International Journal of Project Management 42 (2024) 102647

Contents lists available at ScienceDirect

International Journal of Project Management

journal homepage: www.elsevier.com/locate/ijproman

Projects as drivers of sustainability: How the adoption of the reuse principle affects the front-end of a construction project

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ARTICLE INFO

Keywords:
Project front-end
Project management
Circular economy
Value creation potential
Construction industry

ABSTRACT

Project research has long considered sustainability, but more knowledge is needed about how projects can drive the sustainability transition. In the context of project business, the circular economy (CE) principle of reuse displays considerable potential for reducing resource usage. The front-end of a project is a critical phase as the value potential of the project depends on how project actors commit to its objectives, such as sustainability. In this study, we elaborate on how value creation and actor roles are affected during the front-end of a demonstration project that applies the reuse principle in construction. We show that as a project applies this principle, project actors must assume different roles during the front-end and that new types of values emerge through knowledge-sharing, joint development of new practices, and new business opportunities. Based on our observations, we argue that reusing concrete elements has the potential to create significant environmental and economic value and despite several remaining barriers, it could contribute to a wider systemic sustainability transition.

1. Introduction

Over the last decade, the concept of the circular economy (CE) has gained significant traction as companies and governments face increasing pressure to find strategies enabling profitable growth while responding to concerns about environmental degradation and climate change (Christensen, 2021; Ghisellini et al., 2016; Zhang et al., 2022). The CE is an alternative economic model that promotes the efficient use of resources by adopting closing-the-loop production patterns and maintaining the value of materials, components, and products through “R-imperative actions,” the most commonly cited of which are recovery, recycling, reuse, and reduction (Bolger & Doyon, 2019; De Wolf et al., 2020; Ghisellini et al., 2016). In this paper, we focus on the construction industry, which consumes around 40 % of all materials globally while generating 35 % of the world’s waste and 39 % of its total greenhouse gas emissions. Concrete alone is responsible for around 4–8 % of global CO_2 emissions annually. Therefore, the CE approach of reuse is particularly relevant to the construction industry, as it demonstrates potential for providing higher environmental and economic impacts than the more prevalent principle of recycling (Ghisellini et al., 2016; Harala et al., 2023; Rakhshan et al., 2020; Többen & Opdenakker, 2022; Yang et al., 2015).

Many project organizing scholars (e.g. Huemann & Silvius, 2017; Keeys & Huemann, 2017; Silvius & Schipper, 2014; Silvius, 2017) state that projects and their management play crucial and central roles in addressing sustainability issues and that projects are inseparable from the impacts they have on their environments (Daniel, 2022). The CE can be seen as part of this sustainability debate. From the project management point of view, attention can be shifted, for example, toward the effective use of materials in construction projects and how new practices bring potential value to all the actors involved. Because the role of projects is central to the sustainability discussion, we need more knowledge regarding how, in practice, projects apply CE practices. A transition to the CE in construction projects can be seen as involving not only technological changes, but also changes related to user practices, regulation, industrial networks, and infrastructure (Geels, 2002). The multi-level perspective (MLP) is often used as a theoretical approach to conceptualize this kind of socio-technical transition where the diffusion of innovation into a new system requires momentum to be gained and barriers overcome in industry and society (Geels, 2002; Geels & Turnheim, 2022).

In this socio-technical transition (Daniel, 2022; Geels & Turnheim, 2022), the roles of the involved actors, their collaboration practices, and the potential value they accrue (Martinsuo et al., 2018; Zerjav, 2021)

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https://doi.org/10.1016/j.ijproman.2024.102647
Received 9 October 2023; Received in revised form 30 August 2024; Accepted 13 October 2024
Available online 19 October 2024

may change when the reuse principle is incorporated into the construction of new buildings and other infrastructure. For example, project owners might achieve a more positive image, and construction companies might make additional cost savings when various materials are reused. Demonstration projects that involve experimentation with novel technologies or managerial approaches play a central role in the initiation of socio-technical transitions, as they allow actors to test innovative practices and technologies in real-life contexts in a setting that does not attempt to maximize short-term profitability (Bandeira Barros et al., 2023; Chan et al., 2022; Nigra & Bossink, 2023). Moreover, as a project's ability to deliver value is significantly affected by the decisions made in its front-end phase (Keeys & Huemann, 2017; Kivilä et al., 2017; Liu et al., 2019; Martinsuo et al., 2018), this phase is expectedly a particularly fruitful context for studying the adoption of the reuse principle. It is during the front-end phase that the actors involved and their roles in the project are determined, which eventually affects what kind of value they receive (Martinsuo et al., 2018). It is thus important to understand the dynamics of value creation in project front-end when new ways of working are introduced and tested and further study how these changes can contribute to systemic transition as viewed from MLP.

In project organizing research, the sustainability discussion has concentrated on sustainability in general (Aarseth et al., 2017; Huemann & Silvius, 2017; Keeys & Huemann, 2017; Sabini et al., 2019; Silvius, 2017) or the sustainability of projects rather than the sustainability driven by them (Winch et al., 2023). With the application of the MLP (Daniel, 2022; Geels, 2002; Geels & Turnheim, 2022), we approach the project as a driver for a socio-technical transition, that is, the shift from the linear economy model to the reuse model in construction. We thus answer the calls made by Winch et al. (2023) for cross-fertilization between transition studies and project studies and the need for further research on how projects can contribute to wider systemic transitions. Similar calls have been made by CE scholars (Hagbert & Malmqvist, 2019; Harala et al., 2023).

Despite the importance of the CE within the wider sustainability discussion (Ghaffar et al., 2020; Ghisellini et al., 2016; Harala et al., 2023; Rakhshan et al., 2020; Riuttala et al., 2024), few studies (Lehtimäki et al., 2023; Santos and Fernandes, 2024) link the CE and project organizing research, especially in journals focusing on project organizing research. Here the recent study by Lehtimäki et al. (2023) on how different project praxes affect the outcomes of a sustainability transition project that applies circular economy principles in new types of housing models is a notable exception that links with the focus of our study. We may note that many CE studies (Bressanelli et al., 2019; Ghaffar et al., 2020; Ghisellini et al., 2016; Többen & Opdenakker, 2022) mention projects or their management but fail to tie them to any project organizing theories or concepts, hence leaving a gap in the discussion on how projects can play a role in a systemic sustainability transition driven by the CE. The CE literature demonstrates that the CE transition has the potential to create economic, societal, and environmental benefits (Ghaffar et al., 2020; Ghisellini et al., 2016; Harala et al., 2023; Rakhshan et al., 2020; Riuttala et al., 2024), which makes the application of project management thinking potentially fruitful. Moreover, the literature on the CE has extensively studied CE applications but is dominated by the recycle principle rather than the more effective reuse principle that is discussed in the present study (Ghisellini et al., 2016; Ranta et al., 2018).

To understand the potential drivers and barriers for a project applying the reuse principle and thus acting as a driver for a potentially nascent socio-technical transition, we seek to answer the following research question (RQ):

RQ: How does the adoption of the reuse principle influence the value creation potential for different actors involved in a construction project's front-end?

To answer the RQ, we conducted a qualitative single case study drawing on 22 semi-structured interviews, 41 months of ethnographic observations, and related documents in a demonstration project that aims to preserve and reuse concrete elements in construction. Our analysis identified the key project actors, their roles in the adoption of the reuse principle, and the kind of value creation potential that emerged in the front-end of a project that aimed to reuse concrete elements. We show that the application of the reuse principle results in actors taking broader roles at the front-end stage; moreover, we demonstrate that the greater the complexity of the project, the more critical this stage becomes. Finally, we demonstrate that reusing concrete elements has the potential to create significant environmental and economic value and, despite several remaining barriers, could contribute to a wider systemic sustainability transition.

Apart from our contributions to the project sustainability literature (Huemann & Silvius, 2017; Keeys & Huemann, 2017; Silvius, 2017; Silvius & Schipper, 2014), we contribute to the CE research on reuse (Aarikka-Stenroos et al., 2022; Bocken et al., 2018; Harala et al., 2023; Ranta et al., 2018). By framing this phenomenon as a socio-technical transition (Geels, 2002; Geels & Turnheim, 2022) and approaching it through the MLP framework (Daniel, 2022; Geels, 2002; Riuttala et al., 2024), we also contribute to the project transition literature and tie our findings to a large body of literature discussing project front-end value (Martinsuo et al., 2018; Matinheikki et al., 2016; Zerjav et al., 2021)

The paper is structured as follows. We first introduce the theoretical background on project sustainability and draw links to CE principles that may be applicable in the context of the construction industry. We then discuss the socio-technical transitions brought about by projects and the value creation potential and configurations of value determined at the front-end of projects. Next, we present the methods used, the research process, and the empirical case context. Thereafter, we present and discuss the findings and present the managerial and theoretical implications.

2. Theoretical background and conceptual development

2.1. Sustainability of construction projects

Many scholars (e.g., Huemann & Silvius, 2017; Keeys & Huemann, 2017; Silvius, 2017; Silvius & Schipper, 2014) argue that projects and their management play vital roles in contributing to the sustainable development (SD) of organizations as well as society. Sustainability is commonly defined as the balance between economic, social, and environmental sustainability through which stakeholders also evaluate value (Bocken et al., 2018; Martinsuo et al., 2018; Silvius, 2017). Despite the recognized role of projects in the sustainability transition, Winch et al. (2023) argue that from the project's perspective, relatively little attention has been paid to sustainability. The project management literature (Keeys & Huemann, 2017) has noted the difficulty of linking projects to business benefits due to short-term considerations of project outputs; this short-term mindset also impedes the application of the SD approach to projects. Moreover, while there is relevant literature on the sustainability of projects (Huemann & Silvius, 2017; Keeys & Huemann, 2017; Silvius & Schipper, 2014; Silvius, 2017), there is significantly less research on sustainability transitions by projects that reveals how projects can be organized and managed to contribute to wider systemic transitions (Winch et al., 2023).

