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Demolition of the cereal elevator building located in the conservation protection zone in the aspect of technical, functional-utility and economic conditions

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Abstract

The article presents a description of the technical condition of the Grain Elevator building situated on the port quay, which after many years of operation has been decommissioned. The immediate reason for the cessation of operation was the change in the use profile of the port quay, which caused the handling of other goods at the quay than the bulk materials originally stored in Elewator Zbożowy. The work contains a detailed analysis of the technical condition of the building, also taking into account the functional and utility aspect as well as the economics of renovation works. The article showed that despite the location of the building in the conservation protection zone, the optimal solution was the demolition of Grain Elevator and its reconstruction of a new warehouse facility with parameters adapted to the current needs and target handling capacity of the port quay.

Keywords: renovation, conservation protection, grain elevator, demolition, technical condition assessment.

1 Introduction

Economic development results in the necessity to change the way of using building objects. Sometimes the change of use turns out to be insufficient for the newly designed method of exploitation, often it is also unprofitable for economic reasons [1] - [3]. Deciding whether to demolish a building that does not meet the target expectations is very difficult due to the fact that these facilities are very often located in a conservative protection zone [14].

The article is a case study of the Grain Elevator building, which after many years of operation has been decommissioned due to the inability to store goods currently being transhipped at the port quay [8], [19] - [20]. As part of this article, the following questions were answered [4] - [7], [16] - [17], [24], [26]: renovation works, b) whether after the renovation and repair works it would be possible to use the Grain Elevator building in accordance with the current and target needs of the users of the port quay, c) whether any renovation and repair works will be in the area of economic profitability [15], [25].

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2 General data

The Elevator building covered by the project was constructed as reinforced concrete, in monolithic technology, with local fillings of external walls made of ceramic bricks. The inter-story ceilings are made of reinforced concrete, monolithic (mushroom-shaped). The internal supports for the inter-story footings were orthogonally arranged girders (transoms and ribs), while the support for the girders was made of monolithic reinforced concrete columns placed in the grid axes of 4.8 × 4.8 m. The building had 11 above-ground storeys and 1 underground storey.

The height of the above-ground storeys varied, some of the storeys had a contour variable along the height of the building. The building had transport ramps along the external longitudinal walls. In addition, the building had a transport (communication) tower with an elevator shaft. There were outbuildings adjacent to the building, and there was also a communication ramp for pedestrians.

3 Condition of the existing building of the Grain Elevator

On the facade of the building, there were visible remains of the installation used in the past period for the transport of loose materials (Photo 1). The transport ramp along the outer longitudinal wall had extensive damage in the form of concrete defects - chipping and falling off of the concrete cover.

On the roof of storey +10, damage to the roofing felt was visible, and the concrete elements in the horizontal roof had extensive erosive damage (Photo 2).

In the rooms on the +10 level, mechanical damage to the ceiling above this level was visible. Elements of devices used for transporting loose materials were also visible (Photo 3).

The rooms on the +7 level, as well as the higher rooms: +8, +9, and the lower ones: +6, +5, +4, +3, +2 and +1 floors had sections for storing materials separated by wooden partitions loose. In the rooms, inoperative devices for transporting the stored materials were visible. Traces of freezing of external walls were visible in the floor zone. Loss of concrete cover was visible on some of the pillars between the windows (reinforced concrete columns) (Photo 4).

Reinforced concrete elements, in practice at the level of all above-ground storeys, especially at the level of +5, had local mechanical damage visible on the ceiling, walls and columns. As in the case of other storeys, in the rooms there were visible inoperative devices for transporting loose materials. Loss of concrete cover was visible on some of the pillars between the windows (reinforced concrete columns) (Photo 5).

The reinforced concrete elements in level -1 had mechanical damage visible on the ceiling, walls and internal columns. Most of the internal columns showed very intense damage to the concrete cover of the bars, its falling off and dampness. Traces of freezing and dampness on the outer walls were visible in the floor zone. The floor in the underground level had extensive cracks and chipping (Photo 6).

