Analysis of underground garage roof slab no-return roof structure in the construction phase travel route area

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Abstract. This paper adopts the calculation method of finite element combined with manual analysis to analyze the structural deformation of the underground garage roof slab without back roofing in the construction stage of the traffic route part, and proposes the structural slab reinforcement method combined with the actual construction situation, which shortens the construction period and reduces the cost compared with the traditional full scaffolding back roofing method and has a strong promotion, which can provide the theoretical reference basis for the subsequent works.

Keywords: Structural no-return roofing; travel load; finite element analysis; manual analysis.

1. Introduction

In the project construction stage, it often needs to drive on the basement roof laden material vehicles, at this time need to be the part of the basement roof accounting, accounting for its bearing to meet, such as cannot meet should be reinforced, the conventional reinforcement method using full frame for back to the top of the reinforcement. The practice occupies a long time, the rack rental fee is high, affects the subsequent process interpolation of the basement, and has a greater impact on the construction period constraints. In order to save the construction period and reduce the cost and increase the efficiency, the top-free measures were carried out through the method of structural reinforcement. This paper combines the construction stage of the underground garage roof of a residential community project to carry out the analysis of the construction stage of the roof of the traffic route part of the roof free back to the top of the structure, and put forward the theoretical basis of the underground garage roof construction stage of the traffic part free back to the top, which can effectively guide the project construction.

2. Project Overview

The underground garage of a project is mainly a general garage, the form of frame structure, the total construction area of the garage is about 61,000m2, the seismic intensity is 8 degrees (0.2g), the concrete strength grade of the foundation is C35, the concrete strength grade of the wall is C35, the concrete strength grade of the column and beam plate is C35, the thickness of the garage roof slab is 250mm, 300mm, the height of the structure is 5.10m, the design of backfill on the roof slab is overburden. The load is considered in accordance with the thickness of 1.5m, and the overburden capacity is not more than 18KN/m³. The load design profile of the underground garage roof slab is as following Table 1.

Table 1. The load design profile of the underground garage roof slab.

Serial No.	Category	Standard value of live load (KN/m³)
1	Basement roof (fire lane, fighting surface, return yard range)	35(Before discounting)
2	Basement roof (non-fire lane, extinguishing surface, return yard area)	5
3	Power distribution room, generator room, pump room, strong and weak power room, fire control room, air conditioning room, electrical room	10

The construction load is not allowed to exceed this live load after the cladding is completed. The load that can be withstood is the total weight of the overburden plus the basement roof (fire lane, firefighting surface, return yard range)

Temporary road set in the fire lane, in accordance with the 70t class car consideration, (more than 70t vehicles in the garage roof before the need to unload, to a total weight of less than 70t before), the road is 4m wide, designed for one-way lane, two 18m*18m return yards are planned, and the drawings in the basement roof (fire lane, fighting surface, back to the car park range) position to maintain consistent, later if the adjustment of planning may exist across the back pouring belt situation, as shown in Figure 1.

