INFLUENCE OF WEAR ON BUILDING – LIFETIME

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Summary

An existing lifetime of buildings leans mostly against table values which are published either in legislation or in next special publications. However, in more cases the real lifetimes do not correspond to these table values – sometimes they are shorter (e.g. at wooden buildings) or the contrary longer (e.g. at historical, massive but also at panel buildings) in the dependence on depreciation of building in consequence of their wear. But this dependence was not cleared up by now. From this reason it is necessary to analyse the depreciation of buildings on the basis of their maintenance rate.

Keywords: Depreciation of buildings, maintenance rate, wear, lifetime, age of building, initial value, lifetime remainder, wear measure.

1 Depreciation of buildings on the basis of their maintenance rate

Buildings can be divided from point of their maintenance rate into three groups:
- Badly maintained
- Normally maintained
- Very well maintained

1.1 Badly maintained buildings

This group proves linear course of depreciation (**Fig.1**) according following relation:

$$W = \frac{A}{L} \tag{1}$$

W wear in given moment,
A age of building in given time,
L lifetime of building

1.2 Normally maintained buildings

It is possible to use for calculation this Unger´s formula with the graph on the **Fig. 2**:

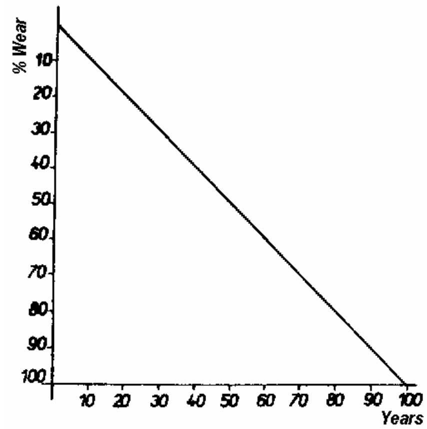


Fig. 1 Wear course of buildings during bad maintenance

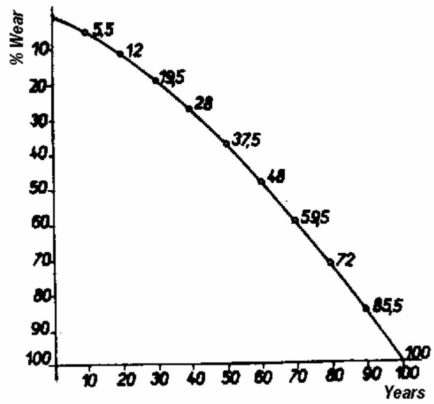


Fig. 2 Wear course of buildings during normal maintenance

$$W = \frac{A+L}{2.L^2}.A \tag{2}$$

1.3 Very well maintained buildings

The calculation is realized according to following relation with the graph on the **Fig.3**:

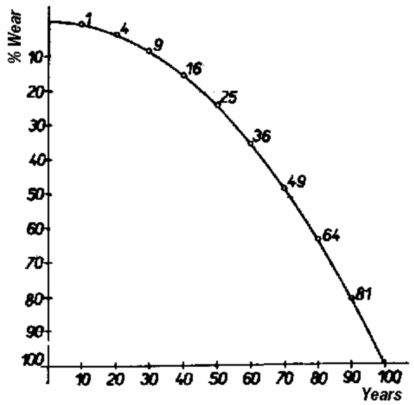


Fig. 3 **Fig.3** Wear course of buildings during very well maintenance

$$W = \frac{A^2}{L^2} \tag{3}$$

All graphs on the **Fig. 1-3** are considered for the comparison in the same time intervals 100 years. Because coefficients during bad maintenance are for their simplicity easy ascertainable from linear course the coefficients will presented in following 4 tables (**Tab. 1-4**) only for normal (**Tab. 1, 2**) and very well good maintenance (**Tab. 3, 4**). The values of coefficients are given up to 10 and 15 years per one year (**Tab. 2, 4**), in other cases per 10 years. The shorter this assessed time will be the more precisely coefficients of depreciation can be determined. For simplicity these tabulated values can be interpolated in meantime.

