

# **INFLUENCES ON INNER CITY CONSTRUCTION SITES: A COMPARISON OF THEORY AND PRACTICE**

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In recent decades, social development and demographic changes have led to a significant decline of the number of new building constructions and an increase of refurbishments and building activities in projects in the built environment. Those changes force building companies and construction site managers to adapt their site management concepts due to inner city influences. Especially emissions like noise and dust, transports, and construction site waste should be limited to a minimum to prevent inhabitants and neighbors from surpassing inconveniences. To compare theory and practice in terms of efficient and environmental friendly construction site management in inner cities, qualitative interviews were taken, to figure out what actions are applicable to keep emissions on a minimum level and where the construction processes and logistic can be improved. The results show, that possibilities - like shifting the transports to railway - could be a proper approach, but are seldom applied. Due to cost and logistical reasons, most efforts are put into neighbor involvement, rather than changing the process of building itself.

*Keywords:* Built environment, New building development, Construction processes, Logistics.

## **1 INTRODUCTION**

The high population density of city centers and the concomitant dense building stock lead to cramped conditions at inner city construction sites - this in turn influences the choice of construction methods and places high logistical demands on the timely provision of building materials and their interaction with the already high level of urban construction traffic. Haider (2017) states, that in addition to the direct impact on construction projects caused by the high population density, many people are affected in their everyday and working life because of dust, noise, and increased traffic. In order to protect the environment and to guarantee a coherent life as unimpeded as possible, a multitude of laws are necessary to protect the interests of the inhabitants and neighbors (Staber 2016).

## **2 CHARACTERISTICS OF INNER CITY CONSTRUCTION SITES**

Hofstadler (2007) states, that the type and the size of the construction site, the planned project, the necessary tools and equipment for the execution of the works, together with the limited space in the city, are the crucial factors for the site design and the construction site logistics. Depending on the extent of the construction project and the spatial conditions on site and the surrounding

area, a suitable solution for the organization and coordination of the logistics has to be found. The possible options range from the coordination done by the foreman with a mobile device, through the involvement of external logistics companies to elaborately thought-out systems with outsourced logistics facilities (Derler 2012).

Also, the work preparation plays an important role for inner city construction activities. The equipment and the construction process selection must be adapted to the boundary conditions (protection of the residents, available space, technical feasibility). The material flow is also strongly dependent on those boundary conditions. Thus, the transport of materials and waste cannot always be carried out by lifting tools, but must be carried out manually, and the transport distances are severely limited by the permissible payloads and existing room heights. Likewise, the coordination of the trades and construction teams is important, since concurrent activities on higher and lower levels of the site are not allowed and must be executed time-displaced (Bauarbeiterschutzverordnung 1994). If existing ceilings are to be used, small appliances must be used for the work to be carried out (Meister 2012).

Building and the execution of works is made particularly difficult by ongoing operations. This results in increased safety measures and additional restrictions on construction methods, such as fire, noise, and dust protection (Berner *et al.* 2008). This may mean that the loads that are raised cannot be intercepted by scaffolding so as not to cause any restrictions on usage in the floors below. Continuous operation in the building and in the vicinity of the construction project may lead to restricted execution deadlines (holiday or completion before the Christmas business). Increased security measures are not only necessary during construction under continuous operation, but also the remaining components or areas used in public areas must be protected; this leads to measures such as temporary installation of fire walls and seals (Meister 2012).

Also, building projects in the inner-city areas are embedded in numerous and partly very strict legal relations. Starting with the questions of land ownership, planning and construction laws as well as technical regulations and laws, which must be observed and followed during the construction, up to the classification of the later use (Staber 2015).

### **3 METHOD**

The aim of the research was to determine the decisive factors of inner city construction sites for executing companies (contractors) in their work preparation and how they influence the calculation of the construction services.

Furthermore, the extent to which the factors are actually taken into account and the influence of construction companies on those factors was in the focus of the research.

In order to answer these questions, interviews with 9 experts of the construction industry were conducted. The experts were construction site managers and project managers of executing construction companies.

For the selection of the interviewees, sufficient experience of the experts with inner city construction sites was required (Flick *et al.* 2000). The minimum amount was set at 5 years and the range of the chosen experts then lied between 6 and 30 years of experience. To carry out the qualitative interviews, a partly standardized interview guideline was designed. This method guaranteed, that special attention was paid to the influencing factors that were identified in the literature research.

