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Application of Retaining Wall in the Control of Flooding and Gully Erosion

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Abstract: *This research concerned itself with the development of an approach which can be used in the reduction of perennial problems of flooding and gully erosion. It, however, applied the retaining wall as a technological means of reducing flooding and gully erosion. In the analysis, it was established that the retaining wall possesses all the engineering characteristics and potentials that will not only check, reduce, control or eliminate flooding and gully erosion but can be applied in the reclamation of lands already devastated and rendered useless by gully erosion menace.*

Keywords: *retaining, wall, erosion, flooding, pressures.*

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I. INTRODUCTION

Flooding and gully erosion have constituted great hindrances to land development and its effective use for agricultural and infrastructural advancement. Land is a major natural resource whose value in national development cannot be overstated. Government of various nations of the world spend huge sums of money in the preservation and conservation of land which houses their natural resources like petroleum deposits, minerals, forest reserves etc. In the light of the overwhelming importance of land, global and natural efforts are intentionally geared towards its protection. However, flooding and gully erosion are inimical to land development and usage. The adverse effects of flooding and gully erosion are not limited to land usage and development but extended to the destruction of lives, properties, plants, animals and promote economic downturn. Retaining wall is an engineering structure which can be tactically applied in the reduction of flooding and gully erosion. This has become necessary since population explosion, urbanization, industrialization and other uncoordinatedhuman activities have drastically eliminated the use of such natural methods like aforestation.

FLOODING

Flooding menace has become a normal reoccurring phenomenon which has caused significant and devastating impacts on human lives and infrastructure. The causes of flood have been attributable to population explosion, deforestation, poor drainage systems, poor governance decaying infrastructure and poor/lack of planning and management strategies. Flooding which is a natural disaster can be proactively managed by putting in place appropriate engineering structures, such as drainage systems, dams, reservoirs, retaining walls etc.

Flooding occurs during the high duration rainfall when rivers overflow their banks. This has become the common pattern in Nigeria. As a common environmental hazard in Nigeria, flooding occurs when a body of water moves over and above an area of land which is not normally submerged. Flooding is a major risk to riverside populations and flood plains apart from causing enormous environmental impacts.It also affects adversely aquatic fauna, flora and banks of the river/flood plain. Due to its incessant occurrence, flooding has become a major issue of concern to Nigerians and her government. It has been observed that the poor in the society are more vulnerable as they set up their homes/houses on the floodplains and river banks. Floods have been adjudged as the most occurring, widespread, disastrous and painful hazards of the world. Action Aid (2006) categorized flooding into four namely; localized flooding (which occurs many times in a year due to blocked drains), small stream in urban areas overflowing their banks, major rivers overflowing their banks and season flooding in lowland and coastal areas. Flooding can also be classified as urban flooding, river flooding and coastal flooding.

A flood is a relatively high stage of the river which is usually accompanied by overtopping of the natural banks of the river in a particular reach. The flood occurs because of heavy rains, or melting of snow or

both when the discharge in the river is so high that its natural cross section is unable to contain it. Consequently, the river banks are submerged and the flood water spreads over the neighbouringareas. Flood control is needed to mitigate the disastrous consequences of flood. Flood control is also known as flood management.

IMPACTS OF FLOODING

Flooding has caused major loss of human lives, destruction of economic and social infrastructure, like electricity installations, water supply systems, roads, and railway lines.It has also inflicted untold hardships on the citizenry through the destruction of their business outlets and farmlands. Agricultural productivity would always be forced to zero value due to devastating effect, of flooding. Most often flooding negatively affects the aquatic animals in the rivers and streams as they are transported to environment where they cannot survive. The roads and railways are eroded massively by flooding thereby living the soils bar-and expose the areas to the development of gullies. Flooding activates and enhances the outbreaks of epidemics by carrying the disease-vectors to areas where they could not have reached on their own. According to the National Emergency Management Agency, (NEMA), it was revealed that the 2012 flooding menace which affected the coastal people of Rivers, Niger, Benue, Sokoto, Katsina, Lagos, Ondo, Bayelsa, Delta, AkwaIbom and Cross River claimed 363 lives and displaced 2, 152, 419 residents. The 2011 and 2012 flooding appear to be worst incidence of flooding in Nigeria with a lot of cases indicating how the menace ravaged many areas when water from Lagdo Dam in Cameroun was released.

