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Research on integrated innovation of prefabricated buildings based on improving quality and efficiency

Posted by: Jiechao Liu

Participating unit: Hunan Architectural Design Institute Group Co., Ltd.

Design institute introduction:

Hunan Design Institute Group Co., Ltd. was established in 1952 and has rich experience in exploring construction industrialization. Hunan Design has undertaken nearly 100 national , provincial and municipal projects and standard preparations work in the field of prefabricated construction. More than 10 million square meters of prefabricated construction projects have been completed. Hunan Design plays an important role in developing prefabricated building technology in Hunan.

2010	2014	2015	2017	2019	2021
Research on prefabricated building technology	The leading unit of Hunan Provincial Housing Industrialization Alliance	Establishing the prefabricated building design and research center	Hunan Province Design National Prefabricated Construction Industry Base	Awarded as National Assembly Technology Research Center	Awarded as the most influential prefabricated enterprise in Hunan Province

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CONTENTS

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01 Current situation

Background:

Green transformation and upgrading of the construction industry

reduce building energy consumption, develop green buildings, and achieve high-quality construction

- **Transformation and upgrading of the construction industry has become an inevitable trend**

Prefabricated building

+

Green construction
Smart construction

Current status of practice: The prefabricated construction method has been vigorously promoted since the 14th Five-Year Plan, but it still faces a series of problems that need to be solved urgently.

Development trend

Green construction,
architecture
Industrialization

Reflection

Poor quality
Low efficient
High cost

Problems: It is necessary to further improve the application efficiency of prefabricated construction methods through quality innovation

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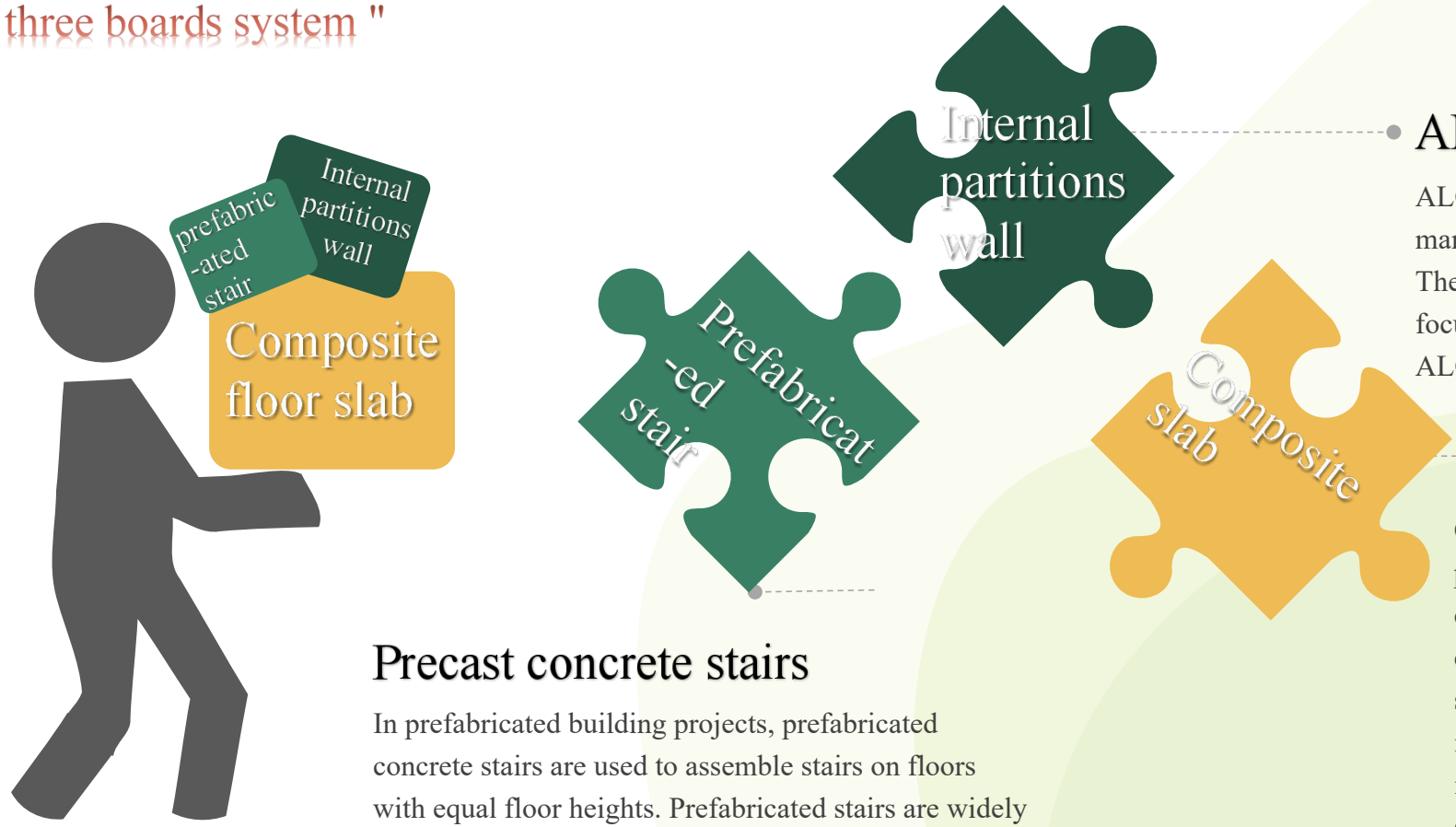
02 Innovative topics

Industry situation in Hunan:

The current prefabricated characteristics of Hunan Province - " three boards system "



ALC slats wall

ALC slats wall is widely accepted by the market for low price and easy construction. The main research of internal partition walls focuses on pipeline integration. The benefits of ALC slats innovation are limited.

Precast concrete composite slab

Composite panels are currently the most widely used precast concrete components in our province. Sales of composite slabs account for more than 80% of all component types. However, composite slabs have single functions and low technical content, and their improvement in building quality is limited. The innovation of High-quality and efficient composite slabs will promote development of the industry.

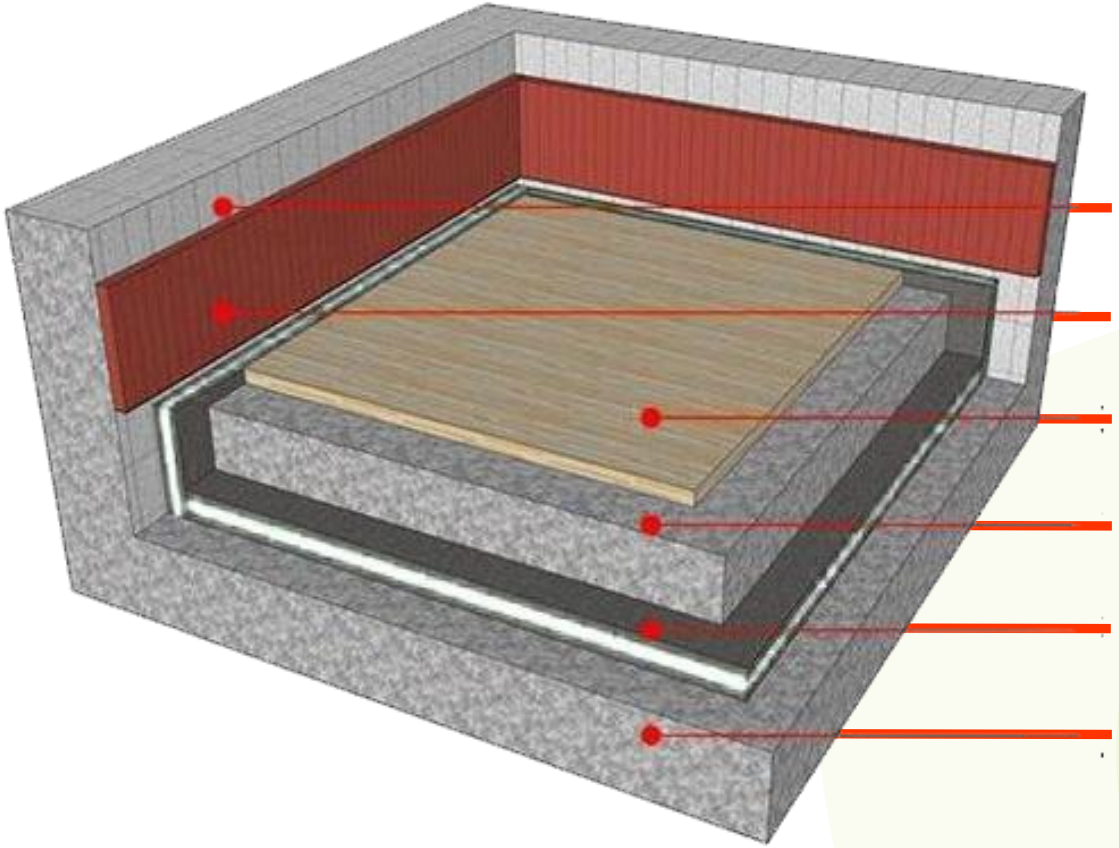
Precast concrete stairs

In prefabricated building projects, prefabricated concrete stairs are used to assemble stairs on floors with equal floor heights. Prefabricated stairs are widely used, but there is a lack of innovation space. Current innovative research and development for stairs are focused on lightweighting.

Innovation goal - Precast composite slabs√

The defects of slabs:

1) The insulation process is complex



The construction method of traditional floor slab

The construction process is cumbersome;
Poor construction quality

Floor base is uneven;
Uneven settlement of concrete;
Hollowing and cracking on surface

Residents do not accept that the increase in the thickness of the slab will affect the clear height of floors

The defects of slabs:

2) Poor sound insulation

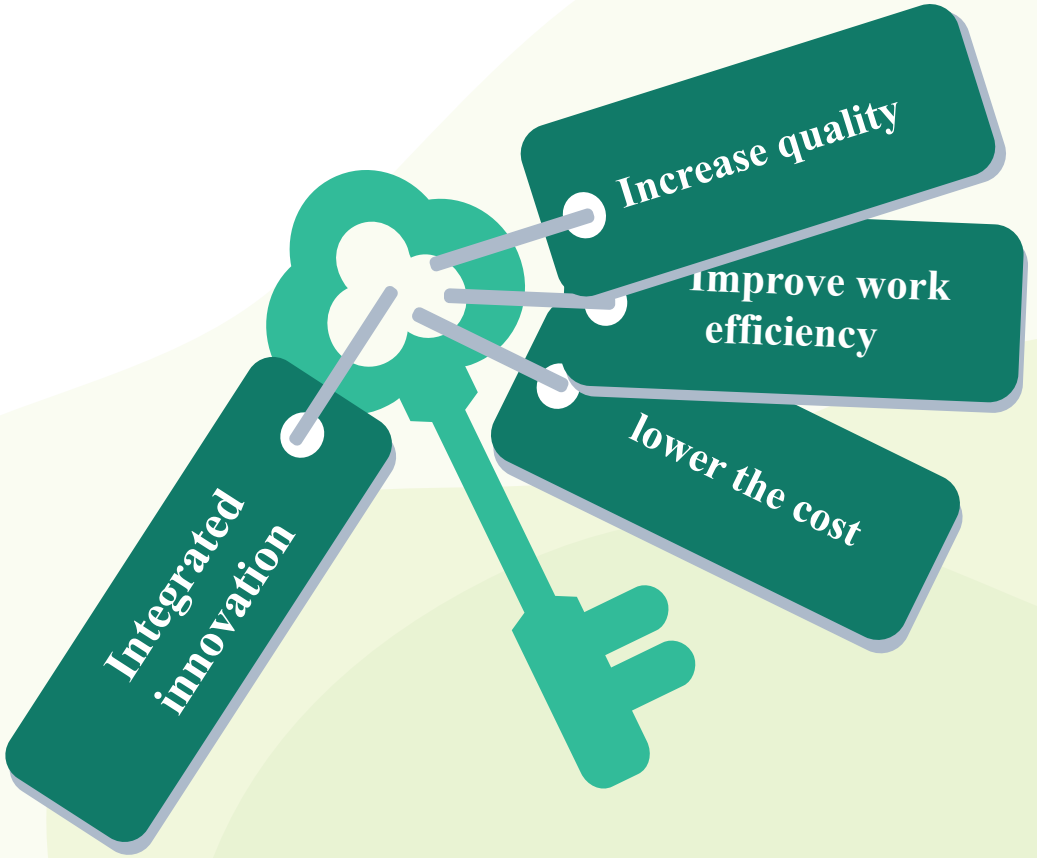
In residential buildings, complaints caused by floor sound insulation account for more than 60% of current property complaints . Poor floor sound insulation directly affects the quality and comfort of the building.

