COURSE CODE: FIS509

COURSE TITLE: Fish farming Engineering

NUMBER OF UNITS: 3 Units

COURSE DURATION: Three hours per week

COURSE DETAILS:

Course Coordinator: Prof. S.O. Otubusin

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Office Location: Room D202, COLERM

Other Lecturers: Dr. W.O. Abdul and Dr. O.J. Olaoye

COURSE CONTENT:

General surveying, site selection; fresh water and brackish water pond construction. Design and construction of dykes, sluice gates, drainage facilities, tanks, ponds, pens, cages, rafts and other types of fish rearing facilities, design of inland fish farms, pumping stations and fish hatcheries. Design and maintenance of machines.

COURSE REQUIREMENTS:

This is a compulsory course for all students in Department of Aquaculture & Fisheries Management. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be eligible to write the final examination.

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READING LIST:

FOA Training Series: simple methods of Aquaculture pond construction Surface Area (m^2)

LECTURE NOTES

FISH FARMING ENGINEERING

POND CONSTRUCTION

A pond is a water enclosure or a confined body of water where fish are raised or reared under a manageable controlled condition. Pond could either be earthen or concrete. Nowadays fish are raised in plastics, fiber-stars and wooden rafts which are either locally fabricated or imported from developed countries. But here, in this course, emphases are laid only on earthen and concrete pond constructions.

TYPE OF PONDS (Earthen**)**

There are two major types, namely:

(i). Excavated pond

(ii). Embankment/ pond
Sometimes, depending on the terrain or topography of the site, there is what we called excavated- levee pond, barrage pond and contour pond.

Site selection for fish pond construction:

The failure or success of fish farm enterprise depends on the selection of a good site. The layout and the management of fish farm will largely be influenced by the kind of site selected. The site has the following influences:

(i). strongly affects the cost of construction
(ii). amount of fish that can be produced
(iii). ease of pond management
(iv). the economics of the enterprise

During the lecture the distinctions shall be made clear to students diagrammatically

Decisions prior to site selection:

a) Do i have a clear ideal of the type of fish farm I want to construct
b) Of what production level is my target?
c) What is the system of culture to be adopted?
d) Which fish species should be produced?
e) Is it necessary to produce fingerlings for the farm?
f) At what stage of fish should you start selling?

Answers to these questions will assist greatly during site selection exercise

Factors to consider when selecting site for fish farm construction

a) Water — quantity, quality, source, activities around it
b) Nature of soil — texture, permeability, retention ability, etc
c) Topography of the land
d) Environmental consideration
e) Accessibility
f) Vegetations density/cover
g) Expertise

Other important factors include:

h) Proximity and size of market
i) Poaching
j) Availability of farm inputs

Figure 1: Site selection decision-making cycle

Define kind of site needed
Can you find this site?
Reconnaissance Survey
water - soil - topography
Ca you change the site
that is needed?
Can you change what
you want to do?
Look for alternative solutions

Students are to be given practical exposure with training manual on the necessity of these aforementioned factors

Decides what you want to do

Detailed planning for fish farm construction

Once the site has been selected, then initiation of planning begins. There are two main related components of planning in construction. These include:

a) Organizational planning —decides where, how and which order the farm is to be built.
b) Physical planning — decides on layouts, detailed design and earthwork.

SITE SELECTION
RECONNAISSANCE SURVEY
Water - soil - topography
Does site meet requirement? No Return to site selection

process
Yes
DETAILED SURVEY Yes
Soil - Topography
Try out sketches of the layout
Do they meet your needs? No Is there a problem with
Yes the site?
Prepare detailed draft layout
Earthworks and water levels
satisfactory?
No
ALL ok?
Yes
Prepare final detailed design
Prepare final evaluation of the site
Figure 2: Flow - chart on matching the fish farm and its layout to the selected site
Things include:
1. Time of construction
2. who will construct the fish farm ?
3. How will the construction be carried -out?
These when critically considered, may lead to further activities such as
a) Some more detailed plan and drawings
b) A series of specifications for the contractor
c) A detailed schedule of activities will be drawn.

