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STRUCTURAL FLOOD DEFENCE MEASURES AND EFFECTS ON THE SURROUNDINGS

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Abstract:-
Floods are one of the major natural disasters that threaten many human lives and causes significant economic losses globally every year. The aftermath of flood on society depends on the affected country's economic strength prior to the disaster. The larger the disaster and the smaller the economy, the more significant is the effect. This is clearest seen in developing countries, where weak economies become even weaker afterwards. The research work emphasizes structural Engineering work as measures for flood defence, which include: Levees, Storm sewer system, Storm surge protection works, Spillways, Dyke, Renaturalization and Dams. The influences and drawbacks of these measures were discussed and the enormous advantages of Dam which is the major defence measures analyzed.

Keywords:-*Dam, Developing countries, Economic losses, Effects of flood, structural Flood defence.*

INTRODUCTION

Floods are one of the frequently occurring natural disasters that threaten human lives and cause significant economic losses and social disruptions around the world. The history of mankind is filled with the stories of struggles with floods to protect humans and to sustain the progression of human civilizations. Despite the centuries of experiences accumulated and tremendous amount of progress made on flood defense, floods still appear to be "public enemy Number 1" in the category of natural disaster. Berz (2000) compares flood disasters with earthquakes, storms, and other forms of nature disasters in the world. Berz's study indicates that floods contribute to 58 percent of total deaths and 33 percent of economic losses. A great majority of the flood-related death toll and economic losses occurred in developing countries.

Decisions for a flood defence system are multi-dimensional and involve a set of goals and constraints arising from political, environmental, social, economic, and engineering aspects. Engineering design often is at the final stage for finding technical means to best tackle menace of flood. Over the years, engineering design concepts have evolved as the science and technology for dealing with flood issues progress and improve. Reliability analysis methods have been applied to design hydraulic structures with or without considering risk costs. Risk costs associated with a flood defence system are those cost items incurred due to the unexpected failure of the system, and they can be broadly classified into tangible and intangible costs. Tangible costs are those measurable in terms of monetary units, which include damage to properties and structures, loss in business, cost of repair, etc. On the other hand, intangible costs are not measurable by monetary unit such as psychological trauma, loss of lives, social unrest, and damage to environment, just to name a few. Without considering risk costs, reliability has been explicitly accounted for in the design of various flood defense systems, such as storm sewer systems (Yen and Ang, 1971; Yen et al., 1976; Yen and Jun, 1984), levees (Tung and Mays, 1981), dams and spillways (Tang and Yen, 1993), storm surge protection works (Vrijling, 1993; Vanoorschot and Preuijssers, 1995).

Levee: An embankment that is built in order to prevent a river from overflowing. Spillways: A channel that carries water over or around a dam or other obstruction. Storm sewer system: A waste pipe that carries sewage or surface water. Storm surge protector: A vertical construction like a dyke to prevent sudden forceful flow of flood from causing hazard. Dams: A barrier constructed to contain the flow of water for irrigation, human drinking, generation of hydropower and reducing flood hazards.

The populations in hazardous areas and the vulnerability of human settlements have grown dramatically over the past fifty years. The growth of disaster losses is to a large part due to human decisions and human investments (Benson and Clay, 2004; Freeman, 2000). Nigeria is not an exception in flood menace. The worst fluvial flood in Nigeria was the Kaduna flood disaster of 2006 which affected hundreds of thousands of human lives with economic loss worth millions of US dollars (Adebayo et al, 2013; Obeta 2009). On August,9th 2016 NEMA, Zonal Coordinator in charge of North-West, Musa Abdullahi Ilallah, disclosed that about eight local government areas in Kaduna State were affected by flood. The agency alerted the State government asking the affected communities to evacuate from the river banks to reduce casualties in the flood scene. Again, within a week of early warming No fewer than 300 houses in some parts of Kaduna State, North-west Nigeria, have been submerged by flood, as a result of a heavy rainfall. Following the Incident, more than 10, 000 people have been forced out of their homes (NEMA 2016). Flood kills 12 in Kaduna, houses submerged and thousands of inhabitants rendered homeless(Vanguard 2015).On September,25th 2015 another flood monster occurred in Kaduna leaving a lot of affected people in tears as a result of the colossal loss of lives and properties (Daily Trust 2015)
The objectives of the study are:
(1) To examine structural flood defence
(2) To examine the effects and drawbacks of the structural measures
(3) To analyze the advantages inherent in Dams as major defence measure

METHODOLOGY

A search process to identify the body of literature relevant to flooding and structural defence measures towards curbing its menace was undertaken. The study adopted the secondary source of data collection by exploring previous works on the subject matter using internet, journals and books.