The defects of slabs:

3) Inconvenient construction

Although the composite floor slab is constructed without bottom formwork, it still requires the erection of scaffolding and multi-point supports . At the same time, the reinforcement at the edge of the slab needs to extend below the longitudinal reinforcement at the top of the beam, The construction efficiency is low.

- **Research objective: Integrated innovation of prefabricated buildings to improve quality and efficiency**



Innovation Vision: Provide more integrated technology solutions for the industry

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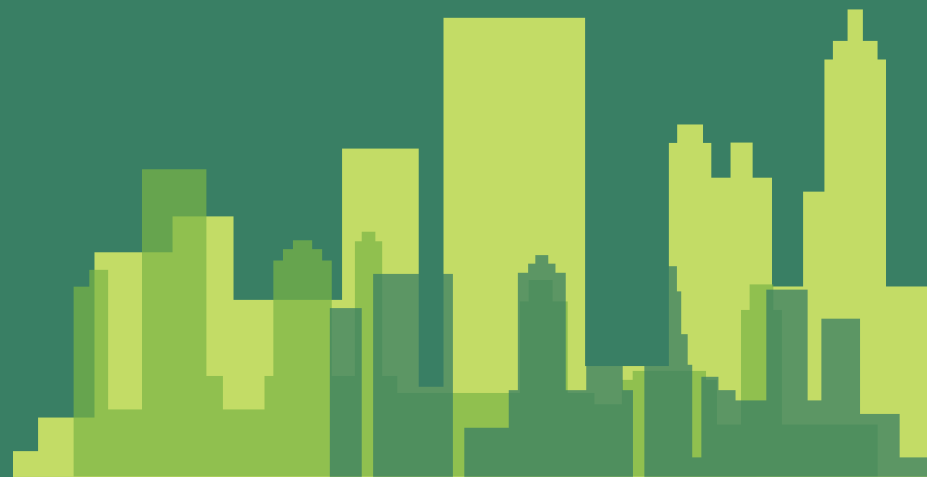
03 Innovation goals



03 Innovation goals

The sound insulation layer and the thermal insulation layer are combined through an integrated approach. The air sound insulation performance of slabs can be improved by more than **50%** , and the vibration sound insulation performance can be improved by more than **30% .**

Improve the stiffness of the bottom plate of the composite board by more than **50%** and combine it with aluminum film construction to achieve **support-free construction** of the composite board within a span of **4 meters**. Through exposed aggregate and **shear key settings**, **trusses are eliminated** and costs are reduced.

Integrated thermal insulation

Improve the floor insulation method and increase the floor insulation performance by more than **50%** , so that the floor insulation can meet the future building insulation needs under **the 75 standard/80 standard.**

Integrated sound insulation

No ribs on the edge of the board

Through **structural measures** and experimental calculations, **the edges of the laminated panels are not reinforced.**

Improve production and construction efficiency to improve quality and efficiency.

No supports No trusses

Innovation goals

Indicator classification	Details	Target quantification	Check method	Collaborative agencies
Structural properties	Increase the thickness of precast panels through integrated structures, thereby increasing the stiffness of precast floors. Support-free construction is achieved through two-point support of aluminum film fasteners on beams and walls. The truss-free function is realized through water-washed aggregate and shear key settings.	I. Increase stiffness by more than 50%; II. Reduce support by more than 50%; III. The steel content is reduced by more than 10%.	Test inspection	Central South university
Insulation performance	The floor slab achieves higher thermal insulation performance through measures such as upper insulation, lower insulation and self-insulation	I. The thermal insulation performance is improved by more than 50%; II. Meet the relevant requirements of energy-saving standards at one time.	Test inspection	Central South University Hunan University
Sound insulation performance	Sound insulation layers are set up through integrated methods to further block sound transmission between floors and achieve higher sound insulation performance.	I. Airborne sound insulation is increased by 50%; II. Impact sound insulation is increased by 30%.	Test inspection	Central South University
Improved work efficiency	The three on-site processes required for the construction of the insulation layer are formed in one go through prefabrication. The innovative construction method optimizes the floor reinforcement method.	I. Construction efficiency is improved by more than 20%; II. Optimize the reinforcement method;	Project pilot	Project contractor
Cost Control	Reduce construction costs through improved work efficiency and achieve production capacity conversion	Cost savings of more than 10%	Project pilot	Project contractor

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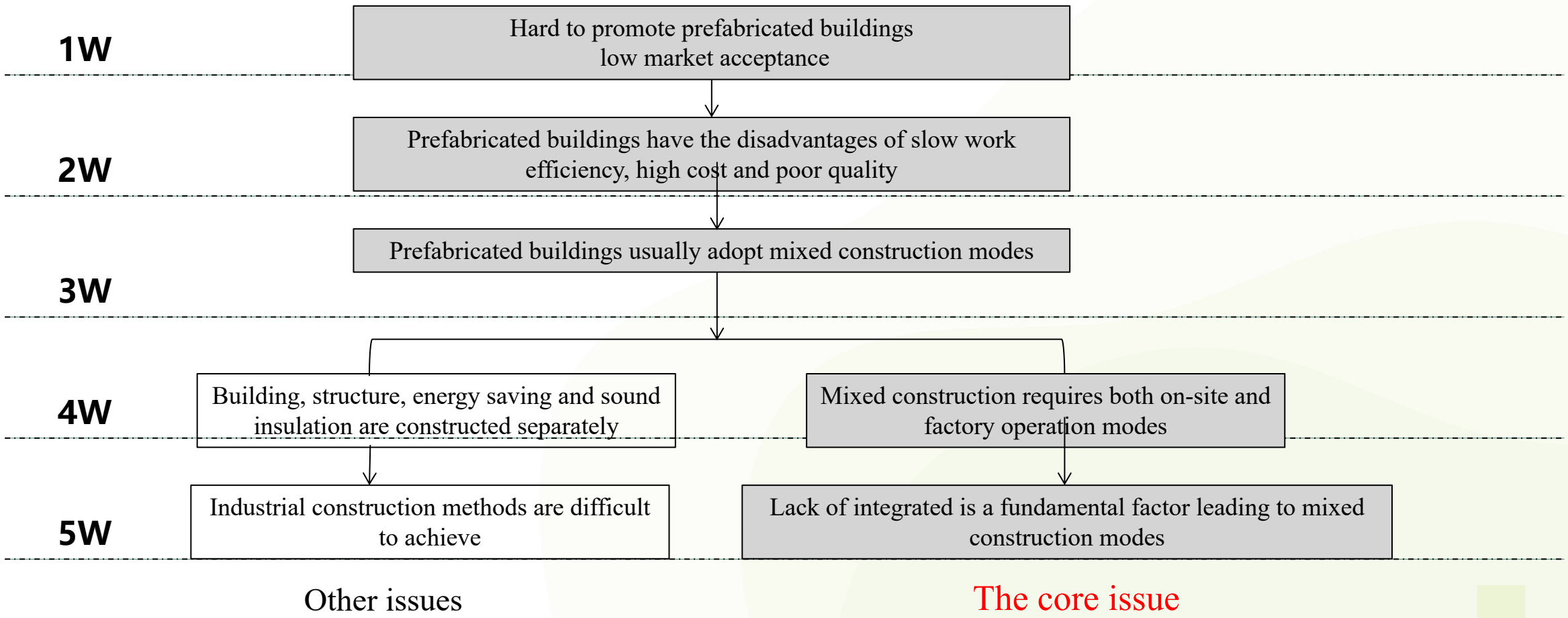
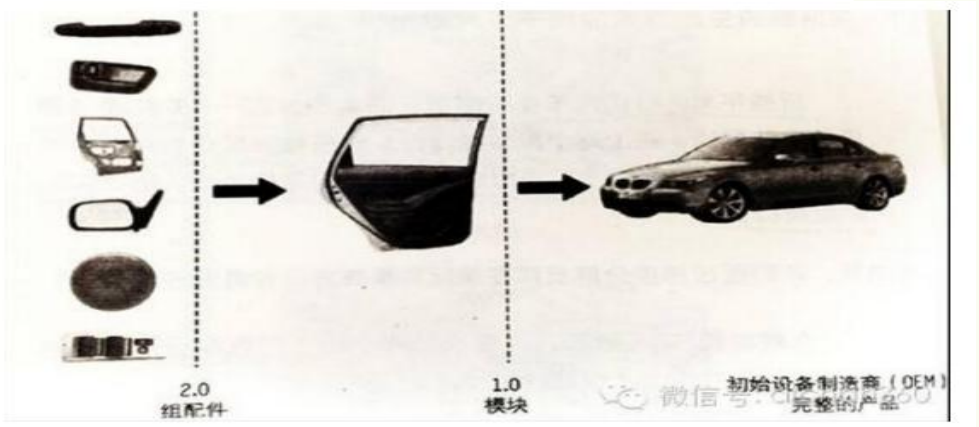
04 Innovative ideas

5WHY analysis



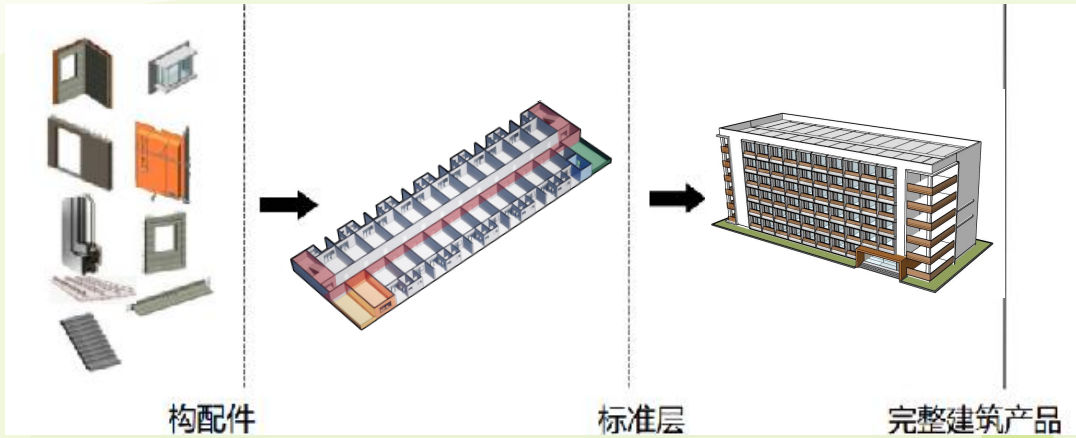
Innovation model reference

"Building a house like building a car" is the vision and goal of the construction industry to achieve industrialization. Referring to the development history of the automobile industry, functional integration is the only way to improve quality, reduce costs, and improve work efficiency. In the construction industry, **single-function** components often lead to fragmentation of the construction process and affect the quality of the building. Therefore, this innovation will **integrate** a variety of single functional components to achieve the construction method of **multi-functional components**. This innovation will solve the current pain point problem in the industry - hybrid construction to achieve **quality improvement, efficiency increase and cost reduction**.