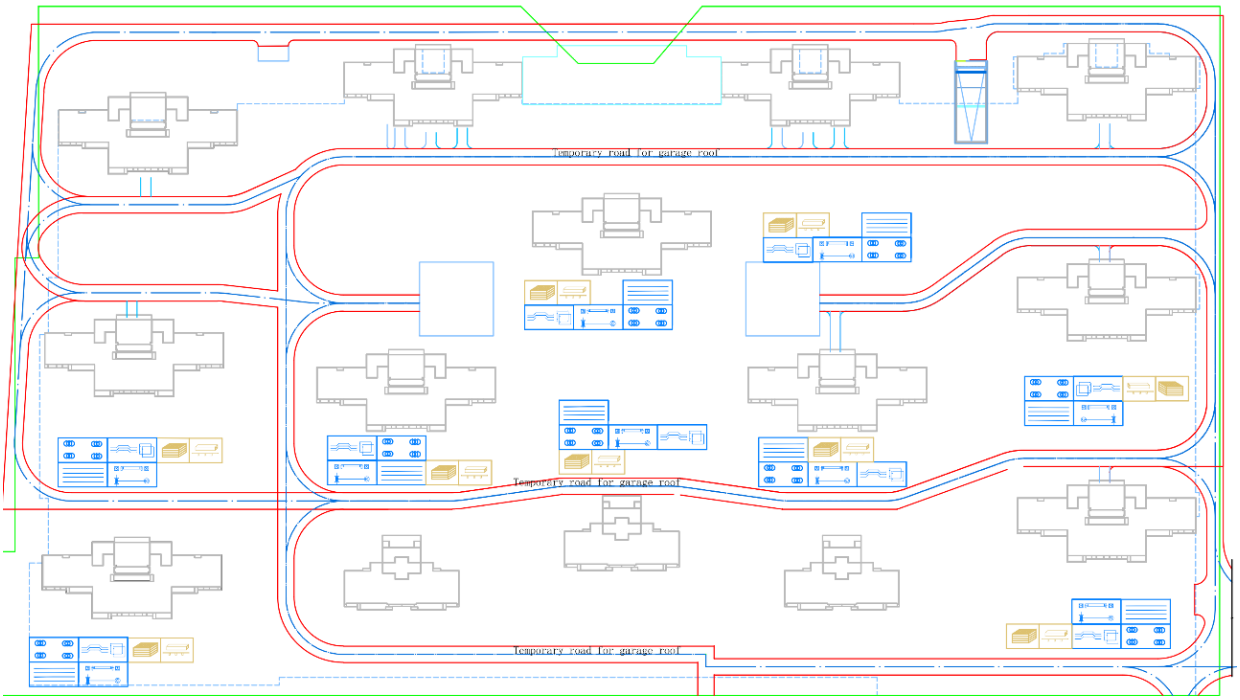


Figure 1. Temporary road set in the fire lane.

3. Analytical modeling

3.1. Calculation Software

The reliable structural model established by using yjk4.0 structural calculation software analysis software can reflect whether the reinforcement of structural beams and slabs in the process of vehicle driving meets the original design requirements, and can gradually move the load to find the most unfavorable arrangement of the load location to verify the deflection and cracking of the original structure under the action of the vehicle load to meet the code limit requirements.

3.2. Structural analysis modeling

3.2.1. Calculation parameters

The model was established according to the original project design drawings. To reduce the influence of vehicle load on the structure, a 300mm thick plain soil bedding layer was set on the slab span of the traffic route. Then the effect of vehicle load on the structure is calculated according to the maximum value of 70T vehicle wheel load acting on the middle of the slab span, the top of the main beam and the edge of the slab span respectively.

The load acting on the structure is mainly 300mm thick plain soil bedding layer, the weight of the bedding layer is 18kN/m³, the constant load is calculated by 0.3x18=5.4kN/m^2, and the live load takes the value of 0.5kN/m^2. The vehicle load is considered with the load of City-A class 70T, and its wheel

