TOPIC :- DISASTER MANAGEMENT
SUB TOPIC :- NATURAL DISASTERS RELATED TO WATER AND CONSEQUENCES OF DAM FAILURES AND REMEDIAL MEASURES

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ABSTRACT

The natural disasters which is related to water mainly are cyclone, floods, tsunamis, storms affect the human life a lot and hence it is necessary to take steps to mitigate the effects of the disasters and develop management techniques for the same. Prevention and Preparedness are the basic tools for this. As per the definition given by Susman, "Disaster is the interface between an extreme physical environment and a vulnerable human population." Disaster is very clearly defined by Turner, " An event, concentrated in time and space, which threatens a society or a relatively self sufficient sub-division of a society with major unwanted consequences as a result of the collapse of precautions which had hither been culturally accepted as adequate."

Every year thousands of people die, injured, lose their homes, because of natural disasters, especially those related to water the trends are on the rise. Natural disasters constitute a very important threat for millions of people, and particularly those who are poor suffers more. The history of disasters which is related to water gives ***alarming*** *figures. Out of the total disasters average of disasters which is related to flood is amounting to 50%. These flood disasters sometimes affects the dams constructed to store the water for irrigation purposes or for drinking purpose or any other purposes, and heavy flash floods destruct the dam construction and due to this people residing in the vicinity of dam suffered and sometimes lost their life.*

The history of dam failures in the world is now well known to all. The recent issue relating to the dispute over dam and release water of from Mullaperiyar dam- one of the world's oldest dam; aged over 100 years- which gives a direction for proper management of water resources. Also the incidents of the Bangiao Dam failure in china in the year, 1975, Morvi dam failure in the year 1979 in Gujarat-India, breach of Kosi embankment near Indo-Nepal border in August-2008 and collapse of Jaswant Sagar Dam in Rajasthan-India are the eye-opening to the world. Such big dam failures incidents threatened for the safety of dams all around the world and many conferences were organised by many Governments and outcome of such debates had helped for making dam safety plans and programmes to take immediate actions for the safety of dams and mankind. I hope that the debate during this India Water Week-2012 will also be beneficiary for the next generation.

1. INTRODUCTION:-

Natural Disasters which is related to water mainly are Flood and Tsunami. Floods are natural phenomena that occur at irregular intervals anywhere in the drainage system of river and stream. The prediction is difficult for flood. The scale of the floods also varies widely from minor flashes to major events. Among the 234 bigest disasters of the last 50-55 years; 90% of them are constituted of storms and floods, amounting to about 1.45 million deaths. The flood can be managed basically by two ways, which includes Structural Measures and Non-Structured Measures. The reasons for damages occurs due to floods are poor planning of flood management and settlement of people in high risk areas on flood plains. Disaster resulting from floods can be prevented through the help of early warning system. Dam failures occurs due to heavy flood, in which the mass of water spilling over the dam wall erodes the structure and causes failure. The other reasons are structural failure of materials used in dam construction, movement and/or failure of foundation supporting the dam, settlement and cracking of concrete or embankment dams, Piping and internal erosion of soil in embankment dam, inadequate maintenance and upkeep and deliberate acts of sabotage.

2 FLOODS AND ITS MANAGEMENT:-

2.1-Floods:- Floods are natural phenomena that occur at irregular interval anywhere in our drainage system of river and streams. Floods are unexpected and one cannot say where and when floods will strike, the predation is difficult for flood. The scale of the floods are very widely from minor flushes to major event

2.2-Management of Flood:-

There are basically two methods for managing the flood which include structural and non-structural measures.

2.2.1 Structural measures:-

This includes physical measures, construction of flood attenuation of dams, river draining works such as levees and urban storms water system to control flood run of and river flows. Levees and flood walls the principle purpose of levees and flood walls is to confine flood waters to stream channel and selected portion of the flood plain. This barriers protect only the land area immediately behind them and are effective only against flood depth up to the fusion level for which they were designed, flood exceeding the levels for which levees are designed can cause losses of life and property.

The other flood management structures can be named as below:-

2.2.2 Channel modification
2.2.3 By pass flood ways
2.2.4 Retarding basins and flood storage area
2.2.5 Flood mitigation reservoirs
2.2.6 Drainage evacuation system

2.3 Non Structural Measures-

In this we can include the introduction of enforcement of sensible land use practise on flood plains promulgation of dam safety legations and regulations, further in flood preparedness and contingency planning, adaption of flood warning system etc. The venerability of land and property to water related natural disasters can be reduce by structural works the potential impact of this events can be further reduce by the imposition of land use control design to mange land degradation and minimize explore to the risk of disasters which cannot be avoided.

