# Problems of natural lighting for deepened buildings and underground premises under screen effect of high-rise construction

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**Abstract.** The main rationale and objective of the submitted research work is to create a quality lighting environment in the premises of deepened buildings and below-ground structures under screen effect of high-rise construction (high-rise buildings). It is noted, that in modern megapolises, a deficiency of vacant urban territories leads to the increased density of urban development with increased amount of high-rise construction and tendency to increase efficiency in the use of underground space. The natural lighting of premises in underground buildings and structures is the most efficient way, but it can be implemented only under use of roof lighting system in the form of roof monitors or skylights. In this case the levels of indoor natural lighting will be affected with serious screening effect of high-rise buildings in surrounding development. Such an situation is not regulated, or even considered by the contemporary building Codes and Regulations on natural lighting of interiors. The authors offered a new formula for a daylight factor calculation with roof lighting system in the described cases. The results of theoretical calculations and experimental studies showed very similar values. This proved the truth of the offered formula and elaborated method of calculation on the basis of an offered hypothesis. It prooves, that it is possible to use some factor and guide points in the daylight factors design under system of side natural lighting in the same design for a system of roof lighting.

## 1 Introduction

In the present time the intensive development of large cities with tendency of megapolises` creation shows the deficiency of vacant territories. This activates the high-rise construction, as well as use of an underground space.

The deepened and underground premises of buildings and structures might be used for public, industrial or even for residential functions. Unfortunately, such a premises are usually lit by artificial light. This lighting system, from contemporary point of view cannot be appraised as efficient one, due to high expense of electricity and specifics of artificial lighting effect on a human health and psych-conditions.

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Thus, the creation of microclimate` environment with high quality for the premises of buildings and structures considered in such an non- ordinary conditions is quite actual. In this case it is possible to solve this problem only with use of roof natural lighting system in form of monitors, skylights or hollow tabular light guides.

But, in modern urban reality of dense city` development, the income of natural light through the elements of natural lighting system might be seriously reduced by the screening effect of surrounding high-rise buildings. For the time being, such an situation is not considered by modern codes and regulations on natural lighting and these are require to be actualize [1,2,3,4].

This determines the basic objectives of the said scientific investigations, which can be determines as "creation of qualitative natural lighting environment in premises of deepened buildings and underground structures under the screening effect of a surrounding high-rise buildings [5,6,7,8,9,10,11,12].

## 2 Literature review

The researches, described in this article are based on general conceptions, data and conclusions of principal works of leading researchers in the scientific field discussed, namely: A.K. Soloviev [7,13,17,20], R.Kittler [15], V.M. Slcikin [8,18], J. Mohelnikova [16], L. Brotas and M.Wilson [9,10], as well on works of the given article` authors and their postgraduates [5,6,14].

## 3 The researching` methods

The investigations were conducted in theoretical and practical form. Experimental studies were conducted in National Research University «Moscow State University of Civil Engineering». The studies were based on deepened block of laboratory of building physics, attached to a high rise buiding of the said university, as shown on Figure 1.

The tests were made under diffuced natural lighting, conditions which were provided by the cloudy sky, and corresponds` to the "Standard overcast skyvault of C.I.E.". During the experiments, the cloudiness percentage of the sky varies from 80 to 100%, provided the clouds were dense and low. Under the investigations of a real deepened premise all design geometric and lighting parameters were taken as a constant. The natural lighting of the interior in this case was provided with a single skylight of a pyramid shape. On the results of this stage, an working hypothesis was offered. The working hypothesis adopted says, that under universal character of an exteral natural light destribution in a space, the universal character of an internal natural light distribution in interiors must take place. Such a suggestion might be used to elaborate an universal method of a daylight factor` (D.F.) calculation, in spite of different systems of natural lighting of interiors adopted [5, 6].

