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Original Paper

Comparison of daylighting in the original and reconstructed housing buildings

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ABSTRACT

The contribution is aimed at the comparison of daylighting in the original and reconstructed housing buildings. On the basis of the measurements of daylighting we calculated the values of the daylight factor in both stables. The distribution of the measuring points in the stables was different. In the original stable were two rows of measuring points, in the reconstructed stable were four rows of measuring points. The course of lighting at the measuring points was shown in program Excel using graphs. The values of the daylight factor were compared in each row in both stables using Scheffe′s test (ANOVA) and box-plot. The results show that lighting in the reconstructed building has increased significantly. The statistical analysis of the results showed that significant difference is not between the rows in which the illuminance measured ($P > 0.05$) in spite of assumption the lighting under the skylight will certainly be higher. This is caused especially inappropriately selected measuring points. There are in reconstructed stable significant differences in illuminance between the rows, that were under the skylight and rows that were located near the open side walls ($P < 0.05$). Daylighting is significantly higher under the skylight ($P > 0.05$).

KEYWORDS: daylight factor, daylighting, dairy stable, Scheffe′s test, F test

JEL CLASSIFICATION: C10

INTRODUCTION

The lighting is one of the basic factors of work environment but also stable environment. It affects not only man and his work performance, but also livestock. The sufficient light in the stable is a prerequisite for a smooth and safe work process and is necessary for animal control and care [4]. Animals need plenty of light to be able to navigate to places to feed, lying and the like. It is important for animals to see themselves, to know each other and to avoid one another [2]. According to [8], cattle are sensitive to light intensity.

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According to [3] proper lighting is an environmental factor that is often overlooked, or given little attention during the planning, construction, and maintenance of livestock facilities. However, it is just as important to the efficient operation of a livestock as ventilation, heating, or cooling. Autors [1] analyzed the lighting and the effects of day length, the daily change in day length, and heat load prevailing on test days, and on milk yield and composition of dairy cows in hot weather. The difference of 4 hours between the shortest and the longest day, plus the seasonal change in day length, accounted for the addition of 1.9 kg of milk/day for cow calving after the shortest day compared with cow calving after the longest day.

The work is aimed at monitoring of daylighting in the original and reconstructed building.

MATERIAL AND METHODS

The subject of the research was two housing buildings for dairy cows with free housing in Oponice. One building was in the original state with dimensions of ground plan 66.9 x 27.7 m. Dairy cows were housed in it in four rows of boxes. Daylighting of stable was secured by window openings that were placed in the side walls of stable. 34 windows were on each side with dimension 900 x 900 mm. Skylight was located on the ridge of a roof. Ground dimensions of the skylight were 54 x 2.4 m. The second building underwent an extensive reconstruction, where the side walls of the stable between columns made a hole in and replaced with low wall with height 600 mm. The space between columns was filled with net against flying of birds. Simultaneously, the net was used as a supporting reinforcement against the vibrating of the plastic blind. The plastic blind was used only exceptionally, mostly in winter. Hereby the side walls opened up completely.

The daylighting assessment was performed in the stables using the daylight factor DF (%). We were calculated these values from the measured values of the internal illuminance E (lx) in the individual measurement points and simultaneously measured values of the external comparative illuminance E_h (lx). According to standard STN 36 0088 [7], minimal value of DF = 1 % for dairy cows with loose housing.

The measurements were made by two identical lux-meters Testo 545. The measurement points in both stables are shown in Figures 1-4. The rows of measurement points in the original stable are shown in Figure 1 (CH1 and CH2) and in the reconstructed stable in Figure 3 (K1, K2, S1, S2). The values of the daylight factor were graphically evaluated in programme Excel. The assessment of daylighting factor values was performed in Statistica 7 using the F test and the Scheffe′s Post hoc test (ANOVA), where were evaluated differences in daylighting in individual parts of stable in both stables.

