carried out specially along the rim of large reservoirs to prevent sliding of the embankment into the reservoir and reduce its life through an increased sediment load.

In addition to the general issues mentioned above, engineers in India engaged in the field of water resources are presently concerned with certain purely technical issues to prevent damaging the environment on account of the construction, design and operation of dams. These issues relate to provision of low level outlets in the dam to enable evacuation of the reservoir during its maiden filling and at times of distress in the dam which may lead to its collapse. The second issue concerns conducting dam break analysis for all major dams to determine the arrival time of the flood wave and the inundation area in the event of a dam failure to enable preparation of emergency management plans to reduce loss of life and property. The third problem concerns guidelines for conducting investigations and application of advanced analytical techniques for conducting seismic resistant design of dams for dams located in seismic zones, to have an assurance on their safe performance during earthquakes and to protect the environment from the disaster that could occur in the event of their failure during earthquakes.

3. SPECIFIC ENVIRONMENT RELATED PROBLEMS

3.1 Sizing low level outlets for evacuation

Evacuation facilities by the provision of low level outlets in dams impounding reservoirs are essential to enable evacuation of the reservoir for controlling the reservoir levels during the critical period of maiden filling and also for evacuating the reservoir when the dam is in distress with the purpose of preventing its sudden failure and cause enormous environmental degradation. Low level outlets are also utilised for inspection and maintenance of those areas of the dam that generally remain covered by the reservoir. In general; the designers take a lot of care for designing surplussing arrangements above the crest of spillway by appropriately designing spillway gates, but more often than not, adequate care is not bestowed on the location and sizing of low level outlets.

Certain criteria and guidelines were worked out in 1986 in the Central Water Commission in India for sizing low level outlets for evacuating storage reservoirs based on the requirements of initial reservoir filling and depletion of the same during distress.

Low level outlets for emergency drawdown during initial filling should be located at the lowest possible level and should have discharge capacity sufficient to maintain reservoir filling rate as specified and to hold reservoir level reasonably constant for elevations approximately above fifty percent of the hydraulic height. Inflows into the reservoir should be assumed as the average of the mean monthly inflow in the selected filling period and reasonable frequency flood.

The initial filling of the reservoir is done in stages. The criteria is more stringent for embankment dams as compared to gravity dams. The first stage consists of filling the reservoir upto the Minimum Drawdown Level (MDDL). This filling can be done without restraint for all dams. The second stage consists of filling the reservoir from MDDL to crest of spillway. The rate of filling should not exceed 3 metres per fortnight and for embankment dams should be temporarily stopped at 50% elevation from MDDL to crest of spillway in order to assess the behaviour of the structure, and take a decision about further storage. Further filling is continued in gradual sub-stages of 2 to 3 metres per fortnight upto the crest of the spillway. For gravity dams, the reservoir above MDDL should be gradually built up at a rate not exceeding 3 metres per fortnight and held at the level of crest of spillway in order to assess the behaviour of the structure and to decide on further storage. The third stage consists of filling above crest of spillway to Full Reservoir Level (FRL). The rate of reservoir filling in this zone is not more than 30 cm in 48 hours. The reservoir should be temporarily held at half the height between crest of spillway and FRL for sufficient time for monitoring and evaluation of the performance of the dam and to take a decision for further storage. Further filling up to FRL is continued at the same rate. The filling criteria is the same for both gravity and embankment dams in this stage. For gravity dams having high earthen flanks, the procedure suggested for embankment dam applies.

Sizing of low level outlets for evacuation of the reservoir is dependent on the reservoir volume and evacuation time specified for the reservoir. Guidelines for evacuation time generally take into account the hazard potential of the downstream population and installations along with the risk potential of the dam. For evacuating storage reservoirs and sizing low level outlets, three categories have been suggested as below: These assume a general balance between hazard and risk and could be adjusted on the basis of detailed site specific studies.

Sl. No.	Depth of Evacuation (from initial pool level)	Degree of hazard or risk (High)	(Significant)	(Low)
		Evacuation time in days		
1.	25%	20	30	50
2.	50%	40	50	70
3.	75%	80	90	100

The above evacuation periods may not be technically feasible for unusually small or large dams.

