Usage of Interface Management in Adaptive Reuse of Buildings

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Abstract

Adaptive reuse of buildings is considered a superior alternative for new construction in terms of sustainability and Circular Economy (CE). Adaptive reuse takes existing buildings that are reaching the end of their lifespan, restores them, and in some cases, changes their use. The conceptualization and execution phases of adaptive reuse projects involve the integration of emergent complex processes. In comparison to green-field construction projects, adaptive reuse projects require distinct stages, definition of interfaces, decision gates, and planning methods. Therefore, there is a need for defining better ways to identify, record, monitor, and track the project interfaces required for adaptive reuse of buildings. Interface Management (IM) systems are a potential solution for managing the project complexities in these types of projects. Using IM in adaptive reuse projects has the potential of bringing cost and time benefits during project's execution. The present study proposes a framework for a IM in adaptive reuse projects. First, the concept of adaptive reuse and IM will be explained. Then, an ontology of interfaces for this class of projects will be defined. Finally, a discussion of how IM could be a part of a solution for adaptive reuse projects problems will be presented with a case study.

Keywords

Adaptive reuse • Interface management • Circular economy

87.1 Introduction

Due to environmental concerns, the global trend of trading in the construction industry is shifting from a resource-based economy to a Circular Economy. Adaptive reuse of buildings plays a key role in this transformation. It takes existing buildings that are obsolete, restores them, and in some cases, changes their use [1]. Adaptive reuse is considered superior to new construction in terms of sustainability [2]. However, the current implementations of adaptive reuse rely on descriptive approaches, with little objective measurement, that depend on the intuition and experience of practitioners. Intuitive planning and execution procedures are easy to apply but often lead to suboptimal results. Therefore, there is a need to define better ways to identify, record, monitor, and track the project interfaces required for adaptive reuse of buildings. The conceptualization and execution phases of adaptive reuse projects involve the integration of emergent complex processes, such as supply chain management and logistics, and require numerous work packages distributed across multiple contractors. These emergent processes follow the transformation of the construction industry towards more sustainable development through the implementation of circular building principles, such as product recovery management, Life Cycle Assessment (LCA), design for disassembly, adaptability, deconstruction, closed material loops, and dematerialization. Interface Management Systems (IMS), which focus on managing the communications, relationships, and deliverables between project stakeholders, are a potential solution for managing the complexities of adaptive reuse projects, through defining better ways to identify,

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record, monitor, and track the project interfaces. In general, IM is used in complex projects executed by a large number of stakeholders who have different specializations, with many overlapping activities; so adaptive reuse projects are a good class for IM system implementation.

87.2 Background

87.2.1 The Role of Adaptive Reuse in a Circular Economy

Due to the growing concern for the environment, design for sustainability and Circular Economy (CE) have become a requirement rather than merely a desirable characteristic for products and services in the construction industry [3, 4]. To remedy this situation, the construction industry is implementing designs and systems with improved long-term life-cycle performance. The main objective is to consider closed-loop circular design principles. Closed-loop material cycle (CLMC) in construction can be defined as recovering construction materials and building elements from old buildings and infinitely recycling them through natural or industrial processes [5]. Several studies have recognized the opportunity to minimize the negative environmental impacts in the of the End of Life (EoL) stage of buildings through Product Recovery Management (PRM) [3, 5, 6]. The main goal of PRM is to recover as much of the economic and ecological value of a product and its components as possible [6]. Additionally, several studies have demonstrated that the application of green design methods in the building industry, such as design for disassembly, design for deconstruction, planning for disassembly, and Life Cycle Assessment (LCA), presents a way to fully exploit the lifecycle expectancy of buildings and their materials/components [7–10].

The processes associated with the project management of an adaptive reuse project are diverse and dynamic. The difficulty lies in all the different aspects that have to be taken into account, such as the physical integrity of the building, economic issues, functionality, technological retrofits, social impact, and legal and political challenges [11]. The transition from the current linear economic model towards a circular one, implies a radical rearrangement of: (1) the value chain of the built environment [12, 13], (2) the ownership models for buildings [4], (3) the business models for profitability in the construction industry [14, 15], (4) the engagement of stakeholders in all the levels of society, e.g. government, suppliers, builders, and owners [16], and (5) the technical protocols and the methodologies utilized for sustainable construction [17]. For these reasons, little research has been done regarding the establishment of feasible systems for the planning [1], assessment [17, 18], and management [19] of adaptive reuse projects. Some authors stress that intuition and experience are the only guides in making decisions about adaptive reuse [20]. However, there is enough evidence to suggest that the shortcomings of adaptive reuse will be addressed in the coming years to move towards more sustainable development in the construction industry.

