Novel 3d – printing for Civil Engineering

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Abstract: The construction industry is undergoing a significant shift toward technological advancement and 3D printing is one of the groundbreaking technologies leading the way. 3D printing technologies a widely protected by many patents, mainly in USA & China. Petrone's team are focusing on the integrity and performance of structures built using 3D-printed LEGO-like concrete modules.
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The construction industry is undergoing a significant shift toward technological advancement and 3D printing is one of the groundbreaking technologies leading the way. 3D printed homes, which once seemed like science fiction and futuristic concepts have now been materialized into reality. In this blog, we'll explore how 3D printing works, its benefits, challenges, and future potential. The third industrial revolution started at the end of the 20th century when computers and automation technologies emerged and when the internet and mobile devices were invented. Now, we are living in the era of the fourth revolution. Smart machines and interconnected systems are being created due to the remarkable reliance on emerging technologies such as artificial intelligence and the development of 3D printing technology

3D printing technologies a widely protected by many patents, mainly in USA & China: below the are described novel patents, published out only in 2014 year.

WO2024238914 (A1) - COMPOSITION AND PRODUCTION METHOD FOR 3D PRINTING CONSTRUCTION MATERIAL

A composition of 3D printable photocurable material can include acrylate monomer(s) between about 0-30.0 composition wt%; acrylate oligomer(s) between about 0-30.0 composition wt%; photoinitiator(s) between about 0.02-1.0 composition wt%; chopped fiber(s) between about 0.1-3.0 composition wt%; flame retardant(s) between about 2.0-20.0 composition wt%; processing aid(s) between about 0.05-3.0 composition wt%; additive(s) between about composition 0-3.0 wt%; and filler(s) between about 20.0-80.0 composition wt%.
The composition can have a viscosity of about 10,000-300,000 mPa·s, can be configured to be extruded at a printing speed of about 7-90 cm^3/s during 3D printing, can be photopolymerized under UV or visible irradiation at a material depth of about 4-8 mm, and can be cured to form a building construction material.

WO2024237926 (A1) - 3D-PRINTED INTEGRATED WALL PANEL ASSEMBLY

A 3D-printed integrated panel, assembly, or other building element configured to form part of an overall building can include 3D-printed panels, connectors, and load transfer components. 3D-printed panels can be integrally formed by 3D printing technology using a photocurable composite material. A 3D-printed panel can include an

outer frame shell defining a geometric shape having interior and exterior outer surfaces, side edges therebetween, and an infill structure there within, the infill structure forming internal cavities within the outer frame shell. Connectors can couple 3D-printed panels to each other and/or to separate building components of the overall building. Load transfer components can be coupled to and transfer loads across 3D-printed panels. Waterproofing elements can be coupled to 3D-printed panels, and thermal insulation material can be disposed within the internal cavities. The panel, assembly, or other building element can comply with building construction standards. Panels or assemblies can include wall panels.

US2024376710 (A1) - 3D-PRINTED INTEGRATED BUILDING PANEL SYSTEMS

A 3D-printed integrated building panel system configured to form a portion of an overall building can include 3D-printed building panels, connectors, and one or more load transfer components. Each 3D-printed building panel can be formed by 3D printing technology using a photocurable composite material, and at least a portion of the 3D-printed building panels can be integrally formed. The connectors can be coupled to one or more of the 3D-printed building panels and can couple the 3D-printed building panels to each other and/or to one or more separate building components of the overall building. The load transfer component(s) can be coupled to at least a portion of the 3D-printed building panels and can transfer loads across the 3D-printed building panels. The load transfer component(s) can be configured to form at least a portion of an overall super structure for the overall building.