The CE model can be regarded as a driver of sustainability (Bocken et al., 2018). The CE is an umbrella concept that has been developed as a response to public dissatisfaction with the predominant linear economy model and aims to displace primary production by closing material and energy loops and using restoration and regeneration throughout various value chains (Bolger & Doyon, 2019; Hansen & Revellio, 2020; Paavilainen et al., 2021). In the literature, the CE appears primarily through varieties of hierarchically framed R-imperative actions (Ghisellini et al., 2016; Kirchherr et al., 2017; Zhang et al., 2022.) One of the most commonly referred-to 4R (recover, recycle, reuse, reduce) frameworks is at the core of the European Union's (EU's) Waste Framework Directive

(European Commission, 2008) depicted in Fig. 1:

Recycling has been the most prevalent CE principle. Less attention has been paid to reuse and reduce, even though reuse, as the higher-level principle (Fig. 1), has greater potential to deliver both economic and environmental benefits (Ghisellini et al., 2016; Harala et al., 2023; Ranta et al., 2018). The construction industry's high economic and environmental impacts, such as waste and emission outputs, high use of virgin raw materials, and consumption of energy (De Wolf et al., 2020; Ghisellini et al., 2016; Rakhshan et al., 2020), imply a high potential to apply the reuse principle of CE. Currently, most recovery of construction and demolition waste takes the form of recycling (Rakhshan et al., 2020; Ranta et al., 2018). This can divert waste from landfill, but the processes involved are energy- and resource-intensive and produce a homogenous material used for low-value applications or as replacement feedstock for remanufacturing (Ghaffar et al., 2020; Rakhshan et al., 2020). Reusing building components can enable cost savings, waste reduction, the design of durable and adaptable buildings, and an overall reduction of negative environmental effects (Ghaffar et al., 2020; Riuttala et al., 2024).

Currently, the dominant end-of-life scenario for concrete is demolition. In some cases, the demolished concrete passes through a recycling process in which it is crushed and separated from the reinforcing steel to be used in roadbeds or other technically simple applications (Salama, 2017). In the European context, the reuse principle has been used in, for example, a housing estate rehabilitation project in Finland (2008–2010) and a housing project in Germany, both of which resulted in significant (30–36 %) cost savings in construction costs (Huuhka et al., 2015; Salama, 2017).

2.2. Socio-technical sustainability transitions in project-based industries

2.2.1. Socio-technical transitions brought about by projects

Daniel (2022) argues that research on the projectification of organizations, economies, and society has shown that projects are inseparable from the impacts they have on their environment. The transition to sustainable CE practices in construction represents a technological transition, defined by Geels (2002) as, by nature, involving not only technological changes but also elements such as user practices, regulation, industrial networks, and infrastructure. Moreover, the adoption of CE principles implies the redesign of technologies, products, services, operations, and business models (Aarikka-Stenroos et al., 2022; Ranta et al., 2018). Sustainability transition studies often apply a so-called socio-technical approach (Daniel, 2022): when a technology is embedded in societal functions, it has the power to bring about change and, in Geels' (2002) conceptualization, the technological transition consists of a change from one socio-technical configuration to another. This requires not only the substitution of technology but also changes in other linked elements (Geels, 2002), which means that other elements in the socio-technical system might act as barriers to or drivers of the technological transition. When the reuse principle is applied, such barriers, alongside the drivers discussed earlier, were identified by Rakhshan et al. (2020) as mainly technical, economic, and social, such as increased costs, difficulties in designing with the reused elements, and an increased likelihood that building components will break during the deconstruction phase. One of the most significant economic barriers to reuse, however, lies within the supply chain, as the absence of a mature reuse market makes the sustainable supply of recovered components for use very challenging (Bressanelli et al., 2019; De Wolf et al., 2020; Rakhshan et al., 2020.)

To conceptualize these socio-technical transitions, the MLP is a widely accepted middle-range theory combining insights from evolutionary economics, the sociology of innovation, and institutional theory (Geels & Turnheim, 2022). Geels (2002) conceptualized the MLP as a relation and interplay between three analytical levels, namely, niches, socio-technical regimes, and landscape, which represent trajectories that technological transitions follow non-linearly. Radical innovations are generated at the micro level, in niches, whereas the *meso* level of socio-technical regimes accounts for the stability of existing technological development, and the macro level of landscapes consists of slow-changing external factors, such as macro-economic trends and societal concerns (Geels, 2002; Geels & Turnheim, 2022). Therefore, the micro level represents, for example, individual companies, actors, and projects, the *meso* level refers to industries and markets, and the macro level concerns such exogenous contexts as demographics, politics, societal concerns, and macro-economic trends (Geels & Turnheim, 2022). Instead of a single driver, the MLP emphasizes alignments between processes at different levels and on multiple dimensions, such as those of the techno-economic, socio-cultural, and political, where different types of innovations, markets, companies, and political processes interplay and culminate in system transition (Geels & Turnheim, 2022).

The foundational characteristic of the MLP is the idea that first, radical innovations emerge in small niches that gradually build internal momentum while facing battles against entrenched systems and second, external landscape pressures and bottom-up niche pressures eventually help destabilize the existing system and thus diffuse innovations, so they ultimately replace the existing system (Geels & Turnheim, 2022). In the context of sustainability transitions research, the MLP explains that economic, social, and societal transitions arise from interactions between processes at the three levels (Daniel, 2022; Geels, 2002).

The CE literature (Ghaffar et al., 2020; Ghisellini et al., 2016; Harala

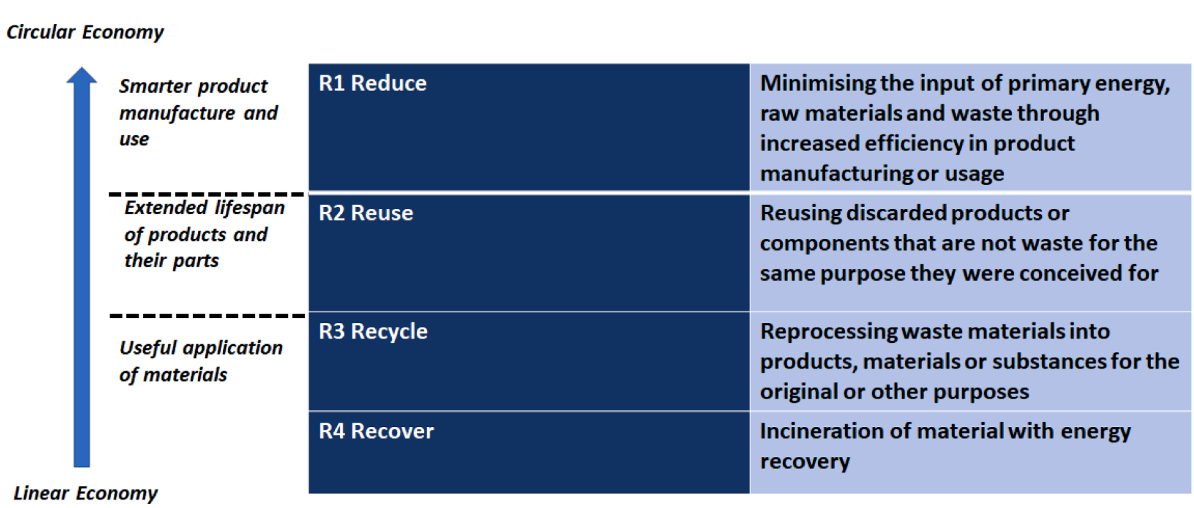

Fig. 1. The 4R Model (cf. Ghisellini et al., 2016; Többen & Opdenakker, 2022).

et al., 2023; Rakhshan et al., 2020; Riuttala et al., 2024) demonstrates that the CE transition to reuse has the potential to create economic, societal, and environmental benefits. The adoption of the reuse principle in the construction industry requires transition-driving changes to emerge at the three levels of MLP discussed above to enable it to move away from its current linear economy practices. At the micro level, the project actors need to develop new technological solutions and new circular business models related to reuse; at the meso level, companies and stakeholders need to alter their collaboration to allow for supply chain restructuring; at the macro level, the systemic transition is enabled through, for example, economic incentives and legislation (Aarikka-Stenroos et al., 2022; Harala et al., 2023). Although the centrality of projects and SD within socio-technological transitions is recognized, neither project management nor sustainability transition scholars have established a viable link between the two (Daniel, 2022). Moreover, as Lehtimäki et al. (2023) conclude, although cities are key organizations in urban sustainability transitions that coordinate multi-actor, multitemporal, and multi-regime societal transformations, research on the urban context in sustainability transitions research remains sparse.

