SELF-GROWING CONCRETE STRUCTURAL SYSTEM

WITH AUTONOMOUS MATERIAL DELIVERY, CONTROLLED STRUCTURAL EXPANSION, AND REPEATABLE STRUCTURAL INTEGRATION

FULL PATENT SPECIFICATION DRAFT

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ABSTRACT

A self-growing concrete structural system is disclosed for selectively increasing the dimensions, load-carrying capacity, functional volume, or structural continuity of a concrete structure after an initial construction stage. The system includes an original concrete structural body having one or more predetermined growth zones, material-delivery pathways, structural interfaces, and optionally distributed sensors. A control unit determines a growth requirement based on a predefined schedule, measured structural condition, predicted loading demand, user instruction, or combinations thereof. A structural growth material is delivered to a selected growth zone through an internal channel, external supply interface, replaceable reservoir, pumping system, or additive placement mechanism. The growth material is formed within a controlled boundary and integrated with the original structure through reinforcement continuity, mechanical interlocking geometry, shear-transfer surfaces, chemical bonding, embedded connectors, or combinations thereof. After curing or setting, the expanded region is evaluated using one or more structural verification procedures. The system can perform multiple growth cycles, thereby enabling a concrete member, building, foundation, bridge component, wall, slab, column, or other structural assembly to grow, strengthen, repair, or adapt over time.

1. TECHNICAL FIELD

The disclosure relates to concrete structures, structural materials, smart construction, autonomous infrastructure and controlled structural expansion. More particularly, it relates to an engineered structural architecture configured to increase physical dimensions or structural capacity after initial construction by selectively adding and integrating new structural material into predetermined or dynamically selected growth zones.

2. BACKGROUND OF THE INVENTION

Conventional concrete structures are normally constructed to substantially fixed dimensions and capacities. When additional capacity or space is required, conventional practice may require demolition, reconstruction, jacketing, separate extensions, replacement or major strengthening. These interventions can be costly, disruptive and difficult to integrate into the existing load path. The present concept treats future enlargement as an intentionally engineered structural function by providing growth zones, material-delivery infrastructure, controlled formation boundaries and structural integration interfaces from the beginning of the structural life cycle.

3. PROBLEM ADDRESSED

The invention addresses technical challenges including future structural enlargement, localized capacity upgrading, controlled addition of new structural material, reliable load transfer between original and newly formed regions, repeatable growth cycles, post-growth verification and retention of a structural growth history.

4. SUMMARY OF THE INVENTION

In one embodiment, the system comprises an original structural body, one or more growth zones, at least one material supply interface, a delivery network, a structural growth material and a structural integration interface. A growth zone may comprise a void, cavity, recess, expandable cell, external attachment region or other region configured to receive new material. A controller, operator or predefined schedule selects a target growth zone. Structural material is then pumped, injected, cast, extruded, robotically placed or otherwise introduced. The material is formed within a controlled geometry, integrated with the original structure and subsequently verified. The procedure may be repeated to create multiple generations of structural growth.

5. STRUCTURAL SYSTEM ARCHITECTURE

The system may contain five functional layers: (a) a Structural Base Layer including the original concrete load path; (b) a Growth Layer containing growth cells or interfaces; (c) a Material Delivery Layer containing supply ports, reservoirs, pumps, valves and channels; (d) a Control Layer containing manual, programmable or computational decision functions; and (e) a Verification Layer containing sensors, inspection ports and testing procedures.

6. DETAILED DESCRIPTION — ORIGINAL STRUCTURE

The original structure may be cast in place, precast, modular or composite. During manufacture, predetermined growth zones can be reserved. Growth zones may be distributed through a member or located at critical structural regions. The original body may contain projecting reinforcement, couplers, embedded plates, shear keys, roughened surfaces, ducts, channels, removable boundaries or combinations thereof to support later growth.

7. DETAILED DESCRIPTION — GROWTH MATERIAL

The growth material may be selected from concrete, high-performance concrete, ultra-high-performance concrete, fiber-reinforced concrete, geopolymer concrete, structural mortar or another compatible cementitious composite. Material selection may consider strength, shrinkage, thermal response, durability, workability, bond characteristics and environmental exposure.

