**NAME: IKHENOBA ELIZABETH AMANDA**

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**COURSE CODE: CVE 504**

QUESTION ONE

1. Define flexural strength

Flexural strength can be defined as the stress in a material just before it yields in flexural test. Flexural strength is an indirect measure of the tensile strength of concrete. It is a measure of the maximum stress on the tension face of an unreinforced concrete beam or slab at the point of failure in bending.

1. A group of four piles supports a 450 x 450 mm rectangular column which transmits an ultimate axial load of 4000 kN. If the pile diameter is 500 mm spaced at 1350 mm Centre - Centre, design the pile cap using fcu =30N/mm2, fy=410N/mm2.



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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ø | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 700 |
| Cap depth (mm) | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1400 | 1800 |

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Design for reinforcement

Total area =

Provide Y25 @ 250 c/c

Shear capacity

Shear along critical section

QUESTION TWO

2a. A cantilever retaining wall has angle of friction 450 and supports a granular materials of saturated density of 1820kg/m3. Check the stability of the wall and determine the overturning and restrained moments. Assume 30-410N/mm3 grade of concrete.

Coefficient of active pressure =

Vertical load

Variable load

Overturning moment

Restricting moment

2b. Give reasons for the following; (a) Bored piles are enlarged at base (b) Precast piles must be reinforced and design to resist bending moment.

Bored piles are enlarged at base so that they have larger bearing capacity and resistance to uplift.

Precast piles must be reinforced to withstand the impact of the driving hammer and designed to resist bending moment caused by lifting and stacking.

QUESTION THREE

3a. Write a well detailed explanation of the construction procedure including materials used, tests on soil bearing capacity, pile length etc. during the construction of Fajuyi Park Bridge, Ado-Ekiti.

Construction of bridge

A bridge is divided into two main parts:

 Superstructure
The superstructure is the upper portion of the bridge above the beam seats where you drive or walk. Its members include:

1. Beams
2. Bearings
3. Curbs
4. Deck
5. Deck wearing surface
6. Floor beams
7. Girders
8. Parapets
9. Sidewalks
10. Traffic barriers
11. Trusses

Substructure
The substructure is under the superstructure and supports all of the bridge loads. Its members include:

1. Abutments
2. Backwalls
3. Beam seats
4. Cheekwalls
5. Footings
6. Piers
7. Piles
8. Wingwalls

Materials used

Steel

Steel gain high strength when compared with any other material. This makes its suitable for the construction of bridges with longer span. steel is a combination of alloys of iron and other elements, mainly carbon.

Based on the amount and variation of the elements, the properties of the same is altered accordingly. The properties of tensile strength, ductility and hardness are influenced by the change in its constitution. The steel used for normal construction have several hundred Mega Pascal strength. This strength is almost 10 times greater than the compressive and the tensile strength obtained from a normal concrete mix. The major inbuilt property of steel is the ductility property. This is the deformation capability before the final breakage tends to happen. The chemical composition and the method of manufacture determines the properties of structural steel. The main properties that are to be specified by the bridge designers when it is required to specify the products are:

* Strength
* Toughness
* Ductility
* Durability
* Weldability

### Concrete

Most of the modern bridge construction make use of concrete as the primary material. The concrete is good in compression and weak in tensile strength. The reinforced concrete structures are the remedy put forward for this problem. The concrete tends to have a constant value of modulus of elasticity at lower stress levels. But this value decreases at a higher stress condition. This will welcome the formation of cracks and later their propagation. Other factors to which concrete is susceptible are the thermal expansion and shrinkage effects. Creep is formed in concrete due to long time stress on it. The mechanical properties of concrete are determined by the compressive strength of concrete.

The reinforced or the prestressed concrete is used for the construction of bridges. The reinforcement in R.C.C provides the ductility property to the structure. Nowadays, ductility reinforcement is provided as an additional requirement mainly in the earthquake resistant construction.

RCC is nowadays made from steel, polymer or other combination of composite materials. Much sustainable materials is available that can take the role of cement. This is a new innovation in sustainable bridge construction. When compared with RCC bridge construction, prestressed concrete is the most preferred and employed. A pre-compressive force is induced in the concrete with the help of high strength steel tendons before the actual service load. Hence this compressive stress will resist the tensile stress that is coming during the actual load conditions. The prestress is induced in concrete either by means of post tensioning or by means of pretensioning the steel reinforcement.

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of subgrade soil for design of flexible pavement.

