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Identifying building obsolescence: towards increasing buildings' service life

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Abstract

Purpose – Obsolescence is a decline or loss of utility of an object, building or product. Different types of building obsolescence decrease buildings' utility and shorten their service life. The purpose of this paper is identification of building obsolescence types and the relevant factors that affect buildings to become obsolete. It is also intended to categorise building obsolescence types to provide a contribution towards increasing building service life and delivering sustainability.

Design/methodology/approach – A systematic literature review is applied to conduct this research. It follows five steps: (1) formulating the research question; (2) locating studies; (3) selecting and evaluating relevant studies; (4) analysing the findings; (5) reporting and making use of the results.

Findings – Via this study, it is revealed that there are 33 types of building obsolescence. They are clustered in 10 categories regarding their conceptual and causing aspects and are presented based on their recurrence in the literature. According to the findings, economic obsolescence (including economic, financial and market obsolescence types) and functional obsolescence (including functional, use and utility obsolescence types) are the most remarkable categories.

Originality/value – Investigating the literature makes it clear that building obsolescence types have been studied intermittently with infrequent profound exploration of the relationship between them. This paper presents a comprehensive identification of building obsolescence types and introduces obsolescence categories that classify connected obsolescence types. It is a new framework for further studies on building obsolescence to find more effective prevention strategies to mitigate social, economic and environmental consequences of building obsolescence.

Keywords Building obsolescence, Obsolescence type, Obsolescence category, Service life, Sustainability

Paper type Literature review

Introduction

During their life, buildings experience technological advancements, political shifts, economic and social alterations and changes in users' and stakeholders' needs and demands. Such conditions can decrease buildings' capability to meet their functions and lead them to become obsolete prior to the end of their physical life and in many cases to be demolished. The decline in a building's performance is so-called "obsolescence". Obsolescence is defined as a decline or loss of utility, performance, values or usefulness of an object, building or product (Nutt *et al.*, 1976; Flanagan *et al.*, ,1989; Baum, 1991; Burton, 1933; Khalid, 1994; Ashworth, 2004; Ahmad *et al.*, 2005; Kintrea, 2007; Mansfield and Pinder, 2008; Thomsen and Flier, 2011a;R. Grover and C. Grover, 2015; API, 2017). Circa 1910, obsolescence was first applied in English for the built environment (Abramson, 2012), and it was about in 1960 that obsolescence turned to an acknowledged concept worldwide for perceiving and managing the change in urban environment (Abramson, 2016).

Obsolescence is a threat to sustainability, and at the same time, it could be a result of unsustainability. There is an increasing need to make sure that properties will not have rapid or accelerated obsolescence due to unsustainability (Reed and Warren-Myers, 2010). According to a study by housing associations in the Netherlands, more than 60% of the

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demolitions were motivated by functional and structural obsolescence, in the pre-war stock even over 90%. Including economic motives and oversupply, 87% of the demolitions were attributed to one of the obsolescence types (Thomsen and Flier, 2011a). Pinder and Wilkinson (2001) state that building obsolescence has turned to an important issue in property market of the United Kingdom, and in recent decades, the increasing rate of building obsolescence has reduced the average life of office buildings to less than 25 years Gann and Barlow (1996) had previously mentioned that life cycle of office buildings in the United Kingdom is reduced to 20–25 years in 1990s from 40–50 years in 1950s and 1960s.

Therefore, obsolescence is a serious threat to built property, and necessary measures must be taken to avoid building obsolescence or to mitigate this problem. Prevention can be the most effective and efficient approach for avoiding obsolescence (R. Grover and C. Grover, 2015). Identifying building obsolescence and its different types can be the first step in the preventing approach. In spite of its importance, building obsolescence has not been studied thoroughly. As Thomsen and Flier (2011b) have previously mentioned, the literature shows a confusing variety of obsolescence types and each scholar refers to different numbers and types of building obsolescence. There are similar and overlapping obsolescence types, and common causes could be found for different obsolescence types. These similarities make the literature indistinct and even more complicated. In this regard, a comprehensive identification of building obsolescence types is indispensable to a better understanding and, subsequently, more effective management of obsolescence towards increasing buildings' service life and delivering sustainability as well.

Research method

In this study, a systematic literature review is applied to identify and classify building obsolescence types. According to Kilubi (2016), a systematic literature review follows five steps: (1) formulating the research question; (2) locating studies (keywords identification and database search; (3) selecting and evaluating relevant studies (criteria to include or exclude the papers); (4) analysing the findings; (5) reporting and making use of the results.

(1) Formulating the research question

Buildings' obsolescence is a threat for built property which can decrease buildings' service life. The main research questions are: (1) what types of buildings' obsolescence are there? (2) Could certain building obsolescence categories be introduced to contain similar building obsolescence types?

(2) Locating studies (keywords identification and database search)

Academic and research databases have been used to identify potential documents/publications for further investigation by searching for keywords, initially including "building obsolescence", "obsolescence types", "building service life" and "building useful life". The keywords were identified based on a brief overview of a limited study on the literature and were chosen in accordance with the authors' own knowledge due to their previous studies on the subject.