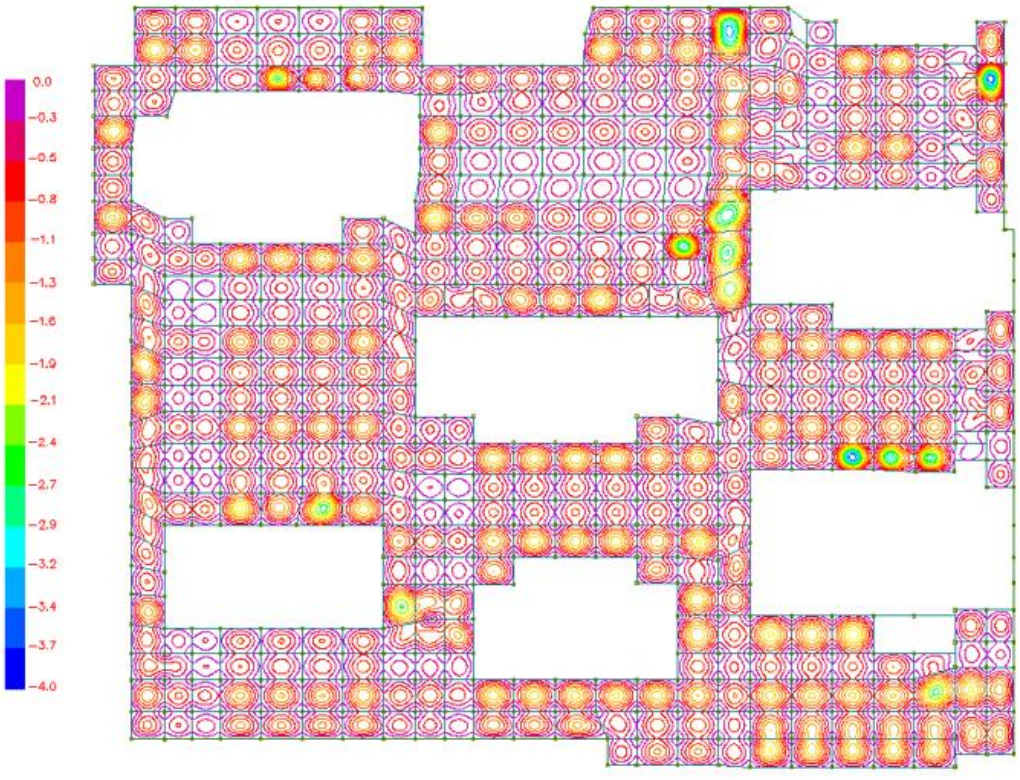
pressure distribution is shown below. According to the building structure load code, the vehicle load should be multiplied by the power factor of 1.3.

3.2.2. Finite element method analysis

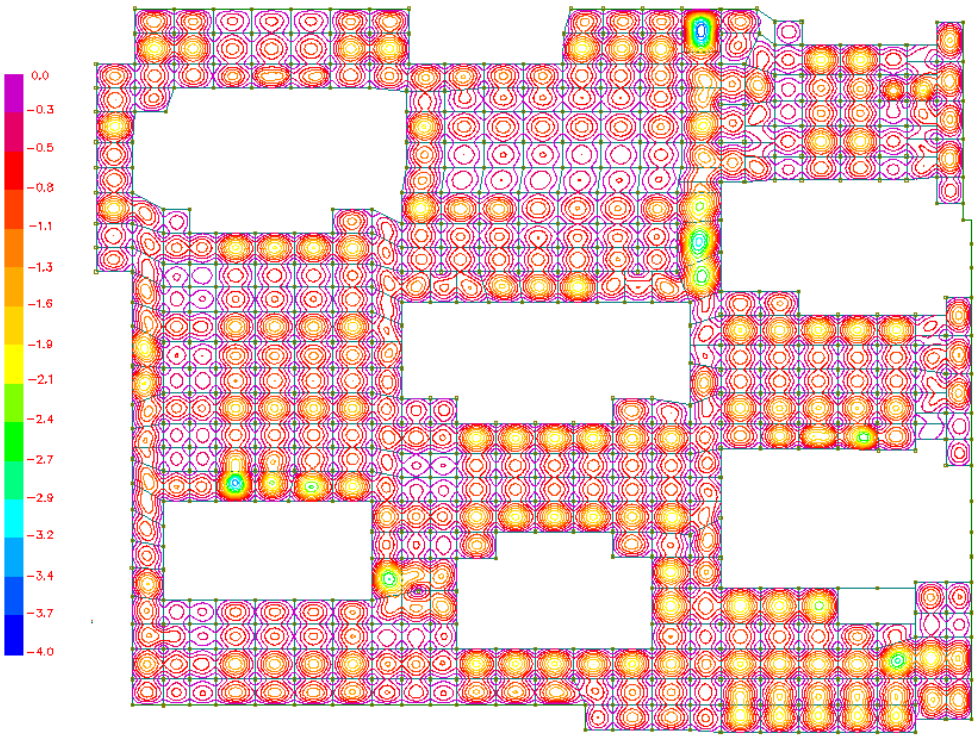
The finite element analysis method takes the beam and slab as a whole and coordinates the deformation calculation, the calculation results are as following Figure 2.