8. DETAILED DESCRIPTION — MATERIAL DELIVERY

A main delivery channel may connect an external or internal material source to one or more distribution channels. Pumps, pressure sources, gravity systems, robotic placement equipment, extrusion devices or additive manufacturing heads may introduce material. Valves may isolate individual growth zones. Venting and pressure-monitoring elements can assist controlled filling.

9. DETAILED DESCRIPTION — CONTROLLED FORMATION

A growth zone may include permanent boundaries or temporary formwork that define the final geometry. Material sensors may monitor filling, temperature, pressure, moisture or curing state. A growth operation may enlarge a wall, slab, beam, column, foundation, bridge member or other structural component.

10. DETAILED DESCRIPTION — STRUCTURAL INTEGRATION

Structural integration may be achieved through reinforcement continuity, mechanical couplers, headed bars, embedded connector plates, roughened interfaces, shear keys, interlocking geometry, bonding layers, post-tensioning elements, fiber bridging or combinations thereof. The interface is engineered so that the newly formed region becomes a load-carrying continuation of the original structural system.

11. GROWTH DECISION AND MONITORING

Growth may be initiated manually, according to a schedule, according to measured structural demand, or by computational analysis. Sensors may measure strain, cracking, acoustic response, temperature, humidity, pressure, displacement, corrosion state, electrical response or ultrasonic response. A decision system may prioritize growth zones according to structural demand, predicted loading, deterioration, environmental conditions or available material resources.

12. VERIFICATION AND REPEATABLE GROWTH

After curing or setting, the system may perform verification through sensor comparison, load testing, geometric measurement, ultrasonic evaluation, acoustic monitoring or other suitable procedures. The structural record may be updated. The same or another growth zone may subsequently be activated, enabling repeated cycles of BUILD → MONITOR → GROW → INTEGRATE → VERIFY → GROW AGAIN.

13. EXAMPLE EMBODIMENTS

Example 1: A reinforced concrete column includes circumferential growth cells that receive high-performance material when additional axial capacity is required. Example 2: A foundation mat includes peripheral growth corridors to enlarge bearing area or stiffness. Example 3: A building frame includes reserved external growth interfaces for future expansion of walls, slabs and columns. Example 4: A bridge member includes a growth region for increasing section depth or stiffness. Example 5: An emergency shelter contains compact structural cells that can be expanded by controlled material delivery. Example 6: A remote construction platform is designed as a structural seed capable of repeated enlargement using locally available or transported material.

14. INDUSTRIAL APPLICABILITY

The system may be applied to buildings, bridges, tunnels, foundations, retaining structures, marine infrastructure, industrial facilities, temporary shelters, modular cities and remote construction environments. Potential advantages include planned future expansion, reduced reconstruction, targeted capacity upgrades, repeatable adaptation, integrated monitoring and preservation of an engineering history for each growth stage.

15. TECHNICAL DRAWINGS

The following patent-style technical drawing sheet illustrates the overall concept, internal architecture, growth cycle, material delivery network, interlock interfaces, reinforcement connections, monitoring arrangement and example applications.

