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STUDY OF GEOMETRICAL PARAMETERS INFLUENCE OF PROFILED DECKING ON BEARING CAPACITY OF THE ROOF

Abstract. *Nowadays, roofing is one of the most important features of our home. It controls temperatures, adds architectural appeal and protects from different kind of natural disasters. Depending on what roof type you choose for your structure, you may be using roof tiles, ridge caps, metal roofing sheets, underlayment and roof insulation. The main advantage of the metal roof panels and corrugated roofing have a much longer life. They are possess of good fire-resistance abilities and reflects the heat. Moreover, metal roofing sheets are maintained quite quickly and easily. Nevertheless, the metal roofing has a few cons mainly related with the massive weight of such construction and the huge metal consumption as well, let alone of their cost.*

In this case, the article considers of the current problem, related with the searching of ways of the metal consumption decreasing in the processes of roofing manufacturing by means of modeling of the different overlapping construction of industrial buildings at the accounting of rigidity of a profiled flooring in the modern mathematical packages: APM WinMachine, SolidWorks, and ANSYS.

The main results of this study can be summarized, as follows: the profiled flooring increases rigidity of a roof, reducing a trusses deflection (by 20–30%); the profiled flooring changes a picture of stresses distribution in the trusses elements dramatically. By taking into account of profiled flooring rigidity there is an opportunity to reduce metal consumption of overlapping designs of industrial buildings. Studies need to be conducted for each case of profiled decking (depending on the parameters roof – type of trusses, step of trusses, span values etc.). The calculation of roofing structures should be considering building carcass as a whole rather than the individual trusses.

Key words: metal construction, overlapping, profiled flooring, truss, metal consumption.

Introduction. Roofing is one of the most important structural elements of buildings as industrial and civil use. The main purpose of the roof is to protect of the building from precipitation as rain or snow, as well as the heat loss in winter and overheating in summer. The series of the research related with the buildings destruction due to the natural rainfalls was conducted in [1]. Considerable distribution was gained also are not warmed, so-called "cold roofs" (shelters for equipment, some warehouse, not heated industrial buildings, hot workshops, etc.).

In a general view the building's roof is consists, directly, of the roofing (protecting) designs, the bearing elements (runs, farms) and the communications providing a spatial permanence, rigidity and stability of a roof in general and its separate elements [2; 3].

The bearing elements are made of metal, wood or reinforced concrete as a rule. The wooden roofing structures are fully considered in [4].

In [5] the impact of the welded reinforce joints onto the bearing capacity of the concrete structures was shown. The greatest distribution was gained by metal designs, thanks to a number of advantages:

1. *The high bearing ability*. Metal designs can perceive considerable efforts at rather small cuts owing to the big durability of metal.

2. *High reliability.* Thanks to structural homogeneity of metal and its elastic properties metal designs can be counted most accurately. It allows to provide reliability of the projected construction.

3. *The ease and transportability*. High mechanical properties allow the metal to withstand considerable internal stresses without deformation. Cross sections of metal structures are lighter compared to other materials with the same effort.

4. *Industriality.* Metal designs make from ready rolling, pressed or bent profiles at the high-mechanized enterprises. Their installation is carried out by the specialized enterprises with the minimum expenses of manual skills. They have high degree of factory readiness.

Besides, metal designs are convenient in operation as can be easily strengthened at increase in loadings. They are most fully used at reconstruction and easily are under repair.

However, along with the advantages of metal structures they also have a number of drawbacks, mainly related to low corrosion and fire resistance of most metals, which significantly limit their use.

Statement of Problem. At design of metal structures service conditions, economy of metal, transportability, technological effectiveness, high-speed installation, durability, convenience of leaving during operation and esthetics have to be considered.

The basic principle of metal structures designs is achievement of three main indicators: economy of metal, increase of labor productivity at production, decrease in labor input and terms of installation, which determine the cost of design.

Actual scientific researches analysis. In spite of the fact that these indicators often at realization contradict one another (for example, the most economical on expenses metal design often happens the most labor consuming at production and installation), experience of development of metal designs confirms possibility of realization of this principle [6].

