

Six types of enclosing structures for low-storey houses. Economic comparison

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Abstract. The article represents comparative economic analysis of 6 types of enclosing structures for low-storey houses. They are: masonry, foam concrete blocks laying, glued laminated lumber, timber frame construction, light-weight steel thin-walled framing, glued veneer panel. The last one distinguishes of a high factory readiness level, allow using nonconforming veneer in its compound, may contain underlining depending of the exact region. Analysis was carried out using five-grade scale in several groups of parameters, such as: physical characteristics, building conditions, extra works if needed and maintainability, economical characteristics, probability rate. The results obtained maid it possible to recommend glued veneer panel for universal application.

1 Introduction

As a rule, materials and structures for detached house are chosen based on such parameters as durability, practicability and price. But a potential buyer hardly ever meets a manufacturer who will pay attention to his products defects or gaps.

Based on Saint-Petersburg State Polytechnical University a comparative analysis of structures for low-storey construction has been already carried out in 2013[1]. In Federal state budget educational institution of higher education “Moscow state university of civil engineering (national research university)” data obtained during that survey were updated with regard to the 2018 year prices. In addition to this, the economical parameters of new structure (glued veneer panel) [2, 3] comparison was carried out.

Glued veneer panel [2, 3] – is a new structure type with industrial producing and a high factory readiness level. It combines bearing and enclosing functions. This panel consists of two veneer plates, girt and internal dimensioned frame [3], and in whole used for composing a house.

Glued veneer panel classification, which includes wall structures (solid; filled-in panels: doors or window) as well as flooring or covering [2], has a high factory readiness level. That is why it allows to cut down the construction process duration dramatically.

These types of enclosing structures were examined in this article:

1. Masonry. Compound: plaster 5mm, masonry 250mm, slag wool 100mm, air gap 20mm, slab-type veneer 120mm. Total structure thickness account for 495mm.

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2. Foam concrete blocks laying. Compound: plaster 5mm, foam concrete blocks 200mm, slag wool insulant 100mm, air gap 20mm, slab-type veneer 120mm. Total structure thickness account for 445mm.
3. Glued laminated lumber. Compound: covering of internal side gypsum board + gypsum-fiber sheet 25mm, frame under covering 27mm, lumber 150mm, slag wool insulant 100mm, air gap 20mm, slab-type veneer 120mm. Total structure thickness account for 445mm.
4. Timber frame structure. Compound: covering of internal side gypsum board + gypsum-fiber sheet 25mm, frame filled with slag wool 200mm, furring 44mm, fiber-cement panels as the brick 15mm. Total structure thickness account for 284mm.
5. Light-weight steel thin-walled framing. Compound: covering of internal side gypsum board + gypsum-fiber sheet 25mm, frame filled with slag wool 200mm, furring 44mm, fiber-cement panels “as the brick” 15mm. Total structure thickness account for 284mm.
6. Glued veneer panel. Compound: glued veneer panel filled with slag wool 200mm, cladding by fiber- cement panels as “the brick” 15mm. Total structure thickness account for 215mm.

2 Methods

In order to estimate objectively, general parameters and requirements were chosen:

1. The external side of the wall must satisfy so called “brick finish”;
2. The internal side of wall must satisfy “fine finish”;
3. Thermotechnical characteristics for central federal district value: $3,087 \text{ m}^2 \text{ }^\circ\text{C/W}$;

All structures were estimated by five-grade scale: from point five (5) – the best result among represented structures, to point one (1) – the worst result among represented structures. The comparative analysis was carried out using five groups of parameters [5]. The data obtained were put on into a table.

- The first group of parameters – are physical characteristics:
 1. Actual thermal transmission resistance (For central federal district – $3,087 \text{ m}^2 \text{ }^\circ\text{C/W}$);
 2. Fire-resistance (III grade);
 3. Ecological compatibility (in accordance with the standards);
 4. Noise insulation (in accordance with the standards);
 5. Combustible materials presence;

Eventually the best result in this group of parameters showed light-weight steel thin-walled framing application. This fact is represented in Table 1. Glued veneer panel as well as timber frame construction lost two because of combustible materials presence in it.

Table 1. Physical parameters.

