TECHNICAL PAPER

Reducing the Water, Cement, and Carbon Intensity of Concrete with Reclaimed Water

Executive Summary

The handling and discharge of reclaimed water is an onerous operational burden for concrete producers and carries substantial environmental impacts. It is produced through the periodic cleaning of equipment such as concrete trucks and mixers. The reclaimed water comprises the water used in the cleaning process and materials removed by the washing, particularly fine particles of sand and suspended solids (binder, actively hydrating cement, and hydration products).

Reuse of the water in new concrete production has been limited because of the negative material performance impacts associated with the water chemistry and properties; the effects intensifying with increasing concentration of suspended solids and variability of age of these solids.

However, this waste material can be used as a beneficial additive to concrete by profiting from the cementitious properties of the suspended solids, if variability can be reduced.

CarbonCure Technologies has developed a method of treating the reclaimed water with CO_2 to stabilize the cementitious solids, mitigating the effects of age by inhibiting hydration of the resident cement in the reclaimed water. This treatment allows for improved consistency and predictability of reclaimed water solids reactivity, and higher levels of reclaimed water reuse. This allows the user to replace virgin cementitious materials in new concrete production with the stabilized solids from the reclaimed water.

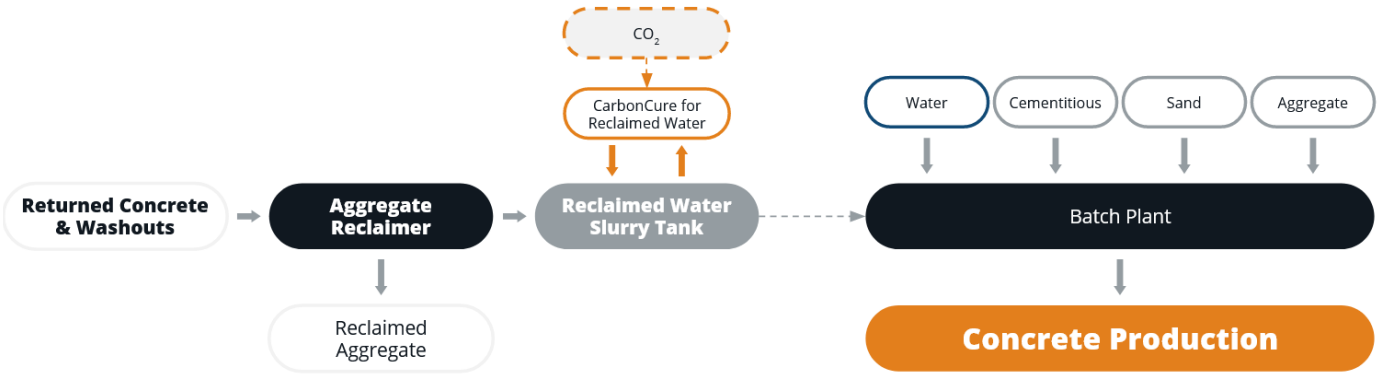


Figure 1: CarbonCure for Reclaimed Water process integration at the concrete plant