The economy of metal in metal structures is reached by realization of the following main directions: applications in the construction designs low-alloyed and high-strength steels, use of the most economic rolling and bent profiles, search and introduction in construction of modern effective constructive forms and systems (spatial, previously intense, tubular, etc.), improvement of methods of calculation and search of optimum constructive decisions with use of computer facilities.

Purpose of the research. The aim of this work is to study the possibility of reduction of metal consumption of overlapping construction of industrial buildings at the accounting of rigidity of a profiled flooring.

Results of the research. From the point of view of metal constructions design, the steel profiled sheets are most interesting material, thanks to a number of advantages: they have rather big range of standard sizes, low cost and weight, can be applied to any tilt angles of a roof. Profiles steel sheet bent with corrugations in the form of trapezes for building are applied in construction as covering, as the barrier material in the barrier constructions (wall panels, partitions, gate, etc.), industrial buildings of light metal structures operating in aggressive and slightly aggressive environments.

Profiled sheets classify on:

1. By appointment: F – for flooring coatings, FW – for a flooring and wall barriers, W – for wall barriers.

2. By material of initial workpiece:

– sheets of zinced rolled sheet by the GOST 14918 (no designation);

– sheets of rolled sheet coated with Al-Zn by TU 14-11-247-88 (designation AZ);

– sheets of rolled sheet coated with aluminum, and Al-Si coated rolled by TU 14-11-236-88 (designation Al, Al-Si);

– sheets of rolled sheet with galvanized zinc coating by TU 14-1-4695-88 (designation GZC);

3 In the presence of protective and decorative paint coating; with and without paint/varnish coating by the GOST 30246 (designation of paints and varnishes is specified).

Profiled sheets shall be made multiple by 250 mm in length (for F and FW sheets), multiple by 300 mm (for FW and W sheets). The Production of any length profiled sheets and of less than 3 and more than 12 m for deck is permitted by the manufacturer and the customer agreement [7].

The profiled decking can be used by itself and as special panels profiled sheets from (for example, the layered assembling structure provides of sequential profiled sheets installation, a vapor barrier and thermal insulation).

As roofing materials used profiled sheets up to 75 mm inclusive as a rule (a profiled sheets without additional materials). Profiled sheets more than 75 mm high use for production of multilayered panels.

The one slope truss with parallel chords and a triangular grate with additional racks was chosen for our researches (fig. 1) Rectangular section of elements of trusses is considered. We have selected the minimum size of span equal to 6 m, and trusses step of 2 m.

The rectangular cross-section girders also were chosen. The step of girders been set at 1 m and 2 m (two cases).

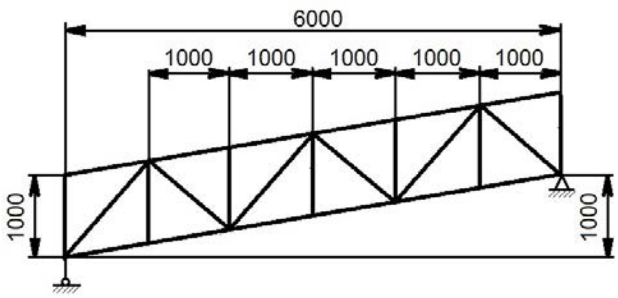

Fig. 1. The diagram of trusses structure

Today for carrying out this sort of researches possibly application of the following packages of system of the automated design: Compas 3D V12, Mathcad, ANSYS 10.0 (Workbench module), Solid Works and APM WinMachine 2008.

In this work the Compass program 3D V12 for creation of a three-dimensional carcass of a design and profiled sheets is used, and APM WinMachine 2008 the Structure 3D module, is applied to calculation by method of final elements of roofs carcass (excluding profiled flooring). As a standard the data obtained at calculation of a flat truss by a matrix method in the environment of Mathcad are used. The main calculation of a carcass with a profiled flooring is carried out in the environment of ANSYS 10.0 – Workbench. Compared to other mathematical packages the advantage of Workbench is less resource consumption.