Structural defence

In general, systems of water flow, cycling, and containment are mass-balanced; that is, water flowing into each part of the system is balanced by water flowing out of that part. In the hydrological cycle as a whole, evaporation is balanced by precipitation. Structural defence strategies are either traditional measures, such as levees or dams, or wider Eco systematic measures, such as renaturalisation.

Traditional measures

Common structural measures include hydraulic structures, which can be used to divert, restrict, stop, or otherwise manage the natural flow of water. The use of structural mitigation measures is principally concerned with reducing risk as a result of disasters. A structural measure can, for instance, be a levee, a dam, a reservoir, or a measure improving infiltration of rainfall into the soil. Some measures involve building structures to retain or redirect runoff. Hydraulic structures change the balanced water system, which in some cases can increase the amount of water in the river since runoff is reduced by the measure leading to a higher risk of flooding downstream. If structural measures are considered by the decision-maker, it is important to conduct an in-depth study. Side-effects from the measures should not be neglected. For example, land protected by structural measures can be reclaimed and cultivated, and this helps in reducing casualties. Furthermore, ecological aspects of diverting and restricting a river are important. The yearly cost of maintaining the measures are dependent on construction choices such as height and material; the cost compared to reduced loss estimations should be included in the evaluation.

Renaturalisation

In flood risk contexts, risk is often understood as a product of low probability of failure and high cost of consequences. The concept of risk can be illustrated in the context of structural flood defenses such as dykes (Zbigniew et al., 2001). Dykes may provide good protection against more frequent small to medium floods. Yet, if a dyke breaks, this defence may not act as a protection but rather as an amplifier of destruction. Flood losses without a dyke could be lower (cf. Jones, 1999). One of the major goals of a future-orientated water policy could be to give priority to the protection of water, e.g., the conservation of flowing waters and wetlands. Dams are now viewed more critically; they could devastate river ecosystems and undermine the rights and livelihoods of affected communities. Increased international recognition of the high environmental and social costs of dams, along with numerous river restoration successes, are inspiring dam removal campaigns world-wide (Hansson and Ekenberg, 2002). Renaturalisation improves the porosity and absorption of water into the soil, provided that the existing groundwater level allows for it. An investigation into this matter should be performed if renaturalisation is considered. Renaturalisation and re-wetting of formerly drained areas can only be efficiently achieved using detailed knowledge of the occurring organic and mineral soil substrates, the terrain characteristics, and the available surface and groundwater resources. However, since the necessary field measurements are costly and time consuming, this is a difficult task for most developing countries. Projects such as the renaturalisation of brooks, the creation and restoration of meanders, the restoration of vegetation, and afforestation, aiming at retaining an optimal amount of water, are key issues in reducing peak discharge. For example, in order to renaturalise and afforest an area, land might have to be expropriated by the government. However, if land has to be acquired, inhabitants in the area have to be re-located. This solution might have long-term benefits, but could be costly for the government to implement. Every cubic meter of water held back by the restoration of flood plains, the renaturalisation of water bodies, the reopening of soil, leakage and site-adapted agricultural and forest management, and by maintaining and promoting small-scale water retention structures in agriculture represents a bonus for the natural balance and reduces the menace of flooding.

