The Challenge of Flood Devastation in India Every Year : The Likely Solutions

*** Mahesh Prasad**

Abstract

The flood problem in India is a chronic issue, the rivers causing devastation almost every year in certain regions of the states like Bihar, Uttar Pradesh, Assam, Kerala, Karnataka, Madhya Pradesh, Gujarat, Odisha, and Bengal. This is happening despite the huge investments done so far in various river valley projects since Independence. Merely attributing the problem to issues like climate change, deforestation issue, and rapid growth in habitations is not enough and certain out of the box thinking is needed to resolve the issue. The article brings out certain untraditional measures, short term as well as long term, which if implemented may reduce and check this chronic problem which is causing large scale physical and mental distress to affected population apart from causing huge losses to nation in the form of damage to crops and other assets.

Keywords : **Floods, hydrology, open channel, pipe flow, reservoirs**

I. BACKGROUND AND HISTORY

Flood devastations, almost every year, have become a part of life of every Indian living in vulnerable states like Assam, Bihar, Uttar Pradesh, Gujarat Kerala, Odisha, and partially in other states also. It becomes a topic of political discussions, calls for relief funds, formal aerial surveys by leaders and expression of sympathy for the people at large for their sufferings. The problem remains a hot issue for discussions during monsoon time and thereafter it is simply forgotten till the time it reoccurs again in the following year.

No consistent effort has been made so far to get rid off the problem forever. Immediately after Independence, an expectation was there that with construction of a series of dams under various river valley projects on major rivers and their tributaries, the flood problem in India will get resolved. It has not happened despite so much of investments in river projects.

In facts the huge reservoirs and dams created so far are proving counterproductive so far as flood devastations are concerned. A typical example in recent past is Kerala Flood devastations in the year 2018. The case is explained below.

Kerala received heavy monsoon rainfall during the year, which was about 116% more than the usual rain fall data. On August 8, 2018 the state witnessed a rainfall of 310 mm (12 inches) in 48 hours, resulting in all the dams in the state getting filled to their maximum capacities. The flood gates of almost all dams had been opened suddenly since the water level had risen close to the overflow level, causing a severe flood situation in the local low-lying areas. There are total of 79 dams in the state but they failed to store up the surplus runoff arising due to heavy rainfall. The flood gates were suddenly opened for the safety of the dams and hence, an unprecedented disaster occurred in the state.

A report on this unprecedented occurrence by Jacob P. Alex, Amicus Curiae appointed by the Kerala High Court said that the devastating floods of 2018 were the result of bad dam management by the state government. All 79 dams in the state were maintained with the objective to generate hydroelectricity or irrigation, and controlling flood wasn't their purpose, Jacob P. Alex's report

Manuscript Received : November 21, 2020 ; Revised : November 24, 2020 ; Accepted : November 25, 2020. Date of Publication : December 5, 2020.

* *M. Prasad* is National Quality Monitor, Ministry of Rural Development, National Rural Road Development Agency, Prime Minister Gramin Sadak Yojna, 17/35 Indiranagar, Lucknow, Uttar Pradesh - 226 016, India.
(Email : mahesh.prasad50@gmail.com)

DOI : https://doi.org/10.17010/ijce/2020/v3i2/156365

highlighted, “The major concern of the dam operators was to maximize reservoir levels, which conflicted with the flood control purpose for which the dams could be utilized. The 'flood cushion' of reservoirs — the storage space earmarked in dams to absorb unanticipated high flows needed review as per the latest guidelines.

The report further mentions, "Sudden release of water simultaneously from different reservoirs, during extreme rainfall aggravated the damage." [3].

II. AN ANALYSIS OF THE SITUATION

This crucial report on the occurrence in August 2018 was lost in political hue and cry and arguments in courts but the technical point for a technical/scientific regulation of the dams is a matter of utmost importance and should not be lost sight off. This can be a powerful tool to prevent flood disasters and consequent damages to public life and properties.

