



Ready-Mix Concrete Technology System

Brad Vickers, PEng
Director of Engineering, CarbonCure Technologies

EXECUTIVE SUMMARY

CarbonCure Technologies ready-mix concrete system sequesters waste carbon dioxide into ready-mix concrete to improve the compressive strength of concrete and reduce the environmental footprint during the manufacturing process. This system can be easily integrated into any ready-mix concrete facility with no disruption to ordinary production. Concrete producers can use the CarbonCure system to improve their concrete products in any ready-mix concrete application with no impact on the concrete mix batching time or fresh properties.

CARBONCURE TECHNOLOGIES READY-MIX CONCRETE SYSTEM

The CarbonCure Technologies (CCT) ready-mix system consists of five main components:

1. Valve enclosure
2. Human Machine Interface (HMI)
3. Programmable Logic Controller (PLC)
4. Injection nozzle
5. Telemetry

The valve enclosure houses the piping configuration of the CCT ready-mix system and is connected directly to the carbon dioxide (CO₂) supply vessel. Solenoid valves permit the flow of CO₂ into the concrete, and pressure and temperature sensors are used to meter the flow of CO₂ as it leaves the system. The system is supplied with both gas and liquid CO₂. The CO₂ gas is used to pressurize the system prior to liquid injection, and to purge out liquid CO₂ in the piping configuration at the end of injection. Once the liquid CO₂ leaves the CCT system, it phase changes to a mixture of gas and solid CO₂ due to the drop in pressure. Although liquid CO₂ is used to supply the CCT ready-mix system, it is actually the solid CO₂ (aka snow) that comes into contact with the concrete and is carried into the ready-mix truck. A mounted and installed valve enclosure is presented in figure 1 at an existing customer's ready-mix plant.



Figure 1: Valve enclosure mounted next to CO₂ supply vessel.

The HMI is the touch screen interface between the CCT system and the batcher, allowing the batcher to view the system during operation, navigate through existing alarms, and adjust system settings. The PLC is the brains of the operation and controls the inputs and outputs of the system. The PLC and HMI are housed in the same enclosure, which is mounted in the batch house of ready-mix concrete plants. Figure 2 shows the HMI/PLC enclosure mounted inside a customer's batch office.

CCT READY-MIX CONCRETE SYSTEM



Figure 2: HMI/PLC enclosure (top left) mounted in customer batch office.

The injection nozzle location varies depending on whether the customer has a central mixer operation or a dry-batch operation. In the case of a central mixer, a fixed CO₂ nozzle is installed at the loading end of the mixer so that CO₂ is injected directly into the central mixer. In the case of a dry-batch operation, a fixed CO₂ nozzle is positioned in the loading boot adjacent to the cement pipe to inject the CO₂ directly into the ready-mix truck. Figure 3 shows the location for the injection nozzle at existing CCT customer's locations for a central mixer plant (left) and dry batch plant (right). A rubber extension is installed on the injection nozzle to reduce build up and increase the length of the injection nozzle.



Figure 3: Location of injection nozzle in a central mixer application (left) and dry batch application (right).

The telemetry system allows CCT staff to take control of installed CCT ready-mix systems to diagnose issues in real time. CCT staff can also gather and monitor sensor data to ensure the system is operating properly and can address problems before they impact the production of the ready-mix plant. The CCT system gathers data of system usage and CO₂ dosages, which can be used by the customer to determine the reduced environmental impact of their concrete products since adopting the CCT ready-mix system. The telemetry system is housed in the HMI/PLC enclosure and its antenna is mounted on top of this enclosure.

INTEGRATION AND INSTALLATION REQUIREMENTS

The first step in the installation process is to source a supply of CO₂ by contacting local suppliers. Local CO₂ suppliers can assist in the selection of CO₂ supply depending on the customer's monthly concrete production and CO₂ demand. Generally micro-bulk, mini bulk or bulk tanks are specified for CCT customers. Bulk tank installation requires a concrete pad to support the tank. Once the CO₂ vessel is installed on the customer's site, the valve enclosure is mounted within ten feet of the CO₂ vessel and the HMI/PLC enclosure is mounted in the batch house. A control cable is run between the HMI/PLC and valve enclosures to allow communication with each other. Steel braided, smooth bore transfer hoses supply the valve enclosure with both gas and liquid CO₂. A steel braided, smooth bore discharge hose delivers the metered CO₂ from the valve enclosure to the injection nozzle. This hose is insulated and covered with foil tape to reduce heat transfer.

The CCT ready-mix system integrates with the customer's batching system in the same manner as other admixtures. The CCT system acts as a direct feed admixture and doses CO₂ in real-time once approximately 75% of the cement content has entered the central mixer or ready-mix truck.

The recommended integration and installation procedure for producers is as follows:

1. Contact a local supplier to arrange a CO₂ supply and tank installation.
2. If a bulk tank is selected, pour a concrete pad that meets specifications and dimensions provided by the CO₂ supplier as close to the truck loading area as possible.
3. Mount the valve enclosure within 10' of the CO₂ supply and mount the HMI/PLC enclosure in the batch office. Provide 120VAC, 15A power to each enclosure.
4. Run the control cable between the valve enclosure and the HMI/PLC enclosure.
5. Ensure there is an open input and output card in the admixture panel for integration into the existing batching system. An open window on the manual station is also required.
6. Supply two 18 gauge wires from the admixture panel to the HMI/PLC enclosure, one is used to turn the CCT system on when batching and the other is to receive pulses from the CCT system.
7. Run both transfer hoses from the CO₂ supply to the valve enclosure.
8. Run and insulate the discharge hose from the valve enclosure to the injection location.
9. Mount the injection nozzle on the loading end of the central mixer in central batch applications or inside loading boot for dry-batch applications. CCT staff will give guidance on where to mount the nozzle when on-site.
10. Add CO₂ into customer batching software and adjust batching sequence as required.