2.2.2. Linking value creation and the project front-end

A precondition for any stakeholders partaking in projects is an expectation of value creation: the expected benefits of participation need to outweigh the sacrifices. Benefits may include making cost savings and attracting new clients (Aarikka-Stenroos et al., 2022; Riuttala et al., 2024), while sacrifices may include the costs of the additional work phases required to reuse materials. The success of the project and its ability to create value are based on the interactions between several types of key actors, such as the owner, stakeholders, and coordinator, with the owner's role as system integrator being particularly important (Daniel, 2022; Winch & Leiringer, 2016). The commercial interface between the investing owner of the project that supplies the financial resources and the contractors they hire to supply the material and human resources is crucial to project success (Winch & Leiringer, 2016), further highlighting the role and capabilities of the owner as drivers of reuse transition projects. It is difficult to evaluate projects due to their complexity and multidimensional nature, as they are realized over different time scales and in different forms for different actors (Martinsuo et al., 2018; Zerjav et al., 2021) This is especially true for complex infrastructure-related projects whose value spans a long period and that require high involvement from public-sector actors as owners and investors (Martinsuo et al., 2018). As the absence of a mature supply chain is a major economic barrier to the adoption of reuse (Bressanelli et al., 2019), the project owner's role and ability to capture value from a project based on reuse seem crucial, as the materials to be reused will usually be the property of the project owner in a project applying the reuse principle.

It is widely recognized that a project's potential to deliver value over its lifecycle is significantly influenced by the decisions and activities implemented during its front-end (Martinsuo et al., 2018; Liu et al., 2019; Williams et al., 2019). Martinsuo et al. (2018) define the project front-end as all the activities undertaken from creating the idea to making the decisions that secure project financing, during which the project owner must form a clear idea of the project's goals and identify the necessary partners for its delivery. Some see the front-end in more practical terms as the crucial element shaping the project, which can only start after the front-end is completed (Williams et al., 2019). This study considers the front-end as the preliminary emergence phase (Williams et al., 2019; Alimadadi, 2022) that ends when the work for which the project was established begins.

Projects in the front-end phase have not yet materialized in any substantive form, and uncertainty is high; hence, the value in the project definition should be focused more on long-term benefits than efficiency considerations related to time and cost (Zerjav et al., 2021). Stakeholders apply different themes when framing their arguments about project value, selectively present information to support their points of view, and can promote funding decisions by determining ways to overcome any uncertainties (Martinsuo et al., 2018; Williams & Samset, 2010). The high uncertainty and low levels of information availability at the front-end (Williams et al., 2019) underscore the importance of demonstrating the value creation potential to project actors (Kroh & Schultz, 2023). While the project value spans long periods, especially in infrastructure projects (Martinsuo et al., 2018), it also occurs across different time frames (project lifecycle versus operations and use) for different actors (Zerjav, 2021). The value for the owner and project actors can often be realized only during the operations and use phase, which creates a discontinuity in project value flows (Zerjav, 2021). This discontinuity requires the owner to manage value ideals, especially in the front-end, where value is more about the desirable than the factual (Zerjav et al., 2021).

To create value in the front-end, one should actively shape and manage the network and its attributes (Keeys & Huemann, 2017; Matinheikki et al., 2016). According to Martens and Carvalho (2017), value should be framed not only through financial gains but also through environmental impact and contribution to social well-being. Zerjav et al. (2021) describe the front-end of infrastructure projects as a space where priorities are defined and justified by key decision-makers. Thus, the value arguments mobilized in the front-end have a key legitimizing role in gaining the commitment of stakeholders. This means that in the design phase of a project, for example, uncertainty can be treated as an opportunity to be maximized whereas in the realization stage, it can be seen as a risk to minimized, highlighting the importance of framing and arguing the value to project actors and other key parties (Zerjav et al., 2021).

2.3. Synthesis

The approach to project value applied in this study is based on Zerjav's (2021) conclusion that actors in project organizations are self-interested: specifically, they will only participate in projects that they assess as favorable in terms of the value such projects bring them and will remain involved only as long as they can appropriate a proportion of the created value. Frequently, value for the owner and their customers and contractors can only be realized during the operations and use phase, which creates a discontinuity in project value flows (Zerjav, 2021) that calls for the owner to manage value ideals, especially in the front-end. Hence, based on our assessment of the literature, a project applying the reuse principle must demonstrate value potential to all its actors in both the short (Aarikka-Stenroos et al., 2022; Riuttala et al., 2024) and long (Martinsuo et al., 2018) term and through mechanisms other than financial benefit, such as environmental and social impacts (Martens & Carvalho, 2017; Zerjav, 2021).

In this study, we concentrate on a demonstration project (Bandeira Barros et al., 2023; Chan et al., 2022; Nigra & Bossink, 2023) applying a radical innovation (Geels, 2002; Geels & Turnheim, 2022); hence, the emphasis is on the micro level of the MLP, albeit the levels and the factors that affect the wider diffusion of the reuse principle within the industry are inherently interconnected. Combining the project value discussion (Matinheikki et al., 2016; Martinsuo et al., 2018; Williams & Samset, 2010; Williams et al., 2019; Zerjav et al., 2021) with the MLP (Daniel, 2022; Geels, 2002), we propose that a micro-level project aiming to promote sustainability through the application of the reuse principle must offer short-term value potential to its actors and stakeholders in the front-end as well as demonstrate long-term benefits and desirable outcomes. These benefits have to be argued in the front-end to motivate the actors to partake in the project, gain the support of the public and private sectors, enable the success of the project so these long-term benefits can be realized (Matinheikki et al., 2016; Martinsuo et al., 2018; Williams et al., 2019; Zerjav et al., 2021), and incorporate the niche-level innovation of applying the reuse principle in construction to diffuse to higher MLP levels (Daniel, 2022; Geels & Turnheim,

2022) and replace current linear economy practices with more sustainable ones. With the added value potential arising from the ownership of the reusable materials (Riuttala et al., 2024), the project owner is also responsible for understanding and aligning the interests of the various actors in the project and must therefore have dynamic capabilities (Winch & Leiringer, 2016; Zerjav, 2021).

3. Methodology

3.1. Research design and case background

To deepen our understanding of the front-end value dynamics and actor roles in a CE project, we conducted a qualitative single-case study of a construction demonstration project focusing on concrete element reuse. This research method was chosen due to the exploratory nature of the study and its objective of developing knowledge about a relatively new phenomenon that has been little studied within project management. A case study is a particularly suitable methodology for studying a contemporary phenomenon and its real-life context where the boundaries between the two are not unambiguous (Yin, 2014). This is the case in the present study, given that the management of sustainable construction projects and the CE are often interconnected. We gained an understanding of the phenomenon not through controlling variables or behaviors directly, but by observing them and their interactions (Yin, 2014).

Our research is connected to an EU-level research initiative that studies how CE principles are applied in construction by reusing precast concrete elements in four case countries: Finland, Sweden, Germany, and the Netherlands. Each country pilot includes the deconstruction of one or more donor buildings and the construction of one or more new buildings using the detached concrete elements.

This study focuses on the front-end phase of the Finnish country pilot (henceforth, NewLife) to address the potential changes in actor roles and value creation potential in the front-end that may result from applying the reuse principle. As reusing precast concrete elements is an almost completely new approach in the Finnish construction industry, it also provides an excellent opportunity to study how it affects the project actors' roles, how they find new ways of creating value, and what they perceive to be the challenges associated with the socio-technical transition.

NewLife's building to be deconstructed (henceforth, the donor building) is located in Tampere, Finland's third largest city, in southwestern Finland. The donor building is a concrete-structured office building in the city center. The intention is that precast concrete elements, especially columns, beams, and hollow-core slabs, will be detached from the donor building in a manner that keeps them intact, after which they will be transported to intermediate storage and refurbished if necessary. Ultimately, they will be reused in one or several new building(s), the exact locations of which are not yet fully finalized, although some of the detached elements will be reused as parts of new building(s) in Tampere. This study focuses on the seven key project actors in NewLife that perform several different tasks to enable the reuse of concrete elements (see Table 1).

As when any project is studied, it is important to understand the owner domains in NewLife. NewLife overall takes the form of a consortium led by the university that has a mandate to coordinate and manage the project, essentially making it the owner of the entire demonstration project that is NewLife. However, the construction company owns the deconstruction site, having already purchased it for property development purposes (the exact date of the purchase is not known). Therefore, the construction company is responsible for the execution of the deconstruction of the donor building, effectively making it the owner within the scope of this paper.

The construction company was also selected as the contractor of the potential new sites, mainly through land acquisition (by owning the land itself and finding an owner for the new building to be built on the plot) and conceptual construction (the owner of the forthcoming new building has a plot of land that requires technical innovations to which the construction company was able to offer solutions). For the next stage of NewLife, that is, the construction of the new building(s) with the reused concrete elements, the owner(s) of the new building(s) will become the owner(s) of the project in the sense that they will have the vested financial interest in and responsibility for the successful execution of the project. It is important to understand these three different owner roles during NewLife, but for the scope of this paper, the front-end stage, the construction company is regarded as the project owner.

Table 1
Key project actors and their roles in NewLife.

Key project actor in NewLife	Role in NewLife
Demolition company	• Deconstruction planning • Deconstruction of the donor building
Architectural design office	• 3D inventory model of the donor building • Design of the new building(s)
Structural engineering company	• Condition survey of the donor building • Deconstruction planning • Structural design of the new building(s)
Construction company (Owner of the deconstruction project)	• Finding the donor building • Deconstruction site owner and owner of the detached elements • Construction of the new building(s)
Element manufacturer	• Concrete element testing and refurbishing • Intermediate storage of detached concrete elements • Logistics planning
City	• Helping with permits and bureaucratic tasks
University (Owner of NewLife)	• Knowledge creation • Project coordination

3.2. Case description—Overview of NewLife

NewLife was launched in April 2021. Its first act was a joint effort by the university and construction company to find a suitable donor building. The building was found from within the construction company's demolition portfolio and chosen due to its location, demolition schedule, and structural suitability. Its location in the center of Tampere brought additional challenges to deconstruction, as the space for large equipment, such as cranes and trucks, was limited, and hazards (noise, waste, dust, etc.) had to be strictly controlled.