To achieve these objectives legislative controls which empower the relevant government authority to direct land use planning policy and practically related to water shade management need to be adopted and implemented.

The other non structural measures can be included as :-

2.3.1 Legislative and regulatory measures for controlling land occupies
2.3.2 Structural and standard emergency polices and services
2.3.3 Land use planning
2.3.4 Warning systems
2.3.5 Emergency agencies facility and equipments
2.3.6 Evacuation and flood reliving services and community educations
2.3.7 Geo physical information system (GIS) provide effective tools for the preparations of basic topographical and geographical information for making warning plans

3 DAMS AND DAM FAILURES:-

Dam can be simply defined as *"an artificial barrier placed on bodies of water that hold back the flow of water they may have many purpose, which includes hydro electrical power generation, safe river navigation, agricultural irrigation, creating recreation areas, water supplies and flood reduction"*.

3.1 Classification of dam:-

Dams may be classified with in sides and hazard potential in order to formulate a basis for selecting dames to be included in the inspection program and there priority and also to provide capability between guidelines requirements and involved risk.

Table -1
Classification of Dames As Per their size and height

Category	Water Storage capacity in hector	Height of dam in meters
Minor	≥ 6 and< 125	<12 to 18
Medium	≥125 and <6250	>12 and <30
Major	≥6250	>30

Dam hazard Classifications:-

High hazard :-The class one denotes high hazard zone category :-Dames located where failure will likely cause loss of life or serious damage to home, industries and commercial facilities , public utility-which are very vital and main high way rail road such dams must be inspected annually.

Significant Hazard:-Dams located where failures will not likely to cause loss of life but may damage homes, secondary high ways, or rail-roads or cause service interruption of important public utilities. Such dams are to be inspected less frequently.

Low Hazard:- Causes minimum property damage, loss of life not expected.

3.2 Dam Failure:-

There are many large dams in the world which are useful to store rain water, but sometimes even they get struck by disasters and lead to loss of human life and also a lot of financial loss. According to the figure published in National register of large dams, 2-3 years back, there are 4710 dams in service and other 390 dams were under construction at that time, the figures might be changed little more in the last 3 years. It is important to note that a majority of existing dams are more than half a century old and have thus outlived their design life of about 50-60 years. Dams usually have a life span, beyond which they become unsafe. In most of the cases 40-50 years is deemed to be active life span of a dam, after which it is prone to be unsafe and thus progressively less productive. Thereafter, the cost of maintaining the dam starts out weighing its benefits, says experts.

The failure of big dams in the recent past all over the world gave a wakening call for urgent steps for the proper and timely repairing work for old dams and to make large mechanism to ensure safety of people and the structures. Needs is there for clear legally binding accountability mechanism in the case of dam failure or unsafe dam operations and for determining what is to be done with old dams that become a threat to lives, livelihood and environment.

Now let us understand the consequences of Dam failures due to Natural Disasters and some other reasons. A dam can fail for one or a combination of the following reasons;
It can either happen during a flood, when the mass of water spilling over the dam wall erodes the structure and causes failure, or these can be so called “sunny-Day” failure, when the dam falls due to structural instability. This can be caused by for example earthquake deterioration of materials over time.
Let us now understand the main causes of dam failures.

3.2.1-Over topping:-

Overtopping occurs when level of a reservoir exceeds the capacity or height of the dam. This can be caused by an inadequate or dysfunctional spillway or by settlement of the dam crest. Over topping occurs when water level rise rapidly and without adequate warning say for example due to flash floods, heavy rains a landslides in the reservoir that creates a tsunami or if a dam upstream collapses. The result can compromise the structural integrity of the dam or it can quickly erodes the land on either side of the dam, in effect disengaging the dam from its river slope
Embankments. In earthen dams the main cause of failure is erosion caused by overtopping or a failed spillway. Example is failure of Morvi dam in Gujarat in the year 1979.