(a)



(b)

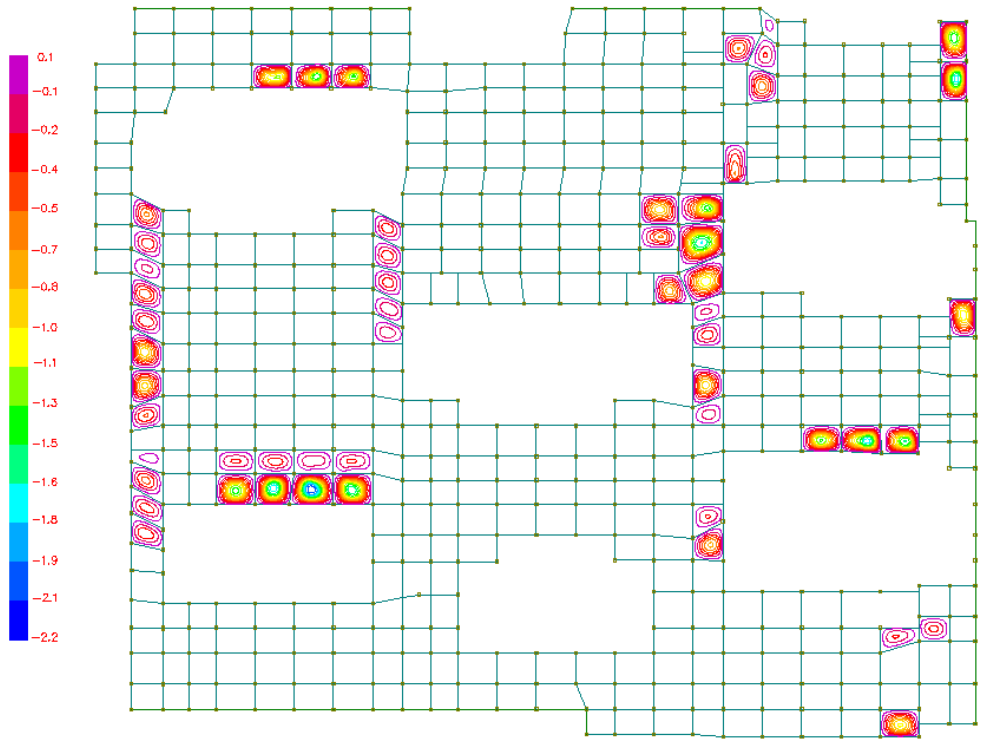


(c)

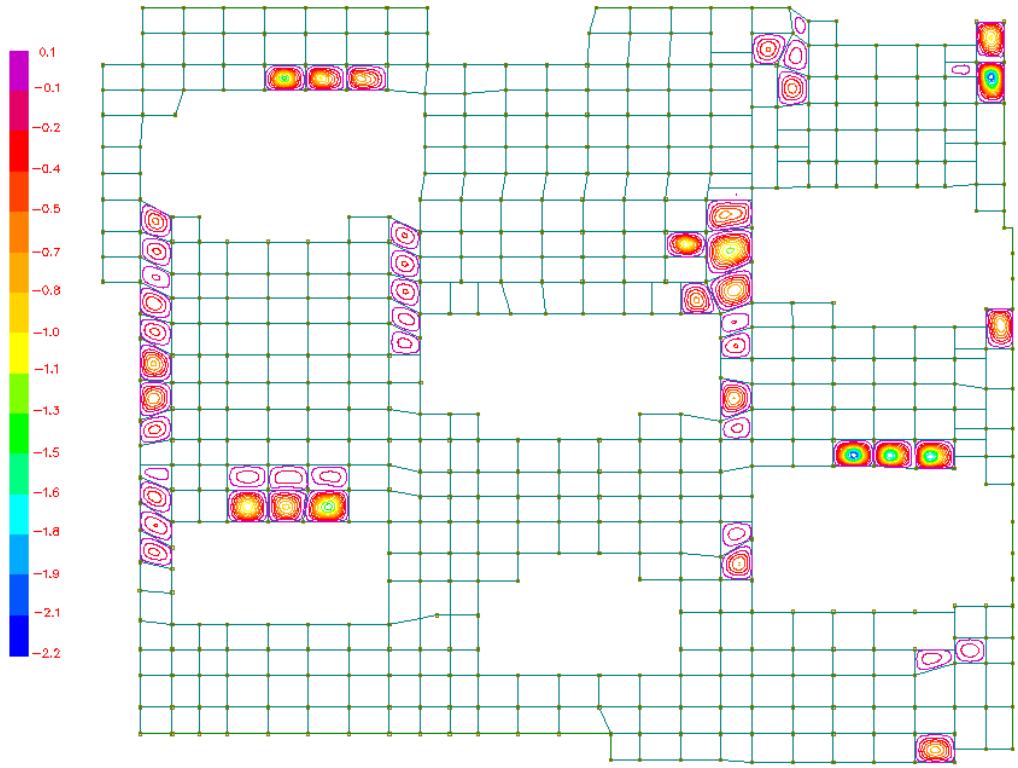
Figure 2. The calculation results.

