



Analysis of the Economic Benefits of Prefabricated Buildings

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ABSTRACT

At present, China's construction industry, mainly adopts the way of on-site pouring (masonry) construction, low resource and energy utilization efficiency, large construction waste discharge, serious dust and noise and environmental pollution. If the construction way is not fundamentally changed, the resulting excessive consumption and waste of resources and energy will not be reversed, and the contradiction between economic growth and resources and energy will be more prominent, and will greatly restrict the sustainable development of the economy and society. In recent years, China's industrialization and urbanization have been advancing rapidly, the reduction of labor force and the shortage of high-quality construction workers have become more and more prominent, and the "hard constraints" on the development of the construction industry has intensified. On the one hand, the labor price is constantly rising; on the other hand, the traditional construction mode is extensive, the low level of industrialization, the shortage of skilled workers, and the low labor efficiency. The development of prefabricated buildings is a major change in the way of construction and an important measure to promote China's supply-side structural reform and the development of new urbanization. The development of prefabricated buildings is conducive to saving resources, reducing construction pollution, improving labor production efficiency and quality and safety level; promoting the deep integration of construction industry and information industrialization, cultivating new industries and new driving forces, and promoting the resolution of excess capacity. Prefabricated buildings adopt the modern industrial production mode to replace the traditional manual production mode, which have many advantages in improving the construction quality, improving the production efficiency, shortening the time period, the energy saving and emission reduction, saving the labor force and improving the working environment of workers.

Prefabricated buildings adopt standardized and collaborative design, which can reduce the problems of "wrong, leakage, touch, lack" and other problems from the design source. Precast prefabricated parts are factory produced with high accuracy and reliable quality; industrial workers' assembly standard construction on site can effectively solve wall leakage and cracking in traditional construction methods and improve the overall construction quality. The Prefabricated building adopts the factory production and assembly construction mode. Compared with the traditional cast-in-place and wet operation mode, it can significantly reduce the comprehensive labor input, improve the production efficiency and shorten the construction period. The dust, noise and sewage discharge of prefabricated buildings are greatly reduced, and the construction process can well achieve the "five sections and one environmental protection", in line with the national energy conservation, emission reduction and green development goals.

Similar to traditional cast-in-place concrete buildings, prefabricated concrete buildings are designed and reviewed according to the relevant building specifications and standard atlas issued by the competent authorities. The Prefabricated components of the prefabricated concrete buildings are produced by the PC production line with high accuracy. At the construction site, the professional assemblers shall install and construct them according to the standardized construction process, and the government and the third-party agencies shall effectively supervise and accept the construction quality of the prefabricated buildings. At the same time, prefabricated concrete buildings have a large number of practical engineering cases in the United States, Europe, Japan and China, which provides valuable construction experience and construction methods, which can effectively support and guarantee the construction quality of the current prefabricated concrete buildings.

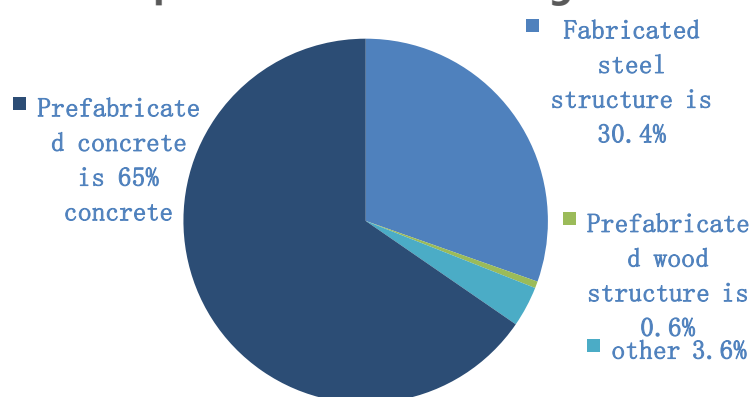
Keywords: Economic Benefits, Prefabricated Buildings

