Aligning practices towards a circular economy in the architecture, engineering, and construction sector

Seven transitions in different stages of reconfiguration

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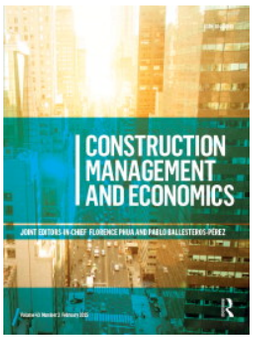

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Aligning practices towards a circular economy in the architecture, engineering, and construction sector: seven transitions in different stages of reconfiguration

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ABSTRACT

The architecture, engineering, and construction (AEC) sector is in need of a transition towards a circular economy. This article offers an analysis of two cases with a wide variation regarding project dynamics in the Netherlands. Alignments and misalignments were analyzed between practices concerning seven design strategies for circular design based on social practice theory and concepts from the multi-level perspective. Results show that many misalignments still hinder the transition, mostly concerning the use of secondary resources, such as notions regarding quality, beauty, and safety among project team members or rapid decision-making processes of the municipality that misalign with the uptake of design with secondary resources. This article offers directions for reconfiguration, such as better tuning between project planning and urban planning and taking up a more flexible stance regarding the function of the building. This research is interesting for practitioners and researchers focusing on the transition towards a circular economy in the AEC sector.

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Circular construction; social practice theory; transition; practice alignment

Introduction

The Architecture, Engineering, and Construction (AEC) sector stands out as one of the world's largest contributors to CO2 emissions and waste, while also consuming significant amounts of energy and resources (UNEP 2020). Consequently, there is a pressing need for a transition. This transition involves shifting from a linear economy, characterized by the 'make-use-dispose' approach (Kirchherr *et al.* 2018), to a circular economy (CE) that emphasizes the creation of social, financial, and environmental value through a systemic perspective on the entire life cycle of buildings and their components (Hossain *et al.* 2020).

The transition towards a circular AEC sector requires radical systemic changes in how buildings are procured, designed, and constructed (Leising *et al.* 2018, Kristensen *et al.* 2021), that go beyond traditional project boundaries (Ababio and Lu 2023, Vosman *et al.* 2023). The transition is complex (Mickwitz *et al.* 2021) and poses various challenges, such as laborious collaboration between different organizations (Eikelenboom and van Marrewijk 2023), the lack of consensus in defining circularity (Kirchherr *et al.* 2017, Hart *et al.* 2019, Wiarda *et al.* 2023), insufficient practical knowledge (Adams *et al.* 2017, Gerding *et al.* 2021), lack of usage of tools that would create practical knowledge (Çetin *et al.* 2022), lack of knowledge transfer across projects (Eikelenboom and van Marrewijk 2024), the lack of standards and standardized practices for circularity (Benachio *et al.* 2020), lack of time to realize ambitions (Arora *et al.* 2021), lacking markets for secondary materials (Adams *et al.* 2017), lack of knowledge on when secondary materials become available (Koutamanis *et al.* 2018, Vandervaeren *et al.* 2022), uncertainty regarding future cycles of materials (van Stijn *et al.* 2021), and other ambitions that require the attention of project actors (Kooter *et al.* 2021). Finally, the sector is known for its conservativeness (Wamelink and Heintz 2015), often due to lock-in mechanisms (Akinade *et al.* 2020, Coenen *et al.* 2023), its lack of trust, and risk avoidance (Ruijter *et al.* 2021). All these hinder the transition towards a CE.

All these barriers are related to practices that hinder other practices. Practices are interpreted as a type

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of behaving and understanding that appears at different locales, in different times, by different bodies and minds (Reckwitz 2002). A practice's internal logic can, through change, start to misalign with other practices in a system. Therefore, the focus of this paper is on alignment and misalignment of practices and how these relate to setting and realizing CE ambitions. Alignment is here conceptualized as practices that stimulate other practices on setting or realizing circular ambitions and misalignment on practices that hinder this. For example, notions of good project management (sticking to budgets, planning, and scope) misalign with flexibility for contractors to change design solutions to achieve circular goals in different ways (Kooter *et al.* 2021). We are aware that the concept of alignment also exists in organizational sciences and might have a different meaning in that context. Circular design strategies, which describe which circular design choices can be made and with which tools, are vital for the AEC sector to achieve its circular ambitions (CB'23 2023).

Ultimately, we are interested in the reconfiguration of practices, so that misalignments can be overcome. The research questions this article aims to answer are therefore: *how do practices (mis)align with each other regarding circular design strategies, and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?*

To analyze these (mis)alignments, Social Practice Theory (SPT) is used, as it is an often used lens to study changing practices (Schatzki *et al.* 2001, Shove *et al.* 2012). Many examples exist of its use in the AEC sector (e.g. Eikelenboom and van Marrewijk 2023, Collinge 2024, Gherardi *et al.* 1998). As SPT is often used to describe transitions (Spaargaren *et al.* 2016) but lacks elements to explain transitions (Geels 2010), this study adopts some concepts from the multi-level perspective (MLP), which has become more common in the last decade (e.g. Watson 2012, Hargreaves *et al.* 2013, Crivits and Paredis 2013). Also the MLP has often been used in the AEC sector (e.g. Van Bueren and Broekhans 2013, Gibbs and O'Neill 2015, Kooter *et al.* 2021). The two approaches are complementary in their units of analysis (Hargreaves *et al.* 2013, Sovacool and Hess 2017): the first focuses on routinized practices; the second on systemic rules.

This research uses a case study method for two cases with a wide variation of project dynamics, as found by Kooter *et al.* (2021), to study alignment and misalignment of practices with a focus on construction projects with circular goals. Project X is the construction of an office building, made using project dynamics that Kooter *et al.* (2021) found to be helpful for setting and realizing circular ambitions. Project Y is a project for renovation of an educational building in which these dynamics played a minimal role, but where instead traditional project dynamics (e.g. risk aversion and short-term orientation (Ruijter *et al.* 2021, Wamelink and Heintz 2015) were dominant.

This article is set up as follows. First, we delve into SPT and its adopted concepts from the MLP. Next, we explain the qualitative research methods used to study these cases. Further, the results section illustrates how (mis)alignments of practices influence the operationalization of circular design strategies. The discussion of these results includes reflections and focal points for reconfiguration to further stimulate the transition towards a CE in the AEC sector. And finally, the paper finishes with a conclusion.

Social practices in the circularity transition

A practice-theoretical understanding of transitions

We understand transitions as a structural change of a societal system (e.g. a technological system) that itself resides in a system of systems (e.g. political, legislative, economical) that affects formal structures (e.g. physics, legislation, economics), informal structures (e.g. culture, ideologies, discourse), and practices (e.g. routines, habits, procedures) (de Haan and Rotmans 2011). Transitions encompass many different actors (Geels 2005), concern multiple aspects (Heurkens and Dąbrowski 2020), are path-dependent, and progress non-linearly (Wittmayer and Loorbach 2016). In analysing systemic changes, Social Practice Theory is increasingly used as approach that takes practices – not structures or individual choices – as unit of analysis (Shove *et al.* 2012, Schatzki *et al.* 2001).

Practices, such as brick laying, or designing schools, consist of an array of activities that require knowledge, skills, and artifacts (Schatzki *et al.* 2001). Practices are self-reinforcing (Seyfang and Gilbert-Squires 2019). The constant reproduction is further enforced by practices on which an individual practice depends; together these form a complex (Shove *et al.* 2012). Complexes are formed by overlapping elements between practices, the sequence in which practices are performed (Huttunen *et al.* 2021), or similarity of space (Spaargaren *et al.* 2016). In the AEC sector these complexes are for instance formed by the supply of materials and building components, their assembly on a construction site, and the procurement, design, and engineering processes. Scholars urge that these

practices should be studied together to further drive CE transition (e.g. Ababio and Lu 2023). All these practices, though uniquely performed in every project contain standards, for instance stemming from building law, industry standards, or relating to standards of design processes. Complexes contain a teleoaffective structure, a 'range of normativized and hierarchically ordered ends, projects and tasks, to varying degrees allied with normativized emotions' (Schatzki 2002, p. 80). In the AEC-sector, contractual relationships (Kesidou and Sovacool 2019) play a central role in this teleoaffective structure. Generally, SPT scholars agree that all activity is perceived as practices; there is no context outside practices (Huttunen *et al.* 2021) or hierarchy between practices (Hargreaves *et al.* 2013, McMeekin and Southerton 2012).

The potential to change practices lies in 1) replacing or altering the elements, 2) the ways they are 'interlocked' in their complex, 3) changing the practitioners that perform these practices, or 4) by changing the networks in which these practitioners interact with each other (Shove *et al.* 2012). Similarly, stabilizing these four ways can stimulate reproduction of practices. With its focus on practices (i.e. not actors), this study takes the first two options into account.

SPT tells us that practices are ever changing (Schatzki 2002). To help us get a grip on how stable and interlocked a practice is, we adopted concepts from the MLP.

Adopted concepts from multi-level perspective

The MLP is an often used perspective to study transitions (Köhler *et al.* 2019) – also in combination with SPT (e.g. Watson 2012, Hargreaves *et al.* 2013, Langendahl *et al.* 2016). It offers the concepts 'niche' and 'regime' that can be operationalized to study different levels of practice stability. We understand niches as the locus of radical innovations (both in technology and practices) and regime as the locus of established rules that help stabilize existing systems (Geels 2011).

Institutional, organizational, and psychological barriers enforce the regime's resistance to change (Brown and Vergragt 2008, Van Bueren and Broekhans 2013). Contrastingly, niches are constantly changing (Schot and Geels 2008). Smith (2007) distinguishes seven dimensions in which the concepts differ, which we operationalized, as can be seen in Table 1.

Following Watson (2012) and Crivits and Paredis (2013), we use these concepts of 'niche' and 'regime' in SPT. Systems are perceived as sets of interlinked practices, where each practice is influenced by either niches or regimes, as can be seen in Figure 1.

We follow Crivits and Paredis (2013) that distinguish practices in elements of agency, material-functional structure, and socio-cultural structure. This interpretation is chosen for its broad interpretation of agency (including motivation, values, and capacities) that is important in this specific transition (Kooter *et al.* 2021), and its explicit focus on structures (both cultural and functional) that influence the AEC sector (Van Bueren and Broekhans 2013, Genovese *et al.* 2017).

When practices are stable they are usually performed relatively effortlessly, but when some practices start changing, especially when niches form, misalignments become apparent (Phipps and Ozanne 2017). Circularity offers concepts that are both new and old (Rockow *et al.* 2021) and (mis)align with existing practices. Here 'sleeping' practice elements (Shove *et al.* 2012) show, as they align with circularity and similarly contrasting notions might become apparent as circularity puts stress on eminently present routines.

Table 1. Niche-regime distinction, based on Smith (2007).

