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The cost of Universal Design for public buildings: Exploring a realistic, context-dependent research approach

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Purpose- A challenge in implementing Universal Design (UD) is the perceived additional cost, which acts as a barrier to its widespread adoption. Few studies that have examined the cost for UD apply a theoretical research approach, failing to account for the unique design context that influences construction costs. This article presents a research methodology to calculate the UD cost in a realistic, context-dependent manner.
Methodology- To address this gap, 'Research-by-Design' is applied in a case study approach involving twelve cases from three typologies: secondary schools, town halls, and small retail shops. Two scenarios are compared to the existing situation: (1) 'renovating into a 100% inclusive building' and (2) 'building fully inclusive right away'.
Findings- Although the methodology is time-consuming, it allows for a fair, realistic and detailed comparison between costs in different scenarios and cases. Findings show how financial implications are strongly related to its scale. Both 'renovation' and 'new build' scenarios involve costs, but these are significantly lower for the latter. 'Circulation' and 'Exterior stairs and ramps' are among the most expensive to renovate, but have almost no additional cost in the examined cases for the 'new build scenario'.
Originality- The applied approach distinguishes this study for its ability to provide rich contextual information on actual cost implications for UD. By considering real cases and their unique design contexts, valuable insights are offered into the true costs of implementing UD in the built environment.
Research limitation/implications: The research methodology presented in this study is time-consuming, which may limit its feasibility for large-scale cost assessments in diverse contexts.
Practical implications: The research methodology proposed in this study provides valuable insights for architects, designers, and stakeholders involved in the implementation of UD. It offers a realistic and context-dependent approach to assess the cost implications of UD, enabling informed decision-making during the design and construction phases.
Social implications: By revealing the specific cost implications of UD in different building contexts, this study contributes to promoting greater accessibility and inclusion in the built environment.

Universal Design · Design for All · Inclusive Design · Accessibility · cost · architecture

Some aspects of this study and its findings have been published in a governmental report (Ielegems *et al*., 2019a, b), written in the Dutch language, see https://gelijkekansen.be/praktisch/onderzoek/toegankelijkheid.

1 Introduction

Public facilities play a crucial role in our daily lives, serving spaces for work, dining, learning, and relaxation. It is essential that these spaces are usable and accessible to everyone, including people with disabilities or additional care needs. The UN Convention on the Rights of Persons with Disabilities (United Nations, 2006) emphasizes the importance of ensuring equal access for people with disabilities to the public built environment, public transport, information and communication. This broader goal contributes to the overall quality of our built environment that is usable, understandable and comfortable for everyone, irrespective of its users' abilities or disabilities (Gossett *et al.*, 2009; Iwarsson and Ståhl, 2003). In this view, the focus is on designing for *everyone*, which goes beyond mere accessibility or removing physical barriers, and connects to the paradigm of 'universal design' (UD) [2] that "*incorporates products as well as building features which, to the greatest extent possible, can be used by everyone without the need for adaptation or specialized design*" (Preiser and Ostroff, 2001, p. 1.5).

The benefits of UD extend beyond people with permanent limitations. In temporary situations, such as when carrying a pram, a heavy suitcase, or when one has a broken arm or foot, people can also benefit from an inclusive design. In these situations, opening a heavy entrance door can create a major barrier where, for instance, automatic sliding doors would be a more inclusive solution. Improving the built environment for all users, with or without disabilities, has been shown in the literature to bring several direct and indirect benefits. Indeed, inclusive buildings result in more independence for its users (Carr *et al.*, 2013; Joines, 2009; MacLachlan *et al.*, 2018). By reducing physical as well as sensory and mental barriers, a wider diversity of people can make use of all aspects of the building and more independent use of a building can lead to a higher degree of social participation (e.g., Aslaksen, 2016; Bjork, 2013; Steinfeld and Maisel, 2012) and, thus, to more social equality (Lid, 2013; Terashima and Clark, 2021). Another advantage is the improvement of its users' subjective wellbeing (Burton and Mitchell, 2006; Glover Blackwell, 2017; Steinfeld and Maisel, 2012; Petermans and Cain, 2019). Finally, several economic benefits are mentioned in the literature, including enhanced brand names, higher potential market and opportunities for innovation, but also an increased consumer base and customer loyalty, reduced renovation and operating costs (Björk, 2009; Dong *et al.*, 2004b; Vanderheiden and Tobias, 2000; Terashima and Clark, 2021).

Although an inclusive built environment might be an ideal shared by many, in reality, however, the existing environment is often not inclusive or accessible for everyone. New public buildings tend to only meet the minimum legal requirements for accessibility, rather than considering the diverse needs of users (Ormerod and Newton, 2005). Several studies have suggested that a major obstacle to resolutely aim for an inclusive building is the perceived additional cost (Bringolf, 2011; Dong *et al.*, 2004b; Dong *et al.*, 2004a; Goodman-Deane *et al.*, 2010; Mohamed Yusof and Jones, 2013). This is also the case in Flanders –the Northern, Dutch-speaking part of Belgium– where the results of a survey among practising architects indicate that the budget is indeed seen as one of the biggest barriers to go beyond the accessibility legislation (Ielegems *et al.*, 2019). Psychological research has demonstrated that stakeholders (i.e. architects, clients and building authorities) often overestimate the extra expenses associated with creating more accessible buildings, leading to reluctance in considering such improvements (Siegrist *et al.*, 2004). Therefore, more knowledge on its actual cost is an important aspect for future communication.

[2] Although the terms 'universal design', 'inclusive design' and 'design for all' have emerged from a different background with a different focus, the authors agree with Ostroff (2001) that their similarities appear to be more vital than their differences. These terms will therefore be used interchangeably here.

