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***Original Paper***

# Assessment of daylighting in the stable for dairy cattle by the computer program simulation Wdls 5.0

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**ABSTRACT**

The proper lighting in the stable is for the health, as well as for the usefulness of dairy cattle very important. In the stable we can assess the lighting by the measurement or by the simulation in an appropriate program. The advantage of simulation is that we are not dependent on the weather conditions, in which is daylighting variable. In this work we simulated the same two stables with different sizes of opening structures in the longitudinal walls. Using a computer program Wdls 5.0 we calculated the values of daylight factor. These values we compared in the selected profiles and rows by the tables and graphs. We have found that the opening of the side walls will improve the light conditions in the stable, but with such stable width do not affect the lighting in the middle of the stable. We can to improve conditions in a stable from overheating by change the technological arrangement and simultaneously we can design of such illuminating elements in skylight through which we achieve the smallest overheating of stable.

**KEYWORDS**: lighting simulation, program Wdls 5.0, stable, daylight factor

**JEL CLASSIFICATION:** C 63

## INTRODUCTION

Light is an important factor of quality environment not only for humans, but also for animals. The light microclimate is an integral part of the environment [1]. It is therefore necessary to monitor in the stable not only microclimatic facilities of environment and air-containing gases, dust and micro-organisms, which are byproduct of the decomposition of animal excrements often due to imperfect metabolism of nutrients [4], as well as the light conditions. According to Chastain [1] 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 operation as ventilation, heating, or cooling.

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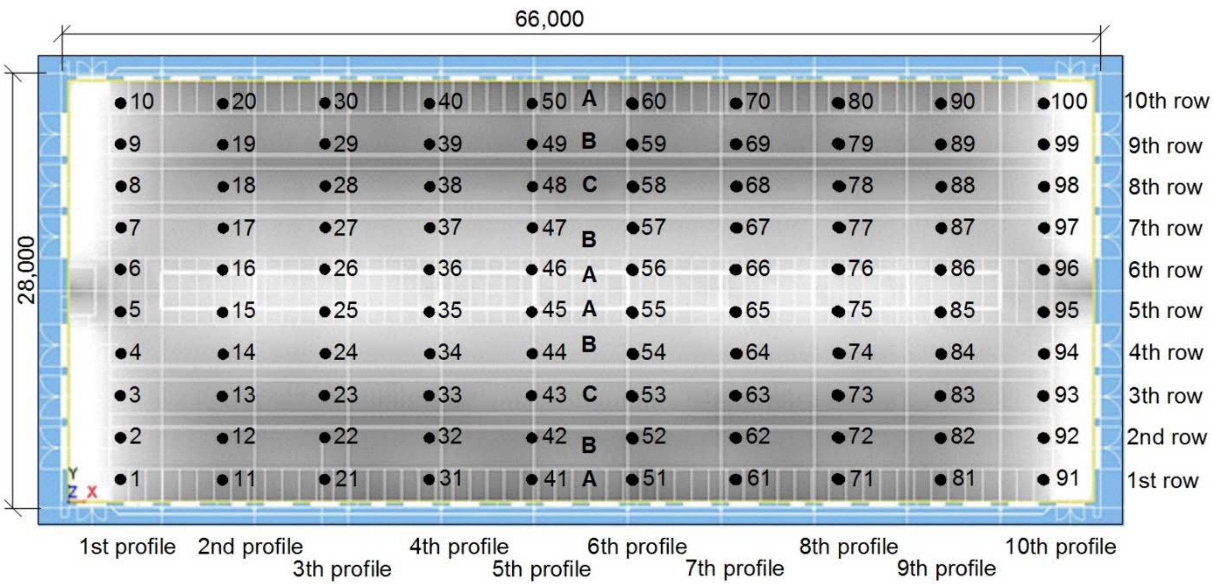
Assessment or design of daylighting in the stable we can do using simulation program Wdls 5.0, that combines a software for calculation of daylighting and new programming environment Building Design. The advantage of this program is, that we can simply model the rooms, buildings and barriers or we can use cooperation with AutoCAD, perhaps even we can use dxf ground plans.

