

## **Arrangement and technological solutions for construction of quick-assembling single-storey houses**

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### **Abstract**

*Quick-assembling single-storey houses are one of the possible design solutions if we want to get ready-made houses in short time. It is especially important in locations where new factories and plants, fields of the fossil fuels extraction are developed, various catastrophes occurred and there is a necessity to carry out recovery works. However, the spread of quick-assembling single-storey houses slows down because of design, arrangement and technological complications, which should be settled comprehensively.*

*The aim of the research work is to provide competitiveness of such houses by improving their manufacturing level, which includes design, arrangement and technological solutions, reducing price and time of getting ready-made houses. The manufacturing level is determined by labor input, time and cost parameters.*

*The research results show that the design solution, improving manufacturing level, is the use of prefabricated flat packets of sandwich-panels, which transform into design position during the assembling process due to transformable joints. The transportation of the flat packets can be carried out if their size allows transporting them by road transport.*

*The arrangement and technological sustainability of the construction system includes the following stages: selection of separate arrangement and technological conditions of the system; determination of groups of arrangement, technological and economic factors, which influence on sustainability of each condition of the construction system, determination of rational spheres of influence of arrangement and technological factors on cost of the transformable houses.*

*The developed solutions can reduce cost and time of the assembling process and improve manufacturing level of single-storey houses.*

**Keywords :** Transformable Quick assembling, Single-storey house, Sandwich-panels, Construction process

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## **I. Introduction**

One of the vital problems, connected with time reduction of the construction process on building site, is settled by reasonable combination of new design, arrangement and technological solutions at various stages of the engineering science evolution.

The problem of developing of new design solutions, which allow assembling houses in short time, rose especially at the period of intensive exploration of new geographic regions and construction of workers settlement. Such design solutions have considerable demand in many countries and they are subject of research of many scientist and engineers nowadays (Iqbal et al., 2018; Seidlein et al., 2017; Tanyer et al., 2018).

The assembling period of single-storey houses depends on their design solutions, functions and the building site features (Chardon et al., 2016; Premrov et al., 2016; Motuziene et al., 2016). The well-known technologies of the single-storey houses assembling, as a rule, mean the use of manual labor. Such technologies are characterized by high labor input. It causes the increase of assembling time and price (Shehata and El-Gohary, 2011; Lee et al., 2017).

The technologies of the single-storey houses assembling evolve and move to the way of labor input and time reduction nowadays. In this case, such technology is called quick-assembling technology.

However, the spread of quick-assembling single-storey houses slows down because of design, arrangement and technological complications, which should be settled comprehensively.

Taking into account the construction experience of modern quick-assembling single-storey houses, the aim of our research work is to provide their competitiveness by improving their manufacturing level, which includes design, arrangement and technological solutions, reducing price and time of getting ready-made houses.

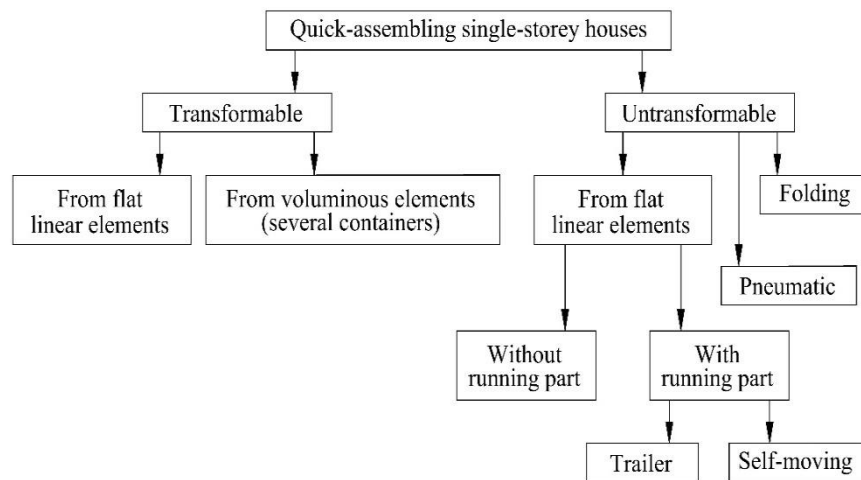
## **II. Design solutions of quick-assembling single-storey houses**

High level of the design solution of the quick-assembling houses means its accordance with normative requirements in the field of arrangement of the construction process (Saieg et al., 2018).

In this case, such houses can be classified in dependence of their design solutions (fig. 1).