Automobile industry

VS

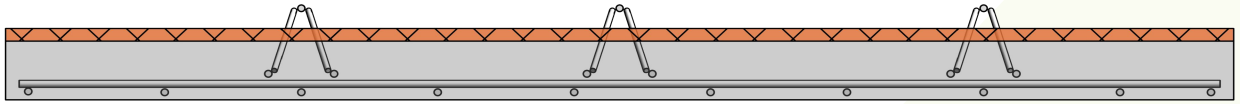


Achitechive

Comparison and selection of innovative approaches:

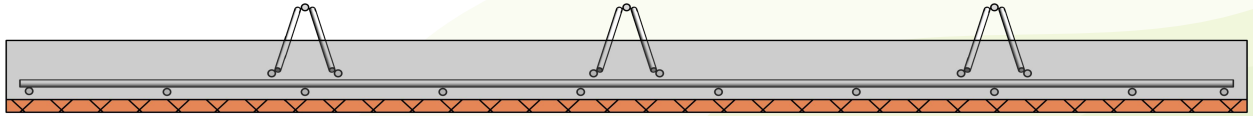
1) Comparison of integration approaches

Upper insulation layer



Insulation materials are easily damaged by disturbances during transportation and construction

Bottom insulation layer

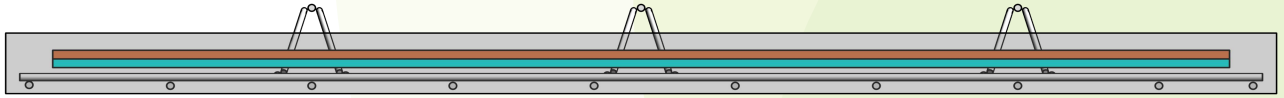


Insulation materials are easily damaged by disturbances during transportation and construction

Unable to combine vibration and sound insulation

Decoration hanging damage

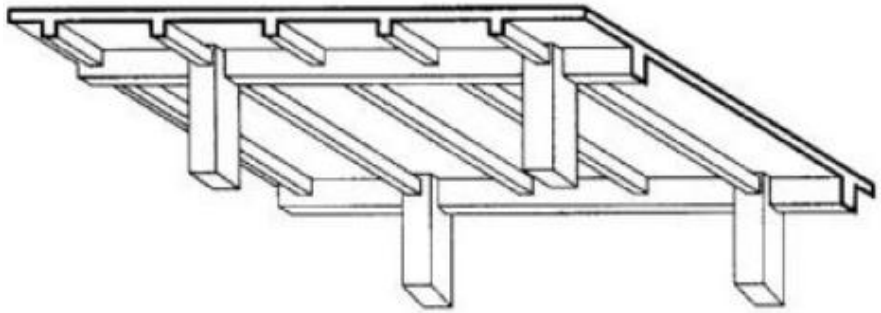
Sandwich insulation layer



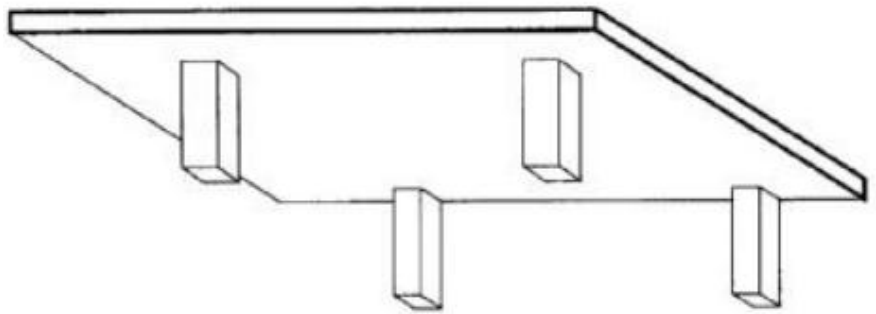
Integration and sound insulation √

Comparison and selection of innovative approaches:

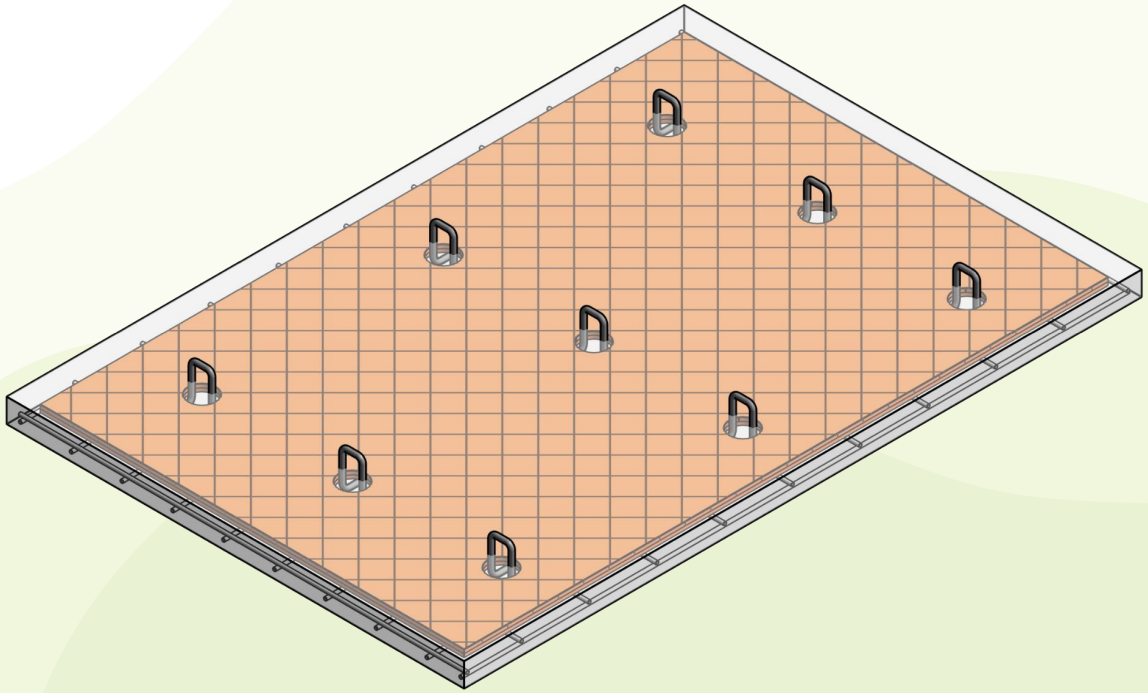
2) Comparison of connection methods - reference to connection methods in structural systems



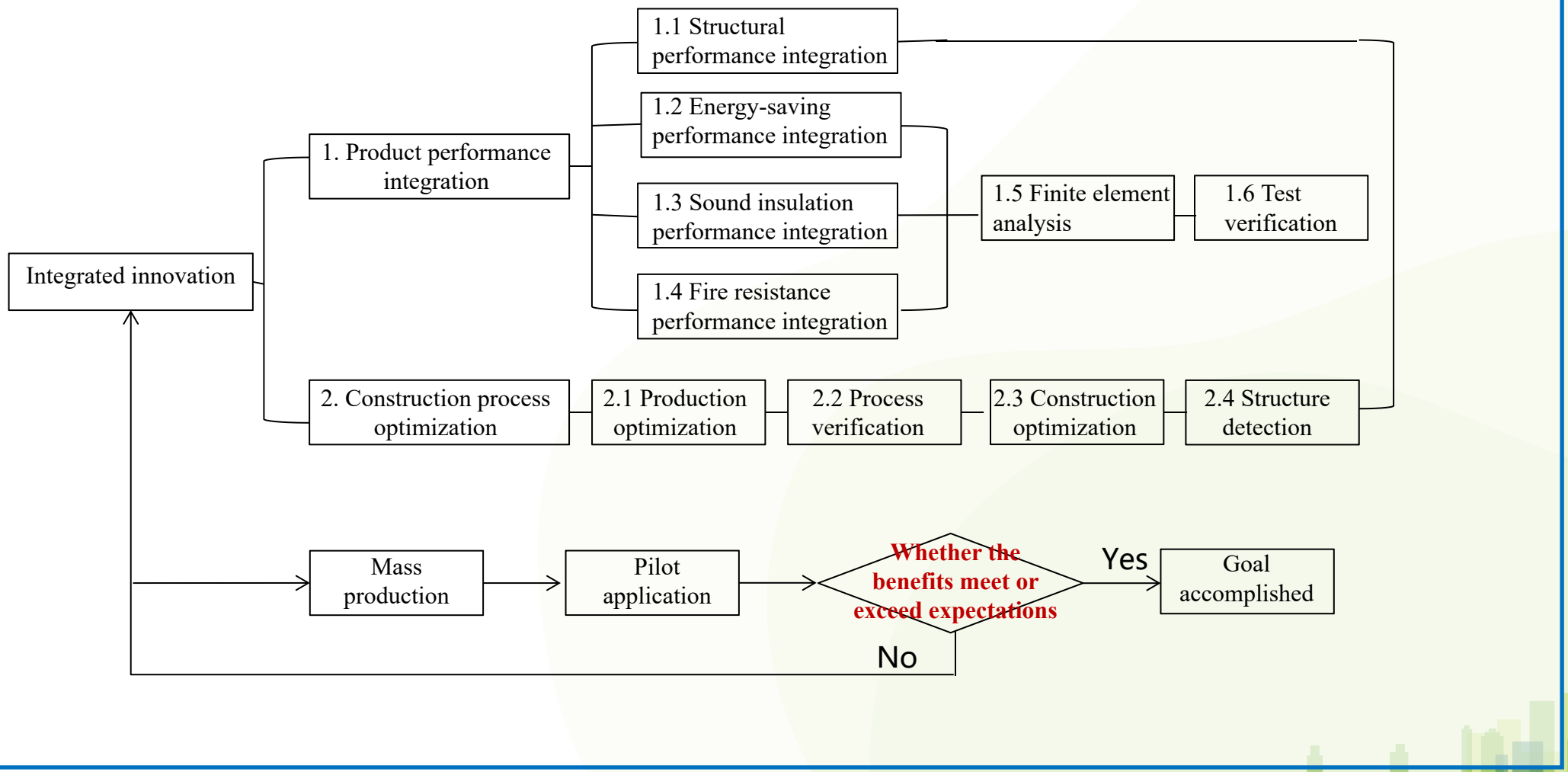
rib beam floor → rib connection



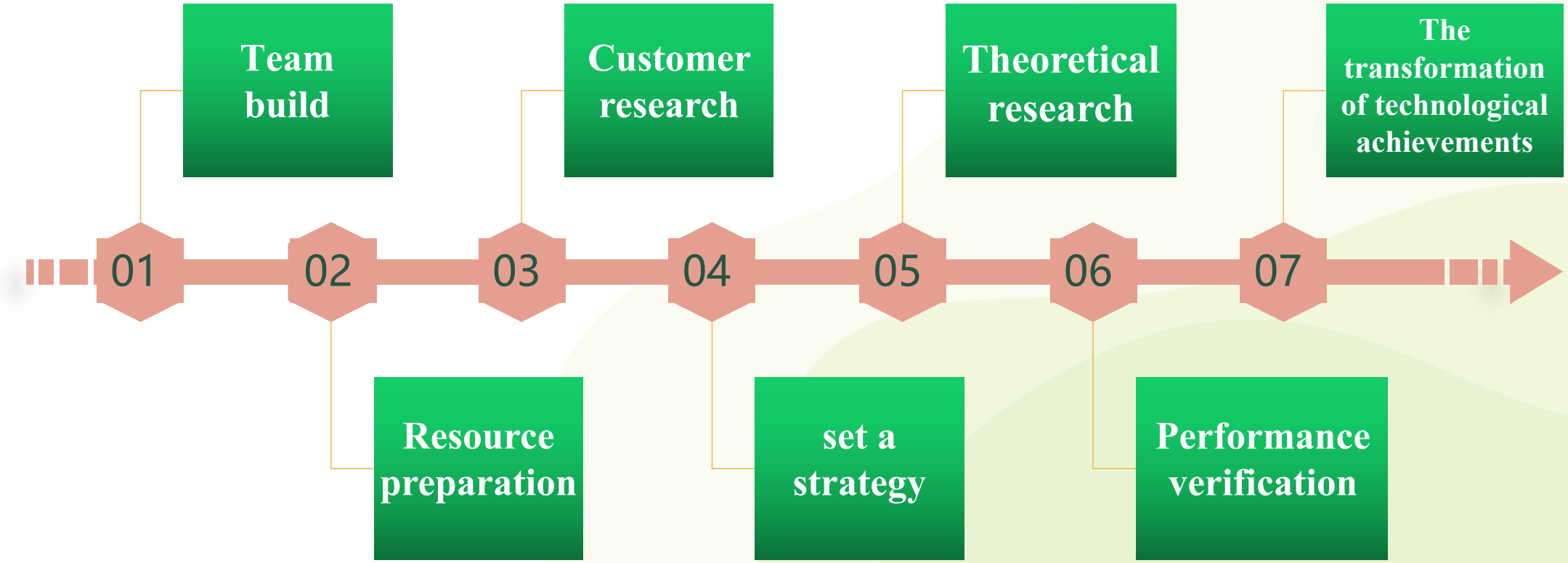
Beamless floor → point connection √



Innovation planning



Innovation path



Risk Analysis

Does product performance meet expectations?

