CHALLEGES OF FLOOD CONTROL AND RIVER TRAINING IN INDIA

S.K. Mazumder,
AICTE Emeritus Fellow and Professor of Civil Engineering
Former Delhi College of Engineering (DCE/DTU)
somendrak64@gmail.com, www.profskmazumder.com

1.0 INTRODUCTION

Floods are natural phenomena. In a tropical country like India, floods are mainly due to excessive rainfall in a short period during monsoon. Other causes of floods are

- Unplanned sudden release of water from reservoirs
- Inadequate channel capacities/Meandering
- Landslides / river blockages
- Poor drainage
- Glacier outburst
- Lack of soil and water conservation

Out of a geographical area of 329 mha , flood prone area in India is about 40mha as estimated by Rastriya Bar Ayog (RBA,1976). Although, floods occur allover India, it is predominant in the north, east and north-east part of our country as shown in Fig.1.

Both urban and rural areas are susceptible to flood damage.Table-1 Illustrates the average and maximum damages that occurred in the past due to flooding. Floods are area specific and hence flood control measures vary from basin to basin. Objective of this paper is to discuss some of the structural and non-structural measures of flood control and River Training in India, highlighting river-structure interaction.

TABLE-1: Flood Damages in India (1953 -2007)

Item	Average	Maximum (Year)
Area Affected (Million Hectare)	7.51	17.50(1978)
Crop Area Affected (Million Hectare)	3.65	10.15(1988)
Population Affected (crore)	3.29	7.045(1978)
Human Lives Lost (Nos.)	1601	11,316(1977)
Cattle Lost (Nos.)	92,828	6,18,248(1979)
Houses Damaged (Nos.)	12,17,461	35,07,542(1978)
Value of damage to crops (crore)	713.25	4246.62(2000)
Value of damage to house (crore)	279.86	1307.89(1995)
Value of damage to public utilities (crore)	825.45	5604.46(2001)
Value of damage to crops, houses & public utilities (crore)	1818.56	8864.54(2000)

Fig.1 Flood Prone Areas in India (CWC, 2007)

2.0 Flood Control in Urban Areas

Most of the metropolitan cities in India e.g. Delhi, Kolkata, Mumbai, Chennai are facing acute problem of communication due to water-logging during rainy seasons when life comes to a standstill. Generally, the cities are built by the side of rivers which are in spate during monsoon. Urbanization leads to higher run-off as most of the open spaces are being covered and the existing water bodies are being filled in to meet the increasing need for human habitations, roads, industries etc. Majority of the people, migrating to cities and encroaching on flood plains for their livelihood, are poor and most affected by the floods.

Safe disposal of storm water without causing water-logging and flooding should be given priority in any urban development program. People curse God when floods damage localities in the pre-development stage. Same people ask for compensation from project authorities when flood damage occurs in post-development period. Urbanization of rural areas and development of smart cities, conceived recently by the Govt. of India, will result in rise in flood peak that will adversely affect downstream floodplains. Many local government are enacting ordinances which require that the post- development flood peaks do not exceed pre-development peaks i.e. zero excess runoff for a defined storm frequency.

Peak flood commonly used in storm sewer design is defined in IRC-50 (2014), ASCE (1992), HEC: 22 (2013). Although it will ensure instant clearance of flood water, too high a design flood will need large size conduits/channels requiring high investment, Apart from cost, such large size conduits/channels will run partially full with low velocity when flow of lower magnitude will occur during low flow season or during floods lower than design peak flood in other years. (Mazumder, 2017).This will result in silting and accumulation of debris thereby increasing annual maintenance cost.

Detention and retention basins are one of the most effective means to control flood peak in urban areas. Detention basins, also called dry ponds, store run-off only during wet weather. Outlet structures are to be designed to completely evacuate the water so that the basin is dry and ready for moderation of following flood during subsequent storms. Retention basins are called wet pool since they retain a permanent water pool- space above which is used for flood routing. Size of the basin can be adjusted to generate outflow peak same as the pre-development flood peak.