I. INTRODUCTION

1.1 Current status of the prefabricated building market

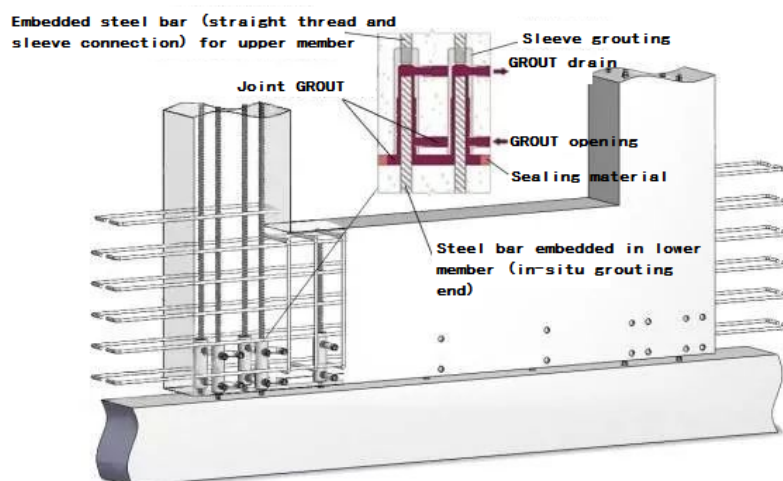
Under the background of the transformation and upgrading of the manufacturing industry, the central government continues to introduce relevant policies to promote the development of the prefabricated construction industry. In September 2016, the General Office of the State Council issued the Guiding Opinions on Vigorously Developing Prefabricated Buildings, which pointed out that the prefabricated building industry should be developed at multi-levels and from multiple angles. In recent years, the promulgation of a series of policies has accelerated the development of China's prefabricated construction industry.

Distribution of structure type of prefabricated buildings



II. LITERATURE REVIEW

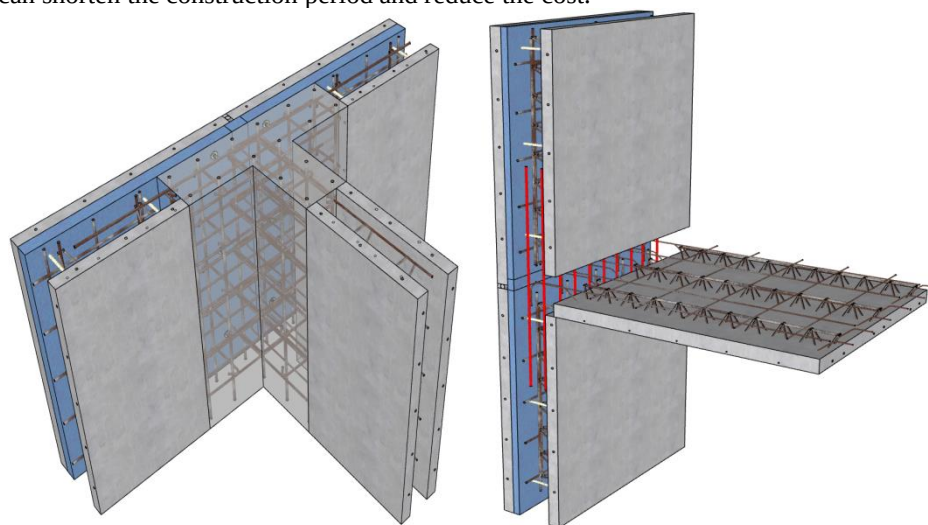
In prefabricated concrete buildings, the common vertical force system of structure has grouting sleeve system and overlapping shear wall system. Advantages and disadvantages of grouting sleeve: compared with welding and straight thread mechanical connection, sleeve grouting connection can reduce the preprocessing workload of reinforcement, reinforcement without secondary stress and deformation, relatively large construction deviation; high cost, high prefabrication accuracy, and difficult field detection are still problems to be solved.



