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CONSTRUCTION OF WELDED TRUSS NODS USING ANSYS SOFTWARE COMPLEX

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Summary. *The behavior of 18000 x 3600 mm welded rectangular truss under external loading was studied in the current paper. The prototype is made of paired steel rolled angular 100h100h7 mm profile. The plates in nodes are tapered and made of the steel 10 mm thick plate. It was selected the loading scheme that identifies the operating mode for this type of construction. According to the results of computer simulation experiment in ANSYS Workbench 14.5 environment the strain-stress state parameters of truss elements at different values of the external loading were obtained. The level of stress in truss nodes was discovered and constructive configuration of gusset plates which enables to increase the fatigue durability by 18.4% was offered. The results obtained are of theoretical and practical interest both for the new trusses design and for control of the remaining lifetime of trusses that are being operated under the cyclic loadings.*

Key words: *welded truss, gusset plates in nodes, fatigue durability.*

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Problem setting. Welded truss elements are widely used in construction due to their high fabricability. It is very important during mounting of large-scale elements on the construction pitch. They include welded trusses (trusses of purlin bridges constructions, sub-rafter and rafter trusses, piers and purlin constructions of trestles for technological equipment, trusses of transporting galleries and so on). The designing and production of welded trusses assumes adherence of normative requirements for such type of elements due to analysis results concerning the calculation of stress-strained state (SSS) parameters in their elements. However, during cyclic stresses the fatigue damages take place along with their propagation at considerably lower SSS rates than at static stresses. The modern condition of IT development and application of a number of calculation methods facilitate solving of this problem and assessing the long-term capability of the element under external stresses by means of computer-based modelling experiment.

Analysis of the latest researches and publications. The application of finite-element analysis systems for different software calculation of strength facilitates selecting the most appropriate weld joints dimensions during the designing stage; foresee the reliability and durability of entire construction.

During elaboration of weld joints in truss nods one has to take into consideration [1…4]:

1) concentration of stresses on the edges and around the base of weld joints;

2) alteration of mechanic properties of the material in the area of weld joint as a result of its fracturing;

3) weakening of weld joint section as a result of welding technological defects (discrepant welding, slags);

4) residual stresses caused by temperature strains.

However, in existing issues little attention was payed to SSS research in gusset plates of different shape during aggregate impact of cyclic and static stresses.

Research objective is identification of SSS rates in welded truss nods under external stresses for different types of gusset plates.

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Task setting. To accomplish the given task one had to run computer-based modelling experiment using ANSYS Workbench 14.5 application software for welded rectangular truss 18,000 x 3,600 mm under external stresses.

The task is to identify the rate of fatigue damage in the nods of rectangular welded truss with different shapes of nodal gusset plates under aggregate static and cyclic operational stresses.

Research results. Research was based on rectangular truss with triangular grate (Figure 1). Plates in nods for basic element are standard tapered ones that were made of steel plate 10 mm thick. The truss material is ordinary ВСт3пс steel. All weld joints are made with DC semi-automatic arc welding using wire electrode with diameter 1.2 mm Св-08Г2С in CO_2 environment under standardized technologies. Operation welding current was 200 A.

It is selected the stress scheme, which is relevant to operation mode for under-rafter truss with determined under-crane leads (Figure 2). They are the stresses coming from crane bridge that form the cyclic stress constituent.

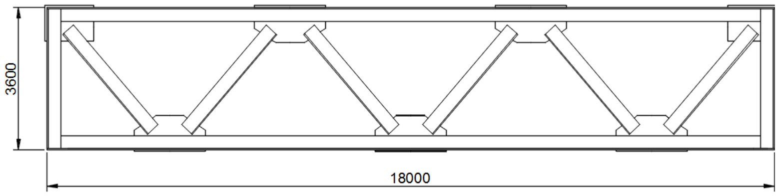


Figure 1. Welded rectangular truss with gusset plates

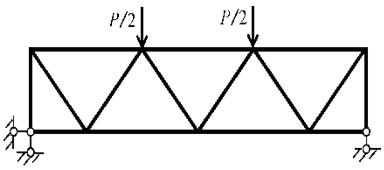
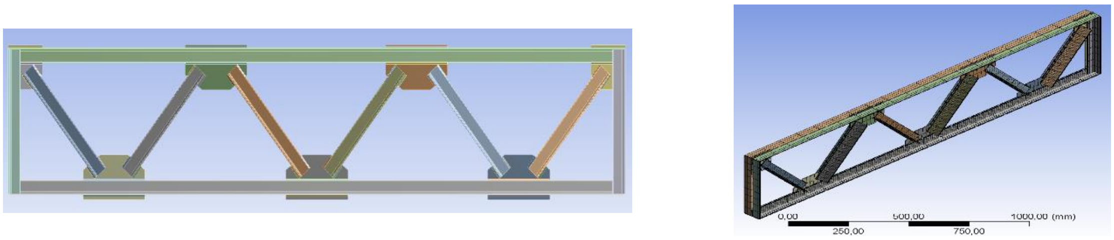


