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Qualitative and Quantitative Assessment of Scaffolding Used in Polish Cities: Focus on Safety

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Abstract. Despite strict safety regulations and general awareness of risks related with work at height, scaffoldings are associated with many accidents. The scale of the problem of unsafe scaffolding can be indirectly analysed on the basis of individual accident reports and statistics. However, the total number, types, purposes, sizes, and condition of scaffoldings used in the practice of Polish construction sites have not been assessed do far. The authors intend to fill this gap by conducting regular observation of scaffoldings erected in selected Polish urban areas. This paper presents the methodology of data collection and compares scaffoldings observed in two big cities, Warsaw and Poznań. Although the method misses scaffoldings out of sight of the assessor and, due to urban locations, focuses on building and not industrial or infrastructure projects, it gives a good idea of the qualities of scaffoldings in use, and enables estimating changes in the number of scaffoldings over the year. As comes from the analysis, frame scaffoldings are the most popular type used in Polish construction. Users commonly choose the narrowest option (less than 70 cm of usable width of the platform) and apply them to a variety of works, be it placing concrete, cladding walls with ETICS or even heavy stone elements, or providing access to roofs. Modular scaffoldings are second most popular, whereas the tube and fitting type is used in extremely rare cases. Small projects (individual housing, small-scale repairs) frequently rely on combination of elements of systems scaffoldings and are often incomplete. Interestingly, “bad scaffoldings” do not appear only in remote suburbs. As for the changes of the number of scaffoldings over the year, the pattern is not as clear as could be expected in the case of a cold climate country. The findings indicate that occupational safety culture is still low.

1. Introduction

Scaffolding accompanies construction and maintenance works in most types of built facilities at any stage of their life cycle. Despite strict safety regulations and general awareness of risks related with work at height, these temporary structures of collective fall protection are associated with many accidents. In some cases, the scaffolding itself becomes the cause of the accident (due to e.g. faulty or missing elements, mistakes in structural design or assembly workmanship that result in structural failure), in some – because users ignore, or are oblivious of, the risk.



The problem of falls from height and unsafe scaffolding has been the object of interest of many researchers [1, 2]. It was analysed on the basis of individual accident reports and statistics [3,4,5,6, 7], opinion surveys among construction practitioners [8,9], case studies of structural failure, and analyses of scaffolding systems or components with respect to load-bearing capacities [10,11,12,13]. A number of research projects were conducted to assess samples of scaffoldings in particular building sites [14,15] to check safety conditions of their use.

Analyses presented in this paper are an element of a research project “Model of risk assessment of structural failures, accidents and incidents related with construction scaffoldings” [16]. The project team adopted the approach similar to that presented in [14] and [15], and decided to test a sample of scaffoldings in real-life conditions of building sites. The object of research was ground supported simple frame scaffoldings that serve new constructions as well as repair works of buildings. However, as the cases for the sample have not been randomly selected, they needed to be checked for representativeness against the population of scaffoldings. As the total number, types, purposes, sizes, and condition of scaffoldings used in the practice of Polish construction sites have not been assessed so far, the authors attempted to fill this gap by conducting regular observation of scaffoldings erected in selected Polish urban areas.

This paper presents the methodology of data collection and compares scaffoldings observed in selected areas of two big cities, Warsaw and Poznań. Although the method misses scaffoldings out of sight of the assessors and, due to urban locations, focuses on scaffoldings that accompany construction and repairs of buildings, it gives a good idea of the types and qualities of scaffoldings in use. It also allows the researchers to quantify changes in the number of scaffoldings over the year. The results provide insight into the scaffolding market in Poland.

2. Method of data collection

To learn on types, sizes, and functions of scaffoldings used in Polish urban areas, five regions (voivodships) of Poland were selected. In each of them, the region's capital and five smaller towns were subject to analysis. In the region's capital cities, the following six areas were selected, each of about three square kilometres, and of distinctive character in terms of predominant age and function of built assets:

1. city centres,
2. residential areas, new single family development,
3. residential areas, old city quarters dominated by individual houses,
4. residential areas, new multifamily development,
5. residential areas, old multifamily estates,
6. areas dominated by industrial and commercial buildings.

As for the small towns, each was analysed as a whole.

