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FLOOD CONTROL TECHNIQUES FOR EFFECTIVE ALLUVIAL RIVER MANAGEMENT

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1.INTRODUCTION:

Water management in a river basin is a timewise redistribution of discharge having basically two main objectives,viz, An increase in the lowest discharge and a decrease in the highest discharge.While an increase in the lowest discharge is required for irrigation, hydropower and navigation purposes, a decrease in the highest discharge is required for flood control and efficient floodplain drainage.The presence of dense ancient as well as present day populations in the prospective domains of riverian areas clearly suggests that flood plains are often fertile flat surfaces having reasonable depth of ground water table.It is now almost universally known that river training essentially means to make the river flow through a predetermined path such as at barrages,bridges and dams etc. and in the open river reach only along big towns and other strategically important areas. For other river reaches from control point to control point, river should not be trained at all, due to the obvious known reasons, and instead should be allowed to follow its own path without any disturbance to adopt its meandering regime within the meandering belt. The meandering alluvial river is said to be in its meandering regime when while flowing in swaying sinusoidal path it simultaneously erodes the land within stable meandering belt while giving an equal surrender of reclaimed land. During floods,the flood water should be retained within flood retaining embankments rather than training it with spur dykes which disturbs the meandering river regime beyond its meandering belt which erodes the fertile lands elsewhere and thus widening the meandering loops beyond scales. Saving lands of those "who matter " results in serious and frequent damages to the poor elsewhere.

2. EVOLUTION OF FLOOD PLAIN DEVELOPMENT

In the areas of regular annual flooding, people used to dwell on high banks or mounds.During floods live-stock were removed and only one harvest was taken during non flooding period as flooding fertilized the lands during the vacant period.In order to make second harvest possible, the embankments/levees were erected which were gradually heightened. This prevented inundation and people started building houses,towns and industrial establishments resulting in higher economic risks thus making it necessary to undertake planned scientific investigation into flood control measures.

The knowledge of character and hydraulics of flood waves, fluvial geomorphology,the probability of occurrence of flood waves of different heights,the meandering pattern of alluvial rivers, the sedimentation, its transport and the hydrology of catchment are essentially required in addition to roughness values, general geometry, sediment sampling, area flooded and river bed forms etc. to effectively tackle the flood control problem requiring an in-depth analysis of previous historic data available. Evaluation of social and economic consequences of floods with different return periods to undertake *risk analysis* is another important factor towards determining flood control strategies. The design flood depends upon weighing of minimum possible cost against the maximum benefits to be achieved with an accepted predetermined degree of risk.It must be remembered that the *cost* includes initial cost of construction and O&M cost over the period of service life of the project.

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3. FLOOD CONTROL METHODS

3.1 PURPOSE.

Flood control is generally required for the following purposes.

a) For a single location across the river at control points including all types of important hydraulic structures locations etc.

b) For protection of particular infra-structure like big towns, canal system, roads and other installations at strategic locations.

c) Flood control in the flood plain to prevent erosion of *precious agricultural lands *.

3.2 METHODS.

The flood control methods are broadly categorized as below.

a) By flood retaining embankments or levees.

b) By storage of flood water.

c) By diversion of flood water.

d) By improving discharging capacity of river reach.

e) By construction of spur dykes.

The selection of any one method or a combination thereof depends upon the purpose for which flood control is necessitated and the degree of control required. The recurrent damages and O&M cost should essentially be the minimum for economically viable solution of the problem.

A. FLOOD CONTROL BY FLOOD RETAINING EMBANKMENTS

This is an old method practiced for the protection of man and his property against floods in riverian areas. It is still the most expedient method of flood control specially when the meandering river regime is undisturbed and stable. The most significant drawbacks are reduction in storage capacity of flood plain and increase in heights of flood waves. The safety requirements in the area to be protected is proportional to the specified return period which ,of course, depends on economic considerations since it determines the design of flood retaining embankment.

A.1 ALIGNMENT OF FLOOD RETAINING EMBANKMENTS

Because of the meandering action of the alluvial rivers in alluvium, the flood retaining embankments should be placed nearly parallel to the meandering axis of the river at a fair distance from the meandering belt and it should be such as to minimize the danger of active parallel flow along the embankments in order to avoid the erosion by migrating channels. The alignment also depends on general topography, infrastructures of canal and road networks, concentration of population and the bearing capacity of the soil etc.

