Optimal Layout of Column grid based on L - plane RC frame structure

Yajun Liu

School of Southwest Petroleum University, Chengdu 610500, China.

1642555698@qq.com

Abstract

This paper summarized seven layout schemes about column which at the corner of L-plane RC frame structure. Related articles[1]have concluded that different layout schemes have different effects in seismic performance. On the basis of the former. From the economic level and then made comparative analysis about different column network layout schemes at the corner of L-plane RC frame structure. Each program which was generated PKPM model was optimized processing, through the network optimization program written in MATLAB, and made economic comparison. The following conclusions are drawn in this paper: (1)When the column at the corner of the L-shaped plane frame structure is arranged in two directions, it is economical to arrange the secondary beam in one way. (2)There is little impact on the total cost of the structure, if only change part of columns layout direction and don't change the

Keywords

L-plane, Structure optimization, Economical efficiency.

1. Project overview

The standard layer of 4.2 m high L-shaped plane office buildings, the seismic fortification intensity is 7 degree, the earthquake group is the third group, designed basic earthquake acceleration is 0.1g, site type for Ⅱ class, characteristic cycle value is 0.45s, seismic grade set to level 3, the ground roughness is C, the basic wind pressure is 0.3KN/M^2. In order to reduce the difficulty of optimization .Only the standard layer of the layout of each cylinder is optimized and compared. The floor load is automatically calculated by PKPM, and the floor of the staircase is dead load. The load distribution of the beams is as follows: Internal wall girder loads are applied to the inner frame girder. External wall girder loads are applied to the external frame girder.

Table 1 Dead load statistical

Item	process	Standard load value
Floor load(KN/M2)	10mm Floor tile	1.4
	20mm cement mortar screed-coat	
	20mm 1:3 cement mortar leveling hacking	
	Latex paint ceiling	
Load on the outside girder(KN/M2)	200mm Shale brick	16.5
	5mm Anti-crack mortar	
	30mm Inorganic insulating mortar	
	Basic level processing	
	Internal plaster	
	Brick wall	
Inside girder load(KN/M2)	200mm Shale brick	11.2
	double-faced plaster	

Table 2 Live load statistical

Item	Section	Standard load value
Live load(KN/M2)	Floor	2
	Corridor	2.5
	Stairway	3.5

2. Project of Column grid layout schemes and load layout

2.1 Project of Column grid layout schemes

Figure 7 below shows the common L-shaped framework structure that is summarized in this article for the seven layouts around the corner. The section size of the secondary beam is 150*500 mm^2, the section size of main girder is 200*600mm^2, the section size of column is 400*400mm^2. According to the conclusion of the relevant literature [2] .The concrete strength level of the columns in each cylinder is selected C35, and the strength grade of the beam is C25.