Observation of scaffoldings consisted in searching through selected areas with the frequency no lower than once every two months. All scaffoldings visible from publicly accessible locations were counted, photographed, and described in terms of size and usage. Assessors operated on foot, used bicycles or cars (whatever suitable from the point of traffic conditions and accessibility), traveling through clearly defined areas along fixed routes. Similar direct methods of taking inventory of objects that occur in random locations are used e.g. in forestry [17]. In analyses of urban areas, direct inventory was used e.g. by Dallo et al. [18] and Ostańska [19] to supply information on actual condition of buildings.

This method of data collection is time-consuming and imprecise: it omits scaffoldings out of assessors' sight. Especially in the densely developed city centres, inner areas of broad perimeter blocks were not visible from the streets, so a potentially large number of scaffoldings were missed. Aerial photos could be of help. However, the cost of collecting data this way was prohibitive. Using unmanned aircrafts was also out of question due to safety reasons, organisational effort and cost: according to aviation regulations, drone flights above buildings have to be planned in advance and

agreed with aviation and city authorities, and can be conducted only as flights with visual contact. The drone operator would have to walk the same areas as the assessors operating on foot, and the logistics of battery change would greatly increase the duration of tests. Considering the number of locations (5 regions times six towns/cities) and frequency of data collection (every two months for two years), using drones was not viable. Therefore, the error of “out of sight” scaffoldings was accepted.

The bi-monthly frequency of data collection was a further compromise between the needs of capturing seasonal changes in numbers of scaffoldings and the effort of data acquisition. Scaffoldings are ephemeral structures – sometimes they are erected to be used for one day, sometimes they stay in one place for a number of years. A bi-monthly frequency was assumed arbitrarily. Observations started in May 2016 and are scheduled to be completed in August 2018.

The next chapter presents data collected until March 2018, in two areas (city centre, and new multifamily development) of two big cities (Warsaw – the capital city of Poland, and Poznań – the capital of a region located to the west of Poland). The first two observations were considered a “reckon by battle” aimed at defining borders of test areas and assessor’s routes with consideration of actual traffic conditions and accessibility. It was necessary because assessors needed to operate in unfamiliar areas. If tests were not possible to be conducted precisely in two month intervals, they were conducted more frequently. Therefore, the number of valid tests vary location to location: Poznań city centre was tested 14 times, Warsaw city centre - 12 times, Poznań new residential area – 13 times, and Warsaw new residential area – 11 times.

3. Results

3.1. Citycentres of Warsaw and Poznań

The test area of Warsaw inner city was 3.0 km², whereas its counterpart in Poznań was larger, 3.74 km². In both cities, the development pattern of these areas is similar: based mostly on regular grid of streets, dense in the old town area, with broader blocks in newer part, with large share of public edifices in historic styles and relatively low share of modern and tall buildings.

The seasonal differences in the number of scaffoldings (figure 1) expressed in absolute numbers look similar: within 3 km² of Warsaw centre, the smallest number of scaffoldings was 17, and the greatest – 41. In Poznań, these figures were 14 and 42, respectively, but in a larger area (3,74 km²). The seasonal trend was quite clear in Warsaw: the number of scaffoldings grew from spring until November (when contractors strive to complete the works before wet and cold winter and end of the fiscal year). In Poznań, where winters are milder, the drop in the number of scaffoldings towards the end of the year was not that obvious, and the construction season seemed to start and finish earlier. However, the data have not been collected long enough to allow for generalizations in this respect.

In both cities, simple frame scaffoldings were the most popular type: on average, 96% of all scaffoldings in Warsaw, and 89% in Poznań. Modular systems seem to be the second choice in Poznań – in some periods over one fifth of scaffoldings were of this type (figure 1).

As for the type of works served by the scaffoldings (figure 2), the majority of observed cases were related with repairs of the existing assets. A considerable number of heavy alteration/expansion works was observed in Poznań (25% of cases), whereas in Warsaw such ventures occurred less frequently (6%). Nearly 12% of Warsaw centre scaffoldings observed during the whole period of analysis served new construction. In Poznań, where some post-industrial plots have been recently reclaimed for construction, the share of scaffoldings accompanying erection of new buildings was greater, and reached nearly 18%.

