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Livable Cities: A Conference on Issues Affecting Life in Cities

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INTRODUCTION

Livable Cities: A Conference on Issues Affecting Life in Cities

What makes a city livable? Transport, housing, health. Open space, mobility and the environment. Matters of culture, entrepreneurship, crime and safety. Affordability and access to education. Depending on whose ‘livability index’ you look at, it may include design quality, sustainability and the digital infrastructures of the smart city. Other criteria applied may encompass food access, job opportunities or walkability. Inclusivity and the politics of participation also come into play. Discrimination in all its forms impacts livability and social and political equity.

The past two decades have seen an exponential rise of livability measures. Reflecting increased urbanity globally, they risk making the notion of the city ever more contested. The two cities that host this event are cases in point. The Mercer Livability Ranking takes New York as the datum by which all other cities globally are graded – as better or worse. London, by contrast, measures itself: the London Assembly scoring everything from air quality to indices of deprivation. When we consider the livability of cities then, it is clear we are dealing with a plethora of issues – both isolated and, inevitably, interconnected.

Responding to this scenario, the papers in this publication tackle these issues above from various angles. They examine how we live in cities, and how every issue we encounter morphs with considerations of others, whether housing, architecture, urban planning, health, IT, crime and safety, city management, economics or the environment.

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OPEN INFILL DESIGN IN CO-CREATION: PRACTICAL STEPS TOWARDS A NEW MODULAR WALL CONCEPT

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INTRODUCTION

Open Building, as conceptualized by John Habraken in the 1960s, implies that residents become facilitated to (re)arrange the layout of their homes in line with their requirements, and without too much effort, while structural architectural elements remain intact.[1] The Open Building philosophy builds on the notion that all residents are different, and so are needs and desires.[2] Dwellings should facilitate this variety and the associated changes through time. This is the foundation of a conceptual and physical divide between *fixed* structural supports and *adaptable* infills of multi-family housing. The fixed structure represents a long-term service life (potentially lasting centuries), whereas the adaptable infill follows shorter term social dynamics (months, years, decades). Changes in the infill domain, through interventions at foreseen and unforeseen moments in time, have a strong material implication, think of adjustments in partition walls, staircases, bathrooms, kitchens, HVAC-installations, and insulation, but also windows or other façade elements. Those products and materials are thus circulating through supply chains – and through the built environment – at rates that may be interesting for circular and regenerative design approaches.[3] From that vantage point, this design-study sets out to establish a prototype for an infill configuration that complies with open and circular principles.

The project-context is a one-year research & design trajectory coined 'Biobased, Inclusive & Circular' (BIC), initiated by Delft University of Technology in close conjunction with partners from design practice and the manufacturing industry. Moreover, the social context driving this innovation is 'Pluspunt' in Rotterdam, the Netherlands. Pluspunt is a social workplace, activation center, and meeting spot for people in Rotterdam with a distance to the labor market, often because of social, psychological, financial, housing or addiction problems. From 2020 to 2024, Pluspunt is developing a former municipal yard in Rotterdam. The old sheds are renovated and rebuilt in line with the current demands and standards, particularly concerning health, comfort, and circularity of material flows. The users of these sheds require appropriate working spaces. In line with the expertise, objectives and planning of the manufacturing partners, the project's contribution was aimed at non-structural inner walls.

OPEN, CIRCULAR CO-CREATION

In an Open Building context, adaptable infill of partitioning walls has a key role in customized interior space-division. The market for such non-bearing walls has seen several interesting innovations over the last years, with both social and environmental gains. However, from a *systems-*

integration perspective, these products are usually suboptimal: the ecological and social performance are seldom assessed adequately. Think for example of material-embedded circularity potential when the wall part is discarded after several years of service: how can that initial potential be safeguarded? This question connects multiple perspectives and disciplines, such as product design, material sourcing, manufacturing, construction, and facility management.