On the base of this hypothesis and pilot stage of investigations, the expresion for a D.F.` design under a roof system of natural lighting with concern to screening effect of surrounding development was offered. Such a formula is based on the requirements of the modern «Codes and Regulations» [2,3,4]:

$$\mathrm{D.F.}_{\mathrm{RL}}^{\mathrm{DES}} = \left[\varepsilon_{\mathrm{RL}} \cdot \mathrm{q} + \varepsilon_{\mathrm{OB}} \cdot \mathrm{K}_{\mathrm{OB}} \cdot \mathrm{b}_{\mathrm{f}} + \varepsilon_{\mathrm{AV}}\left(\mathrm{r}_2 \cdot \mathrm{K}_{\mathrm{M,SL}} - 1\right)\right] \frac{\tau_{\mathrm{G}}}{\mathrm{K}_{\mathrm{S}}} \quad (1)$$

Where the shortenings read:

Des- designed; R.L. – roof lighting; OB- opposite building; F- façade; AV- average; M,SL – monitor, skylight; G- general; S-spare. All the factors within the formula, except $\varepsilon_{\mathrm{OB}}$, $\mathrm{K}_{\mathrm{OB}}$ and $\mathrm{b}_{\mathrm{f}}$ are the factors used, according the «Codes and Regulations» in the design formula for D.F. calculation under system of side natural lighting [1-6].

## 4 Results

The results of experimental investigations show a pretty good matching with the data of theoretical calculations according to the offered formula (1), and this proves the truth and correctness of the concept adopted.

The results show a significant reduction of D.F. values in the situation considered, due to screening effect of opposite building.

Besides, the conclusion was made, that a complex checking of a proposed theory must be conducted, with use of a vast number of real buildings, as well as under an "artificial skyvault" dome in laboratory investigations.

All the major concepts of the work are based on the results and conclusions of former investigations, which, within the problems discussed, were carried out by domestic and foreign scientists. [11,12,15,16,19,20].

As an example of screening effect of an opposite development, determined according the results of experimental and theoretical studies, the graphs of D.F. are shown on Figure 1, and on Figure 2. Hypothetical situation of absence of the opposite building, values are represented in Table 1.

## 5 Conclusions and recommendations

1. The working hypothesis, used as scientific base of the investigations conducted, showed its justice. Field studies on real object installation showed a satisfactory matching of the results resieved with theoretical calculations of D.F. under system of roof natural lighting adopted, with consideration of screening effect of surrounding development, determined according the new design formula (1).

2. The work showed a possibility of correction of basic concepts of «Codes and Regulations on natural lighting», acting for the time being. In this case, the given investigations can be considered as innovative, but requiring future studies for more complex background to review the documents in question.

3. It is shown, that lighting-technique effect of opposite buildings on the D.F. levels in premises of deepened buildings and underground structures with root lighting system of a "skylight" type, has a screening and shadowing character. It is so, because the light reflection from facades of surrounding high-rise buildings, show in formula (1) as a multiplication of «$K_{OB}$» and «$b_f$» factors is much less, than «q» factor, which expresses the non-uniform luminance of a skyvault.

**Table1.** Results of experimental and theoretical studies.

| # of points | Theoretical values of a D.F. in a real deepened premise, % | Mean Theoretical values of a D.F. in a real deepened premise, % | Experi-mental values of a D.F. in a real deepened premise, % | Mean Experi-mental values of a D.F. in a real deepened premise, % | Theoretical values of a D.F. in a real deepened premise. In a hypothetical situation of an opposite building absence, % | Mean Theoretical values of a D.F. in a real deepened premise. In a hypothetical situation of an opposite building absence, % |
|---|---|---|---|---|---|---|
| 1 | 3,08 | 3,106 | 2,9 | 2,74 | 5,11 | 3,702 |
| 2 | 5,27 | | 4,5 | | 5,56 | |
| 3 | 3,89 | | 3,7 | | 4,11 | |
| 4 | 2,0 | | 1,8 | | 2,22 | |
| 5 | 1,29 | | 0,8 | | 1,51 | |