## MATERIAL AND METHODS

Using a computer program to daylighting calculation Wdls 5.0 we simulated two stables. Dimensions of stables were 66 m x 28 m. To the program environment Building Design we have then downloaded from dxf ground plan. Stables had the same dimensions and layout. The same dimensions were also barn doors in the front walls of stables. In the roof construction was a skylight, whose dimensions were 54 m x 2.4 m. The difference was in the longitudinal walls of the stables. The first stable had in the longitudinal walls windows with dimensions 900 x 900 mm and height of parapet 1,600 mm. The second stable had demolished the side walls. In the bottom of walls was installed parapet with a height 830 mm. In the side walls of the stable were situated pillars. To the program we entered parameters of particular openings and environment cleanliness. Before we started to count, we have added system of assessed points (Fig. 1). Height of reference surface, in which are calculated values of daylight factor, were 0.5 m about the ground. This is height, which is used for big sort of animals. Daylighting we assessed by daylight factor (D), which is expressed in percentage. The resulting values were compared with the standard [6] according to the minimum value of daylight factor ($D_{min}$) for dairy cattle should be 1.0 %.




● 1 – number of measuring point
**A** – cubicle, **B** – manure passage, **C** – feed passage

Fig. 1 Plan of the assessed object and measuring points

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## RESULTS AND DISCUSSION

After entering all values into the program we started the calculation of the daylight factor. In the area of the stables were 100 points, which were evenly distributed in the whole building. In the transverse direction was the stable divided into ten profiles, in the longitudinal direction was divided into ten rows (Fig. 1). In Figure 2 and 4a is a graphical representation of the daylight in the stable with the windows in the longitudinal walls. In Figure 3 and 4b is a graphical representation of the daylight in the stable with opened side walls. In Table 2 are calculated values of daylight factor in both stables in the first and fifth profile. The first profile is located near the opened barn doors, that affect the lighting in the stable. In this profile is appropriate lighting at all points. The small differences in the values of daylight factor are only the longitudinal walls. The fifth profile is located approximately in the middle of the stable. The biggest difference in lighting between stables is in cubicles that are near the longitudinal walls. In the manure passages, which are located near the longitudinal walls, in the stable with windows, is insufficient lighting. Under the skylight, which is situated in the middle of the stable is the biggest lighting. Lighting values are in both cases approximately the same. In this section is not influence of lighting from openings in longitudinal walls. We can it see in the model rows (Table 2). The first row is in cubicles, situated in the longitudinal walls. Here we can see the biggest impact of the size of opened structures. In cubicles situated under the skylight is difference in the values of daylight factor minimal. The difference in lighting between the stables we can see in the graphs, which are in Figures 5 to 9.

Tab. 1 Values of daylight factor (D) in the 1st and 5th profile

| The serial number of point | Measurement point 1st profile | D, %; 1st profile | | Measurement point 5th profile | D, %; 5th profile | |
|---|---|---|---|---|---|---|
| | | Stable with windows | Stable with opened side walls | | Stable with windows | Stable with opened side walls |
| 1 | 1 | 3.1 | 4.3 | 41 | 1.4 | 3.6 |
| 2 | 2 | 2.5 | 2.7 | 42 | 0.8 | 1.2 |
| 3 | 3 | 2.3 | 2.4 | 43 | 1.1 | 1.3 |
| 4 | 4 | 2.4 | 2.4 | 44 | 2.2 | 2.3 |
| 5 | 5 | 1.8 | 1.9 | 45 | 3.5 | 3.5 |
| 6 | 6 | 1.8 | 1.9 | 46 | 3.7 | 3.8 |
| 7 | 7 | 2.4 | 2.4 | 47 | 2.2 | 2.3 |
| 8 | 8 | 2.3 | 2.4 | 48 | 0.7 | 0.9 |
| 9 | 9 | 2.5 | 2.7 | 49 | 0.8 | 1.2 |
| 10 | 10 | 3.1 | 4.3 | 50 | 1 | 3.6 |