Adding a cross-border perspective

A river system is usually not bound to a specific country and therefore a change in the system, for instance by renaturalisation or by the construction of a dam, in an upstream country might affect countries downstream dramatically. However, non-structural measures, such as the use of insurance, are difficult to implement in a cross border perspective. Insights are currently growing on the importance of working together over the borders regarding shared water. Probably, the best model for a single system of water management is management by river basins, i.e. by the natural geographical and hydrological units instead of according to administrative or political borders. For each river basin district, some of which will traverse national borders, a river basin management plan could be established. Furthermore, it is important to include other actors, such as the World Bank, in the cross-border co-operation between developing countries in order to facilitate future investments. Development of legislation and formal structures could be complemented by forming a network of stakeholders at a local level. In a strategy for coping with loss this is essential; countries sharing a river must also bear the consequences together. As a first step, an international catastrophe pool could be introduced. Adding a cross-border perspective is important in order to use the water-resources in a long-term sustainable and environmentally friendly way (Hansson et al, 2008)

The Influence of Infrastructure Works on River Hydraulics and River Ecosystem

Floods are natural disasters which should be appropriately managed to reduce their hazard. A range of different measures are actually available to the water manager, yet only a selection of these measures can be practically implemented in flood protection programs. The selection of measures to be implemented is based on a set of socioeconomic and environmental criteria such as the costs/benefit ratio or the environmental impact (Hiver, 1995).Artificial storm basins are efficient in regulating the flows in rivers. The conception and/or modification of storm basin plans is, therefore, considered to be a powerful measure which could be adopted to reduce flood hazard. However, in addition to the storm basin function, artificially-created water bodies often fulfil a series of other functions such as the creation of water reservoirs for recreational and tourist purposes, the promotion of artificial recharge, the creation of additional water resources supporting the drinking water provision or hydro-electric programs.

Decision making in such a multi-functional context is often complicated because of diverging interests and objectives. Any significant modification of the storm basin plans should therefore be preceded by an impact study of the suggested modifications on all the considered functions. This not only means that the hydraulic and hydrological impacts of infrastructure works should be characterized, but also that a multiple criterion analysis should be executed, considering the multiple-functions of infrastructure works. Therefore, it is essential that the structural plans consider multiple objectives related to the different river on a river basin scale. When planning infrastructures, the risk of flooding, the investment cost, as well as the environmental and social impact are inextricably linked. The further the risk of flooding is reduced by large infrastructures, the greater the investment and the ecological impact will be.

When new infrastructures are built, it is necessary to study the impact of the infrastructure on the behavior of the river system at the local and the catchment scale. This implies taking into consideration constraints imposed by different competent administrations belonging to different regions or countries. For the construction and maintenance of the infrastructure works better cooperation between the responsible parties should be encouraged, expanded, and made operational for every river basin.

When works are scheduled, the local population is often very reserved about the new plans. Local stakeholders and population should be better informed on the objectives of the new infrastructure works by means of appropriate campaigns illustrating their anticipated positive effects.

Man-made water reservoirs on rivers are efficient infrastructures for flood protection, since they store the flooding water and thereby reduce flow rates and associated erosion risks. Different alternatives exist for implementing artificial reservoirs. Flood protection projects can consider a few large structures downstream. On the other hand, preference can also be given to the planning of numerous small structures upstream within the catchment.

Large-scale structures are often very expensive and can cause serious social and ecological disruption. The disadvantage of small-scale structures upstream is that they may have only little impact on the control of water downstream. In addition, such measures are spread over a large area which results in a poor area/volume ratio and high management costs. The choice between the structure type and optimal localization of the infrastructures should be made in terms of the protection objectives. The appropriate protection of a concentrated urban area can efficiently be achieved by a large scale storm basin upstream. The protection of distributed urbanization along small water courses, however, must necessarily be achieved by means of numerous small-scale infrastructures. If the provision of drinking water is an additional function of the basin, then the basin is best situated upstream in order to comply with the water quality requirement.

Canalization of the natural river course and raising the height of dykes may be other very efficient flood protection infrastructure works, with major impacts on flooding risk at the local level. A third alternative consists of deepening the river bed, which is particularly efficient in protecting enclosed valleys. The maintenance of existing structures is just as important as the construction of new ones. Poor maintenance can lead to considerable risks when the water rises. For example, sediment that settles in reservoirs reduces the storage capacity. Appropriate legal regulations must be established for the maintenance of the river infrastructure promoting the participation of the private owners and local stakeholders in good management practices, using management susbidies and maintenance contracts.

Dry basins are specifically intended for the management of floods, and will have a smaller environmental impact because artificial stagnant water bodies often cause eutrophication and losses of habitat for flora and fauna. In addition, there is also a research need on the sedimentological consequences of new implemented river infrastructures, during normal periods and during flood periods. The effect of artificial structures on the river ecology and the environment is difficult to quantify. Infrastructures will often dramatically disturb the natural environment. Yet, up till now, ecological objectives such as the potential of green recreation or the aspects of nature and landscape have not sufficiently been taken into account. Each river infrastructure planning project should be preceded by an ecological impact analysis.