Figure 2. Loading scheme of welded truss

The given task was substantially accomplished by mean of computer-based modelling experiment with numeric methods within ANSYS Workbench 14.5 application software which is algorithmically based on finite-elements method.

To model the behavior of sub-rafter truss in ANSYS Workbench 14.5 application software it was elaborated its geometrical (Figure 3a) and finite-element network model (Figure 3b).



a) b)

Figure 3. 18000x3600 mm truss: a) CAD – geometric model; b) CAE – finite-element grid model

Due to the results of computer-based ANSYS Workbench 14.5 modelling experiment, it was obtained the stress distribution in truss elements (Figure 4). It has also been identified the inclined brace under stress-strain state of truss construction elements (Figure 5).

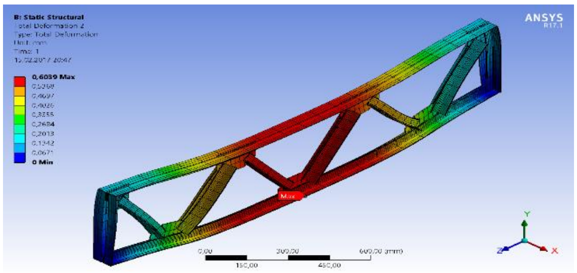


Figure 4. The stresses distribution in truss elements when loaded

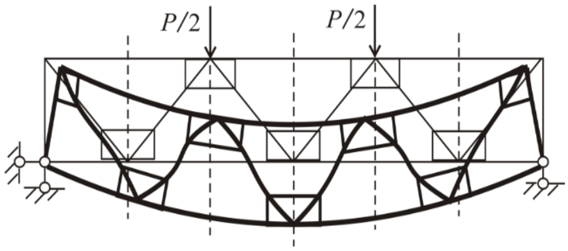


Figure 5. The geometry of studied truss with gusset plates in nodes when loaded

The available plates in nodes facilitate the extension of inclined braces' welding, though it forms the bending strains during extension of the lower layer and compression of upper one. Figure 5 explicitly displays the situation for side nods of lower layer. It creates the substantial negative impact upon operational expectancy of the element under cyclic stress. The affiliated stresses at the very beginning of weld joint between the gusset plate and inclined brace stipulate the origination and propagation of fatigue crack along the thermal impact section.

Computer-based modelling experiment produced the stress graphs in the right cross stay (Figure 6). The peak points on the graph prove the bending of inclined braces (Figure 5). Here, the intensity of these peak points grows at stress strengthening on the truss.