US2024360668 (A1) - COMPOSITION AND METHOD FOR PRODUCTION OF A 3D PRINTED EARTH WALLS, NOZZLE AND MIXING SYSTEM FOR 3D PRINTING DEVICE PERFORMING SAID METHOD

A method for production of a 3D printed earth wall includes steps of:a) preparing a building composition (1), b) preparing a construction area (2), c) compacting the building composition (1), d) providing the building composition (1) in a form of an elastic rod (R) forming a first layer (L1) of the 3D printed earth wall (3) to the predetermined construction area (2) by a 3D earth wall printing device (4), e) repeating step d) for building further layers (L2 to LX) of the 3D printed earth wall (3) according to a specific construction design, f) curing the constructed printed earth wall (3), wherein the cross section of the rod (R) forming each layer of the building composition (1) is substantially rectangular. The nozzle for a 3D earth wall printing device comprises an inlet end (16) and a compacting end (17), wherein the compacting end (17) has a tapering shape which, together with the building composition (1) being supplied at an equivalent pressure (based on standard and modified Proctor tests), allows for a compaction of the building composition (1) during applying. The mixing system for a 3D earth wall printing device is configured to mix and homogenize the building composition (1) inside the mixing channel (20) using the mixing member (21), provide a homogeneous building composition (1) and to output the mixed homogeneous building composition (1) through the nozzle (15).

WO2024216295 (A2) - CONTINUOUS VAT POLYMERIZATION FOR THREE-DIMENSIONAL PRINTING

A system for constructing an article by 3D vat photopolymerization printing is disclosed comprising: a vat having a transparent bottom surface, wherein the vat is configured to hold a photopolymer resin; a building platform configured to elevate upwardly relative to the vat; an objective lens disposed below the transparent bottom surface of the vat; a radiation source disposed below the objective lens and configured to radiate through the objective lens to the vat for curing the photopolymer resin; and the system is configured to produce a continuously changing photomask image that is projected to the photopolymer resin in the vat as the building platform is elevated during 3D printing. The radiation source may comprise: an LCD photomask and a LED disposed. The objective lens and LCD photomask may be configured to move during a printing process as the building platform is moving.

ZA202205295 (B) - COMPOSITION SUITABLE FOR 3D PRINTING

The invention pertains to a composition which is suitable for 3D printing, which composition comprises - a polyester derived from an aliphatic polyol with 2-15 carbon atoms and an aliphatic polycarboxylic acid with 3 to 15 carbon atoms, the polyester having an extent of polymerization, which is the ratio of the fraction of functional groups that have reacted to the maximum of those functional groups that can react, of at most 0.6, - solid filler, - diluent. The invention further pertains to a method for preparing a shaped object comprising the steps of - providing a composition as described herein, - extruding the composition through a printer nozzle to form a layer of the composition in a desired shape, building up the layers onto each other to form a shaped object, - subjecting the shaped object to a curing step to form a cured shaped object, wherein the curing step takes place during and/or after the extrusion step. The shaped object is also claimed.

CN221774804 (U) - 3D printing equipment for building industry

The utility model discloses 3D printing equipment for the building industry, which comprises a horizontally placed supporting base, a freely movable three-axis mounting frame is mounted above the supporting base, a printing head is mounted at the position of a transverse axis at the upper end of the three-axis mounting frame, a printing platform of a rectangular structure is mounted at the middle position above the supporting base, and the printing platform is mounted on the supporting base. And a separating mechanism is arranged on the front side of the supporting base, and the printed product is separated through the separating mechanism, so that the bottom face of the printed product is separated from the upper surface of the printing platform. According to the 3D printing equipment for the building industry, novel structural design is adopted, the separating mechanism is arranged, after a product (namely a building model) is printed, the product is moved out through the printing platform, the printed product and a separating steel wire move relatively in the moving-out process, at the moment, the printed product is cut through a thin steel wire, and the product is separated through the separating steel wire; therefore, the product is separated from the printing platform, and subsequent operation of workers is facilitated.

CN118706831 (A) - Optical in-situ monitoring device and method for 3D printing concrete interlayer cold joint

The invention provides an optical in-situ monitoring device and method for a 3D printing concrete interlayer cold joint, and belongs to the field of intelligent building construction. The optical in-situ monitoring device for the 3D printing concrete interlayer cold joint comprises a superfine optical module which is arranged in the 3D printing concrete interlayer cold joint and is used for observing the 3D printing concrete interlayer cold joint; the digital photosensitive module is connected with the superfine optical module and is used for emitting visible light into the 3D printing concrete interlayer cold joint through the superfine optical module, receiving a returned optical signal and then converting the returned optical signal into a digital signal; and the terminal computer is connected with the digital photosensitive module and is used for receiving the digital signals and carrying out data processing and result analysis on the digital signals. According to the optical in-situ monitoring device and method for the 3D printing concrete interlayer cold joint, the forming process and the form state of the 3D printing concrete interlayer cold joint can be clearly monitored and observed in real time, and then the forming, evolution, damage and self-healing processes of the cold joint are further evaluated.