4 Analysis of the current state

On the basis of the obtained oral information, it was found that in the last decade, no trees with significant dimensions in terms of trunk diameter and height, which could change the soil moisture distribution in the analyzed building, were removed from the area adjacent to the Grain Elevator building. New medium- and high-stem trees or shrubs have not been planted either. Thus, there were no grounds to conclude that the root system of the stand could have contributed to damage to both the structure and the waterproofing of the part of the building embedded in the ground, and that the roots of the stand could have contributed to disturbing the soil and water conditions in the area directly adjacent to the elevator building. Grain, according to the mechanism described in [10].

On the basis of the conducted inspection, a preliminary thesis was formulated that the current state of scratching of the reinforced concrete structural elements is not caused by the foundation of the building in question in the immediate vicinity of the communication system loaded with intense motor vehicle traffic - a radius equal to the height of the building was assumed as the immediate vicinity of intensive traffic (the zone had an internal road port

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on which trucks were moving). In the building, there was no type of damage characteristic of vibrations caused by the movement of motor vehicles (scratches and cracks in the corners and lintels with a typical X morphology).

During the inspection, no perceptible vibrations of the ground subsoil around the Grain Elevator building were found. Thus, measurements of the ground vibrations were abandoned, assuming that they would not provide any relevant information for further analysis of the technical condition of the building in question.

Below is an analysis of the condition of the existing building of the Grain Elevator, carried out due to the following conditions:

• technical [9], [11] - [13], [21] -23], [27],

• functional and utility,

• economic.

4.1 Technical condition analysis

Foundations

The building of the Grain Elevator was erected, in accordance with the solutions presented in the archival design documentation, on the foundation slab. The foundations of the building worked as an inverted slab and rib ceiling.

At level -1, there were no external features on the floor that would indicate uneven settlement of the building as a whole. Also on the walls, both external and internal, there were no signs of uneven settlement of the structure. It is also worth noting that the previous use of the land adjacent to the Grain Elevator building, including the works related to the reconstruction of the quay in the past period, did not cause deformation of the soil substrate, which would contribute to defects and damage to the structure of the Grain Elevator building.

Reinforced concrete elements (ceilings, columns, walls)

The walls and ceilings of the Grain Elevator building were made, in accordance with the solutions included in the archival design documentation, of C16/20 class concrete, while the columns were made of C20/25 class concrete. The inter-story ceilings are designed for a variable (usable) load of 5,0 kN/m^2 (500kg/m^2), which is a typical value for storage facilities. There were no visible signs of damage on the structural elements, which would indicate overloading of the ceiling structure: in the bottom view, no scratching of inter-story ceilings with a typical overload morphology (according to the theory of bend lines), in particular in the area of heads (mushrooms), there was no visible excessive deflection of the beams reinforced concrete and buckling of reinforced concrete columns.

Due to the inability to verify the correctness of the execution of the reinforcement of the heads (mushrooms) of the inter-story ceilings, no scanning of the ceiling reinforcement was performed in order to estimate the degree of reinforcement. It was assumed that the long-term operation period and the accompanying lack of visible signs of overloading the structure verified the correctly adopted design solutions.

The results of laboratory tests confirmed that the concrete embedded in the structural elements could be classified as class: C16/20 (ceilings and walls) and C20/25 (columns).

For the currently applicable standard guidelines (Eurocode EC2), the concrete structural elements of the Elevator did not meet the durability requirements due to the strength class of the concrete and the thickness of the reinforcement cover.

In the case of reinforced concrete monolithic inter-story ceilings, the actual (current) concrete class was C16/20, and the measured cover of the reinforcing bars was 10 to 40 mm. Due to the durability requirements, this class should be min. C30/37 with a cover of 40 mm (assuming exposure class XC3, XS1).