Later that year, the focus shifted to identifying suitable concrete elements to be reused from the donor building, 3D inventory-modeling the donor building, and surveying its structural condition. The deconstruction planning started in late 2021, involving all the key project actors, and ended in June 2023. In the deconstruction planning phase, special attention was paid to the stability of the building to be deconstructed during the deconstruction work, the deconstruction sequence, the safety of workers, and the technical implementation. As of 2023, NewLife had suffered multiple delays due to regulatory issues and the lack of the necessary permits for deconstruction, but deconstruction began in June 2023 and ended successfully in December 2023. During deconstruction, the concrete elements were marked using spray paint and identification tags provided by the element manufacturer and transported to the latter's facilities for storage, refurbishment, and quality control. The concrete elements were tested at the facilities of the university and element manufacturer. In May 2024, potential site(s) and owner(s) of the new building(s) were found, and initial planning for the use of the deconstructed concrete elements in the new building(s) began. NewLife currently anticipates that the detached elements will most likely be used in several different new buildings. The new building projects will also contain different numbers of detached elements and will therefore be of different sizes in terms of the extent to which the reuse principle is applied. For example, the only elements to be reused on one site that is still planned for 2024 will be hollow core slabs. For other new building projects, more detailed structural and architectural design will begin once the contracts between the actors for the construction of the new building(s) have been signed.

3.3. Data collection and analysis

Our research draws mainly upon primary data from 22 semi-structured interviews. The interviews lasted 46–205 min, and >26 h of recorded interviews were transcribed. Secondary sources, such as project documentation, ethnographic observations, meeting memos, and related documents, were used to support the data analysis. The interviews gave us an extensive overview of how different key project actors in NewLife perceived the value creation potential in reuse. They also revealed how key activities and actor roles have changed and what kinds of changes are still needed to make reusing concrete elements a viable option in the future. The longitudinal approach allowed us to observe how the interviewees' opinions, perceptions, and beliefs about the project changed as the front-end phase progressed. The interviewees were chosen as they have significant roles in the key organizations within NewLife and could therefore offer valuable insights due to their experience in the field. Table 2 describes the types of data used in the study and their corresponding roles in the analysis.

We applied an inductive reasoning process to analyze the data through the theoretical understanding and framework created in the literature review. Inductive reasoning was a fitting approach, as the subject is novel, and this study aims to study a phenomenon in its context without any pre-set theories, that is, to make unaffected observations. To help us connect previous theory to the empirical data, we used higher-level categories as inductive codes (collaboration, value potential, challenges, processes) developed based on the theory and first round of analysis of the interview transcriptions (Bradley et al., 2007). During the content analysis (Elo et al., 2014), all data were reviewed by thorough and repeated reading, coded for correspondence to the identified categories, and catalogued in Excel.

As an example of our content analysis, one interviewee commented: "*So, competing with that (concrete element production) is challenging, as the labor in Finland is so expensive. So, each time we need to add labor into the process, it tends to have a significant cost-inducing effect.*" This description was interpreted as a perceived barrier to the adoption of the reuse principle in construction and was therefore labeled under the category "challenges." We give a preliminary interpretation of each quote to further explain its significance for the study. For example, a preliminary interpretation of the quote above stated: "The price comparison of labor versus material costs is disadvantageous for CE solutions requiring manual labor in countries similar to Finland." To ensure the quality of the study, four researchers were involved, some of whom specialized in construction and some in project management. The data analysis was conducted by two researchers in an iterative process whereby they worked in turn to allow for strong triangulation.

Table 2
Data types, descriptions, and roles in the analysis.

Data types	Description of the data	Role in the analysis
22 semi-structured interviews with key actors	**Demolition company (4)** • Project manager (4/2022, 9/2022, & 2/2023) • Site manager (9/2021) **Architectural design office (4)** • Owner/architect (9/2021, 4/2022, 6/2022, & 9/2022) **Structural engineering company (4)** • Business development manager (BDM) (8/2021, 9/2022, & 10/2022) • *Group interview:* Unit manager, project manager, and department manager (5/2022) **Construction company (4)** • BDM (5/2021 & 12/2022) • *Group interview:* BDM & project manager (10/2021 & 5/2022) **Element manufacturer (3)** • Chief technology officer (CTO) in concrete-element manufacturing company (7/2021, 5/2022, & 12/2022) **City (2)** • Project manager/specialist in city organization (6/2022) • *Group interview:* Manager of housing and development & project manager/specialist (10/2022) **University (1)** • Senior research fellow at university (10/2021)	Individual actor interviews allowed us to develop an understanding of the interviewees' individual roles, the roles of the companies they represented, and their thoughts, ideas, and prejudices about circular construction compared to traditional projects. They also enabled us to address possible changes in the interviewees' perceptions of the project. Group interviews were used similarly to individual interviews, but there was more emphasis on the thought development that happened during them.
Minutes and reports	• Project plans (2) • Meeting memos (61) (4/2021–8/2024)	Analyzing the meeting memos and project plans helped us understand the project's structure and verify some of the interpretations of the interviews.
Ethnography	NewLife meetings and international consortium meetings since April 2021 – Taking part in the front-end planning sessions: • Country-cluster meetings involving all actors in NewLife (39) • Meeting on the use of 3D models in NewLife (1) • Deconstruction planning meetings (8) • Quality assurance and factory refurbishment planning meetings (2) • Preliminary planning meetings regarding the use of detached elements in the new building (8) • Site visits (4)	Ethnographic observation supported our interpretations of the interviews.

4. Results

4.1. The key project actors involved in the project front-end design

The interviews clearly indicated that a construction project based on the reuse principle requires the actors to take different roles and perform different tasks in the front-end than they would in conventional construction projects. Most interviewees described how a new type of project comes with challenges related to the fact that processes and practices are not yet defined: "*But if we are trying to reuse the products and the components, the planning is so different*" (Demolition company project manager). Fig. 2 shows NewLife's timeline and key actors and their roles in the project. The front-end of the project remains the key focus, as most actors seemed confident that, apart from the planning of the deconstruction and concrete element salvation, the actual implementation of the project would be somewhat business-as-usual.

The architect's main roles in NewLife were the design of the new building and creation of the 3D inventory model of the donor building in the front-end phase. In the building condition survey and inventory phase, the architect made the 3D model of the building's structures using the documentation provided by the construction company and supplementary building information from the city's official archives. The structural engineering company then built on this model. As the BDM at the structural engineering company concluded: "*Of course, in*

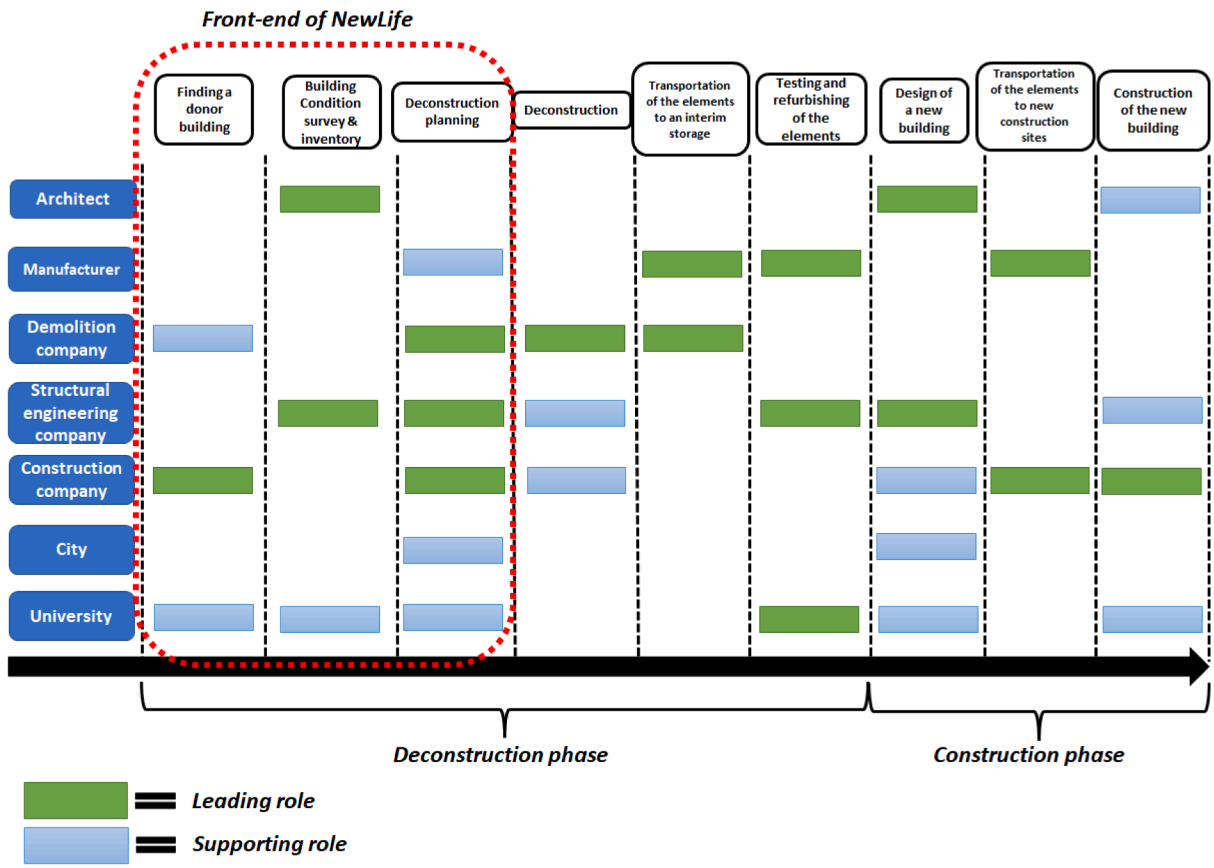

Fig. 2. NewLife phases and key actors.

this particular case, the architect started the model, and we just supplied the information of what might be needed inside the building information model (BIM). Then, the model was delivered to each party."