US2024316870 (A1) - CONTROL OF WITHDRAWAL MOVEMENT IN 3D PRINTING USING A NEURAL NETWORK

Aspects relates to a 3D printer including a vat having an at least partially transparent bottom for receiving liquid photoreactive resin to produce a solid component; a building platform for holding and pulling out the component layer by layer from the vat; a projector for projecting the layer geometry onto the transparent bottom; a transport apparatus for at least downward and upward movement of the building platform in the tray; and a control device for controlling the projector and the transport apparatus. The control device optimally feed forward controls the pull-off movement of the build platform in the 3D printer using a neural network.

CN221736496 (U) - Rotary discharging device for concrete 3D printing

The utility model belongs to the technical field of rotary dischargers, particularly relates to a rotary discharger for 3D printing of concrete, and aims to solve the problem that the spraying angle is inconvenient to adjust in the prior art, and adopts the following scheme that the rotary discharger comprises a shell, a mounting groove is formed in the shell, and a connecting gear ring is arranged in the mounting groove; an adjusting pipe is fixedly installed on the connecting gear ring, a calling-out mechanism is arranged in the shell and comprises a first motor, the first motor is fixedly connected with the shell, a rotating rod is fixedly installed on an output shaft of the first motor, an arc gear is fixedly installed on the rotating rod, and the arc gear is meshed with the connecting gear ring; a second motor is arranged on the shell, a spiral feeding machine is fixedly connected to an output shaft of the second motor, and an angle adjusting mechanism is arranged in the adjusting pipe. According to the spraying device, the spraying angle can be

conveniently adjusted, a needed building shape can be accurately sprayed, and the spraying device is easy to use and convenient to operate.

CN118639869 (A) - 3D printing concrete construction method based on cooperative work of double unmanned aerial vehicles

The invention discloses a 3D printing concrete construction method based on cooperative work of double unmanned aerial vehicles, based on a building unmanned aerial vehicle and a cruise unmanned aerial vehicle, the building unmanned aerial vehicle forms a required building structure through layer-by-layer stacking of printing strip bundles according to a preset printing path; in the printing process, printing strip pictures are collected in real time through an image collection system integrated on the cruise unmanned aerial vehicle, monitoring results are fed back to the building unmanned aerial vehicle in real time for printing parameter adjustment after the printing strip pictures are processed through an image analysis system, and intelligent monitoring and control over the whole 3D printing process are achieved. The unmanned aerial vehicle technology, the 3D printing technology and the artificial intelligence technology are combined, and the system is particularly suitable for ocean engineering, narrow construction space or complex construction terrain and other special environments where large machines are difficult to enter; meanwhile, through the printing quality real-time regulation and control system based on computer vision, the overall printing quality can be controlled, industrial and intelligent development of the whole construction process is facilitated, and the construction efficiency and the intelligent level of the construction industry can be improved.

CN118617546 (A) - Real-time reducing 3D printing head suitable for lunar surface in-situ construction

The invention relates to the technical field of building 3D printing, and discloses a real-time reducing 3D printing head suitable for lunar surface in-situ construction, which comprises a printing head, an adjusting plate, a supporting piece and a driving device, the top end of the printing head is fixed to a discharging port of the hopper, one end of the driving device is fixed to the pipe wall of the hopper through a supporting piece, and the other end of the driving device is fixed to the adjusting plate. The adjusting plate is used for sleeving the printing head and can be driven by the driving device to linearly move up and down to change the diameter of an outlet of the printing head. The diameter of an outlet of the 3D printing head can be automatically adjusted in real time to change the sectional dimension of an extruded mortar strip, and the sectional dimension of the mortar strip can be controlled by accurately and continuously changing the diameter.