	Regime	Niche
Principles	Mainstream guiding principles (e.g. profit and loss)	Alternative guiding principles (e.g. minimize ecological footprint, closing loops)
Technologies	Tried and tested technologies and infrastructure (e.g. design with concrete structure)	New technologies and infrastructure (e.g. design with reused concrete)
Industrial structure	Industrial structure *en masse* (e.g. subcontracted labor, volume building)	Alternative industrial structure (e.g. use of secondary building components)
User relations	Traditional user relations and markets (e.g. passive and conservative consumers)	Active user relations and markets (e.g. actively steering clients)
Policy	Following policy and regulations (e.g. MPG[1] minimum is standard)	Challenging policy and regulations (e.g. lowering MPG goals for a project)
Knowledge	Knowledge based on existing competencies and business practice (e.g. standardized designs/ solutions)	Knowledge base for alternative guiding principles (e.g. knowledge of low-impact materials)
Cultural, symbolic meanings	Broadly shared cultural, symbolic meanings (e.g. markets and regulations)	Alternative cultural, symbolic meanings (e.g. circular housing)

MPG is Milieu Prestatie Gebouwen, the Dutch standard on shadow costs, which are based on Life Cycle Analyses. The current standard is achievable without extensive measures.

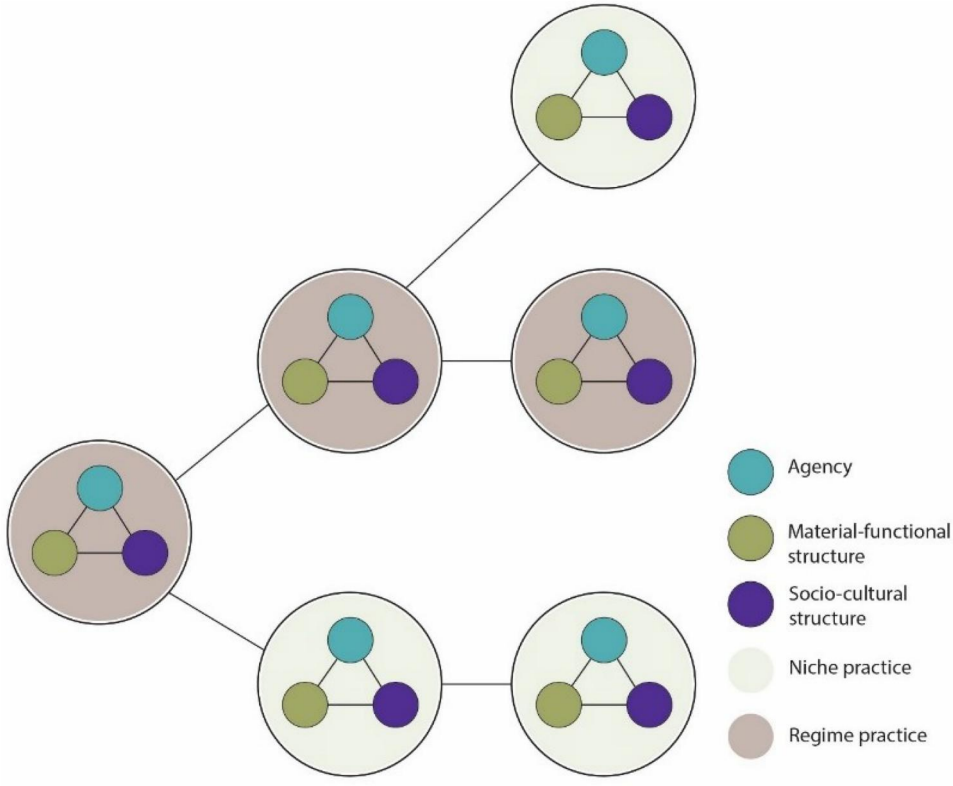

Figure 1. System-of-practices (based on Crivits and Paredis 2013, Watson 2012).

Reconfiguration is a transition path in which the adoption of new elements in regime practices make them slowly change from within (Berggren *et al.* 2015). We argue that for the transition towards a circular economy in the AEC sector, reconfiguration is the most likely transition path, because this conservative, risk avoiding sector (Ruijter *et al.* 2021, Dunant *et al.* 2017) seems to slowly change from within, mainly through efforts of large public and private organizations (Kooter *et al.* 2021). This paper investigates (mis)alignments in the transition and which reconfigurations are deemed likely to overcome misalignments.

Dynamics supporting circular construction

Kooter *et al.* (2021) found fourteen dynamics in and around construction projects that stimulate circular construction, divided in prerequisites, project dynamics, and contextual influences (see Table 2). A dynamic is defined as a 'process of relating activities across boundaries to maintain patterns of change and continuity through time, and to the forces that produce these patterns' (Cropper and Palmer 2008, p. 636), and can therefore here be interpreted as activities that stimulate the formation or reconfiguration of practices. The framework fits earlier findings (e.g. Hart *et al.* 2019, Benachio *et al.* 2020), but has up to this date, to the knowledge of the authors, never been questioned on its completeness or on how specific dynamics change routinized practices. Incompleteness is likely, as recent research (e.g. regarding partnering, Vosman *et al.* 2023) suggests yet uncovered dynamics. We started our research with the hypothesis that when these dynamics are present more alignments would show, and vice versa when these dynamics are absent more (fundamental)

Table 2. Dynamics supporting circular construction, based on Kooter et al. (2021).

Category	Dynamic
Prerequisites	Top–down support
	Partnership based on increased equality
	Shared circular goals
	Involvement of intrinsically motivated people
Project dynamics	Transparency and trust
	Flexibility
	Reciprocal relationships
	Project team identity
	Struggle for new roles
	Pioneering leadership
	Continuity in staffing
Contextual influences	Sector and organization cultures
	Knowledge flows
	Power and tension

misalignments would show. As a result of this study, we reflect on the completeness and effects of different dynamics of the framework. This reflection can be found in the discussion.

Methods

Data gathering and analysis

For this research, a case study method is used, because this allows for a rich understanding of a complex phenomenon (in this case the transition to a CE in the AEC sector) (Yin 2013). This is important, because the transition to a CE is hindered by opposing values (Kooter *et al.* 2021) and a rich understanding of these values is needed to overcome their opposition. As research to this transition has increased, this study aims to test, nuance, and elaborate on existing research (Ketokivi and Choi 2014) by applying a framework (i.e. the System-of-practices framework) that, to the knowledge of the authors, has not been used for research on this transition yet.

Case selection

Two Dutch construction projects with circular ambitions have been researched. One operationalizes dynamics supporting circularity (Kooter *et al.* 2021), whereas the other uses traditional dynamics (see Table 3). The cases have been chosen for their project dynamics on either side of the spectrum and this allows us to test this existing theory. The wide variation between the cases further allows to better see if the patterns of (mis)alignments hold and their polarity regarding project dynamics allows us to perceive them as critical cases (Miles and Huberman 1994), so to better understand the possible directions of the circularity transition in the AEC sector.

The projects had to be in the realization phase or later and circular ambitions had to be present. Cases were brought forth by a consortium of practitioners (i.e. public clients, architects, contractors, and industry organizations), thus forming a short-list. Although more circular construction projects exist that consortium members were not part of, there are only few in the Netherlands and the short-list can be considered representative. For both ends of the spectrum, three cases were brought forth by the consortium that fit all criteria. The final selection was based on their polarity regarding project dynamics. The presence of these dynamics was determined in explorative interviews and validated in in-depth case studies.

Case studies and data collection

Research has been executed by conducting 19 semi-structured interviews (as shown in Tables 4 and 5), 8 observations of team meetings, three workshops, and

Table 3. Project dynamics in two cases, based on Kooter et al. (2021).

	Project X (operationalizing dynamics supporting circularity)	Project Y (traditional dynamics)
Prerequisites	Clear top-down support for all companies in project team	Within the project team only top-down support in architecture firm
	Partnership based on increased equality and collaboration	Traditional partnership
	Collaborative formulation of shared circular goals	Goals are formed by the architect
	Involvement of intrinsically motivated people throughout project team	Only architect was motivated for circular goals
Project dynamics	Communication is explicitly transparent	Knowledge remains with specialists and is not communicated to other project members
	Flexibility regarding budget and scope. Only planning was inflexible	Minimal flexibility regarding budget and no flexibility regarding scope and planning
	Partnerships are reciprocal through alliances	No time was given to establish reciprocal relationships
	The shared circular goals formed an identity for the team	Lack of time and shared goals hindered formation of team identity
	Traditional roles were continuously questioned and reestablished	The architect aimed to take on new roles but was pushed to stick to traditional role
	The client took on a pioneering role of leadership for circularity	The architect aimed to take on a pioneering role for circularity, but struggled with this until the end
	Continuity in staffing was present for all companies.	Continuity in staffing was present for all companies, but not all actors joined the project at the same time
Contextual influences	Organization cultures stimulated circular construction, with the exception of installation companies	Although most companies underlined the circularity transition, most did not stimulate circular construction
	Reasonable knowledge was present among most actors and consultants and Early Contractor Involvement contract stimulated further knowledge development	Knowledge on circularity was largely missing. Lack of specialists made actors hesitant to experiment
	Explicit displays of power remained absent until later stages of the realization phase. The project was set up explicitly with increased equality	Actors were prone to follow client without much questioning of the assignment

Table 4. Interviewees case with project dynamics supporting circularity (project X).

	No.	Interviewee
Case with project dynamics supporting circularity (project X)	1	Civil servant of municipality
	2	Consultant to the contractor
	3	Architect
	4	Client
	5	Installation consultant
	6	Contractor
	7	Interior architect
	8	Corporate Social Responsibility (CSR) manager client
	9	Constructor
	10	Consultant client (ambitions)
	11	Project leader installation company
	12	Contract lawyer
	13	Project manager

Table 5. Interviewees case with traditional project dynamics (project Y).

	No.	Interviewee
Case with traditional project dynamics (project Y)	14	Architect
	15	Client
	16	Contractor
	17	Contractor
	18	Project manager
	19	User

a document analysis of contracts, project agreements, and vision documents for validation of interview results. Interview questions focused on the elements that comprise a practice (agency, material-functional structure, and socio-cultural structure), and the relations between practices. Examples of questions are 'which values influence your choices in setting circular goals?', and 'how do other actors influence you realizing circular ambitions?' In this paper, actors and organizations have been anonymized for privacy reasons.