GULLY EROSION

Soil erosion is a widespread global environmental problem occurring in different parts of the world under varied geologic, climatic and soil conditions. Natural erosion occurs on a geologic time scale. Generally the most dreadful type of erosion is the gully erosion. Gully erosion is described as erosion in which water accumulates in a narrow channel and dislodges substantial amount of soil from the channel over a short period of time. Gully erosion is the terminal phase of a four erosion process involving splash, sheet, rill and gully.Sidorchule (2001), defined gully erosion as a linear deep erosion feature with active head cut, unstable side walls, subject to mass soil movement and non-graded longitudinal profile, with temporal water flow. The first phase of sol erosion commences with falling of rain drops and its flow on the soil surface. The second phase splash erosion occurs when the force of rain drops on bare or sparsely vegetated soil, dislodges soil particles.Inits own phase sheet erosion occurs when the dislodged soil particles are transported easily in a thin layer of sheet by moving water. With increase in velocity the flow, it cuts rills and gullies in its dislodgement of more soil particles hence gullies are developed and this forms the fourth phase.

CAUSES OF GULLY EROSION

Gully erosion is caused principally by two factors namely; (a) factors that dispose water to high speed flow (b) soil characteristics of the area involved.

(a) Factors that dispose water to high speed flow are mostly high or steep slope, unprotected or unvegetated soil etc. It has been known that high slopes enhance the flow of water and induces kinetic energy and momentum to the water molecules. Vegetation obstructs the flow of water and therefore serves as a hindrance to water flow. Vegetation therefore reduces the velocity of flow of water and therefore reduces its velocity and momentum.

(b) Soil characteristics are factors that can encourage or discourage erosion. In rocky based area, erosion occurrence is seldom unlike in other areas where the soils are simply lumped together. It should be noted that such natural factors like tectonics and uplift, climatic factors, geotechnical properties of soil etc cause gully erosion.Generally, other causes of gully erosion include farming, and uncoordinated grazing practices, deforestation, and mining activities.

RETAINING WALLS

Retaining walls are vertically or nearly vertical structures constructed to retain earth, soil or water. Retaining walls are employed to serve such purposes as:

(i) embankments constructed to hold earth walls to prevent them from collapsing
(ii) embankments constructed to retain water and form channels for water flow
(iii) serve as bridge abutment to protect the sub-structure of a bridge from soil erosion
(iv) storage for water

Retaining walls are also structures with the support of backfill and have the capacity to withstand the lateral earth pressures. A retaining is a structure that retains or holds back any material usually earth and prevents it from sliding or being eroded. Retaining walls are designed to restrain the soil to un-natural slopes. They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or ill areas where the landscape needs to be shaped severely or engineered for specific purposes. It is

normally designed and constructed to resist the lateral pressure of the soil when there is a desired change in ground elevation that exceeds the angle of repose of the soil.

LATERAL EARTH PRESSURES

The determination of lateral earth pressures is the trump card for the design of retaining walls. The lateral earth pressures are calculated to enable the retaining wall possess the capacity to withstand this lateral earth pressures. The walls must be designed to keep them stable in their position as the lateral pressures act on the walls trying to move them away from their positions. Gravity walls are employed to resist movement occasioned by lateral pressures by taking the due advantage of its weight. The gravity walls resist movement because of its heavy sections. They are built of mass concrete. Semi-gravity walls are not as heavy as gravity walls and they are normally reinforced. The small reinforcement is used to make up for the reduction of mass of concrete. The stems of cantilever walls are thinner in section and it serves as the base slab of the entire cantilever retaining wall.

Lateral earth pressures are categorized into three namely;

(i) Lateral earth pressure at rest.
(ii) Active earth pressures
(iii) Passive earth pressures

(i) **Lateral earth pressures at rest:** This is the lateral earth pressure exerted on the wall but does not move the wall when the back filling has been done.
(ii) **Active earth pressure:** Is the pressure exerted on the wall and it has the capacity to move the wall away from the backfill. The pressure is termed as active because it is responsible for the movement of the wall. If the wall is smooth, the resultant pressure acts normal to the face of the wall. If the wall is rough, it makes an angle θ with the normal on the wall. The angle θ is called the angle of wall friction.
(iii) **Passive earth pressure:** This is the earth pressure exerted which creates a condition that the wall moves towards the backfill. The pressure is called passive because the pressure of the backfill could not oppose the movement of the wall towards it.

II. METHODOLOGY AND MATERIALS

SAMPLE COLLECTION

Soil samples of the backfill and the site where the retaining wall will be situated are collected. The soil samples for the backfill are collected from approved/designated borrow pits. The soil samples collected from the site are obtained using the auger to a depth not less than 4 meters.