Rise in flood level causes congestion of flow and sometimes backflow into the storm sewers and consequent submergence. To ensure free fall of the storm sewer, it is important to ensure that the submergence does not exceed a critical value (Mazumder and Joshi (1981), Flood peaks in post development stage as shown in Fig.2 can be reduced substantially by construction of detention/retention basins (May, 2012; Mazumder, 2017) resulting in substantial reduction of flood peak which may be brought down to pre-development peak as shown in Fig.2. Shaded area gives the volume of water to be stored in the basin. Higher the storage or larger the basin size, lower will be the flood peak. Specific design criteria for the basins vary under different local conditions. Detailed guidelines for design of the basins are given by Mays (1999) and ASCE (1992).

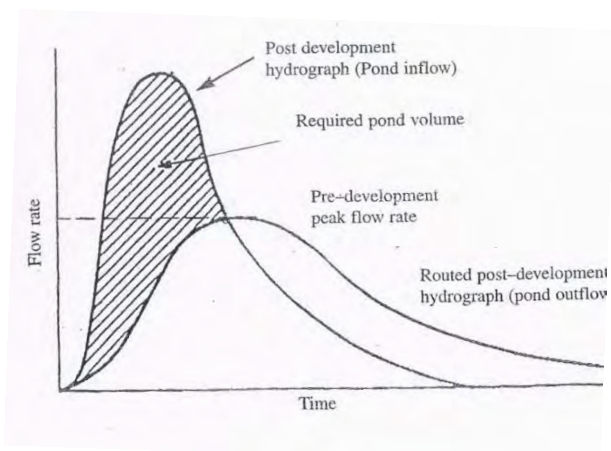


Fig.2 Routing of Inflow Flood by Storage in Detention Basin

Apart from flood control, such basins in the catchment area offers excellent water quality benefits since pollutants are removed through sedimentation, degradation and other mechanisms. Run-off temporarily stored in the basin is helpful in conservation of flood water and artificial recharge of ground water and consequent rise in water table. Retention basins help in fish culture and offer excellent recreational facilities for urban population.

3.0 Flood Control in Rural Areas

Although floods are area specific, some of the major causes of floods have been mentioned earlier. When the carrying capacity of a river reduces due to natural or man-made activities e.g. siltation, meandering, narrowing, obstructions of rivers etc., the incoming flood cannot be carried by the river at its bank full stage, resulting in rise of safe HFL. Spilling of banks and breaches in flood embankment occur when the HFL exceeds the bank full stage. Photographs-1 and 2 depict the severe floods due to breaching of flood embankments. Such wide spread floods are responsible for loss of human life, loss of cattle, damage to crops, disruption in. normal life due to lack of communications etc. Table-1 gives an estimated cost of flood damages occurring mostly in rural areas.

Photograph-1: Disastrous Flood in Malda District in West Bengal after Breach of Left Marginal Embankment Upstream of Farakka Barrage in the year 1998

Photograph-2: Devastation brought about by river Kosi due to change of its course on August 18th,2008 when breach of left flood embankment occurred about 12 km upstream of Kosi barrage

Structural measures of flood control in rural areas consist of construction of storage reservoirs in the head reach and flood diversion. Improvement of the conveying capacities of the rivers by selective dredging, construction of flood embankments, meander control, mattressing etc. are very effective methods of channel improvement and flood control (CBIP, 1989). In USA, Missisipi and Missouri river floods were successfully controlled by flood diversion and channel improvement (CWPC, 1962). In India, large numbers of multipurpose storage reservoirs e.g. Bhakra, Nagarjunsagar, Hirakud, Tehri, Maithon, Panchet, Sardar Sarovar etc. have been built for flood control, irrigation, hydro-power and other purposes. Of late,however, there is stiff opposition against construction of such storage reservoirs by the environmental lobby.

Nonstructural measures of flood control include water and soil conservation, sediment control, recharging underground aquifers etc. Since floods are generated by rainfall excess, rain water harvesting in their respective catchments is a highly effective method of flood control. Construction of check dams, flow diversion to ponds and lakes, plantations, timely preparation of cultivated lands etc. are extremely useful low cost measures of water and soil conservation leading to reduction of flood and silting of rivers/channels/reservoirs.