The stable with windows and the stable with opened side walls

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Tab. 2 Values of daylight factor (D) in the 1st, 3th and 5th row

| The serial number of point | Measurement point 1st row | D, %; 1st row | | Measurement point 3th row | D, %; 3th row | | Measurement point 5th row | D, %; 5th row | |
|---|---|---|---|---|---|---|---|---|---|
| | | Stable with windows | Stable with opened side walls | | Stable with windows | Stable with opened side walls | | Stable with windows | Stable with opened side walls |
| 1 | 1 | 3.1 | 4.3 | 3 | 2.3 | 2.4 | 5 | 1.8 | 1.9 |
| 2 | 11 | 1.2 | 3.8 | 13 | 0.8 | 1 | 15 | 4.2 | 4.3 |
| 3 | 21 | 1.9 | 3.6 | 23 | 0.7 | 0.9 | 25 | 4.6 | 4.7 |
| 4 | 31 | 1.9 | 3.4 | 33 | 0.7 | 0.9 | 35 | 4.5 | 4.6 |
| 5 | 41 | 1.4 | 3.6 | 43 | 1.1 | 1.3 | 45 | 3.5 | 3.5 |
| 6 | 51 | 1.0 | 3.6 | 53 | 1.1 | 1.3 | 55 | 3.5 | 3.5 |
| 7 | 61 | 1.9 | 3.4 | 63 | 0.7 | 0.9 | 65 | 4.5 | 4.5 |
| 8 | 71 | 1.9 | 3.6 | 73 | 0.7 | 0.9 | 75 | 4.6 | 4.7 |
| 9 | 81 | 1.5 | 3.8 | 83 | 0.8 | 1.0 | 85 | 4.2 | 4.3 |
| 10 | 91 | 3.1 | 4.3 | 93 | 2.3 | 2.4 | 95 | 1.8 | 1.9 |

