E3S Web of Conferences **272**, 02017 (2021)
ICEPG 2021 https://doi.org/10.1051/e3sconf/202127202017

Finite element analysis of floor slab of new type assembly structure system

Xiaomeng Zhang[1*], Weilun Ding[1], Qingying Ren[1], Wenting Liu[1], Qiaji Wang[2]

[1]China Architecture Design & Research Group, Beijing 100044, China
[2]Beijing Jiaotong University

Abstract: In this paper, a new type of prefabricated concrete structure system is put forward, and a new type of bi-directional multi-ribbed floor is put forward in combination with this system.Finite element analysis is carried out on the floor, and its mechanical properties are analyzed, and compared with the test hysteresis curve, the rationality and correctness of the finite element analysis are obtained.

1 Introduction

The box structure system refers to that the box type is taken as a unit in the factory, and different box types are hoisted on site to form a box structure. Experts at home and abroad have done a lot of research on box structure. Habitat 67 was built in Montreal, Canada. Prefabricated accessory units, stairs, elevator shafts, air platforms and passageways are all constructed with exposed concrete boxes.The lower box supports the upper box. The support points between the upper and lower boxes are made of steel plates and rubber pads and anchored together with steel bars to form an energy-dissipating structure to absorb seismic loads.In 1972, Hiragawa designed the cabin building of the Bank of China in Japan [2].A total of 140 cabin modules are connected by prefabricated modular units measuring 2.3m x 3.8m x 2.1m. They are suspended from reinforced concrete cores with internal elevators and pipes.In 2009, the Wolverhampton Student House was completed in the United Kingdom. It is the tallest integrated modular building in the world, consisting of three buildings of 8-25 floors.There is also a 12-storey student apartment building in Bristol, England.Module units are special-shaped modules.In this paper, a new prefabricated shear wall structure is proposed, as shown in Fig. 1. Through finite element analysis, its mechanical properties and mechanical properties are analyzed, and its mechanical properties are analyzed, and compared with the test hysteresis curve, the rationality and correctness of the finite element analysis are obtained.

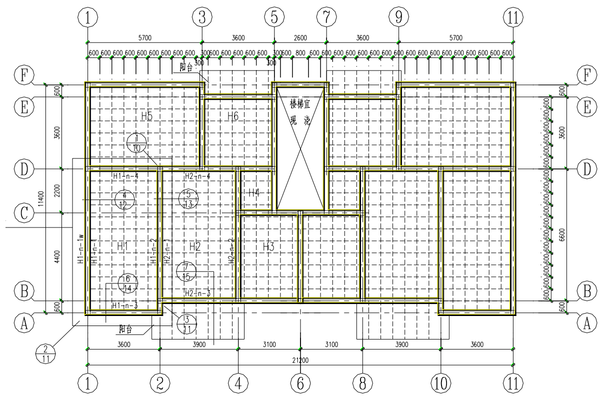


Figure 1. Layout plan of box structure.

1. Determine the thickness of the plate :(1) It should adapt to the requirements of different room spans.(2) the plate can be embedded in the strong and weak current pipeline.(3) shall meet the requirements of comfort.(4) to meet the fire resistance level of the fire limit requirements.

2 plate type determination :(1) should have a larger floor stiffness.(2) as far as possible to reduce the weight, reduce material consumption, reduce seismic force.(3) there are good sound insulation requirements.

In view of the above requirements, choose bi-directional multi-ribbed floor, rib height 150mm, rib width 60mm, rib spacing 600mm, between the ribs with aerated concrete or foam concrete block as the filling material, reduce weight, enhance sound insulation and anti-chatter function. Each room is used as the floor unit, and the steel bars are set aside around the board. The upper steel bars of the ribs are welded with the upper steel bars of the ribs of the adjacent plates, and the rest of the steel bars are anchored into the dark beams to achieve the purpose of multi-span continuous plates. The floor stiffness is larger and the laminated layer is removed from the laminated floors. Floor bottom surface is smooth, do not plastering, save 20mm of cement mortar.