The construction of concrete infrastructures, as well as the reprofiling of water courses, may result in a quality reduction of the landscape and in a loss of valuable biotopes. The re-profiling of watercourses should be avoided as much as possible. Wherever possible, natural banks should be created or restored. When there is great susceptibility to erosion the use of solid materials such as rocks or coarse gravel in steel nets is needed.

Environmental Impacts of Dams

The dam wall itself blocks fish migrations, which in some cases and with some species completely separate spawning habitats from rearing habitats. The dam also traps sediments, which are critical for maintaining physical processes and habitats downstream of the dam. They include the maintenance of productive deltas, barrier islands, fertile floodplains and coastal wetlands. When a river is deprived of its sediment load, it seeks to recapture it by eroding the downstream river bed and banks (which can undermine bridges and other riverbank structures, as well as riverside woodlands). Riverbeds downstream of dams are typically eroded by several meters within the decade of first closing a dam; the damage can extend for tens or even hundreds of kilometers below a dam.

Another significant and obvious impact is the transformation upstream of the dam from a freeflowing river ecosystem to an artificial slack-water reservoir habitat. Changes in temperature, chemical composition, dissolved oxygen levels and the physical properties of a reservoir are often not suitable to the aquatic plants and animals that evolved with a given river system. Indeed, reservoirs often host non-native and invasive species like snails, algae, predatory fish that further undermine the river's natural communities of plants and animals.

The alteration of a river's flow and sediment transport downstream of a dam often causes the greatest sustained environmental impacts. Life in and around a river evolves and is conditioned on the timing and quantities of river flow. Disrupted and altered water flows can be as severe as completely de-watering river reaches and the life they contain. Yet even subtle changes in the quantity and timing of water flows impact aquatic and riparian life, which can unravel the ecological web of a river system.

Riverbed deepening or "incising" will also lower groundwater tables along a river, lowering the water table accessible to plant roots and to human communities drawing water from wells. Altering the riverbed also reduces habitat for fish that spawn in river bottoms, and for invertebrates.

In aggregate, dammed rivers have also impacted processes in the broader biosphere. Most reservoirs, especially those in the tropics, are significant contributors to greenhouse gas emissions; a recent study pegged global greenhouse gas emissions from reservoirs on par with that of the aviation industry, about 4% of human-caused GHG emissions. Recent studies on the Congo River have demonstrated that the sediment and nutrient flow from the Congo drives biological processes far into the Atlantic Ocean, including serving as a carbon sink for atmospheric greenhouse gases.

Large dams have led to the disappearance of many fish and other aquatic species, the disappearance of birds in floodplains, huge losses of forest, wetland and farmland, erosion of coastal deltas, and many other unmitigable impacts.

The Effects of Dams on Riverine Ecosystems

One of the adverse effects of dams that has been poorly understood until quite recently is the impact the fragmentation of watercourses has had on riverine ecosystems. The interconnected ecologies of riparian environments are profoundly altered as the cycles and rhythms of the natural flow of rivers are interrupted. Plant and animal populations are thrown out of all balance as invasive species move into the disrupted riparian ecologies and native species are displaced, reduced and in some cases killed.

Water Temperature

The reservoirs impounded behind dams alter the temperature regimes both within the upstream reservoir and the downstream water channels as the water is released through the dam. Within the impounded water the natural thermodynamics of a free flowing river can be replaced by stratified temperature gradients, which can have profound effects upon the aquatic life both upstream and downstream of the impoundment. Many aquatic planktons, invertebrates, mollusks and fish are extremely sensitive to these thermal changes and must either adapt, relocate or die.

The Effects of Dams on Coastal and Marine Ecosystems

The construction of large dams can have adverse effects on coastal and marine environments hundreds and even thousands of kilometers downstream. The impoundment of not just the water, but also the blocking of the riverine silt and nutrient load as well, has altered the ecologies of many river deltas, estuaries, coastal wetland and marine environments.
Without the annual burden of silt from floodwaters, many delta wetlands have become subject to severe erosion, and the reduced dispersal of organic nutrients from river outflow has severely stressed many marine populations from phytoplankton up through the food chain to many fish populations. Reduced outflow has also increased the salinity of estuarine and coastal wetland ecosystems, having a severe impact on the delicate ecostructures of these environments.