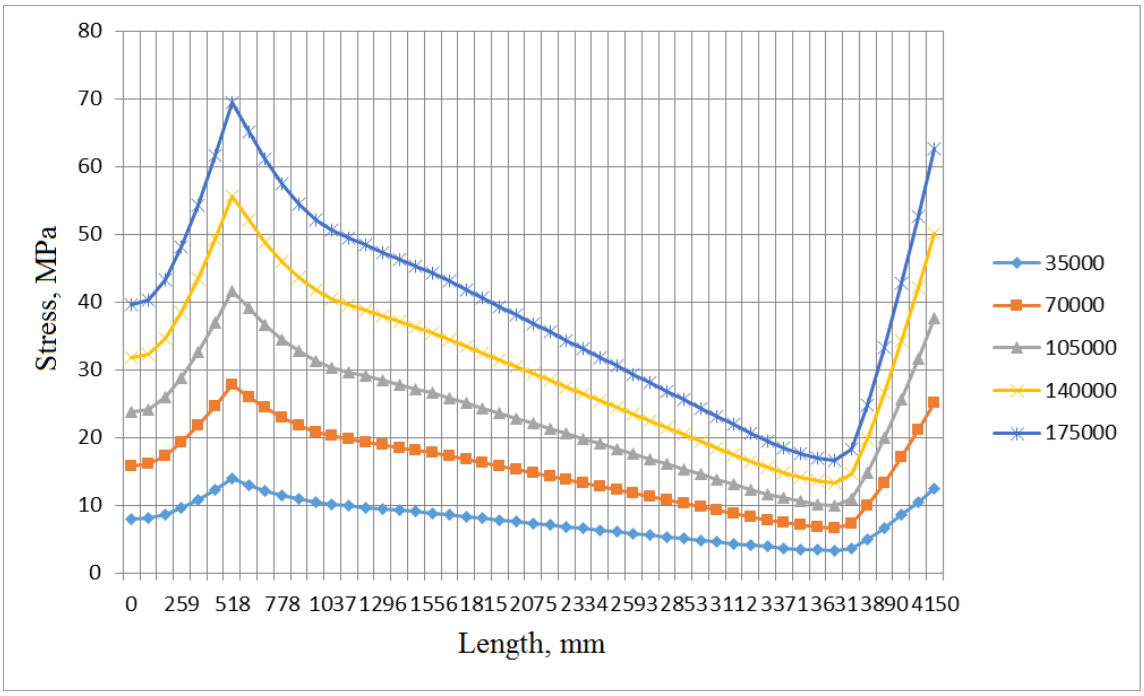


Figure 6. The diagram of stresses in the right cross stay at different loading levels (N)

It was obtained the stress diagram along the weld joint on gusset plate at linking to truss belt (Figure 7) for different values of external stresses. Maximal stresses are spotted at the brinks of weld joint. Like in the previous case with cross stays (inclined braces), the intensity of stresses growth increases at raising of external stress upon the construction element. These sections are probably likely to be the spots where fatigue damages are originated.

Having analyzed the obtained research results, one has to generalize that the gusset plate is a construction element of welded truss, which predetermine the stiffness of entire construction at static stresses and fatigue durability at cyclic ones.

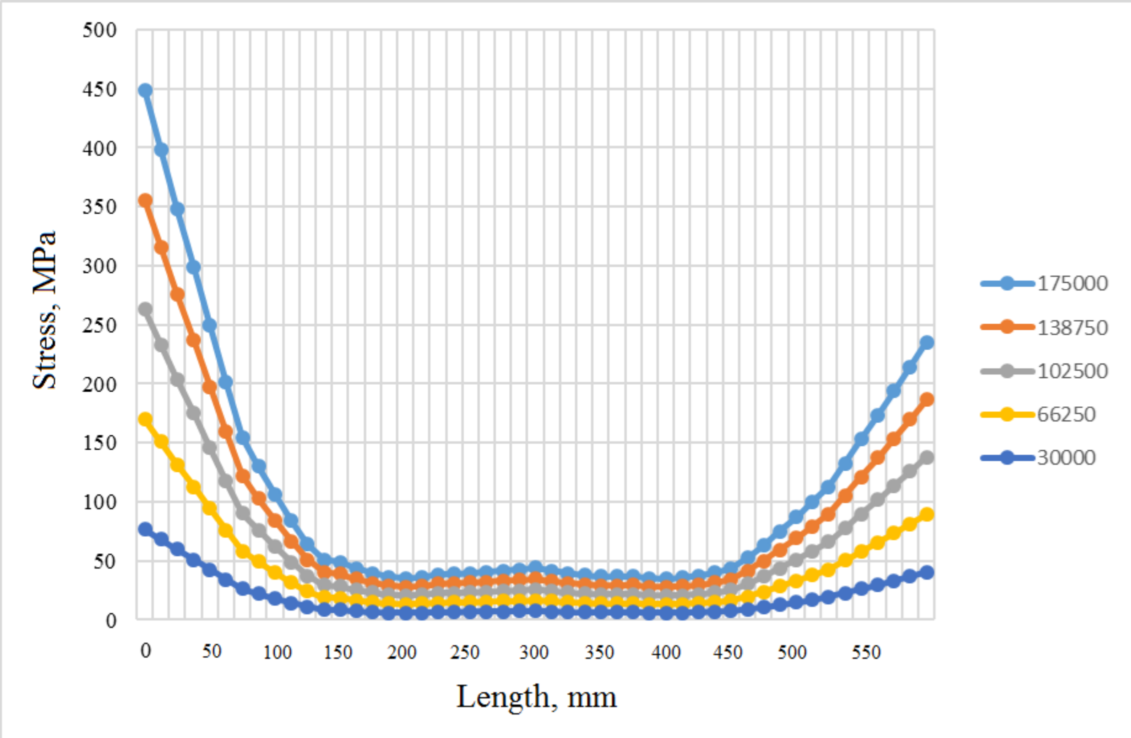


Figure 7. The diagram of stresses along welded joint at different stress levels (N)

To improve the truss operation durability the unique design of gusset plates has been suggested (Figure 8).