While retrofitting existing buildings to enhance UD or building new inclusive buildings may involve certain costs, reliable empirical information on the extent of these expenses remains limited. Only a few studies have been found that examine the cost of UD (see below).

Existing studies predominantly focus on mere accessibility rather than UD, and, to the best of our knowledge, no recent studies have approached the cost analysis of renovations and new buildings from a realistic, practical, and context-dependent perspective. The prevailing approach in cost analyses involves theoretical models with fixed prices or hypothetical cases, allowing for broad generalizations at an aggregated level, but inadequately capturing the nuanced context of actual projects and their associated UD costs. Each unique design process and each design situation requires innumerable design decisions that directly or indirectly affect the final design of the building and its construction cost, such as material use, the construction method, spatial qualities, the available budget, etc. A theoretical approach is therefore less suitable when grasping the actual context of a project and linking this to a UD cost.

An essential complexity arises when allocating costs (in whole or in part) to UD, in cases where certain costs would be incurred anyway, regardless of the intended level of inclusion. This too is related to the actual, unique design context. An example can clarify this: a designer includes a 220 cm double door in the central hall for aesthetic or fire regulation reasons. Having doors that are sufficiently wide to guarantee a comfortable passage for everyone is also a standard UD requirement, so should the cost for this double door then be attributed solely to the cost for UD, regardless of the architect's intentions? The same difficulty also arises for renovations. Consider a historic two-floor town hall. If a designer wants to improve the UD quality of this public building by adding an elevator, one could argue this is a UD cost. But is this still the case if this were a four-floor building? Because here one could say that having an elevator for taller buildings is simply standard practice today and should therefore not be considered a specific UD cost. In other words, we do not know the designer's reasoning for integrating a specific element: it could be UD related or not. To address these complexities, the methodology used to calculate UD costs should account for the context of each building and quantify the additional investment required to meet predefined UD requirements. Consequently, the cost of UD becomes context-dependent. Therefore, this study employs a practical and context-dependent approach to assess the "true cost" of UD. It examines and quantifies the costs of various UD enhancements for inclusive public buildings, encompassing both renovations and new constructions. To provide a broader perspective, we first discuss relevant literature on the financial implications of inclusive buildings.

2 The cost of accessibility or UD: Existing studies

Looking at academic and grey literature, few studies have been found in the last two decades that explicitly examine the construction cost associated with accessibility or UD. Some studies focus on one specific, smaller building aspect to determine its UD cost (e.g., Jones, 2011), while others take a more holistic approach, including indirect operating and maintenance cost next to the construction cost. For example, a study in Norway (Aslaksen, 2016) developed a cost/benefit analysis manual and a calculation tool. Since this study does not provide cost calculations per building (but rather per individual intervention) and no actual prices are published, it is not included in the subsequent discussion. Instead, this section elaborates on the results and methodology of three studies to gain insight into relevant aspects for accurately calculating the UD cost in the most realistic manner possible. They are referred to as the Swiss (Huber *et al.*, 2004; Siegrist *et al.*, 2004), the German (Schmieg *et al.*, 2015) and the Canadian study (Société Logique, 2015).

In the Swiss study (Huber *et al.*, 2004), which is one of the most comprehensive but less recent studies, 140 buildings are analysed to investigate the costs of accessibility, covering nineteen criteria that clearly focus on wheelchair accessibility. When these nineteen criteria are met, the building is considered 100%

accessible. Three categories of buildings are examined: (1) public buildings (various typologies), (2) office buildings for more than 50 people and (3) multi-family housing with more than eight housing units. Interestingly, the applied method considers three situations to determine the accessibility cost: (1) the building in its current as-is condition; (2) conversion to a 100% accessible building and (3) new construction to a 100% accessible building. Comparing the current as-is situation to renovating or building anew allows the researchers to assign the actual cost of increasing accessibility. The main results of this study show that the cost price is 1.8% higher on average for a fully accessible new building. This percentage also depends on the total cost, as, for example, for buildings under 2,000,000 Swiss Francs, this percentage rises to 3.5%. When converting an existing building into a 100% accessible building, there is also a large difference in additional costs between small (+/- 15%) and large buildings (+/- 1%), with a global average cost of about 3.5%. The study further concludes that 78% of the costs for accessibility are in the barrier-free access, lifts and ramps.

The Canadian study (Société Logique, 2015) examines the cost of accessibility for newly built single-family homes. The focus is not specifically on homes for people with disabilities, but on homes that promote lifelong living. Five of the most common housing typologies in Canada are examined for five Canadian cities. Prices are indexed per location and sixty criteria have been identified, mainly (but not completely) focused on limited mobility. Here, the floor plans for each of the housing types are redesigned in order to examine the most optimal design that meets these criteria. The cost price is then determined by means of (1) an existing cost calculation tool for single-family homes (i.e. www.costtobuild.net) and (2) the practical experience of contractors and technicians. The main results of this study show an average additional cost of about 6 to 12% and the effective costs vary according to local conditions, but the majority of the interventions involve a minor cost (less than 500 CAD).

Finally, the German study examines the additional UD cost for office buildings (Schmieg *et al*., 2015). Thirty new-build cases are analysed on the basis of nine general accessibility themes that were found to be cost-relevant. It is not clear how many specific requirements are included in these nine general themes, but they clearly go beyond wheelchair accessibility by including, for example, requirements regarding tactility. To determine the additional cost, a reference book is used from a national architectural expertise centre (i.e. BKO-Objekte N1-N11, Baukosteninformationszentrum Deutcher Architektenkammern, 1998-2012) as well as separately determined fixed individual prices. The main results of this study indicate that, contrary to what is expected on the basis of previous research, the share of the extra costs for new construction does not decrease with the project size for all UD criteria. The additional cost for accessibility varies greatly in this study, from 0% to 20%. For small construction projects, i.e. < 2,000,000€ construction costs, the extra expenditure varies between 2.6% and 20.0%, on average it is 4.87%. For large construction projects, it varies between 0.0% and 4.46%, with an average of 1.19%. The size of the additional cost is largely determined by the number, typology and extent of the measures taken to achieve accessibility. Elevators, sanitary facilities, corridors, doors and ramps influence the cost the most, according to this study.

