CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

No. 9 2012

INTERDEPENDENCE OF BUILDING ELEMENTS IN THE ANALYSIS OF REPAIR

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The paper presents a comparative analysis of the results of the evaluation of technical wear of residential buildings situated in Żary (a town in Lubuskie Voivodship) with the results of calculated percentage values of wear for the same buildings carried out with the use of time methods. The real technical wear of the buildings occurred to be much more advantageous than the one obtained with the help formulas derived from the time methods. An attempt was also made to determine any correlations between the technical wear of the structural elements of buildings erected in a traditional way and the technical wear of their finishing elements.

Keywords: technical wear, technical wear evaluation, repair needs

1. DESCRIPTION OF RESEARCH OBJECTS

The paper presents the analysis of the evaluation of technical wear of one hundred and sixty 90-year-old residential buildings. The buildings situated in Żary (a town in Lubuskie Voivodship).

The applied building materials and the structural solutions are similar in all the buildings. The masonry walls were made of solid bricks; the floors over the ceilings – masonry, Klein type; the remaining floors – wooden beams; the stairs an the roof structure – wooden, rafter framing – purlin-collar-tie type and in some cases – collar-beam type; roofing – flat tiles or roofing paper.

In order to obtain homogeneous research material, the buildings have been divided into two groups: Group I – includes buildings with inhabited attics, wooden rafter framings and flat tile roofing; Group II – buildings with flat roofs covered with roofing paper.

The technical states of all the buildings were periodically inspected by experts in 2012.

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2. RESULTS OF TECHNICAL WEAR OF THE BUILDINGS

The periodic monitoring, according to article 62 of the Act - Building Law, is the basic responsibility of the building manager and the owner, and the realisation of the follow-up recommendations is the basis for the building proper exploitation. The periodic monitoring, consisting in the examination of technical wear, resulted in the reports [2] containing the information on the percentage wear of 25 components of the 90-year-old buildings. The values of technical wear were determined according to the metric criteria given by W.Winniczek [5].

The results of the technical wear carried out in 2012 are listed in Table 1.

Table 1. Percentage values of technical wear of the selected building components

Selected components of a building		Mean value of technical wear of elements in the examined buildings	Standard deviation
Masonry walls	group I	37,93 %	8,93
	group II	39,10 %	9,04
Wooden floors	group I	39,44 %	10,42
	group II	39,96 %	10,92
Wooden stairs	group I	38,12 %	9,24
	group II	38,46 %	9,70
Timber roof structure	group I	39,96 %	12,24

On the basis of the numerical data, included in the reports, it can be stated that the durability periods of particular elements are longer than the ones given in the bibliography. What is more, the low values of the rate of wear of the components of the 90-year-old buildings reveal imperfections of the equations applied according to the time methods.

The analysis of the wear of the load bearing walls, which was carried out according to the systematically estimated percentage values, resulted in the calculation of an average value:

Group I – 37.93 % with the standard deviation 8.93,

Group II – 39.10 % with the standard deviation 9.04.

According to the formulas of the theoretical time methods, the wear rate of the 90-year-old building should range between 70 – 90%. The values obtained for the existing, examined buildings have not exceeded 40%.