In the case of reinforced concrete, monolithic external walls, the actual (current) concrete class was C16 /20, and the measured cover of the reinforcing bars was from 0 to 40 mm. Due to the durability requirements, this class should be min. C30/37 with a cover of 40 mm (assuming exposure class XC3, XS1, XF2),

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In the case of reinforced concrete, monolithic internal columns, the actual (current) concrete class was C20/25, and the measured cover of the reinforcing bars was 10 to 40 mm. Due to the durability requirements, this class should be min. C30/37 with a cover of 40 mm (assuming exposure class XS1, XC3).

It is also worth noting that in the concrete samples taken from the walls, chemical tests showed high carbonation of the concrete, i.e. low pH value (~ 8 *pH*). This means that the concrete cover has lost its natural ability to protect the reinforcement against corrosion, which results in accelerated corrosion of the reinforcement bars. The reason was the direct exposure of reinforced concrete elements to wind blasts containing sea water particles (aerosol action).

The results of the moisture test showed that the greatest dampness occurred in the outer walls of the lowest floors (basement (level -1) and ground floor (level 0)) - it was caused by capillary rising of water from the ground, splashing rainwater in the near zone and inoperative damp insulation of the walls in the part buried in the ground. The degree of moisture content made it possible to classify these elements as dry, with local places of increased humidity.

The results of sclerometric tests showed that the concrete embedded in the structural elements of the object (ceilings, walls and columns) was very heterogeneous on the surface, which was caused by its high degree of carbonation. In the boreholes made, sufficient homogeneity of the concrete in the deeper layers of the elements was found.

The external walls of the Grain Elevator building did not provide adequate thermal protection of the facility, both in the area of storage rooms, as well as in the area of rooms intended (previously) to be used as office and administrative rooms. Comprehensive thermal and moisture calculations were abandoned. The visible signs of freezing on the inside of the external walls sufficiently confirmed the above-standard thermal conductivity of the walls (insufficient thermal insulation), which allows for the formulation of the thesis that the external walls did not meet the requirements set out in the already withdrawn, but commonly used until now, standard [29] ($k_{real} >> k_{max}$), as well as in [28] ($U_{real} >> U_{max}$).

Roofs

The structural elements of the flat roofs above the level of +8, +9 and +10 did not show any significant structural damage - there was no visible excessive deflection. There were signs of freezing in the bottom view. The roofs had a tight, but intimate and decapitalized covering made of heat-welded roofing felt. The gutters on the roofs were not periodically inspected: they were not cleaned regularly, which resulted in their lack of patency and contributed to flooding (damp) the external walls with water.

Woodwork

The steel window joinery (in the warehouse part of the building) had numerous mechanical damages and was intensely corroded: surface corrosion was very extensive, locally it turned into pitting corrosion.

The wooden window frames (in the office and administrative part of the building) were largely unglazed, wooden elements were damaged by biological corrosion (infested with fungi and molds) and had extensive mechanical damage.

The steel door joinery (in the warehouse part of the building) had extensive mechanical damage, in most cases it was blocked, which made it impossible to open the steel gates.

The wooden door frames (in the office and administrative part of the building) were largely dismantled: the door leaves were removed from the frames. The left door leaves had mechanical damages, there were visible signs of biological corrosion development (fungi and mold) on the door leaves.

Pipe and line installations

In the Grain Elevator building, industry installations: pipe (water supply, sewage installation) and cable (electrical installation) have been largely dismantled - this applies in particular to the electrical and water supply installations. Particularly noteworthy is the fact that the installations dismantled in the past years were implemented in accordance with the currently non-binding executive standards.

Industrial installations related to filling, transporting and emptying storage spaces from loose materials have also been largely dismantled. In some storage rooms, inoperative blowers and downspouts have been left.

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4.2 Functional and utility analysis

It was found that in the past period the Grain Elevator building was used mainly as storage space in the area where loose materials were stored. From the end of the 1980s to the beginning of the 11th century, mainly soybean meal was stored in Elewator. Since 2004, the elevator has not been used for the storage of any loose material.