3.2.2-Foundation defects:-

Defects can occur in the foundation supporting the dam. The weight of dam structure has an impact on the ground underneath. If this weight is not properly taken into account in the engineering of the dam, the ground underneath can settle unequally and compromise the foundation. Similarly, dams built on slopes must be properly engineered to avoid issues with instability or landslides. Any event causing the movement of foundation, such as an earth quake, can also compromise a dam’s foundation. The main cause of concrete dam failure is a problem with the foundation, high uplift pressures and uncontrolled foundation seepage can also compromise the dam’s foundation. Example of catastrophic dam failure due to foundation defects of St.Francis dam in the year

3.2.3-Piping and seepage:-

Embankment dams which are generally semi-permeable the can be compromised when too much water seeps or leaks through the structure. Dam failures can occur when the structure becomes weakened from internal erosion, an effect referred to as piping. This can occur along hydraulic structures, spillways, conduits or cracks. Example of dam failure due to piping and seepage is Kelly Barens dam.
Other reasons can named as follow:-
1-Lack of cooperation between various organizations involved in the dam management ,
2-Construction work within short period of time, example of Mahewali scheme of Sri Lanka.
3-Inadequate maintenance and upkeep the example is failure of Val di Stava Dam.
4-Deliberate acts of sabotage

5-Many dam fails as a result of " the pilot project syndrome", as called by widstrand, thus engineers assume that the technology used to built small scale dams can be used with little or no modification, for putting up large dams.
6-Sometimes issue related to distribution of reservoir water between two states or cities creates havoc in the vicinity and threatens the security of the dam. Therefore, precautionary measure for dam safety is an urgent need.

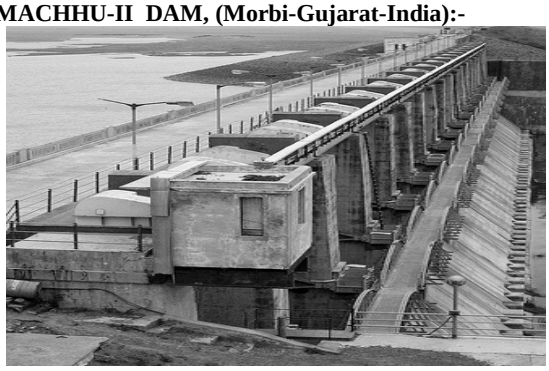
Let us now see some details of few major Dam Failures in India and abroad:-

1-KADDAM PROJECT-(A.P.-India):-
Buit in Adilabad in 1957-58. The dam was a composite structure, earth fill and/or rock fill and gravity dam. It was 30.18 m. high and 3.28 m. wide at its crest. *The dam was overtopped by 46 cm of water above the crest,* in spite of a free board allowance of 2.4 m. that was provided, causing a major breach of 137.2 m. wide that occurred on the left bank. Two more breaches developed on the right section of the dam. The dam failed in August 1958.

2-KAILA DAM (Kutchh, Gujarat, India) :-
It was constructed during 1952-55, as an earth fill dam. It was 23.08 m. height above the river bed and a crest length of 213.36 m. The foundation was made of shale. The spillway was of ogee shaped and un gated. In spite of a free board allowance of 1.83m. at the normal reservoir level and 3.96m. at the maximum reservoir level *the energy dissipation devices first failed and later the embankment collapsed due to weak foundation bed in 1959.*

3-KODAGANAR DAM- (Tamil Nadu-India):-
This dam in the India was constructed in 1977 on a tributary of Cauvery River as an earthen dam with five vertical lift shutters each 3.05 m. wide. The dam was 15.75 m. high above the deepest foundation having 11.15 m. height above the river bed. The dam failed due to overtopping by flood water which flowed over the downstream slopes of the embankment and breached the dam along various reaches. There was an earthquake registered during the period of failure although the foundation was strong.

4-MACHHU-II DAM, (Morbi-Gujarat-India):-



This dam was built near Rajkot, Gujarat on river Machhu in Augaust-1972 as a composite structure. It consisted of a masonry spillway in river section and earthen embankment on both sides. The embankment had a 6.1 m. top width, and a clay core extending through alluvium to the rocks below. The upstream face had a 61 cm small gravel and 61 cm hand packed rip rap. The dam was meant to serve an irrigation scheme. Dam had a height of 22.56 m. above the river bed, a 164.5 m. of crest length of overflow section and a total of 3742 m of crest length for earth dam.
The dam failed on August 11, 1979, because of abnormal floods and inadequate spillway capacity. Consequent overtopping of the embankment caused a loss of more than 2000 lives. A maximum depth of 6.1m. of water over the crest and within two hours, the dam failed. While the dam failed at a peak discharge of 7693 m3/s, the figure was revised to 26,650 m3/s after failure, with a free board of 2.45 m. given, providing also an auxiliary spillway with a full capacity of 21,471 m3/s. The observed actual flood depth over spillway crest was 4.6 m. with an observed flood 14,168 to 19,835 m3/s, while the design depth over spillway crest was 2.4 m.