CN118617547 (A) - In-situ building 3D printing system based on Yellow River sand and printing method thereof

The invention discloses an in-situ building 3D printing system based on Yellow River sand and a printing method thereof. The system comprises an aggregate treatment system and a 3D printing robot. The aggregate treatment system is used for collecting Yellow River sand, cleaning and temporarily storing the collected Yellow River

sand and conveying the Yellow River sand to the material mechanism for later use; the 3D printing robot comprises a first moving mechanism, a position sensing mechanism, a material mechanism, a 3D printing executing mechanism, a control mechanism and a first energy supply mechanism. The position sensing mechanism is used for obtaining position information of the 3D printing robot and comparing the position information with a preset stake position to obtain a position deviation; the material mechanism is used for storing the Yellow River sand, mixing the Yellow River sand with ingredients according to the proportion and conveying the mixed material to the 3D printing executing mechanism; the 3D printing executing mechanism is used for conducting 3D printing on the building component according to the specific track. The device can meet the requirements of using local materials along the bank of the Yellow River and using Yellow River sand to print related building in-situ components.

CN221650283 (U) - Nondestructive testing device for 3D printing building

The utility model provides a nondestructive testing device for a 3D printed building. The nondestructive testing device for the 3D printing building comprises a base assembly, the interior of the base assembly is connected with a sliding plate, the upper surface of the base assembly is connected with a first supporting column and a transmission frame, the outer side of the transmission frame is connected with a connecting rod, the connecting rod is sleeved with a fixing assembly, and the outer end of the connecting rod is connected with a stabilizing frame; a base assembly is connected to the lower end of the dust cover, a magnetic strip is arranged on the inner wall of the dust cover, a cabinet door is connected to the outer end of the dust cover, through two independent sets of transmission frames in different directions, the movement route of longitudinal detection and the movement route of transverse detection are separated, and all-directional detection can be achieved; the use range of a detected object can be limited through the size of the upper surface of the sliding plate, scratching of the detector during movement due to the fact that the size of the detected object is too large is prevented, and external sundries can be prevented from entering the detection device through the dustproof cover.

CN221646013 (U) - 3D printing wall frame structure

The utility model discloses a 3D printing wall frame structure, and relates to the technical field of 3D printing, the 3D printing wall frame structure comprises a wall module, a mounting part and a connecting part, the periphery of the wall module is provided with assembling grooves, the assembling grooves are strip-shaped T-shaped grooves, the assembling grooves are used for inserting the mounting part or the connecting part, and the mounting part or the connecting part is connected with the mounting part or the connecting part. The mounting parts are arranged between the two adjacent wall modules and used for connecting the two wall modules, and the mounting parts are arranged at the assembled edge parts of the wall modules. According to the modular wall body structure, the wall body can be freely assembled according to requirements, the two wall body modules can be in butt joint through the connecting parts between the two wall body modules, the wall body and the building frame are connected through the mounting parts, and therefore the two wall body modules cannot be staggered, and the wall body can be conveniently assembled. And meanwhile, the

whole body cannot be disassembled under the limitation of a building frame, so that a whole wall surface is formed, the use flexibility is high, and disassembly and assembly are convenient.

US2024279939 (A1) - FLEXIBLE AUTOMATED PRODUCTION OF THREE-DIMENSIONAL PRINTED BUILDING ELEMENTS

A system for manufacturing 3D-printed building elements can include multiple production stations, some or all of which can be automated stations. Stations can include one or more printing stations, insulation stations, machining stations, and coating stations. Each printing station can have a large-scale 3D-printing system that automatically forms 3D-printed building elements. Each insulation station can automatically place insulation materials into 3D-printed building elements. Each machining station can automatically machine surfaces of 3D-printed building elements. Each coating station can automatically apply coating layers onto 3D-printed building elements. Each station can be configured to receive 3D-printed building elements in a vertical orientation from other stations and can also perform operations on 3D-printed building elements while they are in a vertical orientation. Additional stations can include relaxation, drying, and framing stations.