Whether resources can support the achievement of goals?

Whether efficiency and cost have been effectively improved?

Whether the transformation of results is accepted by the market?

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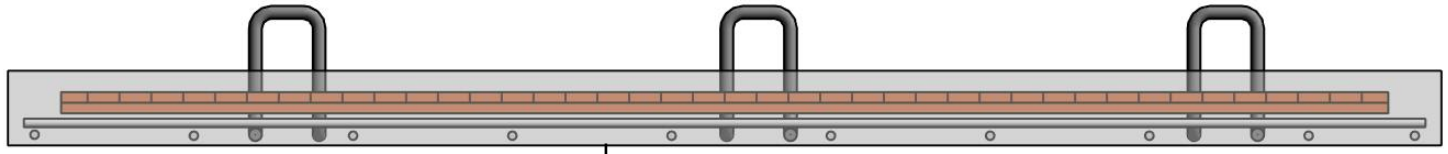
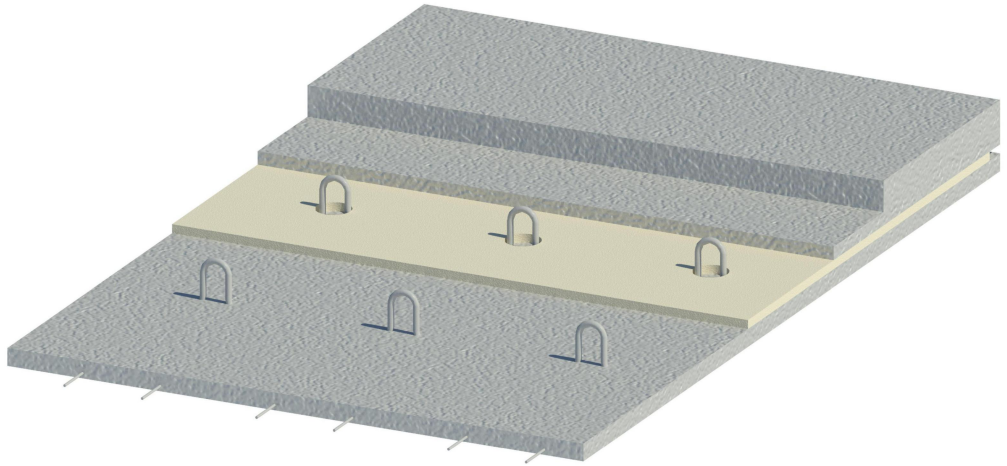
05 Implementation process

Plan confirmed



Sandwich thermal insulation composite panel

Integration: Laminated panels + thermal insulation + sound insulation



Laminated board upper layer (concrete) [30mm]

Thermal insulation material (XPS) [10mm]

Sound insulation pad (rubber) [10mm]

Lower layer of composite board (concrete) [40mm]

Building performance analysis:

——Insulation performance analysis

GB/T50378-2019: "Green Building Evaluation Standards"

DBJ43/T357-2020: " Hunan Province Green Building Evaluation Standards "

GB55015-2021: "General Specifications for Building Energy Saving and Renewable Energy Utilization"

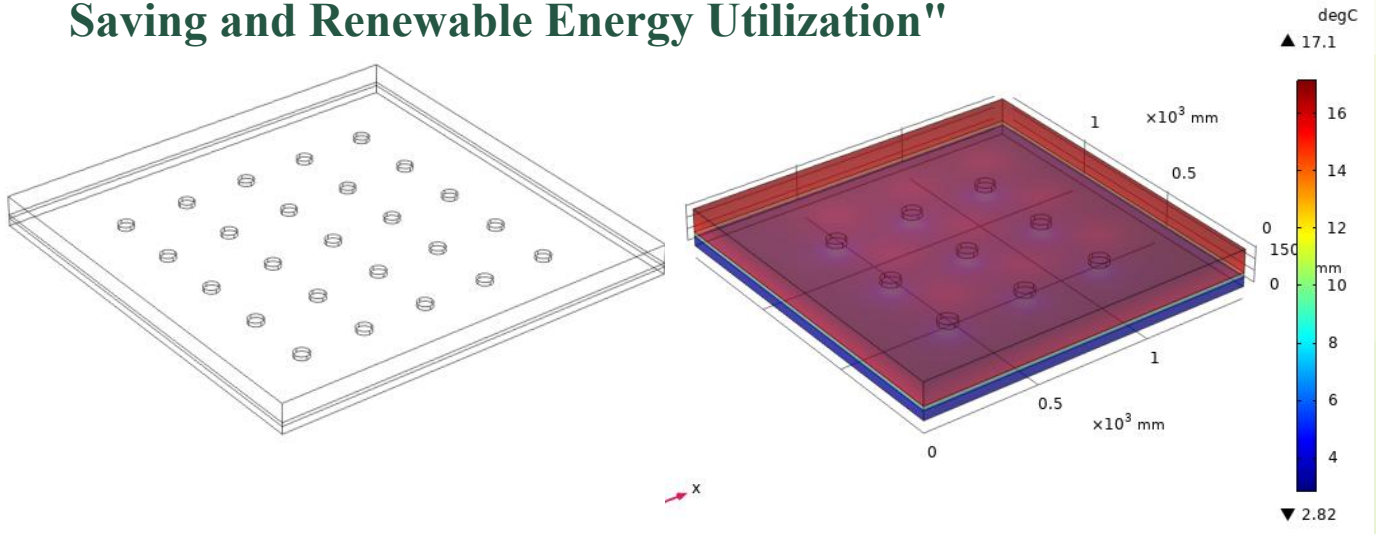


Table 3. 1. 8-6 Limits of thermal performance parameters of residential building envelope in Zone A with hot summer and cold winter

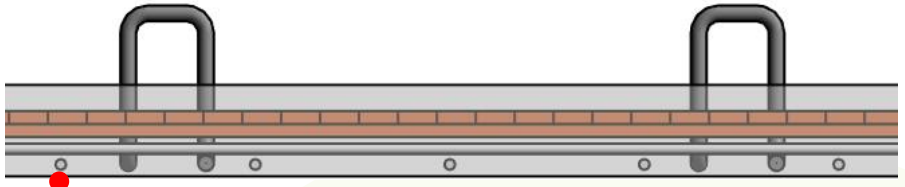
Building envelope parts	Heat transfer coefficient K $[W/(m^2 \cdot K)]$	
	Thermal inertia index D≤2.5	Thermal inertia index D>2.5
Roof	<0.40	≤0.40
Exterior wall	≤0.60	<1.00
Elevated or overhanging floor slabs with bottom surfaces exposed to outdoor air	≤1.00	
Household partition walls, stair partition walls, exterior corridor partition walls	<1.50	
Floor slab	≤1.80	
Gate	≤2.00	

Floor slab Material name of each layer	Thickness (mm)	Heat transfer coefficient
Decorative floor tiles	10	**1.6 < 1.8**
Cement mortar	30	
Reinforced concrete (cast in place)	70	
Reinforced concrete	30	
Flame retardant extruded polystyrene board (XPS)	10	
Sound insulation materials (cross-linked polyethylene pads, etc.)	5	
RC	40	

Building performance analysis:

——Analysis of airborne sound insulation

Airborne sound insulation calculations		
Floor slab Material name of each layer	Thickness (mm)	Calculation results
Decorative floor tiles	10	52 > 50 Meet the high sound insulation standards of the "Civil Building Sound Insulation Design Code"
Cement mortar	30	
Reinforced concrete (cast in place)	70	
Reinforced concrete	30	
Flame retardant extruded polystyrene board (XPS)	10	
Sound insulation materials (cross-linked polyethylene pads, etc.)	5	
Reinforced concrete	40	



Laminated board upper layer (concrete)

[30mm]

Thermal insulation material (XPS) [10mm]

Sound insulation pad (rubber) [5mm]

Lower layer of composite board (concrete)

[40mm]

Table 4. 2.3 Airborne sound insulation standards for high-demand residential subdivision components

Component	Airborne sound insulation single value evaluation amount + spectrum correction amount (dB)	
Household walls, house floors	Weighted sound insulation + Pink noise spectrum correction R+C	>50

Building performance analysis:

——Impact sound insulation analysis

Impact sound insulation cannot be calculated by software such as PKPM and Sver, so the analogy method is used. Due to differences in material thickness, etc., estimate the impact sound insulation performance of this product.

Test results are available		
Floor slab Material name of each layer	Thickness (mm)	Calculation results
Decorative floor tiles	10	**58 < 65** Meet **the high** sound insulation standards of the "Civil Building Sound Insulation Design Code"
Cement mortar	30	
Electronic cross-linked foamed polyethylene	5	
Reinforced concrete floor slab	110	

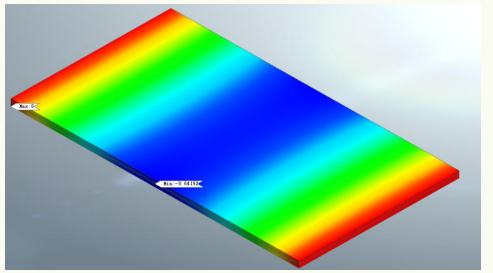
Weighted normalized impact sound pressure level/dB(A)	Hearing and feeling Indoor background noise 30~50dB	Feedback from residents		
		Satisfy	Acceptable	No satisfy
>85	Footsteps, sweeping the floor, etc. can cause strong reactions, but dragging tables and chairs, children running and jumping are unbearable	—	—	>90%
75-85	Footsteps can be heard, but the impact is not big. Dragging tables and chairs, children running and jumping feel strong, but beating is unbearable	—	50%	50%
65-75	Footsteps cannot be felt during the day, but can be heard at night, but weakly. Can hear the sound of dragging tables and chairs, children running and jumping, but it generally does not affect me except when sleeping	10%	80%	10%
<65	Except for knocking, no general sound can be heard; if a chair falls or a child runs or jumps, you can hear it, but the voice is weak	65%	35%	—

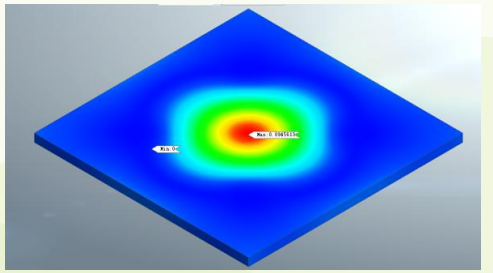
Research refers to National Housing and Living Environment Engineering Technology Research Center test results

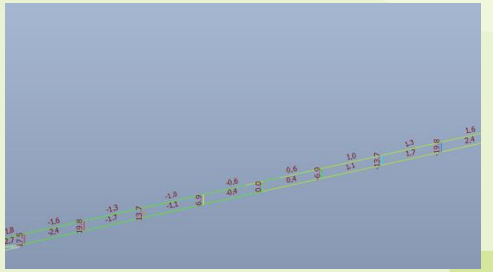
Structural performance analysis:

Model analysis

- Global model analysis software: Midas FEA NX
  - Construction stage analysis
  - Analysis of normal use stage
- Local model Analysis software: Midas FEA NX
  - Local inspection of upper layer on prefabricated slabs
- Local model Analysis software: Midas Gen
  - Simplified to open web truss verification