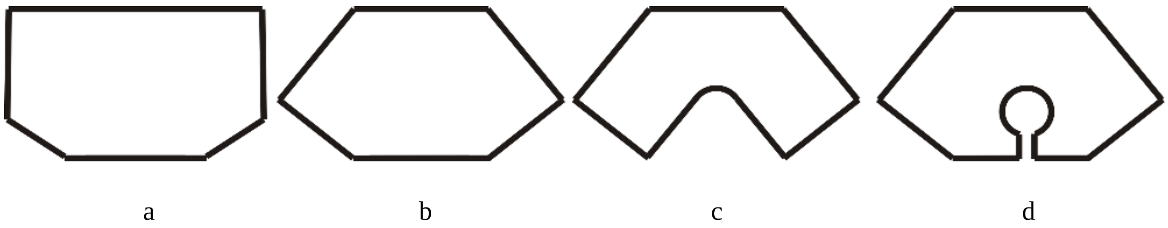


Figure 8. The gusset plates constructions: a, b – the standardized options; c, d – the offered options

The suggested design (as it shown on Figure 8) facilitates decreasing of the affiliated stresses in weld joint at gusset plate brink of inclined brace spot. This is achieved by strain of gusset plate itself resulting in inclined brace deformation. Figure 9 displays the results of computer-based modelling of stress distribution along the surface of gusset plates under external stress upon the truss.

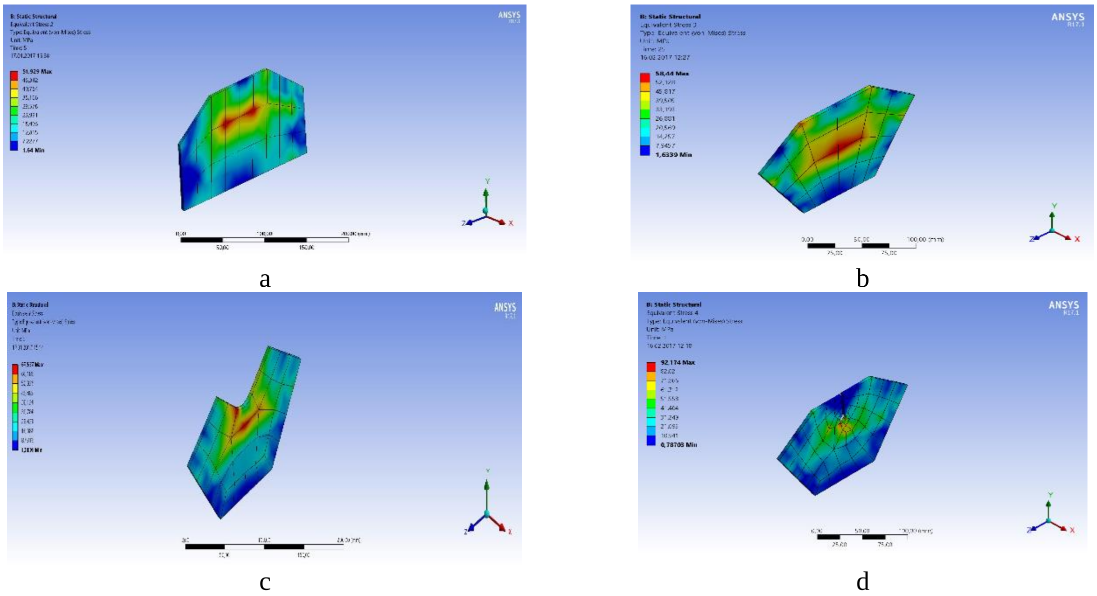


Figure 9. The stresses distribution in gusset plates: a – tapered; b – with cut corners; c – with round cutout; d – with a slot

It has been determined that for the gusset plate with round cutout (Figure 9c) the maximal stresses are 16.2% less than for basic design of tapered gusset plate (Figure 9a) at the same external stresses on the truss.

Using ANSYS Workbench 14.5 the modeling of the fatigue fracturing at the section of weld joint between the gusset plate and inclined brace for different types of plates in nods was performed. The fatigue curves were obtained (Figure 10).