After the CCT ready-mix system has been installed, a commissioning trial is required to determine the optimum dosage of CO₂ for selected mix designs. Typically, customers select their most popular residential and light commercial mixes to test with the addition of CO₂, comparing control samples to a range of CO₂ dosages to find which dose delivers the optimum strength improvement. The optimum dosage is dependent on both the materials and apparatus of injection. The dosage ramp requires a single truck for each mix design being tested. The batcher loads the truck without the addition of CO₂ and a control sample is collected from the truck. After which a dosage of CO₂ is injected directly into the ready-mix truck with an additional discharge hose and injection apparatus. Another sample is collected and tested and is labeled as the low dosage of CO₂. This injection process is repeated two more times until samples are collected for a control, low dosage, medium dosage, and high dosage of CO₂. The commissioning trial injection apparatus (left) and a typical dosage response (right) are presented in figure 4.

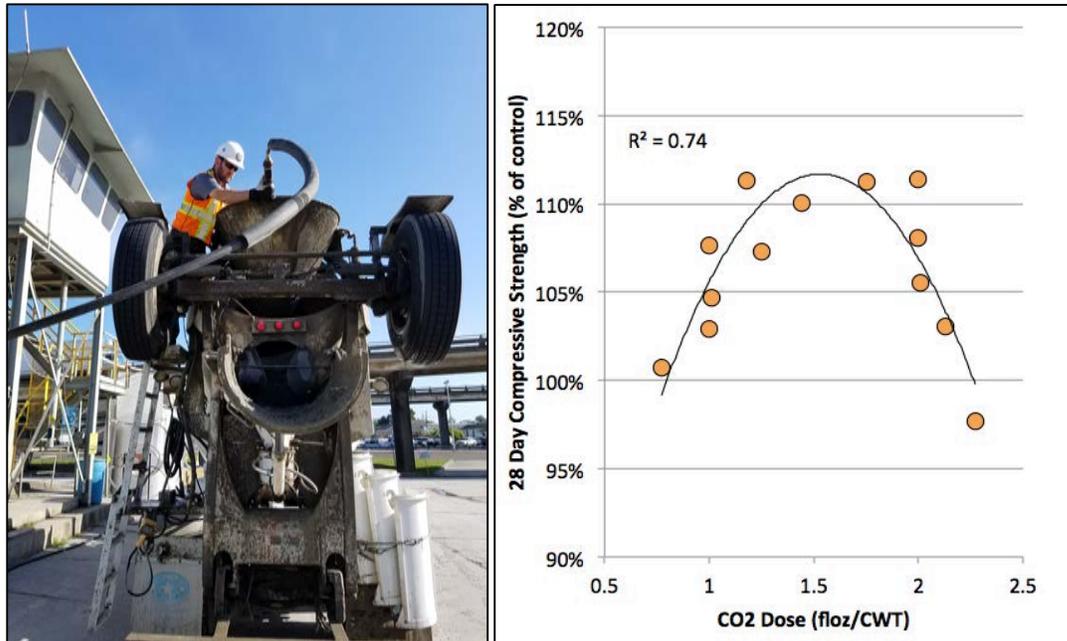


Figure 4: Trial injection apparatus (left) and typical dosage response for a CCT ready-mix system commissioning trial (right).

USING THE CARBONCURE READY-MIX SYSTEM

The typical sequence of events to treat a load of concrete with CO₂ is as follows:

1. A ticket for CarbonCure ready-mix concrete is sent to the batcher.
2. The ready-mix truck driver aligns his truck under the loading boot and the producer's batching system communicates with the CCT system to determine the weight of CO₂ required for that specific truck based on the optimum dosage that was selected during the commissioning trial. This optimum dosage is entered into the mix design in the same manner as other admixtures.
3. For dry-batch operations, the dose is added directly to the truck after the cement discharge. For central mixer operations, the dose is injected directly into the central mixer. The CO₂ injection does not add time to normal concrete mix batching times.
4. The truck leaves from under the loading boot and proceeds to the job site as normal with no change to the concrete's fresh properties.
5. The HMI displays alarms that may arise during the injection process with instructions on how to alleviate them (i.e. low-pressure readings, faulty valves, etc.). CCT staff can be contacted at any time to assist with these issues and can gain remote access to the system for troubleshooting.

SUMMARY

The CarbonCure Technologies ready-mix system requires minimal work on the producer's end to integrate into their existing plants and allows the producer to inject carbon dioxide into any ready-mix truck. The integration process can be done quickly with no disruption to regular production. Carbon dioxide injections take place in the loading area and do not impact regular concrete mix batching times or fresh properties. With the use of CarbonCure Technologies ready-mix systems, producers can create a concrete product that has a greater compressive strength development and reduces the negative impact that the manufacturing of concrete has on the environment.