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Analysis of cost-effectiveness of aircraft hangar reconstruction under new usability requirements

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Abstract: When evaluating the viability of construction investments related to reconstruction, the current value of individual building elements (taking into account the degree of wear and tear) should be assessed. However, the viability of reconstruction of building facilities is also influenced by the suitability of existing elements for new conditions of use in relation to repair needs, which is worth taking into account when making decisions on reconstruction of facilities. The analyzed case shows that the value of usable elements in an existing building facility is negligible in relation to adapting it to new requirements. As a result, deciding on reconstruction is economically unjustified - not profitable. It can be concluded that the cost of renovation works associated with reconstruction will be comparable or even higher than the cost of building a new facility. Moreover, the modernized facility will consist of many elements with significant technical and functional wear and tear, which will have inferior strength parameters than the solutions created in the case of new construction.

Keywords: cost-effectiveness of building conversion, technical condition, building reconstruction.

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1. Introduction

The analysis of the viability of construction investments related to existing building facilities conversion comes down to consideration a few elements. The first of them is designation of outlays related to the reconstruction and comparison them with the costs of building facility demolition and construction of a new one. On this basis, the decision can be made to carry out the reconstruction or to replace the existing facility with a new one, the alternative is to further exploitation of the facility while incurring for this purpose the necessary outlays and repair costs. The essential element allowing to make an economically justified decision is the technical assessment of the condition of the facility, taking into account wear and tear of individual elements [1,2]. Nowadays, the evaluation of the facility's condition can be combined with its inventory by using 3D scanning which allows direct measurements of selected elements of the geometry and definition of the deviation in relation to design dimensions [3]. In addition, when evaluating the viability of construction investments related to reconstruction, it is necessary to take into account the possible growth of the cost of renovation investments such as local demolition, rebuildings, adjustments and structural strengthening which will significantly impact on the cost-

effectiveness of restoring operational and usable capacities of the building [4]. During renovation works, there is a significant risk of additional costs resulting from works which could not have been predicted or planned [5].

General rules for determining the cost-effectiveness of renovations are not applied to historical objects. In the case of this type of buildings the most important thing is to preserve the historic character and architectural qualities [6,7]. Furthermore, there are legal restrictions related to the management of historic buildings and the preservation of their original state [8,9]. When renovating historic buildings, it is important to preserve original materials and workmanship techniques. There is a neccesity to limit interference with the original structure and appearance of the facility.

When assesing the viability of construction investments related to reconstruction, extension, modernization or renovation of building facilities, first of all, it is necessary to determine the degree of wear and tear of the building object in terms of technical, functional and environmental aspects. The building facility consists of a number of elements that perform various functions and therefore are made of materials with different technical properties corresponding to the purpose of the given element. The technical life of particular building elements might be less, equal or exceed the life of the building, technical wear and tear is determined by percentage based on the current technical condition. Taking into account the wear and tear of individual building elements, there is obtained the current value of the facility in relation to the object newly built, of course this concerns the period in which it was built without taking into account functional or environmental wear and tear.

2. Technical condition assessment of the facility

The facility analyzed for the cost-effectivness of the reconstruction is the aircraft maintenance and repair hangar built in the 70s last century. The structure includes the hangar hall with outhouses which pose independent structural systems linked functionally each other.

The hangar hall is made as a system of two steel truss frames which are seeded 21 metres apart. The frame span is 60 metres, whereas the frames transoms are supports for cantilevered roof lattice girders spaced every 6 metres. The roof trusses are stiffened spatially with vertical bracing along the side walls and horizontal bracing in the plane of the roof. On the lattice griders there are stacked I-section purlins at a spacing 1,5 m. The roofing is made of steel trapezoidal sheet over which mineral wool and hard fiberboard with felt roofing is laid. The general view of the roof structure from below is shown in Figure 1.

Fig. 1. The hangar roof structure.

The crane beam is attached to the lower belt of the main frame. The load capacity of the crane is 3,5 Mg. The colums of steel frames are set on reinforced concrete footings, posing a direct foundation. The hangar gate is steel segmented with dimensions: width 59,7 m, height 6,68 m. Above the gates and on the opposite gable over the outhouse there are installed polycarbonate rooflights in steel frames. The floor of the hall is concrete, divided by dilatation strips, laid on the substructure of sand ballast and backing concrete.