In figure 2 the chosen scheme of a trusses which has rectangular the cross section of cores is represented.

In designation of profiled sheets leaf thickness is specified. In parentheses indicate the extreme load on girders.

The snow loads and own weight of a flooring for calculation in the environment of APM WinMachine is put twice more than is specified in table 1 as the step of runs increased twice. Similarly perform the calculation roof depending on number of profiled sheets.

One of the results of carcass calculation`s in the environment of APM WinMachine shown in Figures 3 and 4, and among Workbench – Figures 5 and 6.

Stress Distribution in the carcass allows us to investigate only the point, which is in the middle of the lower trusses chord. It is possible because the calculation in the Workbench environment and APM WinMachine give a similar picture of the distribution of stresses [8].

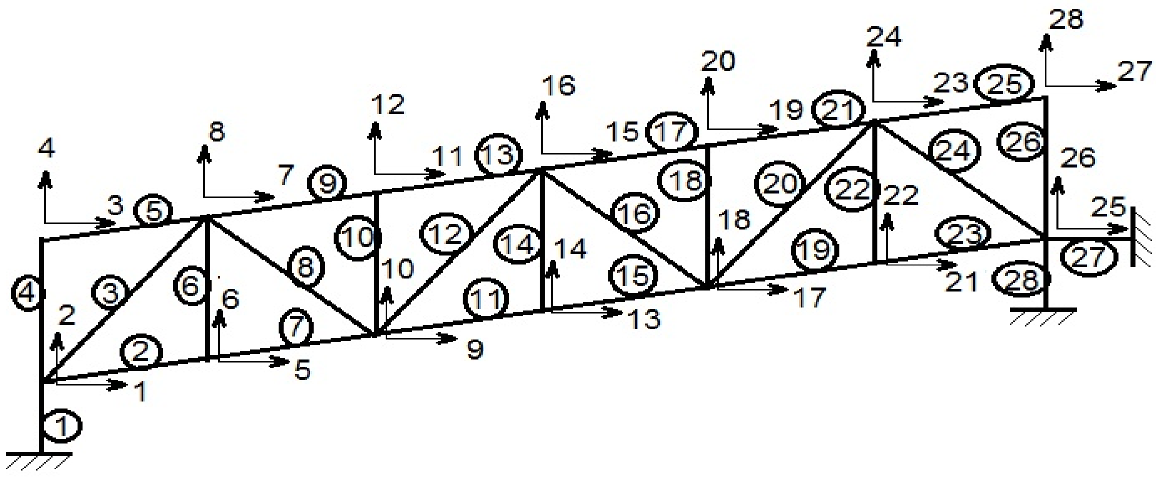

Fig. 2. Diagram of a truss: 1–28 – numbers of coordinate axes 1–28 (are led round) – numbers of rods

Table 1. The load on the carcass

Type of load	The value of load	The given loadings for mathematical packages	
		APM WinMachine, N/mm	Workbench, Pa
Snow	0.0018 N/mmI	–	–
Weight of trusses	240.8 N	0.039456	1972.789
Densities of girders			
50x30x4	45.22 N/m	0.04522	1507.2
60x40x5,5	76.85 N/m	0.07685	1921.287
Specific weight of a profiled flooring + snow load			
FW 35 – 0.7	0.001874 N/mmI	1.89984 (0.94992)	2758.87
FW 44 – 0.7	0.001883 N/mmI	1.90897 (0.95448)	2216.56
F 57 – 0.6	0.001875 N/mmI	1.90086 (0.95043)	2659.87
F 57 – 0.7	0.001887 N/mmI	1.91302 (0.95651)	2676.775
F 57 – 0.8	0.001898 N/mmI	1.92417 (0.962087)	2692.255
F 75 – 0.7	0.001898 N/mmI	1.92417 (0.962087)	2601.285