4.0 River-Structure Interaction/River Training

A large numbers of hydraulic structures e.g. Bridges, barrages, aqueducts, siphons, intakes etc. are constructed on rivers for human benefit. Proper planning and design of these structures has great bearing on floods and future river behavior (Mazumder, 2010). Inadequate waterway results in high afflux and flooding upstream (Mazumder, et al 2003). Normal and natural process of river meandering is affected by these structures. Sometimes the river becomes unstable attacking one bank or the other causing deep erosion on one side and sedimentation on the other. There may be outflanking of the structure (Fig.3 and photo-1). Fig.4 illustrates the anabranching of river Mahananda upstream of a bridge on NH-31 resulting in severe erosion on both banks upstream**.** Photo-2 shows the embayment of the river on right bank with possibility of outflanking of the bridge.Fig.5 illustrates severe meandering of river Bagmati both u/s and d/s of the bridge on NH-57 which is likely to be washed out. Fig.6 depicts the change in Ganga river course upstream of Farakka Barrage. Needless to mention that very costly measures are to be adopted for training the river for safety of the structures so that they continue to serve their intended purpose (Mazumder, S.K., 2001)

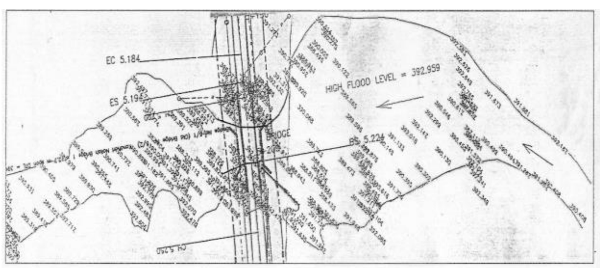


Fig.3 Formation of a Bowl upstream and downstream of a Bridge in a State Highway in M.P. The Bridge is likely to be outflanked

Photograph-1: Outflanking of a vented causeway due to restriction of waterway on the stream'Danab Khola' in Nepal .

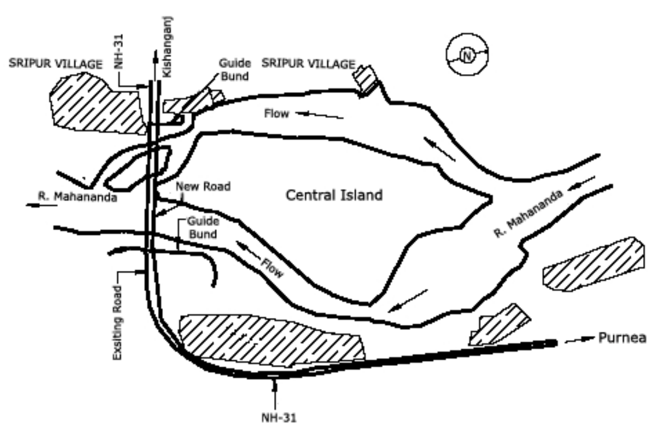
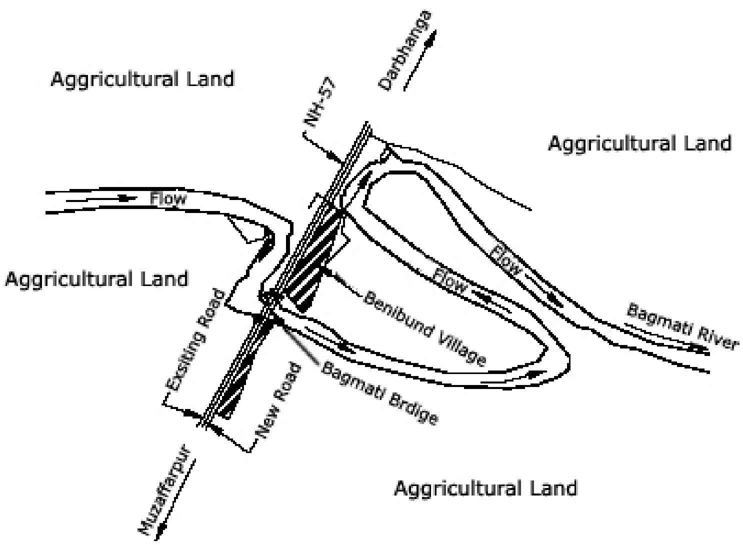