Advantages and disadvantages of overlapping shear wall system:

- 1) The structural connection mode of overlapping shear wall is reliable. The prefabricated wall panels on both sides can serve as templates in the structural construction process, greatly reducing the workload of site formwork support and formwork removal, reducing the construction cost, and are in line with the characteristics of industrial buildings.
- 2) In the structural system of prefabricated stacked shear wall, structural vertical joints and horizontal joints are connected by connecting reinforcement and pouring concrete set in the cavity of the stacked shear wall, which has the advantages of convenient construction and easy quality assurance.
- 3) In the assembly of the integral overlapping shear wall structure, the cavity of the overlapping shear wall is made of on-site post-cast concrete, "connected" from bottom to top, and connected with the cast-in-place parts such as edge components to form a whole. As a "semi-prefabricated and semi-cast-in-place" structure system, the assembly of the integral overlapping shear wall structure has good integrity and excellent waterproof performance.

- 4) Bonded shear wall components are not reinforced, the automatic production efficiency is greatly improved; the body weight of overlapping shear wall components is reduced by about 50%, convenient for transportation and lifting, the whole can shorten the construction period and reduce the cost.



III. RESEARCH METHOD

This paper is qualitative research (Marshall & Rossman, 2011); it is anchored on key documents that provide an understanding of the New Normal Era and it is an update on sustainable development paradigms. It is heuristic (Moustakas, 1990) because it enables the researchers who are presenters and the webinar audience to discover and learn something for themselves in meeting the challenges of the New Normal Era, with lessons learned from managing the COVID 19 as professionals. It makes sense of the past experience with COVID 19 situations in order to manage future economic and educational undertakings (Smith, 2015; Sela-Smith, 2002; Hudtohan, 2005; Gonzalez, Luz, & Tirol, 1984). The methodology is multi-valuate (Richardson, 2015) because it deals with various disciplines related to economics, finance, sustainable development and social development of women. This is an exploratory discourse (Stebbins, 2011) to study, examine, analyze and investigate the need for creativity and innovation in managing local and global economy and for the education sector to respond to the requirements of developing people skills in the New Normal Era.

IV. DISCUSSION

4.1 Cost comparison

Prefabricated buildings have become the main direction of the development of China's construction industry, being encouraged and supported by the state and governments at all levels. As a new prefabricated structure system, double-sided overlapping shear wall structure system integrates overlapping walls, overlapping beams and laminate floors together, which has the advantages of traditional cast-in-place structure system and traditional prefabricated structure system.

At present, the development of prefabricated buildings in China is mainly driven by the top-down policy, mainly because the cost of prefabricated structure engineering is slightly higher than the cost of cast-in-place structural construction engineering, which hinders the market promotion of prefabricated buildings to some extent. Most construction units' understanding of the engineering cost focuses on the dominant cost of the engineering entity, which separates the integrity of the project as an organism. In order to maximize the overall benefit of the project, the cost breadth needs to be further expanded. The scope of cost includes not only the explicit cost of the project, but also the hidden cost, environmental costs such as construction cost or hidden benefits. Therefore, while considering the engineering cost of the project, we also consider the hidden cost or benefit of the project, and reveal the cost difference between the double-sided overlapping shear wall structure, the cast-in-place structure, and the traditional prefabricated structure.

4.2 Cost comparison of double-sided overlapping shear wall structure system and cast-in-place structure

4.2.1 Design Costs

Compared with the traditional cast-in-place design, the assembly assembly increases the link of component splitting and deepening the design in the design process, which increases the corresponding cost. Take the Beautiful Yunxi G1 # Building as an example, the prefabricated design cost is 45 Yuan/ m^2 , and the cast-in-place design cost is 37 Yuan/ m^2 . The economic benefit of assembly in the design stage is: $F1=22-30=-8$ Yuan/ m^2 .

4.2.2 Construction Stage Cost

Take Beautiful Yunxi G1 # Building as an example, the construction cost of prefabricated buildings (overlapping shear wall system, sleeve grouting system) and traditional cast-in-place system is compared in terms of technical index data and cost measurement data of individual projects.