In the years from ~ 2004. until ~ 2010 the rooms on level 0 were used on an ad hoc basis as handy warehouses.

Currently, the building of Elewator Zbożowy is not in use and is completely out of use. The building was secured against access by third parties. The doors and gates to the building were permanently closed and the area around the building was fenced.

It is also important that the storage of loose materials of organic origin was not, and is not currently, a priority course of action - so if the Grain Elevator was left in a state without reconstruction, it would not be fully used, and in practice it would not be used at all.

Due to the relatively low usable height of individual storeys of 290 cm, it is not possible, according to the Owner, to use the existing area of the Grain Elevator as a multi-storey warehouse for packaged goods. It is also important that the structure of the building prevents quick transport (relocation) of goods on individual floors, as the building has only a single elevator shaft.

4.3 Economical analysis

In Table. 1 presents an analysis of the degree of decapitalization of the Grain Elevator building carried out using a simplified method, commonly used in engineering practice, based on a visual assessment of the degree of wear of individual building elements.

On the basis of the assessment, the estimated degree of decapitalization of the building is ~ 81% and thus exceeds 75% of the reconstruction value of the building, usually assumed as the economic profitability threshold for the implementation of an investment project in the form of renovation, reconstruction or modernization of the facility. Therefore, it can be concluded that in the case of the building covered by the study, the overhaul of the facility, which is Grain Elevator, located in quay, is beyond the scope of economic viability.

It cannot be ruled out that in the event of a decision to carry out a major renovation of the facility at the stage of construction works, the real costs of works could increase significantly in relation to the initially assumed costs, which is typical for renovation works (~ 30%). At the same time, attention should be paid to the fact that the object covered by the analysis is located in an area under conservator's protection (protection of the Provincial Conservator of Monuments) and thus economic dependencies as the basis for further engineering activities are not directly applicable here, understood as decisive, when planning activities related to the possible major renovation of the facility. In the planned works, it is necessary to take into account the conservation conditions.

It is also worth noting that in the event of a decision to overhaul, the final object (renovated Grain Elevator building) will not meet the Owner's expectations to a large extent due to functional and utility limitations and the inability to use the facility for current and future utility needs. Thus, the degree of use of the facility in time will be negligible, which for the owner will completely disqualify investments in terms of economic profitability.

5 Conclusions

The immediate reasons for the current technical condition of the Grain Elevator building as a whole were:

• imperfections of technical solutions used during its implementation,

• long-term use of the building,

• lack of regular periodic repairs,

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• no major renovation of the building has been carried out so far.

Due to technical reasons, a major renovation of the Grain Elevator building was possible.

For functional and utility reasons, any works related to the major renovation of the Grain Elevator building were highly debatable. The current layout of warehouse space was completely useless for the Owner due to the current and planned future use of the port quay handling capacity. The port's operational program did not provide for the storage of loose organic materials such as soybean meal at this location, as was previously the practice.

For economic reasons, the implementation of the investment measure covering the renovation of the Grain Elevator building was not profitable: the estimated degree of decapitalization of the building was ~ 81% and was higher than 75% (81%> 75%) customarily adopted in engineering practice as the upper limit of economic profitability for the renovation of the facility.

It should be noted that the execution of renovation works and the related costs of restoring the building to its full technical and operational condition were in practice difficult to estimate due to the renovation nature of the construction works,

As a result of possible renovation works, after incurring costs that are difficult to estimate at the moment, the object is obtained with significant operational limitations, relating, inter alia, to the possibility of storing only certain types of loose materials, resulting from the need to use and adapt to the existing system structural: mullion and transom spatial system realized as reinforced concrete, monolithic.

In the authors' opinion, the optimal one, taking into account the above-mentioned technical, functional-utility and economic conditions, was the demolition of the Grain Elevator building and the adaptation of the obtained land to the current and target operational needs and expectations of the Owner.