India has almost 4200 major/medium dams [2] in existence on major rivers and their tributaries. They are the real assets for the nation as a whole and can be helpful in preventing floods. Dams are generally constructed with multiple purposes in mind : Hydro electric generation, irrigation through canals networks, flood control, tourism/recreation, fisheries etc.

The aim of power generation as well as irrigation remains maximization of water levels, whereas the purpose for flood control / prevention is required to keep the water storage level at lowest possible level and thus, there is a need for implementation of dry dam concept with operation of reservoirs, particularly during the monsoon period.

For dams meant for flood-control, the reservoir must be managed to keep water level below a certain specified elevation before the onset of the rainy season to have certain amount of space in which flood waters can get filled. Reservoirs are required to be properly calibrated to discharge stored flood water gradually, keeping the safe water level on down stream of the river in mind.

In the United States, dam and reservoir design is regulated by the US Army Corps of Engineers (USACE). Design of a dam and reservoir follows guidelines set by the USACE and covers topics such as design flow rates considering meteorological, topographic, stream flow, and soil data for the watershed above the structure.

A. Centralized Control on Operation of Reservoirs

Dams and the reservoirs presently comes under jurisdictions of various state governments and generally operated at level of Assistant Engineers or Junior Engineers and certain contingent of skilled or unskilled staff under them. The team is generally unaware of hydrology concepts and flow behavior of river regime. However, in actual sense, the flood devastations is an inter-state issue where adverse effect generally take place in states on downstream side of river. Most of the times, flood situation occurs because of heavy rainfall in catchment area on upper reaches of the river, falling in other states and consequent and sudden releases of water from the dams of other states without giving advance warnings to the downstream regions or states.

There is definitely lack of coordination among various states and authorities involved. Therefore, a centralized authority is the need of the hour to control the operation of dams and reservoirs on entire basin of the river from start to end including the various tributaries joining the main river.

The tributaries cause havoc by overflowing the banks because of backwater effect of high flood level in the main river and consequent congestion in discharge of peak flood.

B. Underlying Concept of Hydrology

For having effective control and management of surplus run off, it is essential to gather precise and timely data of rainfall in various sectors/zones in catchment of every dam/reservoir.

This is possible by establishing a network of Rain Gauges (preferably automatic type) to communicate rainfall data every hour to designated control rooms. Presently rainfall data collection done by Meteorology Department. This again is required to be brought under central control.

From the accurate data of rainfall from catchment zones, by help unit hydrographs developed for each zone of catchment, the likely surge in discharge at dam site and resultant water level can be well evaluated well in advance (at least 2 to 3 days) using hydrological methods [1] and accordingly the reservoir can gradually be emptied out so that run off is comfortably stored in reservoir without causing river to flow above safe level and the peak effect of heavy downpours is well absorbed and flood situation is avoided.

Flood situation in entire basin of river including the tributaries is required to be watched and controlled centrally by a team of experts by regulating flow of run off and flood water through the spillway and floodgates of reservoirs.

All the dams before onset of monsoon be switched over to concept of dry dam and the aim of keeping water level at maximum as generally required for power generation/irrigation be temporarily suspended.

Since the phenomenon of floods is a technical issue, it needs to be entrusted to a centralized technical body to control it effectively on a permanent basis.

C. Actions Involved

(1) Constituting a flood control team comprising of technical experts in science of hydrology and civil engineering.

(2) Getting instant data of rainfall from rain gauges network in the catchment zones on hourly basis in control room.

(3) Process rainfall data promptly to arrive at the quantum of consequent run off and the water level at reservoir sites of various dams and barrages applying unit hydrographs developed for each of the catchment zones.

(4) Regulate the gate operations in dams/barrages based on advance information in a manner that the peak flows are well retained and gradually discharged into river stream ensuring safe water level of flow throughout the monsoon period.

(5) Team also takes care of tributaries of the river and its contribution of water discharge into main river and ensures a safe water level for flow.

(6) In case situation is anticipated to go out of control, issue advance warnings in vulnerable localities and get assistance from institutions like National Disaster Relief Force (NDRF) and State Disaster Relief Force (SDRF).