(3) Selecting and evaluating relevant studies

The criteria to check the papers on their relevance have been as follows:

(1) Referring to or discussing different obsolescence types or just one type of obsolescence. Some other papers are also included; papers that do not directly focus on obsolescence types but concentrate on a particular building type obsolescence, for example, Allehaux and Tessier (2002), which investigates

functional obsolescence in office buildings, or those that in spite of their main subject refer to some types of building obsolescence, for example, Langston *et al.* (2008), which refers to a number of obsolescence types while discussing adaptive reuse potential (ARP) model;

(2) Being related to building obsolescence (there are many studies and papers about product obsolescence).

In order to widen the scope of investigation, the snowball method (Konijnendijk *et al.*, 2013) is applied. It means that the referred references in the relevant papers are also checked on their relevance, and furthermore, other types of relevant documents including scientific and research reports are also in the scope (see Dixon *et al.*, 1999b; API, 2017; RICS, 2017). Regarding the fact that the number of publications in this field of study is relatively small, the literature review is not limited to a specific period of time and all available publications are taken into account.

The selected relevant studies consist of 63 papers (53 journal papers and 10 conference papers), nine books, four academic theses (including three PhD dissertations and one master thesis) and nine other documents (i.e. scientific and research reports).

(4) Analysing the findings; and

(5) Reporting and making use of the results

Analysing the findings and communication of the results are included in the next sections.

Building obsolescence typology

There is neither an inclusive typology nor a widely agreed classification of building obsolescence types in the literature. Among the documents that clearly discuss about the obsolescence types, there are varieties of classifications and different number of obsolescence types, from Bryson (1997) that touches on two types of obsolescence to Williams (1986), R. Grover and C. Grover (2015) and Remøy (2010) that refer to six, nine and 10 building obsolescence types, respectively (Table 1).

Identification of building obsolescence types showed that there are 33 building obsolescence types including economic, functional, locational, physical, legal, social, technological, aesthetic, environmental, tenure, architectural, financial, use, style, structural, control, community, technical, design, political, equipment, fashion, cultural, statutory, visual, tenant, site, utility, market, regulatory, image, rental and ecological obsolescence. Through an analytical approach and considering similar and overlapping obsolescence types, they are clustered and classified in 10 introduced building obsolescence categories as follows:

Economic obsolescence

Economic obsolescence means that the operation and maintenance costs are higher, when compared to new systems and products (Sarja, 2006). According to Wilkinson *et al.* (2014), economic obsolescence is basically dependent on ensuring that the income stream remains greater than the cost stream and greater than other alternative opportunities of similar risk level. Through literature review (Flanagan *et al.*, 1989; Pugh, 1992; Crawford and Cornia, 1994; Ashworth, 2004; Guangming, 2011; Mora *et al.*, 2011), it is specified that the balance between cost and profit is a key concept in economic obsolescence, and it occurs when the cost is higher than the income and return, or/and other newer and better alternatives are available to achieve financial goals. Different factors can lead to economic obsolescence such as reducing the demands for those building types or products and services produced by the

Number of obsolescence types	Scholars	
2	Baum (1991, 1993, 1994) Raftery (1991 cited Kirwan and Martin, 1972) Bryson (1997)*[a]	Pinder and Wilkinson (2000, 2001)* Yusof (2000) Butt *et al.* (2011, 2015a, 2015b)
3	Bottom *et al.* (1999) Rojas (2002)* Brown and Tjibbe (2008) Mansfield and Pinder (2008)*	Thomsen and Flier (2011a cited Prak and Priemus, 1986) Reilly (2013) Rodi *et al.* (2015)*
4	Mora *et al.* (2011)	Thomsen and Flier (2011a cited Golton, 1997)
5	Lichfield (1968)	Johnston (2016)
6	Williams (1986) Caccavelli and Gugerli (2002) Douglas (2006)	Evelyn and Guangming (2010)* Guangming (2011)*
7	Nutt *et al.* (1976) Ashworth (2004)	Langston (2011a, 2011b, 2011c, 2012)
8	Dixon *et al.* (1999b cited Khalid, 1992)	
9	Flanagan *et al.* (1989)	R. Grover and C. Grover (2015)
10	Nutt and Sears (1972) Blakstad (2001)*	Remøy (2010)* Wilkinson *et al.* (2014)*

Table 1. Number of obsolescence types in scholars' viewpoint

Note(s): a. Those references that are specified by stars, in each table row, are referred to the similar type

asset, oversupply (Williams, 1986; Douglas, 2006; Evelyn and Guangming, 2010; R. Grover and C. Grover, 2015; API, 2017; RICS, 2017), change in the highest and best use for the land (Flanagan *et al.*, 1989; Ashworth, 2004) or as the result of increasing the land value over the building which is sited in it (Flanagan *et al.*, 1989; Mansfield and Pinder, 2008).

In some studies (e.g. Crawford and Cornia, 1994; Reed and Warren-Myers, 2010), external obsolescence has been considered equivalent to economic obsolescence. External obsolescence refers to the factors external to an asset causing its obsolescence. In this regard, external obsolescence can also include some other building obsolescence types (e.g. social obsolescence), and referring to external obsolescence as a specific obsolescence type would be a misunderstanding. Therefore, it is not recognised as a building obsolescence type.