The works were conducted mostly in multifamily residential buildings (62% in Warsaw, 61% in Poznań). Due to the character of development, the Poznań central area encompasses some single family buildings (or rather urban villas), and 1% of scaffoldings were used there; whereas in Warsaw no such buildings were present in the test area. The remaining scaffoldings served works in non-residential buildings (figure 3).

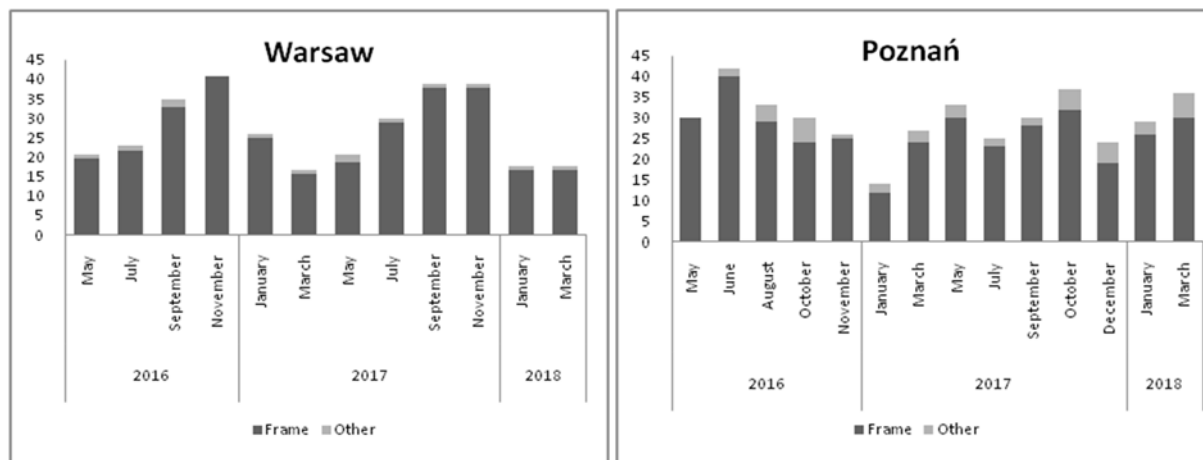


Figure 1. Number of scaffoldings according to type observed in city centres of Warsaw and Poznań

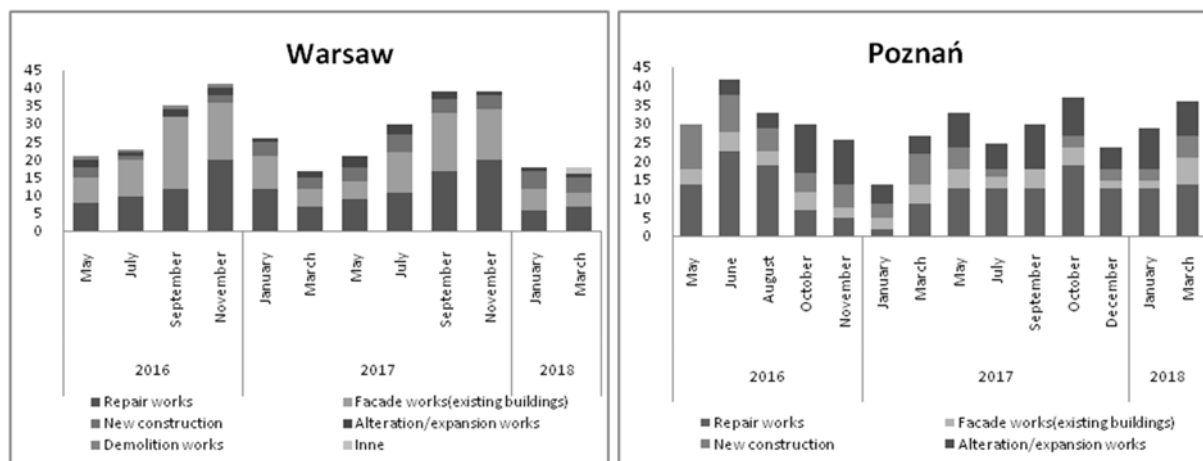


Figure 2. Number of scaffoldings according to the type of works served in city centres of Warsaw and Poznań

