Principles and Practice of Engineering (PE) Civil: Water Resources and Environmental (WRE) Practice Exam (Sample)

Study Guide

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Questions

1. **What is the height of water above the crest of the weir if it is measured at 2.5 ft?**
   - **A. 1.5 ft**
   - **B. 2.0 ft**
   - **C. 2.5 ft**
   - **D. 3.0 ft**

2. **In terms of its engineering properties, what does the term "liquid limit" refer to?**
   - **A. The water content at which soil changes from plastic to liquid**
   - **B. The maximum moisture content soil can retain**
   - **C. The water content at which soil reaches its optimum density**
   - **D. The water content at which soil becomes saturated**

3. **What factor is NOT typically considered in the design of a wastewater treatment plant?**
   - **A. Wastewater flow**
   - **B. Project site details**
   - **C. Mass loading rate**
   - **D. Total dissolved solids concentration**

4. **Which of the following will NOT improve the performance of flocculation in wastewater treatment?**
   - **A. Increasing floc size**
   - **B. Reducing chemical dosage**
   - **C. Optimizing paddle speed**
   - **D. Controlling pH levels**

5. **How do slow sand filters compare to rapid sand filters in terms of filtration rate?**
   - **A. Higher filtration rate**
   - **B. Lesser efficiency in removal of bacteria**
   - **C. Slower filtration rate**
   - **D. Similar filtration rate**

6. When two identical pumps are arranged either in series or in parallel, what is true about the flow rate?

   A. Flow rates are equivalent in both configurations

   B. In series, flow rate is halved compared to one pump

   C. The volume flow rate through the pumps in parallel is equal to the sum of the flow through pump 1 and pump 2

   D. Overall output is higher in series than in parallel

7. Which of the following statements about a eutrophic lake is false?

   A. It is high in nutrients

   B. It supports diverse aquatic life

   C. It is low in oxygen

   D. It has low turbid conditions

8. Which of the following factors affects the compressive strength (□□′□□) of concrete?

   A. Water-cement ratio

   B. Aggregate size

   C. Cement type

   D. All of the above

9. How can the Mean Cell Residence Time (MCRT) be increased?

   A. Increasing the WAS

   B. Decreasing the flow rate

   C. Decreasing the MLSS

   D. Increasing the MLSS

10. When selecting materials for concrete exposed to high sulfate conditions, which component should be minimized?

   A. Water content

   B. Cement paste

   C. Fly ash

   D. Aggregates

Answers

1. **C**
2. **A**
3. **D**
4. **B**
5. **C**
6. **C**
7. **D**
8. **D**
9. **D**
10. **B**

Explanations

1. What is the height of water above the crest of the weir if it is measured at 2.5 ft?

A. 1.5 ft

B. 2.0 ft

C. 2.5 ft

D. 3.0 ft

When measuring the height of water above the crest of a weir, it is the actual depth of the water that directly contributes to the weir's discharge and hydraulic performance. If the measurement shows that the height of the water is 2.5 ft above the crest, this directly indicates that the water level is precisely at 2.5 ft, which affects the flow characteristics over the weir. Understanding this is essential in water resource engineering, as the height of the water can influence flow rates and design calculations for managing water systems. Given that the height is measured and stated to be 2.5 ft, this simply confirms the direct measurement and reflects the state of the water level concerning the weir's structure. This relates to how weir equations such as the broad-crested or sharp-crested weir equations are applied, which take into account the height of water for predicting flow rates or designing weirs for specific applications. This foundational understanding helps clarify that the measurement is indeed indicative of the actual height, ensuring the design and calculations align with the observed operating conditions.

2. In terms of its engineering properties, what does the term "liquid limit" refer to?

A. The water content at which soil changes from plastic to liquid

B. The maximum moisture content soil can retain

C. The water content at which soil reaches its optimum density

D. The water content at which soil becomes saturated

The term "liquid limit" specifically refers to the water content at which soil transitions from a plastic state to a liquid state. At the liquid limit, the soil can no longer maintain its shape and flows under the influence of gravity. This property is crucial for understanding soil behavior under varying moisture conditions, particularly in geotechnical engineering and construction. When soil is in the plastic state, it can be molded and shaped without cracking, but once the water content exceeds the liquid limit, the soil behaves more like a liquid, losing its strength and cohesion. This concept is foundational in classifying soil types and understanding how they will perform as part of a foundation or in stability assessments. The other options describe various soil properties, but they do not accurately represent the definition of liquid limit. For example, the maximum moisture content and optimum density pertain to different behaviors and characteristics of soil. The saturation point relates to when soil voids are completely filled with water, which is also a separate concept from the transition represented by the liquid limit. Thus, the correct interpretation is that the liquid limit marks the critical water content at which soil transitions from a plastic to a liquid state.