Financial obsolescence occurs where capital and recurrent expenditure are not balanced by returns and benefits (Nutt and Sears, 1972). The balance between costs and benefits is also considered as financial obsolescence by Blakstad (2001), Nutt *et al.* (1976), Remøy (2010) and Wilkinson *et al.* (2014). It is mentioned by R. Grover and C. Grover (2015) that financial obsolescence and economic obsolescence are identical.

Market obsolescence is related to decrease in the income compared to newer equipment (Meyer, 1993). Market obsolescence may occur, due to change in the market, for example, reducing the need for a particular building use or good, caused by the change in demands (Reed and Warren-Myers, 2010). It should be noted that obsolescence types are not simply separated from each other and there are some common characteristics and overlapping. For example, change in demands is an important factor in market obsolescence which can occur as a result of change in social taste, needs and behaviours. According to the literature, these factors can cause social obsolescence and aesthetic obsolescence as well. But, considering the common features of economic, financial and market obsolescence types and regarding their focal points of cost and income, they are classified under one building obsolescence category (Table 2).

Obsolescence type	Ref		
Economic	Jacobs (1941)	Kalligeros (2003)	Mora *et al.* (2011)
	Lichfield (1968)	Sarja (2005, 2006)	Thomsen and Flier (2011a, 2011b)
	Williams (1986)	Dunse and Jones (2005)	Beekmans *et al.* (2012)
	Flanagan *et al.* (1989)	Douglas (2006)	Goetz (2012)
	Baum (1991)	Brown and Tjibbe (2008)	Reilly (2013)
	Raftery (1991)	Langston *et al.* (2008), (2013)	Butt *et al.* (2014)
	Pugh (1992)	Mansfield and Pinder (2008)	Tan *et al.* (2014)
	Iselin and Lemer (1993)	Evelyn and Guangming (2010)	Yung *et al.* (2014)
	Crawford and Cornia (1994)	Shen and Langston (2010)	R. Grover and C. Grover (2015)
		Reed and Warren (2010)	Rodi *et al.* (2015)
	Downs (1995)	Conejos *et al.* (2012, 2014, 2015)	Aksözen *et al.* (2016)
	Aikivuori (1996)	Butt *et al.* (2011, 2015a, 2015b)	Johnston (2016)
	Ashworth (1996, 2004)	Guangming (2011)	API (2017)
	Lemer (1996)	Langston (2011a, 2011b, 2011c, 2012)	Chen *et al.* (2017)
	Dixon *et al.* (1999b)		RICS (2017)
	Rojas (2002)		
	Weber (2002)		
Financial	Nutt and Sears (1972)	Douglas (2006)	Thomsen and Flier (2011a, 2011b)
	Nutt *et al.* (1976)	Butt *et al.* (2011, 2015a, 2015b)	Wilkinson *et al.* (2014)
	Blakstad (2001)		
	Caccavelli and Gugerli (2002)	Remøy (2010)	R. Grover and C. Grover (2015)
Market	Meyer (1993)	Reed and Warren (2010)	Thomsen and Flier (2011a, 2011b)

Table 2.
Economic obsolescence category

Functional obsolescence

Functional obsolescence can be attributed to the condition in which the building no longer fulfils the functions and use requirements for which it was originally designed and loses its utility (Bowei, 1984; Baum, 1991; Guangming, 2011; R. Grover and C. Grover, 2015; Rodi *et al.*, 2015). Functional obsolescence can occur because of factors such as technological improvement and consequently change in users' needs and demands, or inflexible design and building. Ashworth (2004) points it out that a building can be functionally obsolete because the original use is no longer required. This definition is applied for *use obsolescence* as well. Therefore, functional obsolescence and use obsolescence are similar concepts that are related to the buildings' function and use.

Thomsen and Flier (2011a), cited Golton (1997), to refer to *utility obsolescence*. Utility obsolescence can be defined as the loss of usability and functionality of a building. It is considered as a building obsolescence type to be categorised with functional and use obsolescence types.

Butt *et al.* (2011) argue that functional obsolescence is also termed as technical obsolescence, but Dixon *et al.* (1999a) indicate that functional obsolescence is often used for the whole building, whereas technological obsolescence often refers to building components. Although technological obsolescence can lead to functional obsolescence, they are not similar concepts and could not be acknowledged as similar obsolescence types. In this regard, functional, use and utility obsolescence types are classified into one building obsolescence category (Table 3).

Locational obsolescence

Locational obsolescence means that the value of a neighbourhood and/or an area is decreased, and consequently existing buildings on that area undergo a drastic reduction of their value.