Many building materials and products that could qualify for a circular application face challenges in doing so. This concerns, both, an organizational and a technical challenge. Regarding the latter, there are obstacles related to renewability and health of the material flows, manufacturing processes, joining techniques, and acoustic performance, amongst others. Within the BIC project, a modular wall component is developed that can cope with such challenges. In a co-creative design/research process with the project partners, a proof of concept emerged, based on existing innovations in new configurations. The main research question is formulated as: *How can we generate an interior wall that is based on biotic material flows, performs circularly at material and product level, and has a strong emphasis on engagement, comfort, and health of the end-user?*

The objectives of the project partners overlapped but had diverging accents. For Pluspunt, the *Do-It-Yourself attitude of the target group* was paramount, anticipating engagement of the end-users, as well as the *acoustic performance* and *robustness* of the partitioning wall, relating to the intended use of the wall: functional separation of a (calm) meeting space/café and a (noisy) workspace. The other partners added *material circularity* and *health & Safety* into the mix, both of which imply a high level of purity of the applied resources. This set of objectives underscores the systemic scope, while integrating the manufacturing, operational, and end-of-use stages.

MATERIALISATION

BIC thus focused on developing a healthy and circular materialization for the non-structural partition wall of a multi-functional space. Primary materials in scope related to cellulose fiber panels, mycelium-fiber-composite insulation, and reversible binders. Below, the associated innovations are described.

Cellulose fiber panels

ECOR is a material as much as a platform technology. *ECOR* produces panels made from any pure cellulose fibres through a process that only uses water, heat, and pressure. Moreover, the fibres originate from a myriad of residual flows (such as agriculture, horticulture, food and beverage production, wood and paper industry, textiles). Thus far, the panels were targeted at the furniture sector. However, through a recent innovation step, the construction industry has become a new domain to explore. This innovation was developed in close collaboration with *NIAGA* – a daughter company of DSM Chemicals – and concerns the binding of separate panels with a reversible polyester adhesive to create solid and robust multi-board panels.[4] Figure 1 visualizes the Niaga Ecor Panel (NEP) production process. The raw material for the NEP in our application was post-industry cardboard material.

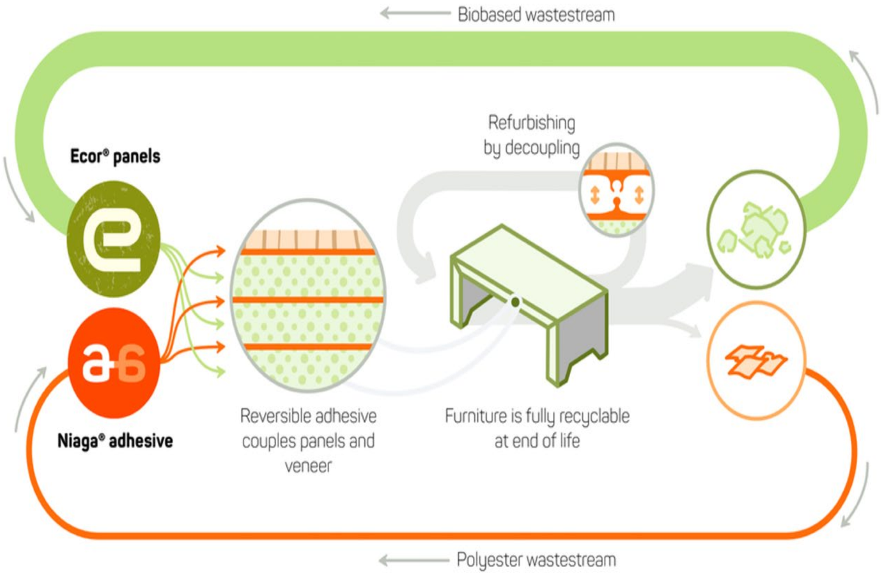

Figure 1. Schematic Niaga Ecor Panel principle, applied to furniture. (Copyright ©Ecor)

Mycelium-fiber insulation

Mycelium concerns the filamentous root-network of fungi. Mycelium strains can be combined with a fibrous substrate to produce boards with favorable insulating properties. For the mycelium-fiber insulation (MFI) two types of primary raw materials are required: fungal mycelium strains combined with cellulose fibers (from biotic – residual – origin). The fibrous residues are cleaned and pasteurized before being introduced to mycelium in standardized molds. The mycelium grows due to its symbiotic relationship with the fibers that feed it, forming a strong yet flexible composite.[5] After the growth is optimal, the process is stopped, and the inert MFI composite panels are dried (Figure 2).

Figure 2. Mycelium Fiber Insulation board drying in the lab.