Data of individual technical indicators of prefabricated and traditional construction projects						
Order Number	Project Name	Unit	Prefabricated Building		Traditional Pouring	Description of the Increase or Decrease of Assembly Vs Traditional Buildings
			Overlap The Shear Wall System	The Casing Grouting System		
1	Concrete indicators	m³/ m²	0.43	0.43	0.35	incremental reasons: 1. The thickness of the floor increases, traditional 10cm, assembly is 6 + 7=13cm; 2. The original outer masonry will be replaced with prefabricated double skin filling wall
1.1	PC member concrete	m³/ m²	0.13	0.23	0.35	
1.2	Concrete for cast-in-place components	m³/ m²	0.3	0.2		
2	Reinforcement index	kg/ m²	50.82	46.78	40.35	Incremental reasons: 1, overlapping shear wall vertical reinforcement, 2, horizontal restraint edge components increase structural reinforcement
2.1	PC member reinforcement	kg/ m²	18.82	22.44	40.35	
2.2	cast-in-place member steel bar	kg/ m²	32	24.34		
3	brick setting	m³/ m²	0.14	0.14	0.19	Reasons for the reduction: 1. The original outer masonry part shall be changed to prefabricated double skin filling wall
4	Internal wall plastering index	m²/ m²	0.36	0.36	1.84	Reasons for quantity reduction: 1. The prefabricated construction site can be free from plastering
5	The shed is pink and gray	m²/ m²	0	0	0.93	Reasons for quantity reduction: 1. Secondary plastering is not required for the overlapping plate site
6	templet	m²/ m²	1.64	1.67	3.53	Reasons for quantity reduction: 1. The original traditional construction walls, plates and columns are changed into prefabricated components, greatly reducing the site template installation
7	The exterior wall is painted at the grass-roots level	m²/ m²	0	0	0.83	Reasons for quantity reduction: 1. The prefabricated construction external wall is a full concrete structure, which can be free from plastering

Construction engineering cost calculation data						
Order Number	Project	Unit	Prefabricated Building		Tradition, Pouring	Remarks
			Overlap the shear wall system	Sleshing, grout, system		
one	major structure	Yuan / m ²	855	1051	692	
1	Installation of prefabricated components	Yuan / m ²	287	522	0	
2	Template works (aluminum mold)	Yuan / m ²	125	125	0	
3	Template works (wood mold)	Yuan / m ²	46	46	223	
4	Reinforcement installation works	Yuan / m ²	175	175	203	
5	concrete work	Yuan / m ²	221	182	267	
two	Building and coarse decoration	Yuan / m ²	278	278	282	
1	batten	Yuan / m ²	83	83	0	
2	blockwork	Yuan / m ²	36	36	108	
3	wall space	Yuan / m ²	112	112	127	Internal and exterior wall plastering, exterior wall paint, interior wall public area latex paint engineering
4	flooring	Yuan / m ²	36	36	36	
5	ceiling	Yuan / m ²	11	11	11	
three	Other works	Yuan / m ²	238	238	238	Door and Windows, railings, flue, roof, waterproof, thermal insulation and other works
four	Measures project	Yuan / m ²	219	226	180	
1	Tower crane and construction elevator	Yuan / m ²	68	85	52	
2	Outreach construction	Yuan / m ²	73	64	52	
3	Other direct costs for project contracting	Yuan / m ²	77	77	77	Inspection and test, winter and rainy season construction, safe and civilized construction, temporary construction, construction water and electricity charges, etc
five	Management fee and fee	Yuan / m ²	57	57	57	
six	expenses of taxation	Yuan / m ²	173	195	153	
seven	Small cost of civil works	Yuan / m ²	1819	2044	1601	

Judging from the above table:

The economic benefit of the overlapping shear wall structure system than the traditional cast-in-place system is: $F2=1819-1601= -218$ Yuan/ m². The economic benefit of the sleeve grouting structure system compared with the traditional cast-in-place construction system is: $F2'=2044-1601= -443$ Yuan/ m²

4.2.3 Economic Benefits of The Construction Period

Preform part of the components in the component factory, manually transfer the site wet operation to the factory, and improve the work efficiency through intelligent manufacturing, and the required components are completed in advance according to the construction schedule, to save the construction period. Compared with the 30-storey prefabricated concrete housing projects with a prefabricated rate of about 50% and the traditional cast-in-place building projects of the same scale, the prefabricated buildings can shorten the construction period by about 30%. The economic benefits of the construction period shall be calculated comprehensively in the construction stage.