SOIL LABORATORY TEST

The soil samples are subjected to laboratory tests to enable the determination of important parameters that will be used in the design. These tests resulted to the emergence of the unit weight of the soil, angle of internal friction of soil, depth of foundation, bearing capacity of the soil at the site, etc.

DESIGN CONSIDERATIONS

(i) Consider and allow a minimum surface load for the design. This is necessary because various loads may be later imposed on the retained earth or water.
(ii) Determine the depth of foundation excavation by applying the values obtained from the soil tests. The depth of foundation can be obtained by using the formular;

$Depth of foundation = \frac{Q_a}{\delta_s}\left[\frac{1-Sin\alpha}{1+Sin\alpha}\right]$ where Q_a = allowable bearing capacity of soil, δ_s = unit weight of soil, ά = angle of internal friction of soil

(iii) Consider the minimum bearing pressure on the soil which must be less than the allowable bearing capacity. The minimum bearing pressure analysis is based on service loads and not on ultimate loads. This includes the self-weight of retaining wall, weight of retained material, weight of surcharge and active lateral earth pressures.The self- weight of the retaining wall $=V_r б_c$ where V_r= volume of concrete and $б_c$ =24kN/m^3 (unit weight of concrete). The weight of retained material= $V_m б_m$where V_m = volumeof retained material and $б_m$ = unit weight of retained material. The total lateral earth pressure = 0.5 $K_a \Upsilon H^2$where K_a=coefficient of lateral earth pressure= $\frac{1-Sin\Theta}{1+Sin\theta}$, Υ= unit weight of backfill and H= depth of retaining wall.
(iv) Stability analysis should be carried out on the structure by checking for sliding and overturning. The plane of sliding is the interface between the base of the retaining wall and the foundation floor. The resistance to sliding is provided by the friction between base of retaining wall and soil of the foundation floor. The force resisting sliding = $\mu\sum F_v$, where μ = coefficient of friction between retaining wall base and foundation bottom soil, and F_v = sum of vertical forces. Therefore forces resisting sliding / forces causing sliding

>$f_s$where f_s = factor of safety.The check for overturning is to investigate and ensure that sum of moments that resist overturning is greater than sum of moments causing overturning around the toe. Sum of resisting moments about toe/sum of overturning moments about toe > 1.5

(v) The final sections of the proposed concrete retaining wall should be drawn in place of the conventional final design detailing since the proposed retaining wall is a concrete gravity retaining wall and does not contain reinforcement.

III. DISCUSSION AND ANALYSIS

The results showed that the retaining wall can be designed with great stability to resist force from flow which would aggravate the erosion condition of an area. The retaining wall designed will also minimize or stop the width increment of an existing erosion area thereby conserving much land for agricultural purposes. With the proper positioning of the retaining wall, it can serve as a protected channel for floodplain and this, inevitably will enhance the discharge of water in an environmentally-amicable manner devoid of flooding. With its stability, retaining wall can be useful in land reclamation through the use of appropriate backfills with recommended and tested backfill materials. The capacity of retaining wall in the absorption of energy and forces of water and wind which are agents of erosion growth makes it a suitable structure for erosion control.

At construction sites, retaining walls can be combined with minor sediment controland silt fences, to minimize further degradation of a gully erosion bed. In this case, it stands very helpful in sedimentation management. Retaining walls are indispensable as they address two erosion issues of prevention and the elimination of existing gully erosion.

IV. CONCLUSION AND RECOMMENDATIONS

CONCLUSION

Flooding and gully erosion are very serious consequences of environmental neglect occasioned by bad governance and carelessness exhibited by the citizenry. Flooding and gully erosion are monumental national hazards that had consumed billions of naira which would have used for economically viable projects. This underscores the importance attached to the development of possible ways of reducing or curbing these two monsters.

It has been proved beyond all doubts that concrete retaining walls can be applied in controlling gully erosion and flooding. Its importance extends to sediment control management and land reclamation. This paper addressed fully the engineering characteristics of the retaining wall and its structural suitability as a unique instrument that can be applied in reducing gully erosion and flooding.

RECOMMENDATIONS

Based on the results of the research, it is recommended that;

(i) Flood plain and river bank areas should be declared green belt zones where constructions of residential houses are outlawed.

(ii) All drainage systems and flood channels should be cleared of impediments and hindrances.

(iii) Retaining walls should be employed in reducing gully erosion and flooding and also for the purposes of land reclamation.

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