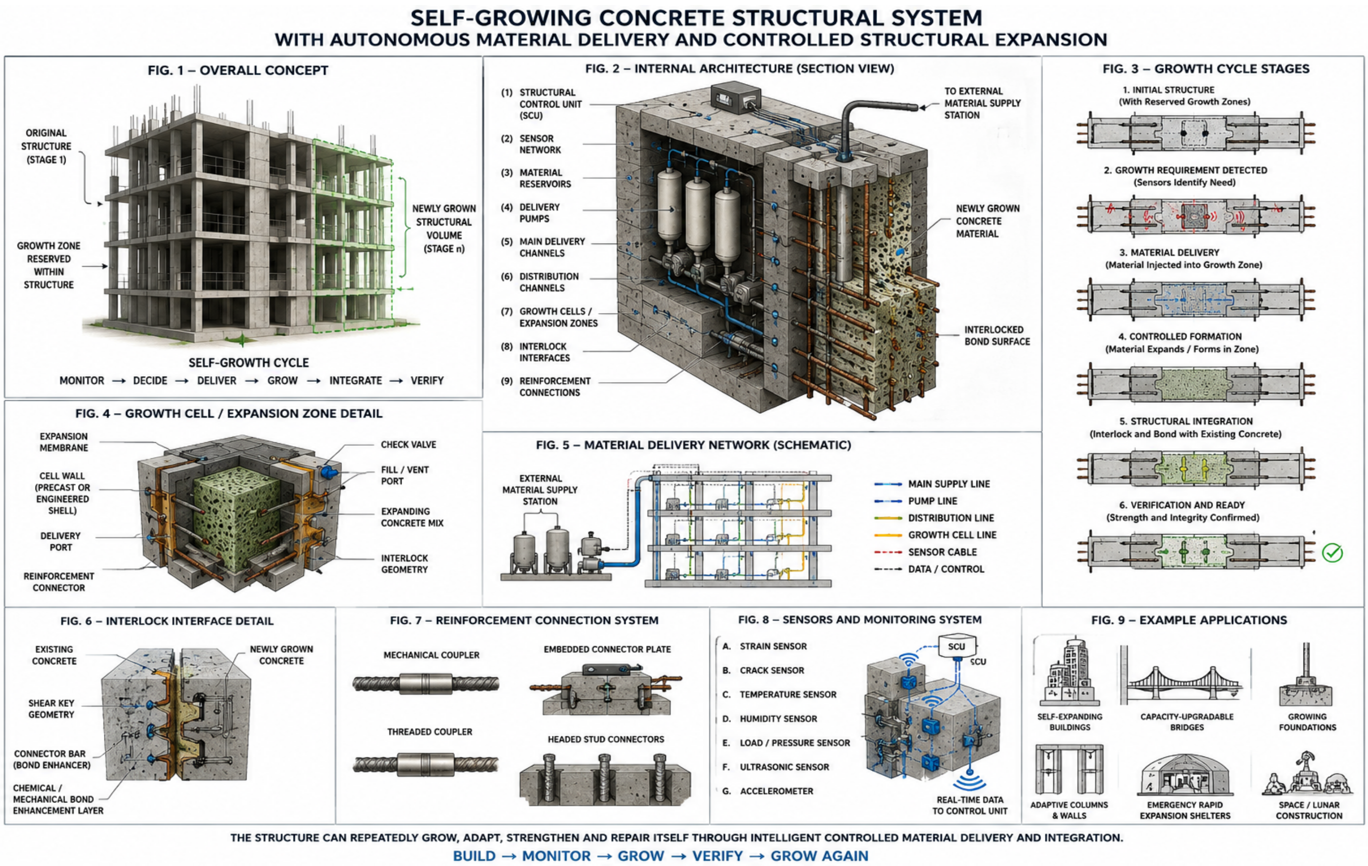

Figure Description

FIG. 1: Overall self-growing structure concept. FIG. 2: Internal architecture with sensors, reservoirs, pumps and growth zones. FIG. 3: Sequential growth cycle. FIG. 4: Expansion cell detail. FIG. 5: Material delivery network. FIG. 6: Interlocking interface. FIG. 7: Reinforcement connection system. FIG. 8: Sensor and monitoring system. FIG. 9: Example applications.

16. CLAIMS

1. A self-growing concrete structural system comprising an original structural body comprising concrete, at least one predetermined structural growth zone, at least one structural material supply interface, and at least one structural integration interface configured to transfer structural load between the original structural body and structural material subsequently introduced into the structural growth zone, wherein the structural growth zone is configured to receive the subsequently introduced structural material and thereby increase at least one physical dimension or structural capacity of the system.

2. The system of claim 1, wherein the structural growth zone comprises a cavity, recess, void, cellular region, external attachment region, or a combination thereof.

3. The system of claim 1, further comprising a material delivery pathway extending from the material supply interface to the structural growth zone.

4. The system of claim 3, wherein the material delivery pathway comprises a main channel and a plurality of selectively controllable distribution channels.

5. The system of claim 1, wherein the structural material comprises concrete, fiber-reinforced concrete, high-performance concrete, ultra-high-performance concrete, geopolymer material, mortar, or a combination thereof.

6. The system of claim 1, wherein the structural integration interface comprises mechanical interlocking geometry.

7. The system of claim 6, wherein the mechanical interlocking geometry comprises one or more shear keys.

8. The system of claim 1, wherein the structural integration interface comprises reinforcement extending between the original structural body and a subsequently formed structural region.