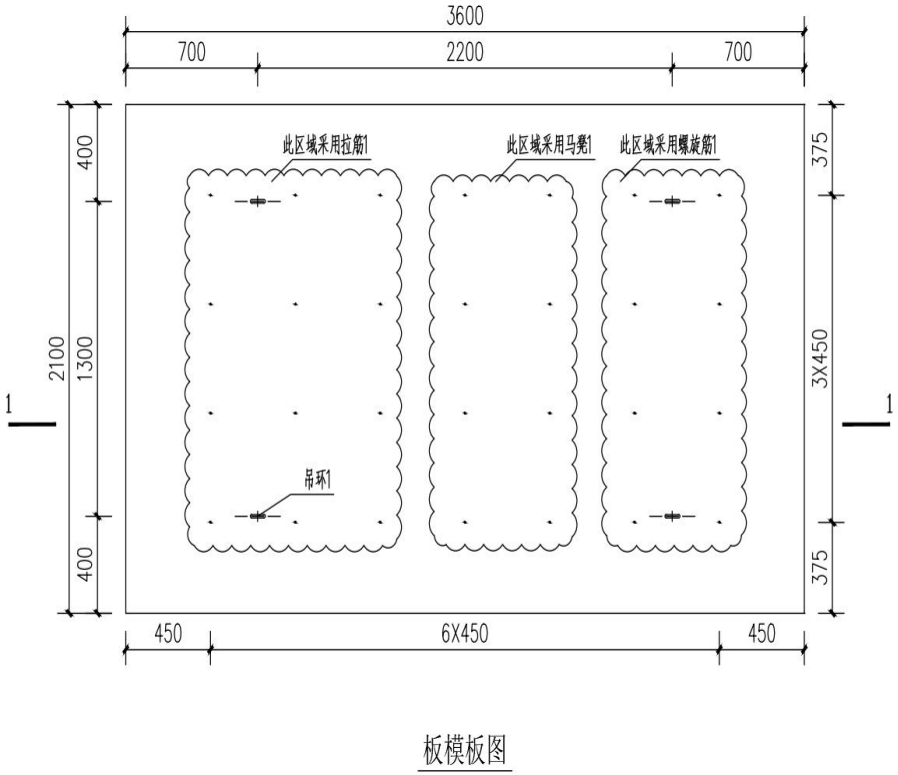




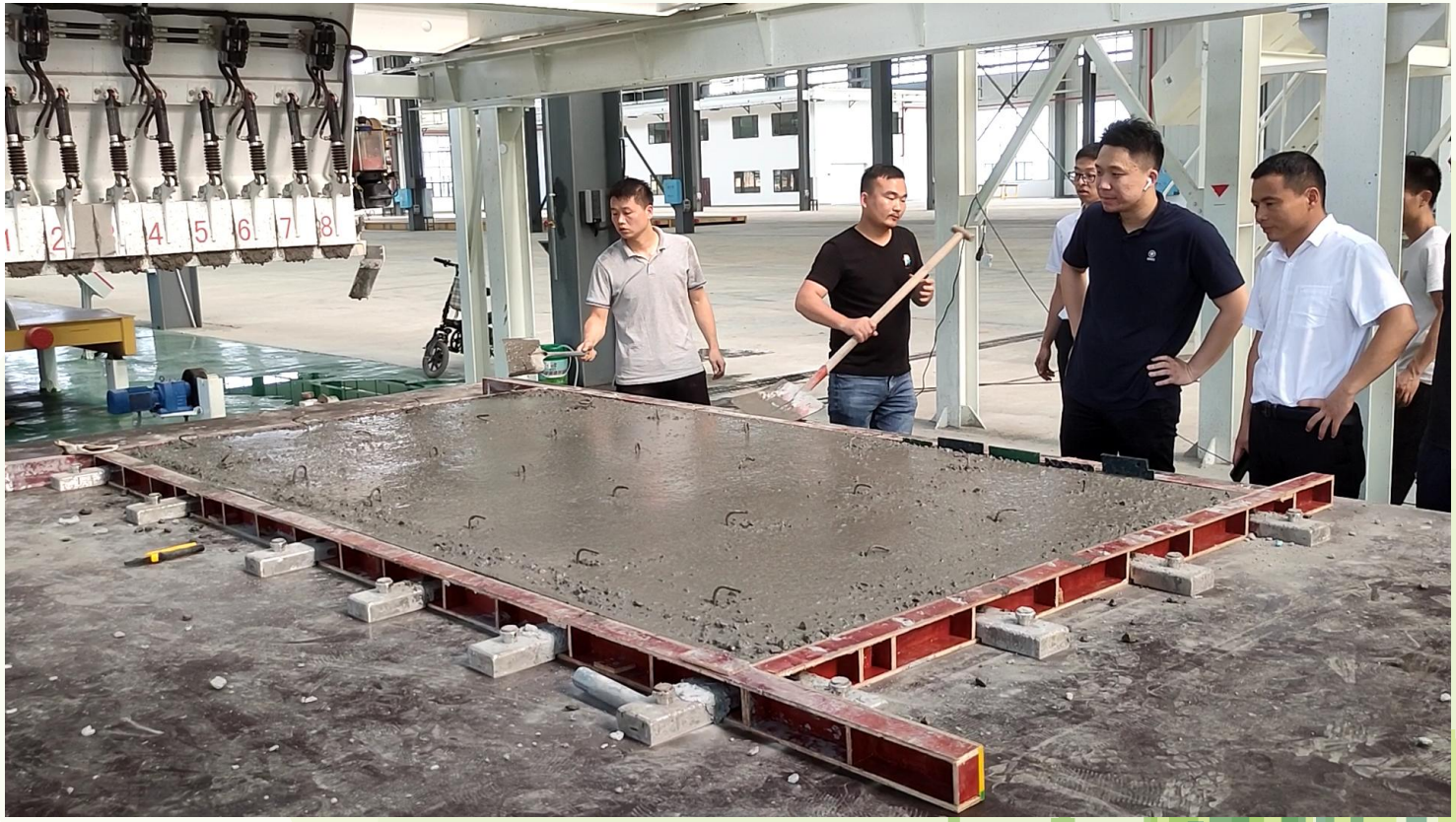
Process Validation:

1) Verification of stability of connecting ribs

Verification of the stability of short column connectors in different forms (Z -shaped, stirrup-shaped, spiral-shaped) during the production process of sandwich insulation panels.



板模板图



Process Validation:

2) Anti-floating verification of insulation layer

The floating phenomenon of the insulation layer during the trial production of sandwich laminated panels was optimized, and the anti-floating verification of the insulation layer was carried out through the process and tooling.

Process Validation:

Through three product process verifications, the conclusions are as follows:

1) The upper and lower layers and edges of the sandwich laminated board can be evenly distributed and vibrated, and the finished surface is smooth and smooth.

2) When stirrup-shaped connecting ribs are used, the connecting ribs have good stability.

3) Through the integrated placement of tooling pressure beams and thermal insulation and sound insulation steel wire mesh, the floating phenomenon during the pouring process of the insulation layer can be effectively solved.

Trial production process video

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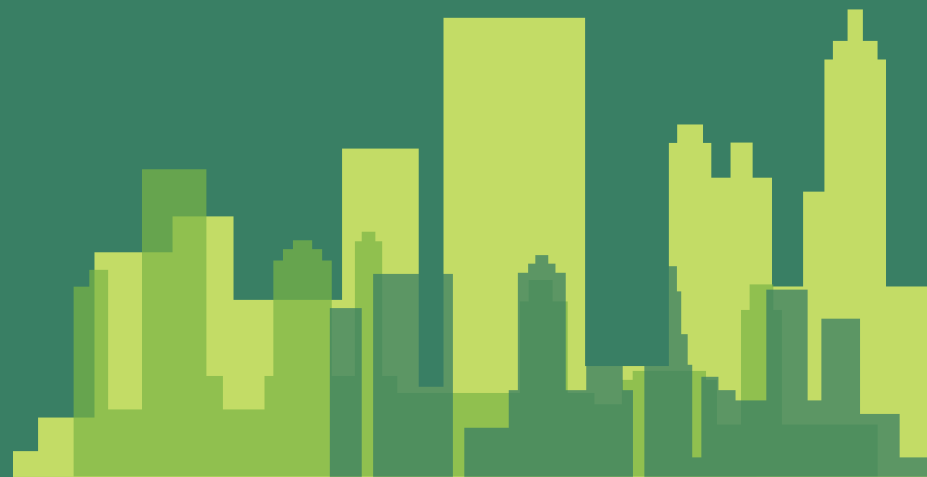
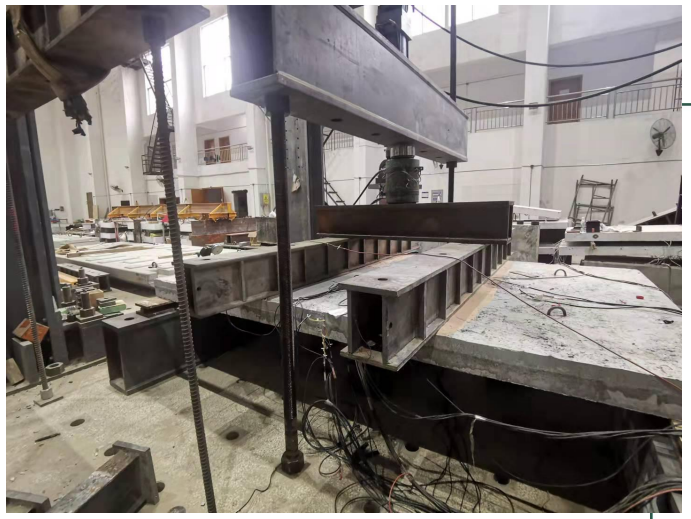
06 Target check



Structural performance analysis:

The bending capacity of the one-way plate and the two-way plate of this product are 134% and 127% of the theoretical value respectively , and the structural performance is superior.



4 结论与展望

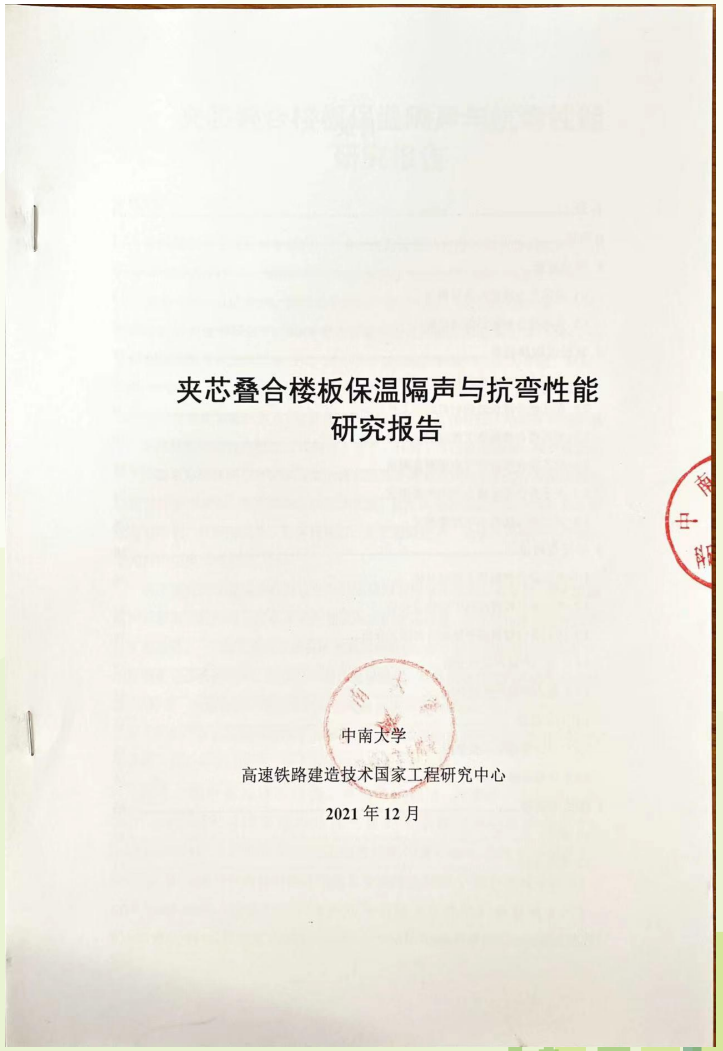
4.1 结论

通过上述分析和试验研究,得出以下研究成果:

1) 基于传热学原理,模拟计算出的夹芯叠合楼板热工性能参数指标和实测结果吻合较好,表明其具有优良的保温隔热性能。夹芯叠合楼板传热系数实测值为1.78W/(m² · K),满足湖南省地区建筑围护结构热工性能设计规范要求。