Data analysis (within case)

Transcripts of the interviews have been analyzed using Atlas.Ti. First, focusing on teleoaffective structures (Schatzki 2002), a distinction between practices has been based on assignments, often materialized in contracts. Further, per practice, the practice elements (i.e. agency, material-functional structure, and socio-cultural structure) have been used as codes. Secondly, using inductive coding, components of practice elements were grouped. Lastly, we coded when interviewees mentioned other practices that influenced their practice. Based on this set of codes, we analyzed whether setting and realizing circular goals (mis)-aligned with other practice elements. We grouped these (mis)alignments based on the seven circular design strategies, as defined by CB'23 (2023). We used the CB'23 framework and not dominant frameworks like the R-model (e.g. Potting *et al.* 2017), as this is made specifically for the AEC sector. It for instance allows to differentiate between design for disassembly and reusing itself, which are very different, and also includes design with renewable resources. The design strategies are:

1. Design for prevention, which focuses on reduction of objects, building components, and materials.
2. Design for quality and maintenance, which focuses on prolonging life of buildings, components, and materials.
3. Design for adaptability, which focuses on making adaptations easier in the future. This includes design for flexibility (i.e. creating spaces that can house various functions).
4. Design for disassembly and reusability, which focuses on enabling reusing building components later without damaging components.
5. Design with existing building (parts), which is self-explanatory.
6. Design with secondary resources, which focuses on reusing building components and materials again.
7. Design with renewable resources, focuses on materials that can be renewed (e.g. biobased materials).

Some (mis)alignments concern all of these. These were grouped under 'circularity in general'. We visualized the system-of-practices for each circular design strategy. The units of analysis are practices (not actors), and the visualized distances are based on ease of representation and do not resemble perceived distances between practices.

Practices have been divided into niche or regime. This distinction was made using Table 1, based on Smith (2007). Practices can be considered regime on certain elements, but niche on others. Making distinctions as such eliminates the often contested dichotomy between niches and regimes (Smith 2007, Genus and Coles 2008). Distinctions have been determined in a multi-step procedure. First, one researcher determined the categories based on quotes. Then, a second researcher challenged these assumptions in dialogue. Third, the rest of the research team challenged these distinctions.

Cross case analysis

In the cross case analysis, explanations were sought for similarities and differences between results within

the cases. This was coded inductively. Emerging themes regarded context, project dynamics for circularity, and formal contracts. In a second round of inductive coding sub-themes within these three categories were formed that explained differences between the projects per design strategy.

Validation and reliability of findings

Three workshops have been conducted to validate results. Workshop participants were consortium members: architects, contractors, public clients, and academic researchers, who have worked together semi-annually for over three years. In the workshops preliminary results were presented, which were discussed in public and deepened in smaller groups that focused on pattern explanations. This helped us understand which reconfigurations were deemed most important for the transition.

The cases

Case with project dynamics supporting circularity (project X)

Project X is the development of several buildings for utility purposes including an office building, a work hall, and a parking garage. The design focused on becoming energy neutral in use, having limited CO_2 emissions (measured with the MPG, the national standard), and reusing as many building components as possible. Energy neutrality has been achieved, the CO_2 emission limitations have been accomplished mostly due to the wooden construction, and secondary resources played a dominant role in the design process, but only in 'unimportant' elements of the building. The project was initiated because the client company had to move to a new site within the same municipality. The municipality had plans to redevelop the site of the old building, ended the lease of the land, and offered help to find a new location.

The case with traditional project dynamics (project Y)

Project Y is the renovation of an educational building, focusing on both public and private education. The client, the owner of the building, is a public organization, but the main user is a private organization. Although the board had circular ambitions, for practical reasons very few ended up in the tender. The ambitions concerned energy reduction (e.g. by updating installations), energy generation (i.e. by using solar panels) and updating installations to remain operational for 10 years. This scope derived from uncertainty regarding larger urban development. During the project, the architect aimed to raise circular goals by using bio-based materials and designing for disassembly. The project was initiated because installations were almost outdated and unsafe. Because the user wanted to remain in the building during renovation, realization took place during summer, which also caused pressure on the design phase.

Results

The results first discuss the two cases, by elaborating on the system-of-practices in either case, the division of practices in regime- and niche-practices, and (mis)-alignments concerning the seven circular design strategies, including circularity in general. Lastly, this section discusses reconfigurations of practices that actors deem necessary to overcome misalignments.

The system-of-practices

Throughout project X and Y, practices influence each other, which is further illustrated in a complete overview in Appendix A. Influence of one practice on the next can take multiple forms (e.g. setting norms, transferring knowledge, or delivering secondary building components) and extend far from traditional project boundaries. This means the transition does not only take place within construction projects, but also in practices around projects and the interdependencies between them.

Project X is more complex than project Y. This partly stems from the size of the projects - project X comprises more aspects and therefore more practices - but a key difference stems from the different contracts: in project X an Early Contractor Involvement contract is used, which adds practices in the heart of the project. The case with traditional project dynamics (project Y) used traditional contracting (i.e. a top-down structure where the client takes ownership of the design, and late involvement of actors, such as the contractor), which limits the amount of practices. This will be further discussed below.

Niche- and regime-practices

In project X, many practices are leaning towards niche, as is illustrated in Appendix A. The most notable exceptions to this are practices involving installations. Not only were circular ambitions not realized, actors also found it difficult to set them and challenge business-as-usual. They considered reuse extremely

difficult, because components had become outdated. Further, colleagues were skeptical if secondary resources could live up to the quality of new components (interviewee 5,11).

Project Y was dominated by relatively regime-practices, as illustrated in Appendix A. Contrastingly, the architect had alternative guiding principles, involving design for disassembly and incorporating biobased materials, but because of influencing regime-practices, the architect struggled changing business-as-usual (interviewee 14, 16). Further, two aspects seemed dominant for this regime reinforcement. First, the limited time and small scope hindered developing mindsets for innovation (interviewee 15). More concretely, especially the given horizon to remain operational for 10 years and the limited time in the design phase (interviewee 17) hindered thinking out of the box. Second, the traditional contract stimulated a culture to follow the client's wishes, instead of challenging them, as is more common with Early Contractor Involvement contracts (interviewee 17).

Being niche for many practices means that actors are actively trying to achieve circular goals, but not necessarily realizing them. Reflection on activities was clearly present for actors involved in these niche-practices (e.g. in project X, the architect wondered if the design of the building should follow from an overview of available building components, instead of vice versa). This was less so for actors working on regime-practices in both projects. The installation employee (interviewee 11) for instance explained his linear rationale: 'often it is cheaper, easier, and faster to build with primary resources.'

Below the alignments and misalignments of these practices will be presented per circular design strategy, based on CB'23 (2023): 1) circularity in general, 2) design for prevention, 3) design for quality and maintenance, 4) design for adaptability, 5) design for disassembly and reusability, 6) design with existing building parts, 7) design with secondary resources, and 8) design with renewable resources. We present a selection here. A more complete overview can be found in Appendix A. In all figures, the niche-regime division will be presented. The numbers and letters in every figure correspond with the text below.

Circularity in general

Figures 2–4 show the system-of-practices and the (mis)alignments regarding circularity in general. As many (mis)alignments were vital, we made a distinction between (mis)alignments regarding setting circular ambitions, and (mis)alignments regarding realizing

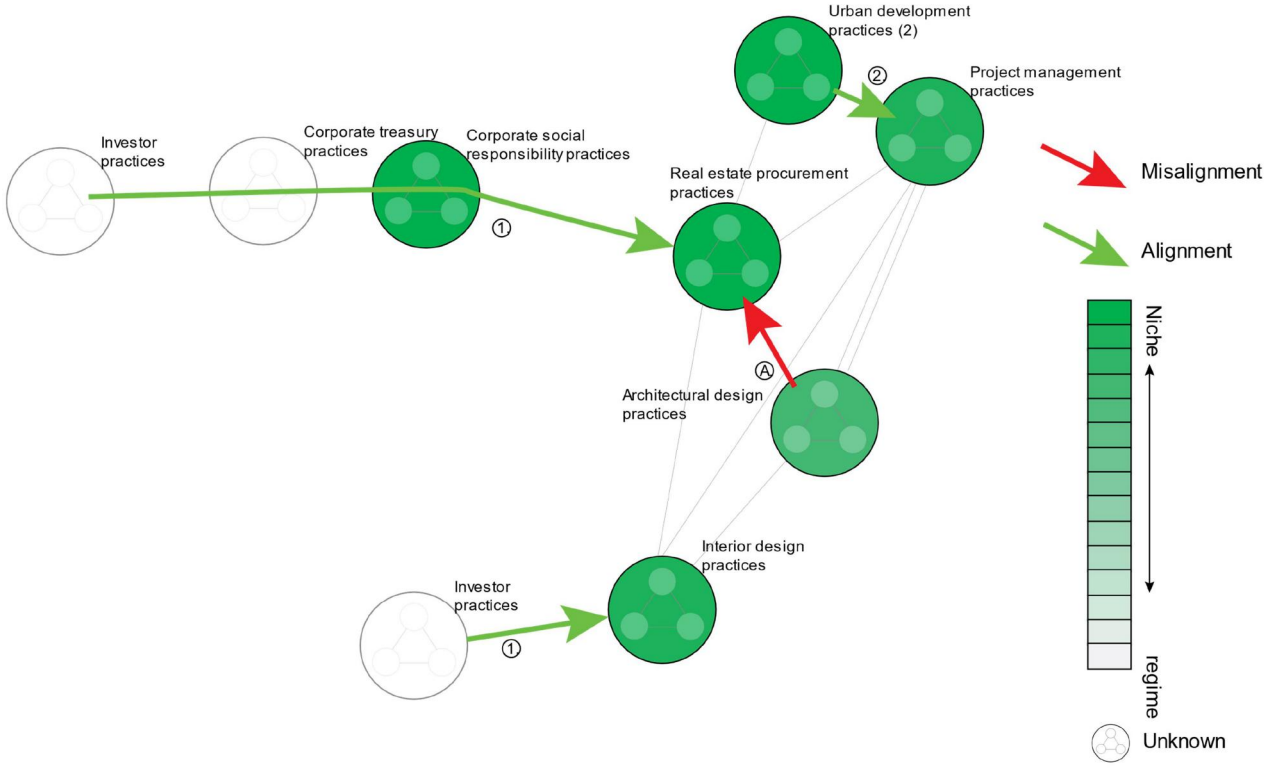

Figure 2. circular goals in general (ambitions) project X.

these. Figures 2 and 3 show these regarding setting ambitions, and Figure 4 regarding realization.

Several practice alignments seemed pivotal for circular goals in general regarding ambitions in project X (see Figure 2), two of which are highlighted here. 1) ESG ratings influenced investor practices and stimulated creating policy on circular goals for the client and interior architect (interviewee 7, 8), which showed in the tender. These ESG ratings did not push for very ambitious policies (yet), but the mechanism to influence circularity policies showed with the incorporation of biodiversity ambitions. 2) The municipality owned the land on which the client was going to build, which allowed setting circularity demands and ambitions as part of the urban development (interviewee 1, 4, 8). As such, the municipality functioned as a fail safe for circularity ambitions, as the ambitions in the real estate tenders were higher. The municipality used a combination of hard, extralegal demands and a set of soft ambitions. The first was an option as they owned the land, but the latter was always an option that they could use to set goals that matched the culture of specific clients.