9. The system of claim 8, wherein the reinforcement is connected through a mechanical coupler, threaded coupler, embedded connector plate, headed connector, or combination thereof.

10. The system of claim 1, further comprising a controlled boundary configured to define a geometry of the subsequently formed structural region.

11. The system of claim 10, wherein the controlled boundary is permanent.

12. The system of claim 10, wherein the controlled boundary is temporary and removable after the structural material has developed a predetermined property.

13. The system of claim 1, further comprising at least one sensor configured to measure a structural or material condition.

14. The system of claim 13, wherein the at least one sensor measures strain, cracking, acoustic response, temperature, humidity, pressure, displacement, corrosion state, electrical response, ultrasonic response, or combinations thereof.

15. The system of claim 13, further comprising a processing unit configured to determine a growth requirement from sensor data.

16. The system of claim 15, wherein the processing unit selects a target growth zone according to predicted structural demand.

17. The system of claim 15, wherein the processing unit generates a structural growth priority for a plurality of growth zones.

18. The system of claim 1, wherein the structural material supply interface is connected to an external material supply station.

19. The system of claim 18, wherein the external material supply station is detachable from the structural body.

20. The system of claim 1, wherein the structural material is introduced by pumping, injection, casting, extrusion, additive placement, robotic placement, or combinations thereof.

21. The system of claim 1, further comprising a valve arrangement configured to selectively isolate individual growth zones.

22. The system of claim 1, wherein the original structural body comprises a column, beam, slab, wall, foundation, bridge member, or combination thereof.

23. The system of claim 1, wherein the structural system is configured to perform multiple sequential structural growth cycles.

24. The system of claim 23, wherein a structural record is updated after each structural growth cycle.

25. The system of claim 1, further comprising a verification system configured to evaluate a condition of the subsequently formed structural region.

26. The system of claim 25, wherein the verification system compares a post-growth response with a pre-growth baseline response.

27. The system of claim 25, wherein failure to satisfy a verification criterion causes an inspection indication or an additional structural treatment.

28. A method of growing a concrete structure comprising providing an original concrete structural body containing a predetermined growth zone, determining a requirement for structural growth, selecting the growth zone, supplying structural material to the growth zone, forming the structural material within a controlled geometry, structurally integrating the formed material with the original concrete structural body, and verifying the resulting structural condition.

29. The method of claim 28, wherein determining the requirement for structural growth comprises processing data from one or more embedded sensors.

30. The method of claim 28, wherein determining the requirement for structural growth comprises predicting a future load demand.

31. The method of claim 28, wherein structurally integrating the formed material comprises engaging reinforcement connectors and mechanical interlocking geometry.

32. The method of claim 28, further comprising repeating the method to create a plurality of sequentially grown structural regions.

33. A concrete structural member comprising an original concrete region and at least one subsequently formed concrete region, wherein the subsequently formed concrete region occupies a growth zone intentionally reserved during formation of the original concrete region and is structurally connected to the original concrete region through at least one engineered load-transfer interface.

34. The structural member of claim 33, wherein the engineered load-transfer interface comprises a combination of mechanical interlocking and reinforcement continuity.

35. A foundation system comprising the structural system of claim 1 and configured to increase a bearing footprint or structural stiffness through addition of structural material to one or more peripheral growth zones.

36. A building system comprising a plurality of structural systems of claim 1 arranged so that structural growth of one or more members increases usable structural volume or load-carrying capacity.

37. A bridge system comprising the structural system of claim 1, wherein at least one growth zone is configured to increase section dimensions or stiffness of a bridge member.

38. A computer-implemented structural growth control method comprising receiving structural condition information, identifying a candidate growth operation, selecting a growth zone, selecting a growth material or material formulation, initiating or authorizing material delivery, and storing verification information after structural integration.

17. PATENT DEVELOPMENT NOTICE

Before any filing, the concept should undergo a targeted prior-art search and patentability assessment. The strongest final application should be based on a specific technically novel implementation, supported by detailed engineering embodiments, calculations, prototypes or test data where appropriate. Jurisdiction-specific filing requirements and claim strategy should be reviewed by a qualified patent professional.