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[29] PN-82/B-02402 *Ochrona cieplna budynków. Wymagania i obliczenia.*

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Tabl.1: Estimated (simplified) assessment of the degree of depreciation of the Grain Elevator building

No	**Building elements**	**Item share in the facility [%]**	**The degree of decapitalization of an element [%]**	**The degree of decapitalization of the facility as whole [%]**
1	Foundations	3,79	40	1,52
2	Structural walls (level -1, 0, 1,……9, 10)	10,58	85	8,99
3	The ceiling between the storeys above the -1 level with elements of supporting structures (columns, binders)	4,82	80	3,86
4	The ceiling between the storeys above the level 0, 1, 2,… 8, 9 with elements of supporting structures (columns, binders)	47,21	75	35,41
5	Roof (flat roof) - structure	3,8	70	2,66
6	Roof - covering	1,16	25	0,29
7	Staircase	1,8	85	1,53
8	Walls	1,18	98	1,16
9	Internal plasters	3,24	98	3,18
10	External plasters	4,5	95	4,28
11	Window openings (steel and wooden)	2,82	95	2,68
12	Open door joinery (steel and wooden)	1,26	95	1,20
13	Painting works	2,25	98	2,21
14	Floors and flooring	3	95	2,85
15	Electrical installation	1,4	98	1,37
16	Water and sewage installation,	0,99	98	0,97
17	Heating installation	0,82	98	0,80
18	Specialized installations	5,08	98	4,98
19	Various elements	0,3	98	0,29
	Σ	**100,00**		**80,21**

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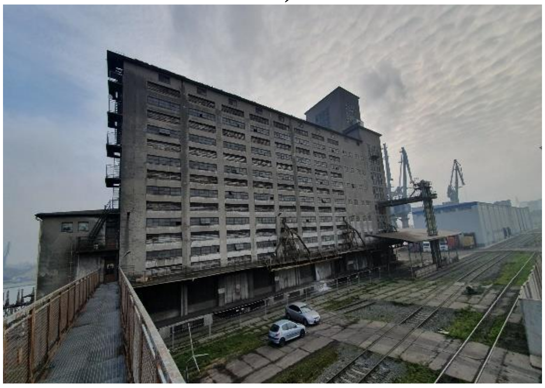
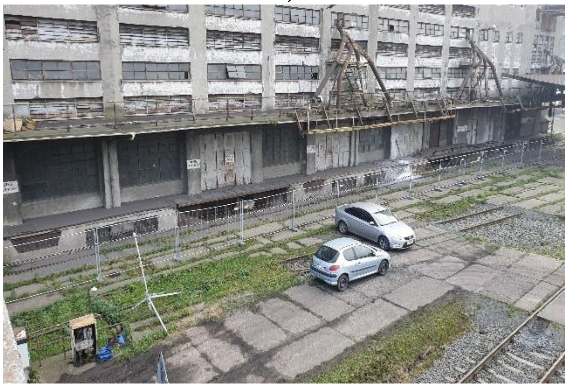
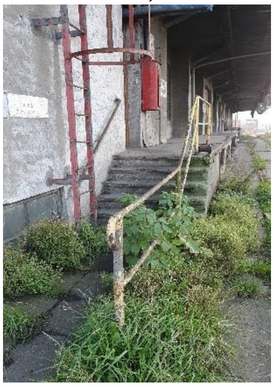
a)



b)



c)



d)