The Social Effects of Dams

The building of dams can also have far-reaching and often unintended social consequences as well. It is estimated that almost a quarter of a million square kilometers of land has been inundated by the impoundment of river waters over the last one hundred years.

The World Commission on Dams estimates that 40-80 million people have been displaced by dam construction in living memory. There are also increased health risks associated with the construction of large dam and reservoir systems, especially in tropical and sub-tropical areas where the disruption of the natural drainage ecologies provides fertile ground for the growth of waterborne disease vectors.

The increased transmission of malaria has been directly linked to the construction of dam impoundment reservoirs especially in Asia and Africa. Again, toxins that can leech into impounded waters and be released downstream into the water supply used by humans for drinking.

IMPORTANCE OF DAMS

When a river is dammed, the water pools and forms a reservoir. This allows the surrounding communities to collect fresh water during periods of heavy rainfall for use during droughts and dry spells. In addition to helping farmers in irrigation, dams help prevent the loss of life and property caused by flooding. Flood control dams impound floodwaters and then either release them under control to the river below the dam or store or divert the water for other uses. For centuries, people have built dams to help control devastating floods.It also, provides a buffer to extreme or irregular weather.

The total quantum of flow and size and frequency of peak floods in the flood season reduce in the downstream due to a dam, reducing flood hazard due to inundation of land, crop and property which might result into economic upheavals. It also reduces congestion of runoff in plains and coastal lands. Dams, reservoirs, flood levees, embankments, and river training works constitute structural measures for better flood management. In the lean season, the river flow in the downstream reduces depending on withdrawals from dams through canals or pipelines, however, it can be augmented with supplies from upstream withdrawals. Reduced frequencies of floods and reduced peak flows reduce the agricultural and non-agricultural losses. On the other hand, if storage is used for generation of hydropower in the river bed, then seasonal flow is enhanced ameliorating several difficulties downstream (ICID, 2000).

Conclusions

Serious caution is required for the construction of additional new and expensive infrastructures to protect against flooding hazard. Infrastructures such as structural defence measures should be preceded by detailed impact analysis considering hydraulic and hydrological, ecological, social, and financial objectives. The local or surrounding communities should be taken along considering the adverse effects of these structural measures. A lot of lowlands have lost their water absorbing capacity as a result of the canalization of the river and the drainage of its natural floodplain. To combat the ugly trend there should be an ecological management of low lands, which covers the preservation of marshland and fens and the restoration of the natural meanders of the river. It also, consists of setting aside less productive agricultural areas in favor of fallow land and wetland. This will increase the storage capacity of the river and restore the ecosystem. Flood mitigation measures implementation are based on variety of features among which are impacts on environment and socioeconomic reasons Man made storm basins are efficient in regulating the flows in rivers. Storm basin plans are, considered to be a powerful measure which could be used to mitigate flood hazard. However, in addition to the storm basin function, manmade water bodies often fulfill a series of other functions such as the creation of water reservoirs for recreational and tourist purposes, the promotion of artificial recharge, the creation of more water resources supporting the drinking water provision or hydropower needs.

Due to the multi-functional nature of structural defence measures such as Dams, decision making is normally complex because of the different objectives and interests. Consequently, any significant modification should firstly have an impact analysis of the suggested modifications on all the considered functions. This not only means that the hydraulic and hydrological impacts of infrastructure works should be characterized, but also that a multiple criterion analysis should be executed, considering the multiple-functions of the structural defence especially Dams. For mitigating flooding risk, there is need to increase the storage of water at the upstream end of the watershed in non-urban sites, thereby decreasing river flow velocity and increasing infiltration, by appropriate river infrastructure to be applied.

Structural flood defence measures have their advantages and disadvantages as discussed in the research work. However, efficient flood measures can be achieved with the inclusion of the nonstructural measures like early warning, appropriate disaster warning and strategies, monitoring of precipitation, river and reservoir stages and flow measurements.

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