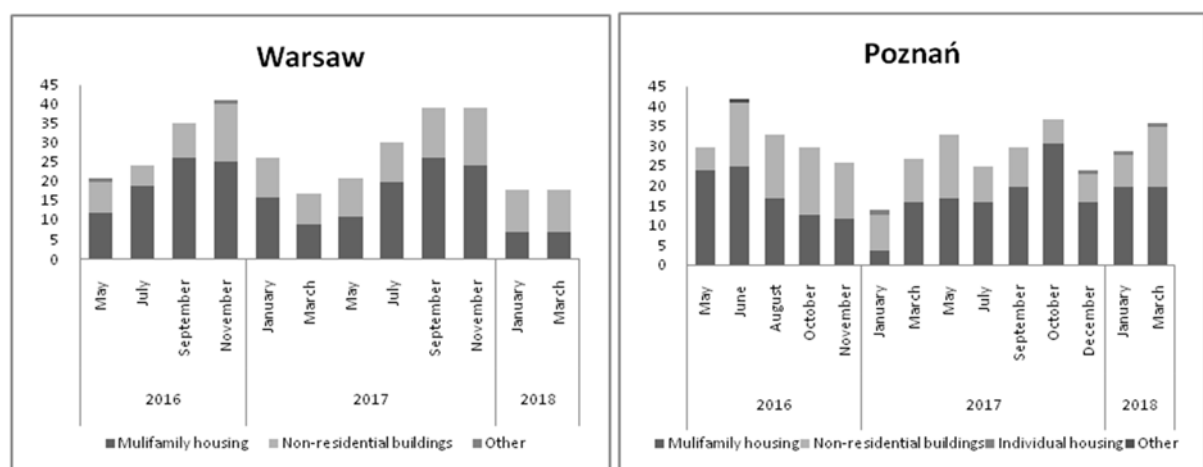


Figure 3. Number of scaffoldings according to the type of buildings served in city centres of Warsaw and Poznań

So far, the difference between the central areas of Warsaw and Poznań in terms of purpose and intensity of scaffolding use seems minimal. However, if one compares fluctuations of the total scaffolded area (figure 4), the discrepancies become visible. Of course, the period of data collection is too short to generalize, but the area of scaffoldings in Warsaw seems to fluctuate with some regularity and according to the same pattern as the number of scaffoldings: surprisingly small number and small areas of scaffolding in late spring and summer, the peaks in late autumn (November). As for Poznań centre, the total area of scaffolding seems to drop from June 2016 (the effect of two large office projects being completed between May and October 2016), and the relationship between the number and the area of scaffolding is less clear.