Table 3.
Functional obsolescence category

Obsolescence type	Ref		
Functional	Lichfield (1968)	Weber (2002)	Langston (2011a, 2011b, 2011c, 2012)
	Nutt and Sears (1972)	Chaplin (2003)	Mora *et al.* (2011)
	Nutt *et al.* (1976)	Kalligeros (2003)	Thomsen and Flier (2011a, 2011b)
	Bowei (1984)	Sarja (2005, 2006)	Beekmans *et al.* (2012)
	Flanagan *et al.* (1989)	Dunse and Jones (2005)	Crosby *et al.* (2012)
	Baum (1991, 1993, 1994)	Douglas (2006)	Goetz (2012)
	Raftery (1991)	Brown and Tjibbe (2008)	Reilly (2013)
	Pugh (1992)	Langston *et al.* (2008, 2013)	Tan *et al.* (2014)
	Iselin and Lemer (1993)	Mansfield and Pinder (2008)	Wilkinson *et al.* (2014)
	Downs (1995)	Butt *et al.* (2011, 2015a, 2015b)	Yung *et al.* (2014)
	Aikivuori (1996)	Evelyn and Guangming (2010)	R. Grover and C. Grover (2015)
	Ashworth (1996, 2004)	Shen and Langston (2010)	Rodi *et al.* (2015)
	Bottom *et al.* (1999)	Reed and Warren (2010)	Aksözen *et al.* (2016)
	Dixon *et al.* (1999a, 1999b)	Remøy (2010)	API (2017)
	Blakstad (2001)	Conejos *et al.* (2012, 2014, 2015)	Chen *et al.* (2017)
	Allehaux and Tessier (2002)	Guangming (2011)	RICS (2017)
	Caccavelli and Gugerli (2002)		
	Rojas (2002)		
Use	Johnston (2016)		
Utility	Thomsen and Flier (2011a)		

Locational obsolescence is where an area suffers from devaluation. It reflects the fact that part of the value of any property is determined by the neighbourhood in which it is located (R. Grover and C. Grover, 2015). Locational obsolescence occurs when buildings located within a particular area suffer from devaluation because the area is seen as less attractive by current or prospective occupiers (Pinder and Wilkinson, 2001). Locational obsolescence occurs as the result of factors such as physical deterioration of the neighbourhood, low accessibility to infrastructures and changes in local environment conditions (Pinder and Wilkinson, 2001; Thomsen and Flier, 2011a; R. Grover and C. Grover, 2015). *Environmental obsolescence* occurs when the conditions of the neighbourhood are inappropriate for current usage patterns (Nutt *et al.*, 1976; Raftery, 1991; Blakstad, 2001; Remøy, 2010). In this regard, locational obsolescence and environmental obsolescence are related to the quality and condition of the neighbourhood. *Site obsolescence* occurs when potential value of the site becomes higher than the potential value of the building and current value of the site is high enough to justify demolition and redevelopment (Nutt *et al.*, 1976; Raftery, 1991; Blakstad, 2001; Remøy, 2010; Wilkinson *et al.*, 2014). The factors that cause site obsolescence, including deterioration in accessibility and other environmental factors (Yusof, 2000), are the same factors that can lead to locational and environmental obsolescence. In fact, locational, environmental and site obsolescence types have similar concepts, but they differ in terms of scale as it is also noted by Remøy (2010). Locational obsolescence, environmental obsolescence and site obsolescence types are classified into one building obsolescence category (Table 4).

Physical obsolescence

Physical obsolescence occurs where buildings become increasingly inadequate solely due to the deterioration of their physical fabrics (Nutt *et al.*, 1976). It is a loss of utility due to the physical deterioration of the asset or its components, caused by its age and normal usage, which results in a loss of value (API, 2017). It is also defined as any loss of utility due to the physical deterioration of the asset or its components resulting from its age and usage (RICS, 2017).

Obsolescence type	Ref		
Locational	Lichfield (1968)	Dixon *et al.* (1999b)	Remøy (2010)
	Nutt and Sears (1972)	Pinder and Wilkinson (2000, 2001)	Thomsen and Flier (2011a, 2011b)
	Grigsby *et al.* (1983)	Blakstad (2001)	Beekmans *et al.* (2012)
	Williams (1986)	Caccavelli and Gugerli (2002)	Crosby *et al.* (2012)
	Flanagan *et al.* (1989)	Chaplin (2003)	Reilly (2013)
	Raftery (1991)	Sarja (2006)	Wilkinson *et al.* (2014)
	Downs (1995)	Mansfield and Pinder (2008)	R. Grover and C. Grover (2015)
	Aikivuori (1996)	Reed and Warren (2010)	Rodi *et al.* (2015)
	Bryson (1997)		
Site	Nutt *et al.* (1976)	Yusof (2000)	Remøy (2010)
	Grigsby *et al.* (1983)	Blakstad (2001)	Guangming (2011)
	Raftery (1991)	Evelyn and Guangming (2010)	Wilkinson *et al.* (2014)
	Downs (1995)		
Environmental	Lichfield (1968)	Bowei (1984)	Blakstad (2001)
	Nutt and Sears (1972)	Baum (1991)	Mansfield and Pinder (2008)
	Nutt *et al.* (1976)	Raftery (1991)	Remøy (2010)

Table 4. Locational obsolescence category

Physical obsolescence may happen due to certain external factors such as natural events or it might be rooted in the users' acts and behaviours or poor maintenance policy.