(7) Display high flood level signs in entire regions which are having risk of getting affected by floods so that people while constructing houses remain aware of flood levels and keep a safe place for themselves as shelter during flood durations and self manage the inconveniences during flood.

D. Enhancing Flood Discharge Capacity of River Streams

The river streams for main river as well as the tributaries, with passage of time are subjected to change in flow characteristics. River courses are changed, stream channels get silted up resulting in reduction of depth of flow. Such changes are also big factors behind flood disasters. Therefore, an extensive study is required to be done on entire river regime by a team of experts to identify the vulnerable stretches where risks of water spilling over natural banks are there. Thereafter, team needs to take effective measures to enhance the discharge capacity of river streams. Some of these measures are :

(1) De-silting of river bed and create stable bunds son river sides.

(2) Construct high embankments as protection to adjoining habitations.

(3) Embedding large size closed conduit in river beds (as explained next).

III. OPEN CHANNEL FLOW VERSUS PIPE FLOW

Concept Involved - Higher Flow Efficiency of Closed Conduits Over Open Channel

A simple calculation shows that for a given cross sectional area and hydraulic gradient, the quantity of flow through closed conduits is approximately two to three times higher than the discharge in an Open Channel (as the case in river flow). Therefore, this fact can be implied that if an additional area of cross section is created by imbedding medium/large size pipes deep in river beds to discharge water flow beyond safe discharge level of river upto safe section of river stretch where the surplus flow merges with main discharge of river without increasing the water level beyond danger mark.

Table I compares the flow rate of open channel gravity flow and piped flow under gravity.

Thus, embedding of multiple number of pipes along both the flanks of main river streams along shallow stretches can be helpful in enhancing carrying capacity of river channels to some extent. Fig. 1. Shows embedded pipes in river stream.

This concept can be further used for quick and safe discharge of peak flows in tributaries upto down fall

TABLE I.

COMPARISON OF FLOW RATE OF OPEN CHANNEL GRAVITY FLOW AND PIPED FLOW UNDER GRAVITY

OPEN CHANNEL FLOW	CLOSE CONDUIT GRAVITY FLOW
Shape of channel -- Trapezoidal	Pipe Flow
Bottom width 5 meter	Area of Pipe/Conduit 33 SqM
Top width -- 17 meter side slope 2:1	Dia $=(33*4/\pi)^{1/2}=6.48$ m
Depth --- 3 meter	Using HAZEN WILLIAM equation
Area of c/s -- 5*3 +2*6*3/2 = 33 sq. m.	Discharge
Applying Mannings formula	$Q = A*(K*C*R^{0.63}S^{0.54})$
$Q=(1/n)A(R^{2/3})(S^{1/2})$ Cumec	K Conversion factor metric sys 0.849
R= Hydraulic radius	S Slope of pipe 0.001 i.e 1 in 1000
$= A/P = 33/(5+2*(6^2+3^2)^{1/2}) = 1.79$	R Hydraulic radius = A/P
n roughness factor 0.025 for natural earth	= dia/4 (for circular pipes)
S is hydraulic gradient 0.001	C Roughness coefficient = 150 for plastic pipes
(assumed 1 M in 1000M)	Discharge $Q = 33*0.849*150*(6.48/4)0.63\ 0.001^{0.54}$
Discharge Q = (1/0.025)*33*	=3081.87*1.355*0.024
$1.79^{2/3}x0.001^{1/2}$	=134.65 Cumecs
= 40*33*1.47*0.0316	*** more than twice of open channel discharge
= 61.31	
Cumecs	

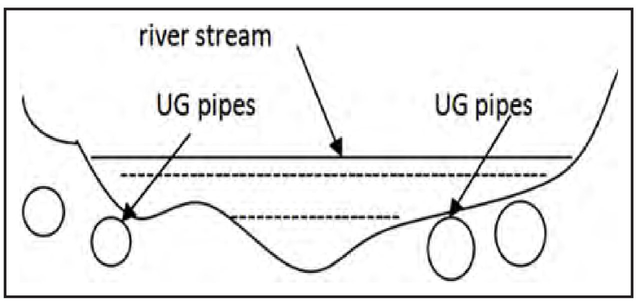

Fig. 1. Embedded Pipes in River Stream

points/ confluence points in the main river. The rivers in Bihar are causing havoc due to peak discharges coming from Nepal and spreading all over in thickly populated area of North Bihar. Laying of pipes along river stretch right up to confluence points with river Ganga can prove to be a remedy for recurring floods in Bihar. The concept may be further technically examined, experimented, and needs to be implemented thereafter.