*12016129@cadg.cn

 https://doi.org/10.1051/e3sconf/202127202017

The lifting weight of multi-ribbed floor with aerated concrete filling block is about 233kg/m2, which is equivalent to the weight of 95mm thick concrete slab. Its index is better than cast-in-place floor slab and even better than precast composite floor slab. Material saving, reduce self-weight, reduce earthquake action.

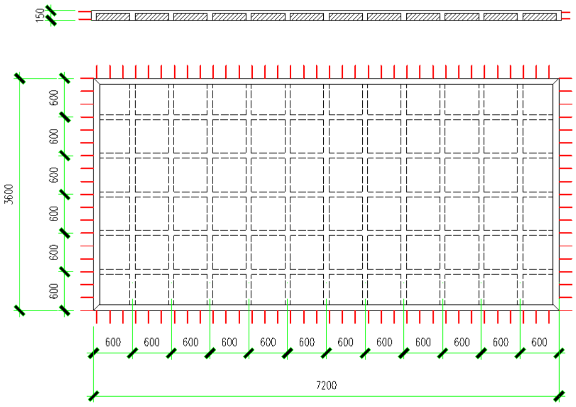


Figure 2. Typical floor plan.

The temporary supporting Angle steel of the floor shall be fixed on the box in advance, and the design shall align the ribs of the whole floor vertically and horizontally. The upper steel bars of the ribs of the adjacent floor shall be welded. The length of the weld seam shall be 10D on one side and 5D on both sides.After pouring the concrete, it becomes a continuous slab.

2 Finite element analysis of floor slab

2.1 Component design

The upper reinforcement and the lower reinforcement (through the block) of the plate are d8@200 (HRB400), and there are tensile bars distributed in the rib, which is a (HRB400).The material used for the cushion block is autoclaved aerated concrete.Before the production of autoclaved aerated concrete cushion block, the steel bar should be inserted into the cushion block mold, and then the prepared cushion block and the steel bar together form a part of the floor formwork to carry out the casting of floor members.At the same time, the shape of the contact surface between the pad and the floor should be changed in the experiment to avoid the pad coming out of the floor after the floor is stressed and deformed. The inclined Angle or steps should be used to constrain the pad.

Considering the limitations of laboratory space and equipment, the failure modes of the following two models were compared in numerical simulation, and the experimental results were predicted:

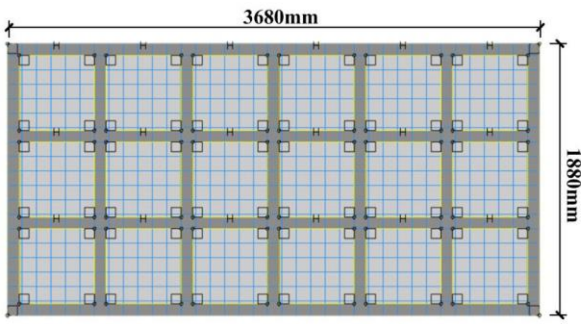
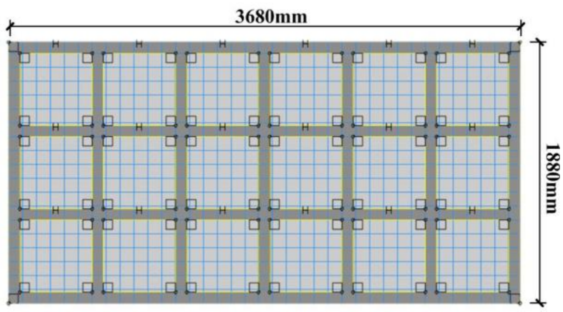
serial number	Component diagram		scantling	boundary conditions	
1			3.6m*1.8m	Side with hinge One side clamped	
2			All parameters are the same as 1, without padding block		

Figure 3. Schematic diagram of specimen

3 Material constitutive and interaction setting

The floor concrete is cast by C30, the reinforcement is HRB400, and the material constitutive is the same as the shear wall part.