Flanagan *et al.* (1989) and Ashworth (2004) have differentiated physical deterioration and physical obsolescence. According to them, building physical deterioration is largely a combined function of time and use. Physical deterioration can be controlled to some extent by selecting suitable materials and components at the design stage, implementation of appropriate construction methods and good maintenance during building operation. Although the same considerations are applicable to manage physical obsolescence, it is much more difficult to control since it is also concerned with unpredicted, intermittent and individual events. Physical deterioration is a continuing process unlike physical obsolescence which is irregular and unpredictable (Ashworth, 2004). In some other studies (Nutt and Sears, 1972; Nutt *et al.*, 1976; Iselin and Lemer, 1993; API, 2017; RICS, 2017), the term "physical deterioration" has been used to define physical obsolescence. In this regard, physical deterioration and physical obsolescence can be considered as similar concepts with a narrow difference indicating that physical deterioration is the basic form of physical obsolescence.

Structural obsolescence occurs due to deterioration of building materials and structure (Blakstad, 2001; Remøy, 2010; Wilkinson *et al.*, 2014). It occurs when the fabric of the building has reached to the point of being unable to offer adequate physical shelter (Lichfield, 1968). According to certain studies (Nutt and Sears, 1972; Blakstad, 2001; Remøy, 2010; Wilkinson *et al.*, 2014), physical obsolescence and structural obsolescence are similar concepts and have been considered as the same. In fact, structural obsolescence can be recognised as a part of physical obsolescence, yet a different building obsolescence type (Table 5).

Legal obsolescence

Legal obsolescence is related to compliance with building regulations (Evelyn and Guangming, 2010). It occurs due to changes in legislation (Reed and Warren-Myers, 2010), and it is also considered as resulting from the introduction of new standards (Baum, 1994). A building which originally is designed according to building regulations might be obsolete over time due to changes in the relevant regulations. A building is legally obsolete when it no

Obsolescence type	Ref		
Physical	Nutt and Sears (1972)	Douglas (2006)	Crosby *et al.* (2012)
	Nutt *et al.* (1976)	Langston *et al.* (2008, 2013)	Goetz (2012)
	Bowei (1984)	Mansfield and Pinder (2008)	Reilly (2013)
	Williams (1986)	Remøy (2010)	Tan *et al.* (2014)
	Flanagan *et al.* (1989)	Evelyn and Guangming (2010)	Yung *et al.* (2014)
	Baum (1991)	Shen and Langston (2010)	Wilkinson *et al.* (2014)
	Raftery (1991)	Reed and Warren (2010)	R. Grover and C. Grover (2015)
	Pugh (1992)	Conejos *et al.* (2012, 2014, 2015)	Rodi *et al.* (2015)
	Aikivuori (1996)	Guangming (2011)	Aksözen *et al.* (2016)
	Ashworth (1996, 2004)	Langston (2011a, 2011b, 2011c, 2012)	API (2017)
	Dixon *et al.* (1999b)	Thomsen and Flier (2011a, 2011b)	Chen *et al.* (2017)
	Blakstad (2001)		RICS (2017)
	Caccavelli and Gugerli (2002)		
	Rojas (2002)		
Structural	Lichfield (1968)	Blakstad (2001)	Thomsen and Flier (2011a, 2011b)
	Nutt and Sears (1972)	Remøy (2010)	Wilkinson *et al.* (2014)
	Grigsby *et al.* (1983)		

Table 5.
Physical obsolescence category

longer meets the legal requirements. These definitions and causes correspond with *regulatory obsolescence* mechanism as well. *Control obsolescence* occurs when regulating mechanisms that govern the building's development and renewal induce obsolescence to the building (Nutt and Sears, 1972; Nutt *et al.*, 1976; Raftery, 1991). Therefore, legal obsolescence and control obsolescence refer to similar concepts, as Douglas (2006) has also considered them related. *Political obsolescence* can be evaluated by the extent of public and local community interest surrounding a building (Wilkinson *et al.*, 2014). Although this definition overlaps with social obsolescence, but having in mind that political interferences are normally translated into regulatory principles, it is more reasonable to categorise it with legal obsolescence. Finally, *statutory obsolescence* is related to the difficulties arisen from statutory and regulatory requirements (Williams, 1986). In this regard, legal, regulatory, control,

Obsolescence type	Ref		
Legal	Flanagan *et al.* (1989)	Dunse and Jones (2005)	Remøy (2010)
	Baum (1991, 1993, 1994)	Douglas (2006)	Guangming (2011)
	Pugh (1992)	Sarja (2006)	Langston (2011a, 2011b, 2011c, 2012)
	Iselin and Lemer (1993)	Langston *et al.* (2008, 2013)	Crosby *et al.* (2012)
	Aikivuori (1996)	Evelyn and Guangming (2010)	Tan *et al.* (2014)
	Ashworth (1996, 2004)	Shen and Langston (2010)	Wilkinson *et al.* (2014)
	Dixon *et al.* (1999b)	Reed and Warren-Myers (2010)	Yung *et al.* (2014)
	Blakstad (2001)	Conejos *et al.* (2012, 2014, 2015)	R. Grover and C. Grover (2015)
	Chaplin (2003)		Iselin and Lemer (1993)
Political	Shen and Langston (2010)	Thomsen and Flier (2011a, 2011b)	Tan *et al.* (2014)
	Conejos *et al.* (2012, 2014, 2015)	Goetz (2012)	Yung *et al.* (2014)
	Langston (2011a, 2011b, 2011c, 2012)	Langston *et al.* (2013)	Chen *et al.* (2017)
Control	Nutt and Sears (1972)	Douglas (2006)	Thomsen and Flier (2011a, 2011b)
	Nutt *et al.* (1976)	Evelyn and Guangming (2010)	
	Raftery (1991)	Guangming (2011)	
Regulatory	Downs (1995)	Lemer (1996)	Kalligeros (2003)
Statutory	Williams (1986)		

Table 6.
Legal obsolescence category

political and statutory obsolescence types refer to similar concepts and are classified into one building obsolescence category (Table 6).