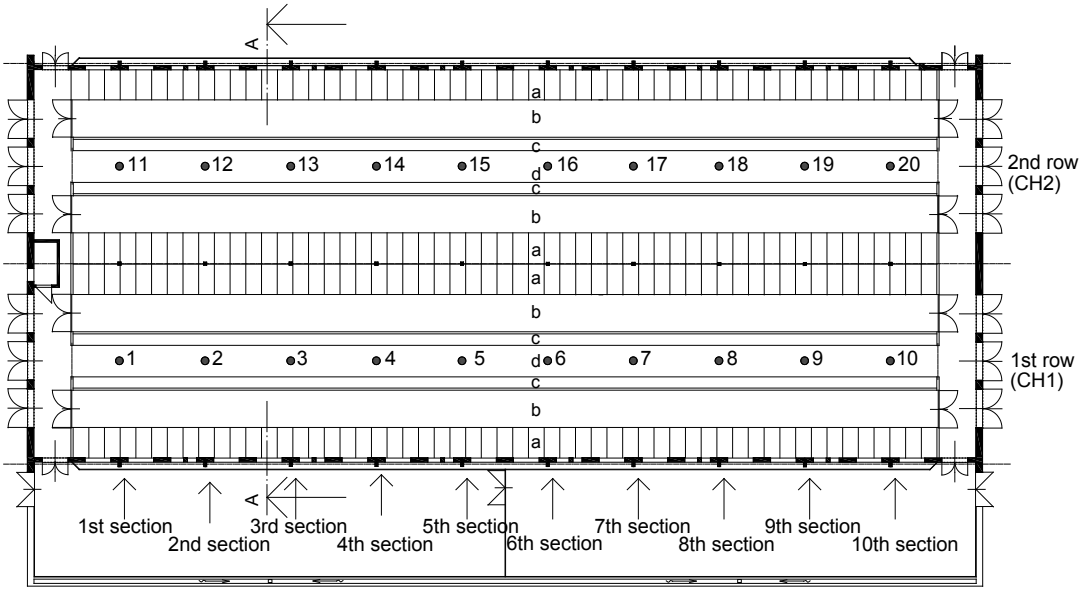

Figure 1 Ground plan of the housing building in the original housing building
a – cubicles, b – manure corridor, c – feeding trough, d – feeding passage, •1 – measurement points

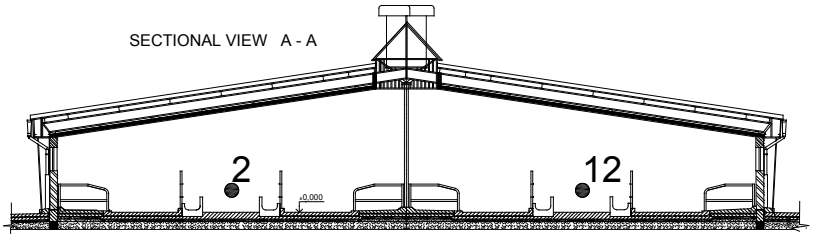

Figure 2 Cross-section of the housing building in the original housing building

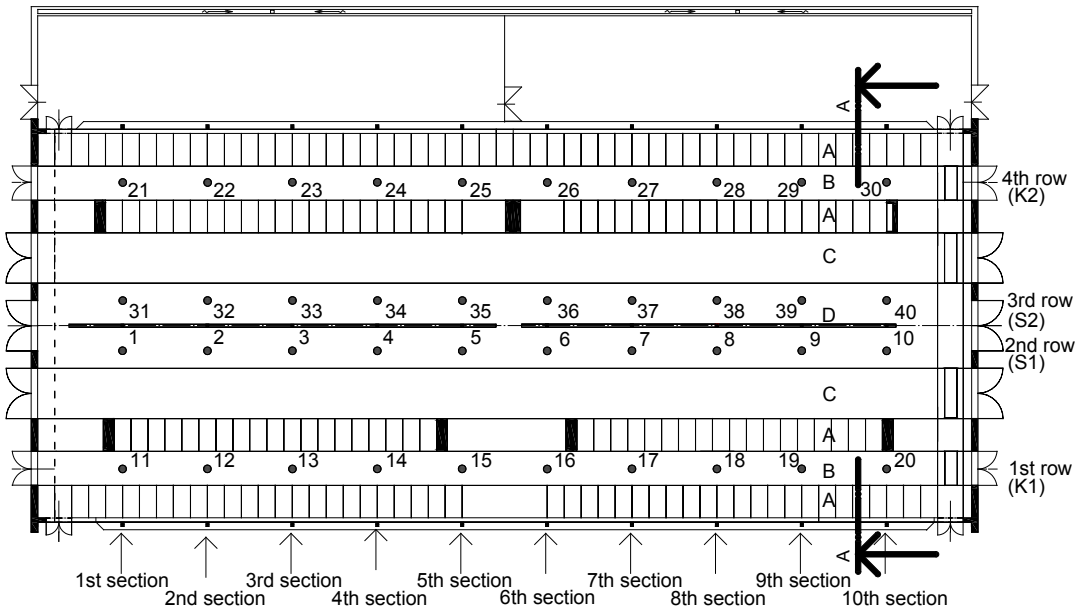

Figure 3 Ground plan of reconstructed housing building
A – cubicles, B – manure corridor, C – feeding area (with liquid manure), D – feeding passage,
•1 – measurement points

