ЕУРАЗИЯ ҰЛТТЫҚ УНИВЕРСИТЕТІ

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ ТҰҢҒЫШ ПРЕЗИДЕНТІ - ЕЛБАСЫНЫҢ ҚОРЫ

«ҒЫЛЫМ ЖӘНЕ БІЛІМ – 2017»

студенттер мен жас ғалымдардың
XII Халықаралық ғылыми конференциясының
БАЯНДАМАЛАР ЖИНАҒЫ

СБОРНИК МАТЕРИАЛОВ
XII Международной научной конференции
студентов и молодых ученых
«НАУКА И ОБРАЗОВАНИЕ – 2017»

PROCEEDINGS
of the XII International Scientific Conference
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«SCIENCE AND EDUCATION - 2017»

14th April 2017, Astana

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ БІЛІМ ЖӘНЕ ҒЫЛЫМ МИНИСТРЛІГІ
Л.Н. ГУМИЛЕВ АТЫНДАҒЫ ЕУРАЗИЯ ҰЛТТЫҚ УНИВЕРСИТЕТІ

«Ғылым және білім - 2017» студенттер мен жас ғалымдардың XII Халықаралық ғылыми конференциясының БАЯНДАМАЛАР ЖИНАҒЫ

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2017 жыл 14 сәуір

Астана

УДК 378

ББК 74.58
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«Ғылым және білім – 2017» студенттер мен жас ғалымдардың XII Халықаралық ғылыми конференциясы = The XII International Scientific Conference for students and young scholars «Science and education - 2017» = XII Международная научная конференция студентов и молодых ученых «Наука и образование - 2017». – Астана: http://www.enu.kz/ru/nauka/nauka-i-obrazovanie/, 2017. – 7466 стр. (қазақша, орысша, ағылшынша).

ISBN 978-9965-31-827-6

Жинаққа студенттердің, магистранттардың, докоранттардың және жас ғалымдардың жаратылыстану-техникалық және гуманитарлық ғылымдардың өзекті мәселелері бойынша баяндамалары енгізілген.

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УДК 378

ББК 74.58

ISBN 978-9965-31-827-6

УДК 624.04

OPTIMIZATION OF TECHNICAL PARAMETERS OF FRAMELESS COVERS MADE FROM WOODEN PANELS

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ABSTRACT: This article describes the study that focuses on researching the possibility of modification the traditional frame systems, widely used in design and construction, and the further possibility of substituition of such systems with frameless covers. The main area of application is the building structures used in agriculture. The reduced quantity and weight of the structural elements in a building with frameless covers allows the reduction of material consumption, manufacturing labour costs, transportation and installation costs. The optimization of technical parameters was done with analysis of the stress-strain state of the structural elements of frameless covers.
Keywords: frameless covers, stress-strain state, material consumption, optimization.

1 INTRODUCTION

The material and energy costs for manufacturing, transportation and construction should be reduced in the design and construction of modern buildings to implement the strategy of "green economy". Efficiency of frameless buildings from wooden panels is reached with the lack of traditional frame (columns, beams and frames). This reduces the quantity and weight of the structural elements [1]. The building is constructed only with prefabricated panels, which do not require heavy construction lifting equipment. The combination of bearing and protecting functions in frameless covers allows to reduce material consumption from 25 to 50%. The manufacturing labour costs, installation and transportation costs can be reduced by two to three times. The amount of cost reduction depends on the optimization of technical parameters of frameless covers and their further improvement.

Technical parameters of frameless structures determine the appearance of the building, its construction and operation costs. This research study analyzes the ways to optimize the technical parameters of the existing frameless covers. One of the main factors affecting the resource consumption for frameless covers is the stress-strain state of its structural elements. Therefore, the study of regulation methods of stress-strain state of the frameless covers' structural elements will lead to the creation of the control mechanisms for material consumption and conditions for optimal design.

2 METHODOLOGY AND RESULTS OF TECHNICAL PARAMETERS OPTIMIZATION FOR FRAMELESS COVERS

Figure 1 demonstrates the constructed models that were used to conduct the study on the optimization of the technical parameters of frameless covers made from wood. The development of new types of design (Figure 1) was carried out taking into account the several directions. The first direction is reduction of material consumption. This reduction in construction material consumption was achieved with closer convergence of design schemes with their real work [2]. Another way to reduce the material consumption was a combination of bearing and protecting functions of structural elements in one design: simplification of structural connections with the subsequent reduction of their manufacturing complexity and finding an optimal combination of materials in structural elements.