The model created by the architect had to be complemented with specific information about the structural aspects of the donor building that affected the deconstruction planning (e.g., joints), as the architect was more interested in the actual inventory of the concrete elements whereas the demolition company and structural engineering company needed detailed modeling for deconstruction planning. The structural engineering company was also responsible for applying the findings to the actual deconstruction plan, for example, by developing new solutions and attachments for the physical lifting of the concrete elements in collaboration with other key project actors. In addition, the structural engineering company participated in planning the refurbishment (how the concrete elements would be repaired if needed) as well as testing the concrete elements together with the element manufacturer and university once the elements had been detached and had passed the initial condition screening at the deconstruction site. Detached concrete elements that passed the initial on-site condition screening were sent to the element manufacturer's facilities for further processing. Their physical condition was also re-assessed, and they were refurbished if needed. Some of these concrete elements (pre-determined by the structural engineering company, element manufacturer, and university) were sent for testing (experimental loading of the concrete elements at the research center) to determine more detailed structural characteristics, with the results used, for example, for design purposes.

The demolition company had a central role in planning the deconstruction of the donor building, as it was responsible for the actual practical deconstruction work that started in June 2023. According to the project manager at the demolition company, in a traditional project they would make all the plans for demolition by themselves, but in NewLife, the roles were different:

When planning new deconstruction, if it's more like conventional demolition, usually [demolition company name] can make the plans. But if we are trying to reuse the products and the components, the planning is very different. In that case, a consulting company – an engineering company – is going to do the plans. Like here in the [project name], it's [structural engineering company name].

The element manufacturer participated in the deconstruction planning, storing, testing, and refurbishing the concrete elements, as it had expertise in the structural use of the concrete elements as well as the practical matters and costs that arose from their handling. As the construction company owned the deconstruction site, it was responsible for matters related to work safety there and the allocation of the reusable concrete elements for the new building(s). Being the owner of the deconstruction site, the construction company was also the project actor responsible for applying for the demolition permit for the donor building. In addition, the construction company became the owner of the detached concrete elements, whereas in a conventional demolition project, the demolition company (i.e., the owner) is usually responsible for all the demolition material generated. The university coordinated NewLife, organized and led the meetings, and was responsible for knowledge creation, NewLife funding allocation, and delivering the documentation to the funder (i.e., the EU). Representatives of the city of Tampere undertook active bureaucratic and legislative work on the city council and with administrative parties to enable the legitimate use of reusable concrete elements as approved construction materials. Apart from these roles, all actors in NewLife participated in the monthly meetings, planning, reporting, and developing.

4.2. Key project actors' contributions to applying reuse in NewLife's front-end phase

The data indicate clearly that planning the deconstruction of the donor building and the later phases of the reusable concrete elements, that is, NewLife's front-end, was far more complex than planning traditional demolition. All the interviewees reported having had to establish relationships with different actors than those they were used to cooperating with in traditional construction projects (Fig. 3), as detaching concrete elements intact is more complex than a conventional demolition process. Thus, they had to devise new ways of working. In fact, it was observed that applying the reuse principle in a construction project seems to increase the interdependence of the project actors, as the added complexity of the processes requires more collaboration between them. The added complexity mainly occurred because there were no predetermined processes or standard operating procedures for detaching concrete elements that had not, in the construction phase of the building, been designed to be detached: *"It is important to understand that we have no readily defined processes or practices for this kind of reuse"* (Demolition company project manager).

Of the seven key project actors in NewLife, all had significant roles in the front-end phase of the project, and the four companies, namely, the element manufacturer, structural engineering company, demolition company, and construction company, worked very closely in planning the actual deconstruction of the donor building. The university was the coordinating actor in NewLife, as it led the collaborative efforts of the other project actors. The city's overall objective was to be able to develop procedures to support the reuse of concrete elements and make this a viable option for companies in the future by applying the findings of NewLife. Among the main concerns about the deconstruction were the safety of workers when detaching the concrete elements that had not been designed to be detached, the techniques needed to make detaching and lifting the concrete elements possible and establishing the condition and safety of concrete elements for reuse after they had been detached. Careful planning was considered essential, as a detailed workflow and sequence planning minimized the hazards associated with work safety and excess time usage, which was already a major issue in terms of project costs. All in all, it was considered essential that NewLife consisted of different actors with different backgrounds working toward a joint objective and openly sharing knowledge:

> *It has been really important that we've had different actors, that along with architects we've had a construction company that has insisted that we must bring this forward and that they, too, want to be a part of it – it is the fact that there are these kinds of actors with us that we would normally think that 'they will definitely be the last ones to join in on this'.* (Structural engineering company BDM)

The interviewee from the element manufacturer also indicated that they would not play any role in demolition in a traditional project. In NewLife, in contrast, the element manufacturer provided valuable insights on deconstruction planning through their knowledge and expertise regarding the concrete elements, their joints, and how they should be lifted. In addition, the element manufacturer's expertise in concrete (from a material point of view) was needed during the collaboration between the structural engineering company and university to plan how to test the concrete elements for reuse, specifically, to decide which test methods would allow potentially harmful substances in the concrete elements to be traced and what kind of tests had to be carried out on which concrete element types to gain information on their condition. Planning for the testing was crucial:

> *We demolished [company name]'s old pulp factory, and we were able to detach maybe 50– 60 % of the outer wall elements intact as they were in relatively good condition. They ended up fighting for the permit to reuse them for months after taking samples from the concrete as there was too high a level of chrome in them when they were analyzed.* (Demolition company site manager)

The conclusion about the detachment of concrete elements was that they could be detached in a way that left the concrete elements intact, but the more sophisticated the method needed to be, the more expensive

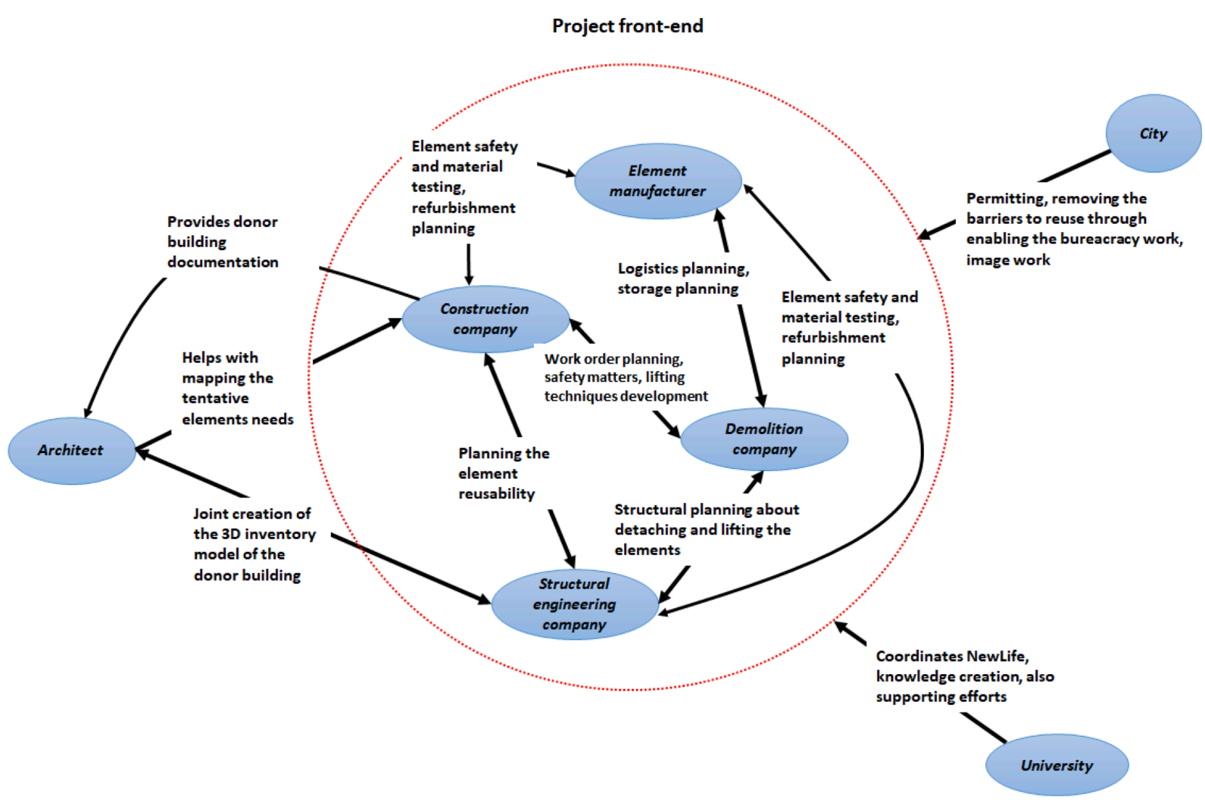

Fig. 3. Collaborations between key actors in the project front-end.

the deconstruction would become, as the added labor would increase the costs very quickly. Most interviewees elaborated that having a very detailed and thorough plan for all the project phases was of paramount importance, as there would be no time to make additional or differing plans on site during the deconstruction; hence, the success of the deconstruction was essentially defined in the planning phase.