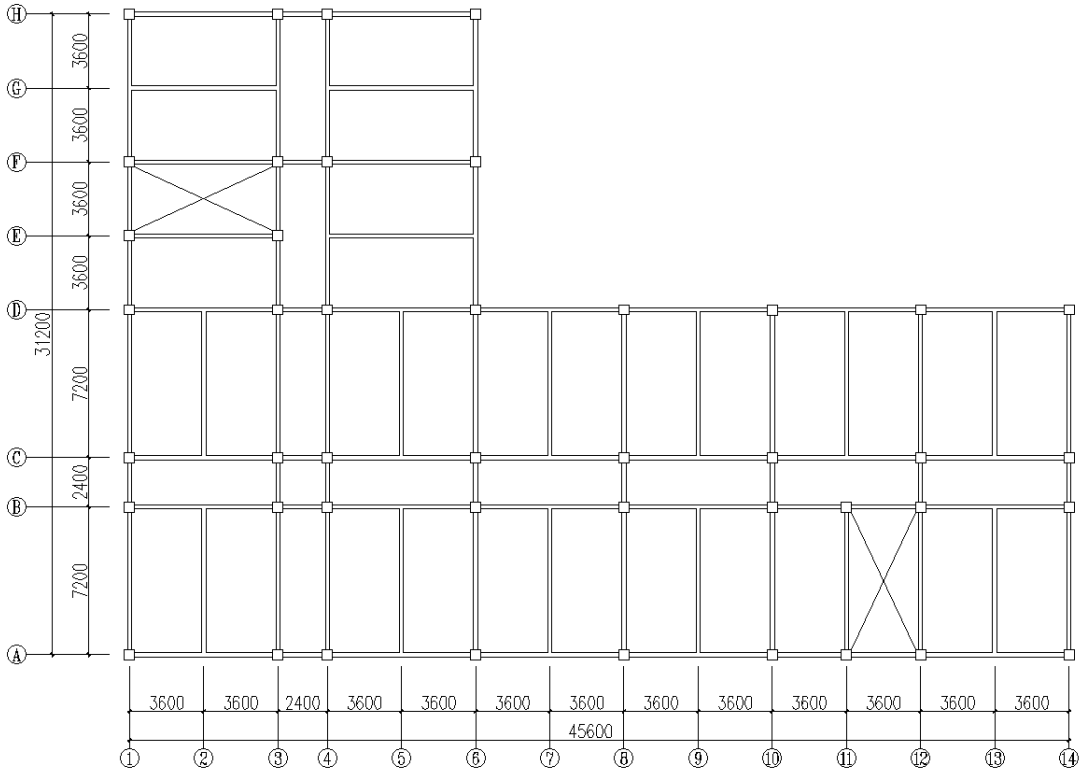

Fig. 1 The column grid layout of scheme 1

The first formula is the most common form of the L-shaped layout, which features a two-way corridor on the corner, and is arranged in a similar manner to the column network of X.

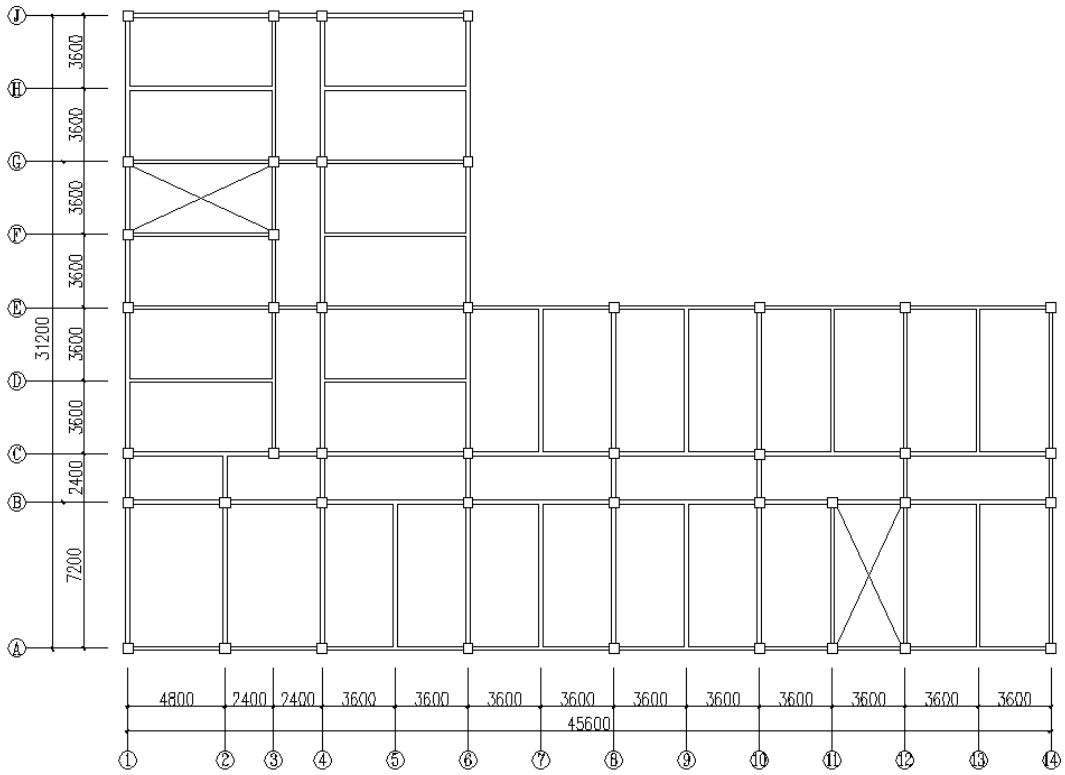

Fig. 2 The column grid layout of scheme 2

The feature of the second scheme is that the short side corridor of X is preserved and the short side corridor of Y is canceled. The column grid layout of A-B is similar to the X direction, and the C-E is arranged in the same direction as Y.