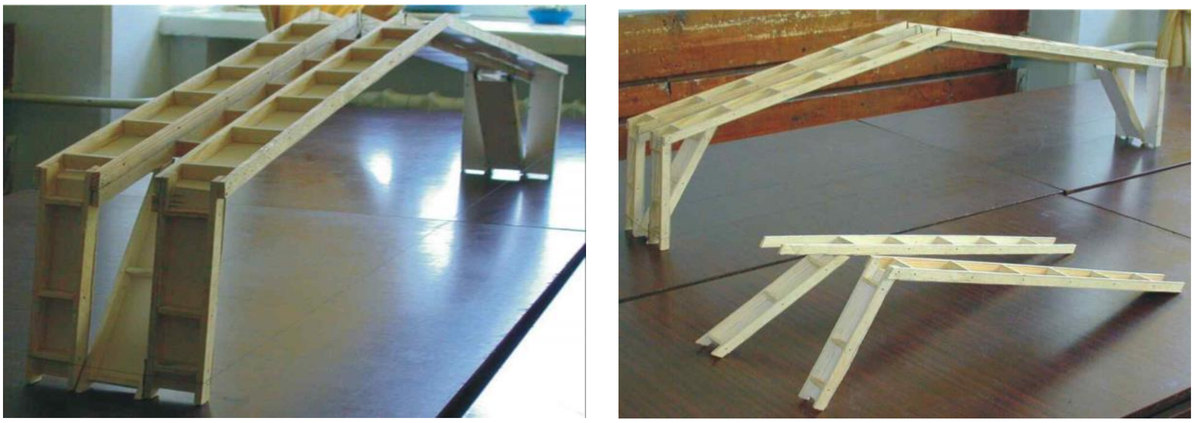

Figure 1. Frameless cover models.

The search for new types of structural design principles for frameless covers made it possible to regulate the internal forces and to regulate the material consumption as well.

One of the methods of reducing the material consumption during design was the creation of conditions to regulate the internal forces in the sections of structural elements. One method of internal force regulation was implemented in the compressed and bent structural elements. This method is used widely and only for the design of the upper zones of truss, when the stress-strain state of structure can be controlled with eccentricity of axial force application. The implementation of this method was performed by creating a moment from axial force, which is exactly the same, but with opposite sign, as the moment from the shear forces. The extended use of the noted method for the bracing structural elements, which are related to the compressed and bent elements, may also create the possibility to regulate the internal forces.

The tensest area of the cross-section for frameless covers was appeared to be the cornice section. The cornice section is a node, where the destruction of bearing cover slab is occurring due to the impact of maximum moment or maximum shear force under different design schemes of loading as shown in Figure 2.

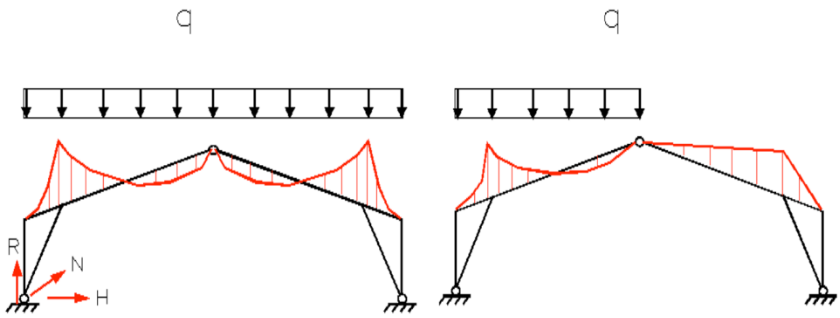

Figure 2. Scheme of loading and moment diagrams for frameless covers.

Figure 2 displays the internal force diagrams for the bracing structural elements. It can be seen that regulation of the internal force values could be done in several ways. The first way was to change the level of cornice node, which depends on the functional purpose of any building. The shortest height of the cornice node was taken as 2 meters. It was concluded that the moment varies with the increasing height of the building according to the following equation depending on the applied load [1]:

$$M = M_0 * \frac{H}{H_0} - \Delta M[(H - H_0) * k] \qquad (1)$$

where M_0 – the bending moment at the cornice height of 2 meters, M_0=33.03kN*m,

ΔM – correction bending moment, ΔM=4kN*m,
H- cornice height of the frameless cover,
H_0 - minimum height of cornice node - 2 meters,
k – conversion factor, k=2.2$м^{-1}$.