Social obsolescence

Social obsolescence is associated with society's changing taste or perception (Rodi *et al.*, 2015). A building can simply become socially obsolete even as it functions appropriately. Social obsolescence can occur due to changes in expectancy levels (Douglas, 2006), and changes in fashion and style can result in buildings becoming outdated (Wilkinson *et al.*, 2014).

Cultural obsolescence corresponds with social obsolescence, and it is related to local cultural traditions, life and work styles and the image of owners and users (Sarja, 2006). *Community obsolescence* is related to the local conflicts of interest arising from the use of a building (Williams, 1986). Therefore, social, cultural and community obsolescence types are all related to the social trends and can occur because of shifting social tastes and demands. These building obsolescence types are clustered as one category regarding their similarities and overlapping concepts (Table 7).

Technological obsolescence

Technological obsolescence can occur because of technological development and introduction of new technologies and as a result of accessibility of more efficient technologies and better services. These descriptions are also applicable for *technical obsolescence*. Dixon *et al.* (1999a) indicate that technological obsolescence refers to the building components, such as mechanical and electrical facilities, becoming inefficient technically. According to Grigsby *et al.* (1983), *equipment obsolescence* is related to archaic electrical wiring and water piping systems. Therefore, equipment obsolescence and technological obsolescence are related to the obsolescence of building components and its mechanical and electrical systems (Table 8).

Aesthetic obsolescence

Aesthetic obsolescence can occur because of change in fashion and architectural style (Ashworth, 2004; Douglas, 2006) or old and outdated appearance (Baum, 1991; Bottom *et al.*, 1999; Blakstad, 2001; Remøy, 2010; Wilkinson *et al.*, 2014). Changes in fashion, style and aesthetic values are inevitable. Buildings and building components that once were considered beautiful may now be considered unpleasant. Therefore, by maintaining its own functions, a building might be obsolete aesthetically. *Style obsolescence* is also related to visual and stylistic qualities of a building (Nutt and Sears, 1972; Raftery, 1991) and therefore, refers to a

Obsolescence type	Ref		
Social	Flanagan *et al.* (1989) Baum (1991, 1993, 1994) Pugh (1992) Iselin and Lemer (1993) Aikivuori (1996) Ashworth (1996, 2004) Lemer (1996) Bottom *et al.* (1999) Dixon *et al.* (1999b) Blakstad (2001) Douglas (2006) Sarja (2006)	Langston *et al.* (2008, 2013) Evelyn and Guangming (2010) Shen and Langston (2010) Reed and Warren-Myers (2010) Remøy (2010) Conejos *et al.* (2012, 2014, 2015) Guangming (2011) Langston (2011a, 2011b, 2011c, 2012) Thomsen and Flier (2011a)	Crosby *et al.* (2012) Tan *et al.* (2014) Butt *et al.* (2014) Wilkinson *et al.* (2014) Yung *et al.* (2014) R. Grover and C. Grover (2015) Rodi *et al.* (2015) Thomsen *et al.* (2015) Johnston (2016) Chen *et al.* (2017)
Cultural	Iselin and Lemer (1993)	Sarja (2005, 2006)	Douglas (2006)
Community	Williams (1986)		

Table 7.
Social obsolescence category

Table 8. Technological obsolescence category

Obsolescence type	Ref		
Technological	Flanagan *et al.* (1989)	Langston *et al.* (2008, 2013)	Douglas (2006)
	Raftery (1991)	Evelyn and Guangming (2010)	Mora *et al.* (2011)
	Iselin and Lemer (1993)	Shen and Langston (2010)	Tan *et al.* (2014)
	Downs (1995)	Reed and Warren-Myers (2010)	Yung *et al.* (2014)
	Aikivuori (1996)	Conejos *et al.* (2012, 2014, 2015)	R. Grover and C. Grover (2015)
	Ashworth (1996, 2004)	Guangming (2011)	Rodi *et al.* (2015)
	Lemer (1996)	Langston (2011a, 2011b, 2011c, 2012)	Johnston (2016)
	Dixon *et al.* (1999a, 1999b)		Chen *et al.* (2017)
	Sarja (2005, 2006)		RICS (2017)
Technical	Caccavelli and Gugerli (2002)	Sarja (2005, 2006)	Aksözen *et al.* (2016)
	Kalligeros (2003)		
Equipment	Grigsby *et al.* (1983)		

concept similar to aesthetic obsolescence. Johnston (2016) has used the term *design obsolescence* and related it to style and fashion. Whereas a number of studies (including Flanagan *et al.*, 1989; Blakstad, 2001; Dunse and Jones, 2005; Sarja, 2006; Remøy, 2010; Wilkinson *et al.*, 2014) consider aesthetic obsolescence equivalent to *visual obsolescence*, others (Flanagan *et al.*, 1989; R. Grover and C. Grover, 2015) define it as *fashion obsolescence*. Flanagan *et al.* (1989) consider aesthetic obsolescence as *image obsolescence*, and Douglas (2006) identifies *architectural obsolescence* as a part of aesthetic obsolescence. Therefore, aesthetic, style, design, visual, fashion and architectural obsolescence types could be classified into one category (Table 9).