Autoclaved aerated concrete blocks are made of C3D8R elements, which refer to the ideal elastoplastic

 https://doi.org/10.1051/e3sconf/202127202017

double-line concrete compression constitutive model and four-line concrete tension model used by Zhilong Li (2014, Tongji University, Experimental and Finite Element Analysis of Flexural Behavior of Autoclaved Aerated Concrete Floor Sabs).

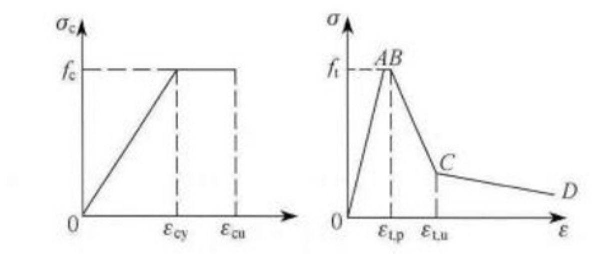


Figure 4. Material constitutive curve

EC =2300MPa, FC =4.86MPa, peak compressive strain of aerated concrete is 0.002, ultimate compressive strain is 0.003;The ordinate of point A is 0.31MPa, and the abscissa is 0.00013;The abscissa of point B is 0.00015;The abscissa of point C is 0.0003, and the ordinate is 0.25 times the peak tensile stress.The abscissa of D point is 0.0012, and the ordinate is 0.02MPa.

The steel skeleton is embedded into the overall model via the built-in area command.In order to facilitate the convergence of numerical simulation results, the use of TIE command between the pad and the bi-directional multi-floor plate may lead to higher numerical simulation results than the actual results.

The numerical simulation results are as follows:

（1）NO.1

According to the finite element calculation, the cracking load and ultimate load are 20.05kN and 38.46kN respectively. When the final failure occurs, the vertical deflection of the middle span of the bottom of the plate is 2.61mm. The failure mode is shown in the figure below:

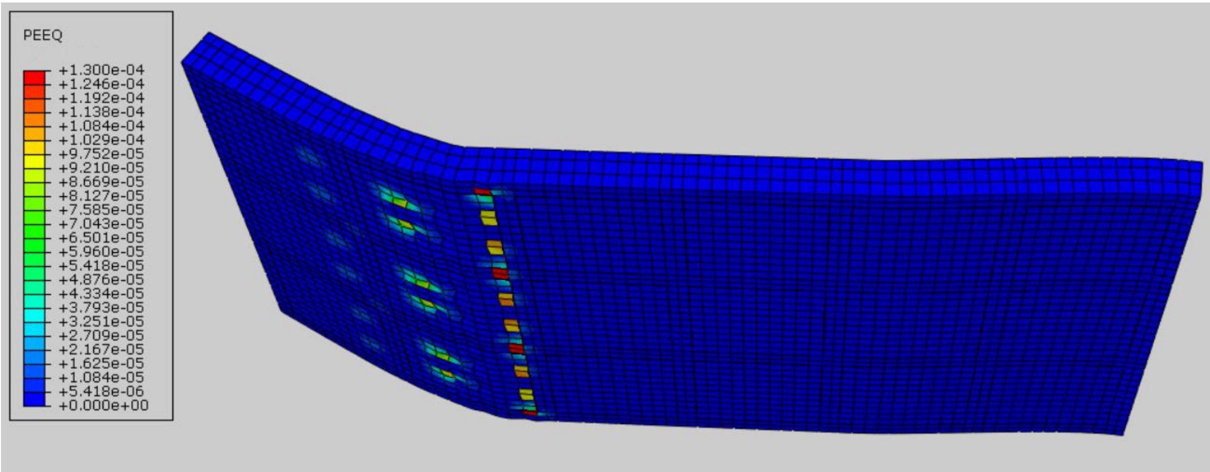


Figure 5. Finite element results of No. 1 wall-1

The reinforcement stress is extracted from the finite element calculation results. When the plate is damaged, the reinforcement stress distribution is shown in the figure:

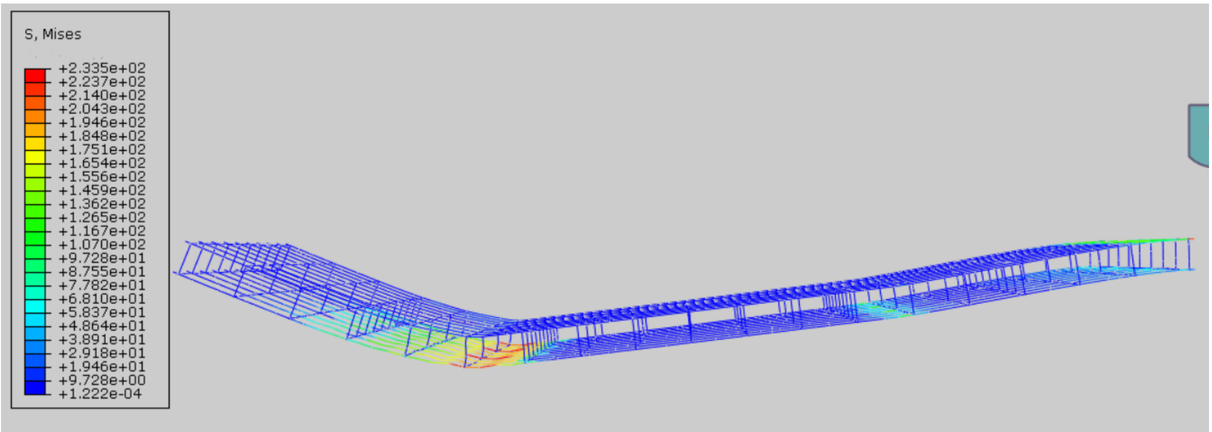


Figure 6. Finite element results of No. 1 wall-2

The results of finite element calculation show that the maximum stress of the steel bars in the tensile zone reaches 233.5MPa and the maximum stress of the steel bars in the compression zone reaches 68.1MPa, both of which fail to reach the yield strength of the steel bars at 400MPa, and the strength of the steel bars is not fully utilized.

(2）NO.2

According to the finite element calculation, the cracking load and ultimate load are 11.663kN and 22.095kN respectively. When the final failure occurs, the vertical deflection of the middle span of the bottom of the plate is 1.994mm. The failure mode is shown in the figure below:

 https://doi.org/10.1051/e3sconf/202127202017

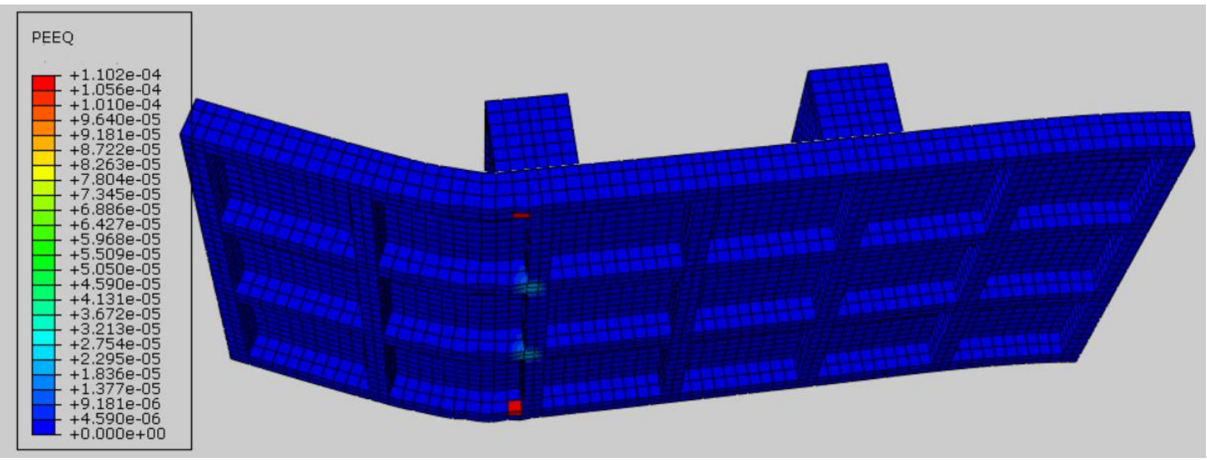


Figure 7. Finite element results of No. 2 wall-1

The reinforcement stress is extracted from the finite element calculation results. When the plate is damaged, the reinforcement stress distribution is shown in the figure:

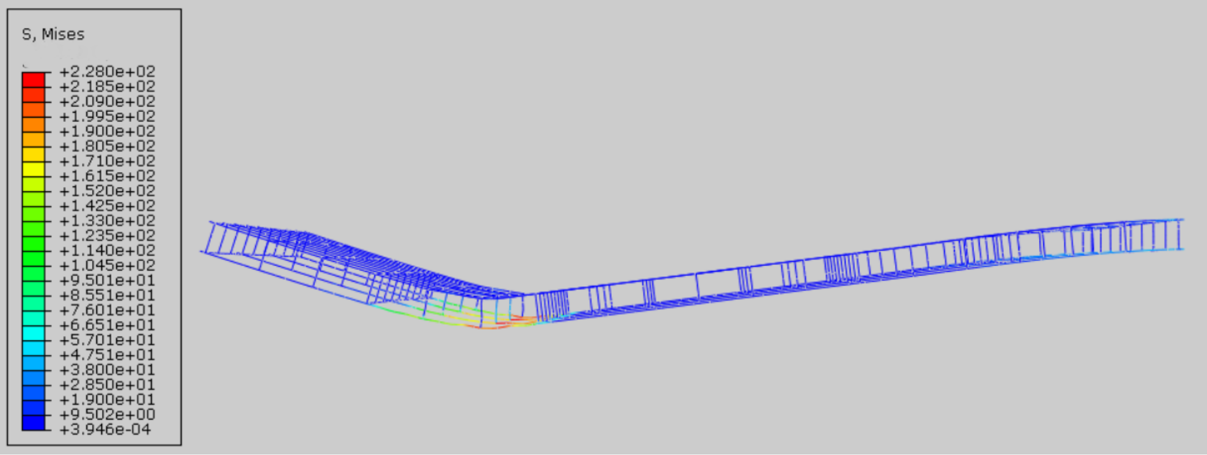


Figure 8. Finite element results of No. 2 wall-2

The results of finite element calculation show that the maximum compressive stress of the reinforcement in the tensile zone reaches 228.0MPa, and the maximum compressive stress of the reinforcement in the compression zone reaches 66.5MPa, both of which fail to reach the yield strength of the reinforcement of 400MPa, and the strength of the reinforcement is not fully utilized.

4 Conclusion

Until the failure of the plate, the tensile and compressive steel bars in the plate do not yield, and the strength of the steel bar is not fully utilized, showing obvious characteristics of super-reinforced failure.

In the finite element simulation, the rebar embedded and TIE command resulted in lower mid-span deflection and higher load than the field experiment results.Therefore, the load value predicted by the finite element can meet the experimental requirements.

References

1. Xiaodong Zheng. HABITAT ’67, MONTREAL, QUEBEC, CANADA,1967[J], World Architecture, 2011(8):32-37.
2. Yuanyuan Qu. Research on the Development of Modular Building Space Design[D], Suzhou:Soochow University,2009.
3. R.Mark Lawson, M.ASCE, Ray G. Ogden, Rory Bergin, Application of Modular Construction in High-Rise Buildings[J], Joural of Architectural Engineering, 2012, 18(2):148~154.
4. Lawson RM, Richards J. Modular design for highrise buildings. Proc Inst Civ Eng Struct Build 2010;163(SB3):151–64.
5. Qingbo Yang. Experimental study on seismic performance of full-scale model of precast concrete shear wall box structure[D], Harbin Institute of Technology,2015.
6. Kexin Qu. Research on Steel Structure Modular Building Structure System[D]. Tianjin University, 2014.