System Installation

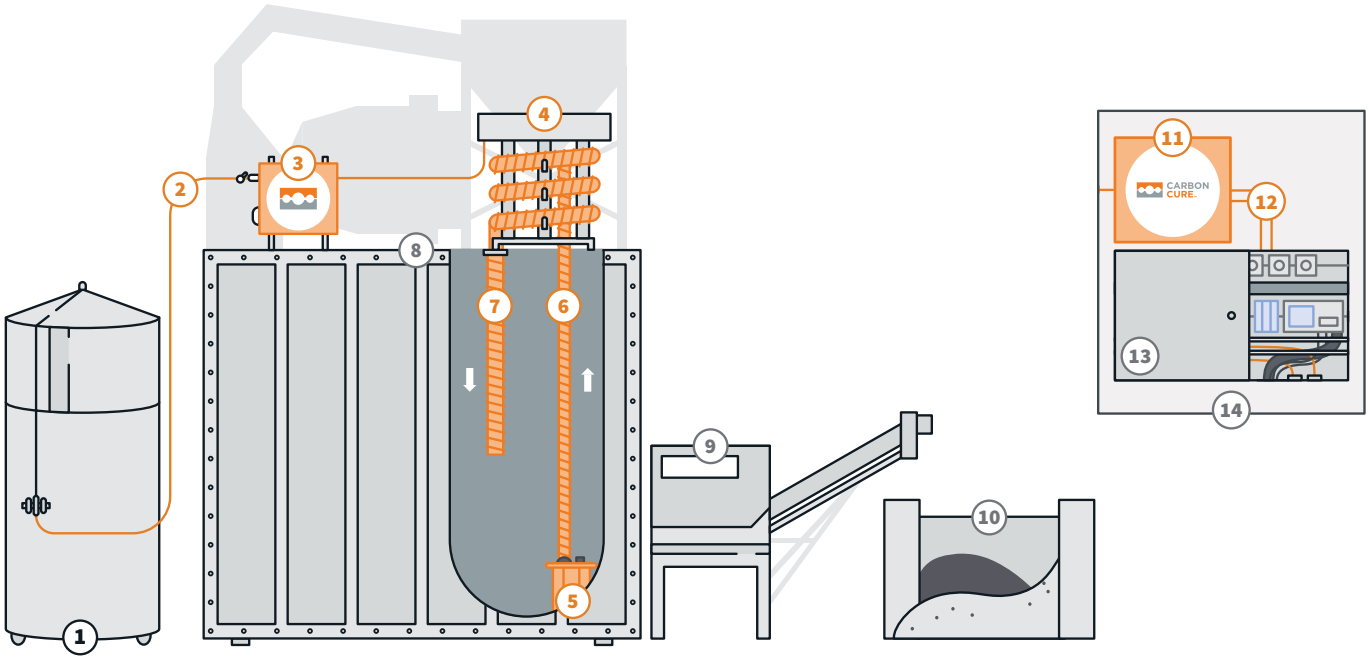
CarbonCure designs and assembles the system based on the producer's specifications and retrofits to their reclaimer. See Figure 2 below.

The reclaimer process does not change, the only difference is the CO_2 injection loop that will be added. The system will be monitored in real-time using telemetry to ensure that all the systems are functioning properly and that the desired amount of CO_2 is being added to the reclaimed water.

System monitoring provides an additional benefit to the producer by providing daily and seasonal insights into the operation and management of the reclaimer equipment. Monitoring also provides tracking of operational trends at the concrete plant such as reclaimed water usage, reclaimed water solids disposal, the influx rate of new reclaimed water solids, and the amount of carbon dioxide utilized.

Carboncure for Reclaimed Water Installation schematic

1. **CO_2 Tank** Sized according to anticipated CO_2 usage
2. **Gas CO2 Transfer Line**
3. **CarbonCure Valve Box**
4. **Reclaimed Water Treatment System**
5. **Slurry Pump**
6. **Slurry Infeed Pipe**
7. **Treated Slurry Return**
8. **Reclaimed Water Slurry Tank**
9. **Aggregate Reclaimer**
10. **Reclaimed Aggregate**
11. **CarbonCure Control Box**
12. **Process Monitoring Sensors**
13. **Reclaimer Control Panel**
14. **Reclaimer Control Room**



Orange: Supplied by CarbonCure
Grey: Supplied by Concrete Producer
Black: Supplied by CO_2 Supplier

Figure 2: Schematic of the CarbonCure reclaimed water treatment system

Commercial Pilot:

TRIO READY-MIX

The system has been implemented at a ready mix concrete plant in Victoria, British Columbia, Canada with the treated reclaimed water being used in a variety of concrete mixes across a range of strength classes and binder loadings. The present discussion concerns the performance of one mix design where the concrete was tested for fresh properties, setting time and compressive strength. This mix design had a design strength of 30 MPa (4,351 psi) at 28 days and did not have entrained air (target 1 to 4% air). Two cases for comparison were considered. Treated wash water was used in each case but different mix design strategies for the reclaimed water use were pursued.