Environmental obsolescence

Certain causes including high greenhouse gas emissions, incompliance with climate conditions or toxic waste generation can lead to *environmental obsolescence* (R. Grover and C. Grover, 2015). It is also related to negligence in using renewable and clean energy sources, passive heating and cooling systems and other features of green buildings. Sarja (2006) considers *ecological obsolescence* related to high waste and pollution productions, heating and cooling energies and emissions such as CO2 and acid substances into the air. Therefore, environmental obsolescence and ecological obsolescence have a close similarity and are classified into one building obsolescence category (Table 10).

It should be pointed out that environmental obsolescence has been used in two different concepts. One of them is close to the definition of ecological obsolescence, and the other one is

Table 9. Aesthetic obsolescence category

Obsolescence type	Ref		
Aesthetic	Flanagan *et al.* (1989)	Caccavelli and Gugerli (2002)	Mora *et al.* (2011)
	Baum (1991, 1993, 1994)	Ashworth (2004)	Crosby *et al.* (2012)
	Aikivuori (1996)	Dunse and Jones (2005)	Wilkinson *et al.* (2014)
	Bottom *et al.* (1999)	Sarja (2006)	R. Grover and C. Grover (2015)
	Dixon *et al.* (1999a, 1999b)	Douglas (2006)	Rodi *et al.* (2015)
	Blakstad (2001)	Remøy (2010)	
Visual	Flanagan *et al.* (1989)	Dunse and Jones (2005)	Remøy (2010)
	Blakstad (2001)	Sarja (2006)	Wilkinson *et al.* (2014)
Fashion	Flanagan *et al.* (1989)	R. Grover and C. Grover (2015)	
Architectural	Douglas (2006)		
Design	Johnston (2016)		
Style	Nutt and Sears (1972)	Raftery (1991)	Thomsen and Flier (2011a, 2011b)
	Nutt *et al.* (1976)	Evelyn and Guangming (2010)	
	Grigsby *et al.* (1983)	Guangming (2011)	
Image	Flanagan *et al.* (1989)	Chaplin (2003)	

similar to locational obsolescence. Consequently environmental obsolescence is recognised as a building obsolescence type, but it is classified into two different obsolescence categories.

The other remark could be made on sustainable obsolescence. Reed and Warren-Myers (2010) raised the question on whether sustainable obsolescence could be considered as the fourth type of obsolescence, along with the other three main types, namely physical, functional and economic obsolescence. Considering that, sustainability can include social, economic and environmental dimensions, sustainable obsolescence could also include social, economic and environmental obsolescence, earlier discussed in this paper. Therefore, the authors did not consider sustainable obsolescence as a type by itself. However, some scholars as R. Grover and C. Grover (2015) define sustainable obsolescence as environmental obsolescence.

Tenure obsolescence

Tenure obsolescence occurs as a result of disagreements between landlord and occupier (Wilkinson *et al.*, 2014). There are two other relevant obsolescence types including *tenant obsolescence* that occurs when tenants no longer consider a property as suitable for occupation and *rental obsolescence* that happens when the landlord feels that the existing rental agreement is out of date and the rate of rent should be changed (Nutt and Sears, 1972; Raftery, 1991). Even if the stated conditions cannot make a building really obsolete and can be managed simply via substitution of occupier and changing the rent rate, tenure obsolescence, tenant obsolescence and rental obsolescence are recognised as potential building obsolescence types and are clustered into one building obsolescence category (Table 11).

Discussion

A building's life cycle is closely connected to its state of obsolescence (Wilkinson *et al.*, 2014), and an increased rate of building obsolescence will reduce building's average life. According to Butt *et al.* (2014), the factors that cause obsolescence are the same factors that cause unsustainability of the built environment, and there is an inverse relationship between obsolescence and sustainability. Obsolescence can lead to consuming excessive natural resources, and it can be considered equivalent to unsustainability. In order to reach a sustainable built environment, obsolescence needs to be managed either in new construction or when remediating the existing built environment. The more obsolescence is mismanaged, the more obsolescent, and consequently, the less sustainable the property will be (Butt *et al.*, 2014). On the other hand, the value of the building is related directly to

Obsolescence type	Ref		
Environmental	Dixon *et al.* (1999b)	Butt *et al.* (2014)	R. Grover and C. Grover (2015)
Ecological	Sarja (2005, 2006)		

Table 10. Environmental obsolescence category

Obsolescence type	Ref		
Tenure	Blakstad (2001)	Remøy (2010)	Wilkinson *et al.* (2014)
Tenant	Nutt and Sears (1972)	Raftery (1991)	
Rental	Nutt and Sears (1972)	Raftery (1991)	