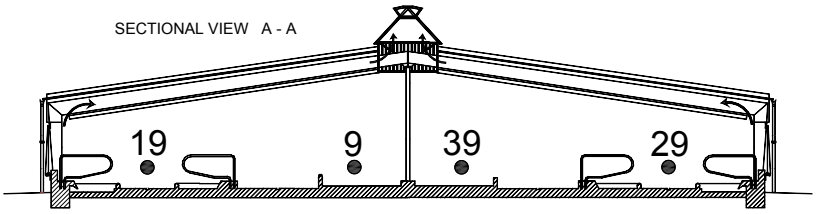

Figure 4 Cross-section of reconstructed housing building

RESULTS AND DISCUSSION

Despite the fact, that the original stable has on the roof construction skylight and gates in the front walls of the stable were open, thanks to also what daylight were in the stable, DF did not reach in any part of the stable required value. Values DF approximated to this value just at the open gates (1st section, Fig. 5). The average DF value was only 0.36 %. This value is low not only for animals but also for nursing work environment. The course of daylight factor values at the measurement points in the rows CH1 and CH2 is shown in Figure 5.

If the ridge slit has a sufficient width, it allows better light entry as windows on the external walls, because the light from the top is better and more intense distributed in the space, but the open side walls can exceed these values. The open stables often provide stronger light compared to open ridges, which are often undersized [6]. After the side walls have been removed, the illumination of the stable has increased considerably and thus the value DF. We take into account the state when the plastic blind has been pulled out. The low DF values were only at the measurement points, where the stable adjoins with milking parlor, which shadows the stable. DF did not reach the desired values at these locations. The course of daylight factor values at the measurement points in the rows K1, K2, S1 and S2 is shown in Figure 6.

