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THE WATER TO CEMENT RATIO IS A KEY ASPECT IN AN AUTOMATED MOISTURE CONTROL SYSTEM

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Concrete is an artificial building material composed of cement, water, and aggregates such as sand, gravel, or crushed stone. This material is used for the construction of building structures and components due to its properties of strength, durability, and moldability. The process of making concrete involves mixing cement, water, and aggregates in specified proportions, followed by compacting and curing the resulting mixture.

The water to cement ratio is defined as the ratio of the mass of water to the mass of cement in concrete and plays a crucial role in its characteristics. In the context of an automated moisture control system, it becomes a key aspect in ensuring optimal conditions for the curing of concrete.

Undesirable water can be added in a concrete batch either by mistake or deliberately during the manufacturing process, transportation and placement of concrete.

Manufacturers must adhere to ASTM C94 standards [1], which state that the water added to the batch should be measured by volume using a volumetric tank or water meter with an accuracy of ±1% of the design total mixing water. There are many ways of addition of extra water in the concrete mix, which cause change in the designed specification of concrete. The extra source of water in the concrete is as follows:

- the extensive way of water addition in the concrete is from aggregates. The aggregate moisture causes significant variation in the mixing water content. If the aggregates are stored in the outdoor environment then rain and sun exposure can cause water variation. Therefore, it is important to monitor the water content of aggregate constantly to ensure the accurate water to cement ratio because aggregates contain the largest volume in concrete mix design;
- in the construction site, concrete is accepted based on the slump level or visual consistency. After loading the material in the truck, the operator does the visual inspection and slump test. After that the truck is allowed to go to the desired place the distance might change the workability of the concrete because of the hydration process or heat. Therefore, truck driver added water in the truck to ease their work but it should be done under the supervision of expert or the best way is to add superplasticizer to get the desired slump on construction site;
- addition of water on the construction site is also the cause of variation in the water to cement ratio. Water is added in the concrete to get the desired workability.

- another source of unwanted water in concrete is the repeated use of same concrete truck. After pouring the concrete on the construction site, the truck owner washes his truck to remove the old concrete. This process allows the large volume of water staying at the bottom of the drum. Therefore, when the concrete truck returns to the plant to be loaded again, the volume of water remains at the bottom and causes the variation in the water to cement ratio.

Water to cement ratio is one of the reliable parameters to determine the porosity of matrix and strength of the concrete. The factors affecting the strength of the concrete are degree of hydration, admixture, specimen parameter, aggregate size and moisture condition [2]. Pores within the material also affect the strength of the material because air voids does not provide the resistance against force and cause cracks. Comparing two materials one with denser porosity will have greater strength as compared to the other which has more pores. In most materials, an inverse relation between porosity and strength of solid exists as defined in equation:

$$S=S_0 \cdot e^{-kp}$$

Where: S is the compressive strength of the material,

p is the porosity,

k is constant

S_0 is an intrinsic strength at zero porosity.

The optimal water to cement ratio is crucial for achieving the required strength and durability of concrete, as well as managing its moisture during the drying process. An automated moisture control system provides a reliable mechanism for monitoring and regulating this parameter, which is essential for the quality formation of the concrete structure and preventing potential issues such as cracks or deformations.

This system will be able to consider changes in internal and external factors, such as temperature, air humidity, and other factors affecting concrete moisture. Automated regulation will allow maintaining the optimal water to cement ratio, promoting quality uniformity, and ensuring stability in material properties.

Such an approach will enable the preservation of efficiency and quality in building constructions, reducing the risks of damage or loss of strength. Thus, highlighting the role of the water to cement ratio in the context of an automated moisture control system underscores the importance of this parameter in achieving optimal results in construction and material preservation.

References

1. ASTM C94/C94M, Revision 22A – Standard Specification for Ready-Mixed Concrete.

2. Workability of Concrete – Types and Effects on Concrete Strength. [Electronic resource]. – 2023. – Retrieved from https://theconstructor.org/concrete/workability-of-concrete-types-strength/11739/