Steps involved in earthen ponds construction

The following steps are required:

- Clearing of proposed site
- Setting-out which involves site clearing
- Mark-out the areas inlet and outlet
- Topsoil removal and storage
- Construction of embankment
- Construction of inlet drainage pipes / water control structures
- Construction of screen at both inlet and outlet.

Steps involved in block tanks for fish farming

- Clearing of proposed site
- Settings-out which involves pegging and lining with the rope

Figure 2 is to be used in ensuring proper and appropriate appraisal of the work to be done.
Assignment: students are expected to visit any chosen location at COLERM field and carry-out fish farm site selection exercise and prepare a report

- Topsoil stripping to form strong basement
- Surface blinding with concrete mixture (sharp sand, cement , and gravel/ granite at ratio 3:1:6)
- Block laying and stuffing of holes with concrete mixture
- Placement of water inlet and outlet pipes
- Plastering of tanks

Calculating dike and excavation volumes

Width of the dike base
Base width = crest width + (CH x SD) + (CH x SW)
Where CH (in m) = construction height
SD = slope ratio of dry side
SW = slope ratio of wet side
While estimating this, use the constructing height as well as the settlement

EXERCISE:

A 0.04ha pond has to be built in clayey soil with dikes 1.50m high and 1m wide at the top. If SD =
1.5: 1 and SW = 2:1. Calculate the base width of the dike (Hint : settlement allowance of expanded clay volume is 20%).

Solution:
Design height = (100% – 20%) = 80% of constructing height
Construction height = 1.50m/0.80 = 1.88m
Dike base width = 1m + (1.88m x 1.5) + (1.88m x2) = 7.55m
Note: Design height, DH, is the height dike should have after settling down to safely provide the necessary water depth in the pond = Water depth + Free board.
Construction height, CH, is the height the dike should have when newly built and before any settlement takes place =design height + settlement height
CH = DH ÷ [(100 - SA) ÷ 100]

Calculating the cross-section of a dike on horizontal ground

For the above 0.04-ha pond to be built in clayey soil, calculate the size of the cross-section of the dike as:

- area 1 = 1 m x 1.88 m = 1.88 m^2;
- area 2 = (1.5 x 1.88 m) x (1.88 m ÷ 2) = 2.6508 m^2;
- area 3 = (2 x 1.88 m) x (1.88 m ÷ 2) = 3.5344 rn^2
- cross-section = 1.88 m^2 + 2.6508 m^2 + 3.5344 m^2 =8.0652 m^2.

Calculating the cross-section of a dike on sloping ground

The cross-section of a dike *on sloping ground* can be calculated most easily using a scale drawing.
(a) Draw a horizontal line from D, meeting AE at E'.
(b) Draw a horizontal line from C, meeting BF at F'.
(c) Draw a vertical line PO down the centre line of the dike.
(d) Cross-section = ADE + AEFB + BFC = 0.5(AE x DE') + (AB x PO) + 0.5(BF x F'C).
Calculating the cross-section of a dike on sloping ground using a scale drawing
Calculating the cross-section of a dike on irregular ground using a scale drawing
Calculating the cross-section of a dike on irregular ground using squared paper
1 cm = 0.5 m
1 square of 0.5 m x 0.5 m = 0.25 m^2
15.2 squares x 0.25 m^2 *= 3.8* m^2

Calculating the volume of dikes on horizontal and regular ground

To estimate how much soil will be needed for the construction of a dike, you need to know its volume. The calculation method depends on the site topography and on the type of pond to be built.
If *the topography* of the construction *site is reasonably flat* (less than 0.30 m difference in average site levels) and regular, you can calculate the volume of the dike (in m^3) by multiplying the*cross-section of the dike*(in m^2 and halfway along the dike for an average area) *by its length* measured along the centre line (in m).
EXAMPLE
Using the figures from the example above, the cross-section of the dike equals 8.0652 m^2. If the length of the dike to be built is 20 m x 4 = 80 m, its volume is 8.0652 m^2 x 80 m = 653.216 m^3.