Also, several misalignments were deemed important, of which two are discussed here (see Figure 2). A) The function was considered unnegotiable by the architect if it conflicted with circularity goals (interviewee 3, 9, 13). The architect for instance elaborated on using concrete slabs on top of the wooden floors: 'if you're constructing a house for a private client who cares greatly for sustainability, I don't mind if the floor is not fully soundproof. However, if you're constructing an office for 500 people who have to concentrate on their work, I think you need to consider the best solution within the chosen system; I don't consider it a sustainability failure if you choose for good acoustics, it's a boundary condition.' Similarly, an empty plot was chosen, as no existing building fitted the functional demands (interviewee 13).

Several alignments for setting circular ambitions in general, played an important role in project Y, of which one is highlighted here (see Figure 3). 1) It was

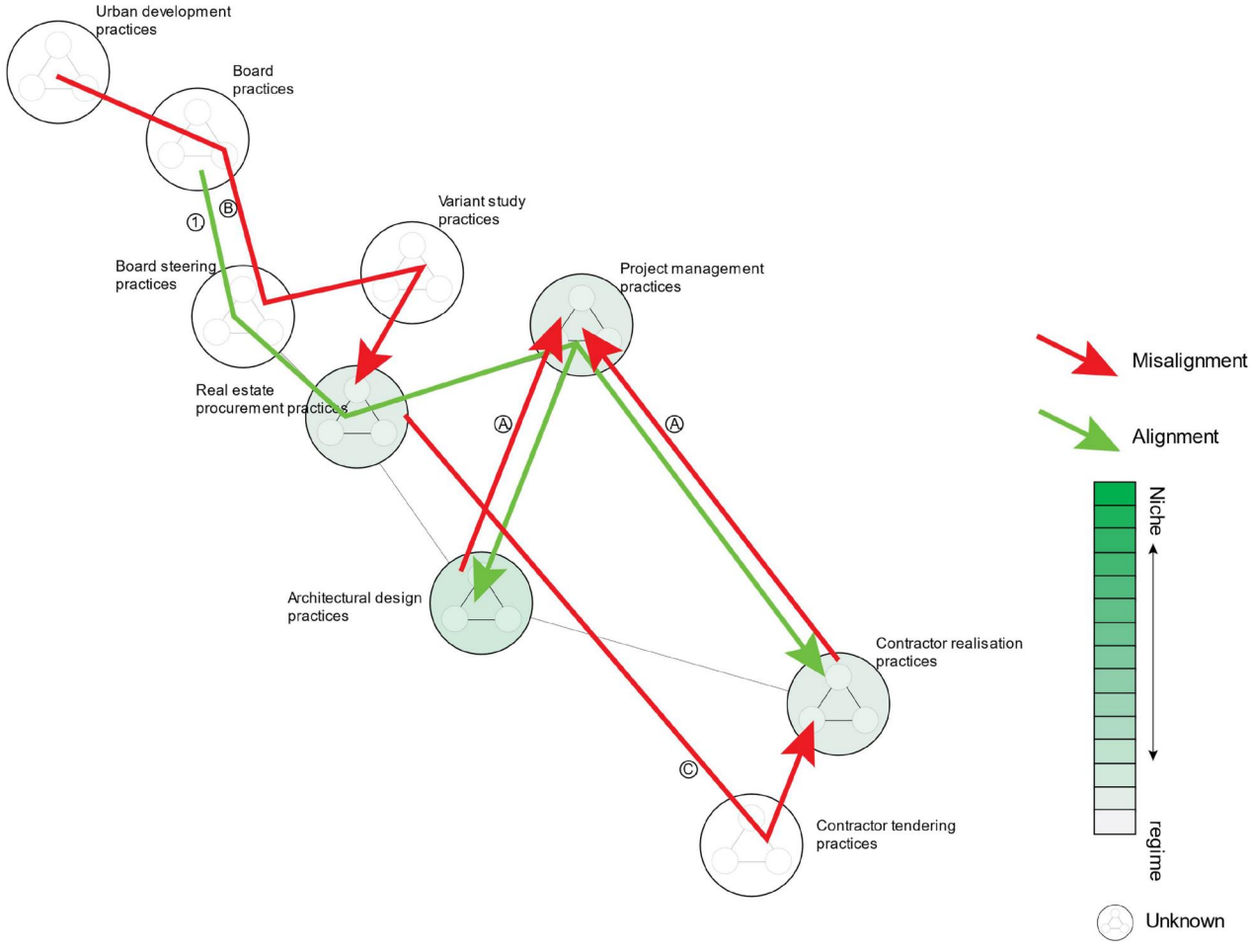

Figure 3. Circularity in general (ambitions) project Y.

understood that public clients (have to) steer the circularity transition, making private companies follow through procurement. However, the board of this public client largely followed societal trends; they would not dare to be a frontrunner, only an early adopter (interviewee 14, 18, 19).

Several misalignments played a pivotal role in setting circular ambitions in general for project Y, five of which are mentioned here (see Figure 3). A) When the client is not challenging the other actors (i.e. architect and contractor) regarding circularity, they have very few moments to suggest circular ambitions to the project manager, only around the quotation/tender (interviewee 15, 17). Here actors have to be precise: after that moment is gone, very little is likely to happen. B) Because the urban development vision remained uncertain, it was uncertain what the client wanted with the future of the building (interviewee 15, 19). The client therefore decided to keep the building open for 10 years, which hindered many ambitions, as their investment would be too large for this time period. C) The traditional contract, as used in the procurement phase, technically allows for innovation, but culturally contractors do not feel the urge to be innovative under such contracts (interviewee 16, 17), but follow the ambitions the client sets. For instance, reclaimed steel was not considered although it fitted the formal ambitions of all actors.

The difference between project X and Y regarding setting circular ambitions in general have several origins, of which we list two here: 1) the municipality could raise the bar in project X, as they owned the land, but they were not involved similarly in project Y. 2) As the project was considered small, the client of project Y never perceived the project potentially innovative and applying dynamics supporting circularity seemed too much effort. Contrastingly in project X, the building was perceived as a showcase of the circular ambitions of the client. Application of dynamics supporting circularity in general was stimulated from the start of the project.

Realization of circular goals in general had several practice alignments in project X, of which we highlight three (see Figure 4). 1) The contractor managers hired a consultant to win the tender. This allowed her to gather lessons from earlier projects and teach these to the project team (interviewee 2). Setting up a company CV to win the tender resulted in an

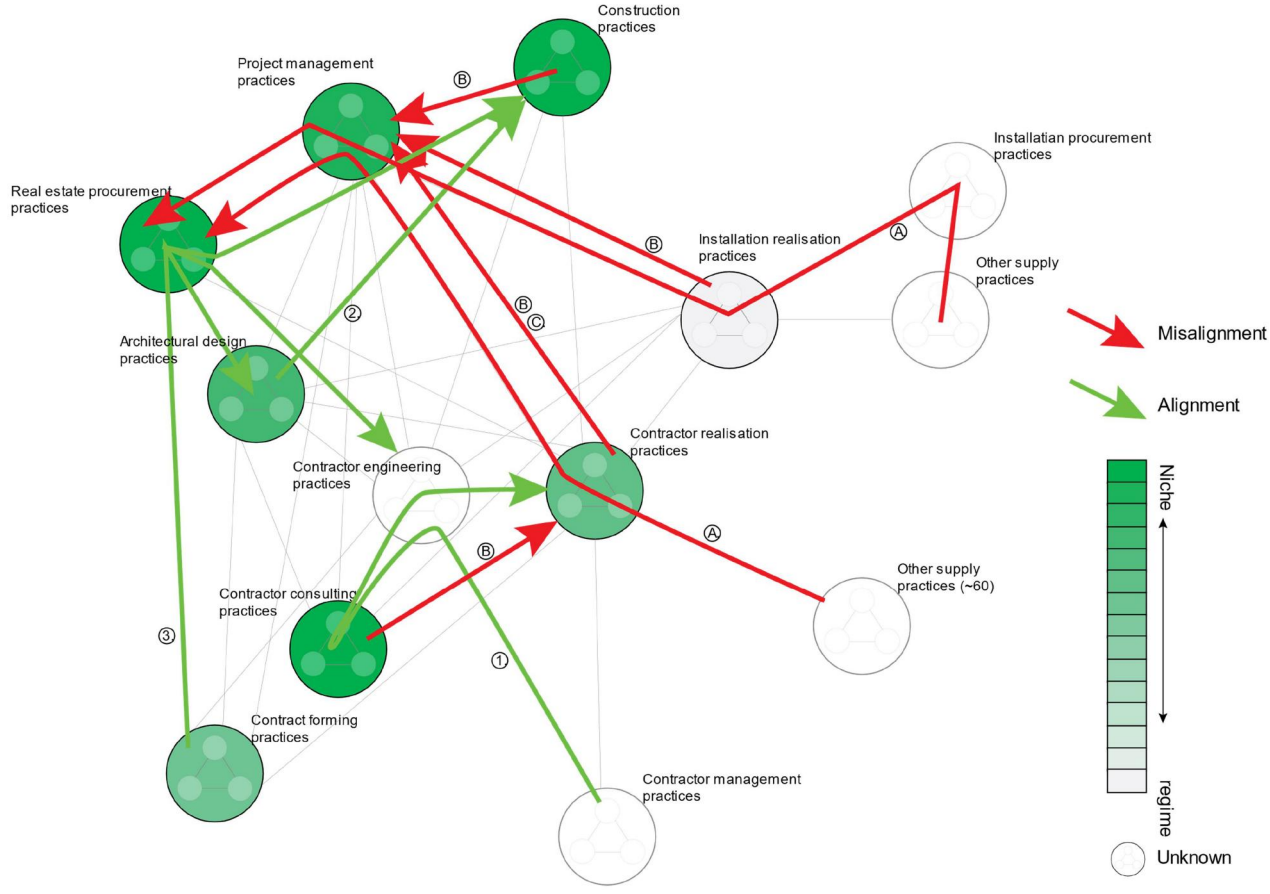

Figure 4. Circular goals in general (realization) project X.

accumulation of practical knowledge that could be shared with the project team of the contractor. 2) Functional segregation, dividing functions into separate buildings, allowed the constructor to design unique solutions for each building, based on functional demands (interviewee 3, 4, 9). 3) An Early Contractor Involvement contract stimulates a learning environment (interviewee 4, 12). Dealing with change is deemed difficult for private parties. The early contractor involvement contract allows for a change mindset, allowing actors involved to try new things and experiment. Further, even though the contract is no requirement for contractors to share their circularity expertise, it does stimulate a setting in which it is more likely.