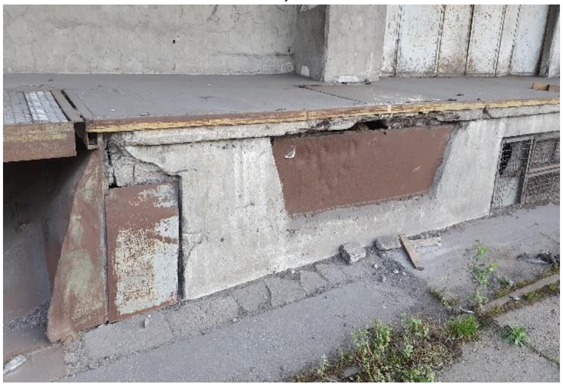
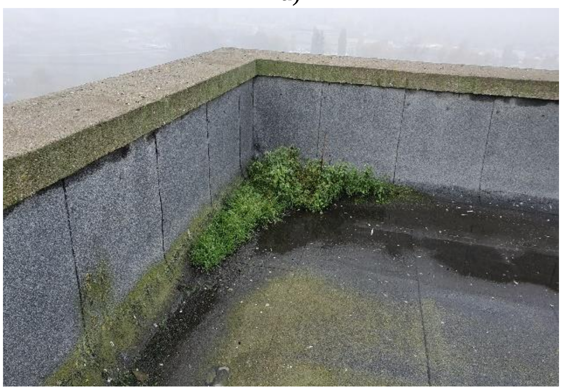


Photo 1: Grain Elevator building - elevation from the land side: a) general view, b) close-up, unloading ramp at the ground floor level: c) general view, d) damage in close-up

a)



b)

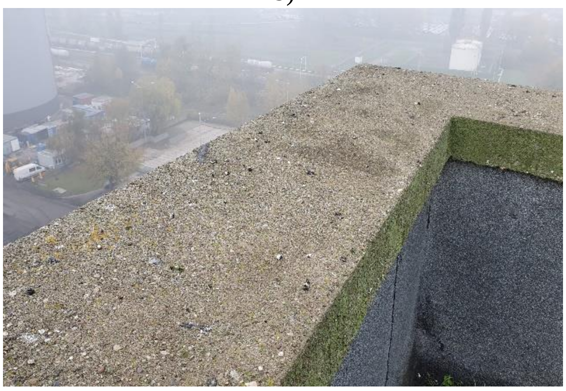


Photo. 2: Grain Elevator building - roof level: decapitalization of: a) roofing felt (blistering and unevenness), b) cornice elements (carbonation)

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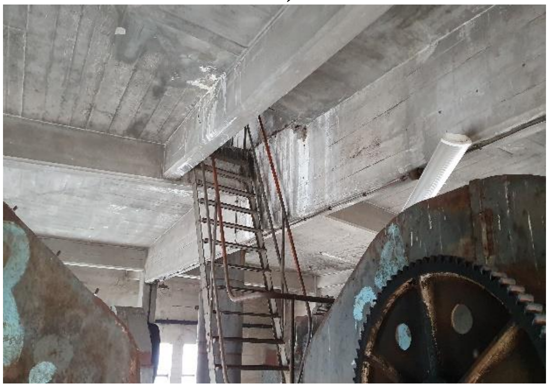
a)



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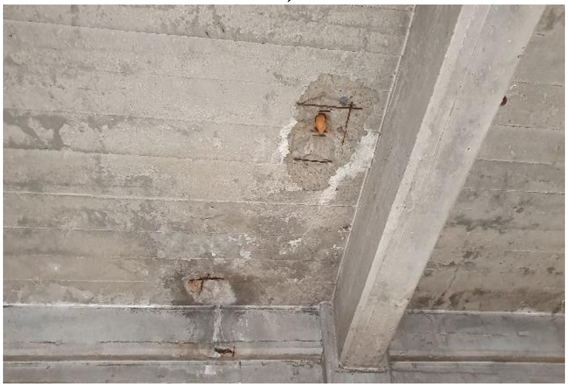
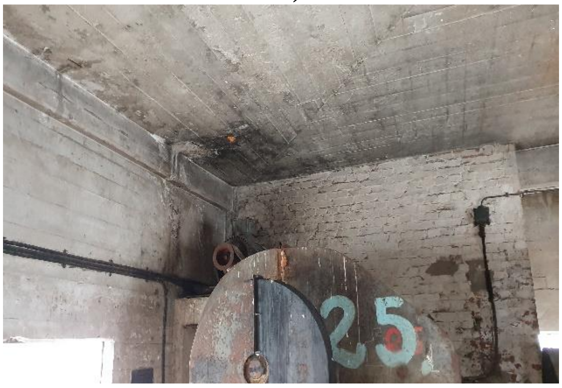


a)