Control

The 'business as usual' case used reclaimed water as a component of a blended mix water (fresh water and reclaimed water) with a nominal specific gravity of 1.03 or lower.

- The slurry solids are present at <1 wt% by mass of the virgin binder.
- The binder is not adjusted in relation to the solids loading of the reclaimed water.

2 to 4% Replacement

Reclaimed water is used as a component of a blended mix water with a nominal specific gravity of 1.04 to 1.05.

- The mix design is adjusted to use the reclaimed water solids as a partial replacement for the cement.
- For a calculated mass of reclaimed water solids incorporated into the mix a corresponding mass of solids were replaced: 0.7 units of cement and 0.3 units of sand.
- The adjustment saved 2 to 4% of the virgin cement.

The fresh concrete was assessed via on-site measurement of slump, temperature, air content and setting time. The concrete was then cast into cylinders for compressive strength testing at seven and 28 days. All sample preparation and testing adhered to the relevant ASTM standards. This comparison comprises five control batches and 10 batches with 2 to 4% replacement, collected during the period of March-June 2021. A third-party testing company, EXL Engineering verifed all slump, air, and strength tests.

Results

Concrete Performance: Fresh Properties

Results for the slump, air content and temperature are shown in Figure 3 through Figure 5. The slump was consistent between all tested conditions with an average of 120 mm (4.7 inches) in the control case and 115 mm (4.5 inches) in the 2 to 4% replacement case. The air content was in the acceptable range for a non air mix, which showed no impact from the added reclaimed water. Since concrete temperature can be greatly influenced by ambient temperature, a smaller dataset was selected for this comparison. A date was selected where both comparative conditions were batched. The data consists of one control batch and four batches with 2 to 4% replacement. It can be seen that the concrete temperature was not impacted by increased addition of reclaimed water.