3. What factor is NOT typically considered in the design of a wastewater treatment plant?

A. Wastewater flow

B. Project site details

C. Mass loading rate

D. Total dissolved solids concentration

In the context of wastewater treatment plant design, total dissolved solids (TDS) concentration is generally not a primary factor considered in the initial design parameters. Wastewater treatment plants are primarily designed based on factors that directly influence the treatment process and plant capacity, including the flow rate of wastewater, the characteristics of the wastewater, and the mass loading rate of contaminants. Wastewater flow refers to the volume of wastewater that must be treated and is essential for determining the size and capacity of treatment units. Project site details encompass various considerations, such as geographic features, local regulations, and proximity to populations, which are crucial for the effective placement and operation of the facility. The mass loading rate is an important design consideration as it relates to the concentration of pollutants entering the treatment system and helps in evaluating the adequacy of treatment processes to handle these pollutants effectively. While TDS concentration can have implications for the treatment process, especially in terms of salinity and its effects on certain treatment technologies, it is not a primary design factor like the other three options. Thus, it is less critical when establishing the overall framework for designing a wastewater treatment plant.

4. Which of the following will NOT improve the performance of flocculation in wastewater treatment?

A. Increasing floc size

B. Reducing chemical dosage

C. Optimizing paddle speed

D. Controlling pH levels

Flocculation is a crucial step in wastewater treatment that involves the aggregation of fine particles to form larger flocs that can be easily removed from the water. Each of the listed practices plays a significant role in enhancing the flocculation process, except for one. Reducing chemical dosage will not improve flocculation performance because sufficient chemicals, typically coagulants, are necessary to destabilize the particles in the wastewater. If the dosage is too low, the coagulation process could be inadequate, leading to smaller floc sizes and reduced settling characteristics. The other options actively contribute to improving flocculation: - Increasing floc size is beneficial because larger flocs settle more quickly and effectively, which facilitates easier removal from the wastewater. - Optimizing paddle speed ensures that the mixing is adequate to promote particle interactions without breaking apart the flocs that have already formed. - Controlling pH levels is important as the charge of particles and the solubility of certain chemicals can be significantly influenced by pH, impacting the effectiveness of the coagulation and flocculation processes. By ensuring the correct chemical dosage and optimizing these other parameters, the efficiency of the flocculation process can greatly improve, thereby enhancing the overall treatment of wastewater.

5. How do slow sand filters compare to rapid sand filters in terms of filtration rate?

A. Higher filtration rate

B. Lesser efficiency in removal of bacteria

C. Slower filtration rate

D. Similar filtration rate

Slow sand filters operate at a significantly lower filtration rate compared to rapid sand filters, which is a key characteristic that distinguishes the two types of filtration systems. The typical filtration rate for slow sand filters is approximately 0.1 to 0.5 liters per square meter per second, primarily due to the design that relies on biological processes and a layer of sand that allows time for natural filtration and sedimentation to occur. This slower rate promotes the development of a biological layer called the "schmutzdecke," which is crucial for the effective removal of pathogens and suspended solids. In contrast, rapid sand filters work at much higher filtration rates, generally between 3 to 8 liters per square meter per second, using gravel and sand layers that allow for quicker passage of water while relying on frequent backwashing to maintain efficiency. Therefore, the slow filtration rate of slow sand filters is intrinsic to their operation and performance, particularly in terms of biological filtration. This lower rate is deliberately designed to maximize the contact time between the water and the filter media, enhancing the removal capabilities of the system for various contaminants, including larger particles and microorganisms. Thus, the characterization of slow sand filters as having a slower filtration rate is accurate and rooted in their operational and design principles

6. When two identical pumps are arranged either in series or in parallel, what is true about the flow rate?

A. Flow rates are equivalent in both configurations

B. In series, flow rate is halved compared to one pump

C. The volume flow rate through the pumps in parallel is equal to the sum of the flow through pump 1 and pump 2

D. Overall output is higher in series than in parallel

In the context of two identical pumps arranged in parallel, it is indeed true that the volume flow rate through the pumps is equal to the sum of the flow rates through each individual pump. When pumps are placed in parallel, they operate at the same pressure head, allowing each pump to contribute its maximum flow rate simultaneously. This configuration effectively doubles the total flow rate, assuming both pumps are operating under identical conditions and are capable of delivering their rated capacities. This characteristic of parallel pump arrangement is pivotal in fluid dynamics and pump systems design, as it allows for increased flow capacity without significantly increasing the pressure. This is distinct from the configuration in series, where, although the pressure is increased, the flow rate remains the same as that of a single pump because the same volume of fluid must pass through each pump sequentially.