Side additions are single-story, the rear one is two-story. They are made as independent reinforced concrete structures with the use of prefabricated elements, founded on reinforced concrete footings. The outer and partition walls located on foundations, intermediate ceilings and flat roofs are made of prefabricated panels.

In 2011, the facility uderwent thermomodernization consisting in insulation using styrofoam panels and replacement of skylights with reinforced glass for aluminium showcases. Other works also included renovation of parts of office, technical rooms and sanitary facilities. Fragments of the central heating system were also replaced in some rooms.

The general condition of the facility corresponds to the state resulting from natural wear and tear of particular elements, with good maintenance management. Sample photographs of the condition of individual elements are shown in Figure 2.

Fig. 2. The condition of the facility: a) damage of the column of supporting structure, b) wall cracks, c, d) condition of the hangar floor, e, f) condition of the steel roof structure.

The evaluation of the technical condition is shown in Table 1, which presents the assessment of individual building elements taking into account the degree of technical wear and tear of each building component:

- the first column (1) lists the building elements,
- the second column (2) provides a brief decription of the technical condition of the element,
- the third column (3) specifies the percentage value of the element in relation to the value of the whole building newly erected,
- the fourth column (4) specifies the percentage value of the element in relation to the value of the entire newly constructed building after taking into account the degree of wear and tear; the sum of

the values in this column gives the answear to the question of what value the entire building represents in relation to the newly constructed building,

- the fifth column (5) shows the value of the building in relation to the use of its elements for the reconstruction in terms of new equipment.

The column (5) includes the need for additional work related to reconstruction of the hangar with regard to meeting new requirements. Among new requirements should be mentioned:

- a compressed air dispensing point at pressure up to 125 psi (8,62 bar),
- a crane with a lifting capacity of 5 Mg (the existing one has a lifting capacity of 3,5 Mg),
- an oil-resistant, anti-slip, anti-electrostatic, easily washable with epoxy covering floor,
- devices providing proper temperature and humidity on the maintenance plane as well as in the workshop rooms,
- additional fuel system service plane for new equipment positions.

Table 1. The assessment of the technical condition of building elements

No.	The element	Brief description of the technical condition	% value of the element in relation to the new building	% value of the element in relation to the current technical condition of the building	% value of the element in relation to the reconstruction needs
	1	2	3	4	5
1.	Foundations and earthworks	No signs of excessive subsidence and deformation, except for the wall on the substructure of the sewer failure place – medium/poor condition	8,5	5,1	1,5
2.	Waterproofing insulations	No signs of capillary rise and moisture in the lower part of the walls – good condition	0,5	0,42	**0,0**
3.	Steel hangar structure with crane	No signs of improper operation of the structure, no foci of corrosion, load capacity of the crane 3,5 Mg, lifting height 7,0 m – good condition	20,5	16,4	**0,0**
4.	Hangar roof structure	No signs of improper operation of the structure, no foci of corrosion; from the interview results that in case of large thickness of snow cover it is hampered to open the hangar gates – medium condition	4,0	3,0	**0,0**
5.	Hangar roof covering	Local leaks, it does not meet modern thermal insulation requirements – satisfactory condition	2,0	0,9	**0,0**

6.	Reinforced concrete structure of extensions	Cracks in walls, cracks at the joints of prefabricated elements and fillings, local subsidence of the wall on the washed-out foundation beam, too low thickness of reinforcement lagging of prefabricates – medium condition	13,0	6,5	4,0
7.	Ceilings and flat roofs of extensions	Traces of leaks, cracks in the lines of joining prefabricates, no signs of excessive deflection or deformation – good condition	1,5	1,2	0,5
8.	Roof covering of extensions	Lack of new traces of leaks, it does not meet modern thermal insulation requirements – satisfactory condition	1,0	0,45	**0,0**
9.	Interior plasters	Local cracks and blisters, part of rooms after renovation – medium condition	7,0	4,9	1,0
10.	Window and door joinery	New PVC window frames, door frames partially replaced – medium condition	6,5	4,16	**0,0**
11.	Hangar gates	Local general corrosion, no deformation – good condition	9,5	4,18	**0,0**
12.	Painting of walls and ceilings	Part of rooms renovated, in unrenovated rooms, among others, traces of leaks – satisfactory condition	1,5	0,66	**0,0**
13.	Hangar floor	Numerous cracks, local uneven subsidence – „keyboarding” of panels, exfoliated and uneven surface – poor condition	9,5	3,42	**0,0**