Some misalignments were also present that hindered realizing circular goals in general, of which we highlight three (see Figure 4). A) Earlier agreements between contractors and suppliers make realizing some circular goals impossible (interviewee 6), as not every supplier is a previously defined preferred supplier. Similarly, for installations (interviewee 11) preferred suppliers seemed mainly chosen because of their use of safety and quality measures and finances, at the cost of circularity (e.g. with no or limited packaging). B) Lack of ready knowledge led to longer procedures, which made deviating from business-as-usual, though asked for, extra difficult within the limited amount of time that was set for the construction project (interviewee 2, 4, 13). Deviating from business-as-usual became more difficult as market pressure grew and actors (i.e. contractor, constructor, and installation company) had a limited amount of time to spend (interviewee 2). C) Circularity realizations lead to other-than-standard outcomes, which involves risks. As contractors traditionally carry these risks, they often veto them beforehand (interviewee 3, 4, 9).

Some misalignments for realization of circularity in general were crucial in project Y, of which we mention two. A) As the project manager divided the assignments in parts, relying on the expertise of the responsible actors, the architect was unable to steer the project to common circularity goals, as he was not involved in certain parts of the renovation (interviewee 14). B) Changing routines requires extra time. Pressure from the user (that only wanted to close for a brief period in summer) and the installations (that were getting outdated) limited available time (interviewee 15, 18). Here differences in circular solutions become apparent, for instance, wood has become mainstream enough, whereas reuse is considered too niche under traditional contracting.

Differences between project X and Y regarding realization of circularity in general dominantly stem from two sources: 1) limited time in project Y made it difficult to change business-as-usual. Although time constraints were also mentioned in project X, they were not experienced as limiting. 2) The Early Contractor Involvement contract of project X pushed for an innovative culture with mentioned project dynamics that was absent in project Y. Use of this contract is by many considered a hassle (workshop 3).

Design for prevention

Several alignments help design for prevention in project X (see Figure 5), of which we highlight two. 1) Measuring environmental impact, obligatory in upcoming EU legislation, already influences reduction policies (interviewee 8). Reporting CO2 impact already stimulates reduction. The CSR manager explained: 'we always anticipate legislation before it strikes us' (interviewee 8). 2) Reducing energy use, as demanded by both the client and the municipality, aligns with cost reduction (interviewee 1, 4, 13). That makes it easy to achieve, contrasting other circular ambitions (e.g. reuse or green roofs).

Some misalignments also play a role for design for prevention in project X (see Figure 5), of which we mention four. A) Energy reduction (or even neutrality) requires more materials (e.g. in insulation and solar panels), some of which are critical and/or toxic (interviewee 5). B) There is distrust about the LCA scores of materials in the NMD (national environmental database) that functions as the basis of MPG calculations (interviewee 3), for instance because they are considered lobby results. As the NMD is being updated regularly, LCA information changes often. This hinders the uptake of the MPG as sustainability criterion and its use as transition tool to keep raising the bar.

We highlight one alignment for design for prevention for project Y (see Figure 6). 1) The board of the client company wanted to reduce energy consumption. Many energy reduction solutions (e.g. solar panels) pay themselves back within the 10-year scope of the building and were therefore also attractive financially (interviewee 15).

In project Y, two misalignments were dominant in design for prevention (see Figure 6). A) The user only accepted renovation during the summer months, which put pressure on the design phase. Time limitations made it less attractive to calculate impact of the design solution on the building (interviewee 14), which was a time-consuming activity itself. B) Personnel shortages for installation design resulted in unfinished

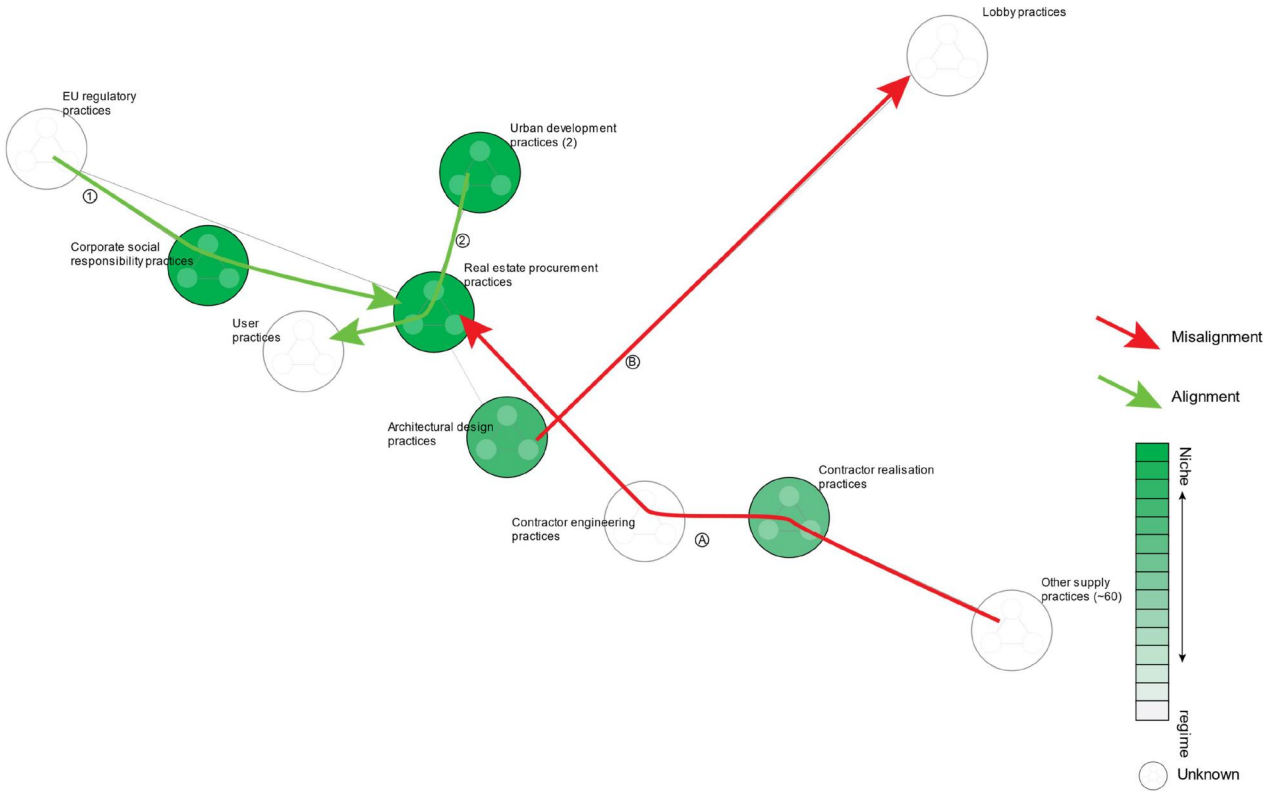

Figure 5. Design for prevention (project X).

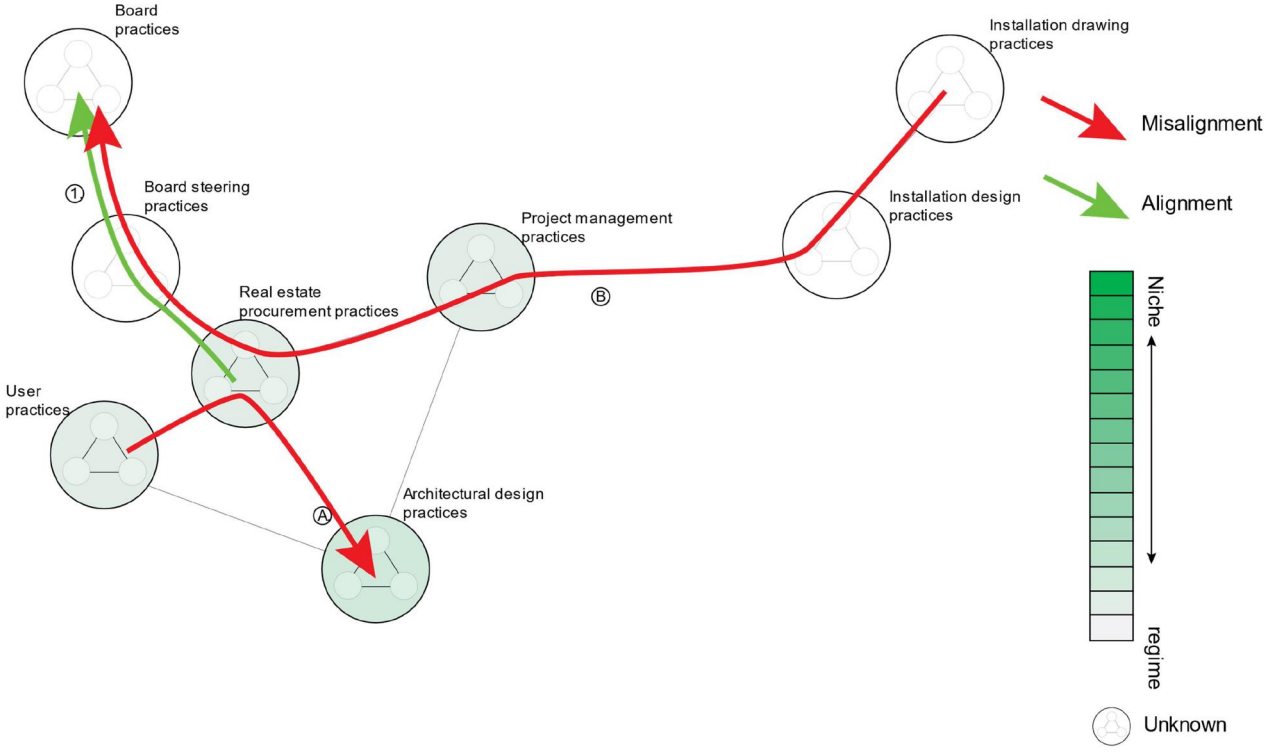

Figure 6. Design for prevention (project Y).

drawings when production started, resulting in wrongly produced building components. The architect (interviewee 14) said: 'if you look at what we saved by designing with wood, and compare that to what we had to throw away because of mistakes … to me that is out of proportion.'

Though not always explicitly mentioned, logically all (mis)alignments of project X apply to project Y. However, project Y has some extra challenges. The most striking differences between the two projects is 1) the calculations (e.g. MPG) of project X that impacted design decisions. These were absent in project Y, due to lack of time. Further, the proactive attitude towards EU legislation regarding impact measurement in project X contrasts the regime attitude (following policy and regulations) in project Y, due to prevalence of other values (e.g. financing education instead of education buildings). This hindered setting shared circular goals.

Design for quality and maintenance

Design for quality and maintenance played a central role in project X, of which 1 alignment is especially striking. 1) What the architect considers a good building (interviewee 3) largely relates to how materials age. Here steel cladding was chosen as façade material, because it would be able to withstand the harsh environment. He said: 'we could have used [wood] as façade material, but that would be greenwashing. […] That façade has a different component, namely that it should stand the test of time.'