Reviewing the methodologies, the conceptualisation and operationalisation of accessibility/UD is very different for each study. Three elements stand out in considering a more realistic and context-dependent research approach compared to a theoretical one. First, the Swiss and German study employs fixed prices to determine costs for accessibility or UD improvements without considering contextual factors. In contrast, the Canadian study combines practitioners' experience and a 'research by design' approach to find optimal solutions, potentially providing a more realistic estimation of expenses. However, the cost determination still relies on hypothetical cases instead of actual realised housing projects and their unique context. Second, the Swiss study offers an interesting approach comparing the current as-is situation with a renovation and new build scenario. This allows for the consideration of the existing context when determining which costs to assign to the actual UD cost. In this study, the focus is on accessibility, but a similar approach could be applied from a UD perspective. Finally, the Canadian study is the only one to explicitly index the prices with regard to the market prices in the different cities. While these elements are promising as a first step to consider a particular design context in the calculation of the UD cost, none of the studies go as far as to consider actual, unique cases with regard to e.g., material use, the degree of finishing details, or spatial conditions.

3 A practice-based research methodology

In this section, a methodology is proposed to estimate the cost of UD for public buildings in a more realistic manner. In order to understand the applied approach and ensuing research results, five research steps are described below, together with the measures and considerations to realise a realistic, context-dependent approach. To further ensure the realistic nature and practical relevance of this 2-year study (2018-2020), an advisory committee with representatives of the design and building sector, government, and different user organizations, was consulted to provide feedback throughout the study.

3.1 How to attribute the cost for UD: The as-is situation compared to two 'inclusive building' scenarios

The cost price comparison conducted in the Swiss study mentioned earlier allows for a valuable understanding of the cost differences between converting an existing building into an inclusive one (i.e. renovation scenario) and constructing a new building that was fully inclusive straight away (i.e. new build scenario). These scenarios were compared to the current state of each case (i.e. as-is situation) at the time of evaluation. Referring back to the earlier two examples (see section 1), of the door width and the elevator in a four-floor building, this approach enables to unravel which costs could be allocated to going a step further to make the building more inclusive, and which to general construction costs that would been made anyway. The degree of inclusion was evaluated on the basis of UD criteria and related to the total cost of the building in its current as-is situation. This was the basis against which the cost of the following two scenarios was compared:

(1) Renovation scenario
With the 'renovation scenario', each case was viewed from the perspective of renovating the current situation into a 100% inclusive building. In other words, the UD criteria that did not comply in the as-is situation were adjusted in such a way that the building became fully inclusive. The direct costs in this scenario, then, were for renovating the current building with a specific (undetermined) degree of accessibility to a fully inclusive building, including the demolition and/or adaptation costs.

(2) New build scenario
In the 'new build scenario', each case was viewed from the perspective that the building would meet all UD criteria at the start of the design process. In other words, we examined how the building could be rebuilt, but then immediately 100% inclusive. All proposed design adjustments were to be considered as close as possible to the actual as-is situation, without fully changing the design concept in order to be able to make a "fair" comparison of the cost price.

3.2 Development of UD evaluation criteria

To assess the cost of UD, a specific set of criteria was employed to evaluate the level of inclusion in the existing situation. This evaluation facilitated the identification of areas requiring UD-enhancing improvements. The Belgian Quality Label for Inclusive Building[3] (Inter, 2018) was used as a base to determine the UD criteria of this study. This Quality Label was developed to assess the degree of inclusion for public buildings, more specific office buildings. It included an extensive checklist of 600 UD criteria, including requirements for lighting, wayfinding, sanitary, room layout, flooring, acoustics, surroundings of the building…

Criteria were examined to be (1) applicable for the examined building typologies, (2) manageable with regard to determining the cost, and (3) within the spatial scope of the study. After close consideration with the research team and advisory committee, the following criteria were excluded: criteria that were located outside the physical building, such as features related to the public domain (e.g., footpath requirements, neighbouring bus stop, parking garages, gardens or outbuildings on the surrounding domain, with the exception of the entrance area), criteria that applied very specifically to the typology of office buildings or areas that were not publicly accessible (e.g., technical areas, kitchen staff, cellars). As the focus was on the architecture of public buildings, criteria with regards to loose furniture (e.g., specific requirements for chairs, tables, desks) were also removed. Finally, criteria with very specific technical requirements for which it was not feasible to determine the extra cost compared to the as-is situation were excluded as well (e.g., ventilation system or acoustic requirements).

After elimination, 119 of the original 600 criteria remained, which, compared to previous studies discussed above, is more comprehensive and detailed, taking a wider inclusive perspective into account. From these 119 criteria, 33 criteria -or 28%- were linked to the Flemish Accessibility Regulation at that time (Peeters *et al*., 2009). The remaining 86 criteria therefore go beyond Flemish legislation. These 119 criteria have been compiled into 15 UD building elements that were used to further examine the costs for UD of public buildings:

1. Circulation (#8 criteria)
2. Exterior Joinery (#9 criteria)
3. Exterior stairs and ramps (#17 criteria)
4. Indoor floor covering (#4 criteria)
5. Interior doors (#9 criteria)
6. Indoor stairs and ramps (#20 criteria)
7. Fixed furniture (#6 criteria)
8. Signalisation (#4 criteria)
9. Sanitary equipment (#8 criteria)
10. Interior lighting (#4 criteria)
11. Elevator (#10 criteria)
12. Platform lift (#4 criteria)
13. Communication (#9 criteria)
14. Fire extinguishers and smoke detectors (#2 criteria)
15. Colour contrast (#5 criteria)

[3] This is the Belgian A++ Quality Label, developed by the Flemish Centre of Expertise in Accessibility and Universal Design, on behalf of the Agency for Facilities and Services of the Flemish Government.