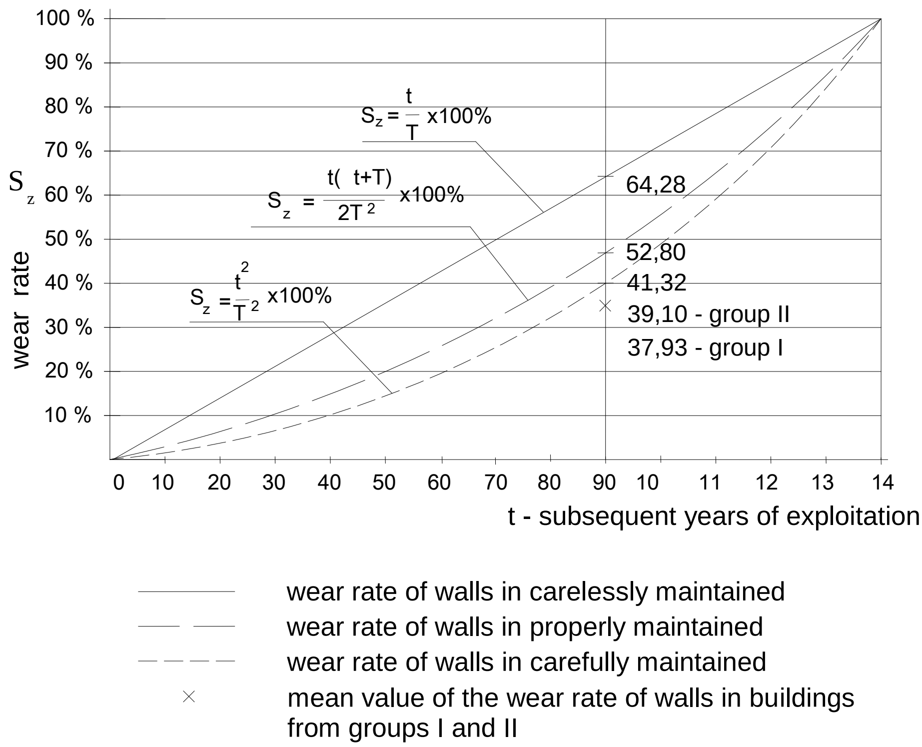

Fig. 1. Comparison of average results of technical wear of masonry walls in the examined buildings with the ones obtained from formulations of time methods

The durability period of the wooden floors is given in the bibliography as 60 -80 years. In the examined 90-year-old buildings, the wear rate in 2012 was estimated 39.44% for buildings in Group I, and 39.96% for Group II. Thus theoretically, the wear rate should amount 100%, whereas the obtained mean value which amounts about 40% – varies considerably.

By the analysis of the results for the rafter framing, a mean value 39.96 % has been obtained, with the standard deviation 12.24. It indicates the divergence of the results, which is due to the repairs carried out in some of the buildings, which included the repairs to the rafting frame and the replacement of the roofing.

Percentage values of technical wear of walls in the 90th year of exploitation calculated with the use of theoretical formulations used in time methods amount:

- in buildings carelessly maintained – 64.28%

- in properly maintained buildings – 52,80%,
- in carefully maintained buildings – 41,32 %.

Time methods determining the technical wear base on two parameters: the prediction of durability time T and the building current age t. The methods are to a large degree simplifications. The obtained results indicate the necessity of further research to determine the durability of building materials more realistically.

3. TECHNICAL STATE OF ELEMENTS CONDITIONED BY TECHNICAL WEAR OF OTHER ELEMENTS

The required values of building utility are conditioned by their proper maintenance and repairs. A considerable degree of wear in the examined buildings was the result of the presence of moisture in structure elements, which occurred due to the leaks in roofs, gutters and downpipes as well as to the lack of insulation of foundations and basement walls. The persistent lack of maintenance and repair of the damaged elements contributes to the further process of the building deterioration.

Z. Ściślewski in [2] proposes a division of buildings into particular parts:

- permanent elements (foundations, bearing walls, ceilings), durability period of which is longer than the assumed durability of the building itself, minor repairs are required,
- replaceable elements (floors, carpentry, external and internal plasters, fittings), partial repairs or total replacement of the components are required,
- repairable elements (electrical and sanitary installations, coats of paints), total replacement of such elements is required.

The permanent elements will be in a better condition if the required repairs of the replaceable and repairable components are carried out in the due time. The mutual relations between the components are also an essential factor conditioning their technical state.

The technical state of a building is conditioned by the susceptibility of its components to the damaging influences of the other components. The coefficient of the relation between the components r_{SzASzB} is the measure of the damaging reactions between elements A and B.