As the construction company owned the deconstruction project site, they needed to be certain of the viability and details of the safety protocols and thus aware of all the details regarding the deconstruction planning. The construction company helped in the deconstruction planning by providing its expertise and knowledge as well as ideating optimal ways of executing the deconstruction. The 3D model created from the inventory by the architect and engineering company allowed the construction company to undertake detailed work planning:

> *And we can, for example, plan every week differently. How we work during every week and what kind of safety things we need to use every week. I believe that safety is big… This is something new which we didn't do… demolition companies, I think they never used this kind of technology before. This is the first time, and I believe they like it when they see our model. They say that this gives a lot of good things that they can see what kind of order, good things…* (Construction company BDM)

Moreover, the construction company was going to be the contractor for the new building(s) where the detached concrete elements would be reused, which increased the company's need to collaborate with the structural engineering company, architect, and element manufacturer to ensure the reuse of the concrete elements and their locations in the new building were safe. In addition, the potential owner of the new building would be a third party in NewLife; thus, the project actors, in particular, the construction company, architect, and structural engineering company, had to consider the constraints and requirements of the owner(s) of the new building(s) regarding the reuse of the detached concrete elements. Therefore, the project actors would ultimately be accountable to the owner of the new building and related work.

4.3. Perceived value creation potential during NewLife's front-end

In the front-end phase of NewLife, the most important areas of value creation potential were the new connections with project organizations and potentially their customers, image and brand value, and gaining knowledge and a skill advantage against competitors that did not yet have experience in concrete element reuse. On the other hand, there were several significant concerns about whether concrete element reuse could compete against virgin products, as the current supply chain for concrete element reuse is inadequate, initial costs are most likely higher, and bureaucratic barriers remain. Generally, the success of the project was regarded as determined in the front-end planning. Moreover, when the reuse principle was applied in construction, all actors needed to be aware of the value of the whole reuse process as well as that of the detached concrete elements, since a single actor could ruin the value for everybody. For example, poorly handling the concrete elements (e.g., breaking reusable concrete elements) at any stage of the project would render all previous and following efforts obsolete. Table 3 illustrates the value creation potential and barriers to it the actors identified.

4.3.1. Identified value creation potential in NewLife

All key project actors in NewLife regarded the environmental value that comes from reusing concrete elements as the most important reason for participating in the project as well as the transition toward more sustainable practices in construction in general. Refurbishing and recirculating concrete elements from old buildings can save virgin resources and reduce carbon emissions, resulting in significant positive environmental impacts. All project actors reported that gaining experience, competence, and new knowledge of reusing concrete elements were among the main motives for their participation in NewLife. The adoption of more sustainable practices in construction was seen as

Table 3
Identified value creation potential and barriers to it when applying the reuse principle in a construction project.

Key project actor in NewLife	Identified value creation potential	Identified barriers to value creation potential
Demolition company	• Cost savings on landfill fees • Establishing a new business model by selling reusable elements to the element manufacturer's customers would be possible • Mutual benefits from collaboration with the element manufacturer	• Detaching the elements intact is more expensive than demolishing them • The added logistics and warehousing increase costs • Currently, there are no buyers or market for the wider adoption of reused elements
Construction company	• Brand value from being at the forefront of development • Ability to use the existing buildings as a source of building materials, i.e. material banks and simultaneously avoiding waste generation • Gaining the ownership of the detached concrete elements	• Currently, the risk buffer for this kind of project in the open market would be so high that no customer would be interested • In its current state, there is no demand for reused elements • Justifying to customers why they should pay for used elements instead of new ones • Finding the right customer groups
Structural engineering company	• Reaching new desired customers through other project organizations • Developing processes and techniques that will likely become commonplace in the future, resulting in increased competence and competitiveness • A potential resource bank of reusable materials for future applications	• Competitive interfaces with other organizations in the CE project • New elements are cheap whilst refurbishing detached ones is labor-intensive and therefore expensive • Logistics and warehousing actors are missing from the supply chain • Changing people's perceptions of reuse in general
Element manufacturer	• Even with a rather low percentage of reused elements, significant brand value could arise for all actors • Knowledge benefits from being at the forefront of developing element detaching and refurbishing techniques: possibly adopting reused business processes	• Difficulty of competing with new elements in terms of price • Strong financial incentive needed at government level to make reuse a viable business
Architect	• Societal value through more enjoyable living spaces and buildings that would retain historical value • Environmental impact by renewing the whole construction industry • Creating and understanding ways of working that will be necessary in the future to enable concrete element reuse	• The over-efficiency of construction processes in general has led to interdependencies that make the construction value chain very vulnerable to disruptions • There are no established processes or routines for reusing elements. • Revit and other 3D model software programs are not designed for planning deconstruction: suitability issues
University	• Investors will see investing in sustainable technologies as a risk-aversion tactic: increasing demand for circularity and opportunities for actors that can provide it	• Due to widespread indoor air problems in Finnish buildings, some people will be convinced that reusing concrete elements is not safe
City	• Significant and positive image value for the city Ability to affect government-level decision-making	• There are some public safety concerns regarding the process of deconstructing elements, increasing the risk for reputational damage in case of accidents

inevitable at some point in the future when international and national sustainability requirements force industries to reduce their carbon output. Being among the first to have knowledge and competence of the processes and techniques needed for concrete element reuse was therefore regarded as a major asset for when concrete element reuse will be the standard way of doing things:

> *In a way, we are investing quite a bit in something that isn't necessarily viable as a business today, this year, or even the next year. But we still feel this is important, as we've recognized that it will be increasingly relevant in the future. So, we want to gain an understanding of the potential solutions that could let us achieve the goals that have been set for carbon neutrality and waste generation.* (Architect)

Another important way of creating value through concrete element reuse, according to several project actors, was the establishment of new channels for potential customers through the new types of collaborations that emerged in the project. For example, the demolition company could realize significant benefits by becoming a part of the supply chain by selling reusable concrete elements instead of being responsible for the demolition waste. As the element manufacturer already has a pre-established supply chain to deliver concrete elements to its customers, significant synergies could arise if the parties were to set up a supply chain for the reusable concrete elements:

> *If we know that there's an obvious demand for a certain construction element or a machine, for example, or someone's interested in them, and we happen to have a demolition project that might have these elements or machines, we can directly take that into account in the pricing and planning of the demolition project and then calculate if this machine or part should be detached intact and not demolished.* (Demolition company project manager)

The construction company interviewees noted that, through the reuse projects, they can reach customers willing to pay more for sustainable buildings and that when the price for reuse has come down, there will be very high demand for this. Moreover, as the construction company becomes the owner of the reusable elements, significant material cost reductions arise, especially when the reuse of concrete elements becomes more established and cost-efficient. Currently, the biggest value lies in the environmental savings due to the significantly lower environmental impact (e.g., reduced carbon emissions and lower generation of waste) of reusable concrete elements compared to virgin alternatives. Indeed, it seems that the project actors regarded value creation potential in the front-end as a long-term benefit and desirable outcome.

Project actors also reported that being part of the sustainability transition was regarded as valuable for the company image in itself, and some actors reported that being part of NewLife was already realizing image benefits in the short term. The CTO at the element manufacturer stated, for example, that, *"in these kinds of pilots, even in the very short term, there could be business potential in that even with a rather insignificant percentage of reused elements the [construction company name] can brand their buildings and we can brand our production."* As most companies now have their own strategies for environmental actions, the interviewees felt that NewLife enabled them to develop these. As the architect noted, *"internationally, it is becoming more and more common that institutional investors are divesting from assets which, in one way or another, don't take carbon neutrality efforts into consideration."* The senior fellow at the university agreed, arguing that investors see having sustainable assets in their portfolio as a risk-aversion technique.

4.3.2. *Identified barriers to value creation potential in NewLife*

In the first interviews conducted at the beginning of NewLife, in particular, some level of doubt about the actual business potential of reusing concrete elements was apparent. Early on, it was stated that it is certainly possible to detach concrete elements and completely safe to reuse them after refurbishing and testing. In fact, the properties of concrete (as a material) improve over time. However, each layer of hindrances, such as the differences among concrete element structures in the initial models or the desired level of element condition testing, was reported to raise the price per concrete element. Many interviewees expressed worries about the comparable price of new concrete elements produced from virgin materials, as their production is very efficient. The issue relates to the relative costs of labor and materials in Finland, as the production of concrete is currently cost-efficient, and the labor required to detach and refurbish it is expensive. The following quote from the construction company BDM sums up many of the interviewees' general feelings about the price of reuse:

> *If someone tells you at this moment to give us an offer for deconstructing that building over there and reusing 30 % of its concrete elements, we probably wouldn't dare to make that kind of an offer. It wouldn't pass our risk management, and even if it did, the risk buffers for it would be so high that nobody would buy that house, it would be so terribly expensive.*

As NewLife is a demonstration project with no established standard practices or supply chain actors, the project actors noted that currently there are no dedicated actors in the supply chain to take care of the refurbishment and storage of the concrete elements or, in the future, resell the detached concrete elements. Consequently, the project actors had to figure out which of them would be responsible for these tasks. In NewLife, all these tasks were assumed by the project actors, some of whose activities thus expanded beyond their normal business. In the open market, however, the interviewees felt that no such actors currently exist, which makes the adoption of reuse more difficult. Moreover, even though circular construction practices are becoming more popular, the direct transport of detached concrete elements from the deconstruction site to a new building site in the near future was regarded as unrealistic. On the other hand, interviewees mentioned that in the long run, the supply chain for reuse would eliminate other links in the traditional supply chain, such as the mining and transportation of the raw materials for concrete, which would, in turn, have a cost-lowering effect.