Table 11. Tenure obsolescence category

the degree of obsolescence evident in the building. The long-standing theoretical approach for assessing the depreciated value of a building has commonly been linked to the identification, quantification and assessment of the effect of obsolescence. The future income streams of a property may be jeopardized if obsolescence is not recognised and dealt with in the management of the property. As Reed and Warren-Myers (2010) have also mentioned, understanding what obsolescence is and how it affects a built property is very important. Identification of building obsolescence types has a pivotal role in taking effective measures to mitigate or prevent building obsolescence and to move toward a sustainable built environment. The variety of classifications that include different numbers of building obsolescence types, together with similarities and overlappings, make the literature rather confusing and complicated. To overcome the problem, this study provides a comprehensive identification of obsolescence types and introduces 10 building obsolescence categories that classify and include all identified building obsolescence types according to their distinctive and similar aspects appropriately. The introduced building obsolescence categories are as the followings:

(1) Economic Obsolescence
(2) Functional Obsolescence
(3) Locational Obsolescence
(4) Physical Obsolescence
(5) Legal Obsolescence
(6) Social Obsolescence
(7) Technological Obsolescence
(8) Aesthetic Obsolescence
(9) Environmental Obsolescence
(10) Tenure Obsolescence

It is necessary to point it out that there is always a degree of overlapping in different obsolescence types, but here they are categorized into groups where they have the most similarity and overlapping. To rank the building obsolescence categories according to their importance, the number of references is used as the basis. Therefore, according to Table 2, based on the number of references, economic obsolescence, functional obsolescence, physical obsolescence, legal obsolescence and locational obsolescence are the five most referred to building obsolescence categories. But in several cases, the papers have overlapping authorships, and it is more reasonable to consider this overlapping in obsolescence ranking. The ranking (1–10) is based on the number of references with regard to overlapping authorships. In this way, economic obsolescence (including financial and market obsolescence), functional obsolescence (including use and utility obsolescence), locational obsolescence (including environmental and site obsolescence), physical obsolescence (including structural obsolescence) and legal obsolescence (including control, regulatory, political and statutory obsolescence) are the five most referred to and important building obsolescence categories. Other obsolescence types are also arranged in a descending order according to the number of references.

Conclusion

Technological improvements, changes in building codes and regulations, alterations in taste and fashion or changes in people's needs and demands can lead to different building

obsolescence types and make a building obsolete. Currently, such changes are happening even more quickly, which causes many buildings to be at the risk of obsolescence. Obsolescence shortens the useful life of buildings and in many cases can even lead to the premature demolition of a building. In this way, buildings will be demolished while still a long period of their physical and structural life is remaining. Identifying, preventing and mitigating building obsolescence types not only contributes to maximising the use of structural, physical, social, economic and environmental potential of the building, but also helps to meet sustainable development goals and provides a greater understanding on where cities stand concerning the obsolescence of their building stock. Obsolescence prevention seems to be the most effective and efficient approach in avoiding building obsolescence. Avoidance and/or mitigation of obsolescence is associated with extending building service life and identifying different obsolescence types, which can be the first step in the obsolescence prevention approach.

In the literature, there is not a general agreed number and classification of building obsolescence types. By means of a systematic literature review, it is identified that there are 33 different types of building obsolescence. There are also some similar definitions and causes for these different obsolescence types that make building obsolescence a problematic and interpretative field of study. Meanwhile these similarities, together with the relevant interpretations, have been used to classify 33 building obsolescence types into 10 obsolescence categories as follows: (1) economic obsolescence (including economic, financial and market obsolescence types); (2) functional obsolescence (including functional, use and utility obsolescence types); (3) locational obsolescence (including locational, environmental and site obsolescence types); (4) physical obsolescence (including physical, structural obsolescence types); (5) legal obsolescence (including legal, control, regulatory, political and statutory obsolescence types); (6) social obsolescence (including social, community and cultural obsolescence types); (7) technological obsolescence (including technological, technical and equipment obsolescence types); (8) aesthetic obsolescence (including aesthetic, design, fashion, architectural, style, visual and image obsolescence types); (9) environmental obsolescence (including environmental, ecological obsolescence types); (10) tenure obsolescence (including tenure, tenant and rental obsolescence types). The large number and the confusing variety of building obsolescence types can be an obstacle to the full recognition and, consequently, effective management of different obsolescence. The 10 presented categories, covering all identified types through a logical classification, can provide a good framework for a more effective study and planning approach that aims to avoid or mitigate building obsolescence. The final results of the paper, thus, are useful for architects, real estate managers, asset managers, investors, developers and other practitioners from various built environment disciplines.

Future research

This article provides a new foundation for further investigation on building obsolescence for practitioners in the industry and researchers from real estate disciplines and scholars of various built environment disciplines.

The first step in a future study is to investigate all factors and causes that can lead to each building obsolescence category and set priorities among them. Weighing building obsolescence categories according to different buildings types is another step in future research. In fact, different building types have different vulnerabilities to obsolescence. By identifying building obsolescence types, weighing them according to different buildings categories and identifying the most important causes of each obsolescence type, appropriate and necessary measures can be taken to avoid or mitigate obsolescence.

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