3.1. Interrelationship between the technical state of the timber roof structure and a roof covering

The author carried out a comparative analysis of the technical state of the interrelated components. The relation between the degree of technical wear of a timber roof structure and a roof covering was examined.

The coefficient of the correlation between components was determined with the use of linear Pearson correlation [4]:

$$r_{xy} = cov(X, Y) / \sigma_x\sigma_y \tag{3.1}$$

r_{xy} - correlation coefficient,
cov(x,y) - covariance, a digit denoting a linear relationship between random variables x and y,
$\sigma_x\sigma_y$ - standard deviation.
Where:

$$cov(X,Y) = E(X\cdot Y) - EX\cdot EY \tag{3.2}$$

E - denotes the expected value.

For correlation between the degree of technical wear of a timber roof structure and a roof coating, formula (3.1) takes the form:

$$r_{SzAB} = \frac{\sum_{i=1}^{n}(SzP_i - \overline{SzP})(SzK_i - \overline{SzK})}{\sqrt{\sum_{i=1}^{n}(SzP_i - \overline{SzP})^2 \sum_{i=1}^{n}(SzK_i - \overline{SzK})^2}} = \frac{\sum_{i=1}^{n} SzP_i SzK_i - \overline{SzP}\,\overline{SzK}}{\sqrt{(\frac{1}{n}\sum_{i=1}^{n} SzP_i^2 - \overline{SzP}^2)(\frac{1}{n}\sum_{i=1}^{n} SzK_i^2 - \overline{SzK}^2)}} \tag{3.3}$$

Where:

$\overline{SzP}, \overline{SzK}$ - respective averages:

$$\overline{SzP} = \frac{1}{n}\sum_{i=1}^{n} SzP_i, \quad \overline{SzK} = \frac{1}{n}\sum_{i=1}^{n} SzK_i \tag{3.4}$$

r_{SzPSzK} - correlation coefficient between the degree of technical wear of a timber roof structure and a roof coating,
$\overline{SzP}$ - average value of the degree of the roof coating's wear,
$\overline{SzK}$ - average value of the degree of the timber roof structure wear.
$\overline{SzP}$ = 46.28 % for standard deviation 13.95,
$\overline{SzK}$ = 39.96 % for standard deviation 12.24.

Coefficient r_{SzPSzK} may take the values from -1 to 1; the greater its absolute value, the stronger relationship between the variables. When the coefficient equals 0.00, it indicates the lack of the mutual relationship.

The obtained value of coefficient r_{SzPSzK} for the examined buildings equals 0.573. It may be stated that the degree of technical wear of the timber roof structure partially depends on technical wear of the roof coating.

3.2. Interrelation between technical wear of a timber roof structure and technical wear of gutters and downpipes

The analysis of the relationship between technical wear of a timber roof structure, expressed in percentage points, and the technical wear of gutters, downpipes, and roof flashings was carried out analogously.

$$R_{SzOSzK} = \frac{\sum_{i=1}^{n}(SzO_i - \overline{SzO})(SzK_i - \overline{SzK})}{\sqrt{\sum_{i=1}^{n}(SzO_i - \overline{SzO})^2 \sum_{i=1}^{n}(SzK_i - \overline{SzK})^2}} = \frac{\sum_{i=1}^{n} SzO_i SzK_i - \overline{SzO}\,\overline{SzK}}{\sqrt{\left(\frac{1}{n}\sum_{i=1}^{n} SzO_i^2 - \overline{SzO}^2\right)\left(\frac{1}{n}\sum_{i=1}^{n} SzK_i^2 - \overline{SzK}^2\right)}} \tag{3.5}$$

r_{SzOSzK} - coefficient of the correlation between the degree of technical wear of the timber roof structure and the degree of technical wear of roof flashings, gutters and downpipes,

SzO - mean value of the degree of technical wear of roof flashings, gutters and downpipes,

$\overline{SzK}$ - mean value of the degree of technical wear of the timber roof structure.

SzO = 41.47 % for the standard deviation 13.67,

SzK = 39.96 % for standard deviation 12.24.