The competitiveness level the design solutions is determined by level of their demand in innovative projects (Bygballe and Ingemansson, 2014; Chirkunova et al., 2016; Rantala et al., 2018; Wang and Seidle, 2017).

The manufacturing level is determined by labor input, time and cost parameters, which can be comparable with traditional technologies (Rawat et al., 2018; Eysers and Potter, 2017).



**Fig. 1.** Classification of quick-assembling single-storey houses

Our research results show that the main ways of effective using of quick-assembling single-storey houses are the following:

- Temporary residential and public houses, which are assembled after various catastrophes during recovery works.
- Houses for long-time settlements (trailers, cafes, motels, canteens, camping, sport complexes, storehouses, shops, medical posts, bathhouses, laundromats).
- Storages and warehouses for different products, such as forage for animals, fertilizers, raw materials, agricultural goods).
- Houses for workers in locations, where new factories and plants, fields of the fossil fuels extraction are developed.
- Quick-assembling military bases for long-time accommodation of soldiers.

We consider that one of the most perspective solutions in accordance with the above-mentioned requirements is transformable and quick assembling single-storey houses from sandwich-panels (Abdolpour et al., 2016; Woltman et al., 2017; Reengwaree et al., 2013; Gara et al., 2012).

Transportation of such houses is carried out in form of flat packets, which transform into design position during the assembling process due to transformable joints. The transportation of the flat packets can be carried out if their size allows transporting them by road transport.

Such design solutions has the number of advantages, the main of them are the following:

- Transformable houses from sandwich-panels are light in weight as compared with houses from concrete, built by using cast-in-situ technology, in 3-4 times. It allows reducing the load on foundations.
- Life cycle of such houses is almost equal to houses, built by using traditional technologies, under conditions of quality assembling works.
- Short time of assembling works, which allows reducing price of such houses.

### III. Results and discussion

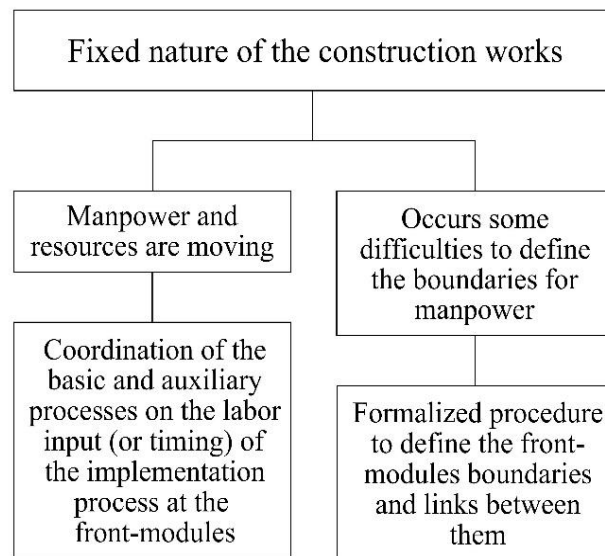
As we mentioned above, introduction of the transformable single-storey houses into building market can be implemented by increasing the manufacturing level of these houses.

The manufacturing process, as any other sector of material production, bases on the following rules:

- Movement or standing of the technological cycle elements from each other at any moment of time;
- Different time of the technological cycle;
- Variety of the operations combination in space and time;
- Dynamic and flexibility of the technological cycle;
- Necessity and sufficiency of staff with various specialty and qualifications.

The arrangement theory considers various models of arrangement of the construction process(ELZomor and Parrish, 2016). However, the mechanical model, which has certain connections, functions, labor division and acts as single system, characterizes construction of the transformable houses(fig. 2).

The volume of construction works can change in rather large limits in the planning process in particular conditions (table 1).



**Fig. 2.** Preparation of the input information for working out of construction schedule, taking into account the fixed nature of construction

**Table 1.** Stages of construction of quick-assembling single-storey houses

Stage 1	Manufacturing of flat packets at the plant
Stage 2	Finish of internal and external surfaces of the elements
Stage 3	Laying of engineering networks, connection tools, engineering equipment and their preparing for transportation to building site
Stage 4	Transportation of the flat packets to the building site
Stage 5	Marking of the house axes
Stage 6	Assembling of pile foundation
Stage 7	Assembling of the single-storey house
Stage 8	The check of cross position of the house elements
Stage 9	The check of the house joints
Stage 10	Rigid fastening of the house joints and pile foundation
Stage 11	Construction of blind area around the house
Stage 12	Assembling of engineering equipment inside the house
Stage 13	Assembling of engineering networks outside the house
Stage 14	The building site improvement. Commissioning of the house

The arrangement and technological sustainability of the construction system includes the following stages:

1. Selection of separate arrangement and technological conditions of the system. We considered two conditions, reflecting: the process of prefabricated construction of the elements of the transformable houses under flexible technology; the assembling process on building site.
2. Determination of groups of arrangement, technological and economic factors, which influence on sustainability of each condition of the construction system.
3. Determination of rational spheres of influence of arrangement and technological factors on cost of the transformable houses. We determined the rational spheres of influence: materials consumption of the basic unit of the houses; level of mechanization and specialty of prefabricated production of the basic unit.