3.3 Case selection: 12 existing buildings

Based on discussions with the advisory committee of the research project, three different public building typologies were examined, enabling to explore cases of varying scales and programs: secondary schools, town halls and small retail stores (i.e. bakeries and butcher shops). For each typology, four cases were selected. For the secondary schools, one or two blocks of the entire school complex were assessed since the entire school complex was often spread across multiple sites. Since the literature clearly indicates that real estate prices and construction costs can differ significantly per region within the country (StatBel, 2023; Arch-Index, 2018), all cases were located in one region (i.e. province of Limburg, Belgium). It is important to emphasise here that the current level of inclusion was not a selection criterion and researchers had no preceding knowledge regarding the degree of inclusion of the selected cases. Instead, a selection was made with the purpose of achieving a fairly representative picture of the current situation of public buildings in Flanders and with the pragmatic criterion that the cases could be visited and assessed. Table I shows an overview of the 12 selected cases, showing how all cases considerably differ regarding the year of construction, surface area and program.

Case	Year of construction	Total surface area (incl. cellars) - m²	Publically accessible surface area - m²	Project description + program**
1. SECONDARY SCHOOL				
1.1	2016	8271	6819	Two screened blocks are part of a bigger school complex. One block is newly constructed and one is fully renovated in 2016 (date of original construction of the latter is not known). Program: reception area, classrooms, refectory, offices & meeting rooms, sanitary, theatre and changing rooms.
1.2	2013	2068	1379	Screened block is part of a bigger building complex. Program: classrooms, sanitary and student shop.
1.3	2012	4029	3666	Screened block is part of a bigger building complex. Program: reception area, classrooms, offices and meeting room and sanitary.
1.4	2018	10823	9827	Screened block is part of a bigger building complex. Program: reception area, classrooms, sanitary, offices & meeting rooms, refectory, sports hall and changing rooms.
2. TOWN HALL				
2.1	2017*	2159	632	The existing building from the '60s has been fully renovated in 2017. Program: reception area, sanitary, offices & meeting rooms.
2.2	2017*	1558	998	The building from 1890 has been partially renovated multiple times, but a thorough renovation with a new extension added to the rear was finished in 2017. The first floor (which is also publically accessible) remained unchanged. Program: reception area, sanitary, offices & meeting rooms.
2.3	2016*	3035	1534	The existing townhall (1899) was fully renovated in the '80s and again in 2016 together with a new building next to it. Program: reception area, sanitary, offices & meeting rooms.
2.4	2018	3602	1693	Apart from the the multifunctional entrance area that a protected building (from the 19th century), the town hall is completely new. Program: reception area, sanitary, offices & meeting rooms.
3. SMALL RETAIL: BAKERY / BUTCHER STORE				
3.1	2015*	113	54	An existing butcher shop and bakery where the interior and the entrance door were fully renovated. Program: shop with displays
3.2	2017	97	62	New bakery Program: shop with displays
3.3	1986	38	23	Existing bakery in which no recent renovation has been carried out on the interior or exterior. Program: shop with displays
3.4	2011*	40	26	Existing butcher shop is completely redesigned in 2011 and partially adapted in 2018. Program: shop with displays

* Year of thorough renovation

** Program focus on publically accessible areas

Table I: Overview of the examined cases

3.4 Evaluating the degree of inclusion of the as-is situation and 'Research by Design' for 'renovation' and 'new build' scenarios

First, the degree of UD was evaluated for all selected cases (i.e. the as-is situation): the 119 UD criteria were checked, first on plan and subsequently during an on-site visit where all the publicly accessible spaces of the cases were examined. This enabled a detailed overview on the criteria that were met and the ones that needed to be adjusted in order to obtain a 100% inclusive building.

Next, for each of the non-compliant criteria, the most optimal solution was sought for the 'renovation' and the 'new build' scenario, including all the relevant details to allow a realistic cost estimation in the next step. For various criteria, the most optimal solution could be simply described and no real design was necessary. For example, if there was no double handrail on an internal staircase in a building but only a handrail at one height, one extra handrail was required at a specific height and length in the 'renovation scenario'. For the 'new build scenario', railings would then immediately be placed at two different heights in the implementation of the 'new building'. Next to a description, photos and quantities were added (i.e. for the missing handrails, this is the number of running metres).
For some criteria, a design-based solution was required. For example, if a corridor is found to be too narrow, the best way to widen it was investigated for the scenarios (1) 'renovation' and (2) 'new build'. The most optimal design solutions were examined in order to meet all UD criteria simultaneously. To avoid researcher bias in this more open-ended phase as well as to ensure a realistic design, this part was not carried out by the research team, but by a professional design office with extensive experience in the typologies studied, complemented with a number of selected master students in architecture and interior architecture who participated for course credit.
Importantly, there were some boundaries determined within which design solutions needed to be sought. If, for example, adjustments were required where spaces, such as meeting rooms or corridors, were too small in terms of surface area, design solutions had to be sought within the outer walls of the building. So, expansion beyond the outer walls was not allowed. Also, as already mentioned, only publicly accessible spaces were considered. As a result, the private areas, such as the staff kitchen or technical areas, were not to be included in possible design solutions. For the 'new build scenario', the design teams were instructed to always seek a design solution that remained as close as possible to the original concept of the current state. The entire design concept of, for example, the main circulation routes were not to be changed completely in order to meet all UD criteria. The main reason for these boundaries was the comparability between the three scenarios.