Initially, many different legislative interpretations of the environmental regulations and building inspection laws essentially challenged the reuse of concrete elements. The most important legislative challenge concerned the waste status of the detached concrete elements, namely, whether reusable concrete elements are interpreted as waste. To clarify this, the project actors sought different opinions from the authorities, and the final opinion was that the reusable concrete elements of NewLife were not considered waste due to the systematic deconstruction, testing, and documentation of the process and the planned use of the detached concrete elements. Strong regulatory guidance through taxation and subsidies was seen as one way to make reusing concrete elements a viable business model that could compete with traditional construction. Currently, multiple bureaucratic challenges remain, such as traditional ways of interpreting certain laws and regulations that would prevent reusing concrete elements in certain applications. The interviewees mentioned that, for example, a carbon tax that considers carbon emission reductions from reuse and/or penalties for taking virgin materials would guide the adoption of the reuse principle:

> *...because we could calculate that if we bought emission trades for the virgin elements and then we utilize, for example, 30 % of reused elements, and then the total costs would be lower. The whole industry would benefit from this, but it does require strong regulative guidance. [For example], if the work safety legislation wasn't this strict in Finland, we would not make such efforts to ensure work safety.* (Construction company BDM)

Generally, the public perception of reuse was regarded as a challenge to the wider adoption of concrete element reuse. In Finland, specifically, which has suffered indoor air quality problems in buildings, many interviewees felt it might be a significant challenge to convince the public that buildings incorporating reused concrete elements would be perfectly safe. As the senior research fellow at the university stated, *"some people will be afraid of our elements even though they are only steel and concrete."* Moreover, not only safety concerns were seen as a challenge; rather, communicating to people why they should buy something regarded as "used," rather than new, remains difficult in general:

> *For example, if you're buying a car, would you rather buy one that's made of new pieces or gathered from old ones? And I think you know it's better to buy the one with the old pieces for the environment, but I think you still want the new one for yourself, in a way. But I think it's a challenge of communication and how we share the information and how we tell the story and sell it to the customers. I think that's the key point, in a way.* (Construction company project manager)

Other challenges included the unsuitability of the current BIM software to plan for reuse, the conservative nature of the construction industry in terms of allowing for changes in conventional processes and supply chains, and, in particular, the lack of experience, understanding, and standards for reusing concrete elements. In addition, the requirements and constraints imposed by the owner of the new building and the site (especially zoning) where the new building is to be constructed affect how well concrete elements can be reused, for example, in terms of how well detached concrete elements from the donor building are compatible with the new one. Remarkably, as NewLife progressed, the key project actors seemed to become increasingly optimistic about the challenges, which could indicate that they saw increasing opportunities and possibilities within concrete element reuse as the planning phase advanced.

5. Discussion & conclusions

5.1. Adoption of the reuse principle in construction projects: front-end and value creation potential

The objective of the study was to determine how the adoption of the reuse principle influences the value creation potential for different actors involved in a construction project's front-end. To address this question, we studied how the conventional-industry actor roles and activities at the front-end change when concrete elements are to be detached intact and reused and, more specifically, how promoting concrete element reuse in a construction project could improve sustainability and create potential value for the actors involved. The sustainability driven by projects needs further study (Winch et al., 2023); in particular, our analysis revealed that studies linking the CE and project organizing (Lehtimäki et al., 2023) are limited. To understand how a demonstration project, such as NewLife, can contribute to a wider systemic transition (Winch et al., 2023), for example, shifting toward circularity, we approached the question through the MLP framework (Daniel, 2022; Geels, 2002). Our emphasis was on the project's front-end, where we observed how project actors took unorthodox roles in finding and surveying the donor building, planning its deconstruction, and jointly planning the later phases of the project, as a project's front-end phase significantly influences its ability to create value over its lifecycle (Matinheikki et al., 2016; Zerjav et al., 2021).

Our findings highlight that applying the reuse principle in construction projects increases the importance of the front-end phase as the determinant of project value. We suggest that the application of the reuse principle in construction represents a socio-technical transition (Daniel, 2022; Geels, 2002; Geels & Turnheim, 2022) with value creation potential that increases between the three levels of the MLP. Although multiple barriers remain to the wider adoption of the reuse principle in construction, there is significant value-creation potential in reuse at all three levels 1) individual project actors, 2) the construction industry, and 3) society. Moreover, we suggest that the developments on each level feed back to value potential on lower levels as the barriers between MLP levels are overcome (Fig. 4). Additionally, we observed that when a project applies the reuse principle and is consequently subsidized by the EU, environmental value appears to become the most salient motivator for project actors despite the apparent need for economic value creation.

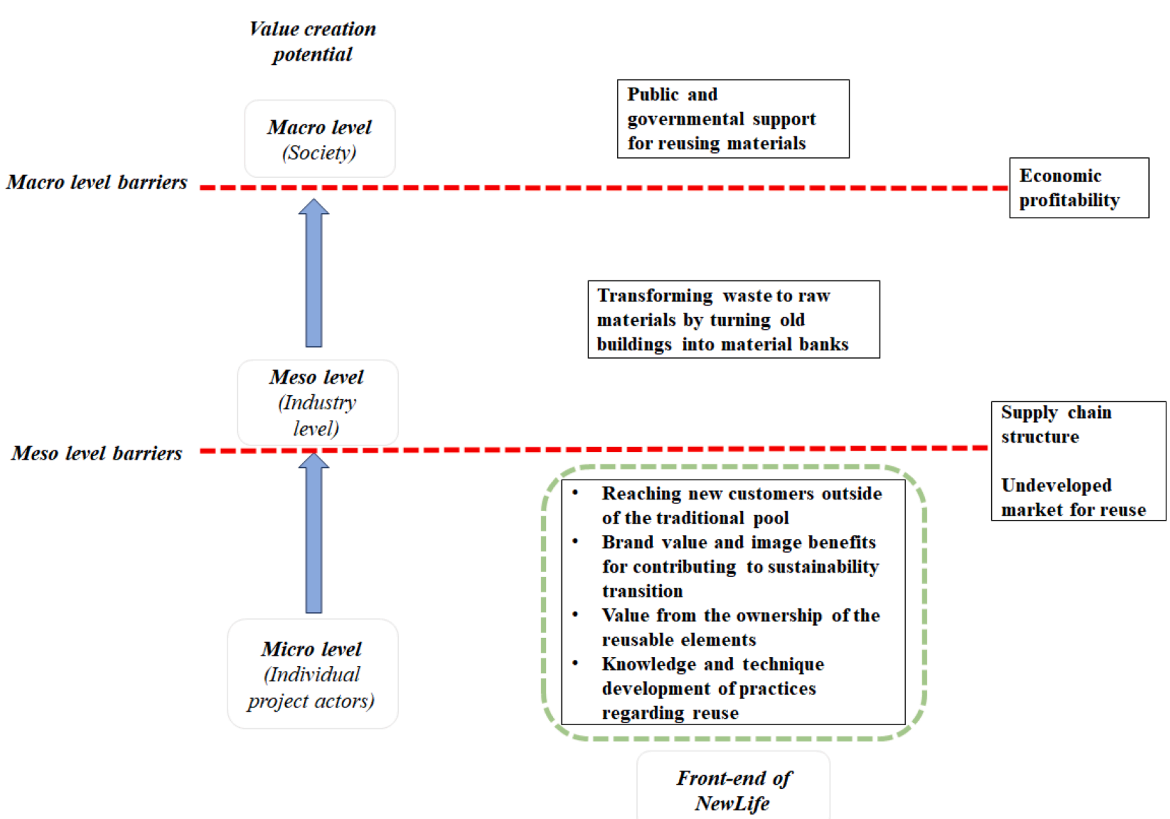

Fig. 4. Potential value and barriers to generating it at MLP levels.

On the *micro level*, our findings imply that a project based on reuse can create new types of value for its actors. As planning to detach concrete elements intact is a novel process for which there were no established standard practices, the actors took different and broader roles in the project's front-end than what is typically the case to facilitate knowledge sharing and expertise. We observed that detaching and processing concrete elements increases labor costs, and therefore a detailed and efficient work order plan developed in collaboration seems essential in reuse-based projects. The added knowledge of and expertise in new techniques and means of working that were developed realized value for actors from as early as the front-end phase. Furthermore, the collaboration during the front-end enabled most actors to reach new potential customers through other project actors' networks and the reputation they gained by being part of the demonstration project. Despite doubts about NewLife's success, particularly in the economic sense, it was clearly the quest for a more sustainable transition that most motivated the project actors to collaborate during the front-end to create long-lasting environmental value through the project.

Our findings regarding the actors' value perception in the front-end are in line with Zerjav et al. (2021) in that the value in the front-end is, indeed, more about the desirable than the factual; therefore, it requires certain skills on the part of the owner to frame a project persuasively and argue its value. Hence, we argue that the application of the reuse principle appears to highlight the project owner's role in the front-end. In our case, the entire economic value of the project based on the reuse of concrete elements was dependent on how successfully it managed to detach the concrete elements intact, and this required intricate planning and clear communication of the project's objectives to all involved actors by the owner. The experiences of NewLife showed that a lack of commitment and understanding among the project actors could result in the breakage of the elements. Thus, the project value needs to be well-argued and communicated in the front-end, and actors must be tied to the project's sustainability objectives. If the owner of the reuse-based project gains ownership of the salvaged materials, as is the case in NewLife, we argue that the owner's value creation potential from reuse increases significantly, as does their commitment to the project's sustainability objectives in the front-end. Similarly, there are increased risks involved as the warranties for reusable elements can be unclear, and there might be reputational damage if problems arise due to the innovative approach taken. The value dynamics would be affected greatly if some other actor, such as the demolition company, as in the case of conventional demolition waste, should become the owner of the reusable materials.