The first step is to arrange the manufacturing of transformable houses from sandwich-panels in form of the flat packets as well as all necessary engineering equipment and prepare them for transportation (stages 1-3).

These stages are especially important because the use of prefabricated elements and constructions with high manufacturability level of transformable units allows reducing the assembling period with providing quality of construction works (Gopinath et al., 2014; Ferreira et al., 2016; Fernando et al., 2017).

Sandwich-panels can be manufactured with using steel or concrete as material of external layers of the panels. Concrete has high durability then steel, but it has higher weight.

The second step is to settle the problem of the cost reduction of their transportation (stage 4). As we mentioned above, the transportation conditions of the flat packets depend on their size, which should allow transporting them by road transport.

Traditional machines and equipment are used for most quick assembling houses, including the foundations assembling (stage 6). Pile foundation has certain advantages as compared with other types of foundations, the main of them are short time of assembling and possibility of using in almost all types of soil.

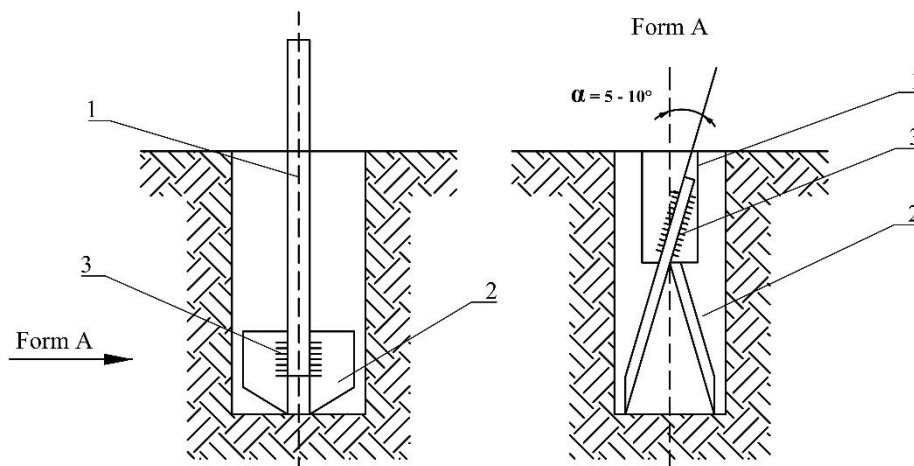
However, it is important to finish all works, connected with foundation assembling, including curing period of concrete of bored piles, before starting assembling of transformable house and it should be taken into account in construction schedule.

We developed new technology and equipment for assembling of bored pile foundation with widened base, which allows increasing the bearing capacity of foundation and reducing the material consumption and, as a result, price of the foundation assembling (fig. 3).

Concreting of borehole is recommended with using the concrete with the compressive strength not less than 50 MPa (Stashevskaya et al., 2018).

The system of quick assembling of the transformable single-storey houses (stage 7) bases on the main arrangement and technological principles, which are the following:

- a) The assembling period of the single-storey house should not be more than 1.5-2 days;
- b) Transformability of the system, which includes:
  - The house transformability due to its design solution;
  - The building site transformability due to various design solutions of the houses and building sites, it speeds up the assembling process;
- c) Evolutional-convertible scheme of manufacturing of the transformable houses, it means the type specialty of the elements for the technological lines.



**Fig. 3.** Dipping the equipment into the Soil  
1 - barrel; 2 - blades; 3 - welded joint

#### IV. Conclusion

The obtained research results testify to the manufacturing level of quick-assembling single-storey houses can be improved by solution of design, arrangement and technological problems complexly.

The research results show that the design solution, improving manufacturing level, is the use of prefabricated flat packets of sandwich-panels, which transform into design position during the assembling process due to transformable joints.

The developed arrangement and technological solutions can reduce cost and time of the assembling process, and, as a result, improve manufacturing level of single-storey houses.

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