2) 夹芯叠合楼板具有优良的空气声隔声和撞击声隔声性能,其计权标准化空气声声压级差试验值为 61dB,标准化撞击声声压级试验值为 64dB。该结果满足标准 JGJ11-82《住宅隔声标准》中分户墙与楼板的空气声隔声标准分级的一级标准(≥50dB 为一级),撞击声隔声标准分级的一级标准(≤65dB 为一级)。满足标准 GB50118-2010《民用建筑隔声设计规范》中关于高要求住宅的隔声量要求(空气声隔声量>50dB 且撞击声隔声量<65dB)。

3)夹芯叠合板抗弯试验研究结果表明:该夹芯叠合板的整体性能良好,承载能力较高,刚度大,适用于装配式楼盖体系。夹芯叠合楼板的抗弯承载能力高,其试验值远超过理论计算值,其中 DBD01、DBS01 的试验承载力分别为 127kN、296kN,分别为理论计算值的134%和 127%。DBD02 出现横向贯通裂缝,提前发生剪切破坏,因此其试验承载力略低于理论计算值。该夹芯叠合板承载能力及抗弯刚度满足《混凝土结构设计规范》规定的正常使用要求,可以用作楼板(屋面板)等横向承重



夹芯叠合楼板保温隔声与抗弯性能研究报告

中南大学

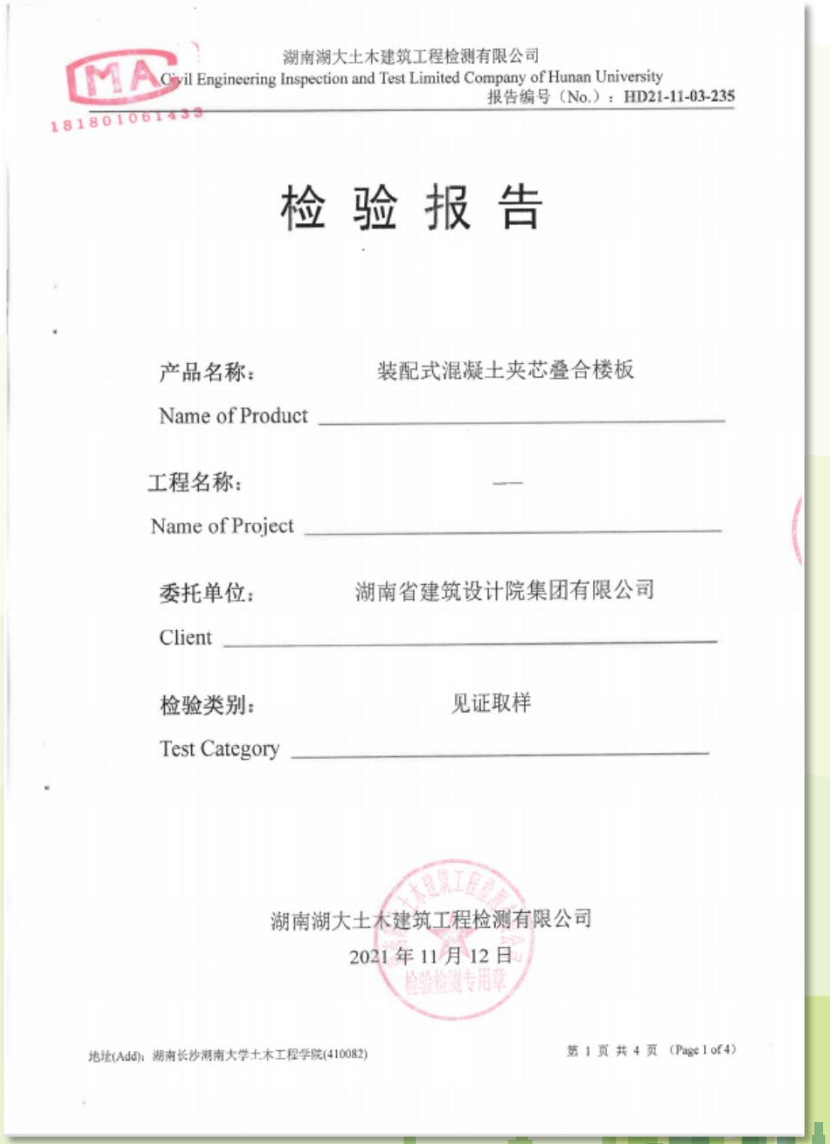
高速铁路建造技术国家工程研究中心

2021 年 12 月

Building performance analysis:

——Insulation performance verification

The heat transfer coefficient measured by the hot box method is 1.78W/(㎡·K). Using integrated floor insulation, **the heat transfer coefficient is reduced by 50%** , which greatly improves the building's energy-saving performance.



湖南湖大土木建筑工程检测有限公司
Civil Engineering Inspection and Test Limited Company of Hunan University
报告编号（No.）：HD21-11-03-235

检 验 报 告

产品名称： 装配式混凝土夹芯叠合楼板
Name of Product

工程名称： —
Name of Project

委托单位： 湖南省建筑设计院集团有限公司
Client

检验类别： 见证取样
Test Category

湖南湖大土木建筑工程检测有限公司
2021 年 11 月 12 日

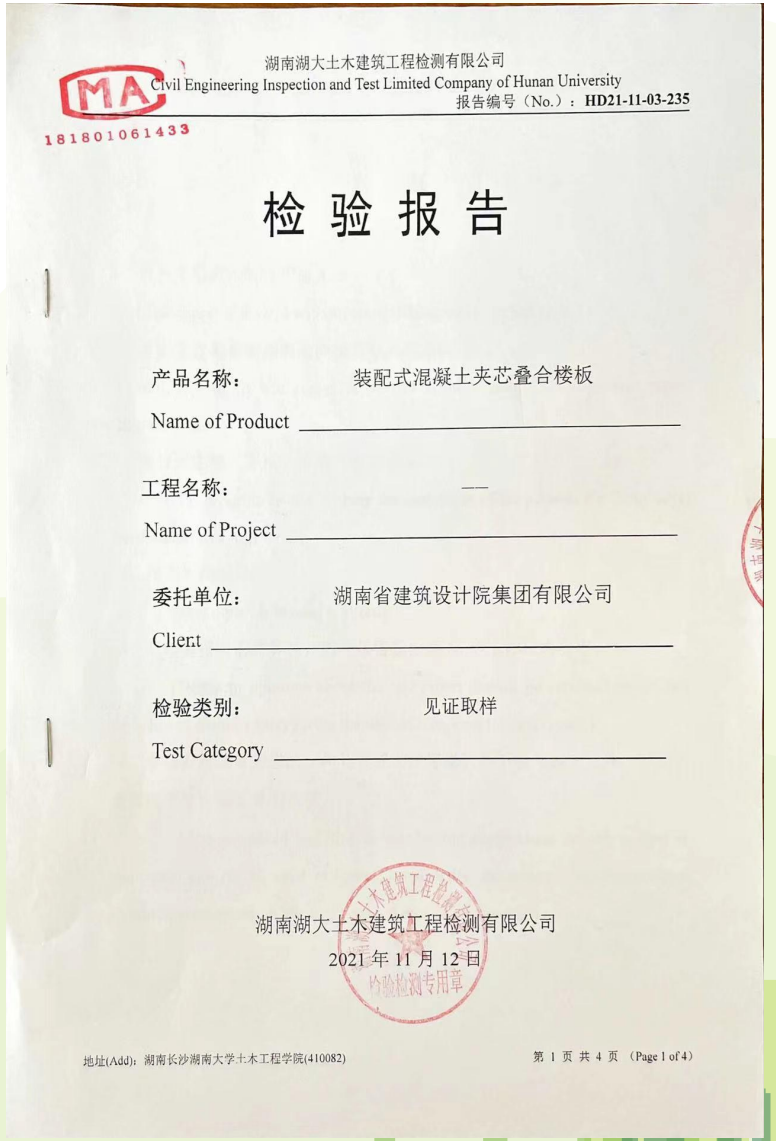
地址(Add)：湖南长沙湖南大学土木工程学院(410082)

第 1 页 共 4 页 (Page 1 of 4)

Building performance analysis:

Airborne sound insulation: 64dB; sound insulation performance improved by 60%.

Impact sound insulation: 59dB; sound insulation performance increased by 40%.



湖南湖大土木建筑工程检测有限公司
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报告编号（No.）：HD21-11-03-235

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湖南湖大土木建筑工程检测有限公司
2021 年 11 月 12 日

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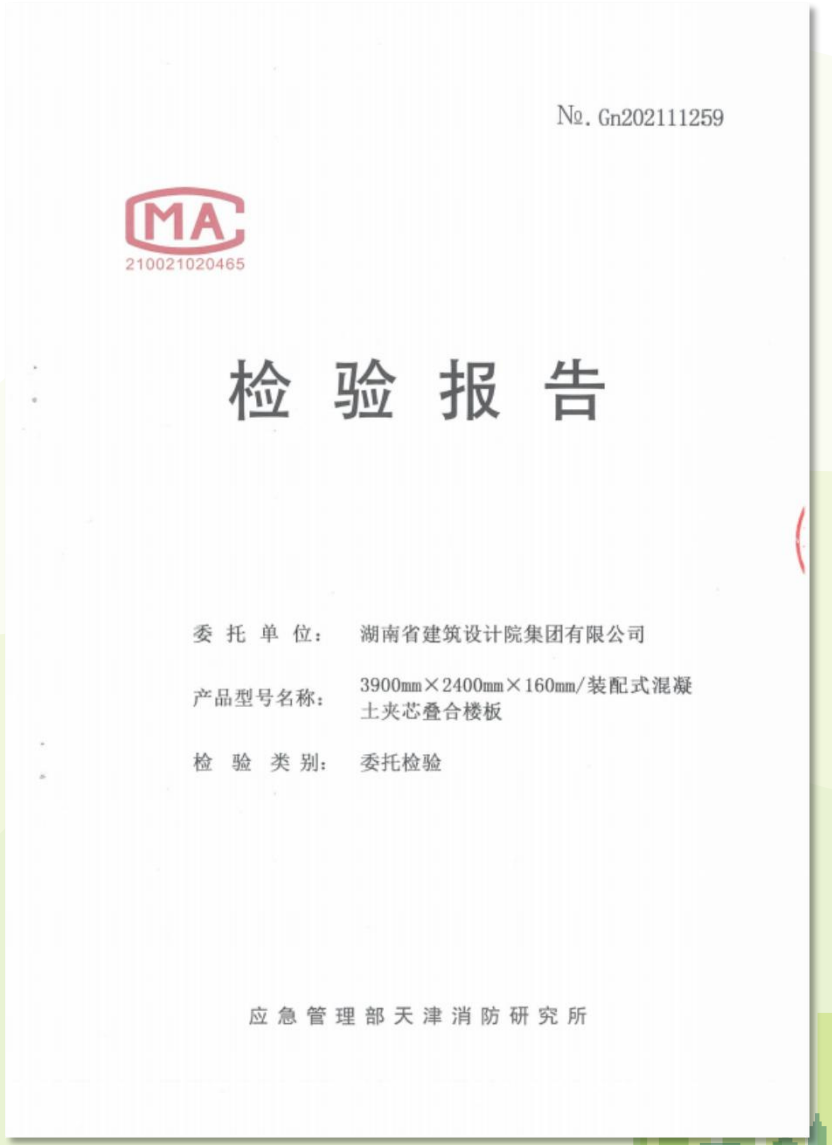
第 1 页 共 4 页 （Page 1 of 4）

Fire resistance verification:

The fire resistance limit of this product is greater than 2 hours. the relevant requirements of "General Code for Building Fire Protection" GB55037-2022