7. Which of the following statements about a eutrophic lake is false?

A. It is high in nutrients

B. It supports diverse aquatic life

C. It is low in oxygen

D. It has low turbid conditions

A eutrophic lake is characterized by an abundance of nutrients, particularly nitrogen and phosphorus, which promote the rapid growth of algae and aquatic plants. While these nutrient levels support a variety of life, they can lead to problems over time. The statement about low turbidity conditions is false because eutrophic lakes typically experience high turbidity. This turbidity is caused by the excessive growth of algae, which can reduce water clarity. The high levels of nutrients in these lakes often lead to algal blooms, which can decompose and further reduce oxygen levels in the water. In summary, eutrophic lakes are known for being nutrient-rich, can suffer from low oxygen levels due to decomposition processes, and are often turbid due to high algal concentrations. Therefore, the assertion that they have low turbidity is incorrect, making it the false statement among the options given.

8. Which of the following factors affects the compressive strength (f'_c) of concrete?

A. Water-cement ratio

B. Aggregate size

C. Cement type

D. All of the above

The compressive strength of concrete, often denoted as \(f'c \), is significantly influenced by several factors, including the water-cement ratio, aggregate size, and cement type. Each of these elements plays a crucial role in defining the overall strength of the concrete. The water-cement ratio is particularly critical because it dictates the amount of water available to hydrate the cement particles. Reducing the water-cement ratio generally leads to higher compressive strength, as less water results in a denser and more durable concrete structure. Conversely, a higher water content can lead to increased porosity and reduced strength. Aggregate size also affects compressive strength. Smaller aggregates can help fill voids between larger particles, leading to a denser concrete mix, whereas excessively large aggregates might create weak points within the mixture. The proper selection of aggregate size ensures a better bond within the concrete matrix. The type of cement used is another determinant of compressive strength. Different types of cement have varying chemical compositions, which influence the rate of hardening and the ultimate strength achievable in the mix. For example, some cements are formulated for rapid strength gain, while others are designed for durability or resistance to specific environmental challenges. Considering all these factors, it becomes clear that each

9. How can the Mean Cell Residence Time (MCRT) be increased?

A. Increasing the WAS

B. Decreasing the flow rate

C. Decreasing the MLSS

D. Increasing the MLSS

Increasing the Mean Cell Residence Time (MCRT) can be achieved by increasing the Mixed Liquor Suspended Solids (MLSS) concentration in a biological treatment process. MCRT is a measure of the average time that microorganisms remain in the treatment system. When MLSS is increased, it indicates a greater concentration of active biomass in the reactor, which allows for enhanced biological treatment processes. Higher MLSS concentrations imply that more microorganisms are present to break down organic material, which can lead to increased resistance to variations in loading and better overall treatment efficiency. Consequently, the time that the biomass remains in the treatment process (and hence its MCRT) can be effectively prolonged. This connection is crucial in wastewater treatment, as it helps optimize the performance of biological reactors, specifically in systems like activated sludge processes where the balance between biomass production and decay is sensitive to the operational parameters. By increasing the MLSS, the retention of cells in the system is promoted, directly enhancing the MCRT.

10. When selecting materials for concrete exposed to high sulfate conditions, which component should be minimized?

A. Water content

B. Cement paste

C. Fly ash

D. Aggregates

Minimizing the cement paste in concrete exposed to high sulfate conditions is essential due to the chemical reactions that occur when sulfate ions interact with the components in the concrete mix. Sulfates can react with the compounds present in the cement, particularly tricalcium aluminate (C3A), leading to the formation of expansive products such as ettringite. This expansion can cause significant damage, including cracking and spalling, which compromises the integrity of the concrete structure. By reducing the amount of cement paste, you effectively decrease the potential for these harmful reactions. It is also advisable to use cements that are low in C3A, such as sulfate-resisting cements, in conjunction with minimized cement paste to further mitigate the risks associated with high sulfate environments. The other materials, such as aggregates, water content, and supplementary cementitious materials like fly ash, do not directly relate to the expansive reactions with sulfates in the same manner as the cement paste does. While water content must be managed to ensure proper workability and strength, it is not the primary factor in preventing sulfate attack. Similarly, incorporating fly ash can help improve long-term durability but does not focus on the specific risks posed by sulfate exposure as effectively as minimizing the cement paste does.