A. Concept Involved :

Siphoning Surplus Flood Water Through Shortest Route Directly to Sea :

Safe Exits for Surplus Flood Water on Main Rivers (Ganga & Brahmaputra)

Siphon is a simple device created using a glass tube/ flexible plastic pipe with a purpose to empty out liquid in a vessel kept at higher level and pour the same in another vessel at a level much lower than level of the first vessel. To start the flow a suction force is applied at the lowest end of pipe and once liquid comes down, a continuous flow of liquid takes place till the entire liquid is transferred from first vessel to the second vessel.

A very simple example of Gravity Flow which can

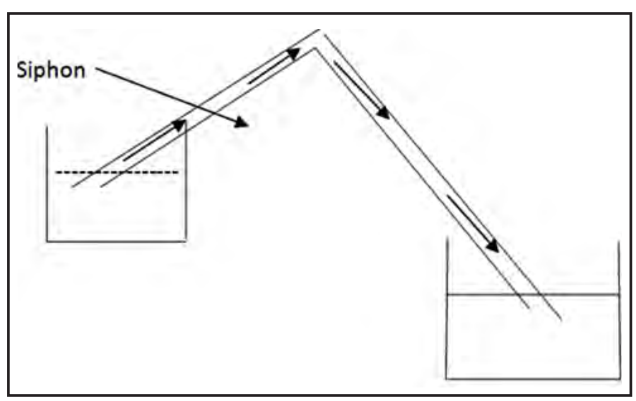

Fig. 2. Siphon Flow Under Gravity

be well explained by Bernoulli Theorem for pipe flow. This concept can be well utilized to discharge out surplus flood water from vulnerable locations on the rivers Ganga and Brahmaputra. Fig. 2 shows siphon flow under gravity.

IV. SIPHON LINK IN RIVER GANGA AND BRAHMAPUTRA

A. Siphon Link 1 (Ganga basin) - Patna to Balasore Through Jharkhand Straight

A level difference of 52 meter is available between vulnerable location Patna on river Ganga and sea level at the nearest point on sea coast, that is, Balasore which is at a distance of 350km through shortest route passing through Jharkhand and Odisha. Fig. 3 shows siphon flood exit n Ganga. Fig. 4 shows proposed locations of Siphon Flood Exits in Ganga and Brahmaputra.

The siphon pipe passes through Jharkhand, crossing the hills of Chhotanagpur at mean sea level of 350 m and thereafter, the pipe gradually lowers down upto the sea coast point near Balasore in Odisha. It is roughly assessed that a pipe size of cross section area 1.0 sq.m. can discharge out flood water at rate of 35 cu.m. per second which means that approximately 30 lacs cu.m.

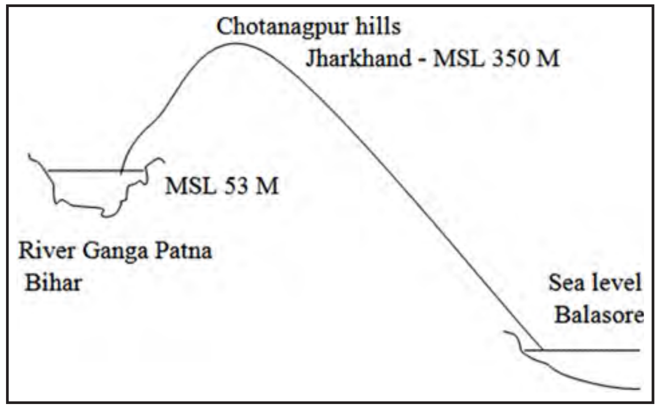

Fig. 3. Siphon Flood Exit in Ganga

per day. The pipe needs to be routed carefully to avoid sharp vertical and horizontal curves and needs to be designed to withstand water pressure atleast up to 400 to 500 kg/cm^2. The designed pipe must remain air tight and water tight throughout its length.