A.2 HEIGHT OF FLOOD RETAINING EMBANKMENTS

It is primarily determined by the accepted probability of exceedance based on economic analysis and the required degree of protection which eventually fixes the *Design flood*. The additional protection necessitated by adopting a smaller probability of exceedance may give relatively large increase in the incremental cost because of the extent of the levees system.The height of embankment is determined considering design discharge, flood heights, wind action, wave uprush, subsidence of the embankments in the wet soils, subsoil water level after construction, sedimentation pattern and finally the degree of protection required.

A.3 ATTENUATION OF FLOOD WAVE WITH FLOOD RETAINING EMBANKMENT

Wider the flood plain better the influence on attenuation of flood waves because of the larger storage capacity of flood water which is further improved due to the differential discharging capacity of the main river channels and of that of flood plain. If the flood plain does not offer any resistance to flow (Generally this assumption is not correct), then it is assumed that same water level exists in the river and the flood plain as shown in the fig. 1a and b. In this case the storage capacity is proportional to both the vetted perimeter of flood plain and velocity of rise of river level ($\delta h / \delta d$). This type of storage is called uniform storage.But in actual practice when the river is in spate and overtops its banks,water starts flowing into the flood plain. Because of the shallow water depths and possibly the presence of bushes, sarkandas, vegetations, plantations,small field divides and other objects presenting additional resistance, the flow is retarded resulting in a difference of water level between river bed and the flood plain. This

increase in storage is called nonuniform storage. With rise in discharge the resistance decreases and at the crest of flood wave the levels are often nearly equal.

B.FLOOD CONTROL BY STORAGE OF FLOOD WATER

This is the most direct method of flood control. The peak of the flood wave is attenuated by detention of flood water in a reservoir in the upstream part of the catchment.This stored water can subsequently be utilized for power generation,irrigation and other industrial and domestic water usage's. In fact this is one of the best methods of water conservation for arid/semiarid land development with efficient water management which is a typical case of this country.There are two types of reservoirs i.e. controlled reservoirs like Tarbela and Mangla dams and uncontrolled reservoirs like detention basins being constructed to harness hill torrents.The detention reservoirs are basically the flood control structures. It is provided with a spill way and as long as it is not overtopped, the flood volume is stored resulting in attenuation of flood wave as shown in figs 2a and b before which Figs 1a and b show non uniform storage in flood plain while Fig 3 shows the barrages of Pakistan.These reservoirs con successfully be used on [illegible] tributaries of river Indus and Jhchlum on feasible sites and can be helpful in providing drinking water and [illegible] facilities in one of the most terrains.There can also be unfavorable effects of detention basins when [illegible] successive tributary floods can give a larger maximum discharge in the main river than in the original [illegible] such a situation warrants a controlled reservoirs lower down on the main river.These reservoirs are usually [illegible] purpose and are programmed for flood control,power generation and release of irrigation water as per [illegible] The Mangla dam when operated professionally can eliminate occurrence of floods almost completely in the river Jhelum. [illegible] failure of its correct operation and regulation can yield catastrophic floods as it happened in 1992 which resulted in a colossal loss of life and property. This is one of the terrific example of inducing flood by reservoir rather than controlling it.But the fact remains that reservoir storage is one of the best methods of flood control if it is done expediently.