Fig.4 Anabranching of River Mahananda upstream of Bridge on NH-31

Photograph-2: Embayment of Right Bank U/S of Mahananda Bridge on NH-31



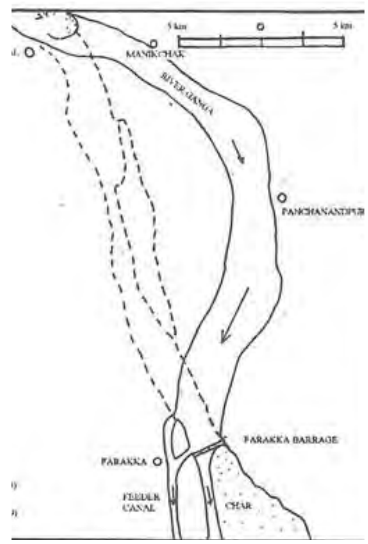


Fig.5 Plan view of River Bagmati showing Sharp Bends u/s and d/s of Bridge on NH-57

Fig.6 Shifting of main Course of Ganga Upstream of Farakka barrage

CONCLUSIONS

Flood control and river training are costly measures. Proper investigation and planning are to be done since the problems are area specific. Some of the structural and non-structural measures of flood control in urban and rural areas have been discussed. Hydraulic structures built on rivers have to be carefully planned both for river improvement as well as safety of the river structures. Few typical cases of river-structure interaction have been illustrated with figures and photographs.

REFERENCES

ASCE(1992), “Design Manual for Storm Drainage”, American Soc. Of Civil Engineers, New York,USA

CBIP,1989) “River Behavior, Management and Training”,Central Board of Irrigation and Power, Malcha Marg, Chanakyapuri, New Delhi 7

CWC(2007) “Seminar Lecture by Sh.G.S.Poorva”, at Central Water Commission, Govt. of India

CWPC (1962) “Flood Control Procedures and Practices in the United States”, pub. by Central Water & Power Commission, Govt. of India

HEC:22(2013) “URBAN DRAINAGE DESIGN MANUAL” Hydraulic Engineering Circular No. 22, Third Edition Publication No. FHWA-NHI-10-009, September 2009 (Revised August 2013)

IRC-50 (2014) “Guidelines on Urban Drainage”-First Ed. Pub. By Indian Roads congress, R.K.Puram, New delhi

Mays, Lary W.(2012) “Ground and Surface water Hydrology”, Chapter-11: Hydrologic Design and Floodplain Analysis”,John Willey & Sons,Inc.

Mays (1999) “Hydraulic Structures Design and Construction Hand Book”, Chapter-14, ‘Hydraulic Design of Urban Drainage Systems’ by Ben Chie Yen & A.Osman Khan, pub.McGraw Hill

Mazumder, S.K. (2017) “Role Of Detention and Retention Storage in Controlling Urban Flooding”, paper presented in the All India Seminar on Urban Flood Management: Challenges and Strategies in India held on June 16-17, 2017, organized by The Institution of Engineers (India), Delhi State Center, jointly with Institution of Public Health Engineers, India (IPHE) and Indian Water Resources Society (IWRS), Roorkee at Engineers Bhawan, New Delhi

Mazumder, S.K. (2010) “Behavior and Training of River near Bridges and Barrages-Some case Study”- Paper presented and pub. in the “Int. Conf on River Management-IWRM-2010” Org. by IWRS and WRDM, IIT,Roorkee and held at New Delhi, Dec.14-16

Mazumder, S.K. and Dhiman, Rajni (2003) “Computation of Afflux in Bridges with particular reference to a National Highway” Proc. HYDRO-2003, Pune (CWPRS), Dec 26-27.

Mazumder, S.K.(2001a) “Training of River Ganga Near Farakka Barrage: Proc. of National conference on Hydraulics and Water Resources HYDRO –2001, organised by Indian Soc. for Hydraulics (ISH) & CWPRS, Pune, Dec. 6-7

Mazumder, S.K.,2001b “Training of River Ganga Near Farakka Barrage: Proc. of National conference on Hydraulics and Water Resources HYDRO –2001, org by Indian Soc. for Hydraulics (ISH) & CWPRS, Pune, Dec. 6-7

Mazumder, S.K. and Joshi, L.M.(1981) “Studies on Modular Limit of Critical Flow Meter” Proc of XIX Congress of IAHR held at New Delhi in 1981.

RBA (1976) “Rashtriya Barh Ayog”, A Govt. of India Publication

US Army Corps of Engineers (1989), Riprap Protection, U.S. Army Engineer Manual 1110-21601 Ch.14