5-TETON DAM-TETON RIVER- USA:-

The construction of Teton dam began in April, 1972 and dam was completed on November 26, 1975. The dam was designed as a zoned earth and gravel fill embankment, which was having height above the bed rock of 126m. And a 945 m long crest. The dam had a height of 93m., a crest width of 10.5 m. The embankment material consisted of clayey silt, sand and rock fragments taken from excavations and burrow areas of the river's canyon area. It had a compacted central core. Narrow trenches 21 m. deep, excavated in the rock and compacted with sandy silt and a deep grout curtain beneath a grout cap the central zone were the measure taken to control the foundation seepage.

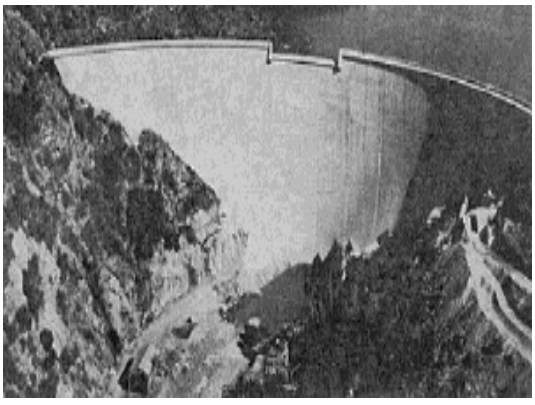
The dam failed on June 5, 1976, releasing 308 million m3 of reservoir water. A flood at an estimated peak discharge in excess of 28,300 m3/s had occurred. The peak outflow discharge of the time of failure was very high in volume.

A breach 46 m. wide at its bottom and 79 m deep had formed. The time of failure was recorded as four hours. The cause of failure was attributed to piping progressing at a rapid rate through the body of the embankment.

The main findings suggested that erosion on the underside of the core zone by excessive leakage through and over the grout curtain was the cause of destruction. "Wet seams" of very low density in the left abutment extended into the actual failure area. These caused local deficiencies in the compaction of the fill, and might have been the locus of the initial piping failure. Earlier on the day of failure, leaks were observed about 30 m below the top of the dam. After four hours, efforts to fill the holes failed and the dam breached by the noon time. The fundamental cause of failure was regarded as a combination of geological factors and design decisions, which taken together allowed the failure to occur.

Numerous open joints in abutment rock and scarcity of more suitable materials for the impervious zone were pointed out by the panel as the main causes for the failure of the dam. Furthermore, complete dependence on deep dry key trenches that developed arch action, cracking and hydraulic fracturing as a measure adopted against seepage and reliance on compacted material for impervious zone were also attributed as possible causes of failure.

6-MALPASSET DAM-USA:-



An arch dam of height 66 m. with 22 m long crest at its crown. When the collapse occurred, the dam was subjected to a record head of water, which was just about 0.3 m below the highest water level, resulting from 5 days of unprecedented rainfall.
The failure occurred as the arch ruptured, as the left abutment gave away. The left abutment moved 2 m horizontally without any notable vertical movement. The water marks left by the wave revealed that the release

of water was almost at once. The volume of water relived was 4.94 Mm3 of water.421 lives were lost and the damage was estimated at 68 million US dollars.

7-VAIONT DAM- ITALY:-

This is an arch dam, 267 m high during the test filling of the dam, a land slide of volume 0.765 Mm3 occurred into the reservoir and was not taken note of. *During 1963 the entire mountain slide into the reservoir.* This material occupied 2 km of reservoir up to a height of about 175 m above reservoir level. *This resulted in a overtopping of 101 m high flood wave, which caused a loss of 3000 lives.*

Some other major dam failures are as below:-
(9)KHADAKWASLA-DAM-Maharashtra-India,-in July-1961
(10)PANSHET DAM- Maharashtra-India, in July-1961
(11)NANAK-SAGAR DAM-Punjab-India, in August-1967
and many more in all over the world. We have to learn from such type of disasters.