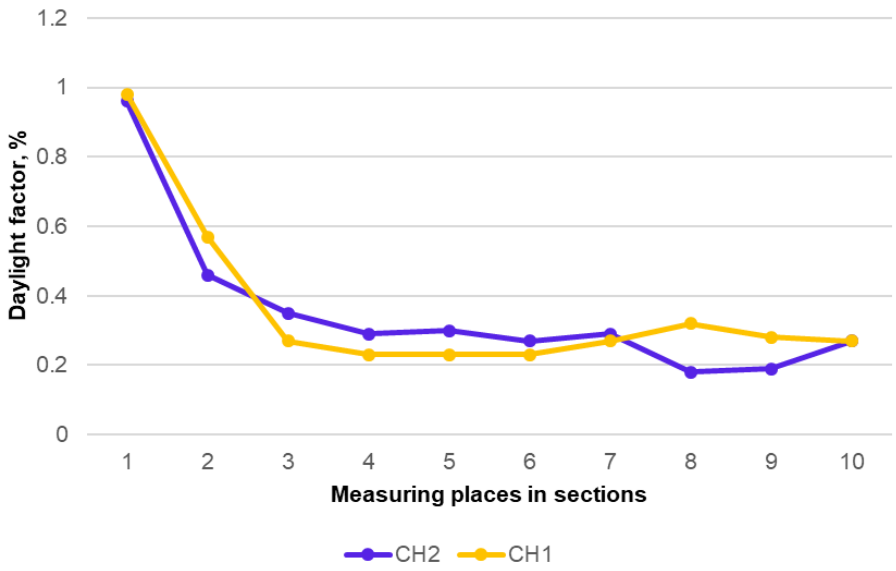

Figure 5 Daylight factor values in the original stable

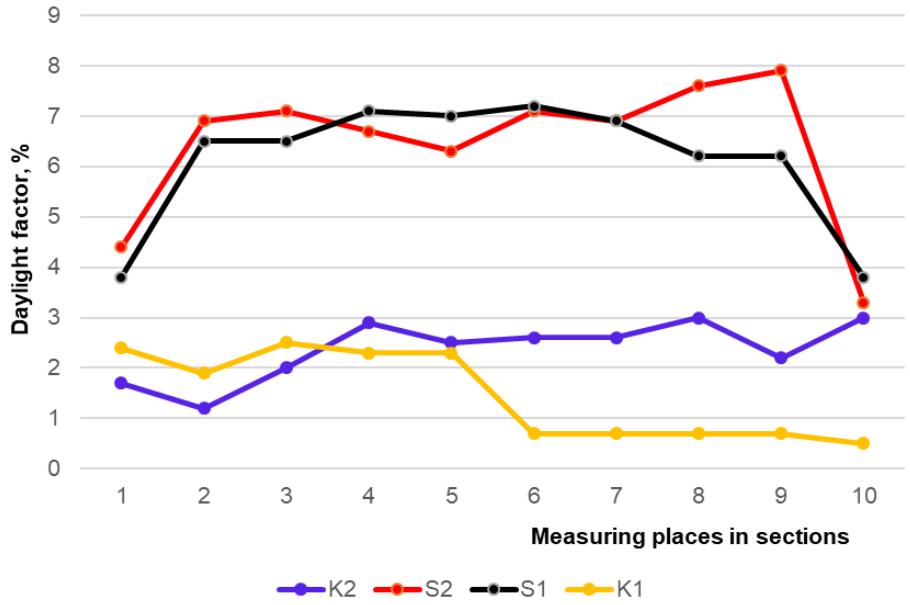

Figure 6 Daylight factor values in the reconstructed stable

Tables 1 through 3 present the descriptive statistics. In Table 1 are the basic parameters of researched daylight factor values in original stable in each row. In Table 2 are the basic parameters of researched daylight factor values in reconstructed stable in each row. In Table 3 are the basic parameters of researched daylight factor values in both stable.

Research of differences in daylight factor values in the stables was performed using the Scheffe′s Post hoc test (ANOVA, Statistica 7). Using it, we found that in the original stable, there were significant differences between the rows in which measurements were made (Table 4). There were significant differences in the reconstructed stable in the rows, where the measurements were made under the roof skylight and in the rows that were located near the open walls (Table 5).

Significant differences in illuminance between the individual parts of the stable in the original stable and in the reconstructed stable were also found using box-plot (F - test). In Figure 7 (original stable), there is no significant difference in illuminance between the examined rows ($P > 0.05$). Figure 8 (reconstructed stable) is a statistically significant difference between daylighting factors in individual rows ($P < 0.05$).

Table 1 The basic parameters of the researched values of the daylighting factor in the original stable in individual rows

Row	Count	Average value, %	Median, %	Minimum, %	Maximum, %	Standard deviation
CH1	10	0.356	0.29	0.18	0.96	0.226284
CH2	10	0.365	0.27	0.23	0.98	0.238339

Table 2 The basic parameters of the researched values of the daylighting factor in the reconstructed stable in individual rows

Row	Count	Average value, %	Median, %	Minimum, %	Maximum, %	Standard deviation
S1	10	6.12	6.5	3.8	7.2	1.272618
S2	10	6.42	6.9	3.3	7.9	1.448217
K1	10	1.47	1.3	0.5	2.5	0.869291
K2	10	2.37	2.55	1.2	3	0.594512

Table 3 The basic parameters of the researched values of the daylighting factor in the individual stables

Stable	Count	Average value, %	Median, %	Minimum, %	Maximum, %	Standard deviation
Original	20	0.3605	0.29	0.18	0.98	0.226239
Reconstructed	40	4.095	3.15	0.5	7.9	2.465968

Table 4 Original stable - Scheffe′s Post hoc test (ANOVA, Statistica 7)

Row	DF – average in %	1
CH1	0.356	****
CH2	0.365	****

1 - homogeneous groups

Table 5 Reconstructed stable - Scheffe′s Post hoc test (ANOVA, Statistica 7)

Row	DF – average in %	1	2
K1	1.47	****	
K2	2.37	****	
S1	6.12		****
S2	6.42		****