Physical		Parameters				
		1.	2.	3.	4.	5.
Enclosing structures	Masonry	2	5	5	5	5
	comment	$3.17 \text{ m}^2 \text{ }^\circ\text{C/W}$	satisfy	satisfy	satisfy	absent
	Foam concrete block	4	5	5	5	5
	comment	$4.181 \text{ m}^2 \text{ }^\circ\text{C/W}$	satisfy	satisfy	satisfy	absent
	Glued laminated lumber	3	5	3	5	4

	comment	3.69 m ² °C/W	satisfy	satisfy	satisfy	present
	Timber frame	5	5	4	5	5
	comment	5.461 m ² °C/W	satisfy	satisfy	satisfy	present
	Light-weight steel thin-walled framing	5	5	5	5	5
	comment	5.46 m ² °C/W	satisfy	satisfy	satisfy	absent
	Glued veneer panel	5	5	4	5	4
	comment	5.56 m ² °C/W	satisfy	satisfy	satisfy	present

- The second group of parameters – building conditions:
 6. Capability of building and normal operation processes in different regions;
 7. Building in complex terrain and unstable ground;
 8. Seasonal construction variability (exclude foundation);
 9. Capability of building with high seismic hazard;
 10. Weather conditions influence;
 11. Transport expenses (considering mass – m and volume – v);
 12. Delivering to remote places;

The results for the second group of parameters are represented in Table 2.

- The third group of parameters – extra work required/ maintainability:
 13. Extra work before internal “fine finish”;
 14. Facade finishing changes;
 15. Utility systems laying;
 16. Special requirements to bearing structure of the building, extra works;
 17. Reconstruction capability [6,7];

The results for the third group of parameters are represented in Table 3. Glued veneer panel showed one of the best value by collecting the highest amount of points in all of the criterias.

Table 2. Building conditions.

Building conditions		Parameters						
		6.	7.	8.	9.	10.	11.	12.
Enclosing structures	Masonry	5	3	3	4	4	4	4
	comment	any region	foundation increasing price	seasonal operation	additional cost	present	heavy = m+V	heavy = m+V
	Foam concrete block	5	3	3	4	4	4	4
	comment	any region	foundation increasing price	seasonal operation	additional cost	present	heavy = m+V	heavy = m+V
	Glued laminated	5	4	4	5	5	4	4

	lumber							
	comment	any region	foundation increasing price	seasonal operation	low cost	non	heavy = m+V	heavy = m+V
	Timber frame construction	5	5	5	5	5	5	5
	comment	any region	light weight structure	any season	low cost	non	low	possible
	Light-weight steel thin-walled framing	5	5	5	5	5	5	5
	comment	any region	light weight structure	any season	low cost	non	low	possible
	Glued veneer panel	5	5	5	5	5	5	5
	comment	any region	light weight structure	any season	low cost	non	low	possible

Table 3. Additional works.

Additional works		Parameters				
		13.	14.	15.	16.	17.
Enclosing structures	Masonry	4	4	3	5	1
	comment	Plaster required	Costly	Wall chasing	Absent	Foundation strengthening
	Foam concrete block	4	4	3	3	2
	comment	Plaster required	Costly	Wall chasing	Additional reinforcement	Foundation strengthening
	Glued laminated lumber	3	4	3	4	3
	comment	Plaster required	Costly	Wall chasing	Antiseptics and antipyrenes	Foundation strengthening
	Timber frame	5	5	4	4	4
	comment	Not required	Easy	Easy	Antiseptics and antipyrenes	Complex joints
	Light-weight steel thin-walled framing	5	5	5	5	5
	comment	Not required	Easy	Easy	Absent	Low cost
Glued veneer	5	5	5	4	5	

	panel					
	comment	Not required	Easy	Easy	antirots and antipyrenes	Low cost

- The forth group – economic parameters:
 18. Active area of internal rooms for a house dimensions 8x10m (m²);
 19. The building cost with the “fine finish” (rub.);
 20. The one m² structure cost – solid part of the wall (rub.);

Estimated cost of all structure was calculated with the use of price-list from March, 2018. The results are represented in Table 4. The best value has glued veneer panel, because of its high factory readiness level and automated process of panels setting-up.

Table 4. Economic parameters.

Economic		Parameters		
		18.	19.	20.
Enclosing structures	Masonry	2	4	3
	comment	63.16	51696	25684
	Foam concrete block	3	3	1
	comment	64.78	63875	39646
	Glued laminated lumber	4	3	2
	comment	64.87	63521	32469
	Timber frame	5	4	4
	comment	70.1	55008	15360
	Light-weight steel thin-walled framing	5	2	5
	comment	70.1	74714	10595
	Glued veneer panel	5	5	5
	comment	70.1	33612	12306

- The fifth group probability parameters:
 21. Changes in configuration and properties of the bearing structure of the building, because of the external factors influence (shrinking, changes in the vertical bearing structures straightness);
 22. Error probability as a result of a “human factor” (meaning the experience level in raising such structures);

The analysis of regarding enclosing structures by probability parameters is represented in Table 5.