3.5 Determining the costs

This study specifically focused on direct costs, meaning the cost directly related to the construction cost and not, for example, to the maintenance cost. The construction cost of the existing 'as-is situation' served as the baseline reference against which the cost of the 'renovation' and 'new build' scenarios were compared. In other words, how much more (or less) did each of the proposed changes cost compared to the cost of the current as-is situation? To establish the cost of the 'as-is situation', the clients themselves provided the total construction cost of the building, which was then adjusted by excluding non-public areas based on their proportional surface area. As complete cost prices were unavailable for the small retail stores, average square meter prices for this typology and location were consulted with an external architectural expert to determine their costs.
Next, for both the 'renovation' and the 'new build' scenario, four independent, practising contractors were asked to separately calculate prices for the criteria that did not meet the current situation for the 12 cases[4]. This way, the actual market cost could be estimated for each UD criterion as if the contractor would adapt the existing situation, or rebuild it, but then 100% inclusive from the first time. Each UD criterion that did not meet the requirements, was supplemented with a short description of the proposed design solution, the unit in which the cost price had to be calculated and associated quantities. Where necessary, plans of existing and new conditions as well as photos were added. In this way, all contractors had access to the same information to determine the cost price for each intervention. For each intervention, the contractor was asked to always answer the following question: "*Is there a cost for this*

[4] One contractor has not calculated the cost of the small retail stores since it did not match their area of expertise. For a similar reason, one contractor did not calculate the UD building elements related to electronics (i.e. building elements 10 to 14) for all typologies.

intervention compared to the 'as-is situation'? If so, what is its additional or minus cost when (1) renovating the existing situation, or (2) building it immediately new this way?". To be clear, we did not ask to provide us with estimated costs of UD criteria as such, but with estimated costs needed to meet UD criteria, compared to an existing situation. So, for example, if an existing elevator in a building was not large enough, in the 'new build' scenario, they would not provide the total cost of this larger elevator, but only the additional cost of a larger elevator and the required modifications compared to the already existing elevator.
Next to a fixed price, the contractors had the possibility to enter a price range, which enabled them to consider possible materials, conditions and finishes that were suitable for that particular situation. This, again, allowed them to remain as close as possible to the specific design situations and to estimate as realistically as possible. In case price ranges were employed, the average was used in further analysis.

4 Results and analysis

4.1 Analysing the 'as-is'-situation of the cases

Each selected case was evaluated against the 119 UD criteria, grouped into 15 UD building elements (see section 3.2). Table II shows an overview of how many of the 119 criteria were applicable in each case, and how many of those applicable criteria were evaluated as satisfied. On average 100 criteria were applicable in the analysed schools, 88 criteria in the town halls, and 31 for the small retailers. The lower number of the latter category reflects the fact that these bakeries and butcher shops did not have elements such as interior staircases, elevators or publicly accessible toilets. Other differences within categories reflect naturally occurring variation in the cases. In case 1.1, for example, the higher number of applicable criteria was due to a more elaborate program of the school, including for example a theatre where a platform elevator was needed to access the podium and backstage, while in case 2.4, interior or exterior ramps were not relevant due to barrier-free access and circulation in the whole building.

	Applicable criteria		**Criteria not fullfilled**		**Criteria fullfilled**	
	n	**%**	**N**	**%**	**N**	**%**
total	**119**	**100%**				
school 1.1	113	95%	34	30%	79	70%
school 1.2	93	78%	28	30%	65	70%
school 1.3	96	81%	39	41%	57	59%
school 1.4	97	82%	24	25%	73	75%
town 2.1	87	73%	28	32%	59	68%
town 2.2	92	77%	50	54%	42	46%
town 2.3	98	82%	39	40%	59	60%
town 2.4	73	61%	21	29%	52	71%
retail 3.1	27	23%	8	30%	19	70%
retail 3.2	25	21%	4	16%	21	84%
retail 3.3	38	32%	18	47%	20	53%
retail 3.4	35	29%	18	51%	17	49%

Table II: UD criteria (n=119) that apply to and meet the requirements in the examined case

When focussing on the applicable criteria per case, 16% to 54% of them did not meet the requested UD requirements. For cases 2.2, 3.3 and 3.4 almost half of the criteria did not comply. A clarification can be found for case 3.3 and 3.4 in the fact that fewer criteria were applicable, and that for both cases the entrance party did not comply in several areas. For case 2.2, the ground floor had been thoroughly rebuilt with a new rear extension, which made the existing building quite complex with different level differences on the ground floor and the first floor resulting in a less accessible and inclusive building.

4.2 The cost for UD: Comparison by typology

Since the three investigated typologies differed greatly in different areas (e.g., building program, scale, current construction cost…), we will discuss each typology separately. Within each typology, and even within each individual case, price settings in this study varied greatly: When exactly the same information was given to different contractors to determine the cost, there was a considerable difference in price settings between contractors. It could be argued that this is inherent to a tendering process since the price quote from contractors also include, e.g., labour costs and fixed costs, which vary for each firm.

For school buildings, more large-scale buildings with an average construction cost of more than 8 million €, renovating them to make these buildings fully accessible had an estimated nominal cost of 116,040€ (1.44%). The relative cost, by averaging the percentages per case, amounted to an average of 2.34%. The results for the new build scenario indicated an additional cost of 43,609€ (0.54%). The relative additional cost, averaged over the percentages calculated per case, was then 0.64%.

For town halls, which in terms of construction cost are at an intermediate level of about 950,000€, the nominal cost of the renovation was on average 80,938€ (8.58%). The relative cost, averaging over the percentages of the cases, was 17.67%. When building the examined town halls immediately fully accessible (i.e. new build scenario), the calculated additional cost was 39,938€ (4.24%) and the relative cost averaged 9.16%.