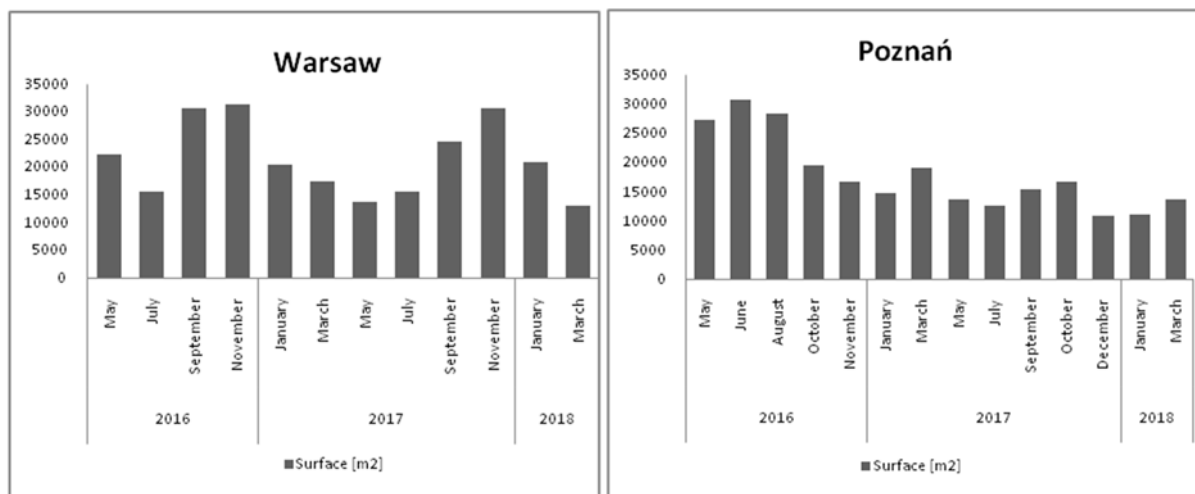


Figure 4. Total area of scaffolding in city centres of Warsaw and Poznań

Nevertheless, in terms of the share of smallest scaffoldings (up to 200 m²), average over the whole period of analysis, the centres of Warsaw and Poznań were similar: 24% and 24,8%, respectively. The share of those smallest scaffoldings' area in the total area of scaffoldings was also similar: 3,42% for Warsaw and 3,87% for Poznań. The biggest observed scaffoldings served construction of new buildings: in Warsaw, the biggest one was of 6500 m², whereas in Poznań 6800 m² (in both cases, construction of office towers). The total scaffolded area in central Warsaw fluctuated between 13,010 and 31,340 m², and in Poznań between 10,767 and 30,638 m².

The difference can be seen in the average size of a scaffolding: in central Warsaw it was 804.4 m², whereas in Poznań only 615.5 m². Considering the size of test areas, the average density of scaffoldings, measured by the area of scaffoldings per square kilometre, was: 7011.8 m²/km² (Warsaw) and 4716.4 m²/km² (Poznań)

3.2. Areas of new multifamily housing development of Warsaw and Poznań

The areas selected in Warsaw and Poznań are similar in their function (in municipal plans, both were defined as residential with small share of public utility and commerce), and include large empty greenfield plots among recently erected housing estates. However, the housing ventures in Warsaw are greater by an order of magnitude. The scaffolding data confirm this difference.

The area in Warsaw (Wilanów) covers 2.83 km². Its counterpart in Poznań (Naramowice) is slightly smaller, of 2.5 km²; its function is also less uniform, as it contains small areas of single family houses and areas occupied by small industrial establishments. This is reflected in the distribution of scaffoldings according to the types of buildings served (figure 6).

The total number of scaffoldings in Warsaw fluctuated between 4 and 15, whereas in Poznań – between 2 and 8 (figure 5). Interestingly, the number of scaffoldings in Warsaw did not vary significantly between winter and summer months. In Poznań, changes in the number of scaffoldings

were considerable. This can be explained by the character of works (figures 5 and 6). In Warsaw, these predominantly consisted in construction of new large housing blocks (95.8%), so the works took a long time; it was not economical to dismantle scaffoldings for winter even if weather did not allow to continue works. In Poznań, the share of scaffoldings for new construction was smaller (73.5%), and the remaining ones served repairs, so they were needed for short-term works (less than 2 months). Thus greater changes in scaffolding numbers over time (figure 5).

As illustrated by figure 7, only frame scaffoldings were used in the Warsaw residential district under observation. In Poznań, frame scaffoldings were dominant, but other types were also present (modular, mobile towers, Warsaw towers and combinations of these).

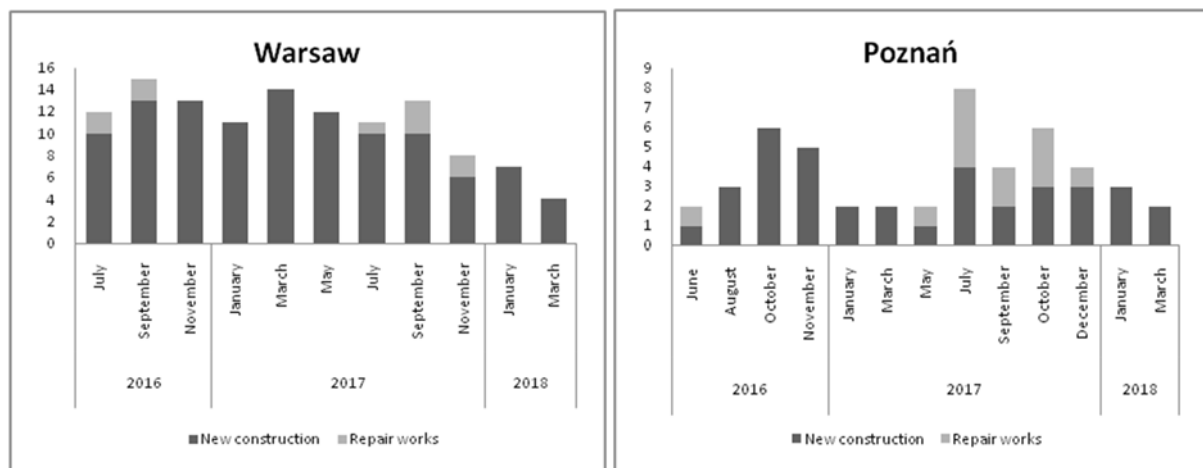


Figure 5. Number of scaffoldings according to the type of works served in new residential districts of Warsaw and Poznań



