

The rise in 3D printing is due to a number of factors, including, but not limited to: (i) a push for automation to reduce labor costs in certain markets and to fili#4(ii)ke000000212c00st(1)}fibir@q0a000009ii2 (h6i@a5002 reW*nBT/F1 11 production in k,.00000912 0 612 792 reW592 reW*n29(c)9ns0.0000TETQq0.00000912 0 eW512 792duton

Engagement of the 3D Printing Technology

NAHB members that are interested in using 3D printing technology may engage a company possessing 3D printing technology in several different ways

3D Printing Best Practices

Is the architect or engineer of record involved in integrating the digital information into the 3D pr

Who is responsible to any damage to the 3D Printer while it is transported? While it is on site?

Carefully consider contractor's professional insurance if the builder is directly contracting with the 3D printer; require the subcontractor employing the 3D printing to have professional E&O coverage.

Review with insurance consultant/counsel the need for cyber insurance – whether for the builder, but certainly for the 3D printer

- Review the exclusions in the policy provisions to ensure that the risks for 3D printing are not carved out from the coverage.
- Evaluate the builder's risk policy in particular for coverage for all of the 3D printing aspects of the project. Any off-site construction should be carefully evaluated.
- Warranty Issues and Procedures.
 - Did you engage in pre-construction discussions and agreements to determine who will be responsible for warranty issues for any equipment issues during the course of construction?
 - Develop and maintain a checklist for troubleshooting and addressing any issue that occur during the printing-process.
 - Have a point person set up for warranty issues and an agreed-upon process for what amount of time for any warranty response will be provided.

Labor & Personnel Iwill be proided.

- Determine the necessary nozzle shape and size for the extrudability of the mix by the 3D printer to meet relevant construction standards and design criteria.
- Pre-construction needs must be evaluated for transportation and set up of the equipment at the project site, and any needs for adaptability during the course of construction.
- Emergency contact information if there is a problem during the 3D printing process.
- Have a troubleshooting outline and plan in place before problems occur; a backup plan should be discussed and documented to address breakdowns in the 3D printer, material or supply issues or impacts, and weather impacts.
- Have a safety and preparedness plan in place including utilities and emergency generators to ensure the printing process can continue.

Contract Language

All contracts involving construction that utilize3D printing must include the standard provisions for all other types of construction; however, there are some unique issues that require special consideration in the terms of the agreement. There are multiple types of contracts that will require consideration of how the 3D printing integrates into the project and they will depend on the delivery mechanism for the project. Some of the following issues should be considered and negotiated in the contracting stage when a 3D printing company is involved. In addition, the agreements with the architect and engineer require close examination to ensure a proper allocation of responsibility for the design portion of your project. Additionally, subcontractor and supplier agreements require coordination with other project elements to avoid gaps in scope and to confirm the nuances associated with 3D printed construction work.

Checklist for Contract Language:

- Scope.
 - What are the boundaries of what the 3D printer must do as part of its scope of work: What design confirmation must be made?
 - Who designates the materials to be made and to ensure the printer can accurately generate the consistency of the product (whether it be concrete, plastic, etc.)?
 - Identify the required physical properties of the 3D printed elements.
- Roles and responsibilities of the parties.
 - State and describe the role and responsibility of each of the parties to the project.
 - Clearly identify what contracts and agreements establish the details of each party's responsibilities.
 - Quality control over off-site production.
 - o Details regarding interfacing with other construction materials and building elements.
- Deliverables.
 - Define the specific deliverables for each of the parties.
 - Specify the printed objects' intended application, desired detail level, and any specific requirements, and requirements for the 3D printer to comply with project specifications.
- Project timeline, including milestones.
 - Tie in the 3D printed work with the overall project timeline.
 - Define milestones and delay issues.
 - Risk of loss (e.g., delay of delivery, or damage or destruction while in transit from the manufacturing site to the project site).
- Materials and Allocation of Responsibility for the Materials.
 - The agreement must have a delineation of responsibility for compliance with the specifications, in particular, whether the supplier of the concrete mix (or polymers/metals being used for the composite printed material) will bear responsibility to meet the requirements or whether this responsibility sits with the 3D printer or other inspector.

- Also, does the agreement include designation of who is the designer of the concrete mix and if that is the same designer of the overall construction project?
- Terms also must be considered for how to address problems with the printer hardware or software.
- Indemnity.
 - Ensure the indemnity provision provides the builder indemnity by the 3D printer regardless of whether the contract is direct or via a subcontractor.
 - Ensure that the indemnity language is consistent throughout the contracts between the builder, subcontractor, designer, and 3D printer.
 - Verify that the indemnity provision is enforceable under the relevant state law.
 - Confirm the indemnity provision is connected with how the scope of work is divided and that the 3D printing company has agreed to indemnify the necessary upstream parties.
 - Include a separate express defense obligation.
 - Carefully look at the scope of design work and ensure that you can legally obtain the necessary indemnity and defense associated with the design elements.
- Warranty & Repairs.
 - Who is responsible for "rework" costs? Address and consider how the builder will recover "rework" costs if the project owner does not approve of the 3D-printed aspects of the build.
 - What notice and right to cure, if any, will be provided?
 - Consider carefully the timing that needs to be stated and required for warranty work.
 - Disclaimer of warranties consider the language and ensure that it meets the overall allocation of the parties' roles and risk transfer.
 - Include a provision that the builder is not responsible for any misuse, modification, or negligence of the 3D printer, engineers, and/or suppliers.
 - Confirm and delineate the allocation of fault if 3D-printed work products cause harm to someone or damage property and how claims are to be addressed.

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Increas [prevalence of/this emerging/technology will also have an impact on/material/suppliers. If/3D printers/will/be/used/in/a/specific/project,/designers/and/contractors/should/provide/proper specifications for material compatible with the specific 3D printer./Material/suppliers will also have/to certify their materials/as/compatible/ with the/printers. The/developer must/be/aware/and/understand/who/has/the responsibilities/for/these/designations/and comport/these/responsibilities/with carefully crafted contract terms. Failure to/do so could/open designers/and/material/suppliers to liability/for construction/defects resulting/from/the/incompatibility/of/the material/with the specific 3D printer.

The/use/of/3D printers/in/construction projects may/pose/conflicts/with current/licensing/and/permit regulations. The/increas [spe [with which 3D printers can complete/projects could/be/slow [down by/ current inspection requirements/and/inspection scheduling procedures./That said, there is a move/toward/ enacting/regulations, with the/International Code/Council's/recent introduction of/Appendix/AW/to the International/Residential/Code/regarding/3D printing.²/Appendix/AW/provides guidance for/the/3D printed construction industry, using the Underwriters Laboratories' UL 3401/to set/forth/guidelines/for/officials'/ evaluation/of/3D printed construction regarding/both/building/elements/and structures./Builders/must/be vigilant/to check in with the jurisdiction to/determine whether the locale/has/adopted/this section. //

It/ is/ notable/ that an acceptance/ criterion for/ 3D concrete/ walls/ (AC509)/ has/ been/ developed/ under International Building Code ("IBC") Section 104.11, which allows/for/alternative materials, design, and construction methods/provided/that such alternatives meet/the/intent of/the/IBC. How ver, again,/local

- Review and confirm material compatibility.
- Assess any intellectual property issues and releases.
- Confirm the contract terms have been addressed and are coordinated.
- Determine what insurance and risk transfer is required and ensure that these mechanisms have been documented in the contracts.
- Identify the responsibility and evaluation criteria for the 3D-printed work products meeting aesthetic and engineered expectations.

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