For design for quality and maintenance in project Y, we want to highlight 1 alignment. 1) Similar to project X, what is considered a good building, partly depends on how materials age (interviewee 14).

One misalignment for design for quality and maintenance played a central role in project Y. A) The architect was given a scope of 10 years. Solutions that would last shorter were discarded, but solutions that would take long to pay themselves back were also not considered, as 'a new owner could do that too' (interviewee 18).

Whereas both projects have similar alignments, the mentioned misalignment of project Y specifically stems from the limited time frame that is based on uncertainty of future urban developments. This hindered the prerequisites of dynamics for circularity, such as involving intrinsically motivated people and formulating shared circular goals.

Design for adaptability

We highlight one alignment for design for future proofing in project X. 1) Design for flexibility, here interpreted by the interior architect as boxes in a larger space that could be changed (e.g. moved or taken down), makes it easier to continue working when the function changes (interviewee 7). It is therefore perceived as the smart, cheap (on the long run), and easy choice.

Design for adaptability did not play a dominant role in project Y, but similar statements were made by the architect (interviewee 14), as the building that was to be renovated was designed very adaptable itself.

Design for disassembly and reusability

We highlight 1 alignment for design for disassembly and reusability for project X. 1) Design for disassembly is considered a better job than traditional design (interviewee 9), as this gives them a) a challenge they often lack, and b) extra hours and therefore money.

For project Y, 2 misalignments were important for design for disassembly and reusability. A) The contractor is used to making things as simple as possible (interviewee 16). This is often cheap, easier to make, and requires less (stress on) personnel. Creating demountable building components seldom is simple. B) Because the expected life expectancy of buildings is so long, it remains uncertain what will happen with building components in the future. This hinders effort for designing for disassembly (interviewee 15, 18).

An important reason for the differences between project X and Y can be found in the contracts: project X used an Early Contractor Involvement contract before the traditional (UAV) contract and project Y used only a traditional (UAV). This offered less time for the architect who initiated design for disassembly in project Y (interviewee 14, 15, 17, 18) to convince the client and contractor (interviewee 16). Consequently, the client, though unopposed, remained skeptical until the end of the project and the contractor first remained unaware of the design values. Most actors were not intrinsically motivated for circularity and shared circular goals were never formulated.

Design with existing building (parts)

One important misalignment in project X for design with existing building (parts) is highlighted here. A) None of the existing buildings were considered able to house the intended function (interviewee 13), design logic stemmed from function, not availability.

We highlight one important misalignment in project Y for design with existing building (parts). A) It requires time and money to do a proper inspection beforehand. Here, an inspection had taken place, but not properly. When it turned out the building was constructed differently than expected, many last-minute changes

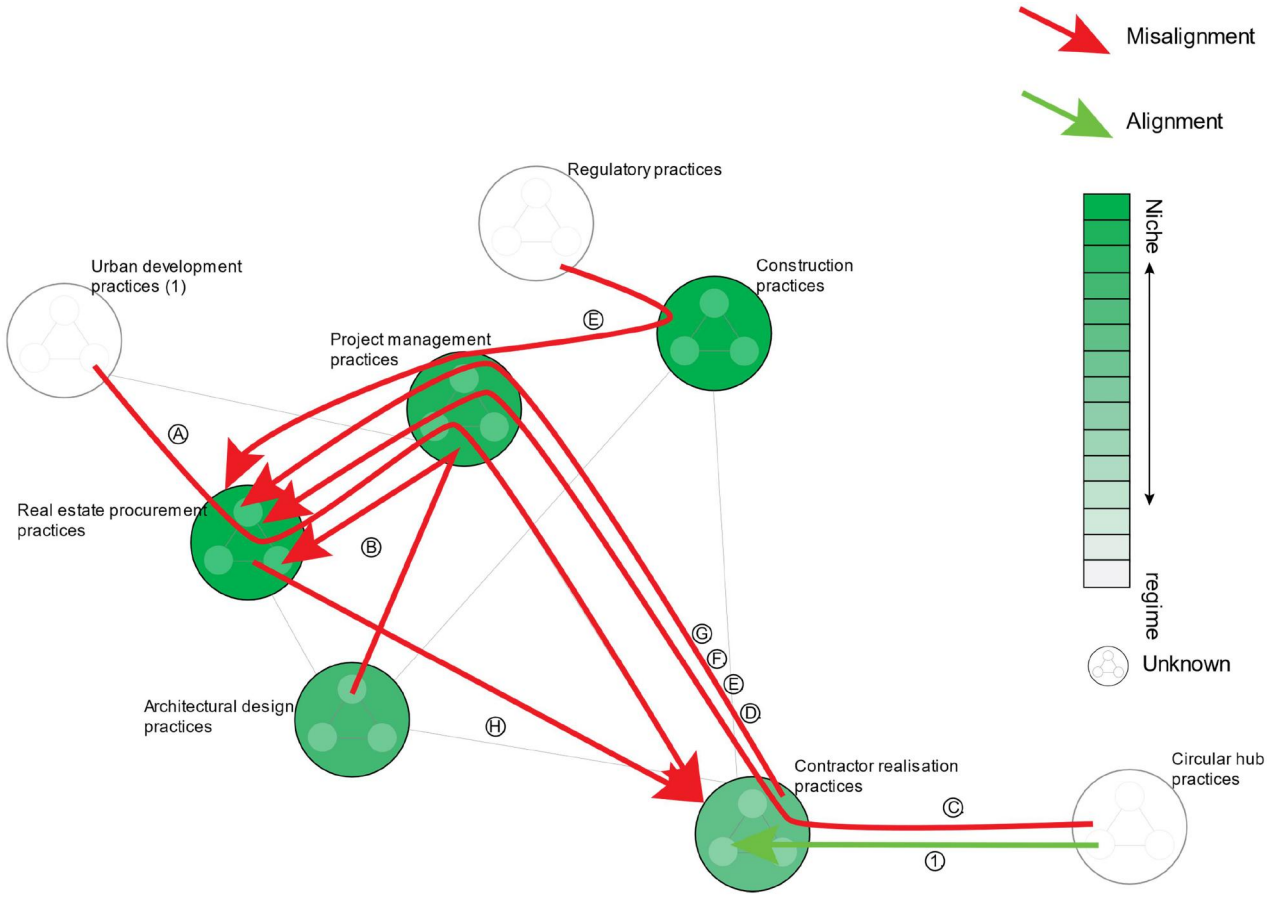

Figure 7. Design with secondary resources (project X).

were required at the cost of time and (therefore) circularity (e.g. due to production mistakes).

The most important difference between the projects is that reuse of buildings did take place in project Y, but was never seriously considered in project X. In project Y, the function of the building remained, which was not an option in project X; the client was pushed to move.

Design with secondary resources

Although the system-of-practices for design with secondary resources is riddled with misalignments, we highlight one alignment in project X too (see Figure 7). 1) Actors shared an idea that to stimulate circularity, the message of circularity's importance should be repeated (interviewee 6). Therefore, secondary resources were chosen as solutions on small scale (e.g. a single wall with reused plasterboard). Building components were not available for larger scales, such as a complete building.

Many misalignments hinder the uptake of reusing building components (see Figure 7), of which we highlight nine. A) the rapid decision-making process of the municipality (here: to develop a new neighborhood) limits time for projects to find secondary building components (interviewee 3, 4, 5, 9, 13). Time constraints further stemmed from European procurement law that sets time frames for procedures (interviewee 4). Renegotiating about time constraints was not considered, as 1) there is no culture to do so, and 2) extra time is not considered to lead to a better project (interviewee 13). B) Functional design limitations were considered so important that reused building components did not enter the design discussions until these were overcome (interviewee 3, 13). For instance, the oddly shaped plot pushed the architect to make a design that fitted that without first considering potential secondary resources. C) Circular hubs are still relatively small and unable to offer materials for a complete large building (interviewee 6, 7, 12). Some suppliers offer secondary resources too, but not in the needed quantities for large buildings. Therefore, clients set soft demands for reuse (interviewee 4, 6, 8). D) Labor costs for repairing or remanufacturing building components often make secondary resources more expensive than primary resources (interviewee 3, 5, 6, 9, 11). This is especially problematic, as many actors think these should

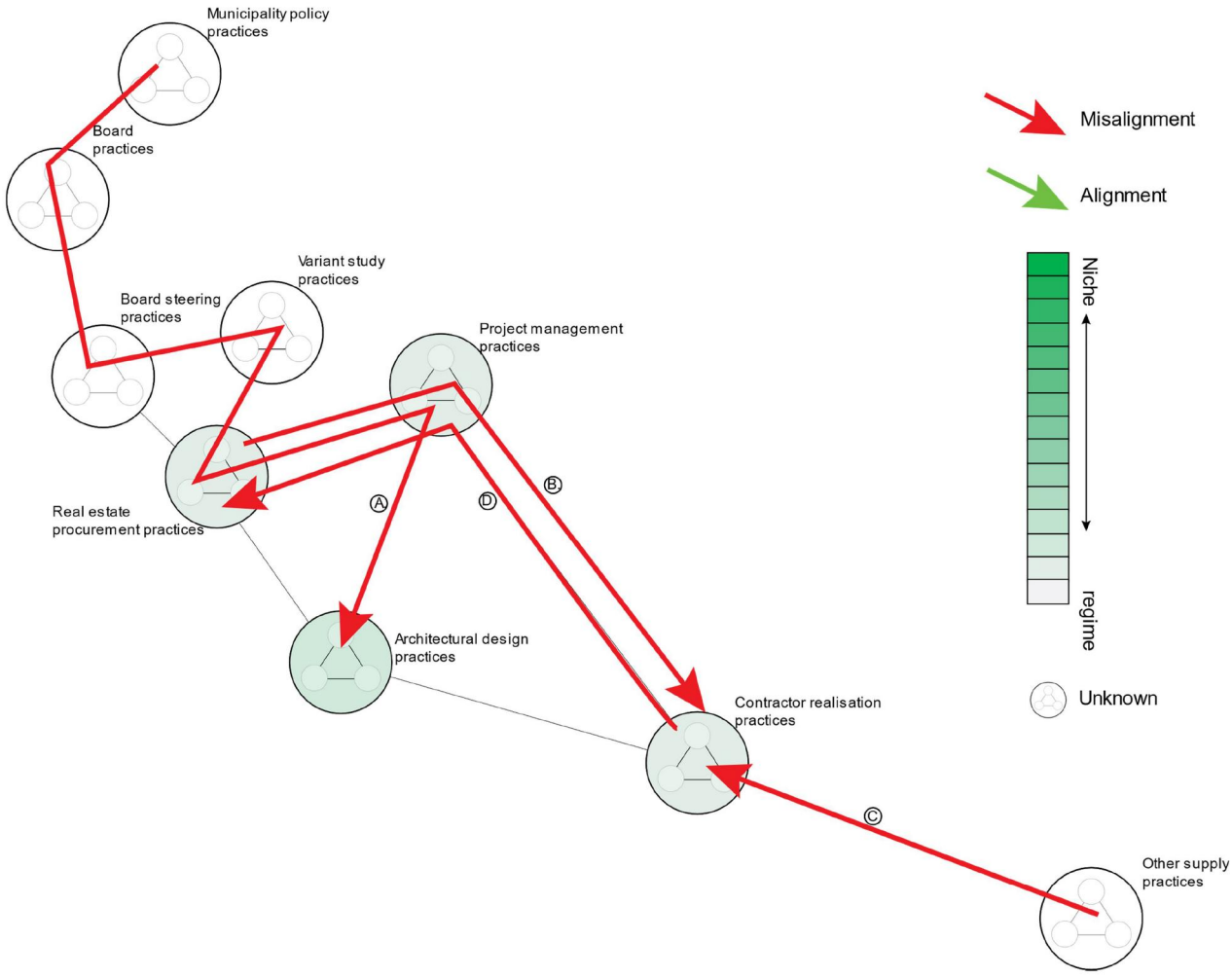

Figure 8. Design with secondary resources (project Y).