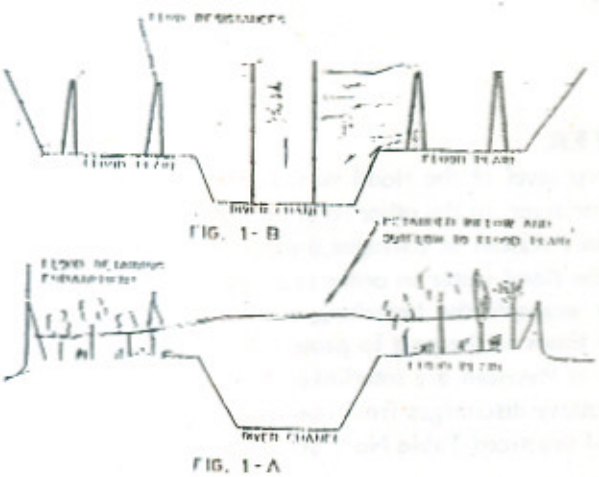


FIG. 1-B

FIG. 1-A

Non-Uniform Storage in Flood Plain

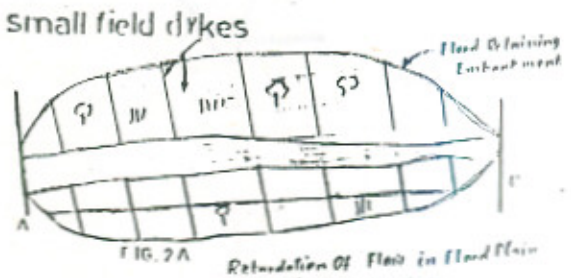


FIG. 2A

Retardation Of Flow in Flood Plain

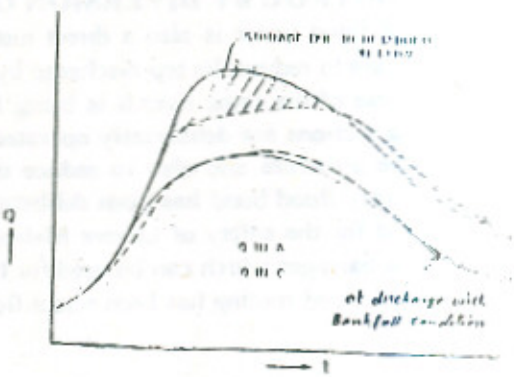


FIG. 2B

Attenuation Of Flood Wave

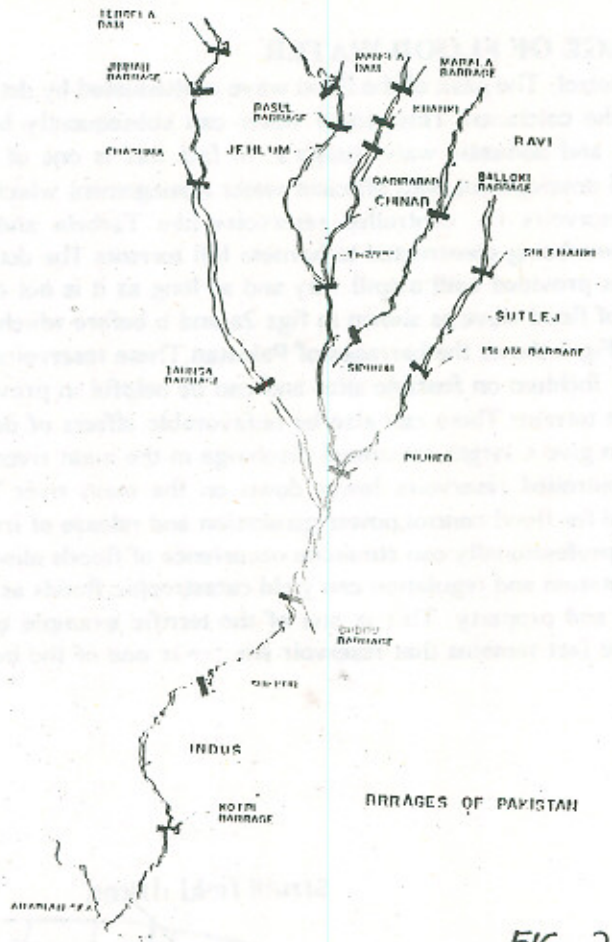


FIG. 3

C.FLOOD CONTROL BY DIVERSION OF FLOOD WATER

The diversion of flood water is also a direct method to lower the top level of the flood waves. Sometimes it is technically possible to reduce the top discharge by diverting it from one river to the other river or from one course to the other course of the same river.It is being frequently applied in Pakistan at barrages,bridges and big cities where breaching sections are deliberately operated to divert part of the flood water in order to reduce intensity of flow through the structure and also to reduce the flood height.For example the breaching section provided in shahdara distributry flood bund has been deliberately operated many times in the past to protect Mahmood Booti Bund constructed for the safety of Lahore Metropolis.All the rivers in Pakistan are interlinked by means of link canals at various barrages which can be used for the diversion of excessive discharges from one river system to the other provided the flood routing has been scientifically worked out and practiced.Table No 1 below gives details of rivers.