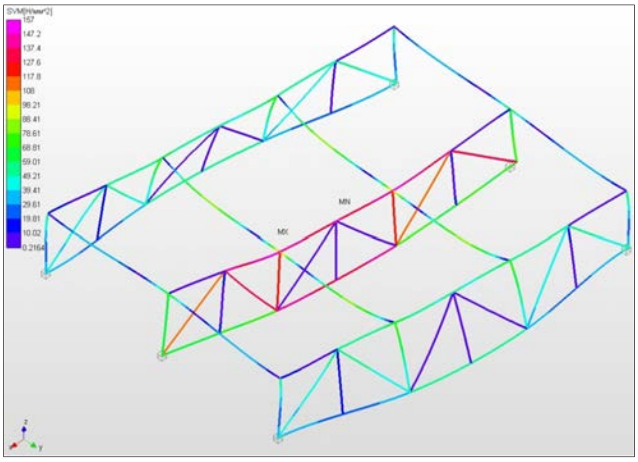

Fig. 3. The Results of carcass calculation's in APM WinMachine (equivalent tension)

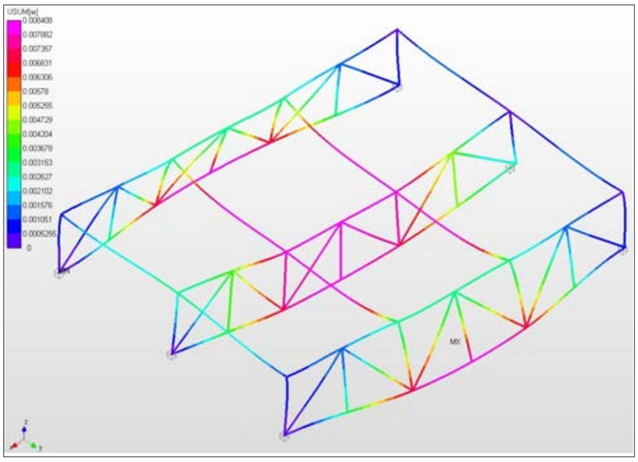

Fig. 4. The Results of carcass calculation's in APM WinMachine (total displacement)

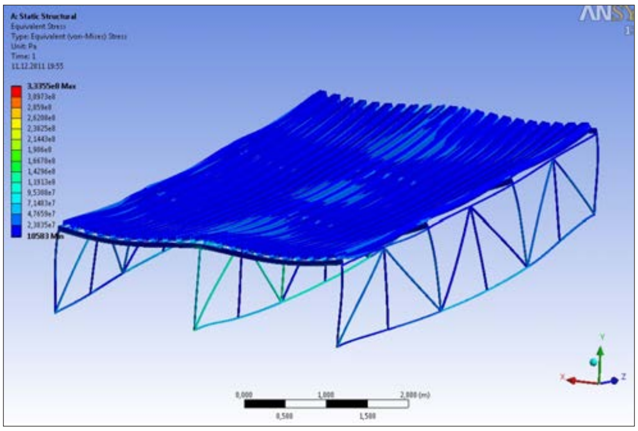

Fig. 5. Calculation of a roof in Workbench (equivalent stress)

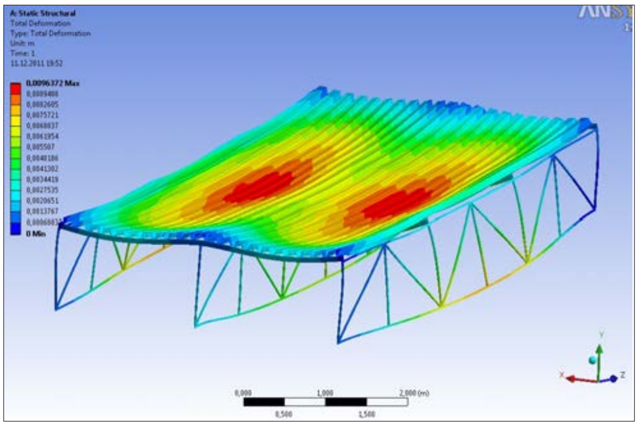

Fig. 6. The roof calculation's in Workbench (displacement)