Tab. 1 Depreciation coefficient of normally maintained buildings of various lifetimes per 10 years

Lifetime of building	Lifetime of buildings [years]								
	100	90	80	70	60	50	40	30	20
10	0,055	0,062	0,070	0,082	0,096	0,120	0,156	0,221	0,370
20	0,120	0,136	0,156	0,184	0,221	0,280	0,375	0,555	1,000
30	0,195	0,260	0,254	0,305	0,375	0,480	0,660	1,000	
40	0,280	0,320	0,372	0,450	0,550	0,710	1,000		
50	0,375	0,432	0,506	0,610	0,760	1,000			
60	0,480	0,556	0,655	0,800	1,000				
70	0,595	0,690	0,820	1,000					
80	0,720	0,840	1,000						
90	0,855	1,000							
100	1,000								

Tab. 2 Depreciation coefficient of normally maintained buildings within 10 and 15 years per 1 year

Lifetime of building	Lifetime of buildings [years]							
	1	2	3	4	5	6	7	8
10	0,055	0,120	0,195	0,280	0,375	0,480	0,590	0,720
15	0,032	0,067	0,107	0,152	0,200	0,252	0,310	0,370
Lifetime of building	**Lifetime of buildings [years]**							
	9	**10**	**11**	**12**	**13**	**14**	**15**	
10	0,855	1,000						
15	0,430	0,5000	0,570	0,650	0,725	0,810	1,000	

Tab. 3 Depreciation coefficient of very well maintained buildings of various lifetimes per 10 years

Lifetime of building	Lifetime of buildings [years]								
	100	90	80	70	60	50	40	30	20
10	0,055	0,012	0,015	0,020	0,027	0,040	0,063	0,110	0,250
20	0,040	0,049	0,063	0,081	0,110	0,160	0,250	0,440	1,000
30	0,090	0,100	0,141	0,183	0,250	0,360	0,560	1,000	
40	0,160	0,197	0,250	0,326	0,440	0,640	1,000		
50	0,250	0,3000	0,390	0,510	0,694	1,000			
60	0,360	0,440	0,563	0,734	1,000				
70	0,490	0,6000	0,765	1,000					
80	0,640	0,790	1,000						
90	0,810	1,000							
100	1,000								

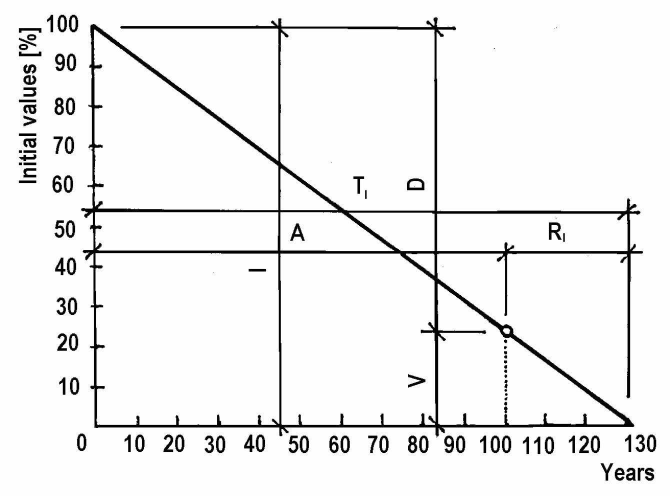
Tab. 4 Depreciation coefficient of very well maintained buildings within 10 and 15 years per 1 year

Lifetime of building	Lifetime of buildings [years]							
	1	2	3	4	5	6	7	8
10	0,010	0,040	0,090	0,160	0,250	0,360	0,490	0,640
15	0,004	0,017	0,040	0,071	0,110	0,160	0,217	0,284
Lifetime of building	**Lifetime of buildings [years]**							
	9	**10**	**11**	**12**	**13**	**14**	**15**	
10	0,810	1,000						
15	0,360	0,440	0,537	0,640	0,751	0,871	1,000	

As long as this point of view is corrected by technical view that better maintenance of structures and structural parts results in the reduction of their natural aging. On the contrary a neglected maintenance reduces this lifetime which is to show also on the value of building in every case. Besides, the lifetime of building is possible to regulate by calculated maintenance.