87.2.2 The Concept of Interface Management

There are several definitions and classifications for “interfaces” in the literature. According to the CII’s Interface Management Guideline, “interface” is defined as “a soft and/or hard contact point between two interdependent interface stakeholders”, and “interface management” is defined as “the management of communications, relationships, and deliverables among two or more interface stakeholders” [21].

When a project is divided into several sub-projects undertaken by different organizations, many interfaces occur between these organizations [22–24]. There are several different interface classifications in the literature. In this research paper, interfaces in the adaptive reuse projects will be studied under three main categories: physical, organizational, and contractual interfaces. Physical interfaces are the physical connections between two or more elements or components in a project. These are generally the easiest interfaces to notice in a project. Contractual interfaces can be defined as connections between interface stakeholders through contractual agreement. These type of interfaces can also be related with a physical interface. Organizational interfaces are the interactions between several interface stakeholders that are involved in the project. These interfaces include all the relationships and connections between any individual and any parties involved in the project throughout the project lifecycle [24, 25]. Other classifications for interfaces including soft and hard interfaces, time interface, geographical interface, and technical interface can be also found in literature [22].

A typical Interface Management System (IMS) would consist four main components: Interface Stakeholders, Interface Points (IP), Interface Agreements (IA), and Interface Agreement Deliverables (IAD). Basically, IAs are the documents that present communications and agreements between two interfaces stakeholders over an IP, and IADs are combination of the documents that are required to fulfıl related IA such as documents that show the tasks and activities completed. Generally, an IMS may include many IPs, and each IP can include many IAs, and each IA can include many IADs. Therefore, there could be numerous IADs in a system [24].

87.3 Research Methodology

This research paper is being carried out according to the following methodology steps:

1. Conduct an extensive literature review on adaptive reuse projects and define a list of barriers in these projects,
2. Conduct an extensive literature review on interface problems in construction projects and compare these interface problems to the barriers on adaptive reuse projects,
3. Pair interface problems with similar adaptive reuse barriers defined in the literature and explain them in a case study,
4. Discuss how these problems can be solved and how interface management system usage presents a solution for improving the performance of adaptive reuse projects.

87.4 Barriers in Adaptive Reuse Projects

Although adaptive reuse has many economic, social, and environmental benefits, these projects face many challenges and barriers during the project lifecycle, especially the project involves heritage buildings. Hein and Houck [26] conducted research regarding construction challenges in adaptive reuse of historical buildings in Europe, where adaptive reuse is widely practiced to preserve these historical buildings [26]. The main construction challenges explained with examples from four significant European adaptive reuse projects are: compliance with building codes and preserving laws, temporary structural support of preserved components, expectations of modern tenants such as new electrical, plumbing, HVAC systems etc., toxin removal, modification on structural integrity of the building such as modification of the structural skeleton, foundation system, or roof system, and site access problems [26].

In 2016, Conejos et al. identified fourteen barriers that occur in building type adaptive reuse projects: building codes and regulations/legal constraints, physical restrictions, high remediation costs and construction delays, complexity and technical difficulties, inaccuracy of information and drawings, maintenance, availability of materials and lack of skilled tradesmen, limited response to sustainability agenda, inertia of production and development criteria, classification change, economic considerations, social considerations, commercial risk and uncertainty, and financial and technical perceptions [27]. In this research, these barriers defined by Conejos et al. will be used as base point for defining adaptive reuse project problems. In addition to that barriers, “Management problems” is added to this list as 15th barrier.

More than half of the barriers defined by Conejos et al. [27] are due to physical interfaces between project participants such as compliance with building codes, physical constraints, complexity and technical difficulties [27]. These barriers are also a subject of interface problems in any construction projects and they can be managed by creating interface points and interface agreements between project participants in the early phases of the projects, such as the conceptual design and detailed design phases. In the case study presented in this paper, the concept and how IM system can be a solution to some of these problems is explained.

87.5 Common Interface Problems in Construction Projects

In literature, interface problems in construction projects are studied mainly under varying constraints for example limiting the study to only two parties involved to the project, or limiting the project type to a specific construction category, to a specific phase in the project lifecycle, to a country/region, or to a specific interface type, etc. In order to define the connections between common interface problems and adaptive reuse barriers, different types of articles addressing interface problems in construction projects were studied.