Calculating the volume of dikes on sloping or irregular ground

If the topography of the site is more steeply sloping or more irregular, you cannot calculate the volume of the pond dikes just by using one cross-section. There are several possible methods, depending on the type of ground and the accuracy you require.
With a first group of methods you can calculate the dike volumes by using *averages of the dike*

*cross-sections*or you could use the average of the *cross-sections at the corners* of the dike.

EXAMLPE

A 400-m^2 (20 x 20 m) pond is to be constructed with wall heights of 0.5 m at corner A, 0.3 m at corner B, 1.1 m at corner C and 1.5 m at corner D. Crest width is 1 m and side slope 2:1 on both sides. The cross-section areas at each corner are:

A: (1 m x 0.5 m) + 2 x (0.5 m x 0.5 m x 1 m) = 1.5 m^2,

B: (1 m x 0.3 m) + 2 x (0.5 m x 0.3 m x 0.6 m) = 0.48 m^2,

C: (I m x 1. 1 m) + 2 x (0. 5 m x 1. 1 m x 2.2 m) = 3.52 m^2,

D: (1 m x 1.5 m) + 2 x (0.5 m x 1.5 m x 3 m) = 6.0 m^2.

Average area for wall AB = (1.5 m^2 + 0.48 m^2) ÷ 2 = 0.99 m^2 and volume for wall AB = 0.99 m^2 x 20 m = *19.8 m^3*.

Similarly:

- for BC, average area = 2 m^2 and volume = *40* m^3;
- for CD, average area = 4.76 m^2 and volume = *95.2* m^3;
- for DA, average area = 3.75 m^2 and volume = *75* m^3.

Consequently, total volume of dikes = 19.8 m^3 + 40 m^3 + 95.2 m^3 + 75 m^3 = 230 m^3.

Average of areas at corners of dike

For a more accurate measurement of dike volume on rough ground, you should apply the following formula, known as Simpson's rule, where: $V = (d \div 3) \times [A_1 + A_n + 4(A_2 + A_4 + ... A_{n-1}) + 2(A_3 + A_5 + ... A_{n-2})]$. Proceed as follows:

(a) Divide the length of the dike into an *odd number n* of cross-sections at equal intervals of *d* metres.

(b) Calculate the area *A* of each cross-section as explained earlier.

(c) Introduce these values into the above formula.

The dike is 60 m long.

(a) At intervals *d* = 10 m, identify seven crosssections A_1 ... A_7 and calculate their respective areas to obtain A_1 = 10 m^2 ; A_2 = 16 m^2; A_3 = 18 m^2 ; A_4 = 11 m^2 ; A_5 = 8 m^2; A_6 = 10 m^2 ; A_7 = 12 m^2.

(b) Introduce these values into the Simpson's rule formula:

$V = (d \div 3)$ [A1 + A7 + 4(A2 + A4 + A6) +2 (A3 + A5)].

(c) Calculate V = (10 m ÷ 3) [10 m^2 + 12 m^2 + 4(16 m^2 + 11 m^2 + 10 m^2 + 2(18 m^2 ÷ 8 m^2)] = 740 m^3.

Calculating volumes of excavated material

You will need to know excavation volumes for:

- topsoil;
- borrow pits, dug near an earth structure to provide the material for its construction;
- excavated ponds, to provide the pond volume required;
- other structures such as harvest pits, supply channels, etc.

You will normally have to remove the topsoil before you reach soil good for construction material. Levels should therefore be taken *from the base of the topsoil*layer. In most cases, the sides of the excavation should be sloped to prevent them from collapsing. In many cases (ponds, channels, etc.) these will be of specified gradients.

For reasonably flat, level surfaces, where *excavated width is at least 30 times the depth*, volume of excavation can be estimated as:

V = top area x depth of

excavation.
Where the *width is less than 30 times the depth*, you should correct for side slopes as follows:
V = [(top area + bottom area) ÷ 2] x depth.