1, 2 – homogeneous groups

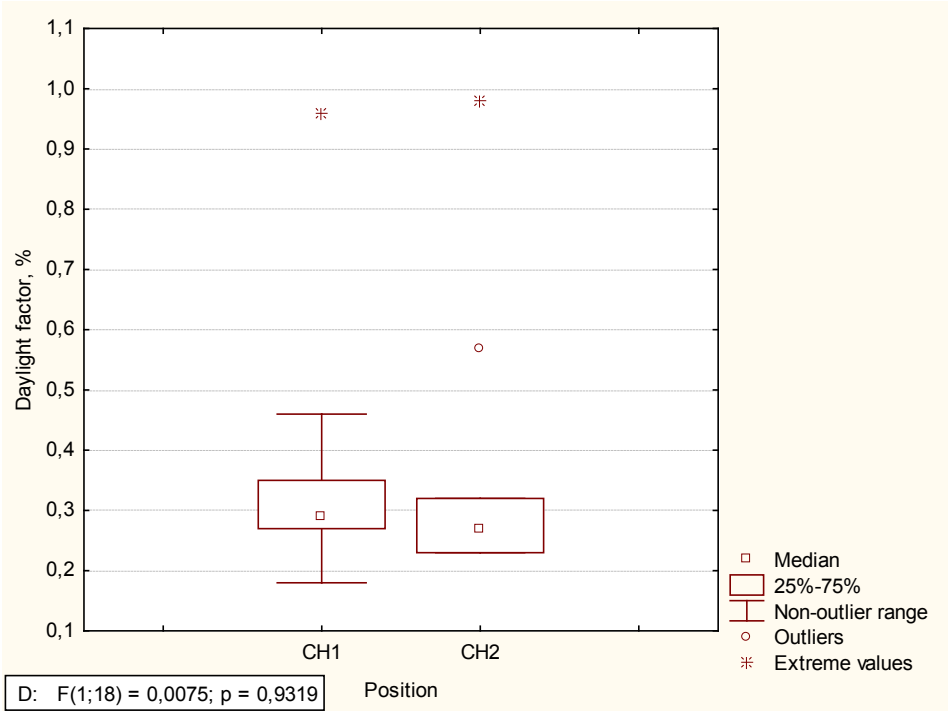

Figure 7 Box-plot of values of daylight factor in individual rows in the original stable (Statistica 7)

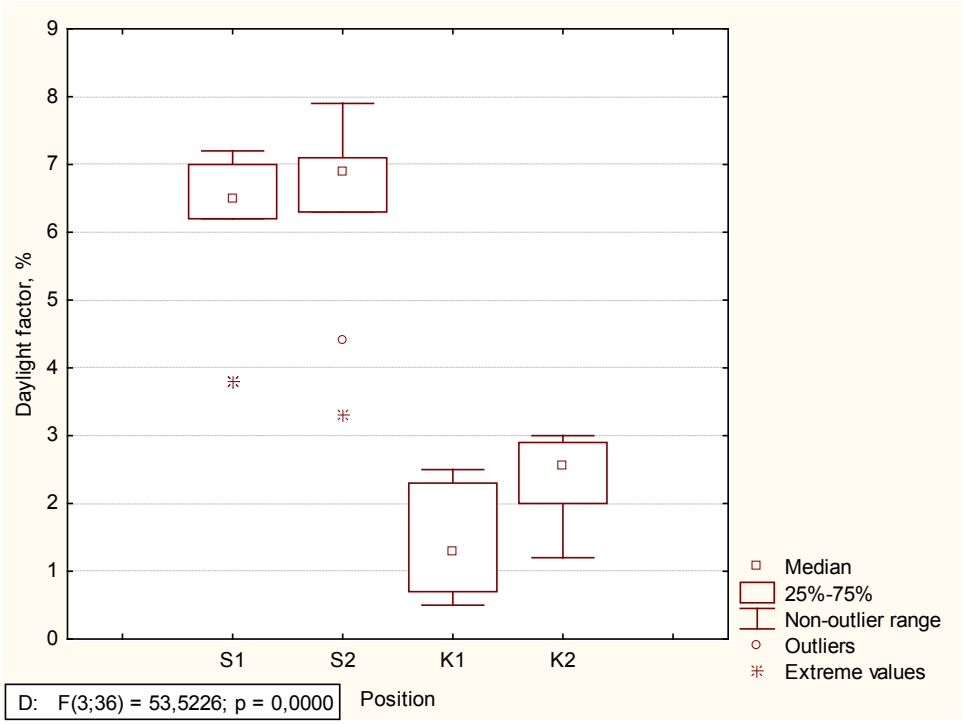

Figure 8 Box-plot of values of daylight factor in individual rows in the reconstructed stable (Statistica 7)

The distribution of lighting in the stable is very important. According to [5], light passages of varying intensity affect the movement of cows. For this reason, it is necessary to take into account not only the overall lighting, but also the lighting differences in the individual parts of the stable.

CONCLUSIONS

Even if the most daylight can be reached through the rooflight, in the case of stable with big dimensions such lighting is insufficient. The design solution of the perimeter walls directly affects the daylighting in the housing space. From the measured values, it is clear that the removal of the side walls significantly increased the values of the daylighting of the stable and hence the values of the daylight factor.

Using Scheffe's Post hoc test and the F test, we determined whether there were significant differences in the measuring sites in the one and the other stable. The places of measurement in the original stable were chosen so that we found out, what is the course of lighting in stable but we did not find out if there is a difference between the illumination under the roof skylight and in places near windows. The measuring places were better chosen in the reconstructed stable in terms of lighting. We found out there significant differences in the part of the stable under the roof skylight and in the part near the open side walls.

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