The stable with windows and the stable with opened side walls

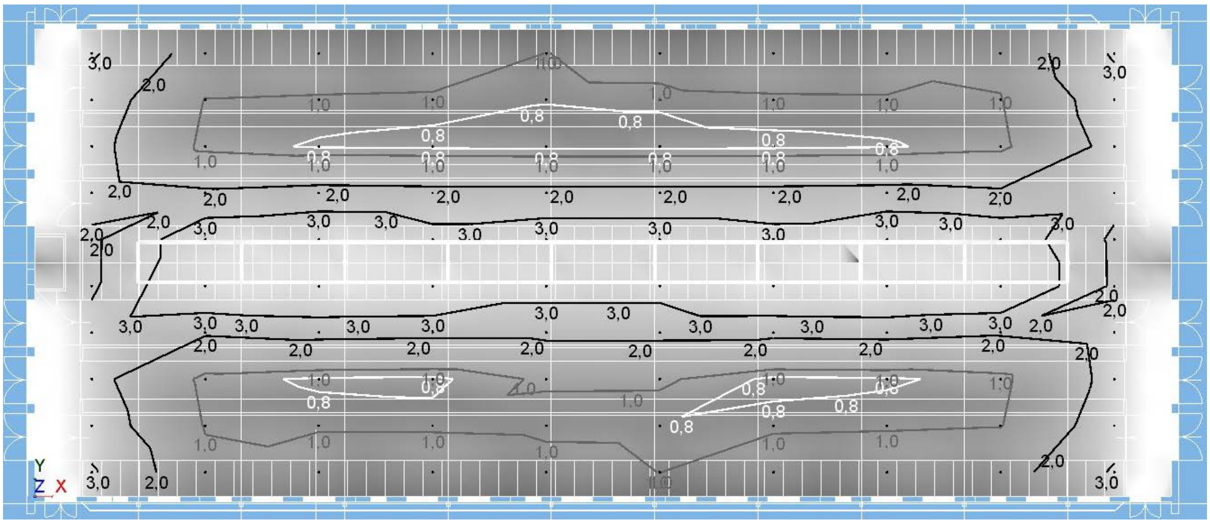


Fig. 2 The graphic presentation of daylighting in the stable with windows

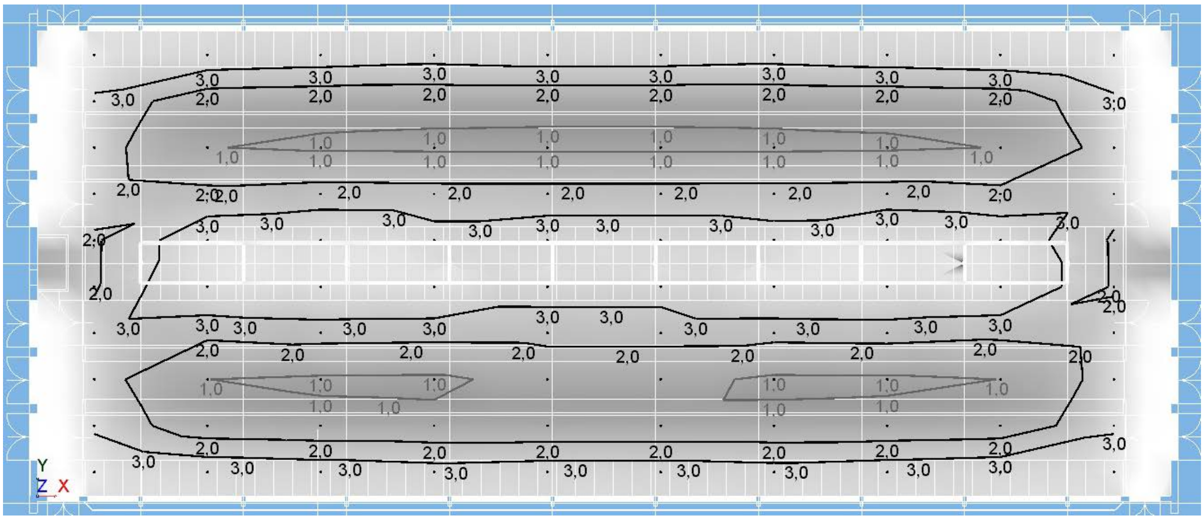
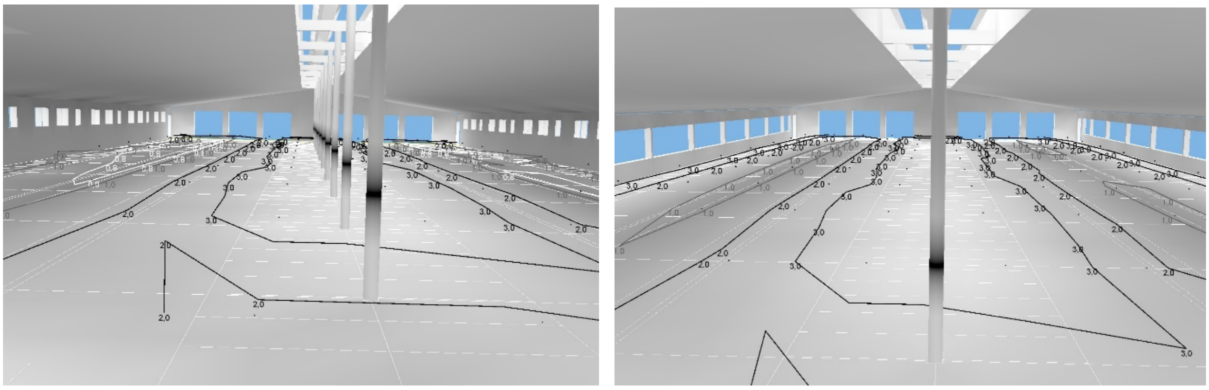