EXAMPLE

A 400 m^2 (40 x 10 m) area is to be excavated, 1 m deep, with side slopes 2:1. As the width (10 m) is less than 30 times the depth (30 x 1 m), the first method is not accurate (estimated volume would be 400 m^2 x 1 m = 400 m^3).
Use the second method, where
top area = 400 m^2 and base area=base length x base width.
Base length = 40 - (2 x slope x depth) = 40 - (2 x 2 x 1 m) = 36 m
Base width = 10 - (2 x slope x depth)= 10 - (2 x 2 x 1 m) = 6 m
Base area = 36 m x 6 m = 216 m^2
Average area = (400 m^2 + 216 m^2)÷ 2 = 308 m^2
Volume therefore = 308 m^2 x 1 m= 308 m^3.
Above all, for precision, prismodal formula can be used to calculate the volume of soil excavated from pond area (excluding topsoil area):
V= (A+4B+C)/6 *D
Where
A = Top surface area
B = Mid-depth surface area
C = Bottom surface area
D = Average depth of excavation

How to calculate the volume of water in the pond

You have thus calculated the surface area of the pond and the average water depth of the pond. Now, using the figures you have found, you can calculate the volume of water in the pond by multiplying the surface in square metres (m^2) by the average water depth in metres (m) to get the volume of the pond in cubicmetres (m^3).
SURFACE AREA x AVERAGE DEPTH = VOLUME
Note: 1 cubic metre (m^3) = 1000 litres (l). To express water volume (in m^3) in litres (l) multiply by 1000. To express water volume (in l) in cubic metres (m^3) divide by 1000.

FIS 509: FISH FARMING ENGINEERING (3 UNITS)

RECIRCULATORY AQUACULTURE SYSTEM (RAS)

Re-circulatory Aquaculture System (RAS) is described as the techniques of reusing the volume of water that has been utilized to produce fish in a closed or semi-closed system. It is mechanically sophisticated and biologically complex. It is biologically intense meaning fish are usually reared intensively to make the system cost-effective. Thus RAS involves the process of recycling the water used in the rearing of fish through series of filtration processes, and disinfection using chlorination, ultra-violet irradiation, ozonation or combination of these to control or remove unwanted organisms and metabolites that enter into the system.
Water from the fish rearing tanks flows by gravity into the sedimentation tank which has filtration materials to filter the solids and suspended materials contained in the used water. The filtered water is then disinfected and pumped into the bio-filtration tank which contains the biofilter
media that harbor nitrifying bacteria. The nitrifying bacteria convert ammonia in the water first to nitrate and then to nitrate. Thus, the ammonia free water flows into reception tank where

it is aerated, and flows back into the tank and the process continues.
Many commercial RAS, to date have filed because of poor design, inferior management or flawed economies component failures, poor water quality, stress, diseases and off flavor are common problems in poorly managed systems.
Re circulatory System must maintain uniform flow rates (water and air/oxygen), fixed water levels and uninterrupted operation in order to provide a suitable environment for intensive fish production. Management of RAS takes education, expertise and dedication.

Flow Chart for Re-Circulatory Aquaculture System

Bio-Filtration tank Header tank
Sedimentation
or settling tank
Culture unit
Make-up
Waste

DESIGN AND CONSTRUCTION OF CAGES

The basic approach to fish cage system design involves the principle of GETTINGWHAT-YOU-WITH-WHAT-YOU-HAVE i.e. to adjust structures and materials to local supply and conditions such that the desired effects or results are achieved.

MATERIALS

There are two types of cage systems in use viz. Floating cages and fixed cages. Both types of cages are made up of the cages and a framework (raft in the floating type) except that there are anchors and floating devices in the floating cages system. The following are used for the different parts;

(i) Cages: galvanized wire mesh, plastic nets, Styrofoam and other nettings, wood and bamboo lattices e.t.c.
(ii) Framework (raft): Bamboo, galvanized iron, weed and plastic.
(iii) Floats: Bamboo, PVC pipes, logs, spherical buoys, metal drum, plastic keg/drum, aluminum cylinders, used rubber tyres.
(iv) Mooring devices: Concrete stones, wooden pegs, large metal anchors.