The results of static analysis of frameless covers with span of 15 meters and bending moments values defined with Equation 1 are shown in Table 1. Table 1 shows, that with an increase of building height up to 1.941 times the value of the bending moment increases to 1.36 times.

Table 1. The effect of building height on the value of the maximum bending moment.

The ratio of H/H_0	1	1.235	1.470	1.706	1.941
Value of M_{bend} according to a finite element analysis, kN*m	33.03	37.07	40.22	42.83	45.01
Value of M_{bend} according to Equation 1, kN*m	33.03	36.39	39.71	43.10	46.40
The error percentage,%	-	1.7	1.2	0.6	2.9

The next way to regulate the internal force values was to create a moment from the axial force at the ridged node as shown in Figure 3. This moment is equal to the moment from the shear force with opposite sign for the bracing structural elements. The method of creating the moment from the axial force gave a positive effect for the whole structural entity of frameless covers. This moment reduced the value of maximum bending moment at the cornice node. Creation of the moment from the axial force in real life is possible with the installation of a ceiling window in the ridged node (Figure 3). Calculations revealed that the creation of the eccentricity within the ridged node section do not significantly affect the value of the bending moment in the cornice node. The internal forces regulation will be more effective by increasing the magnitude of the eccentricity using the cover in the form of the ridged tent (Figure 3).

The following Equation 2 demonstrates the relationship between the changing value of the bending moment and the magnitude of the eccentricity:

$$M = M_0 - \Delta M[(H - H_0) * k] \qquad (2)$$

where M_0 – the bending moment at the cornice height of 2 meters, M_0=33.03 kN*m,
ΔM – correction bending moment, ΔM =2 kN*m,
H - cornice height of the frameless cover,
H_0 - minimum height of cornice node - 2 meters,
k – conversion factor, k=3.7$м^{-1}$

The results of static analysis of frameless covers with span of 15 meters, H_0=2,1 meters and bending moments values defined with Equation 2 are shown in Table 2. Table 2 shows, that with an increase of the tent height up to 1.5 meters, the value of the bending moment was reduced by 1.478 times.

Table 2. Influence of the ridged eccentricity on the value of the maximum bending moment.

The ratio of H/H_0	0	0.25	0.50	0.75	1.00	1.25
Value of M_{bend} according to a finite element analysis, kN*m	33.03	30.78	29.07	27.40	25.73	24.05

Value of M_{bend} according to Equation 2, kN*m	33.03	31.90	29.30	27.45	25.60	23.75
The error percentage,%	-	3.60	0.80	0.20	0.56	1.20

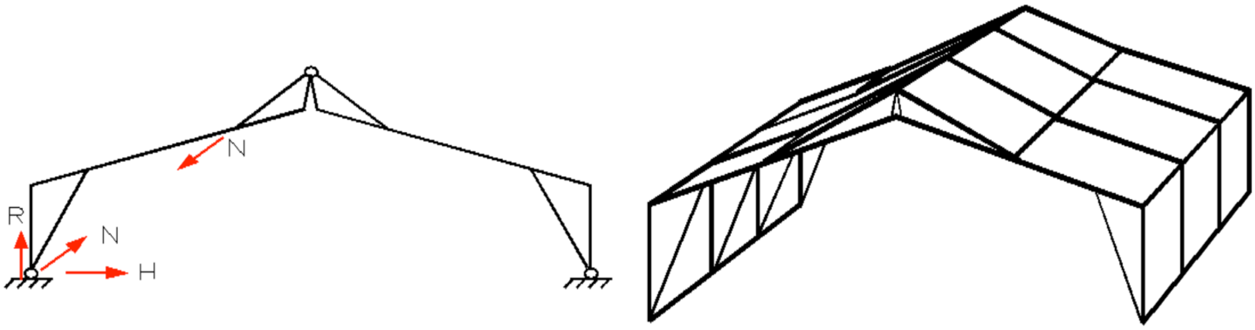

Figure 3. Creation of the axial force eccentricity at the ridged node.

Incorporating the ridged tent into the design of frameless covers benefits to solve the problem of internal forces regulation and functions as a light or ventilation opening (Figure 3).

