

Experience of light thin-walled structures improvement in construction

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Abstract. The authors on the basis of practical experience have analyzed low-rise construction with the use of energy-saving technologies. Characteristic features of possible variants of frame construction are looked at and described. The relevance of the paper consists in the improvement of the building frame design solution based on the analysis and elimination of disadvantages taking into account consumers' point of view.

1. Introduction

At the present time low-rise construction takes on the appearance of mass character and enjoys specific popularity; it refers to the region where innovative energy saving technologies and materials are being introduced most rapidly and effectively. High cost of building materials, lack of knowledge, absence of clear requirements and experience in the sphere of energy efficient design make the realization of most projects unprofitable.

One of the most popular technologies of construction of low-rise buildings is a frame building of light steel thin-walled structures (LSTWS) [1, 2, 3, 4]. Among its advantages manufacturers indicate the resistance to corrosion of galvanized profiles, low weight, lack of shrinkage, quick installation; wall structure do not require preparatory work for finishing. At the same time among the deficiencies they indicate only the suitability of the technology in low-rise construction and unsuitability for the buildings located on heaving soils. The experience of the use and the LSTWS basic technology prerequisites are described in [5, 6, 7].

This article presents the practical experience of construction from thin-walled cold-formed profiles. The authors' task is to share the experience of improvement of constructive solutions on the basis of the analysis of shortcomings and common errors in frame-house construction, including their elimination relying on the opinions of direct consumers as well.

2. Применение ЛСТК при строительстве жилых домов Application of LSTWS at construction of apartment houses

The particular feature of traditional constructive solution is a frame of the building, consisting of thin-walled steel struts (S), connected at the top and bottom by the strapping beams (SB1, SB 2) and additional links (L1). Spatial resistance and the rigidity of the frame on a whole is provided by the formed system of longitudinal and transverse load-bearing walls, rigidly connected by a floor

structure. Layout of thin-walled galvanized cold-formed profiles in plan and in section is shown in Figure 1.

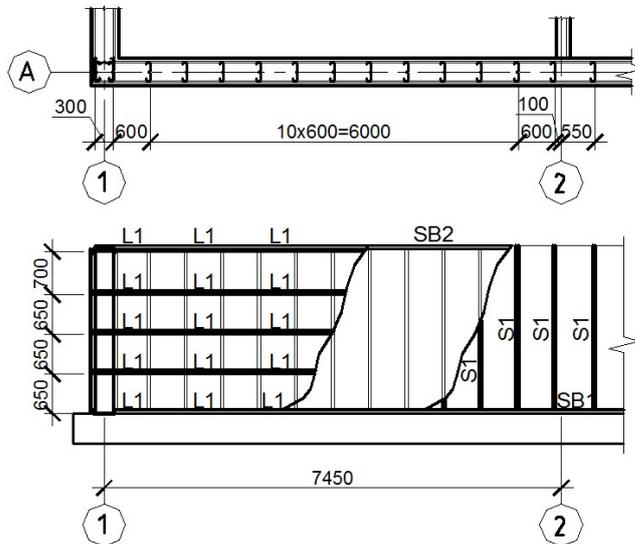


Figure 1. Layout of the thin-walled galvanized profiles in plan and in section

This technology was used in the construction of single-storey semi-detached residential houses built in accordance with "the Program of resettlement from dilapidated housing" in the Birilyuss district of the Krasnoyarsk territory (Figure 2). At the core of the frame C-shaped stands with 50x150x50 mm section of 1.5 mm thick are provided, arranged with a gap of 600 mm with stacked plates of the mineral wool insulation of 150 mm and 50 mm thick. To ensure the frame spatial rigidity the stands are tied with vertical Z-shaped and U-shaped inclined ties. To exclude the "cold bridge" between the steel elements, strips from waterproof plywood are provided. On the inner side walls are sheathed with gypsum fiber plates in 2 layers; between them the vapor barrier is provided with siding from the outside. As bearing elements, cover trusses are provided supported directly on the rack frame. To ensure the stability of frames, their upper belt is fixed by II-shaped spans with a step equal to the grid coverage element step. To reduce the consumption of materials, the insulation coating was carried out along the horizontal plane at the level of the covering plate.