After the survey phase, the guided interviews were transcribed and evaluated with the software MAXQDA in a deeper way in terms of content-structured qualitative content analysis (Kuckartz 2012).

First, the interview transcripts were coded by means of main categories, which were derived from the interview guide thread. In the next steps, the categories on the material were further developed and the entire text was encoded again with the differentiated system of categories.

## 4 RESULTS

Figure 1 shows the influence of the different factors weighed by experts from the literature research on the construction operations in inner cities compared to building project in rural areas. 5 means that there is a very high chance, that those factors have an impact on the construction operations and 1 means that those factors doesn't affect the construction site.

In order to ensure the traceability of the assessment, some of the individual points are defined on the basis of the interviews and their impact is briefly outlined.

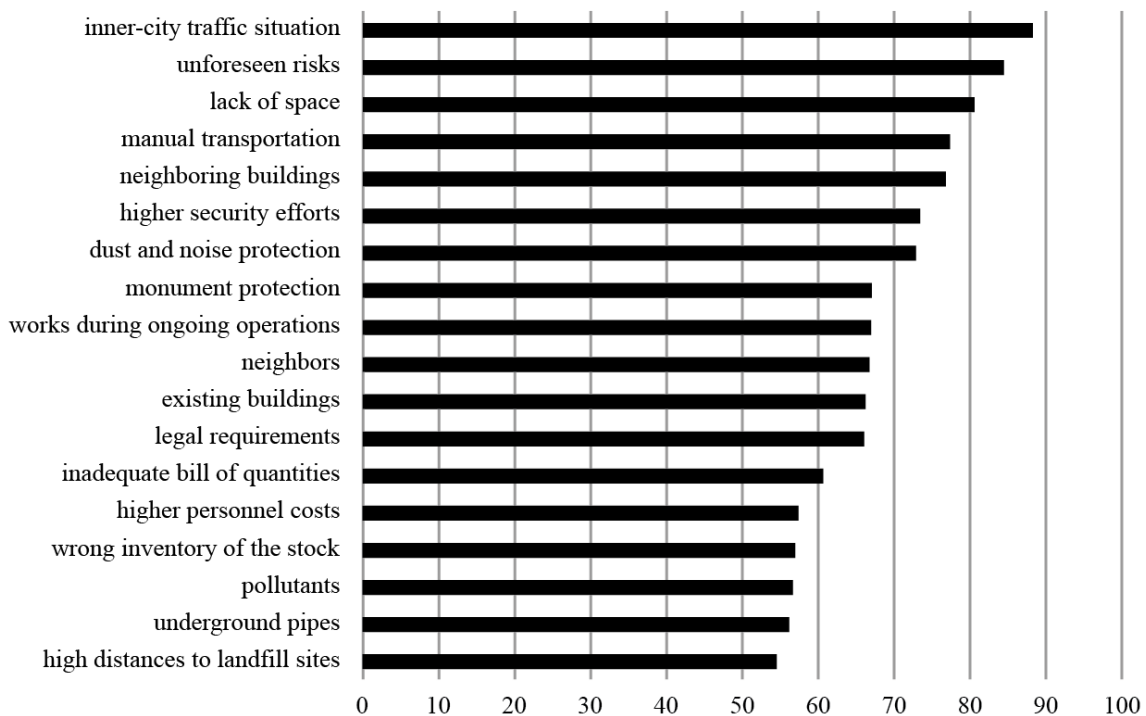


Figure 1. Impact of the inner-city environment on the construction site operations (Haider 2017).

### 4.1 Inner City Traffic Situation

The urban traffic situation is closely linked to the complications listed above due to the lack of space and is seen by all experts as one of the main factors influencing urban construction sites. The access possibilities are to be clarified. When and with which vehicles the material supply for the construction site are delivered.

Further difficulties include: limited accessibility, restricted time for delivery in pedestrian areas, increased costs for delivery, complex coordination of the supply chain, and JIT delivery, which is almost impossible at peak times.

