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Method Of Checking Casting Concrete on-site for Bridge Foundations: Learn from Ratapan Ibu Bridge Payakumbuh-Indonesia

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ABSTRACT

Concrete is a composite material made of coarse aggregate, fine aggregate, cement, as well as water, and other additive materials if necessary. Concrete is a widely used construction material in buildings. In most cases, the main structure of a building consists of concrete. According to the Indonesian Concrete Regulation of 1971 (PBI), the quality of concrete is divided into three classes: class one, class two, and class three, depending on the specific requirements of each concrete. The foundation, located at the bottom of a building, plays a vital role in supporting the entire structure's load. It is an essential component of the lower structure and carries the weight of the building above it. There are different types of foundations, such as shallow foundations and pad foundations. A compromised foundation dramatically increases the risk of a bridge collapsing. Besides withstanding vertical forces, the foundation must also endure horizontal loads. Bridges typically rely on a foundation as their primary support structure. Concrete is commonly used for bridge foundations, which can be cast on-site or prefabricated beforehand. However, not all foundations can be prefabricated due to size limitations on the project site. Extra attention is required when casting concrete on-site. The quality of the concrete has a significant impact on the foundation's quality. An inadequate foundation significantly raises the risk of a bridge collapse. When undertaking on-site concrete casting, extra attention is necessary. The quality of the concrete substantially impacts the future foundation's quality. An inadequate foundation significantly raises the chances of a bridge collapse. Therefore, careful inspection is crucial to ensure the concrete's quality and prevent any undesirable situations.

1. Introduction

Freeze-thaw is a significant factor that impacts the durability of concrete in dams. Previous freeze-thaw tests primarily focused on saturated or highly saturated concrete samples. However, in practical dam operation, certain areas, such as the water level fluctuation zone, dam crest, and the portion above the downstream water surface, typically need to be more saturated. The only consistently saturated section is the submerged part beneath the upstream water surface. Research has shown that if the water saturation level remains below 91.7%, the concrete remains undamaged during freeze-thaw cycles [1]. Consequently, understanding the water saturation levels in concrete and the water distribution at various depths on the exposed dam surface becomes crucial [2].

One of the seven types of supplementary materials, Water Reducing and Retarding (Type D), is a dual-function chemical admixture. Its first function is to reduce the free water content, while the second is to delay the setting time of concrete. However, if the second component overdoses, it can result from an extended setting time [3].

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Concrete is commonly used for bridge foundations, which can be cast on-site or prefabricated in advance. However, not all foundations can be prefabricated due to size restrictions at the project site. A compromised foundation dramatically increases the risk of a bridge collapse [4]. In addition to withstanding vertical forces, the foundation must also withstand horizontal loads. Typically, bridge construction relies on a foundation as its base, serving as the primary support structure. The foundation, situated at the base of a building, plays a crucial role in supporting the entire structure's load. As an integral part of the lowermost structure, the foundation bears significant responsibility for carrying the weight of the building above it. Various types of foundations exist, including shallow foundations and pad foundations, among others[5].

When undertaking on-site concrete casting, extra attention is necessary. The quality of the concrete significantly impacts the future foundation's quality. An inadequate foundation substantially raises the chances of a bridge collapse [6]. Therefore, ensuring the concrete's quality through careful inspection is imperative to prevent any undesirable circumstances. This article will study checking concrete on pipe piles at the Ratapan Ibu Bridge in West Sumatera, Indonesia.

Figure 1. Ratapan Ibu Bridge Payakumbuh, Padang
(Sources: Google Chrome)

2. Literature Review

Concrete

Typically, concrete forms the primary framework of a building. The Indonesian Concrete Regulation of 1971 (PBI) classifies the quality of concrete into three categories: class one, class two, and class three, which are determined by the specific criteria for each type of concrete [7]. Concrete is a versatile construction material composed of cement, aggregates (sand, gravel, or crushed stone), and water. It is one of the most widely used materials in the world for various construction applications due to its strength, durability, and affordability [8]. Here are some critical points about concrete:

A. Cement is a fine powder primarily made from limestone and other materials. It acts as a binder that holds the concrete mixture together when mixed with water. The most common type of cement used in concrete is Portland cement.
B. Aggregates are inert granular materials, such as sand, gravel, or crushed stone, mixed with cement to form the bulk of the concrete. They provide strength and stability to the mixture[9]. The choice

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of aggregates depends on factors like the desired strength, workability, and appearance of the concrete.

C. Water is a crucial component in the concrete mixture. When combined with cement, it undergoes a chemical reaction called hydration, which forms a hardened matrix that binds the aggregates together. The amount of water used affects the workability and strength of the concrete.
D. Mixing and Placement: Making concrete involves mixing the cement, aggregates, and water to form a uniform mixture. This can be done manually or using machinery like concrete mixers. The mixed concrete is then placed into forms or molds and allowed to cure and harden.
E. Strength and Durability: Concrete is known for its strength and durability. It can withstand heavy loads and resist compression, making it suitable for various structural applications [10]. The curing process helps the concrete gain strength over time, but it continues to harden and strengthen for an extended period.
F. Reinforcement: In some cases, concrete may be reinforced with steel bars or mesh to enhance its tensile strength. This combination of reinforced steel and concrete, known as reinforced concrete, allows the structure to withstand compression and tension forcefield[3].
G. Applications: Concrete has a wide range of applications in construction, including foundations, walls, floors, columns, beams, roads, bridges, dams, and many other structures[11]. It can also be used decoratively in architectural elements, such as exposed aggregate finishes or stamped patterns.

It's important to note that different types of concrete are formulated for specific purposes, such as high-strength concrete, self-compacting concrete, or lightweight concrete [12]. The composition and proportions of the mixture can be adjusted based on the desired characteristics and requirements of the project.