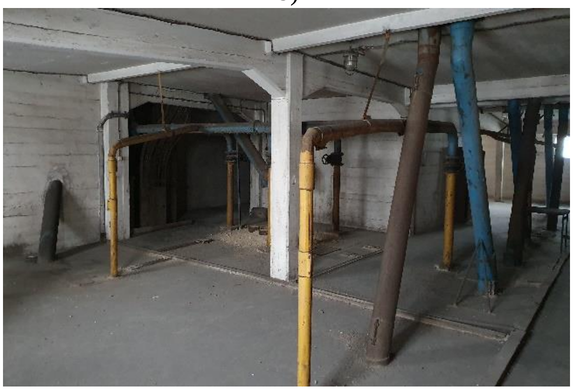


b)

Photo 3: Grain Elevator building - level +10: a) mechanical damage to structural elements, b) defective and incomplete equipment for transporting loose materials

a)

b)



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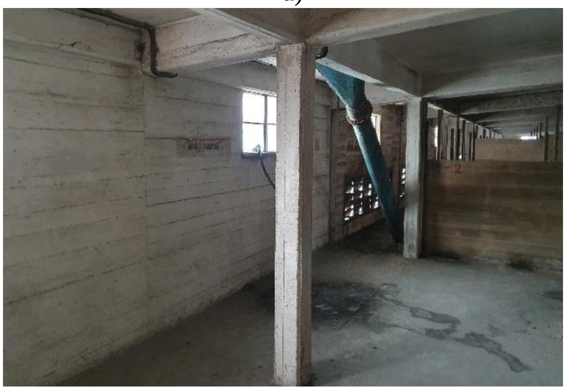

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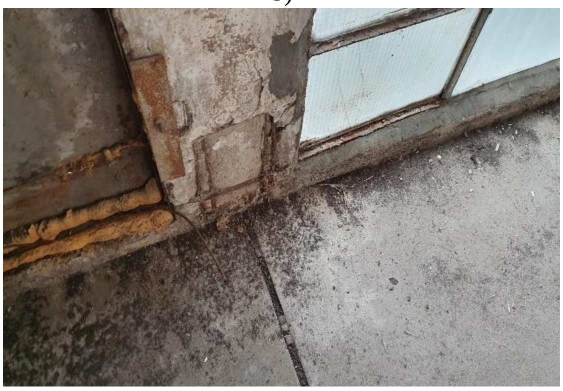

Photo 4: Grain Elevator building - level +7: a), b), c) division of the usable area with wooden partitions, d) falling off the concrete cover in the floor zone

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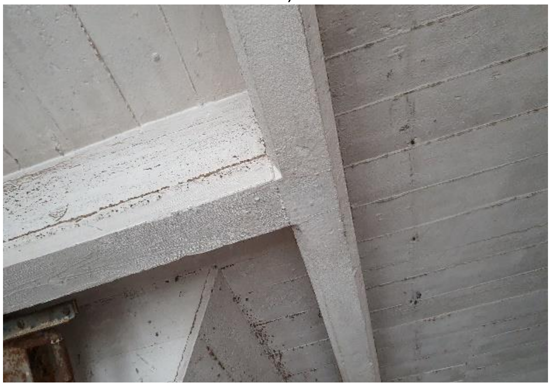
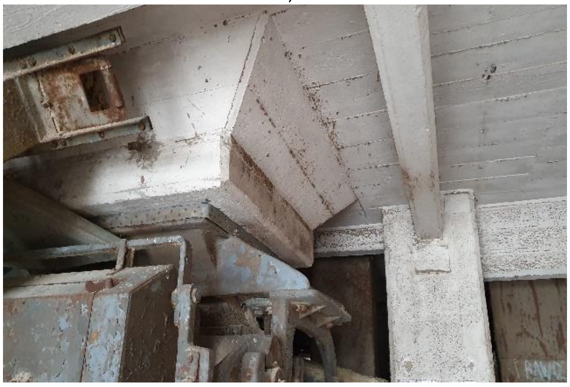
a) b)





a) b)