CBR Test Procedure:

* Normally 3 specimens each of about 7 kg must be compacted so that their compacted densities range from 95% to 100% generally with 10, 30 and 65 blows.
* Weigh of empty mould
* Add water to the first specimen (compact it in five layer by giving 10 blows per layer)
* After compaction, remove the collar and level the surface.
* Take sample for determination of moisture content.
* Weight of mould + compacted specimen.
* Take other samples and apply different blows and repeat the whole process.
* Remove the mould from the tank and allow water to drain.
* Then place the specimen under the penetration piston and place surcharge load of 10lb.
* Apply the load and note the penetration load values.
* Draw the graphs between the penetration (in) and penetration load (in) and find the value of CBR.
* Draw the graph between the %age CBR and Dry Density, and find CBR at required degree of compaction.

Bridge elements

Substructure: foundation of the bridge (piles)

Superstructure: pier, abutment, pile cap and slab

Substructure: Piles

A concrete pile maybe precast, prestressed, cast in place or composite construction. Prestressed piles are formed by tensioning high strength steel prestress cables, and casting the concrete about the cable. When the concrete hardens, the prestress cables are cut, with the tension force in the cables now producing compressive stress in the concrete pile. It is common to higher-strength concrete (35 to 55 MPa) in prestressed piles because of the large initial compressive stresses from prestressing. Max length: 10 - 15 m for precast, 20 - 30 m for prestressed. Optimum length 10 - 12 m for precast. 18 - 25m prestressed.

Realization of the pile

* Preparation of the site
* Preparation of the reinforcement
* Arrangement of pile reinforcement and enclosing with the formwork
* Pouring concrete into the formwork
* Removal of formwork after drying

Superstructure

Realization of pier and abutment

* Pier is a vertical bridge element which is used to transfer load from the deck to the pile and then to the ground
* Abutment is a vertical bridge element used to support lateral pressure at the end of the bridge.
* Prepare the reinforcement
* Enclose the reinforcement and cast
* Remove the formwork after drying

Realization of slab deck

* Slab deck is a horizontal bridge element where vehicle move
* After the removal the removal of formwork for piers and abutment, placement of formwork for slab and arrangement of reinforcement should be done
* Casting and appropriate surface finishes should be done.

3b. If a Bridge structure is to be located within Afe Babalola University, suggest a likely location and justify your assertion.

The bridge structure should be built across ureje river connecting Afe Babalola university and ABUAD farm behind staff quarters because of the river and it will enable ease of movement from one place to another.

QUESTION FOUR

4a). Differentiate between HA and HB loading system.

HA loading is a formula loading representing normal traffic while HB loading is an abnormal vehicle unit loading.

HA loading:

Type HA loading consists of a uniformly distributed load and a knife edge load combined, or of a single wheel load.

(a) A uniformly distributed lane loading. For loaded lengths up to 30m, the value shall be 30kN per m of notional lane. For greater length (L) it shall be:

but not less than 9kN per m of notional lane. (b) One knife edge load (axle load) of 120kN, uniformly distributed across the width of the national traffic lane.

(c) A single nominal wheel load, as an alternative to (a) + (b). The load shall be 100kN and distributed over either a circular area of 0.34m or a square of 0.3m sides. The HA wheel load is applied to members supporting small areas of roadway, where the proportion of the distributed load and knife edge load which would otherwise be allocated to it is small.

HB loading:

The type HB loading is a unit loading representing a single abnormally heavy vehicle. The loading is composed of 4 axle loads, each with a weight expressed in units (1 unit = 10kN). The number of units of HB loading normally required is 45 units (450kN per axle).

**Impact factor:** An impact factor of 1.25 is taken into account in the HA loading. No impact factor is used with the HB loading

4b). Give a mathematical definition of active and passive pressure acting on a retaining wall.

4c.

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| --- | --- | --- | --- | --- |
| PILE | Xn | Yn | X2 | Y2 |
| 1 | +5.5 | -1.5 | 30.25 | 2.25 |
| 2 | -5.5 | -4.9 | 30.25 | 24.01 |
| 3 | -2 | -8.1 | 4 | 65.61 |
| 4 | -2 | +8.1 | 4 | 65.61 |
| 5 | -5.5 | +4.9 | 30.25 | 24.01 |
| 6 | -5.5 | +1.5 | 30.25 | 2.25 |
| 7 | +2 | +4.7 | 4 | 22.09 |
| 8 | +2 | -4.7 | 4 | 22.09 |
| 30 | 38.4 | 137 | 227.92 |