CN118456594 (A) - Unmanned aerial vehicle 3D printing concrete construction method for complex construction environment

The invention discloses an unmanned aerial vehicle 3D printing concrete construction method for a complex construction environment, based on an unmanned aerial vehicle flight system, a control system and a 3D printing system, the method comprises the following steps: slicing a three-dimensional building model to form a 3D printing operation code, and after the 3D printing operation code is identified by the control system, guiding the unmanned aerial vehicle to fly according to a preset printing path, and meanwhile, a 3D printing system loaded with concrete is controlled to stack and print the strip bundles layer by layer according to set printing parameters to form the needed building structure. According to the efficient construction method for the concrete structure in the complex construction environment, the advantages of an unmanned aerial vehicle technology and a 3D printing technology are combined, the problem that construction is difficult in the special complex environment where large machines are difficult to enter in ocean engineering and narrow working environments or complex topographic conditions can be solved, and the efficient construction method for the concrete structure in the complex construction environment is provided; the industrial and intelligent development of the construction process is facilitated, and the construction efficiency and the intelligent level of the building industry can be improved.

CN118438519 (A) - Concrete 3D printing system and method

he invention provides a concrete 3D printing system and method. According to the concrete 3D printing system disclosed by the invention, a high-fluidity interface reinforcing material is automatically introduced into 3D printing concrete layers, and the use amount is accurately controlled, so that the interlayer bonding strength is greatly improved, interlayer gaps can be automatically filled and an interface can be wetted by virtue of the leveling property of the high-fluidity interface reinforcing material; the

problems that a large-size component is poor in long-time interval wettability and low in interlayer strength are solved. The reinforcing material and the concrete matrix material are separately mixed, so that the original properties of the matrix can be kept, and matching with different matrixes is facilitated. The method has wide applicability to 3D printing of different types of concrete, and has important significance in expanding the application of the concrete 3D printing in the building field.

CN221416922 (U) - Segmented jacking type printing platform for building 3D printing

The utility model relates to the technical field of printing platforms, and discloses a building 3D printing segmented jacking type printing platform which comprises a main body frame, the main body frame comprises a bottom plate, a frame body and a supporting assembly, the frame body is connected with the bottom plate through the supporting assembly, a walking mechanism is arranged at the bottom of the bottom plate, a plurality of jacking plates are arranged at the top of the frame body, and the jacking plates are connected with the bottom plate through the supporting assembly. Jacking mechanisms are arranged at the bottoms of the multiple jacking plates correspondingly. The surface of the printing platform is divided into a plurality of jacking plates capable of independently lifting, the jacking plates are lifted to the same height during printing to form a printing plane, the platform can be moved to a maintenance area after printing is completed, and when the strength of a component meets the carrying condition, part of the jacking plates can be lifted according to the shape of the printed component and the width of fork teeth of a forklift, so that the printing plane is formed. The upper portion of the jacking plate which is not lifted is used as a space for insertion of fork teeth of a forklift, the space is vacated for the fork teeth, the carrying conditions of equipment such as the forklift are met, and therefore carrying work can be completed on the premise that it is guaranteed that printing components are not damaged.

The Army needs a building or bridge for a forward-deployment mission in another country. Shipping a full-scale structure or building materials may not be an option, especially if the mission is in a conflict zone. That’s the basis of a current research project led by Civil & Environmental Engineering Assistant Professor Floriana Petrone and Associate Research Professor Sherif Elfass in collaboration with the U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) and supported by the U.S. Department of Defense.

Petrone and her team are focusing on the integrity and performance of structures built using 3D-printed LEGO-like concrete modules. The team’s experimental program, which began in early 2024, involves testing “bridging infrastructure” they have assembled with 3-foot-long concrete modules they have printed. The bridge was tested and numerically simulated— a computational technique to simulate and analyze real-world systems through mathematical models — to validate the experiments. “We are following a structured approach,” Petrone said, “introducing rigor in the way we approach the printing.” Early work in 3D-printed structures has necessarily been conducted in a trial-and-error — or Edisonian — style, but the University of Nevada, Reno is perfecting a more precise way to test 3D-printed structures.

This work aims to advance the Army's ability to construct needed infrastructure in a conflict zone or area where military operations are taking place. Petrone's project differs from many others in this area in that it combines 3D-printing, segmental construction — building large structures by assembling smaller components — and advanced numerical simulation. Together, these provide a basis for building reliably sound, scalable structures.

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