B. Siphon Link 2 (Brahmaputra basin) - Guwahati to Agratala Through Meghalaya

The second siphon link may be for Brahmaputra basin connecting the river Brahmaputra near Guwahati the sea coast near Agartala passing through hills in Meghalaya with straight alignment and shortest distance. This siphon

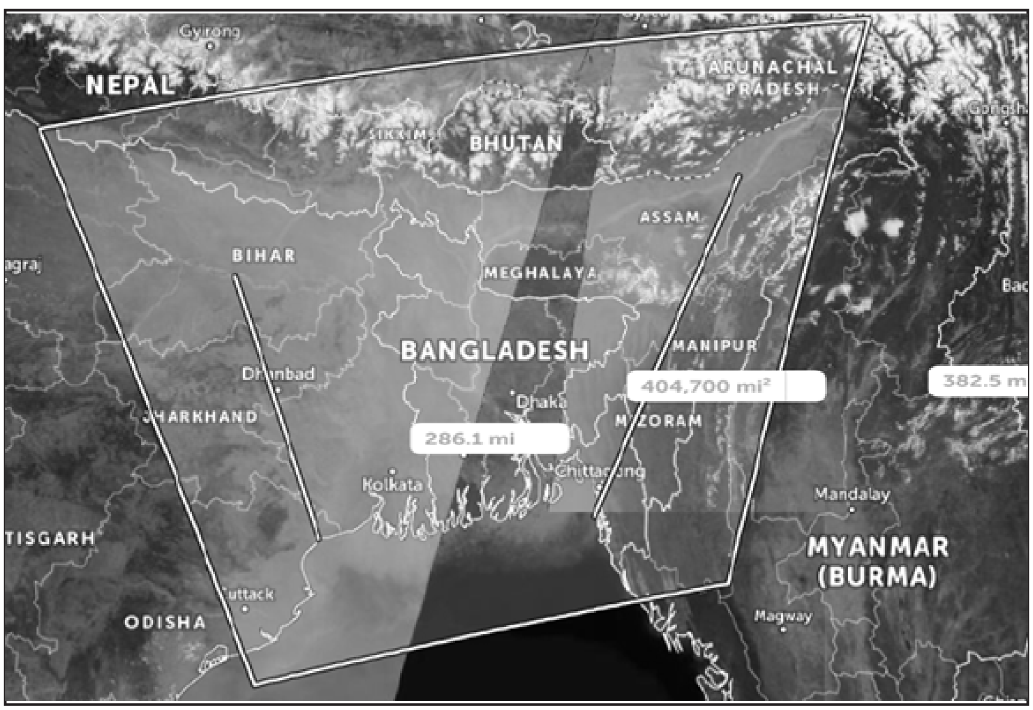

Fig. 4. Proposed Locations of Siphon Flood Exits in Ganga and Brahmaputra

will be able to moderate the peak floods in Brahmaputra basin which normally occurs every year during mid July to August. If operated accurately based on rainfall data received from catchment zones, this link may be able to prevent the peak floods and reduce duration of floods.

V. WATER LOGGING ISSUE IN CITIES DURING MONSOON AND LIKELY SOLUTION

Almost every year it is found that all the major cities and metropolis are getting completely paralyzed because of incidences of water logging after even normal rainfall. All expenditure in upgrading drainage and incurred annual maintenance efforts were found insufficient. The reason is simple as with passage of time cities have witnessed drastic growth and have converted into concrete jungles. The water bodies are filled up and converted into built up area. Cities are lacking in green area.

The concept of rain water harvesting is not effectively implemented by greedy builders. Thus, rain water even after moderate rains just gets accumulated in streets and roads, remains stagnated for long durations till it gradually gets drained out through drainage system. For getting rid off this universal problem, a change in the very concept is required.