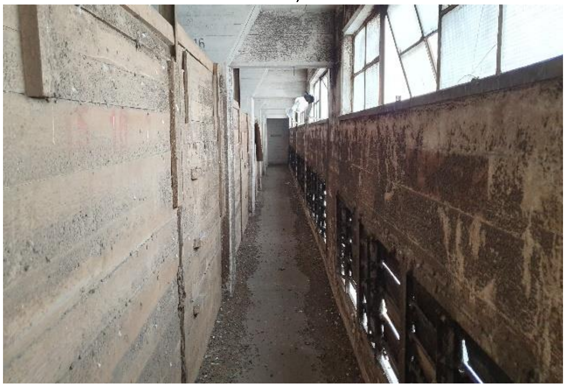
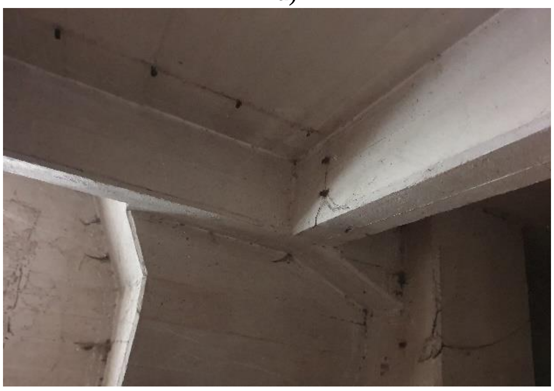
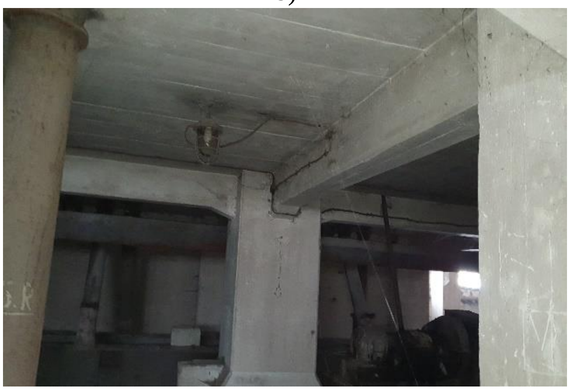


Photo 5: Grain Elevator building - level +5: a) mechanical damage to structural elements, b) equipment for transporting loose materials left inoperative and incomplete, decapitalization of: c) ventilation shutters, d) window joinery

a) b)





a) b)

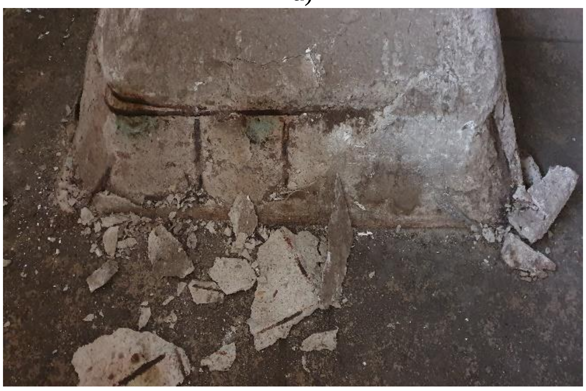


Photo 6: Grain Elevator building - level -1: a) mechanical damage to structural elements, floor zone: c) concrete cover falls off the column heads at the level of the foundation slab, d) moisture in the outer wall

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