2 Derivation of relations for the building depreciation by influence of bad maintenance

The maintenance work can influence a lifetime of building in different measure. The course of linear building – depreciation with the total lifetime 130 years is demonstrated on the **Fig. 4**. Than the assumption is bad maintenance of building in which consequence initial costs and depreciation are given in percentages. If we install the following symbols:



A	age of building (**n** years)
V	value of building
D	depreciation value
I	initial value of building
R_l	remainder of lifetime
T_l	theoretical lifetime

Fig. 4 Fundamental relations at linear maintenance of building

than it is possible to derive from fundamental propositions about triangle resemblance the following relations:

- between the original initial value of building and the lifetime and between the depreciation in given time and the age of building:

$$I : T_l = D : A \tag{4}$$

- between the original initial value of building and the moment value and between thr theoretical lifetime and its remainder of lifetime:

$$I : V = T_l : R_l \tag{5}$$

- in addition between the value of depreciation and the initial value of building and between the age of building and its theoretical lifetime:

$$D : I = A : T_l \tag{6}$$

Elementary relations resulting from individual relations will be than:

$$I = D + V$$
$$V = I - D$$

$$D = I - V \tag{7}$$
$$T_l = A + R_l$$
$$R_l = T_l - A$$

We get the value of building V at the linear course of wear from the relation (7) and (6) as:

$$V = I - D = I - I.\frac{A}{T_l} = I.\left(1 - \frac{A}{T_l}\right), \tag{8}$$

where

$$D = I.\frac{A}{T_l} \tag{9}$$

The fraction $\frac{A}{T_l}$ derived from the relation (6) is at the same time a function of time **y = f (x)** according to that the depreciation of building runs. This function gets for different rate of maintenance rate of these forms:

1. for bad maintenance 2. for normal maintenance 3. for very well maintenance

$$f(x) = \frac{A}{T_l} \qquad f(x) = \frac{A + T_l}{2.T_l^{\,2}}.A \qquad f(x) = \frac{A^2}{T_l^{\,2}} \tag{10}$$

It is possible to determine directly at non-linear course a formula for the value of depreciation D during normal maintenance in the form:

$$D = I.f(x) = I.\frac{A.T_l + A^2}{2.T_l^{\,2}} \tag{11}$$

After the substitution of relation (11) into the formula **V = I – D** we get for a value of building V the following expression:

$$V = I.\left(1 - \frac{A.T_l + A^2}{2.T_l^{\,2}}\right) \tag{12}$$

Analogously it is possible to obtain by the calculation the following data for a very well maintained building:

$$D = I.f(x) = I.\frac{A^2}{T_l^{2}} \tag{13}$$

$$V = I.\left(1 - \frac{A^2}{T_l^{\,2}}\right) \tag{14}$$

We start from in advance determined theoretical lifetime of building in all calculations. However, we can determine several relations for the calculation of other facts which are applied on the one hand for intercalculation in practice but which on the other hand help us at the calculations of the maintenance – influence on the lifetime of building. In this way it is possible to determine these formulae from the fundamental relations:

a) for the calculation of lifetime – remainder:

$$R_l = \frac{V.T_l}{I} \tag{15}$$

b) for the calculation of original initial value:

$$I = \frac{D.T_l}{A} \tag{16}$$

c) for the calculation of building – lifetime:

$$T_l = \frac{I.A}{D} \tag{17}$$

d) for the age of building:

$$A = \frac{D.T_l}{I} \tag{18}$$

3 Conclusions

As long as the individual values will substitute into these formulae according to the fundamental relations valid for the depreciation at different maintenance it is possible relatively quickly to execute some calculations-back. These calculations-back are applied especially for the determination time about which:

- a lifetime of building reduces in consequence of failure or bad maintenance, eventually without maintenance,
- a lifetime of building extends in consequence of timely and first-quality maintenance,
- a lifetime changes in consequence of rebuilding, modernization etc.

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References

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