Table No.1 DETAILS OF MAJOR CHARACTERISTICS OF RIVERS

River	Length Km	Catchment Area (Sq.Km)	Number Of Dams / Barrages		Peak Year	Flood Discharge Cusecs x 1000
Indus upto Guddu	2400	960000	1	3	1992	1087
Chenab	1240	66760	0	5	1957	1100
Jhelum	820	62720	1	1	1929	1100
Ravi	890	39680	0	2	1955	680
Sutlej	1540	120600	0	2	1955	597

D.FLOOD CONTROL BY INCREASING DISCHARGING CAPACITY OF RIVER REACH

The levels of the flood can be lowered if discharging capacity of river reach is increased. This can be done by reducing the roughness of the river bed and/or flood plain, enlarging the vetted perimeter and shortening the river channel which results in steepeninig of slopes.The roughness of the low water bed depends mainly on the bed forms which are determined by the sediment transport and deposit and can hardly be influenced by man in an economically viable method.Partial improvements can however be made by clearing the banks and flood plains from vegetations,plantation and other obstacles.Enlarging the conveying cross-section of the river is achieved by dredging and widening the river channel/flood plains. It is , however, very costly affair and is of recurrent nature because of the heavy sediment carrying capacity of alluvial rivers.The flood plain can be widened by providing flood retaining embankments farther apart.Shortening of river channel is one of the most expedient and successful method for

increasing the discharging capacity of the river reach. This can be achieved by short- cutting meandering bends and loops of the river by providing mandatory cunnets. This should be done very carefully and at appropriate alignment with proper hydraulic levels so that it could subsequently develop itself into main river. This process should be done within stable meandering belt of the river reach.This results in steeping of the bed slope of the river which increases the sediment carrying capacity and the lowering of the water height. It can be applied generally to redress the localized problem of erosion in combination with flood retaining embankments and the spur dykes.

E.FLOOD CONTROL BY SPUR DYKES

The spurs are one of the most favorite of river training structures in Pakistan.Spur dyke is an embankment provided perpendicular or at angle to the river axis in order to divert and guide the flow towards the predetermined path. It is very successfully applied at the cross structures such as barrages,bridgesetc. where the entire river is guided to abandon its meandering and is forced to pass through the waterway provided. These structures are also used to keep the river at safe and respectable distance from big cities and other infrastructures of strategic importance.Untill very recently the spurs are being constructed extensively under floods protection sector project in open river reaches to save the agricultural lands and abadis. This is a misuse of the structures since it disturbs the meandering regime of river from one corneal point to the other and resets in extended looping and embayments for which another spur is proposed at a later stage.The river regime is thus subjected to continuos disturbance and instability.This vicious circle goes on and the purpose of flood control is never achived.If the spur dykes are at all to be employed then full scale physical model studies should be carried out for the entire reach of river and all the problems of erosion etc. marked on it.The spurs at various locations should be determined from these model studies on both sides of the river and no cross structure be provided arbitrarily based on the visual inspection of even the experts.

4. SOME SUGGESTIONS

1. The surplus flood water should be used for groundwater storage/ recharge in the areas where irrigable land is available and drinking water is scarce e.g. in Cholistan, Thar and Thal deserts.
2. The storage reservoirs are not of permanent nature and are subjected to siltation. Therefore all suitable storage sites on major rivers and their tributaries should be investigated in a phased programme should be chalked out to achieve their timely construction. This will solve problems of flood devastation besides providing additional water for lands when required and of course for cheapest power generation.
3. Regulation of reservoirs and link canals should be done in a scientific manner using latest techniques of flood routing in order to avoid waste of precious water into the sea. At present about 40 MAF of water is going in waste down the sea after bringing catastrophe in form of floods all along the rivers of the country.

4. The precipitation record in the catchment areas and the gaging records of the rivers and tributaries are unreliable and sometimes forged. A single gage painted at the pier of a bridge at Jassar and Shahdara can never give a representative discharge at these points of river Ravi. The discharge measurement should actually be done on all discharge measuring sites in a befitting manner so as to make the data available as a basis for river and canal regulation

5. CONCLUSIONS.

1. The spur dykes should be avoided as far as possible to train the open river reaches.It should be restricted at the u/s and the d/s of the control points.
2. The flood control in the open river reach should be achieved by providing flood retaining embankments in combination with short-circuiting the river bends within the stable meandering belt.
3. The river should be allowed to develop its stable meandering belt from control point to control point by avoiding outside interference.
4.The agricultural lands within the floodplain, to whomsoever they belong, should be left at the discretion of undisturbed meandering river to erode or reclaim since they are nearly equal in stable river regime.
5.The diversion of peak discharges should be done in a scientific manner in order to achieve better water resource management besides attenuation of river floods.

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