For small retail stores, which have an average limited total construction cost of around €55,000, the estimated nominal cost was on average €11,384 (20.48%) and the relative cost on average 26.32%. For the new build scenario, these figures were 1,160€ (2.09%) and 2.70% respectively. When comparing the relative percentages for this typology with the other two, we can conclude that the financial implications of inclusive building seemed to be linked to the different scales of the buildings for each typology. A larger sample will however be needed to make general conclusions for the relationship between size and the relative cost.

4.3 The cost for UD: Comparison by building elements

Figure 1 shows the distribution of the total cost for all 12 cases for the different building elements for both scenarios. In other words, to make the 12 cases in our sample fully inclusive, for example, the building element 'Elevator' required approximately 175,000€ in the ‘renovation’ scenario and 75,000€

in the ‘new build’ scenario, compared to the actual as-is situation.

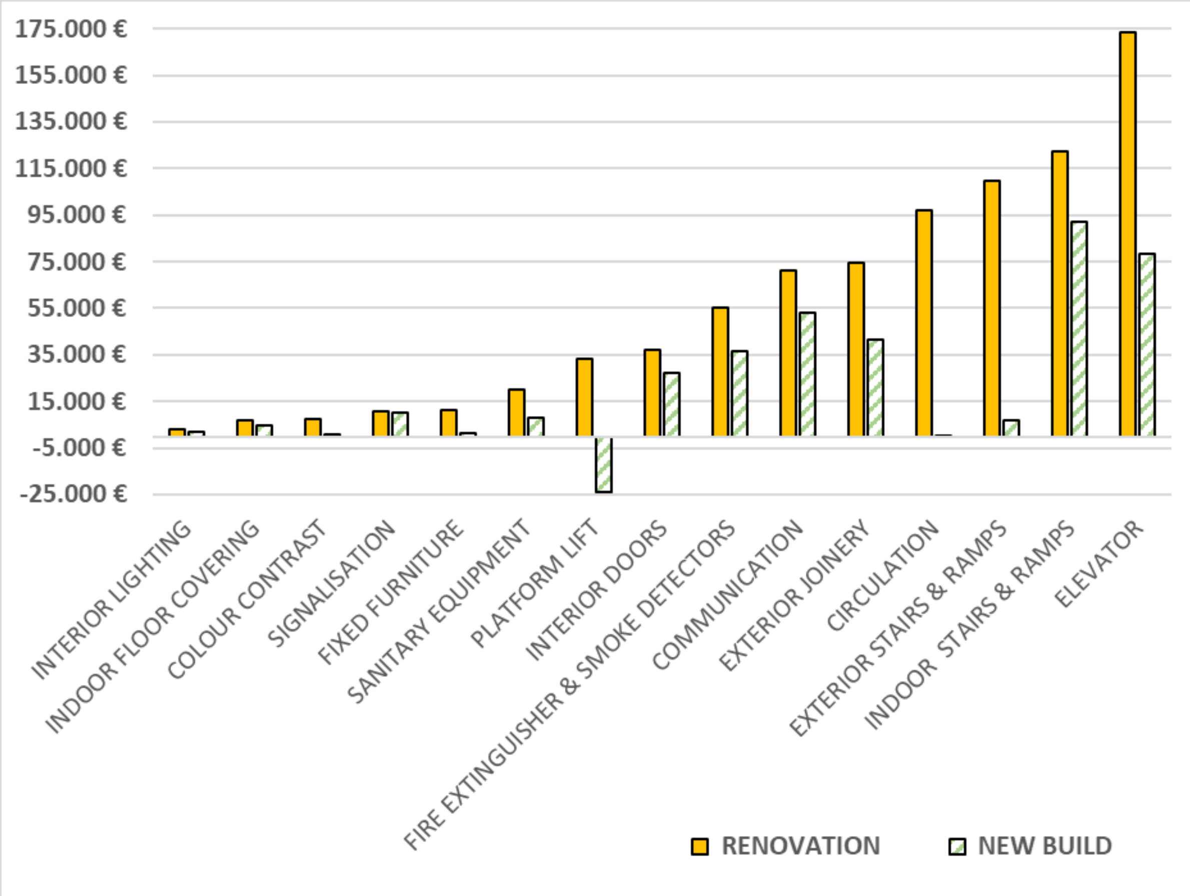

Figure 1: The distribution of total costs, for all 12 cases, across the 15 different building elements for the reconstruction and new build scenario.

Across all cases, the additional cost of the following building elements was quite low (< 15.000€): ‘Interior lighting’, ‘Indoor floor covering’, ‘Colour contrast’, ‘Signage’ and ‘Fixed furniture’. Together they took up only about 5% of the total budget for UD in both scenarios. At the other end, the elements ‘Elevator’ and ‘Indoor stairs and ramps’ were the "most expensive" building elements and this in both scenarios. These findings are in line with previous studies (Huber *et al*., 2004). Taken together, making these two elements “fully UD” took up 35% of the total budget for the ‘renovation scenario’ (833,448€) and 50% for ‘new build scenario’ (339,012€).

Earlier, the ‘new build scenario’ was found to be cheaper than the ‘renovation scenario’ for the examined cases and Figure 1 shows this is similar for each of the 15 examined building elements. However, for some elements, the difference between the two scenarios was much larger than for others. For example, the elements ‘Circulation’ and the ‘Exterior stairs and ramps’ were among the most expensive elements to adapt (for the ‘renovation scenario’), but when done properly from the start had almost no additional cost compared to the initial as-is situation (‘new build scenario’). For the element ‘Platform lift’, there was even a reduced cost in the ‘new build scenario’. This indicates that when, from the start of the design, an optimal handling of level differences and a correct and good circulation can lead to a reduction of the final cost. Of course, this aspect is highly related to the unique context of a case, so may not be possible in each situation, but the current results indicate that it can occur.