3.2 Conducting dam break analysis

Dam break analysis in brief describes the scenario in terms of flood wave arrival time and contours of inundated area in the valley downstream of the dam when under the impact of an extreme event (hydrologic or otherwise) the dam collapses. Since the collapse of a dam followed by the uncontrolled release of water could cause unprecedented ecological damage in terms of loss of life, property and degradation of everything coming under the impact of floodwave, guidelines have been prepared to work out inundation maps for various flood frequencies including peak floods coupled with dam break to enable preparation of emergency action plans in order to ensure minimum loss to life and property in the event of a dam failure.

The "Report on Dam Safety Procedures" approved by the Government of India in 1986 suggests preparation of inundation maps for 25 year flood frequency, 50 year flood frequency, routed design flood, probable maximum flood coupled with dam break. Software used for dam break analysis consists of DAMBRK developed by the National Weather Service of USA and MIKE 11 of the Danish Hydraulic Institute, Denmark. Inundation maps for the above conditions have already been prepared for a few large dams under distress and those which have a large density of population and important installations downstream of the dam. In due course inundation maps for all large dams under distress and in the high hazard category will be prepared to undertake mitigation measures against dam failures to ensure minimum negative impact on the environment.

3.3 Seismic resistant design of dams

India is one of those countries in the world where the development of water resources occurred at an accelerated pace after independence i.e. after 1947 resulting in the near exhaustion of ideal sites for dams. Engineers are now compelled to design and construct dams in the Himalayan terrain where the geology is varying and the area is seismically active. Dams have therefore to be designed with special care from seismic considerations to prevent their failure under extreme seismic events and cause an ecological disaster.

Of late, seismic resistant design of dams in India had received a lot of attention through intensive seismotectonic studies of the dam site, preparation of appropriate response spectra, adoption of dynamic analysis for dams by the application of Finite Element Method and by establishment of seismic network in and around the damsite and mounting elaborate seismic monitoring instruments within the dam and its foundation. There is a National Committee on Design Seismic Parameters for Water Resource Projects in India with representation of senior engineers from the field of Water Resources, Meteorology, Seismology, Geophysical Institutes, Geology and the School of Earthquake Engineering who as a single unit are required to examine the seismic aspects of major dams referred to it and render precise advice on the design seismic parameters for the dam and appurtenant structures.

Reservoir Induced Seismicity (RIS) in India is less of a fact and more of a figment of imagination in the minds of freelance environmentalists who are lobbying against building of large dams in India. The existence of RIS has however not been established by observations at seismic network established at major dams in Himalayas like Bhakra (226 m), Pong (133 m), Mangla (138 m), Tarbela (143 m), Pandoh (76 m), all of which lie near the epicentre of the Kangra earthquake of 1905, which had a magnitude of more than 8 on the Richter scale. For monitoring RIS at dam sites located in areas of moderate to high seismic intensity, seismic networks were established at the dam and in areas surrounding the reservoir, and readings analysed regularly.

4. CONCLUSIONS

The present environmental problems in India related to water resource projects is largely due to post independence government sponsored projects depicting the nation's urgency in providing basic necessities to the ever increasing population through rapid economic development, in which little or no consideration was shown for protection of the environment. However, in recent years, there has been a change in the perception of the environment in the exploitation of natural resources for development activities, which is evident in the regulatory measures enacted like the Water Pollution Act, Air Pollution Act and the Environmental Protection Act. These acts however do not encompass issues concerning environmental imbalances created by dam building activity. Certain guidelines on this issue has been embodied in the National Water Policy issued by the Government of India in 1987, which in brief states that in the planning, implementation and operation of water resource projects, the preservation of the quality of environment and the ecological balance should be a primary consideration. In the last decade water resource projects have been approved for construction only after they were cleared from the environmental angle. Of late in March 1990, the Government of India constituted an Environmental Monitoring Committee for ensuring effective implementation of environmental safeguards in irrigation, multi-purpose and flood control projects. The monitoring committee is headed by Member (Water Planning) of the Central Water Commission (CWC) with representatives from the Ministries of Water Resources, Environment and Forests, Agriculture, Welfare, Planning Commission and CWC as members of the Committee.

Due to restriction of space, only technical issues concerning the impact of dams on the environment has been elaborated in this article, and indicates the awareness of water resource engineers towards maintaining environmental equilibrium in a scenario where due to the heavy demand on hydro-power, the compulsion has been to plan construction of large water resource projects in areas of varying geological formation and are seismically active. Time will only tell how successful has been the structural and non-structural plans for these projects in protecting the environment.