Detailing

Niaga Ecor Panels and Mycelium-fiber insulation are the two main components for our wall configuration. However, several design challenges had to be dealt with. First, we envisioned a modular system, enabling easy stacking of standardized, lightweight, and foldable 'sandwiches' of

two NEP side panels with the mycelium insulation as filling. Regarding this ‘sandwich’ model, we followed the existing *Quickpanell* cassettes, in terms of both size (40x60x10 cm) and foldability, using a cardboard U-profile on the inside. However, the materials used for the side paneling of *Quickpanell* cassettes are different and so are the positioning and binding of the U-profiles. In our design, the side panels were replaced by NEP and we adjusted the binder for connecting the cardboard U-profile to the NEP. Rather than using a conventional glue, we applied an innovation called CircuGlue. This type of glue is a reversible elastic resin, and (recycled) water-based binder with no added toxic or other harmful substances.[6] The operation is based on the principle of ‘cohesion being greater than adhesion’: making detachments easy by 'kinking' the glued products.[7]
The BIC-innovation comprises the following raw materials:
- post-industrial cellulose fibers + reversible polyester resin type 1 (NEP)
- mycelium strains + post-agricultural cellulose fibers (MFI)
- recycled cardboard fibers + reversible polyester type 2 (Connector)

Finally, positioning the connectors within the “cassettes” needed to be done in alignment with the MFI dimensions and the way in which the cassettes were going to be stacked. This closely connects to the effect that seams have for the acoustic performance, more specifically concerning sound leaks. In the end, MFI boards were placed vertically, to cover all seams once built up in a stacked wall. Figure 3 shows the BIC-module proof of concept.

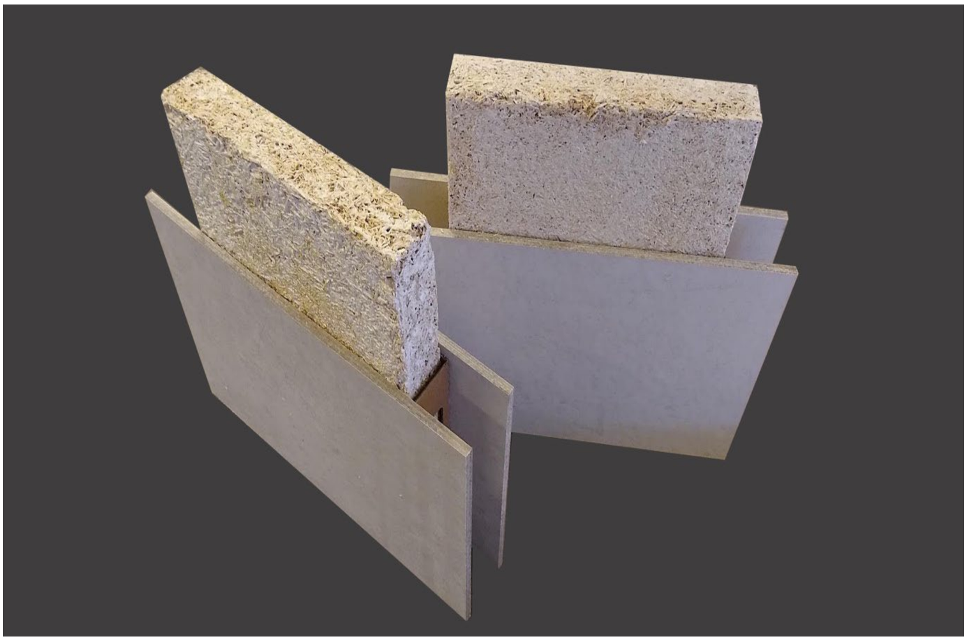

Figure 3. BIC-module proof of concept, first prototypes.