Special diagrams were composed based on data, obtained during the tables 1-5 analysis (Fig. 1. and Fig. 2.). These diagrams represent total amount of points, which was assigned to each of the enclosing structures for low-storey building and also the average point for each of the structural systems.

Table 5. Probability parameters.

Probabilistic		Parameters	
		21.	22.
Enclosing structures	Masonry	5	3
	comment	Non	Significant experience required
	Foam concrete block	5	3
	comment	Non	Significance experience required
	Glued laminated lumber	4	4

	comment	Possible shrinkage	Experience required
	Timber frame	3	4
	comment	Possible shrinkage, straightness changing	Low error rate
	Light-weight steel thin-walled framing	5	5
	comment	Non	Low error rate because of detailed engineering documentation
	Glued veneer panel	5	5
	comment	Non	Almost not needed

3 Results and Discussion

Based on the investigation worked out we may confirm, that glued veneer panel structure characteristics are comparable to the ones of light-weight steel thin-walled and timber frame houses, which are made with the use of framework technology. The main problem of the light-weight steel thin-walled structures is the necessity to prevent the corrosion attack. As for timber frames – the main problem is its low level of maintenance [8].

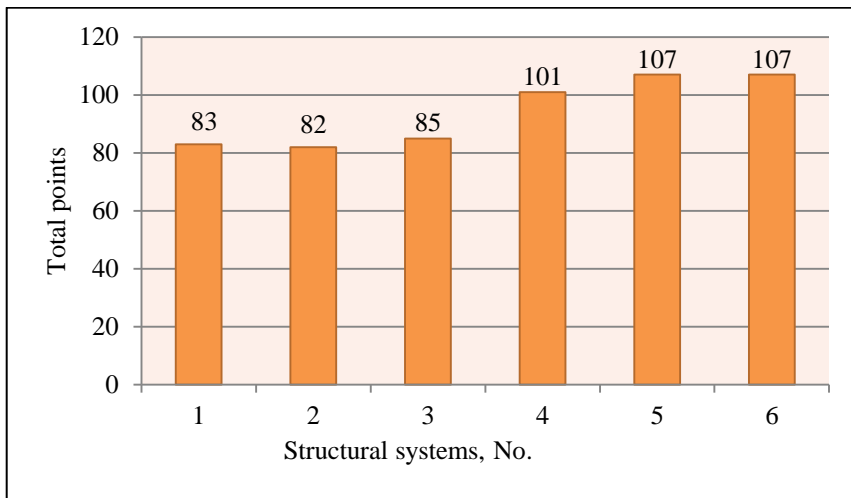


Fig. 1. Diagram total amount of paints for each enclosing structure.

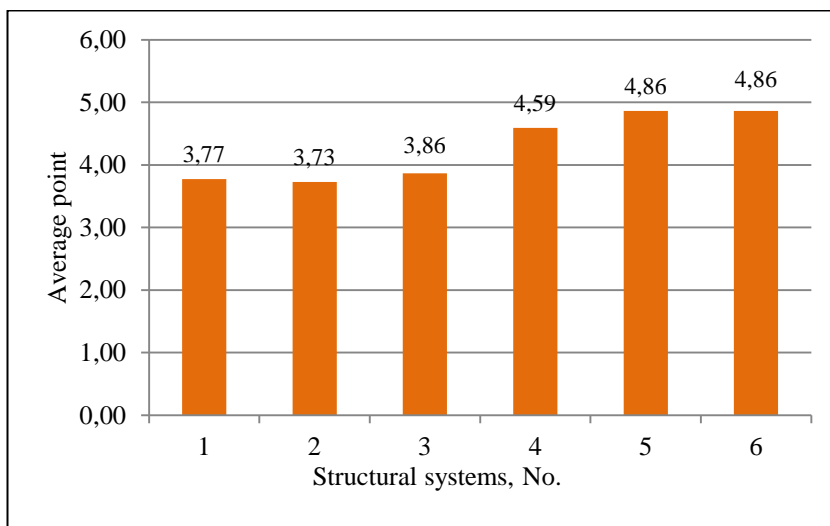


Fig. 2. Diagram of the average point for each enclosing structure.

4 Conclusions

In return glued veneer panel structures has great advantages, such as:

- Low structure mass (doesn't require heavy foundation and craneage equipment);
- High factory readiness level;
- Simple installation process, connection between each other;
- Opportunity to use filling grid (nonconforming veneer) in structural elements;
- Economical positive effect
- High level of maintenance [8].

Conclusion: glued veneer panel may be recommended for the universal appliance in low-storey houses building.

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