4- INSPECTION OF DAMS:-

The following points are to be considered for inspecting a dam for the safety and to take necessary remedial measures for the defect found:
The design, characteristics of their constituent materials, the nature of their foundation, their regional settings, change in the material characteristics which includes general, concrete rocks, soils, metals, timber, rubber and joint sealers etc, seepage and leakage in the dam, drainage system, cavity formation if any and stress and strain and the stability of the dam.
Remedial measures for dam failures The following points should be consider for the remedial measures for dam failure and proper inspection and invitation should be carried out as per the standard norms for the inspections
1 Hydraulic and hydrologic capabilities.
2 Structures stability
3 Operational adequacy
Technical investigations should be conducted under the direction of competent professional engineer experienced , design construction and operation of the dam applying the disciplines of hydrologic hydraulic soil and structural engineering and engineer geology. All field inspections should be conducted by qualified engineer geologist and other specialist including experts on mechanical and electrical operations of gates and controls knowledge in the invitations design, construction and operations of dames.
Inspection of gates
Sometimes it happen that due to the failure of gate non opening of gate to release the flood - the water flows from the dam causes damages in the construction of the dam and as such loss of life may occur for the proper operational working of gated structure the inspection of gates must be carried out as per the slandered norms of dam safety organizations of the concern region.

5-DAM SAFETY:-

It is the art and science ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property and the environment. It requires the collective applications of engineering principles and experiences and a philosophy of risk management that recognizes that dam is a structure whose safe functioning is not explicitly defined by its original design and construction.

It also includes all actions taken to identify or predict deficiencies and consequences related to failures and to document, publicize and reduce, eliminate or remediate to the extent reasonably possible and any unacceptable risks.

5.1 Dam safety programme :-
The programme is useful to protect the life of people and save the environment by ensuring that all dams are designed, constructed, operated and maintained as safely and effectively as much as possible. For this, the personnel working in this field, should be committed and vigilant and should be well aware of the art and science of dam design.
5.2 Dam safety Bill 2010- The proposed bill will be beneficial to all the stakeholders including various states.

5.3 Prevention:-
Disaster prevention is the application of the measures that seek to prevent natural phenomena from occurring and to limit the intensity of their effect, which includes long term policies and programmes. The structural measures can be named as: Channel modification, flood detention, storage and levees which are designed to reduce the incidents over the extent of flooding. In the non-structural measures, we can include: flood insurance, flood zoning, restriction, land use management, economic incentives, public information and community education for plains or low lying areas. For the low lying coastal areas the structural measures include construction of embankments capable of withstanding the anticipated natural disasters and in the non-structural measures: land use zoning and control over occupation in high hazard area, building controls etc are the basic methods to overcome natural disasters.
5.4 Preparedness :-
Disaster preparedness is the application of measures designed to minimise loss of life and property and to organise and facilitate timely and effective rescue, relief and rehabilitation when disasters occur. This includes forecasting and warning systems, evacuation from affected areas, flood fighting, flood relief and cyclone relief centres. As such, natural disasters related to water also include tsunamis and drought, necessary disaster management steps should be taken to minimise the effect of such disasters.

5.5 Basic Precautions to avoid Dam Failures:-
5.5.1 Foundation treatment must be carried out as per requirement of the soil, considering the geological condition and strata of the foundation. Grouting for foundation treatment must be carried out as per the requirements with standard techniques and by using type of grouting as per the strata of the foundation.
Grouting may be defined "as the injection of appropriate material under pressure into certain parts of the earth's crust through specially constructed holes in order to fill and therefore seal-voids, cracks, fissures or other cavities in soils or rock strata."
The grouting will control potential piping of susceptible material, give effective barrier to seepage, thereby reducing the permeability of the rock mass to reduce the hydraulic uplift.
5.5.2 Construction of Big Dams should avoided if there is unavailability of good foundation strata and appropriate geological condition of the land to build a dam.
5.5.3 Proper operation of opening/closing of gates must be checked before monsoon because it has been also observed from some dam failures that due to not operation of gates opening to release the heavy flood , the heavy quantum of flood water overtop the dam and as such dam damaged/fails.
Life of mankind is more important and proper precautions for the safety must be taken before planning for the construction of big dams.
5.5.4 Automation of gates operations:-Automation of gates operation should be implemented now, where there is possibility for modification in gated structures.