Interface problems between two main parties in construction projects such as interface problems between owners and contractors, designers and contractors, contractors and subcontractors, owners and maintenance contractors, owners and

Table 87.1 Comparison of adaptive reuse barriers to common interface problems

No	Type	Adaptive reuse challenges	Paper-1	Paper-2	Paper-3
1	P, C	Building codes and regulations/legal constraints	x	x	x
2	P	Physical restrictions	–	x	x
3	P	High remediation costs and construction delays	x	–	–
4	P	Complexity and technical difficulties	x	x	x
5	P, C	Inaccuracy of information and drawings	x	x	x
6	P	Maintenance	–	–	–
7	O	Availability of materials and lack of skilled tradesmen	x	x	x
8	O	Limited response to sustainability agenda	–	–	–
9	O	Inertia of production and development criteria	–	–	–
10	C	Classification change	x	x	x
11	S	Economic considerations	x	x	–
12	S	Social considerations	–	x	–
13	S	Commercial risk and uncertainty	–	x	–
14	S	Financial and technical perceptions	x	x	–
15	P, O, C	Management problems	x	x	x

designers, etc. have been studied by various researchers [28–34]. A more general research related to interface problems in construction projects was done by Al-Hammad in 2000 [35]. In the aforementioned research, which will be called as Paper-1 from this point on, nineteen common interface problems between various construction parties were defined.

Investigating interface problems that could happen during either the design phase, construction phase, or during both (aka design-construction interface) has been investigated by several researchers [36–39]. Many lists that contain design-construction interface problems are provided in various articles. For example, Sha'ar et al. [37], in a study which will be called Paper-2 from this point on, defined sixty design-construction interface problems in order to identify the causes of these problems in large building construction projects in Palestine [37]. Also, Al Mousli & El-Sayegeh [38], in a study which will be called Paper-3 from this point on, provided a list of 22 design-interface problems [38].

In order to find connections between adaptive reuse barriers and interface problems in the construction industry, the list explained in Sect. 4 of this paper, was compared with the interface problems provided in Paper-1, Paper-2, and Paper-3 individually. Comparisons are made on the basis of ideas rather than words, which means that "Inaccuracy of information and drawings" and "Mistakes and discrepancies in design documents" are accepted as being the same even though they are explained in different words. The result of these comparisons, is presented on Table 87.1.

Many of these defined barriers in Table 87.1 are related with interface points between project participants. For example, any barrier related with physical restrictions in the project would be related with physical interface points between project participants. For the purpose of this research paper, these defined barriers are also categorized into 4 interface groups which are namely: Physical interface (P), Organizational interface (O), Contractual interface (C), and out of scope group (S). The category of the listed barriers is shown in the second column of the Table 87.1.

87.6 Case Study

The case adaptive reuse project subjected to this research is a mid-20th century building built with a modern architectural style. The project is a four-story structure with a basement and has a shape similar to a boomerang with a footprint area of 1233 and 5341 m^2 gross floor area. The primary structural system of the building is a steel frame. The original building was built in 1964 and was redeveloped using adaptive reuse from 2014 to 2015. According to the heritage report of the case project, the building was classified as non-designated property of cultural heritage value. All of the building's subsystems had modifications which were primarily due to the increment of loads, the complete rearrangement of the floor layouts and the expansion of the gross floor area by 487 m^2. One of the changes included the in-filling of two large double-height rooms. The redeveloped project has been rated as a Leadership in Energy and Environmental Design (LEED) Gold Building.

The aim of this case study is to present IP examples for selected adaptive reuse barriers and interface problems documented during the realization of the case project. In order to define these IPs in the project, first project stakeholders were investigated. According to the project documents, there were seventeen stakeholders namely; Owner (OWN), Architecture (ARC), Structural Consultant (STR), Mechanical Consultant (MEC), Electrical Consultant (ELE), Landscape Consultant (LND), Civil Consultant (CVL), LEED Consultant (SD), Geotechnical Consultant (GEO), Hazardous Material Consultant (HBM), Asbestos Abatement Contractor (AAC), Finishing Hardware Contractor (FHC), General Contractor (GC), Mechanical Contractor (MECC), Electrical Contractor (ELEC), and Roofing Contractor (RC), in this project and each of them were responsible for different parts of the project.