Acoustic testing

Acoustic performance of the wall was identified as an important point of attention, particularly regarding middle and high frequencies, which is linked to the human voice and noise resulting from most daily activity. We focused on ‘sound insulation’ tests, measuring how much noise travels through a wall (or floor, ceiling) to adjoining spaces through airborne or physical impact noise. Our main interest was the airborne acoustic insulation, related to sound waves (speech, music etcetera) transmitted through the air, causing vibrations of the wall element.
This test is conducted in an acoustic test-room at the Faculty of Applied Sciences (Delft University of Technology). We followed the EN-EN-ISO 10140-2 norm: Acoustics – Part 2: Measurement of

airborne sound insulation.[8] Figure 4 shows the set-up in the test-room, and Figure 5 displays the results. On the vertical axis of the graph depicted in Figure 5, sound-reduction levels are represented in decibels (dB), and on the horizontal axis, audio frequencies are represented in hertz (Hz). The sound reduction (Rw) is measured on different points through a series of Hz sound impulses. The numbers indicated in red are linked to the range of common environmental sound perception in the human ear. Highlighted are the numbers for the side panel (NEP of 12,5 mm thickness), the Mycelium insulation, and a combination of the two. As an assembled module of side panels (the 'cassette') and the insulating core, the Rw value is 43. This is a rather high score, relative to comparable wall configurations currently on the market.[9]

Figure 4. Set-up of sound insulation test: EN-EN-ISO 10140-2.

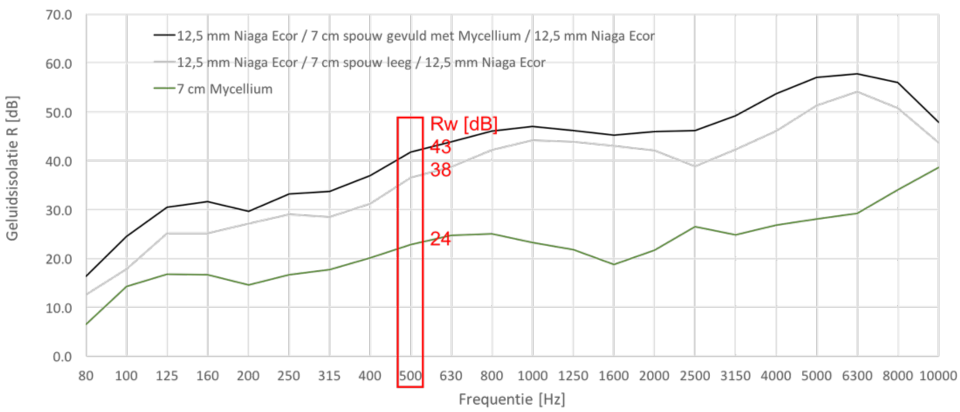

Figure 5. Results of the sound insulation test: EN-EN-ISO 10140-2.

SYSTEM CONSIDERATIONS

The wall module forms a vantage-point to explore other scale-levels in the supply network, whilst unravelling the functional trajectory from origin (raw material extraction) to destination (product in built context). Although much of the production and assembly takes place locally, some raw materials – particularly those relating to the synthetic binders – follow an inherently global market for chemicals. This pinpoints the fact that, despite good intentions and marketing efforts aimed at renewable and local sourcing, reality paints a different picture. Even for rather straightforward and deceptively simple products, such as the one under scrutiny. When zooming into the way raw materials end up in the wall configuration (*Figure 6a, above*) and zooming out again following a – non-specific – spatial grid-model (*Figure 6b, below*), it is illustrated that the smallest parts determine the extent of the spatial footprint or 'catchment area'. This significantly impacts the overall sustainability-potential of the end-product. Figure 6 a & b visualize this phenomenon. The grid represents the spatial range, with the building in question as hyper local point of departure. Extraction, production, wholesale, retail, and transport then take place on the scale of building block, neighborhood, city-region, state, continent, or globe. Generally, embodied aspects become increasingly blurred from view, while "grip" on the associated stakeholders reduces accordingly. This is particularly so in cases where the interest is predominantly in the end-product itself or the building design context. Of course, analytical tools, such as Life Cycle Analysis (LCA), may assist in revealing such barriers. However, these tools are not tailored to guide design and co-creation activities. Moreover, innovative materials are often not accompanied by – nuanced – LCA data.[10]