Fig. 3 The graphic presentation of daylighting in the stable with opened side walls



a) Stall with windows b) Stall with opened side walls

Fig. 4 Daylighting by looking into the interior of the stable

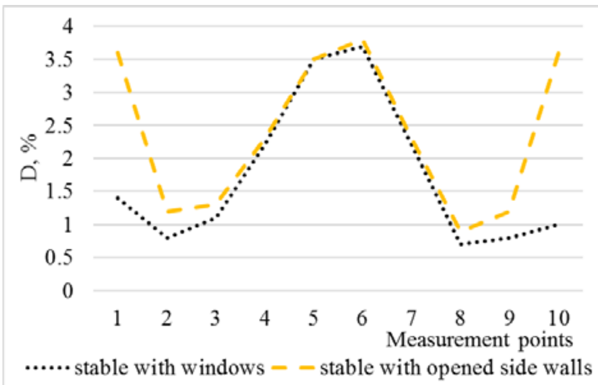




Fig. 5 Values of daylight factor in 1st profile

Fig. 6 Values of daylight factor in 5th profile

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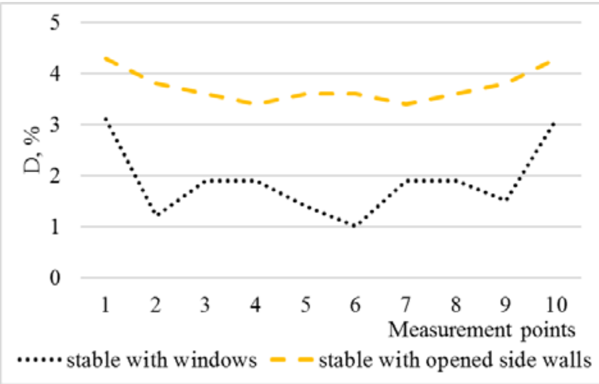


Fig. 7 Values of daylight factor in 1st row


Fig. 8 Values of daylight factor in 3th row

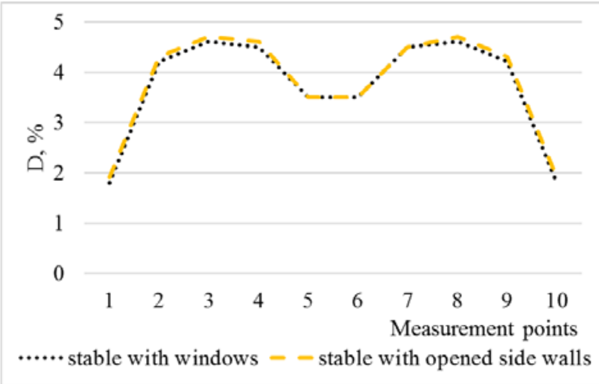


Fig. 9 Values of daylight factor in 5th row

Dairy cows need plenty of daylight. Studies have shown that exposing cows to supplemental light during the short days of autumn and winter can increase milk production by about 5-16 % [2]. In the case, where were the side walls opened, light has improved mainly in cubicles, that had been placed in the side walls. Light has improved partly also in manure passage. On cubicles that were situated under the skylight, the demolished side walls had almost no influence. Lighting under skylight was in both cases sufficient. The disadvantage is that comb skylight lighting improved, but in the summer pose a risk of increased heat load of animals [5]. The way as possible to prevent overheating of the stable is the use of such illuminating elements, that reflect the sunrays. Window glazing with better thermal insulation properties have in many cases reduced transmittance of solar radiation [3]. Another possible solution to improve the lighting is artificial lighting. It is important especially in winter. A suitable solution would be adding a light sensor device to the lighting system which would switch on the system automatically if the lighting levels get worse [7].

## CONCLUSIONS

The work deals with the assessment of stables for dairy cattle by the simulation in computer program Wdls 5.0., which after entering of necessary data directly calculates values of daylight factor. Into this program we simulated two the same stables with different sizes of opened structures in the longitudinal walls. After the extension of these openings in the stable the lighting conditions improved. Part of stables, which was situated under skylight was not by this change affected. Here is more of problem with overheating of stable under skylight. Conditions for animals with cubicles directly under the skylight we can improve in two methods. One method is change the technological arrangement of stable so, that the cubicles under the skylight was not situated. The second method, which is simpler, is design of such illuminating elements in skylight through which we achieve the smallest overheating of stable.

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