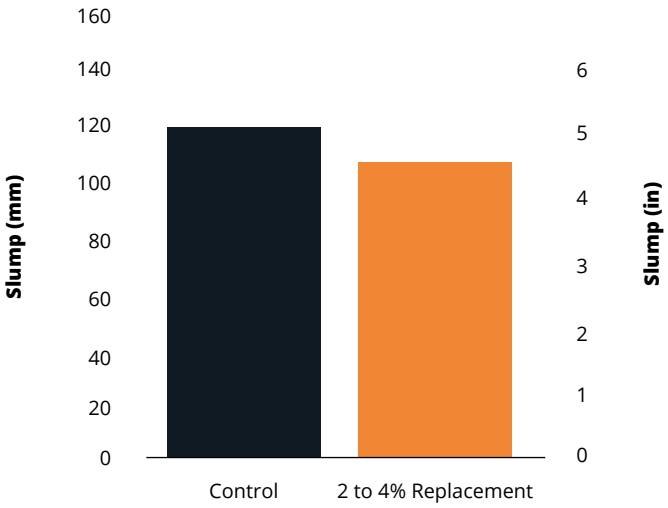


Figure 3: Slump comparison for concrete made with treated reclaimed water

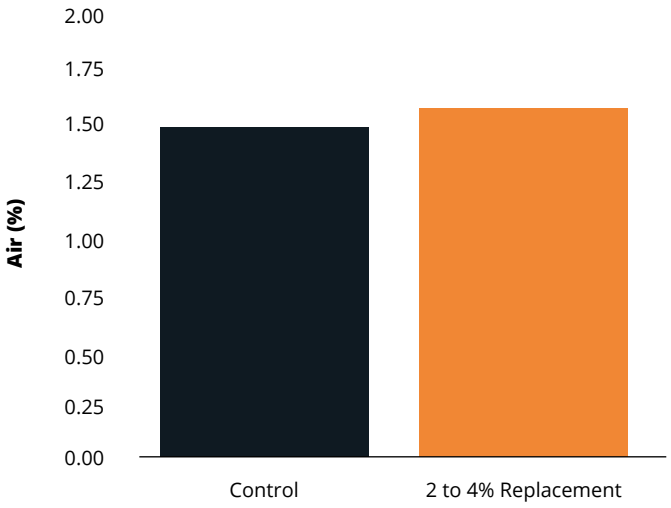


Figure 4: Air content comparison for concrete made with treated reclaimed water

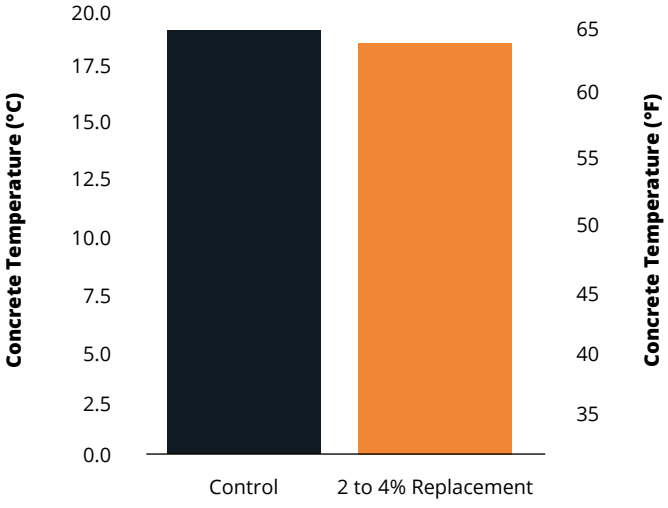


Figure 5: Concrete temperature for concrete made with treated reclaimed water

Concrete Performance: Setting Time

The setting time testing compared a control sample and a sample containing treated reclaimed water with 2.2% replacement of virgin materials by reclaimed water solids.

Results for the setting time testing can be seen in Table 1.

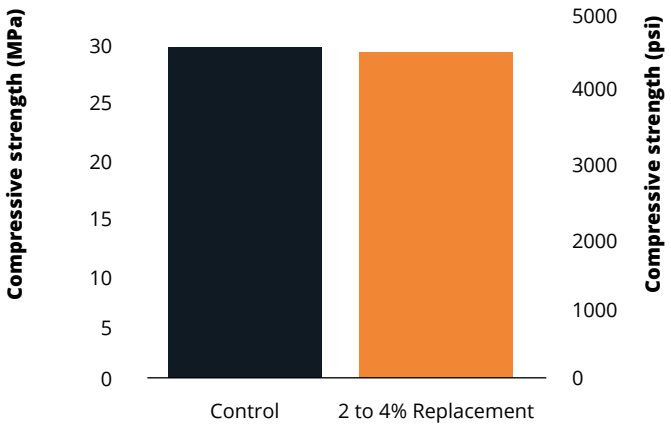
	Control	2.2% Replacement
Initial set (min)	366	373
Final set (min)	495	507

Table 1: Comparison of initial and final set for concrete made with treated reclaimed water

The results show little difference between the set times of the two conditions with the final sets within 12 minutes of each other.

Concrete Performance: Compressive Strength

Compressive strength results are summarized in Figure 7. The compressive strength of batches with a 2 to 4% replacement are comparable to the control mixes. This indicates that the CO_2 treated reclaimed water solids are a viable replacement for virgin cement.



Conclusion

Concrete was examined using reclaimed water to create a blended mix water with specific gravity of 1.04 to 1.05. The concrete was compared to reference concrete that used less reclaimed water to have the blended mix water specific gravity below 1.03. The quantity of solids contained in the reclaimed water were leveraged to act as a replacement for both virgin cement and fine aggregate. The fresh properties were consistent between the two conditions. The slump, air and concrete temperature was not impacted by the increased use of CO_2 treated reclaimed water.

CarbonCure for Reclaimed Water presents a viable solution to the handling and discharge challenge of reclaimed water faced by concrete producers. By treating reclaimed water with CO_2, CarbonCure is able to stabilize the residual cement leading to improved consistency and predictability.

To learn more about CarbonCure for Reclaimed Water, visit carboncure.com/reclaimed-water or get in touch:

- **info@carboncure.com**
- **+1 (844) 407-0032 (toll-free)**
- **+1 (902) 442-4020 (worldwide)**