DESIGN

There are various design of fish cages depending on the purpose, the species for culture, the location e.t.c. the detail as follows:

Rafts

(i) 9m * 6m with six, 3m* 3m apartments
(ii) 9m * 9m with nine, 3m * 3m apartments
(iii) 9m * 9m with sixteen, 2m* 2m apartments
(iv) 7m * 7m with four, 3.5m * 3.5m apartments
(v) 6m * 6m with sixteen, 1.5m * 1.5 apartments
(vi) 6m * 6m with four, 3m * 3m apartments
(vii) 5m * 5m with sixteen, 1.25m * 1.25m apartments

Net-Hapas

Only three net-hapa sizes have been experimented upon: 2*2*1m, 1*2*1m and 1*1*1m

Net Cages

Four different sizes of net-cages have been tried:
(i) 1*1*1.5m
(ii) 2*2*2m
(iii) 3*3*2.75m
(iv) 3*3*3.5m

The mesh sizes of these capes vary from 10mm to 25mm. There is a cage system operation termed TVIS- Tilapia Vertically Integrated System- every stage in the life history of the fish (from hatchlings to adult or table size). The present most portable and practical Tilapia hatchery/nursery is that, it include consisting of 6*6m raft with sixteen, 1.5*1.5m apartments fittable with sixteen, 1*1*1m net-hapas. The net-hapas have top covers which prevent the caged fish, especially the breeders from jumping out. The covers also protect the fry/fingerlings from being preyed upon by aerial predators such as birds. On the other hand, the most ideal design for growing table-size fish and brooders is the module of 7m*7m raft with far 3.5*3.5m apartments to which can be tied four 3*3*2.75m. The mesh size of the net-cages (210/9, 400md) may vary from 3/8” (10mm) to 1” (25.4mm) depending on the size/shape of the fish. The smaller the size of the fish to be stoked, the smaller the mesh size of the net cage. Several modules of these hatchery/nursery and grow-out facilities can be linked together for commercial cage fish culture enterprise.

CONSTRUCTION

Net-Hapa

- The net-hapa is sown into the required shape and size with nylon thread (210/2) using a sewingmmachine.
- Kuralon rope (NO.15) is passed through nylon cloth tape on the vertical corners of the hapa to fortify the hapa.
- The kuralon rope is made such that it extends out of the four bottom rope is made such that it extend, out of the four corners of the hapa in form of loops to which riggers (small sinkers) are tied when the hapa is floated in the water for fish culture/breeding.

Net Cage

The net cage is mounted into the designed shape/size using kuralon rope (NO.15) as reinforcement and nylon rope (210/21) passed into a mounting needle following the procedure for gillnet. The kuralon rope is mounted to extend out at all the corners (top and bottom corners, square or rectangular cage) in form of loops for rigging at the bottom corners and attachment of the cage to the bottom raft at the top four corners.

Floating Raft

The bamboo (floating) raft acts as framework for the net-hapas or net-cages is constructed by first trimming the both bamboo poles to the appropriate or required length. For sixteen apartment’s hatchery/nursery-raft, ten units of bamboo poles i.e. four, 2-piece units and six, 3piece units are nailed together at the 25 intersections with 6” nails.

Well sealed plastic kegs (100 liters capacity) are then fastened to the raft using 1/3” (3mm) diameter iron rods or kuralon (NO.15) rope. The raft is then launched by manual carrying into the water and paddled like a boat to the require site. The raft is anchored to the site with concrete sinkers (30-50kg each) to which are tied nylon or polypropylene anchor rope and then do the raft. The net-hapas or net cages can then be tied to the raft apartments in preparation for stocking.