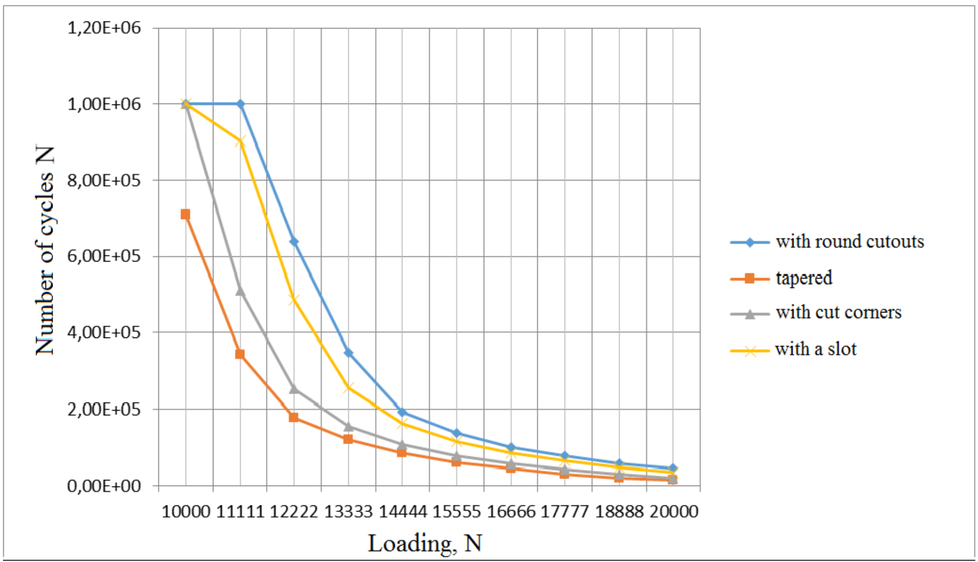


Figure 10. Fatigue curve for the nodes with different gusset plates shapes

According to the obtained fatigue curves it is obvious that the highest fatigue durability of the element is achieved with the usage of gusset plate with round cutout. Comparing to basic tapered gusset plates the truss fatigue durability has increased on 18.4%. The design of gusset plate with a slot is also to be paid attention as it is substantially more technological, and according to its fatigue durability is almost the same as the gusset plate with round cutout.

The obtained results are based on the previously substantiated method of computer-based modelling experiment with verified results and high rates of convergence with the results of natural experiment [4]. The parameters of finite-element modelling were selected due to existing methods that secured the high rate of trustworthiness of obtained modelling results.

Conclusions. According to the results of computer-based modeling experiment it has been obtained the diagrams of stresses for construction elements of welded rectangular truss 18,000 x 3,600 mm of paired rolled angle pieces100×100×7 mm with gusset plates in nods under different values of external stress. In accordance to accomplished experiments, it was discovered that gusset plates are the place of localization of peak stresses and the rates of these stresses were determined. The authors suggested the gusset plates with round cutout design, which enables static stress decreasing on 16.2% and improvement of fatigue durability on 18.4% under cyclic stresses. The suggested methods are worth to be applied both in design calculations for welded trusses and for verification of reliability and durability of welded trusses in order to prevent their force major fracturing.

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КОНСТРУЮВАННЯ ВУЗЛІВ ЗВАРНИХ ФЕРМ ІЗ ВИКОРИСТАННЯМ ПК ANSYS

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Резюме. *Виконано дослідження поведінки зварної прямокутної ферми 18000 х 3600 мм при дії зовнішніх навантажень. Дослідний зразок виготовлено зі спареного стального вальцьованого кутникового профілю 100х100х7 мм. Вузлові фасонки виконано трапецеподібними зі стальної пластини товщиною 10 мм. Вибрано схему навантажування, яка ідентифікує експлуатаційний режим для конструкції такого типу. За результатами виконання комп'ютерного моделюючого експерименту в середовищі ANSYS Workbench 14.5 отримано параметри НДС елементів ферми за різних значень зовнішнього навантаження. Виявлено рівень напружень у вузлах ферми та запропоновано конструктивну конфігурацію фасонок, яка дає можливість підвищити втомну довговічність конструкції на 18,4%. Отримані результати становлять теоретичний і практичний інтерес як для проектування нових ферм, так і для перевірки їх залишкового ресурсу, які експлуатуються при дії циклічних навантажень.*

Ключові слова: *зварна ферма, косинки у вузлах, втомна довговічність.*

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