## **4.2 Unforeseen Risks**

- **Incorrect assumption of the static system:** Non-documented and inadequate conversions (e.g., missing walls in lower levels), change of the deck clearance direction, unpredictable material changes within rooms, foundations of the neighboring buildings.
- **Major structural damage:** Pest infestation, house sponge (typical for incorrectly executed bath installations from the 1970s), poor quality of building materials (for example, lack of reinforcement in concrete, especially in buildings from the 1960s).
- **Pollutants:** In building fabric (asbestos as fire protection in steel structures), contamination of the ground.
- **Explosive ordnance in the ground**
- **Interventions of the monument protection authority**

## **4.3 Difficulties Due to Lack of Space**

- **Missing space for containers and debris dumps:** No or little storage space and manipulation areas
- **Limited possibilities to set up machines:** Due to lack of space or crossing of farmyards (mostly only possible for small equipment like dumpers)
- **Rare acceleration opportunities:** Limited parking facilities for workers

## **4.4 Solutions and Impact**

- Renting of external land, only temporary storage of material
- Just-In-Time delivery, purchase of special equipment, manual manipulation
- Lifting cycles, temporary road locks
- Higher personnel costs due to night and weekend work

## **4.5 Manual Transport**

As of the inner-city traffic situation and restricted accessibility, transportation processes on site often must be carried out partly by hand or with small lifting devices, from intermediate storage locations and within the construction site. This results in higher manipulation times, that are difficult to calculate and cause higher personnel costs. This uncertainty due to non-existing comparative values can be considered in a possible venture surcharge.

## **4.6 Works during Ongoing Operations**

Particularly in the case of construction projects with ongoing operations, the safety regulations must be observed. As examples, hospital conversions, reconstructions in schools and construction works in concert halls were mentioned by the experts. The construction works in the hospital and the kindergarten, as examples, forced the construction manager to adapt the optimal construction schedule and to pause the works quite often. In the case of the hospital, concreting with a bucket could only be executed at certain times because the bucket couldn't be moved in front of the radiology's windows. Works that caused vibrations in the structure were moved to time slots where no surgeries were scheduled.

These impairments of the construction process can also be caused by sensitive operations in the neighboring buildings.

#### **4.7 Neighboring Buildings**

The documentation of neighboring structures is considered as very important. The experts defined this documentation as part of the planning process to be able to estimate the risks that could occur from the neighboring buildings.

Above all, questions concerning the foundation and necessary safety measures must be clarified upfront. But also, the actual static system and the formation of fire walls were mentioned in this context.

This kind of documentation must be carried to also serve as a hedge against any unjustified claims arising from damage that might occur in neighboring buildings during the construction works. In unproblematic building project, the contractor himself does this work, but usually those external experts are commissioned for these documentations.

### **5 DISCUSSION**

The influence factor "inner-city traffic" and the lack of space, resulting from the dense construction and the inner-city traffic, were identified as decisive influencing factors for the calculation and construction of inner city construction projects.

The additional costs resulting from the lack of space and inner city traffic can be significant and must be correctly assessed by the contractor in the calculation phase of a project before the contract is even tendered. According to the experts, in addition to the uncertainties arising from the building structure and materials in existing buildings, this is the greatest risk of urban construction sites for the contractor. The resulting calculation risk can hardly be considered with a "location risk surcharge". So, every project must be planned very accurately and all the documents and circumstances have to be checked for plausibility upfront.

### **6 CONCLUSION**

It is not possible to classify inner city construction sites based on their location and thus to determine the occurring difficulties on site in advance. There are different characteristics within the cities and no clear boundaries between the city center and the rest of the city. The characteristics, which are typical for the inner-city areas and have an influence on the construction operation (hardly any storage space, dense neighboring buildings, increased traffic at peak times, etc.), can also occur in the city periphery. The aim is to describe an inner-city construction site based on the relevant technical, regulatory and logistical conditions that are relevant for the building industry.

The calculation and executional planning of construction companies shall be based on the tender documents and the circumstances, which appear. The uncertainties in this phase and the "unpredictable risks" that can occur in the construction process are well known to the parties involved. However, the necessary costs to cover any eventualities cannot be shown in the calculation, since it is not possible for planners to include them in the bill of quantities. Additional costs, an increase of the project costs, a delay in construction progress, and an accurate record of the resulting additional costs are often the consequences.

The influencing factors on an inner-city construction site and the resulting risks cannot be standardized and considered. The experts agree, that the risks associated with building projects in urban areas can only be minimized by a conscientious planning of the client and a consistent

feasibility calculation of the contractor. This can also be used to create a solid basis for possible additional costs to allow the project to be settled and remunerated in a fair manner.

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