be cheaper, as is for instance the case in clothing. E) There is no norm regarding reuse and it is impossible to give guarantees, resulting in huge risks for the contractor (interviewee 4, 5, 6, 9). For norms, actors are subjected to the whims of the specific civil servant they encounter. Lastly, changing norms is unlikely, as this is expensive and conflicts with upcoming laws on safety, which require actors to prove the performance of building components (interviewee 9). F) Contract penalties for building performance create financial risks for contractors to reuse building components, as they do not know the exact state these are in (interviewee 6). G) Contractors aim to reduce labor hours, as these 1) take time, 2) are expensive, and 3) often lead to physical problems of employees (interviewee 6). Repairing and remanufacturing of building components, however, often increase labor hours. H) Subjective standards for building aesthetics often do not match with reuse (interviewee 3, 11, 13). Often this results in extra materials (e.g. lowered ceilings for reused installations) to cover them up.

Many misalignments hinder the uptake of secondary resources in project Y (see Figure 8), of which we highlight four. A) Architects mention that they find it hard to change their practice and do something they are not good at (especially reuse of building components), whereas they are good at some circular aspects, such as future proofing (interviewee 14, 18). Addition of consultants is needed to the project to make this happen. This misaligns with municipal ambitions. B) The traditional contract technically allows for innovation, but culturally the contractor is not stimulated by it (interviewee 17). They often do not feel any tendency or mandate to change business-as-usual, but instead follow the client's ambitions. For instance, reclaimed steel was not even considered, even though it fitted everybody's ambitions. C) The small market for secondary building components makes reuse unlikely (interviewee 14, 15, 17). D) As contractors cannot give guarantees for secondary building components, reuse becomes very difficult to achieve (interviewee 15, 17).

Misalignments between the projects mostly overlap. Some differences occur, as project X went further in the pursuit of secondary resources, which allowed for alignment.

Design with renewable resources

We highlight one alignment for design with renewable resources in project X. 1) Wood is perceived to be a very beautiful material (interviewee 3, 7). It also results in less material use for the interior, as wood is considered to be so dominant aesthetically (i.e. containing many visual stimuli), that additions often diminish quality of space (interviewee 7).

Several misalignments play an important role, of which two are mentioned here. A) Traditional methods of budgeting hinder choosing wood, as it is more expensive (interviewee 3). However, using wood diminishes costs elsewhere, for instance regarding interior and foundation (interviewee 3, 7), so calculations on the costs have to incorporate these aspects too. B) Wood details highly impact the environmental impact. The bare steel connection elements usually have highly toxic coatings.

Several alignments regarding design with renewable resources play an important role in project Y of which we highlight two. 1) In recent years, material prices have risen extremely. Prices of wood however do not seem to rise as fast as others, making wood increasingly attractive (interviewee 14). 2) The use of renewable energy (using solar panels) pays itself off within 10 years, within the limited scope of the project, so procurers guided installation employees towards that direction.

The most noteworthy difference between the projects stems from the impact of wood prices on materialization choices. In project X, wood pricing had a major impact on the project budget, as the load bearing structure was made with it. In project Y, the wooden construction was considerably smaller in size.

Reconfigurations of practices

This last part of the result section focuses on reconfigurations. Interviewees and workshop participants mentioned several reconfigurations they deemed necessary to overcome misalignments, of which some are already taking place (mostly in project X) and some are envisioned. Some reconfigurations change the elements of a practice; other reconfigurations concern the system-of-practices by adding practices to the system and interlinking existing practices differently. Only once (the second reconfiguration mentioned here) a change in practice performers was mentioned.

Regarding reconfigurations taking place, some interviewees mentioned dominant reconfigurations, especially concerning relatively niche (according to Smith's (2007) elements) practices in project X, here presented following their teleoaffective structure from procurement to realization. ESG ratings stimulated creating circular policies in general, which in turn stimulated circular ambition setting in project X (interviewee 7, 8). Also, the way in which ambitions have been set, changed (interviewee 2, 6, 8, 10, 12, 13). First, hard and soft circular ambitions stemmed from both the client and the municipality. Second, the client set ambitions regarding building performance and collaboration, instead of design choices. This also required different skills of employees (interviewee 8): 'you see that predominantly with the procurers. We used to have employees who were trained to procure for bottom prices. We do not have those anymore.' Further, searching for architects that know about circularity seems easier (interviewee 4, 8). Where several years ago, clients had to be picky, now it has become relatively common practice. One client (interviewee 8) said: 'in 2010-2012 we specifically selected a circular architect, whereas now it is not needed anymore; all of them have the knowledge.' However, this does take different forms, affecting design strategies differently. For instance, the architect of project X (interviewee 3) specialized in design with renewable resources, whereas the architect of project Y (interviewee 14) specialized in design for adaptability. For other design strategies, they needed input from specialists. Knowledge about circularity largely stems from internal specialists from workgroups or sustainability departments (interviewee 1, 6, 9, 14, 16, 17) or external consultants (interviewee 2, 8, 10). Lastly, another important reconfiguration regards emerging circular building hubs to find secondary materials (interviewee 2, 3, 4, 6, 7). This mostly impacts construction calculations (interviewee 9), and logistics (interviewee 2, 6). Many of these reconfigurations were only considered with an Early Contractor Involvement contract (interviewee 6, 12, 17, workshop 3).

Some reconfigurations are expected to overcome misalignments in the future, here again presented following their teleoaffective structure from procurement to realization. Regarding circular ambition setting, interviewees mentioned they expected to be guided by future ESG ratings, EU laws and legislation (interviewee 8), and a change in MPG legislation

(interviewee 2). Interviewees and workshop participants showed different interpretations of how this would affect tenders and contracts. All agree that ambitions should be made clearer from the start, but differences arose for how strict they must be set. Some (interviewee 6, workshop 3) state that ambitions should be loose, so actors can operationalize abstract ambitions per project, whereas others (interviewee 2, 10, 12, 14, workshop 3) state that ambitions should be strict, so actors are stimulated to work harder to realize them.

Also, different trade-offs between ambitions were mentioned. First, some (interviewee 9, workshop 2) mentioned safety measures should be loosened to better allow design with secondary resources. Second, others (workshop 3) said users might need to suffice with suboptimal buildings regarding function and quality of materials. Both remarks have been questioned by others (interviewee 3, 14, workshop 3). Further, innovation seems hindered by a culture of risk avoidance that is embedded in contracts with high penalties to secure building performance (interviewee 3, 6, workshop 3). Refraining from penalties when regarding circular solutions was mentioned as possible solution. Lastly regarding setting project ambitions, interviewees (2, 3, 6, 9, 13, 14, 16, 17, 18) mentioned that more time should be given to realize circular ambitions as this is the most important reason circular ambitions are often not realized. Further, interviewees saw potential in reconfiguration of the design process: instead of designing and searching for secondary resources after, local secondary resources should form the start of the design (interviewee 4, 8). Some (interviewee 6, workshop 2, 3) mentioned it was impossible to realize many circular ambitions in one project, without it taking long and becoming very expensive. However, they saw potential in raising the number of ambitions over time. Further, it was mentioned suppliers should offer more secondary resources or components with smaller environmental impact (interviewee 6, 14). Lastly, as employees of installation companies have very little idea on how to become more circular, it was mentioned that reconfigurations should focus on changing agency, to stimulate circular mindsets (interviewee 5).

Discussion

It has often been mentioned that the transition towards a circular economy in the AEC sector requires radical change for multiple actors, at multiple dimensions, involving multiple aspects (e.g. Heurkens and Dąbrowski 2020). The results presented in this article confirm this and further show how practices in diverse construction projects (mis)align to set and realize circular goals according to different strategies for design for circularity. In this discussion, we further reflect on these results of chapter 4, focusing on how our findings add to or confirm literature on circular construction projects, circular dynamics, the use of Social Practice Theory, and possibilities for practice reconfiguration.

Circular construction projects

This study adds to the literature on circular construction projects with its unique focus on practice (mis)-alignments in four major ways. First, in general, even though alignments exist, many misalignments still play an important factor in setting and especially realizing circular goals. Misalignments exist within traditional project boundaries, but also stretch far outside them (e.g. lobby or investor practices). This highlights the systemic nature of the transition, as mentioned by others (e.g. Kristensen *et al.* 2021, Vosman *et al.* 2023). Both cases showed many misalignments, but project Y, which did not adopt Kooter et al.'s (2021) dynamics, showed more fundamental misalignments. This was worsened by the traditional contract that stimulated regime practices.

Second, the number of misalignments for circular goals in general illustrates that change in general is already difficult to accomplish in such a complex system. Further, the change towards a circular economy, based on these strategies, should also be considered multi-facetted. It is often mentioned that circular economy is an umbrella concept (e.g. Desing *et al.* 2020, Wiarda *et al.* 2023), and these results add to the literature how design strategies have misalignments with each other or even themselves. Circular design strategies, though clearly multi-facetted, are still perceived by many as having to result in a coherent outcome (e.g. Hart *et al.* 2019), not as potential trade-offs, as time and money for instance are used. Perceiving these seven strategies as potential trade-offs would stimulate a more realistic way forward in the transition - or transitions - towards a circular economy in the AEC sector.