Table 2. The calculation results in software packages of APM WinMachine and Workbench

№1 flooring thickness	The calculation results in APM WinMachine		The calculation results in Workbench		The percent of decrease in the characteristic, %	
	The stresses, MPa	ε, мм	The stresses, MPa	ε, мм	The stresses	ε
FW35–0.7	132	8.045	118.5	5.746	10.23	28.58
FW 44–0.7	133	8.082	117.74	5.742	11.47	28.95
F57–0.6	132.5	8.05	117.89	5.8	11.03	27.95
F7–0.7	133.3	8.1	117.61	5.75	11.77	29.01
F57–0.8	134	8.145	117,5	5.72	12.31	29.77
F75–0.7	134	8.145	116.18	5.72	13.3	29.77

ε – Deformation of the central trusses in the middle of the lower belt

The calculation results by means of these mathematical packages given in table 2.

At calculation of decrease, percent in the characteristic the data obtained in the environment of APM WinMachine were accepted to 100%.

Conclusion. So, the use of modern mathematical packages: APM WinMachine, SolidWorks, ANSYS allows to consider influence of a profiled leaf rigidity on the overall work of the roof. During the calculation, the following results were obtained:

1. The profiled flooring increases rigidity of a roof, reducing a trusses deflection (by 20–30%).
2. The profiled flooring changes a picture of stresses distribution in the trusses elements.
3. By taking into account of profiled flooring rigidity there is an opportunity to reduce metal consumption of overlapping designs of industrial buildings
4. Studies need to be conducted for each case of profiled decking (depending on the parameters roof – type of trusses, step of trusses, span values etc.).
5. The calculation of roofing structures should be considering building carcass as a whole rather than the individual trusses.

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ДОСЛІДЖЕННЯ ВПЛИВУ ГЕОМЕТРИЧНИХ ПАРАМЕТРІВ ПРОФІЛЬОВАНОГО НАСТИЛУ НА НЕСУЧУ ЗДАТНІСТЬ ПОКРІВЛІ

Анотація. *На теперішній час покрівля - одна з найважливіших особливостей будинку. Вона контролює температуру, додає архітектурної привабливості та захищає від різного роду стихійних лих. Залежно від того, який тип покрівельного матеріалу ви обрали для своєї конструкції, можливо використовувати черепицю, шифер, сланцеві покрівлі або металевий покрівельний настил та, авжеж, утеплення даху. Основною перевагою металевих панелей даху та гофрованого покрівельного покриття є те, що вони володіють набагато довший термін експлуатації. Вони, також, володіють хорошими вогнестійкістю і добре відбивають тепло. Більш того, металеві покрівельні листи досить швидко і легко монтуються. Тим не менш, металеве покрівельне покриття має кілька мінусів, в основному пов'язаних із величезною вагою такої конструкції та значним споживанням металу, не кажучи вже про їх ціну.*

У зв'язку з цим, дана стаття присвячена розгляду актуальної проблеми, головним чином, пов'язаної із пошуком шляхів зниження витрати металу в процесах покрівельного виробництва шляхом моделювання різних конструкції перекриттів промислових будівель з урахуванням жорсткості профнастилу з використанням сучасних математичних пакетів: APM WinMachine, SolidWorks і ANSYS.

Основні результати цього дослідження можна підсумувати наступним чином: профільований настил підвищує жорсткість покрівлі, зменшуючи прогин ферми (на 20-30%); профільований настил, також, кардинально змінює картину розподілу внутрішніх напружень в елементах ферми. Враховуючи жорсткість профнастилу, існує можливість зменшити споживання металу перекриття конструкцій промислових будівель. Необхідно проводити дослідження для кожного випадку профнастилу (залежно від параметрів даху - тип ферми, крок ферми, значення прольоту тощо). Розрахунок покрівельних конструкцій повинен враховувати будівництво каркасу в цілому, а не окремих ферм.

Ключові слова: металоконструкція, перекриття, профнастил, ферма, витрата металу.

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