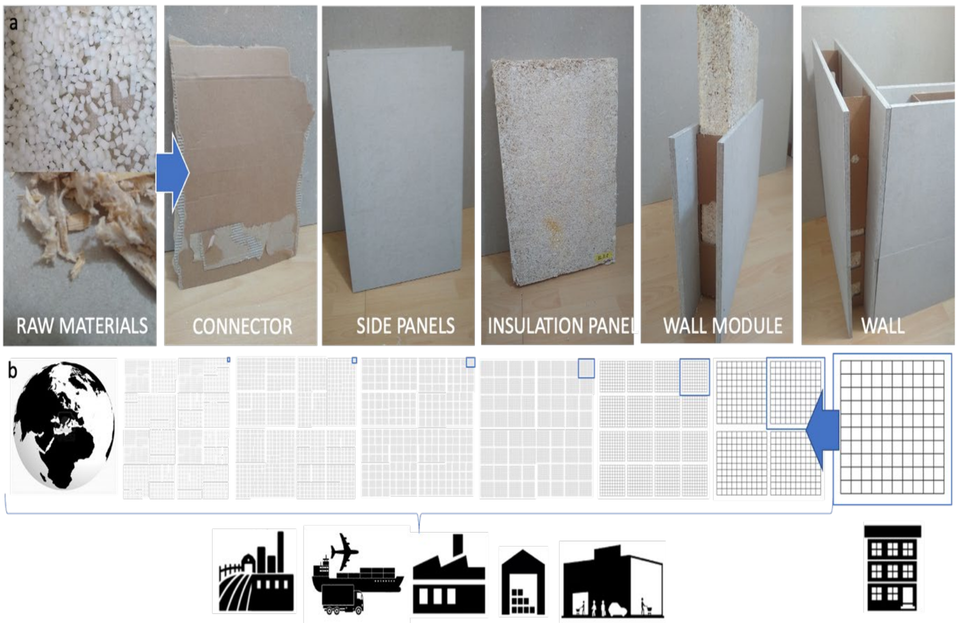

Figure 6. Integrated view on parts and spatial distribution. 6a: From raw materials to wall configuration, and 6b: from building scale to global supply network.

Co-Creation

The integrated view of Figure 6 represents a systems perspective that is hard to come by in common sustainability approaches, which are often rooted in siloed or reductionist thinking.[11] However, the associated complexity can be managed by combining perspectives, disciplines, and methods in a synergistic and co-creative manner.[12] We have guided this process with a matrix based on two frameworks: the shearing layers of change (or: "pace-layering") and hierarchic circular strategies for production chains. The Shearing layers of Change' (S-layers) were first put forward by Frank Duffy and Stewart Brand.[13] This concept is often applied in the discourse and practice around circular building, since it approaches a building as an assembly of parts with differentiating circulation properties. These properties are multi-faceted, concerning amongst others technical, spatial, social, and temporal aspects, relating to – the use and meaning of – various 'layers' of a building. The main – and mostly applied – categories are *structure, skin, services, space-plan, and stuff*. However, multiple sub-categories are imaginable, given the heterogeneity of many associated products (think of our 'simple' wall-module, for example, or an HVAC-device in comparison). Complementary to these S-Layers, the so-called R-Ladder can be applied as a framework, whilst prioritizing the most optimal sustainable and circular approach.[14] The R-Ladder represents multiple circular '*re-application*' routes, usually including 5-10 strategies to narrow material flows (use less), slow down material flows (use longer), close material flows (recycle), and/or regenerate systems.[15] When joined in a matrix, these two methods provide a powerful tool to deal with systemic complexity. It can be applied as an analytical tool as well as a design method, not least for co-creation processes with partners from complementary disciplines. Moving through the matrix, specific points of attention and/or opportunity can be discussed – iteratively – at the crossing of the two parameters: differentiated S-Layers and optimal R-strategies. We have coined this the Circular Design & Impact matrix (CDIM), Figure 7 provides an example, highlighting wall-panels and insulation as part of the space-plan.