Rather than making an attempt at channelizing the runoff to drains and flow under gravity to the nearest water body or *'nallah'*, planners should resort to creating series of local underground reservoirs to quickly store the runoff and thereafter resort to pressure pumping of stored runoff to water bodies and utility points.

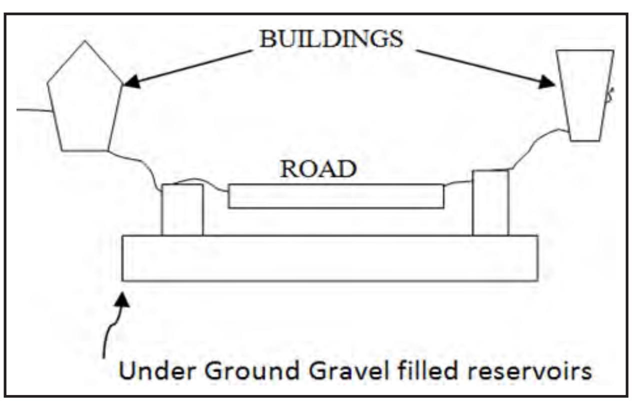

Fig. 5. Providing Gravel/sand Filled Underground Reservoirs

The underground (UG) reservoirs can be located deep upto 15 to 30 m so that surface structures are not affected. The cavities so created need to be well filled with gravel and coarse sand so that the foundation of adjoining structures does not have any adverse effect like earth sinking/collapse.The runoff is channelized to these UG reservoirs through surface drains. It is desirable to locate the gravel/sand filled reservoirs in low level grounds in city so that water flow automatically takes place and water percolates into reservoirs easily and quickly.

Fig. 5 represents providing gravel/sand filled underground reservoirs. The underground reservoirs need to be connected by adequate number of vertical or inclined shafts to trap runoff to avoid accumulations in city streets. Further, these reservoirs are required to be emptied out on regular intervals through non clog submersible pumps placed in porous chambers constructed inside UG reservoirs in adequate numbers. This is necessary to keep these reservoirs always ready to absorb runoff accumulations during monsoon. The pumped water can be routed to nearby natural water bodies or utility points for utilization in gardens, domestic areas etc. as per plan and requirements. The location and size of such reservoirs need to be decided after a careful survey of city area, the contour plan, and peak precipitations expected in an area.

REFERENCES

[1] K.Subramanya, *Eng.Hydrology,* 1994. Tata McGraw-Hill Edu.

[2] "National Register of Large Dams," *Central Water Commission,* Government of India, 2016.

[3] "Kerala: Floods 'man-made disaster," *Deccan Chronicle,* April 4, 2019. [Online]. Available: https://www.deccanchronicle.com/nation/current-affairs/040419/kerala-floods-man-made-disaster.html

About the Author

Mahesh Prasad completed B.E. (Civil Engineering), M.E. (Civil Engineering) (1993), and M.B.A. He started his career as Assistant Professor (Civil Engineering), Department of Technical Education in Bihar. He got associated with erstwhile Central Water and Power Commission, Flood Forecasting Division at Patna in 1975 when Patna City witnessed a historical flood due to peak flows in river Sone and river Ganga. He worked to develop an empirical formula to forecast water levels in river Burhi Gandak, Bihar based on the rainfall data in the catchment area of this river which proved to be quite effective. He served in Military Engineer Service, Ministry of Defence from 1976 to 2010 and retired from the post of Chief Engineer in 2010. Thereafter, he remained associated with an Australian Firm, SMEC International as Senior Consultant, where he got involved in prestigious projects like AIIMS at Rishikesh, Uttarakhand, ESIC Hospital at Lucknow, and Tourism Infra Projects in Sikkim in 2016. He is empanelled as National Quality Monitor with Ministry of Rural Development, National Rural Road Development Agency (NRRDA), Prime Minister Gramin Sadak Yojna (PMGSY) from 2017 to 2020.