4.2.4 Policy and Economic Benefits

The State Council and the Ministry of Housing and Urban-Rural Development have successively issued a series of important documents, such as the Outline for the Modernization of the Construction Industry, the Guiding Opinions on Vigorously Developing Prefabricated Buildings, and the Action Plan for Prefabricated Buildings during the 13th Five-Year Plan. More than 100 provinces and cities have issued more than 100 special guidelines and relevant supporting measures for prefabricated buildings, and effectively promoted the development of prefabricated buildings through preferential policies such as preferential land use, credit support, pre-sale in advance, preferential evaluation, tax incentives, and floor area ratio incentives. According to the prefabricated policy of Hefei: the construction area of the prefabricated part (not exceeding 3% of the planned total construction area) can not be included in the plot ratio of the transaction plot. The prefabricated building area of Beautiful Yunxi G1 # Building is about 289 m², the price is 14,000 Yuan / m², and the subsidy fund is about 299 Yuan/ m². The economic benefits of prefabricated cast-in-place structure in policy is: $F_3 = 289 * (13500 - 3500) / 9651 = 299$ Yuan/ m².

4.2.5 Environmental Benefit

Compared with the traditional cast-in-place mode, prefabricated buildings adopt the factory production mode, making the production process more controllable, and can reduce the loss of unnecessary energy and materials and the generation of construction waste. The prefabricated structure can save resources and energy consumption, and effectively reduce environmental pollution such as dust, noise and construction waste. Specific data are shown in the table below.

Comparison of PC prefabricated buildings and cast-in-place structural buildings

Classify	Pc Prefabricated Building	Cast-In-Place Structure Building	Save and improve
Water consumption	0.051-0.067m ³ / m ²	0.085-0.09m ³ / m ²	35-40%
energy consumption	7.0-7.1Kwh/ m ²	8.9-9.0Kwh/ m ²	20-25%
Construction waste treatment volume	7.34-7.35kg/ m ²	23.75-23.8kg/ m ²	65-70%
Dust level (PM10)	60-75ug/m ³	85-100ug/m ³	20-30%

It can be seen from the above table that prefabricated buildings occupy innate advantages in energy conservation and environmental protection, which are in line with the national sustainable development strategy, and their benefits cannot be estimated. The savings of prefabricated buildings in environmental benefits over cast-in-in-place structure is not temporarily considered here.

In conclusion, the economic benefits of overlapping shear wall system compared with cast-in-place structure is: $F = -8218 + 299 = 73$ Yuan/ m². The economic benefit of the sleeve grouting system compared with the cast-in-place structure is: $F' = -8443 + 299 = -152$ Yuan/ m².

V. CONCLUSION

Since 2016, the state has put forward clear development goals and a series of development measures for the transformation and upgrading and high-quality development of the construction industry. The CPC Central Committee, the State Council and the Ministry of Housing and Urban-Rural Development have issued several Opinions on Further Strengthening the Management of Urban Planning and Construction " (Zhongfa (2016) No.6), the Guidance on Vigorously Developing prefabricated Buildings (State Development (2016) No.71) and the 13th Five-Year Plan Action Plan (CCB (2017) No.77) to support the development of prefabricated buildings.

In recent years, with the continuous implementation of prefabricated projects, the technology has been becoming increasingly mature, comprehensive market and social factors, prefabricated buildings represent a new development direction, and have become an important part of the construction industry. As an important type of prefabricated concrete building system, the assembly of integral overlapping shear wall structure system emerged in Europe in the 1970s and has been widely used in Germany, France and Italy. Since its introduction in China, it has attracted much attention in 2005. After localization integration and development, its BIM positive design, better cost, factory standardized production and efficient construction and other aspects of the advantages have become increasingly obvious, and it has been applied in relevant projects in China on a considerable scale.

After the comprehensive comparison of the actual project in the design, construction, construction period, policy, environment and other aspects, we can conclude that the comprehensive benefits of the prefabricated structure system are basically equivalent to the cast-in-place structure system, and the comprehensive economic benefits of the overall overlapping shear wall structure system are better than that of the grouting sleeve system.

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