Figure2. Housing frame under construction

The application of the above technology in the construction of houses is justified not only by the forced short construction time, but also by the need to use a cost-effective option. The area of one building is 156.6 m². Technical and economic indicators of the project are the following: cost of

construction – 53,330 \$, duration - 3 months, the cost of 1 m² is the 340.5 \$ including delivery of materials to the construction site at a distance of 250 km.

The calculation of the building frame was made according to the spatial pattern with the reduction of the cross-sections of elements. In the construction of houses the respective authors' and quality control were provided. Residents moved into their homes more than 2 years ago with no complaints so far.

3. Improvement of the LSTWC technology in the case of an administrative building

Taking into account the opinion of consumers who have used the LSTWS technology in low-rise construction, we can conclude that there is a large number of projects with defects caused not only by saving on good quality construction materials and installation time, but also by the development of design-estimate documentation. After analyzing the information from various forums [8, 9], where the opinion is expressed not only by manufacturers and builders, but also by the consumers themselves one can make a conclusion that the population has a bias towards this technology.

Most of the buildings built with the LSTWS technology, are not able to find their buyer. People refuse to buy apartments in the houses, considering that the apartments cannot be used in the form of comfortable housing. The main disadvantages that the residents identify are: lack of competent approach to the creation of the project, including its construction; the hollowness of the structures of walls and ceilings [8]; the lack of information on the effects of electromagnetic radiation for safe living in buildings with a metal frame [10]. One of the main issues for future residents is a problem of furniture mounting to the "thin" walls, which is solved by additional strengthening of cross platforms from boards and beams. During the period of construction it is impossible to predict where the furniture will be located. Afterwards, with the introduction of the building the arrangement of additional elements reduces the useful area of the house and requires additional work

The results of consumers' opinions were taken into account in the construction of low-rise administrative building with the use of the LSTWS technology.

The technology which received a positive feedback during the construction of one-storey houses was used as the basis of constructive solution. The customer suggested to cut metal consumption by reducing the cross section of load-bearing profiles (50x100x50 mm), and by binding racks on two sides by braced profiles and wooden bars (50-50 mm with a step of 600 mm) to provide insulation in 3 layers – Figure 3. The racks step was 600 mm depending on the size of the insulation slab.

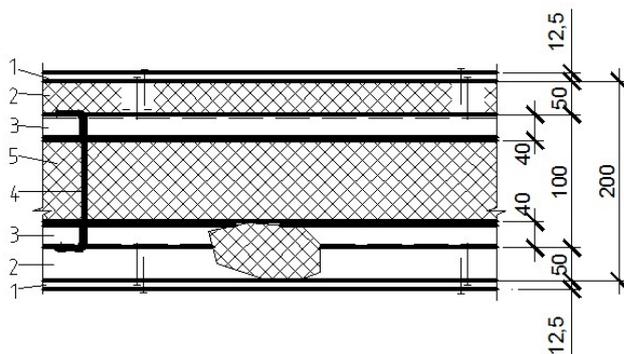


Figure 3. Constructive solution of the wall (variant 1):

1. Gypsum – fiber board
2. 50x50mm wooden block
3. Binding profiles
4. Frame bearing rack
5. Mineral wool insulation

As an alternative of the first variant, the authors of the project proposed to address the technology, when steel thin-walled profiles play the role of a bearing skeleton of the building only during the construction period. At the same time, these elements serve as guides for the formwork fastening - Figure 4. When performing calculations of the bearing capacity of the frame elements, loads acting during the building maintenance are adopted. By reducing the cross-section of the elements the coefficient of their utilization was close to one and the bearing elements of the frame did not have sufficient margin of safety.