Third, more in depth, the relation between design strategy and business-as-usual seems crucial in the formation of misalignments. For instance design for prevention, design for quality and maintenance, and design for adaptability have similarities with business-as-usual, as fits earlier research (e.g. Rockow *et al.*

2021). Design for prevention for instance often reduces costs directly (as is already a common goal in practice). The value of these design strategies are therefore apparent while designing the building. Contrastingly, design with secondary resources has many misalignments with both business-as-usual and other circular design strategies. For example, reuse of building components might lead to additional materials to cover them. Further, the strategy for instance misaligns with the availability of secondary building components at circular hubs and suppliers, the money it costs the client, and the given amount of time for the project to search for secondary building components, in line with Arora *et al.* (2021). Closing loops seems therefore unlikely in the near future. Based on this research, it seems design with secondary resources requires the most radical reconfigurations throughout the system-of-practices.

Fourth, this research confirms earlier research that standards (Benachio *et al.* 2020), and knowledge (Gerding *et al.* 2021) are still lacking. However, contrasting previous research (e.g. Eikelenboom and van Marrewijk 2024, Çetin *et al.* 2022), we noticed that standards are being developed (e.g. regarding fire safety for wooden constructions), that digital tools (e.g. MPG measurements) are increasingly used to inform design decisions on circularity, and that consultants can help with knowledge transfer between projects. This is still an early stage in that development and was mostly observable in project X, which made use of Kooter et al.'s (2021) project dynamics. However, in line with previous research, knowledge and tools for knowledge development for designing with secondary resources are still mostly lacking (Koutamanis *et al.* 2018, Vandervaeren *et al.* 2022).

Circular dynamics

This study further shows that in general when Kooter et al.'s (2021) dynamics are present, more practice alignments are present, and when these dynamics are absent, more and more fundamental misalignments are present. Several of these dynamics (i.e. partnership based on increased equality, involvement of intrinsically motivated people and all project dynamics) seemed to have a dominant role in niche formation. Niche formation seemed most important for design strategies that are less like business-as-usual, such as design with secondary resources. Other dynamics (i.e. top–down support and shared circular goals) helped raise the circularity bar in general. Kooter et al.'s (2021) dynamics, however, do not incorporate new practices or practices outside traditional project boundaries, such as regarding circular hubs, hiring external experts, or urban miners, for knowledge and building components, and changing or getting exempted from regulations. These seem most pressing for design with secondary resources. This research shows (mis)alignments stemming from these practices, highlighting a dynamic of partnering anew, in line with Vosman *et al.* (2023) and Gerding *et al.* (2021). Also, more fundamental, this research shows that although these dynamics are considered important, some factors, such as time availability, can hinder their uptake.

Social practice Theory (SPT) and multi-level perspective (MLP)

The use of the theoretical lens of this research adds to existing literature of SPT and MLP and further shows how concepts of these approaches can complement each other, as mentioned by others (e.g. Watson 2012, Hargreaves *et al.* 2013, Crivits and Paredis 2013). First, this research especially adds understanding of how these can be combined in systems-of-practices. Further, one cannot conclude that being niche leads to practice alignments and being regime leads to practice misalignments; even though most practices in the core of the system-of-practices of project X are relatively niche (on many of Smith's (2007) elements), many misalignments still stem from them. Second, similarly, the contract forming practice (i.e. the practice that produces the contract between client and contractor) that is considered relatively regime itself, functioned as a great potential stimulus for niche formation. In project X, where this practice produced an early contractor involvement contract, this contract stimulated experimentation regarding many aspects of niches (e.g. alternative principles, technologies, and industrial structures). In comparison with project Y, the advantage of the early contractor involvement contract mostly shows in design for disassembly and reusability, design with existing building (parts), and design with secondary or renewable resources, as these divert further from business-as-usual. Lastly, both cases showed that in general niche practices further stimulated other niche practices and that regime practices further stimulated other regime practices.

Reconfigurations

As shown in the result section, interviewees and workshop participants mentioned many potential reconfigurations. In general, some of these focus on niche

formation (e.g. changing meaning of installation company employees, as is also mentioned by Kooter *et al.* (2021)). Other reconfigurations focus on overcoming misalignments directly (e.g. distributing more time to projects, in line with Arora *et al.* (2021)). Further, some focus on regime reconfigurations (e.g. more driving ESG ratings). Interviewees and workshop participants seemed most agreed on boundary conditions for projects, such as time, and laws and legislation (in line with Ababio and Lu 2023), but less on the trade-offs between function, quality, and safety to realize circular ambitions. Some of these have been mentioned earlier in research. Lacking quality of secondary materials is a common notion (e.g. Hart *et al.* 2019) and Eberhardt *et al.* (2022) for instance mention safety rules as barriers. But this research also shows the systemic nature of the safety, as reconfiguration is not just needed in law making practices, but also in for instance contractor procurement practices. Similarly, the priorities given to creating an optional function is also a largely shared counter value to many circular ambitions, especially design with secondary resources. This was for instance perceived leading for architectural design, procurement, and contractor practices. Also, if a design strategy is chosen that is unlike business-as-usual, interviewees recurrently pleaded for contracts based on building performance and collaboration, instead of design solutions. This is in line with earlier assumptions (Bougrain 2020). This highlights that not every design strategies are not developed similarly, but that they are in different stages. Lastly, in line with Gerding *et al.* (2021), this research highlights the growing body of knowledgeable actors regarding circularity and the necessity to have specialists involved early on in the process. This research further elaborates on earlier findings, as it highlights the different specialties relating to circularity, for instance architects who are knowledgeable regarding design for adaptability can lack the specialism for design with secondary resources.

Conclusion

This paper aimed to answer the following research question: *how do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?*

Several conclusions can be drawn, of which we highlight seven regarding (mis)alignments. First, construction projects are complex, and setting and realizing circular goals depends on alignment of many practices in and beyond traditional boundaries of construction projects. This finding is in line with earlier research (e.g. Eikelenboom and van Marrewijk 2024). Second, initiation for circular ambitions primarily lies with the client, but municipalities that own land can function as back-up by setting their own ambitions. The importance of the role of the client has been hinted at in earlier research (e.g. Coenen *et al.* 2023), but little has been written about its crucial role (i.e. that without an explicitly willing client, many circular initiatives are likely to fail) in this phase of the transition. In the future more initiative might come from other parties, for instance, stimulated by ESG ratings. These ESG ratings seemed to have a small role in setting circular ambitions now, but their attributed value hints their potential role in the transition if they develop. Third, contrasting some strategies with many alignments and similarities with business-as-usual (e.g. design for prevention), design with secondary resources has most misalignments throughout the system-of-practices. Reconfigurations throughout the system are needed. This finding is a nuance of earlier research that highlights difficulties regarding reuse (e.g. Harala *et al.* 2023). This research shows that this mostly relates to direct reuse, whereas design for disassembly and reusability seem achievable with more ease. Fourth, the biggest misalignment that hindered setting and realizing circular ambitions involved time limitations, for instance stemming from area development on municipal level, as was the case for both projects. For instance, in project X, the municipality set a deadline for when the company should move to its new location. This misalignment was especially true for design with secondary resources. This contrasts notions in both the industry and academic literature (e.g. Charef *et al.* 2021) that this might be related to money. Fifth, following previous research, other important misalignments involve lacking markets for secondary resources. Sixth, contrasting ideas on quality, function, and safety hinder realization of circular ambitions, especially regarding design with secondary resources. This has been mentioned earlier in the literature. Rules on safety have for instance been mentioned and contrasting ideas on quality are also common. This research adds to that as it shows the systemic nature of notions on safety that is not just enforced in rules (or the lack thereof), but also in procurement (e.g. regarding preferred suppliers). Seventh, contracts highly influence the mindset of actors in construction projects and can stimulate niche formation, important for design strategies that require

innovative mindsets, this confirms earlier expectations (Bougrain 2020). Also, this research adds to this with an exposition of how other elements of tenders impact this innovative mindset: 1) tendering on collaboration (positively), 2) high penalties for building performance (negatively), and 3) stacking (circular) ambitions (negatively).

This research shows that several reconfigurations already take place, such as gaining familiarity with wooden constructions, and rising importance of ESG ratings in policy making. This research confirms earlier research (i.e. Kooter *et al.* 2021) that project dynamics supporting circularity highly affect these reconfigurations, but it adds to earlier research that dynamics regarding adding new practices to the system-of-practices (e.g. urban mining) are also important.

Further, this research highlights potential reconfigurations that seem crucial to realize circular ambitions, for instance concerning 1) time availability in projects to accomplish circular ambitions, in line with Arora *et al.* (2021), 2) stimulating the market for secondary resources, in line with earlier research (e.g. Adams *et al.* 2017), and 3) changing perceptions regarding safety, quality, and function, that hinder uptake of circular design strategies. Whereas barriers regarding these have been mentioned in earlier research (e.g. Eberhardt *et al.* 2022), this research shows the systemic nature of these barriers. For instance, safety does not merely regard rules and regulations, but also who becomes a preferred supplier for the contractor and who does not.

These findings have several implications for practitioners. Perhaps most urgently, practitioners would be advised to track down the origin of their decisions and perceive the consequences of them, so all involved actors can be taken responsible for aligning practices for circularity. Very practically this means for instance that area developers make decisions fast enough so actors involved in the area can allocate resources (e.g. time and money) for their construction purposes with circular goals. Another example is that clients allocate the right amount of time for projects with circular ambitions, or that contractors do not merely aim to realize circular ambitions in projects, but also involve their procurement departments to reassess their preferred suppliers. Further, practitioners would be advised to be both open and very explicit in their discussions regarding values. The transition, or indeed transitions, towards a circular economy in practice shows several conflicting values, for instance regarding safety, quality, and function, and actors would be advised to reassess if their original values should have the same priority they have previously received. Lastly, practitioners would be advised to be explicit about their interpretation of circularity, as this research shows that (mis)alignments between different practices are very different for each of them.

This research also adds to research on SPT and MLP, elaborating on systems-of-practices. It uniquely showed how regime practices can interlock and make it difficult for niche practices to emerge. Further, it showed that sometimes regime practices can stimulate niche practices, as was the case for contract forming practices. Lastly, in line with earlier research, it showed that the distinction between niche and regime is gradual. Smith's (2007) dimensions offer a helpful framework to bring nuance to this. This is particularly helpful in the AEC sector, where being completely niche is unattractive, due to the money and legislation involved.

There are some limitations to this study. First, methodologically, these are two in-depth cases. This allowed detailed mapping of alignments and misalignments within a system, at the cost of missing (mis)alignments, for instance on design with reused objects that was never considered a serious option for project X. Second, analytically, as this research focused on practices, it has less to offer regarding actors.

This research showed the possibilities and difficulties of changing routinized practices in the AEC sector. Future research might focus on specific reconfigurations, and practice (mis)alignment deeper into the supply chains. Lastly, many (mis)alignments were found regarding learning and transitions that have been left out of this study, such as consultants that inhibit learning in organizations. Future studies might focus on these elements. This might create a better understanding of one of the most important transitions we face today.

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Data availability statement

Raw data were generated in the Netherlands. Derived data supporting the findings of this study are available from the corresponding author [MvU] on request.

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