On the *meso level*, our findings imply that the potential value derived from reuse increases as individual demonstration projects, such as NewLife, gradually develop the necessary techniques and practices for reuse and these practices are diffused within the industry, allowing for more widespread and efficient business models to develop around it. However, this model of development calls for changes in the way that the construction industry traditionally functions. Reuse adds phases to a project, such as drawing up a donor building inventory and warehousing, reselling, and refurbishing elements. Our results showed that the simultaneous offer and demand of reusable concrete elements is not realistic in the industry's current state, which currently slows down the systemic transition on a meso level. The absence of bridging actors in the supply chain that would take care of the storage, transportation, and resale of the reusable concrete elements is the most important meso-level barrier to reuse in our analysis.

Finally, on the *macro level*, the results of this study demonstrate that the actual transition to deconstructing buildings and salvaging their concrete elements is technically possible and has the potential to bring value to project actors and change to the construction industry in general. However, the most significant barrier to this systemic transition is financial profitability, which is limited by the lack of government support and therefore exists at the macro level. Incremental improvements to the processes that generate costs for reused elements do not seem adequate to make them directly competitive against the production of new elements. Henceforth, increasing the financial profitability of salvaged concrete elements through taxation guidance, carbon offsetting policies, or other regulatory measures seems to be a prerequisite for the wider adoption of reuse. Moreover, bureaucratic work is needed to facilitate the use of reused elements as valid and safe building materials. We argue that the wider adoption of the CE principle of reuse in construction thus seems to be principally limited by the current regulatory approach to reusable materials and elements. Conversely, the changes at the macro level hold the most potential to increase the value potential of applying reuse in construction.

5.2. Theoretical contributions

Our findings show that applying reuse affects project's front-end value creation potential and actor roles, thus continuing recent efforts by Lehtimäki et al. (2023) to bring CE discussion into project organizing studies. This study contributes to the project sustainability literature by showcasing how a project can *drive* sustainability and contribute to a wider systemic transition (Geels, 2002; Geels & Turnheim, 2022) instead of *being* sustainable in some way (Huemann & Silvius, 2017; Silvius, 2017), which is an issue raised by Winch et al. (2023). The importance of integrating sustainability into project management has been widely recognized (Keeys & Huemann, 2017; Martens & Carvalho, 2017; Sabini et al., 2019; Silvius, 2017; Silvius & Schipper, 2014), but research on operationalizing sustainability in projects has been lacking (Winch et al., 2023). In this study, this operationalization is the application of the reuse principle, which remains understudied in CE research despite its recognized benefits (Ghisellini et al., 2016; Harala et al., 2023; Rakhshan et al., 2020; Többen & Opdenakker, 2022; Yang et al., 2015).

By applying the MLP framework, we have considered how a single project may, in its part, contribute to a wider systemic transition (Geels, 2002; Geels & Turnheim, 2022), a need also voiced by Winch et al. (2023). We have also contributed to the transition literature by explaining the barriers to and drivers of the diffusion of reuse in construction projects identified at the macro and meso levels. According to our analysis, the construction industry's transition to reusing concrete follows the analogy of the MLP, as proposed by Geels (2002) and later other scholars (Daniel, 2022; Geels & Turnheim, 2022). The importance of demonstration projects in initiating these socio-technical transitions has been recognized in the literature (Bandeira Barros et al., 2023; Chan et al., 2022), and we add to this discussion by showing how a demonstration project can develop practices and techniques that are at the forefront of development and thus contribute to a wider systemic transition.

We found that the project front-end becomes an increasingly critical phase at the micro level of the MLP, as the application of reuse principle increases the interdependence of the project phases and actors. This follows the argument commonly made in the front-end literature (Liu et al., 2019; Matinheikki et al., 2016; Martinsuo et al., 2018; Williams et al., 2019; Zerjav et al., 2021) that a project's value is significantly influenced by the decisions and actions made at the front-end. The insight also complements the findings of Zerjav et al. (2021) on how project actors frame the value differently in the front-end, and managers should address the discontinuous nature of value during this phase. Continuing this discussion by Zerjav et al. (2021), we show that the actors' commitment to the project and trust in its success increased as the front-end progressed despite the uncertainty of its value potential. Furthermore, we show that the potential value of a project applying reuse increases according to developments on all three MLP levels.

According to the MLP, any radical innovation needs to gain momentum and overcome different barriers to become a socio-technical transition (Daniel, 2022; Geels, 2002). To understand what would need to happen for reuse applications to gain momentum in construction projects, we evaluated the value creation potential in our case project. Our findings highlight new types of value that the project actors identified as attainable in projects that apply the reuse principle, which enriches the existing project value debate (Artto et al., 2016; Kroh & Schultz, 2023; Martens & Carvalho, 2017; Zerjav, 2021; Zerjav et al., 2021). The notion by Zerjav (2021) that project actors need to realize value from a project to remain involved was also true in a project applying the reuse principle. Thus, we have made a small contribution towards addressing the gap in linking sustainability to economic benefits (Keeys & Huemann, 2017) by showing how environmental value can become a salient motivator for project actors to develop practices that allow for financial gains. Our findings contribute to the project front-end value discussion (Kroh & Schultz, 2023; Matinheikki et al., 2016; Martinsuo et al., 2018; Zerjav et al., 2021) and complement it by arguing that actors are motivated by the potential value to be realized in the long term as well as the environmental contribution potentially made by their efforts in the project front-end.

Finally, we have made contributions to CE research, as we have addressed the understudied reuse principle (Aarikka-Stenroos et al., 2022; Ghisellini et al., 2016; Harala et al., 2023; Riuttala et al., 2024) by showing what shifts in the industry it triggers. The findings resonate with the CE literature in that applying CE principles requires changes in the supply chain Bressanelli et al. (2019), Lüdeke-Freund et al. (2019), value creation (Aarikka-Stenroos et al., 2022; Austin & Seitanidi, 2012; Harala et al., 2023; Paavilainen et al., 2021), and how actors collaborate (Bocken et al., 2018; Harala et al., 2023; Paavilainen et al., 2021; Le Pennec and Raufflet, 2018).

5.3. Managerial implications

By investigating the project front-end in a construction demonstration project, this research has offered insights into how actor roles, key activities, and the value creation potential in the front-end might be unique when a project is based on the CE principle of reuse. The project actors take different and wider roles and collaborate more closely in the front-end. Moreover, there are significantly more phases than in conventional construction projects, which also calls for project management to take a different approach in CE projects. By highlighting how actors perceive the value creation potential of reuse, this study offers managers a starting point to evaluate actors' willingness to partake in similar sustainability transition ventures. Managing the collaboration and value creation in the project front-end calls for added emphasis on the relationships between actors and what the project objectives mean to them, as it seems that the "higher meaning" of a project motivates actors to collaborate. Project managers should also be able to expand value-thinking to dimensions outside mere financial returns and find ways to create financial value through applications that reduce a project's environmental impact. The findings regarding the perceived value creation potential highlight, in particular, that actors themselves place value on things that do not generate financial returns in the short term, such as gaining a competitive advantage on novel deconstruction techniques or improving brand image. Our findings suggest that a CE construction project's front-end is fuzzier and more complex than in conventional construction, which calls for management practices designed for operating under uncertainty.

5.4. Limitations and further research

Our study has certain limitations, mostly related to NewLife's funded nature and the dataset used. The project is an EU-funded research project and, as such, does not necessarily fully represent a project taking place on the open market. All the actors were inherently engaged in the project and motivated to develop and study new types of solutions to allow for concrete element reuse. In a more competitive environment, in contrast, the actors' willingness to collaborate and share information and expertise might be more limited. Furthermore, as the demonstration project in our study is still ongoing, no comprehensive insights can be derived about the actual realized value created for the project actors until the concrete elements have been used to construct a new building and the demonstration project has finished. Moreover, our study concentrated on a single country's construction industry, further limiting the generalizability of the results, as the opportunities and challenges might be different in other countries and industries with different attributes.

Based on our findings and the limitations of this study, we suggest that future research avenues could include studying the management of projects applying CE principles, especially reuse, that have already been finalized, which would allow for the evaluation of practices, key actor collaborations, and supply chain structures that make these kinds of projects succeed. Such studies would also allow for the evaluation of the realized value of the project and its connection to front-end decisions and activities. The third owner domain that was only briefly mentioned in our study due to its early phase remains an important topic to be studied in future research on concrete element reuse projects. Furthermore, we call for research into architectural salvage markets and their potential in supply chains based on reuse, as one of our conclusions was that the undeveloped market for reusable elements is a major barrier to the wider adoption of reuse. Reusing building materials itself is not a novel concept; rather, the novelty lay in the industrial context in which we approached this practice.

CRediT authorship contribution statement

Matias Rokio: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tuomas Ahola:** Writing – review & editing, Writing – original draft, Validation, Supervision, Conceptualization. **Lauri Alkki:** Writing – review & editing, Writing – original draft, Validation, Methodology. **Matias Ståhle:** Writing – review & editing, Writing – original draft, Validation, Conceptualization.

Declaration of competing interest

The authors declare that there are no conflicting interests.

Acknowledgements

This work is supported by European Union's Horizon 2020 research and innovation program (ReCreate) research funding (grant ID 958200). We would like to thank Leena Aarikka-Stenroos, Linnea Harala, Mikko Sairanen, and Mari Riuttala for their participation in the research data collection.

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