Figure 6. Number of scaffoldings according to the type of buildings served in new residential districts of Warsaw and Poznań

However, the greatest difference between the Warsaw and Poznań districts lies in the total area of scaffolding (figure 8). As big projects were conducted in Warsaw, the total scaffolding area fluctuated between 4,095 and 15,530 m², whereas in Poznań - between 24 and 2,465 m². The average size of a Warsaw scaffolding was 1027 m², with only 361 m² in Poznań. Big scaffoldings (above 200 m²) consisted 98.5% of Warsaw, and 93.3% of Poznań samples, and they all were related with new

construction. The average density of scaffoldings, measured by the area of scaffoldings per square kilometre, was: 3,709 m²/km² (Warsaw) and only 463.4 m²/km² (Poznań).

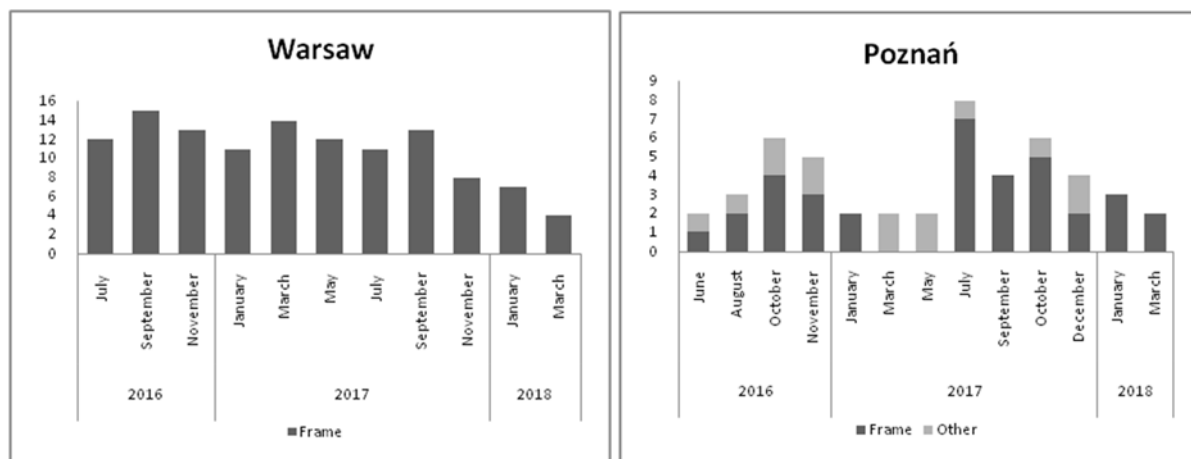


Figure 7. Number of scaffoldings according to type observed in new residential districts of Warsaw and Poznań