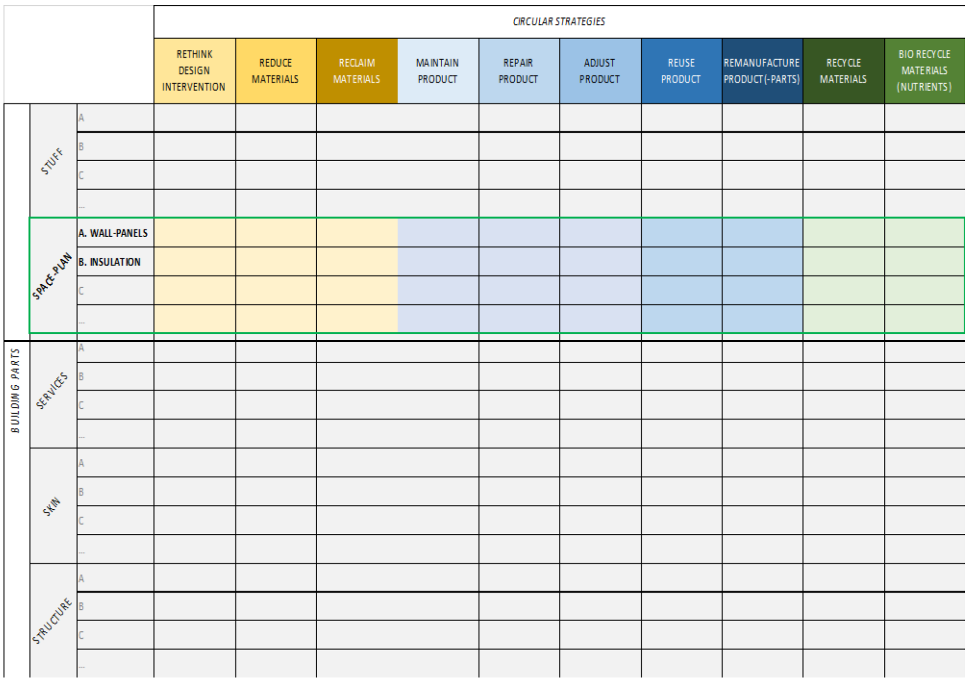

Figure 7. Circular Design Impact Matrix, differentiated building parts (vertical) + circular strategies (horizontal).

OUTLOOK AND CONCLUSION

In this article, the BIC project was introduced, briefly outlining a proof of concept based on five parameters: 1. *Do-It-Yourself attitude, 2. Acoustic performance*. 3. *Robustness 4. Material circularity,* and 5. *health & Safety*. The resulting lightweight and stackable wall module, made from renewable regional fibers, assembled with reversible joints, and customizable for specific communities, addresses multiple Sustainable Development Goals. For example, SDG 3 relating the health & well-being of end-users; SDG 11 concerning the co-creative power of communities, both from a supply perspective and an end-use perspective; and SDG 12 regarding clean and reversible production methods, whilst avoiding potentially harmful substances.[16] It was shown that even a seemingly straightforward product like the BIC-module can be surprisingly complex when resetting the system boundaries to include larger supply systems. We applied the Circular Design & Impact Matrix to guide the discussions among the multi-disciplinary project-team. The CDIM tool enabled us to identify and test fitting design and production choices. This proof of concept is meant as a starting point for follow-up steps, including the construction of a pilot wall in a community center, whilst engaging the end-users in fabrication and, not least, finishing activities. The latter has already been explored with the project-team, based on a recent innovation to secure the panels' integrity with paint and latex based on natural raw materials that are suitable for recycling and are fully degradable. Apart from coloring the side panels, other possibilities arose, for example using the paints for image-printing, to be initiated by the target group. These aspects are essential from the BIC-rationale, since it focuses on one of the main pillars, namely engagement of the target end-user. As such, this provides a step up to the next stage in which the proof of concept meets a real setting. Covid-19 has been a barrier for this implementation-stage, and further progress was put on-hold. However, new opportunities are sought to continue this co-creation project, while securing viable business models. Lastly, the interplay between different stakeholders, interests, and – social and economic – mechanisms has been relatively straightforward in this project. Furthermore, this interplay was driven by diverging yet shared incentives, and with clear agreements on the boundaries of the project, in time, scope, as well as funds. Once reality kicks in and the stakes become higher, regarding security and quality of livelihoods, the – level and intensity of – engagement of stakeholders will most likely change. Although the CDIM tool shows significant merits in collaborative design and implementation decisions, with an anticipative eye on operational scenarios, it only works in combination with complementary tools, methods, and agreements. In that respect, CDIM could be seen as part of the toolbox for 'retaining circularity potential', closely interacting with appropriate facility management strategies and multi-year maintenance plans, as well as tools such as Building Information Modeling (BIM) and Material Registration Systems (Material Passports).

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