3.2.3. Manual method analysis

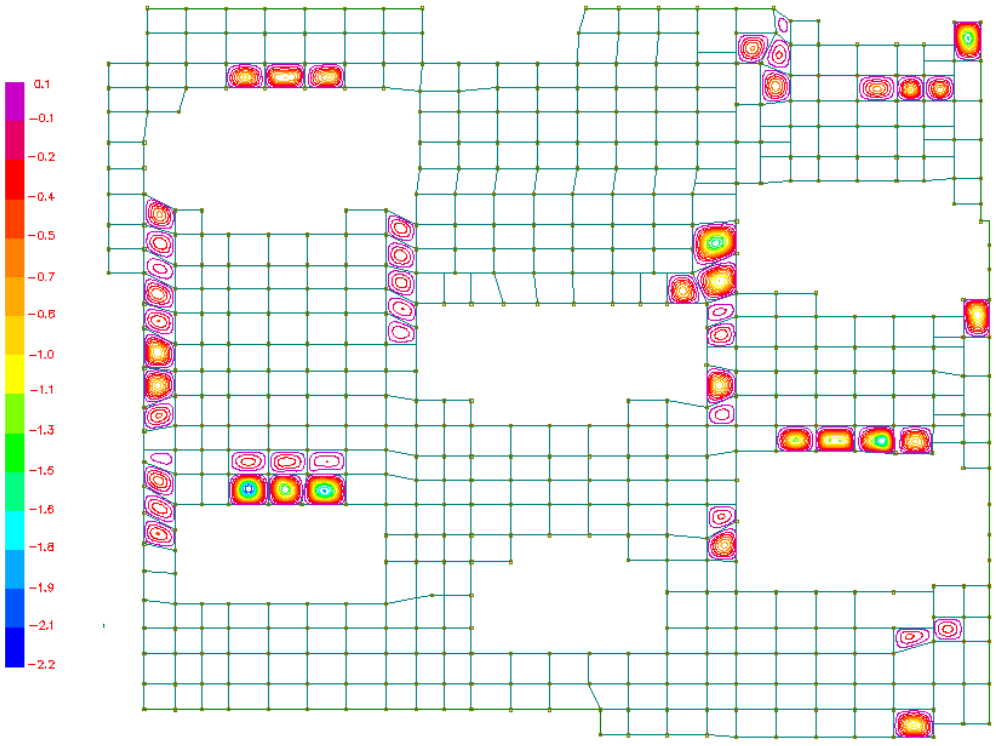
The manual analysis method assumes that the slab is constructed with ideal fixed constraints around the perimeter and no vertical displacements are generated, which are calculated respectively as following Figure 3.



(a)



(b)



(c)

Figure 3. The calculation results with no vertical displacements.

From the above calculation, the maximum values of deformation and reinforcement of the slab are obtained, and the comparison with the original design drawings shows that the original design drawings can meet the traffic requirements.

4. Recommended values for conventional slab span reinforcement

Through the above analysis, the common slab span, slab thickness and reinforcement are finally determined as following Table 2.