The correlation coefficient was calculated and amounted 0.036. The value of the coefficient close to zero indicates an inconsiderable correlation between the technical state of gutters and downpipes on the one hand and the technical state of the roof structure.

3.3. Interrelation between the technical state of external walls and external plasters

Also relations between the technical state of the external walls and the technical state of the external plasters were analysed. The correlation coefficient was determined according to formula:

$$r_{SzTSzS} = \frac{\sum_{i=1}^{n}(SzT_i - \overline{SzT})(SzS_i - \overline{SzS})}{\sqrt{\sum_{i=1}^{n}(SzT_i - \overline{SzT})^2 \sum_{i=1}^{n}(SzS_i - \overline{SzS})^2}} = \frac{\sum_{i=1}^{n} SzT_i SzS_i - \overline{SzT}\,\overline{SzS}}{\sqrt{(\frac{1}{n}\sum_{i=1}^{n} SzT_i^2 - T)(\frac{1}{n}\sum_{i=1}^{n} SzS_i^2 - \overline{SzS^2})}} \quad (3.6)$$

r_{SzSSzT} - correlation coefficient between the technical state of external walls and the technical state of external plasters,

$\overline{SzS}$ - mean value of the degree of the technical wear of external walls,

$\overline{SzT}$ - mean value of the degree of technical wear of external plasters.

$\overline{SzS}$ = 37.93 % for standard deviation 8.93,

$\overline{SzT}$ = 38.08 % for standard deviation

The correlation coefficient was calculated r_{SzTSzS} and equalled -0.110. It indicates the fact that the technical state of walls depends on plasters, but only in an inconsiderable extent, approximately 11-percent.

4. CONCLUSIONS

Any damages to the buildings performed in a traditional technology are caused by various reasons. Apart form the natural material wear, damaging influence of atmospheric processes, topographic factors, mistakes in projects, various kinds of natural disasters, there is also one essential factor resulting in the building damaging – which is the abandoning of the repairs and overhaul activities. During the exploitation period, current repairs and overhauls consisting in the removal of any flaws should be performed.

The technical state of components in a building is conditioned by the degree of wear of other components. The obtained correlation coefficients between the technical states of the selected components confirm the thesis. The obtained correlation coefficients do not reveal a tight relationship between the technical states of building components. They indicate though, needs and demand for the repair of the finishing elements. The correlation coefficients provide information on the influence of the technical wear of finishing elements on the technical state of structure elements.

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WSPÓŁZALEŻNOŚĆ ELEMENTÓW BUDYNKU W ANALIZIE POTRZEB REMONTOWYCH

S t r e s z c z e n i e

Poszukiwanie skutecznych metod programowania działalności remontowej budynków mieszkalnych wymaga określenia potrzeb naprawczych. Potrzeby te wynikają przede wszystkim z postępu zużycia poszczególnych elementów składowych budynku. W artykule przedstawione są wyniki oceny stanu technicznego budynków mieszkalnych w Żarach (miasteczko w woj. lubuskim) wykonanych w technologii tradycyjnej. Stopień zużycia tych budynków okazał się bardziej korzystny niż uzyskany z obliczeń według wzorów metod czasowych. Wartości liczbowe zawarte w protokołach kontroli okresowych wskazują, że budynki są w lepszym stanie technicznym niż wynikałoby to z obliczeń zgodnie z wzorami. Fakt ten stanowi kolejny przykład wątpliwości zawartych we wzorach. W artykule przedstawione są także wyniki analizy wpływu stanu technicznego elementów w budynku na stopień zużycia innych elementów. Podjęta została próba ustalenia korelacji między stanem technicznym elementów wykończeniowych a stanem technicznym elementów konstrukcyjnych. Otrzymane współczynniki korelacji wskazują na potrzeby remontowe elementów wykończeniowych budynku, stanowią podpowiedź na temat wielkości wpływu stanu technicznego elementów wykończeniowych na elementy konstrukcyjne budynku.