Pipe Pile

A pipe pile, also known as a steel pipe pile, is a type of deep foundation element used in construction to support heavy vertical loads or resist lateral forces. It is essentially a long, cylindrical steel pipe that is driven into the ground to transfer structural loads from the superstructure to the underlying soil or rock strata[13]. Here are some key points about pipe piles:

A. Material: Pipe piles are typically made of high strength, welded, or seamless steel pipes. The steel used is chosen for its durability, strength, and resistance to corrosion.
B. Types of Pipe Piles: There are two main types of pipe piles: open-ended pipe piles and closed-ended pipe piles [14].
C. Open-ended pipe piles: These piles have an open bottom and are driven into the ground using impact hammers or vibratory equipment. They rely on the friction between the soil and the pile for load transfer.
D. Closed-ended pipe piles: These piles are capped at the bottom, and the load is transferred through the base of the pile [15]. Closed-ended pipe piles are often filled with concrete to enhance their structural capacity.
E. Installation: Pipe piles are installed using pile-driving equipment, such as a hydraulic hammer or vibratory hammer [5]. The pile is driven into the ground by repeatedly lifting and dropping the hammer or vibrating it to reduce friction and facilitate penetration into the soil.
F. Load Transfer: The load is transferred from the structure to the pile and then to the soil or rock strata through a combination of end-bearing and skin friction [2].
G. End-bearing: In cohesive soils or when the pile reaches a hard stratum, such as rock, the pile transfers load primarily through the end-bearing [16]. The load is supported by the resistance generated at the pile's tip.

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H. Skin friction: In granular soils, the load transfer is mainly through skin friction. The rough surface of the pile and the surrounding soil generate frictional resistance that helps support the load[17].
I. Design Considerations: The design of pipe piles considers various factors, including structural load requirements, soil conditions, and site-specific considerations. Factors such as pile diameter, thickness, steel grade, and pile spacing are determined based on the anticipated loads and site conditions [18].
J. Applications: Pipe piles are commonly used in various construction projects.
K. Building foundations: Pipe piles support high-rise buildings, bridges, industrial structures, and other large structures [19].
L. Marine structures: They are used in the construction of piers, wharves, docks, and offshore structures, where they provide stability and resistance against lateral forces.
M. Retaining walls: Pipe piles can be used as elements of retaining walls to provide support and stability against soil pressure [9].
N. Infrastructure projects: They are utilized in constructing transportation infrastructure, including bridge foundations and roadways.
O. Pipe piles offer several advantages, such as high load-carrying capacity, suitability for various soil conditions, ease of installation, and resistance to environmental factors.

Please note that pipe piles' design and installation requirements can vary depending on the project and local regulations [20]. Consulting with a structural engineer or foundation specialist is recommended for detailed design and implementation.

3. Method

For this research, the required data sources are primary data. This research was conducted in Indonesia. Preliminary data were obtained from site surveys and documentation, a data collection technique using data from testing concrete. The location of Ratapan Ibu Bridge can see in Figure 2.

Figure 2. Location Of Ratapan Ibu Bridge, Payakumbuh, Padang
(Source: Google Earth)

4. Result and Discussion

Ratapan Ibu Bridge used Pipe Pile for the foundations. Pipe Piles must have concrete on their pipe for a strong foundation. We must know the situation with the concrete on the pipe pile for good quality concrete. To check the concrete set in a pipe pile, you can perform the following steps:
A. Wait for the appropriate curing time: The setting time of concrete can vary depending on factors such as the type of cement used and environmental conditions. Generally, concrete reaches the

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initial set within a few hours but takes longer to achieve its full strength. Refer to the cement manufacturer's guidelines or project specifications to determine the expected curing time.

B. Perform a visual inspection: After the expected curing time has passed, visually inspect the exposed portion of the concrete in the pipe pile. Look for any visible changes in the concrete's appearance, such as transitioning from a fluid-like consistency to a solid state. The concrete should no longer appear wet or exhibit any signs of fluid movement.
C. Conduct a finger test: Use a gloved hand or a finger to touch the concrete surface gently. If the concrete has correctly set, it should resist indentation, and your finger should not leave any significant impression or feel wet. However, exercise caution and avoid applying excessive force to prevent damage to the concrete.
D. Consider temperature monitoring: Temperature can affect the setting time of concrete. If accurate tracking of the concrete set is critical, you may use temperature sensors embedded in the concrete or surface temperature readings to assess the curing progress. Temperature monitoring can provide more precise information about the concrete's internal state.
E. Seek professional testing: For critical projects or when precise information about concrete sets is required, it is advisable to engage professional concrete testing services. They can perform the Vicat, penetration resistance, or maturity tests to evaluate the concrete's setting and strength development.
F. It's important to note that the curing process continues beyond the initial set, and concrete gains strength over time. For load-bearing applications or when further construction activities are planned, ensure the concrete has reached the required strength before proceeding.

Always consult project specifications, follow relevant standards and guidelines, and consider engaging professionals to assess and test concrete set in pipe piles accurately.

5. Conclusion

For this research, freeze-thaw tests were carried out on saturated concrete samples as recommended by relevant codes. However, in real-world conditions, most dam sections during their operational phase are unsaturated. There exists a critical saturation level that leads to freeze-thaw failure. This study's main findings focused on capillary water absorption of unsaturated concrete in a low-temperature environment. A simplified concrete dam model was developed using an integrated approach combining laboratory tests, numerical inversion, feedback verification, and engineering prediction. This model utilized a concrete specimen with a suitable water absorption surface regarding shape and geometric characteristics. The model was used to determine and propose a prediction method for the distribution of saturation levels.

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