After determining the project stakeholders and their responsibilities, IPs between these stakeholders were investigated. The documentation of the case study showed many critical IPs between the parties: the assurance of the accuracy of the technical information, drawings, and specifications for the adaptive reuse of the building. The main IPs detected were between the consultants and the designer, during the planning stage, as well as between the contractors and the consultors, during the execution of the project.

87.6.1 Physical Interfaces

As it is presented in Table 87.1, four of the physical interface related adaptive reuse barriers, namely, “Building codes and regulations/legal constraints”, “Complexity and technical difficulties”, “Inaccuracy of information and drawings” and “Management problems” are also mentioned as interface problems in the articles studied. When the documentation of the case project was investigated, it was found out that there was a continuous feedback between the consultants and the designer, as well as continuous corrections of the structural, civil, mechanical, and electrical final design through addendums to the original project. The contract specified reiteratively that the contractor should verify all dimensions and existing conditions on site and should report all discrepancies to the consultant before proceeding with the work. Also, the contract emphasized that the drawings (civil, landscape, structural, mechanical, electrical drawings, geotechnical and acoustical reports) should be read in conjunction with one another. All of these documentations are examples of “inaccuracy of information and drawing” related interface agreements.

Additionally, the fulfillment of the legal constraints related to the adaptive reuse of a building is a point of high interaction between different project parties. In these points of interaction, the responsibility of the consultants is to ensure a final design according to the current normativity, and to report any change in the pertinent timing. Because the consultants have to be aware of the existing conditions of the building asset, they have to develop an accurate and detailed inspection of the site, and then develop accurate reports, drawings, and building specifications for the other parties. It is worth to highlight that just for this kind of projects that involves the restoration of a building asset, it is necessary to create these physical interface points during the planning stage. For new construction, it is not necessary because there is not an existing asset to inspect.

Table 87.2 shows seven example interface points than can be created between the consultants and the designer, as well as the normativity established for the case study under analysis. Also, for the construction phase, the interface points presented in the table would be the same, but the communication of them should be between the contractors as interface EPC and the

Table 87.2 Interface point examples related with physical adaptive reuse barriers

Lead party	Interfacing party	IP type	IP title	Interface agreements topics
ARC	GEO	P	Geotechnical investigation	The due date
ARC	HBM	P	Asbestos removal	Construction methodology
ARC	STR	P	Column renovation	Loads that need to be considered
ARC	STC	P	Foundation Footings	Sizes and types of new footings
ARC	MEC	P	Duct design	Sizes of the ducts required,
ARC	ELE	P	Technical room	Electrical plans, voltages
ARC	VT	P	Elevator shaft	Dimensions of the elevator shaft

designer as the lead. Ideally these interface points should be created and managed from the beginning in order to secure the final accuracy, quality, and veracity of the technical information, drawings, and specifications.

87.6.2 Contractual and Organizational Interfaces

In construction projects, contractual and organizational interface points also exist as well as physical interface points. For example; in the contract between an architect and one of the contractors of the case project, it was written that “The Consultant’s review of shop drawings does not relieve the Contractor of their responsibility to re-view all information pertaining to: 1. detail design; 2. dimensions; 3. information pertaining to fabrication processes; 4. techniques of construction and installation; 5. coordination of the work of Subcontractors”. While this statement allocates responsibilities to the contractor, it also created contractual interface points which are also subject to physical interface points.

The main barrier in the adaptive reuse case project was related with management problems which are classified as physical, contractual, and organizational interfaces in Table 87.1. The case project ended up with cost and time overruns since it had a complex structure of project stakeholders where roles and responsibilities were unclear. The architect was responsible for both design and the management of the project which includes managing different types of consultants and contractors with subcontractors.

These problems can be solved by hiring an interface manager for the project and set-ting an IMS where IPs between project stakeholders can be defined, and IAs and IADs can be tracked more efficiently. Depending on the project size, a shared spreadsheet or a more sophisticated IMS software could be used.

87.7 Conclusion

In conclusion, depending on the project size, either a shared spreadsheet that shows interface points and related agreements between stakeholders, or a more sophisticated IMS software usage is recommended for adaptive reuse projects. The main objective behind establishing an appropriate IMS for adaptive reuse projects is to give more certainty to all the parties regarding their responsibilities in the project. When interface points between stakeholders are defined early in the project, participants can see the work packages, and deliverables can be tracked more efficiently. The workflow can also be streamlined as clear agreements between stakeholders are established. In this way, more and more participants in the construction industry would feel comfortable and secure when they get involved in these kinds of complex projects.

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