№. Gn202111259

CMA
210021020465

检 验 报 告

委 托 单 位： 湖南省建筑设计院集团有限公司

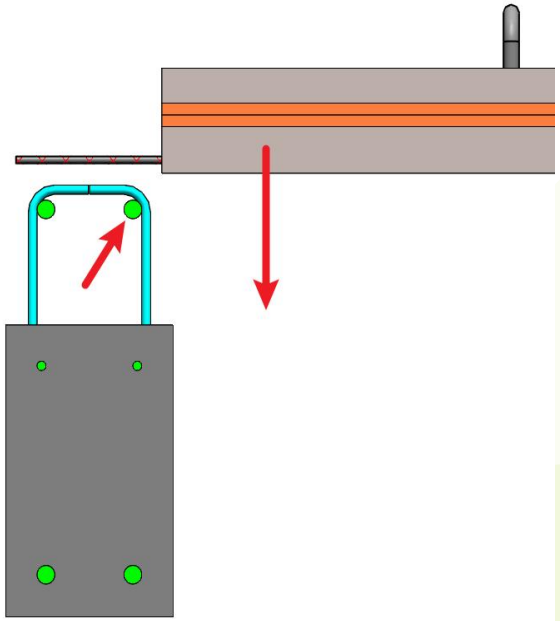
产品型号名称： 3900mm×2400mm×160mm/装配式混凝土夹芯叠合楼板

检 验 类 别： 委托检验

应急管理部天津消防研究所

Work efficiency target inspection:

Flexible steel wire rope extends from the edge of the board



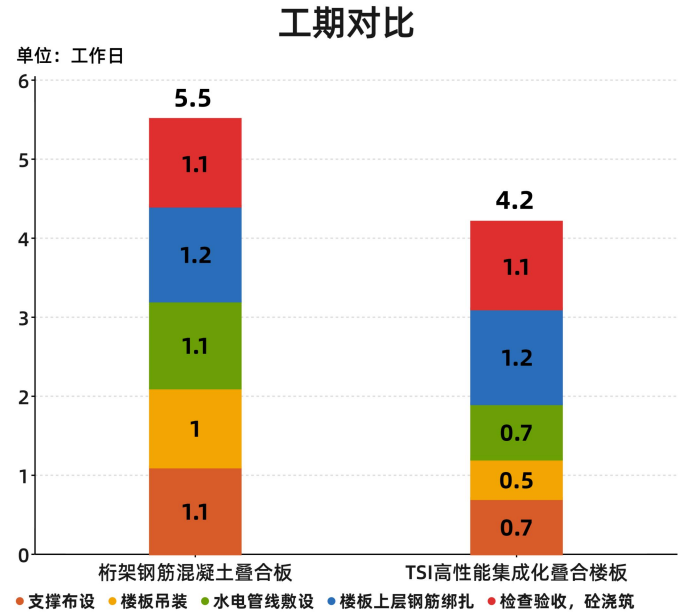
Avoid the collision problem between the protruding steel bars and the beam angle bars during the hoisting and falling process of the composite panels

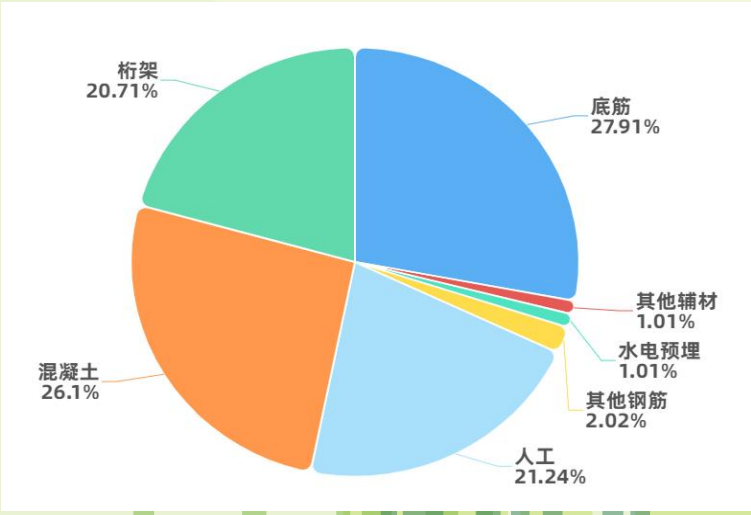
The truss-free on-site pipeline laying operation space is large, which improves the efficiency of pipeline laying.

Conclusion: Through structural optimization, the floor construction efficiency is improved by more than 30%

Cost check:

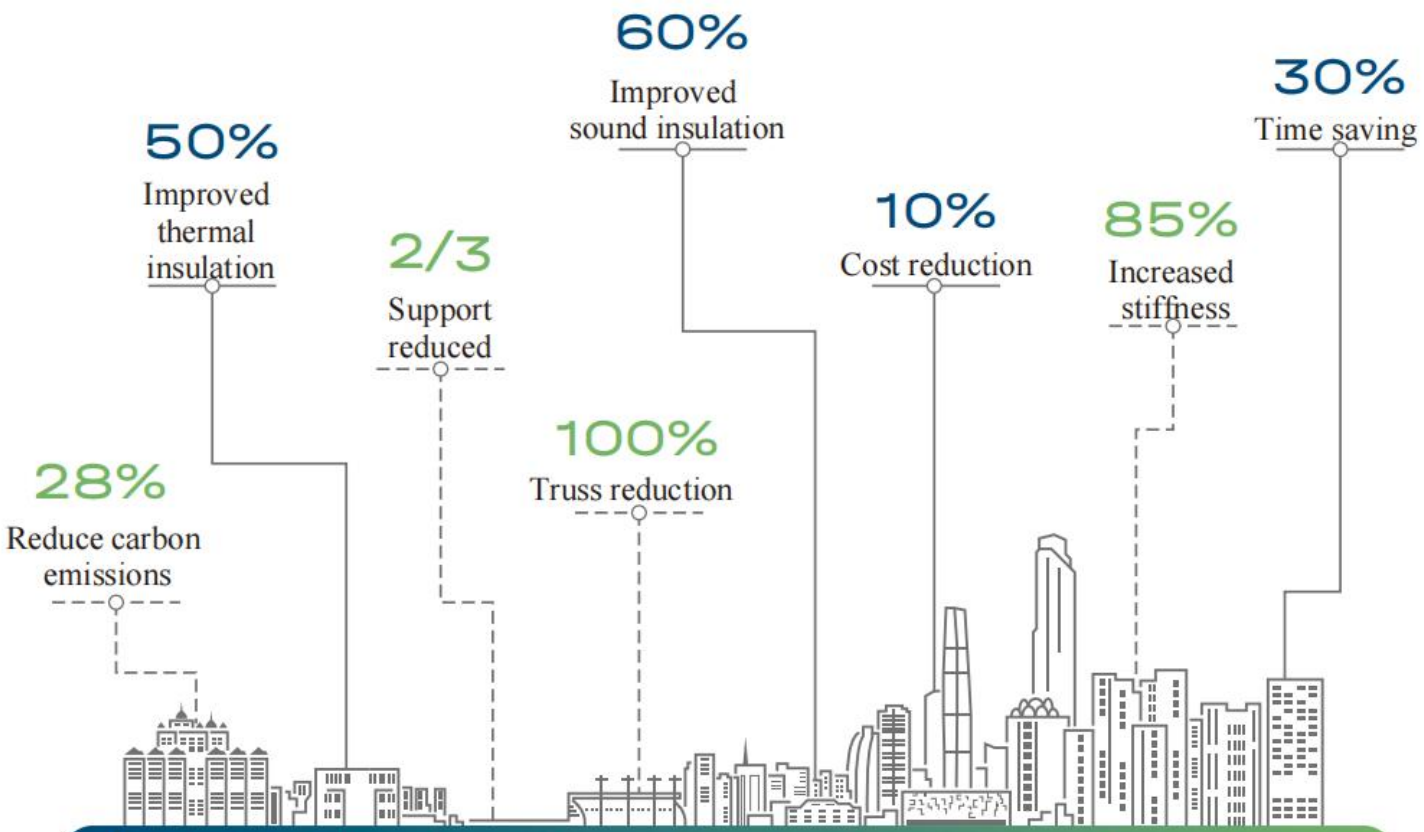
Comprehensive unit price list					
Production and transportationstage	Product name	Ordinary laminated board	TSI high performance laminate	Traditional composite panels + floating floor slabs	Traditional composite panels + thermal insulation mortar
	Rebar	23.88 yuan/m2	21.5 yuan/m2	23.88 yuan/m2	23.88 yuan/m2
	Truss	18.5 yuan/m2		18.5 yuan/m2	18.5 yuan/m2
	Shear resistant		8 yuan/m2		
	Concrete	32.4 yuan/m2	38	32.4 yuan/m2	32.4 yuan/m2
	Production labor	21 yuan/m2	27.3	21 yuan/m2	21 yuan/m2
	Insulation		13		
	Transportation	20 yuan/m2	20 yuan/m2	20 yuan/m2	20 yuan/m2
Production stagecost	Subtotal	115.78 yuan/m2	127.8 yuan/m2	115.78 yuan/m2	115.78 yuan/m2
	converted	1930 yuan/m3	1610 yuan/m3	1930 yuan/m3	1930 yuan/m3
Construction stage	Insulation			5.5 yuan/m2	25 yuan/m2
	Fine stone			20 yuan/m2	
	Concrete poured	37.8 yuan/m2	37.8 yuan/m2	37.8 yuan/m2	37.8 yuan/m2
	Post cast layer	23.88 yuan/m2	23.88 yuan/m2	23.88 yuan/m2	23.88 yuan/m2
	Lower support	15 yuan/m2	10 yuan/m2	15 yuan/m2	15 yuan/m2
	On-site labor	15 yuan/m2	10 yuan/m2	35 yuan/m2	25 yuan/m2
Construction stagecost	Subtotal	91.68 yuan/m2	81.68 yuan/m2	137.18 yuan/m2	126.68 yuan/m2
Comprehensivecost	Total	207.46 yuan/m2	209.48 yuan/m2	252.96 yuan/m2	242.46 yuan/m2



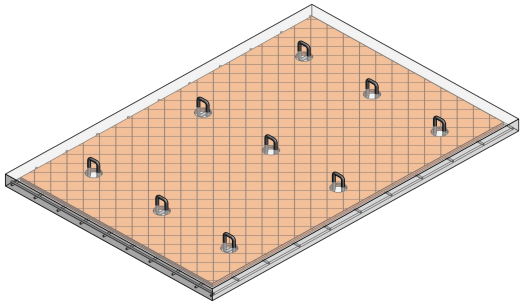


Conclusion: Through optimization of construction period, steel content and materials, the cost is reduced by 42 yuan / ㎡.

06 Target check



Integrated innovative precast floor slabs



Structure thickness：40+20+30+70=160

Heat transfer coefficient K=1.78 < 1.80

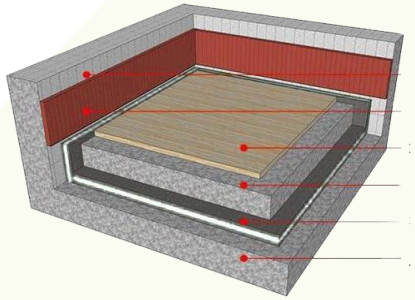
Excellent sound insulation performance

No reinforcements, no trusses, and less supports

Cost: 210 yuan/㎡

VS

Traditional floating insulated floor slabs



Structure thickness：130+20+20+30=200

Heat transfer coefficient K=1.75 < 1.80

No sound insulation structure, poor sound insulation

The ribs emerge from the side under stress, need trusses and support

Cost: 252 yuan/㎡

06 Target check

Indicator classification	Target quantification	Quantitative results	Completion
Structural properties	I. Increase stiffness by more than 50%; II. Reduce support by more than 50%; III. The steel content is reduced by more than 10%.	✓ Increase stiffness by 85 %; ✓ Reduce support by 2/3 ; ✓ The steel content is reduced by about 20 % (no trusses).	Reach the goal
Insulation performance	I. The thermal insulation performance is improved by more than 50%; II. Meet the relevant requirements of energy-saving standards at one time.	✓ The thermal insulation performance is improved by 50%; ✓ It can meet the relevant requirements of energy-saving standards at one time.	Reach the goal
Sound insulation performance	I. Airborne sound insulation is increased by 50%; II. Impact sound insulation is increased by 30%.	✓ Airborne sound insulation increased by 60 %; ✓ Impact sound insulation is increased by 40 %.	Reach the goal
Improved work efficiency	I. Construction efficiency is improved by more than 20%; II. Optimize the reinforcement method;	✓ Construction efficiency increased by more than 30 %; ✓ Innovative use of flexible tendon extraction method (no tendon extraction);	Reach the goal
Cost Control	Cost savings of more than 10%	✓ Cost saving 42 yuan / ㎡ (> 10%)	Reach the goal
Other	--	✓ Reduce carbon emissions by 28% ✓ Meet the 2- hour fire resistance limit requirement	Reach the goal

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07 Evaluation

Novelty :

- The project team fully combined the industry development situation as well as pain points, difficulties and blocking points to carry out targeted research. Combined with current national and local standards, clear and measurable goals were set, making the research results have good application value.
- The project team proposed a brand-new construction method, which effectively solved the problems of complicated floor insulation methods, poor sound insulation, and inefficient construction.1 invention patent (substantive examination) and 11 utility model patents have been formed.The level of innovation is leading domestically and internationally advanced.
- This project solves the industry's pain points, difficulties and congestion points, and improves the construction quality of composite floor slabs. This project meets the needs of industrialization and the development orientation of greening.

