CLAIMS

1. A print head for extruding a cementitious composition, the print head comprising a feed barrel, a print head nozzle, a CO_2 supply, a steam supply, a selective valve assembly in communication with the CO_2 supply and the steam supply, a plurality of dual use extrusion head injectors, and a print head controller, wherein:

the feed barrel is oriented and shaped to receive the cementitious composition and to direct the cementitious composition to the print head nozzle;

the selective valve assembly communicatively couples the CO_2 supply and the steam supply to the dual use extrusion head injectors for the selective injection of CO_2 and steam from individual ones of the dual use extrusion head injectors;

the plurality of dual use extrusion head injectors is positioned downstream of the print head nozzle for selective injection of CO_2 and steam into the cementitious composition extruded from the print head nozzle; and

the print head controller is operatively coupled to the selective valve assembly and is programmed to execute a CO_2 and steam injection protocol where steam is exclusively selected for injection by the dual use extrusion head injectors into the cementitious composition as it is extruded from the print head nozzle to enhance a hydration reaction and formation of hydroxide in the cementitious composition before CO_2 is exclusively selected for injection by the dual use extrusion head injectors into the cementitious composition as it is extruded from the print head nozzle to enhance a carbonation reaction in the cementitious composition.

2. The print head for extruding a cementitious composition of claim 1, wherein the print head controller is programmed to execute the CO_2 and steam injection protocol to establish an alternating and repeating sequence of steam and CO_2 injection into the cementitious composition.

3. The print head for extruding a cementitious composition of claim 2, wherein:

the alternating and repeating sequence of steam and CO_2 injection into the cementitious composition comprises periods of steam injection in the sequence that are

larger than periods of CO_2 injection in the sequence, at equal steam and CO_2 flow rates; and

the periods of steam injection are between 3 and 5 times larger than the periods of CO_2 injection.

4. The print head for extruding a cementitious composition of claim 3, wherein the periods of steam injection are 2.0 minutes and the periods of CO_2 injection are 0.5 minutes.

5. The print head for extruding a cementitious composition of either claim 3 or 4, wherein the periods of steam injection are 2.0 minutes, at a flow rate of 10 ml/min, and the periods of CO_2 injection are 0.5 minutes, at a flow rate of 10 ml/min.

6. The print head for extruding a cementitious composition of any one of claims 2-5, wherein the alternating and repeating sequence of steam and CO_2 injection comprises a series of injection-free periods of duration t in the alternating and repeating sequence of steam and CO_2 injection, and wherein the duration of individual ones of the injection-free periods is between 0 sec and 20 sec.

7. The print head for extruding a cementitious composition of claim 6, wherein the duration of individual ones of the injection-free periods is less than 10 sec.

8. The print head for extruding a cementitious composition of any one of claims 2-7, wherein the alternating and repeating sequence of steam and CO_2 injection comprises a series of steam injection periods of duration t_{H20}, a series of $_{CO2}$ injection periods of duration t_{CO2}, and a series of injection-free periods of duration t_0, satisfying the following relations, at FWHM:

$$t_{H2O} \geq t_{CO2} \geq t_0;$$
$$0\ sec \leq t_{H2O} \leq 180\ sec;$$
$$0\ sec \leq t_{CO2} \leq 60\ sec; \text{ and}$$
$$0\ sec \leq t_0 \leq 20\ sec.$$

9. The print head for extruding a cementitious composition of any one of claims 3-8, wherein the periods of steam injection and the periods of CO_2 injection are characterized by equal flow rates.

10. The print head for extruding a cementitious composition of any one of claims 2-9, wherein:

the dual use extrusion head injectors are positioned to selectively inject CO_2 and steam into the cementitious composition downstream of the print head nozzle; and

the dual use extrusion head injectors are positioned to selectively inject CO_2 and steam into the cementitious composition from positions that at least partially surround an extruded column of cementitious composition.

11. The print head for extruding a cementitious composition of any one of claims 2-10, wherein the selective valve assembly comprises independent valve assembly components dedicated to respective ones of the CO_2 supply and the steam supply, or an integrated valve assembly unit in communication with the CO_2 supply and the steam supply.

12. The print head for extruding a cementitious composition of any one of claims 2-11, wherein the CO_2 supply and the steam supply comprise pressurized gas containers, pressurized supply lines, or a combination thereof.

13. A 3D printing architecture comprising a 3D print head positioning framework and the print head of any one of claims 1-12, wherein the print head is mounted to the 3D positioning framework for 3D movement of the print head nozzle.

14. The 3D printing architecture of claim 13, wherein:

the 3D printing architecture further comprises a source of cementitious material in communication with the feed barrel of the print head; and

the extruded cementitious composition and the CO_2 and steam injection protocol are configured such that the extruded cementitious composition is self-supporting at NTP.

15. The print head for extruding a cementitious composition of any one of claims 1-12, further comprising an extrusion head injector cover positioned around the plurality of dual use extrusion head injectors to minimize the loss of CO_2 and steam to the atmosphere, and optionally a screed bar positioned downstream of the extrusion head injector cover and the print head nozzle to form the cementitious composition.

16. A print head for extruding a cementitious composition, the print head comprising a feed barrel, a print head nozzle, a CO_2 supply, a steam supply, a selective valve assembly in communication with the CO_2 supply and the steam supply, a plurality of dual use extrusion head injectors, and a print head controller, wherein:

the feed barrel is oriented and shaped to receive the cementitious composition and to direct the cementitious composition to the print head nozzle;

the selective valve assembly communicatively couples the CO_2 supply and the steam supply to the dual use extrusion head injectors for the selective injection of CO_2 and steam from the dual use extrusion head injectors;

the dual use extrusion head injectors are positioned downstream of the print head nozzle for selective injection of CO_2 and steam into the cementitious composition extruded from the print head nozzle; and either

the print head controller is operatively coupled to the selective valve assembly and is programmed to execute a CO_2 and steam injection protocol where steam is selected for injection by the dual use extrusion head injectors into the cementitious composition as it is extruded from the print head nozzle to enhance a hydration reaction and formation of hydroxide in the cementitious composition before CO_2 is selected for injection by the dual use extrusion head injectors into the cementitious composition as it is extruded from the print head nozzle to enhance a carbonation reaction in the cementitious composition, or

the dual use extrusion head injectors are positioned to selectively inject CO_2 and steam into the cementitious composition from positions that at least partially surround an extruded column of cementitious composition.

17. A method of extruding a cementitious composition from a print head comprising a feed barrel, a print head nozzle, a CO_2 supply, a steam supply, a selective valve assembly

in communication with the CO_2 supply and the steam supply, and a plurality of dual use extrusion head injectors, wherein:

the feed barrel is oriented and shaped to receive the cementitious composition and to direct the cementitious composition to the print head nozzle;

the selective valve assembly communicatively couples the CO_2 supply and the steam supply to the dual use extrusion head injectors for the selective injection of CO_2 and steam from individual ones of the dual use extrusion head injectors;

the plurality of dual use extrusion head injectors is positioned downstream of the print head nozzle for selective injection of CO_2 and steam into the cementitious composition extruded from the print head nozzle; and

the method comprises operating the selective valve assembly to select steam for injection by the dual use extrusion head injectors into the cementitious composition as it is extruded from the print head nozzle to enhance a hydration reaction and formation of hydroxide in the cementitious composition, and to subsequently select CO_2 for injection by the dual use extrusion head injectors into the cementitious composition as it is extruded from the print head nozzle to enhance a carbonation reaction in the cementitious composition.