14.	Floors in extensions	Part of rooms with renewed floors, in part old damaged pavements – satisfactory condition	3,5	1,54	1,0
15.	Plumbing system	Efficient, lack of comprehensive sewage disposal system – medium condition	3,0	1,5	**0,0**
16.	Electrical system	Airport electric power system during modernization, efficient electrical network – medium condition	3,5	2,45	**0,0**
17.	Central heating system	Power supply to the facility after reconstruction, internal network after partial modification, not always consistent with regulations – medium condition	3,5	2,45	**0,0**
18.	Others	Associated installations (including fire protection), painting of signage etc. – satisfactory condition	1,5	0,63	**0,0**
		TOTAL	100	**58,16**	**8,5**

3. Analysis of the extent of reconstruction

In the event of making a decision to rebuild the facility, the following changes would have to be made to its various elements:

a) It is important to note the significant increase in loads on the foundation and on the load-bearing elements of the existing steel hangar structure. This is due to the growth in the value of loads from the crane and increasing in normative climatic loads as well as increase in the value of partial safety factors.
b) The existing steel hangar structure including the foundations would require reinforcement under new loads, which would be economically unjustified. The cost of making these reinforcements would be comparable to, or even higher than new construction while obtaining components with lower durability than new ones.
c) With a large thickness of snow cover on the hangar roof it is hampered to open its gates, hence it would be expedient to check the permissible thickness of snow cover in terms of the safety of use of the existing building. The legitimacy of replacing or reinforcing the lattice girders of the existing roof construction is similar to the rest of the steel hangar structure.
d) The reinforced concrete structure of the extensions would require repairs and reinforcements, especially in the case of single-story additions for which would be necessary to build a superstructure along with the need to replace layers of thermal insulation and roof covering due to current applicable code requirements.
e) The window and door joinery of the existing hangar requires replacement due to both reduced thermal insulation parameters and due to recommended resistance to surge pressure; the hangar gates are classified for replacement due to technical and functional wear and tear.
f) Due to the previously described requirements for the floor surface finish and the extent of the occuring damages, the whole floor is qualified for replacement. The costs of milling the damaged and uneven top layer, „stitching" the existitng cracks and rebuilding the milled layer with the required fusion to the new layer will exceed the costs of making a new floor. Additionally, the floors in the hangar extensions are eligible for replacement, this applies to unrenovated rooms.
g) The entirety of living and maintenance facilities needs to be replaced due to required new parametres related to the increase in the numer of hangar attendants as well as requirements of the new equipment.

In Table 1 the last of the columns assesses the total value of the facility on the basis of the value of its individual elements in terms of its adaptation to new conditions of use. Most of elements have zero value within the context of possibility of adapting them to their needs and requirements to be met by this building facility after reconstruction.

4. Conclusions

When evaluating the viability of construction investments related to reconstruction, the current value of individual building elements (taking into account the degree of wear and tear) should be assessed. However, the legitimacy of reconstruction of building facilities is also influenced by the suitability of existing elements for new conditions of use in relation to renovation needs, which is worth taking into account when making decisions on reconstruction of facilities.

The analyzed case shows that the value of usable elements in an existing building facility is negligible in relation to adapting it to new requirements. Therefore, making a decision on reconstruction is economically unjustified - unprofitable. It can be concluded that the costs of renovation works connnected with reconstruction will be comparable or even higher than the costs of building a new facility. Moreover, the modernized facility will consist of many elements with significant technical and functional wear and tear, which will have inferior strength parameters than the solutions created in the case of new construction.

Due to use requirements of the new equipment and functional wear and tear of the existing hangar it is not cost-effective to reconstruct the facility.

In addition, the reconstruction of facilities is associated with lots of threats which are difficult to predict at the stage of preparing this venture for implementation [10]. Combining fit for further use in the facility individual elements of an existing building with a newly erected facility makes construction works more difficult and longer and the end result will not be equivalent to the usable effect – which is obtained when a new facility is built that meets modern requirements.

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