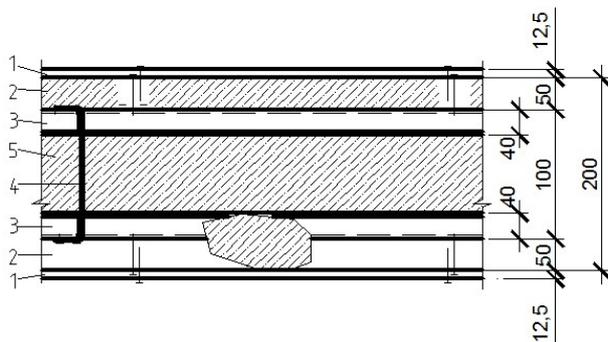


Figure 4. Constructive solution of the wall (variant 2):

1. Gypsum – fiber board
2. 50x50mm wooden block
3. Binding profiles
4. Frame bearing rack
5. Monolithic foam concrete

Figure 5 shows a schematic arrangement of bearing elements of the frame in plan and in section of the improved LSTWS technology. The calculation of the frame is made in two stages: during installation and during operation. The result is that the bearing capacity of all the elements is provided, the utilization coefficient of the cross section equals to 0.8. Mounting values are taken as the loads on the steel frame of the building. During the period of operation of the building, both the steel frame and monolithic foam concrete are included into the work.

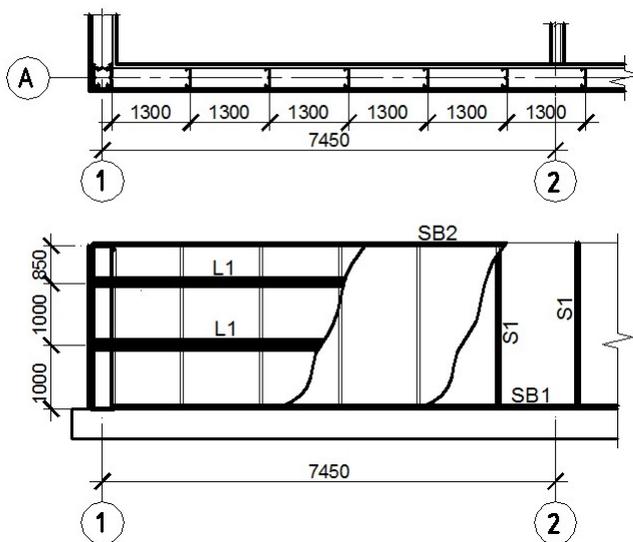


Figure 5. Layout of the thin-walled galvanized profiles of the improved frame of the building in plan and in section

In the analysis of two variants of the constructive decision of the administrative building, it was decided to use the second option. Area – 320 m². Technical and economic indicators of the project: cost of construction – 116,800 \$, duration – 4 months, the cost of 1 m² is 365 \$.

Technical and economic analysis has shown that the timing of construction in the 2nd version increased by 2 weeks, and the difference in cost is not more than 5%. The advantages of this option are: elimination of the walls instability, an increase in the racks step up to 1,300 mm, which reduces the frame material consumption. Disadvantages included an insignificant increase in the term and cost of construction due to the use of monolithic foam concrete.

4. Conclusion

In conclusion it should be noted, that the authors on the basis of personal experience, faults analysis and opinions of actual customers have improved the technology of light steel thin-walled structures in low-rise construction. Comparing the results of construction of residential houses and the administrative building, one can conclude that both options can be used in practice depending on the

requirements of the customer .Application of monolithic foam concrete in frame housing construction has a positive effect on the results without a significant increase in project cost and construction time.

The application of new technologies is treated with suspicion by builders and consumers. The opinion of consumers and customers plays a huge role in the development and improvement of innovative technologies not only in low-rise construction but in other industries as well.

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