Table III shows the relative cost for each of the building elements separately for all three typologies and both the scenarios. The percentage is thus the extra or reduced cost compared to the total construction cost of the public areas.

	Sec. schools		**Town halls**		**Small retail stores**	
	Renovation scenario	**New build scenario**	**Renovation scenario**	**New build scenario**	**Renovation scenario**	**New build scenario**
Circulation	0,15%	***-0,01%***	1,20%	0,15%	1,95%	***-1,66%***
Exterior Joinery	0,12%	0,09%	0,37%	0,25%	9,94%	2,00%
Exterior stairs and ramps	0,29%	0,02%	0,17%	0,01%	3,72%	0,43%
Indoor floor covering	crit. fullfilled in all cases	crit. fullfilled in all cases	0,17%	0,11%	0,28%	0,24%
Interior doors	0,07%	0,05%	0,37%	0,25%	0,28%	0,28%
Indoor stairs and ramps	0,23%	0,18%	1,26%	0,86%	N/A	N/A
Fixed furniture	0,01%	0,00%	0,02%	0,00%	3,62%	0,40%
Signalisation	0,02%	0,02%	0,15%	0,13%	N/A	N/A
Bathroom equipment	0,06%	0,02%	0,03%	0,02%	N/A	N/A
Interior lighting	0,01%	0,01%	0,02%	0,00%	0,00%	0,00%
Elevator	0,07%	0,02%	4,01%	1,91%	N/A	N/A
Platform lift	0,10%	***-0,07%***	0,01%	0,00%	N/A	N/A
Communication	0,19%	0,14%	0,25%	0,23%	N/A	N/A
Fire safety equipment	0,12%	0,08%	0,43%	0,28%	0,54%	0,40%
Colour contrast	0,01%	0,00%	0,11%	0,03%	0,14%	0,00%

T*able III: Relative cost for 15 UD building elements, compared to the total construction cost for two scenarios and three typologies*

When looking in more detail to each of the building elements for the three typologies separately, there was a minus cost for the 'Circulation' element of the new build scenario for schools (-0.01%) and small retail stores (-1.66%). These "negative" prices were the results of a well-considered but realistic design that met all UD criteria and whereby the proposed design solutions were therefore estimated by the contractors to be cheaper than the current 'as-is scenario'.
The building element 'Elevator' and 'Indoor stairs and ramps' did not apply to small-scale cases but did weigh heavily on the total average cost of UD for the other cases, both for 'new build' and 'renovation' scenarios. In the individually examined cases the stairs were assessed as largely satisfactory (with the exception of case 2.2), but in few cases double-height handrails were present. The secondary schools all appeared to have an elevator with suitable dimensions, hence the relative low cost for elevators for this typology. However, the situation was different for the examined town halls. Here, there was no elevator present in one case (i.e. case 2.2). The rather high cost price for this element was therefore due to the provision of an elevator as well as an elevator shaft.
A final remarkable pattern is the fairly high relative cost for the renovation scenario of the small retail stores for the building elements 'Exterior joinery', 'Exterior stairs and ramps' and 'Fixed furniture'.

The cost of these elements weighed more in these small-scale cases, compared to the schools and town halls. For example, all small retail stores lacked wheelchair accessible and lowered cash register furniture, resulting in a nominal average cost for 'Fixed furniture' of 8,060€ for the examined stores, compared to only 2,515€ and 783€ for respectively secondary schools and town halls. However, the results also showed that this cost highly reduced when considering this from the start for new construction projects resulting in an average cost of 894€ for small retail stores.

5 Discussion and Conclusion

This article proposes a methodology to determine the additional cost of various UD-enhancing interventions in a realistic, context-dependent manner, and this for a variety of three public building typologies, being secondary schools, town halls and small retail stores (i.e. bakeries and butcher shops). It is important to reiterate that these results do not indicate the cost of building elements as such (e.g., an elevator), but rather how much extra one would have to invest to ensure that a pre-existing, unique situation goes a step further to fully meet the predefined UD requirements.

5.1 The cost of building anew or renovating buildings into 100% inclusive buildings

Looking at the two scenarios, a clear pattern is visible: Renovating an existing building into a 100% inclusive building or building it fully inclusive right away both come with a price tag, but the costs are considerably lower for the latter scenario (i.e. in some cases only 10% of the renovation cost). This is the case when looking at the typologies on a more aggregated level as well as at the 15 different building elements separately. For the examined cases, the difference between the two scenarios is large for elements like 'Circulation' and the 'Exterior stairs and ramps' where they are among the most expensive for the 'renovation scenario', but have almost no additional cost in the examined cases for the 'new build scenario'. In some instances (e.g., the element 'Platform lift'), even a reduced cost (compared to the initial situation) is found in the 'new build scenario'.

Despite methodological differences, the results of this study are largely in line with what is found in the literature. The earlier discussed Swiss (Huber *et al.*, 2004) and German study (Schmieg *et al.*, 2015) show similar percentages indicating how financial implications for more accessibility and/or UD are strongly related to the size of the building. In the Swiss study, a similar pattern as shown in this study between the 'new build' and 'renovation' scenario is visible as well: The additional cost of building anew varies between 0.94% (total cost > 13,700.000€) and 3.92% (total cost < 460.000€), and renovation between 2.24% (total cost > 13,700.000€) and 14.9% (total cost < 460.000€). It should be noted that small-scale buildings in the Swiss study (total cost <460.000€) are not comparable with the smallest building scale that occur in current study (total cost < 93,000 €), but they are rather similar to the cost of the typology of municipal buildings as they have an average construction cost of 950,000€.