Characteristic	Entry	Points	Self-rating
Novelty 30 minutes	1. selected topic -From customer needs, organizational strategy, or technological innovation, creativity, etc. -The project goals are clear and measurable, and there is sufficient basis to prove that the goal setting is scientific and reasonable	5	5
	2. level of innovation -Adopt new or significantly different technologies or methods, which are significantly different from existing solutions -Project results form the organization's competitive advantage and achieve industry, domestic or international leadership	15	14
	3. timeliness -Accurately and timely responded to new or upcoming needs from customers or the market	10	10

Novelty :

报告编号：202265313926

省级科技查新咨询单位

科 技 查 新 报 告

项目名称：装配式混凝土夹芯叠合楼板

委 托 人：湖南省建筑设计院集团股份有限公司

委托日期：2022 年 11 月 22 日

查新机构（盖章）：山东省化工信息中心
山东省化工情报信息协会

查新专用章（化工）

查新完成日期：2022 年 11 月 25 日

山 东 省 科 学 技 术 厅

二〇二二年制

1

Practicality :

- The project team conducted a systematic survey on the prefabricated construction industry in the region and clarified the implementability of the published results and the suitability of the products for application in relevant areas.
- The relevant results produced by this project have received widespread attention and vigorous promotion by the Hunan Provincial Department of Housing and Urban-Rural Development, and the relevant practices have been included in the "Hunan Provincial Prefabricated Building Evaluation Standards" DBJ43/T542-2022 as recommended practices .
- The integrated innovative products developed in this project can be mass-produced using a generalized assembly line. Currently, we have entered into authorization agreements with three different prefabricated factories, and there are no obstacles to authorized production.

Characteristic	Entry	Points	Self-rating
Practicality 15 points	1. can be implemented -Deploy and implement systematically within the organization -Easy to implement and consistent with organizational resource allocation capabilities	5	5
	2. can be promoted -It has practical promotion value inside and outside the organization and industry, and can be learned from -Be forward-looking and able to meet growing needs	5	5
	3. Easy to use -Easy to use for customers and end users	5	5

Practicality :

UDC

湖南省工程建设地方标准 DBJ

DBJ 43/T 542-2022

P 备案号 J 16676-2023

湖南省装配式建筑评价标准

Hunan Province standard for assessment of prefabricated building

2022-12-07 发布 2023-06-01 实施

湖南省住房和城乡建设厅 发布

4 装配率计算

4.0.1 装配率应根据表 4.0.1 中评价项分值按下式计算：

$$P = \frac{Q_1 + Q_2 + Q_3 + Q_4 + Q_5}{100 - Q_6} \times 100\% \qquad (4.0.1)$$

式中：P——装配率；

Q_1——主体结构评价项的得分值；

Q_2——围护墙和内隔墙评价项的得分值；

Q_3——装修与设备管线评价项的得分值；

Q_4——标准化、信息化、智能化应用评价项的得分值；

Q_5——加分项评价项的得分值；

Q_6——评价项目中缺少的评价项分值总和。

表 4.0.1 装配式建筑评分

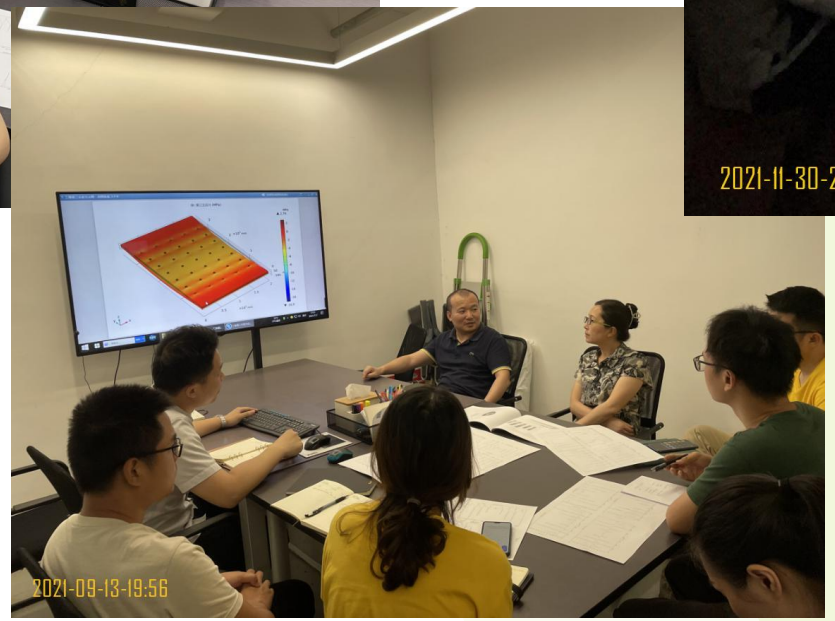
评价项			评价要求	评价分值（分）	最低分值（分）	预评价得分值	项目评价得分值
主体结构 Q_1（50 分）	柱、支撑、承重墙、延性墙板等竖向构件	A. 采用预制构件	35%≤比例≤80%	15～25*	20		
			15%≤比例≤35%	5～15*			
		B. 采用新型模板或免拆模板施工工艺	比例≥85%	3			
	梁、板、楼梯、阳台、空调板等水平构件	A. 采用预制构件	70%≤比例≤80%	10～20*			
			50%≤比例≤70%	5～10*			
		B. 采用免拆模板施工工艺	60%≤比例≤80%	6～8*			
	预制水平构件集成化	预制楼板与保温一体化	50%≤比例≤70%	3～5*			

Knowledgeable :

- The project team gave full play to its creative driving role, drew on structures of different dimensions, and formed a groundbreaking structural connection method. It carried out adequate risk plans for this method and effectively solved the problem.
- The project team generally adopted the method of survey learning + theoretical research + software simulation + experimental verification to carry out the innovation process. The project team mobilized resources from universities and component factories, applied quality innovation theories and plans, and jointly completed the innovation process.
- This project adopted a systematic promotion model and formed a set of overall solutions that can be used for reference, providing a reference for the group's subsequent innovation.

Characteristic	Entry	Points	Self-rating
Informative 15 points	1. idea or discovery -Based on new ideas or discoveries - Fully consider the creative ideas and discover the risks that may be introduced	5	5
	2. Credibility of the innovation process - Fully consider and utilize knowledge and technical resources to ensure the theoretical foundation of creative innovation -Quality innovation theories, techniques, tools and methods should be applied	5	5
	3. The systematic nature of the innovation process -Effectively utilize knowledge and technical resources in multiple ways based on a system-based development process -Refining and summarizing the knowledge and techniques of the creative innovation process and integrating them into organizational resources	5	5

Knowledgeable :



Customer orientation:

- The project team conducted detailed research on customer needs (industry pain points, difficulties, and blocking points), and based on a full understanding of customer needs, targeted innovation goals were formed.
- This project results fully satisfied the customer's architectural and structural performance requirements for the floor slabs. The integrated innovative products effectively helped the customer significantly save the construction period of the floor slabs, while achieving cost savings and forming good application benefits.
- The integrated innovative products not only solve the energy-saving performance of the floor slabs, but also bring customers a substantial improvement in sound insulation performance. The project research results reduced costs, increased efficiency and improved the quality of the building, exceeding customer expectations to a great extent.

Characteristic	Entry	Points	Self-rating
Customer orientation (25 points)	1. Understand customer needs -Clear target customers (or stakeholders) - Fully scientifically analyze customer needs, identify and clearly describe key demand points	10	**10**
	2. Meet customer needs -Fully meet customers' current and/or future needs -Measuring the extent to which needs are met	10	**10**
	3. Exceed customer expectations -Committed to exceeding customer expectations -Describe the extent to which customer expectations are exceeded	5	**4**

Customer orientation:

Effectiveness:

- This project has fully achieved the established innovation goals and has been verified through experiments and pilot applications.
- This project results have been approved according to the local engineering standards of Hunan Province and the China Engineering Association standards, and are expected to be released within the year. The integrated innovative products have been compared with competing products in the market in multiple dimensions, and have good technical and operational application benefits.

Characteristic	Entry	Points	Self-rating
Effectiveness 15 points	1. Goal achieved -Describe the extent to which project objectives have been achieved -It has been tested by practice and can provide sufficient and effective data and proofs	5	5
	2. Technical or operational performance -Achievements such as new products, new technologies, new standards or new specifications, and comparison results -Financial , market and other operating results, as well as comparison results	5	5
	3. Social Responsibility Performance -Performance in social responsibility (environment, public welfare, employment, consumer rights, etc.) -Performance that promotes the development of stakeholders (employees, shareholders, suppliers, etc.)	5	4
Total score		100	97

Effectiveness:

51% of total social emissions

46.7% of total social energy consumption

Green construction

- Reduce operation and maintenance costs
- Promote assembly construction methods
- Improve residential health performance
- Improve building energy efficiency

- Greening
- industrialization
- Informatization
- intensification
- Industrialization

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08 Innovation summary and application

08 Innovation summary and application

Innovation

- ✓ Innovate and use integrated practices to solve pain points .
- ✓ The innovative use of point sandwich connection ensures product performance.
- ✓ Innovatively solve many difficult production and construction problems.

Informative

- ✓ The optimal solution is obtained through theoretical analysis and experimental verification .
- ✓ Obtain valid intellectual property rights .
- ✓ In line with the transformation and upgrading development requirements of the construction industry .

Innovation level

Verified by experts, this innovation has good social, economic and ecological benefits, reaching **domestic and internationally advanced** innovation levels.

Simple and practical

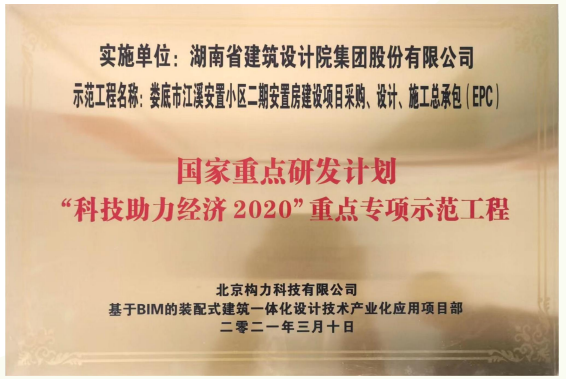
- ✓ Applicable to existing prefabricated component production lines.
- ✓ Simplify the construction process and improve construction efficiency.
- ✓ Effectively reduce costs and improve construction quality.

Application examples :

- Project name: Loudi Jiangxi Resettlement Community Phase II Project
- Construction location: This project is located in Jiangxi Village, Wanbao Town, Louxing District.
- Area index: The land area of this project is 33135.6 ㎡, and the total construction area is approximately 95020.1 ㎡.
- Building height: 2 floors underground, 30 floors above ground, height 97.8 m.
- Building function: residential building .
- General contractor: Hunan Xingcheng Construction Group Co., Ltd.
- Design unit: Hunan Architectural Design Institute Group Co., Ltd.

Application examples - achieving exemplary goals

Industry experts spoke highly of the completion of the project



The project has won many honors

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Thanks for listening