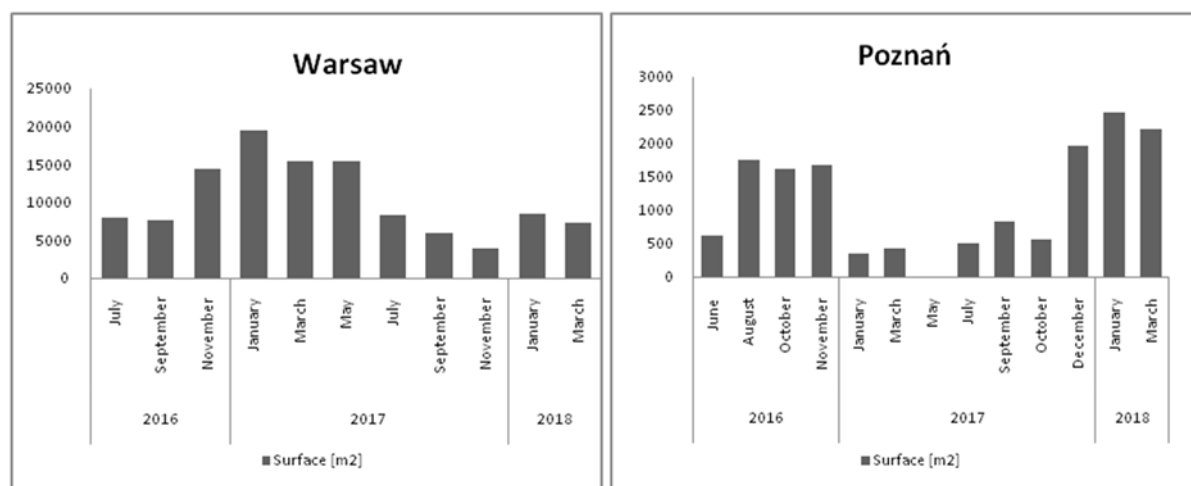


Figure 8. Total area of scaffoldings in new residential districts of Warsaw and Poznań

4. Discussion and conclusions

Observations conducted so far provide a clear insight into the types and character of scaffoldings used in the cities.

- Frame scaffoldings are the most popular type used in Polish construction; users commonly choose the narrowest option (less than 70 cm of usable width of the platform) and apply them to a variety of works, be it placing concrete, cladding walls with ETICS or even heavy stone elements, or providing access to roofs. Their popularity may arise from ease of erection, large supply and competitive prices.
- In Poznań region, modular scaffoldings are second most popular, whereas the tube and fitting ones are used in extremely rare cases. The modular sets often look very worn, and judging by signage, they tend to be owned by specialty contractors rather than being rented.
- Frame scaffoldings in large projects are typically in good condition (new and complete).

- Small scaffoldings (individual housing, small scale repairs) frequently rely on combination of elements of systems scaffoldings and are often incomplete and dangerous to use. Interestingly, “bad scaffoldings” do not appear only in remote suburbs: they can be spotted even in prominent areas of the cities (figure 9).
- On average, bigger scaffoldings accompany new construction – repairs and alterations are served by smaller sets.
- Many scaffoldings stay in one place for a long time (over one year), especially in the case of repairs and alterations of historic buildings, and new construction. This time involves suspension of works for winter – the contractors decide to leave the scaffoldings unused even for a month or two, maybe counting on mild winters and possibility to proceed with works.
- As for the changes of the number of scaffoldings over the year, the pattern is not as clear as could be expected in the case of a cold climate country. This may be specific to the character of works. In Warsaw, the peaks in numbers of scaffoldings in the inner city were observed in late autumn, whereas Poznań centre scaffolding numbers seem to be less affected by seasons. The opposite was observed in the new residential districts of these cities. The period of analysis is too short to draw statistical conclusions in this respect.



Figure 9. Makeshift platforms with missing elements covered with loose planks, main street in Poznań Old Town, 2018



Figure 10. Small modular scaffolding – missing mid-rails and toeboards, Poznań centre, 2016



Figure 11. Incomplete Warsaw tower type scaffolding as a platform for concrete placers 15 metres above the ground, Poznań centre, 2018

The method of data collection does not enable the researchers to check condition of the scaffoldings in detail. However, some deficiencies can be seen even from a distance. From the point of safety, the worst scaffoldings are those smallest, erected “just for a while” and used in repair works or as platforms for structural works. They are often not properly supported, with missing elements (figure 10). The Warsaw tower type scaffolding (according to accident statistics, notorious for being misused) almost disappeared from the building sites in the centres – no construction works were observed to rely completely on them. However, with their loose planks serving as platforms and no guardrails, they still lurk from the shadows even in seemingly well managed sites, as the one spotted at a large office project in Poznań (figure 11).

Recent initiatives to improve construction work safety together with economic prosperity and good supply of construction equipment are expected to increase awareness of contractors and clients on the importance of good scaffolding. However, conclusions from observation of construction sites are not optimistic. The safety culture is still low, and workers' health is compromised for speed of works and savings. Incomplete scaffoldings are apparently not considered a shame for contractors, who use them even in prominent areas of the large cities.

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