CONCLUSION:-

Disaster defined by ISDR, UN as "A serious disruption of the functioning of a society or community causes widespread human, material or environmental loss which exceeds the capacity of the affected society to cope without external intervention. A disaster is therefore an effect to the society of a hazardous occurrence."

Disasters disrupts progress and destroy the hard-earned fruits of painstaking developmental efforts, often pushing nations, in a quest for progress, back by several decades. The entire mankind is to be protected but in priority the most vulnerable people. We need a new vision of security the following new components must be aimed. 1) Recognize the threat- Natural disasters and their various impacts, other related threats. 2) Problem must be studied at all levels like globally, regionally, nationally and individually. 3) Identifying what to protect in priority. 4) Propose a desirable state of security.

The world is facing an increasing frequency and intensity of natural disasters. As per the information available, at least 243 Million people were affected by climate related natural disasters in world during the period of 1998 to 2007, and a huge amount of economic losses occurred due to this. The forecast for 2015 gives a shaking figure of 375 Million.
In the context of human vulnerability to disasters, the economically and socially weaker segment of the population are the one that are most seriously affected. Within the vulnerable groups, elderly persons, women, children-especially women rendered destitute and children orphaned on account of disasters. Thus the efficient management of disasters, rather than mere response to their occurrence has, in the recent times, received increased attention both within India and abroad.

The history of dam failure revels that failure are rare but they are costly in lives and property. Dams and reservoir are complicated system and requires thorough inspection as per the hazard zone classification of the dam and necessary remedial measures for any fault found should be taken on war footed time could anything have been done to prevent the failures should be asked individually who are dealing with the irrigation projects particularly looking the operation of gated structures.

At this point it will be very inserting to know that some research worked carried out to study the relation between earthquakes and dam the finding are very inserting let us understand what is earthquake? Earthquake can be defined as a sudden motion or trembling in the earth caused by the abrupt released accumulated stress along the fault.

It has only recently been recognized that the pressure applied to often geological structure by the vast mass of water impound by a big dam can and often does give a rise to earthquake .
The first time that seismic activity was imputed to reservoir was in California in the year 1935.relation between the large dam and earthquake must be studied at large by all the countries where there are many large dams, because it is clear that the occurrences of an earth quake under a large man-made lakes/dams or in the immediate vicinity not purely fortuitous. These are few examples which gives a clear idea about the relationship between the dam and earthquake-

1-Hoover dam-142 mt. earthquake in the year 1972
2-Kariba dam -Rhohedesia125 mtr. 1963 & 1969
3-Hisfengkiary China-1962-dam damaged 6.1magnitude
4-Kremasta Greese-1966 6.3 magnitude
5- Koyna-India 1967 6.5magnitude.

Flood caused by landslide at the viont dam Italy in 1963 which was probably triggered off by seismic activity killed 2000 people.

To face and tackle disasters, we need tools like disaster mitigation and management and the construction should be made as per the norms and the quality of the dams must be of the highest order possible so that the occurrence of dam failures can be stopped and hence saving the life of people and reduce the monetary loss. Use of latest technology like satellites and ICT should be done to prevent such disasters.
Our vision is to build safer and secure India through sustained collective efforts, synergy of national capacities and people's participation. What looks a dream today will be transferred into reality in the next coming years by sharing the knowledge of technocrats, engineers, architects, economists, management experts, planners and officials of various Government bodies and the political will of our politicians.
This is our goal and we shall strive to achieve this goal with a missionary zeal. The path is ahead, which looks difficult today, will become a lot easier as we move along together.

RECOMMENDATIONS:-

1) Development of Dam Safety Commission at a Centre level for monitoring and maintaining the safety of all the dams.
2) Planning for Natural Disaster Management specially related to water bond disasters.
3) Remedial measures for the dams which have completed their stipulated life span.
4) Constructing small dams should be given priority and unnecessary construction of large dams should be avoided.
5) Development of standard design criteria for the construction of big dams all over the country should be proposed.

6) Constant and vigilant auditing of dam safety.
7) Use of latest technology for forecasting and early warning systems for floods.
8) Construction of major dams should be avoided as much as possible in the Earthquake prone zones.

Last but not the least, the construction of big dams are for improving the lives of people, so their lives should be the priority in every safety measure.

BRIEF PROFILE OF THE AUTHORS

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