Significant reduction of the maximum bending moment values in the cornie node could be achieved with a steel bracing tightening at the cornice node as shown in Figure 4. As maximum bending moment in the cornice node reduces, the span moment value increases. In this case, the bending moment values adjustment can be regulated with the magnitude of the eccentricity, located within the element's cross-section height.

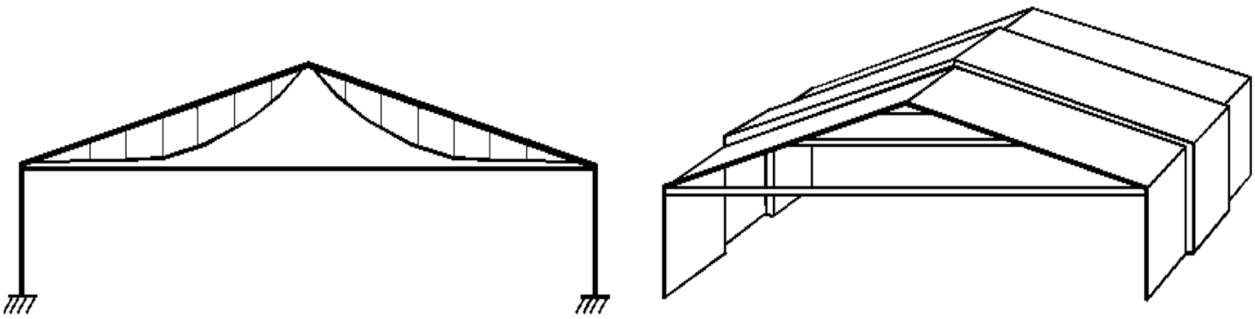

Figure 4. Steel bracing tightening in the frameless cover bracing elements.

It is also possible to control the internal forces with changing the angle of inclination for the structural elements of the frameless covers. The most well-known and widely used slope is i = 1/4 for the frame structures. Modifications for this slope were not considered yet. Modifications of the inclination angles of structural elements for frameless covers can lead to the creation of entirely new types of frameless covers.

3 CONCLUSIONS

It can be concluded that the multifactorial method of modeling the frameless covers allowed to determine joint influence of all factors affecting the magnitude of the bending moments at the cornice node and to determine the optimal parameters for the design implementation. Obtaining the regression model for the relationship between the maximum bending moment and all the affecting main factors will allow to monitor optimally the internal force values at the cross-sections of all structural elements of frameless covers and to monitor optimally the material consumption.

Modern practice is directed to find new ideas, knowledge and scientific breakthroughs. The new search begins with the partial negation of old ideas and this process requires a critical understanding of the theory and practice of the preceding scientific stages. Weak side of the frame structures is seen obviously in excessive duplication of structural functions between the various structural elements of the frame systems. Therefore, there is a need for the modification of the traditional frame systems.

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УДК 624.154

КРАТКОЕ ОПИСАНИЕ МЕТОДА ИСПЫТАНИЯ ГРУНТОВ СВАЯМИ PILE DYNAMIC ANALYZE (PDA)

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1. Введение

Наряду с технологиями устройства свайных фундаментов развиваются и методы оценки погружения и работы сваи, позволяющие производить оценку качества изготовления свайного фундамента и определять его несущие характеристики с высокой точностью и за короткие сроки. В Казахстане и странах СНГ основными методами оценки качества изготовления свай и определения их несущей способности считаются испытания свай на статическую нагрузку, результаты которых считаются эталонными, а так же испытания динамической нагрузкой, описанные в ГОСТ 5686-94 Грунты. Методы полевых испытаний сваями [4, 5]. Однако, как показывает практика, у этих методов существует ряд недостатков, которые относятся как к трудоёмкости проведения подобных испытаний, так и к качеству полученных результатов. Вместе с тем во многих передовых странах, таких как Япония, США, Канада и страны Европы, наряду со статическими испытаниями используются новые методы испытаний свай, которые показывают хорошие результаты, сопоставимые с результатами статических испытаний, а так же имеют ряд преимуществ перед этим методом. Подобные технологии в Казахстане так же являются востребованными.

2. МЕТОД PDA (Pile Dynamic Analyze)

Испытания свай методом PDA являются новым направлением для строительного рынка Казахстана [6]. Иностранные и отечественные крупные строительные компании, уже давно заинтересованы в проведении подобного вида испытаний, т.к. они зарекомендовали себя во всём мире как хороший аналог статическим испытаниям с точки зрения сопоставимости результатов, скорости и стоимости проведения испытаний (см. рисунок 1).