5.2 Reflections on the applied research methodology

When looking at the methodology that is explored in this article, it provides a detailed view, but involves an intensive approach. Visiting the projects (and not only assessing them on plan), finding optimal UD-enhancing design solutions (i.e. 'Research by Design') for two scenarios (i.e. renovation and new build) as well as working with practicing contractors to go through a tender process requires considerable time and energy investments. The time spent for each case may be less suited to examine a larger sample, but it does offer much more detailed information and insights related to the UD cost, also providing an indication of how strongly these costs can differ for different cases of the same typology. A strength of the applied approach also lies in the comparison between the as-is situation and the two scenarios, resulting in a clear view of minus and additional costs to realise a more inclusive building, related to a real, unique case, without unfairly allocating costs to UD that would have been made anyway. Adding to this that contractors had the possibility to indicate a minimum and maximum cost instead of a fixed price appears a more realistic way to give a first indication. This way, contractors could take different aspects into account, such as alternative material use, or a (best or worst case) estimation in working hours. All in all, these aspects could help avoid overestimating the 'cost of UD' (as been reported before, see Siegrist *et al*., 2004), and give stakeholders (i.e. architects, clients and building authorities) a more realistic insight in the financial impact when deciding on adopting these principles at the beginning of the design process.

'Research by Design' has been an essential part of the applied methodology and has proven its value in several ways. Having actual designs makes it possible to approach this cost analysis as a realistic tender process, where contractors -who are used to working with design plans- could be provided with their preferred format to work with in order to accurately and efficiently calculate prices. In addition, 'Research by Design' has enabled to optimize UD-enhancing design solutions regarding both 'renovation' and 'new build' scenarios for the purpose of finding efficient and effective solutions to design problems that could be solved in many different ways. For renovation, this also implies the structured documentation of the elements that are removed, demolished and afterwards re-constructed again. For the new build scenario, the benefits are even more clear since results show how a well-considered design from the start could lead to a positive effect on the final cost. Incorporating considerations such as level differences (both inside the building and at entrances) and ensuring proper circulation (not just within corridors but also within individual rooms) right from the beginning of the design process significantly impacts the ultimate cost of a new building. This aspect is also recognized in cost control guidelines for various contexts, including schools (Steinfeld, 2005). Naturally, the impact of these factors on the cost of UD cost is closely tied to the specific context of each case, and their application may vary from one situation to another.

5.3 Limitations and opportunities for future research

Our study is spatially limited to the public areas of the building itself and the pathway leading to the main entrance, excluding surrounding areas and non-public spaces. This focus was chosen to facilitate comparative analysis and establish a well-defined scope. However, it does mean that certain aspects that ideally would be considered in reality are not covered. Additionally, some factors influencing price estimations have not been taken into account in this study. For instance, this research was conducted in a single province in Flanders since prices differ for different regions (StatBel, 2023). The prices provided by the clients have not been adjusted for inflation. Moreover, significant fluctuations in resource costs (e.g., energy, materials) at any given time can impact the absolute cost figures.

In this study, a limited number of real cases encompassing diverse scales, programmes and budgets were thoroughly examined. However, as a consequence, it is not possible to straightforwardly generalize the findings of the study. Converting these existing cases into fully inclusive ones was based on the evaluation of an extensive set of 119 UD criteria. Nevertheless, it is important to note that this criteria set may not be exhaustive, and the quality of buildings could be further enhanced by incorporating additional UD requirements.

The methodology utilized in this study presents opportunities for future research. Although this paper does not delve into the details of specific UD-enhancing design solutions resulting from the 'Research by Design' process for renovation and new build scenarios, the findings do indicate the presence of recurring design situations or patterns (Froyen, 2012; Alexander *et al*., 1977), across cases and typologies. Examples of such patterns include 'providing a ramp to overcome a height difference' or 'an inclusive reception desk with a lower, roll-under part'. Instead of offering generic prices for standard solutions, presenting these recurring design situations with illustrated examples from real cases, including photographs and plans, and connecting them to UD solutions and associated costs, could provide practicing architects with a user-friendly and accessible means to enhance their understanding of these aspects and apply them to their own design practice.

Indeed, existing literature suggests that practitioners prioritize context-dependent knowledge over context-independent knowledge when seeking to learn about accessible design or UD, particularly during the initial stages of the design process where numerous decisions are made (Kirkeby, 2015; Ielegems, 2018). In this regard, transferable, context-dependent design knowledge plays a crucial role (Schön, 1983; Kirkeby, 2011; Ielegems *et al*., 2016). By establishing a reference library of projects that encompass various contexts, practitioners can gain valuable insights into the context-specific costs of UD, allowing for a better understanding of each case's unique conditions, such as the level of finishing, the construction system, material usage, and dimensions in relation to UD costs. This, in turn, empowers practitioners to make more informed decisions throughout the design process.

To some extent, a practice-based study conducted by Rick Hansen Foundation (2020) serves as an example by presenting different case studies and their associated costs in a more visual manner. While the study may be somewhat general and primarily focused on floorplans (without detailed photos or other more spatial information), it does demonstrate the potential of a context-dependent visual representation. Thus, it would be interesting for future research to investigate the specific experiences and needs of designers in terms of gaining insight into the costs of UD. Furthermore, exploring different layout approaches for communicating these costs and assessing their impact on the UD quality of the resulting designs would be also worth exploring.

In summary, this study underscores the importance of moving beyond theoretical approaches and accounting for the unique design context in assessing the cost of UD. The research methodology presented here provides a foundation for future studies to explore and refine the understanding of cost considerations in relation to UD, ultimately promoting its wider adoption in architectural design practice.

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