Table 2. Slab thickness and reinforcement are determined.

Span(m)	Plate thickness(mm)	payload (kN/m^2)	C35		C30	
			Rebar	Cracks / Deflection	Rebar	Cracks / Deflection
9x9	400	28	18@150	0.15/24.55	18@150	0.17/27.71
		23.4	16@150	0.17/22/31	16@150	0.20/25.26
	350	28	20@150/ 18@100	0.14/35.12	20@150/18@100	0.15/37.88
		23.4	18@150	0.14/32.48	18@150	0.16/35.74
	300	28	20@100	0.09/43.03	20@100	0.10/45.29
		23.4	18@100/ 22@150	0.10/40.98	18@100	0.10/43.52
8.1x8.1	350	28	18@150	0.11/21.96	18@150	0.13/24.58
		23.4	16@150	0.13/19.23	16@150	0.15/22.33
	300	28	18@150	0.16/39.38	20@150/16@100	0.14/35.98
		23.4	18@150	0.12/31.18	18@150	0.14/33.93
	270	28	20@100/ 22@150	0.07/35.60	20@100	0.08/37.50
		23.4	20@150/ 16@100	0.12/38.42	18@100/22@150	0.08/35.67
7.2x7.2		28	16@150	0.14/23.89	16@150	0.16/26.52
		23.4	16@!50	0.09/17.59	16@150	0.11/20.20
		28	18@150	0.12/29.99	18@150	0.14/32.26
		23.4	16@150	0.12/27.90	16@150	0.14/30.61
		28	18@100/ 20@150	0.07/29.24	20@150	0.12/35.44
		23.4	18@150	0.11/31.16	18@150	0.12/33.47
		28	——	——	——	——
		23.4	18@100/ 22@150	0.07/35.88	20@100	0.06/33.11
6.0x6.0	250	28	14@150	0.14/20.32	14@150	0.16/22.72
		23.4	14@150	0.10/14.52	16@150	0.12/16.86
	220	28	16@150	0.13/27.67	16@150	0.14/29.70
		23.4	16@200	0.16/26.59	16@200	0.18/29.13
	200	28	20@150/ 16@100	0.08/27.98	18@100	0.06/26.06
		23.4	18@150/ 14@100	0.08/25.91	18@150/14@100	0.09/27.66

5. Conclusions and Recommendations

1) Since the lower part of the top plate is not reinforced by the shelf back to the top, the size of the structural beam of the travel route and the thickness of the plate are quite critical and require comprehensive consideration of all factors to determine the most unfavorable in all cases, and should not be altered at will.

2) Vehicle transportation is a temporary load, which only needs to satisfy the static calculation. Therefore, the other constant loads of the superstructure are not applied, and the temporary vehicle loads do not affect the foundation, but only the structural members in the load change area.

3) The vehicle limit is 70t, for vehicles with more than 70t load, they need to be unloaded to less than 70t before going on the garage roof, 30cm of soil is laid on the planned road to buffer the vehicle load, set up vehicle weight warning signs and protective rails, route guide signs, strict control, and follow the route planned by the program.

4) The finite element calculation method is based on the joint action and coordinated deformation of beam and slab, and its calculation results are more economical than the manual algorithm. However, the overall displacement of the structural slab of the finite element algorithm is greater than that of the manual algorithm.

5) When the maximum wheel pressure is applied to the span of the plate, the span deformation of the plate is the largest.

References

[1] GB 50010-2010 Code for the design of concrete structures [S]. Beijing: China Construction Industry Press, 2016.

[2] GB5009-2012 Code for structural loading of buildings [S]. Beijing: China Construction Industry Publishing House, 2012.

[3] GB50205-2020 Construction Quality Acceptance Standard for Steel Structure Engineering [S]. Beijing: China Planning Press, 2020.

[4] JGJ7-2010 Technical regulations for space grid structures [S]. Beijing: China Construction Industry Press, 2011.

[5] JG/T10-2009 Steel mesh frame bolted ball nodes [S]. Beijing: China Standard Publishing House, 2010.