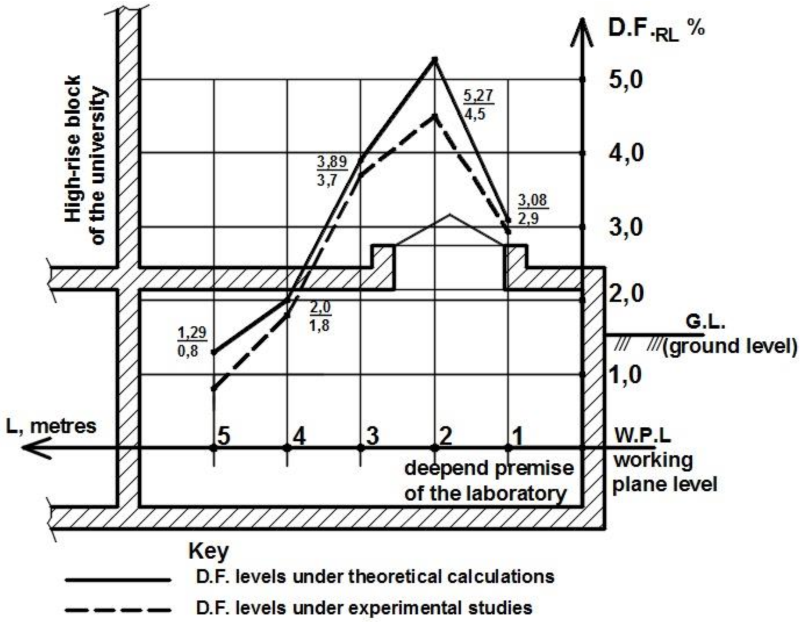


**Fig. 1.** Theoretical and experimental values of a D.F. in a real deepened premise. In a situation of opposite-standing high-rise building.

Note. In the case considered, the theoretical calculation of a D.F. values are conducted on the formula (1).

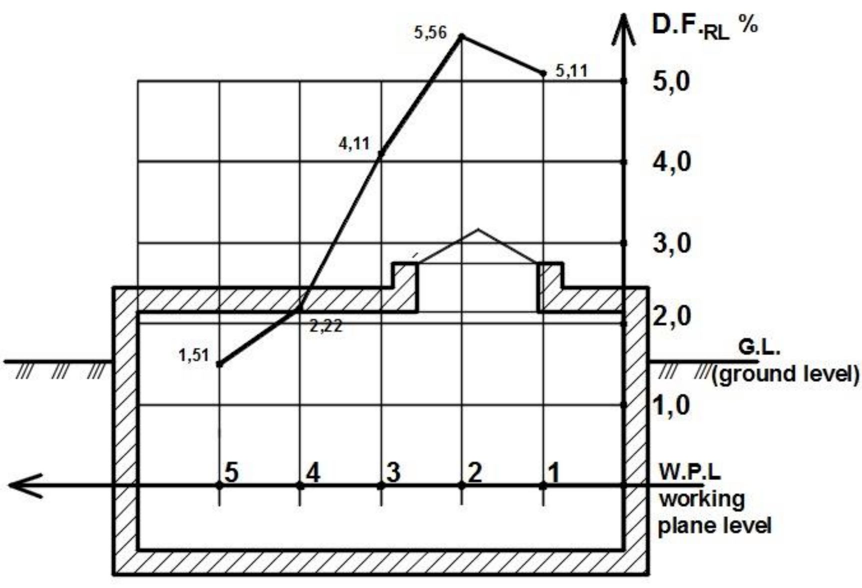


**Fig. 2.** Theoretical values of a D.F. in a real deepened premise under hypothetical situation of an high-rise opposite building absence.

Note. The theoretical calculation of a A. D.F. in this case is conducted on the standard formula:

$$D.F._{RL}^{DES} = \left[\varepsilon_{RL} \cdot q + \varepsilon_{AV}\left(r_2 \cdot K_{M,SL} - 1\right)\right]\frac{\tau_G}{K_S}. \quad (2)$$

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