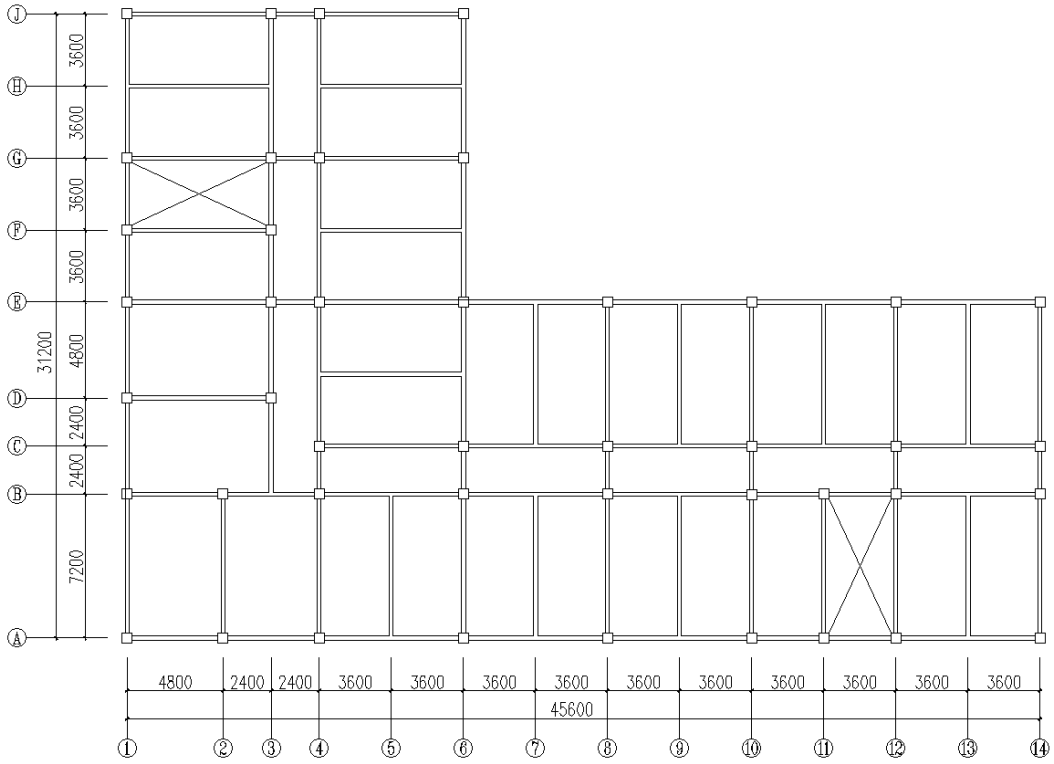

Fig. 3 The column grid layout of scheme 3

Plan 3, though, cancels the bi-directional corridor at the corner, but the C-E column grid layout and the Y direction are consistent, and the A-B column network layout is similar to the X.

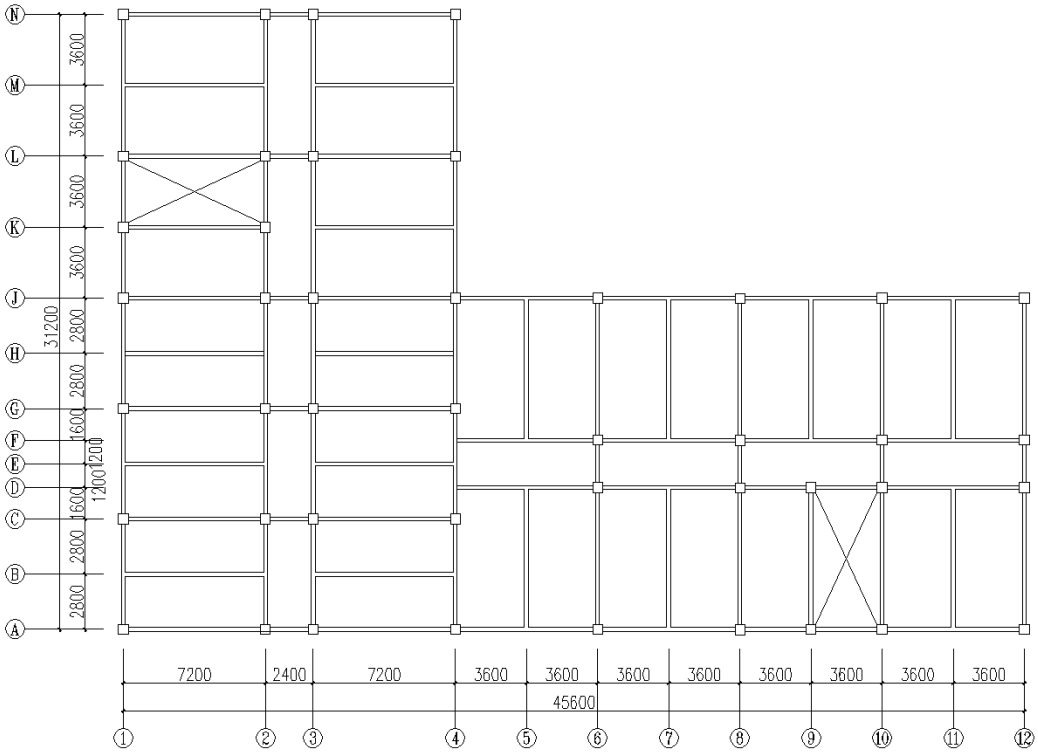

Fig. 4 The column grid layout of scheme 4

Plan 4 cancels the short side corridor of X, but at the corner of the diagram, the Y is kept in the corridor, and the Y is evenly distributed in the three dividing point

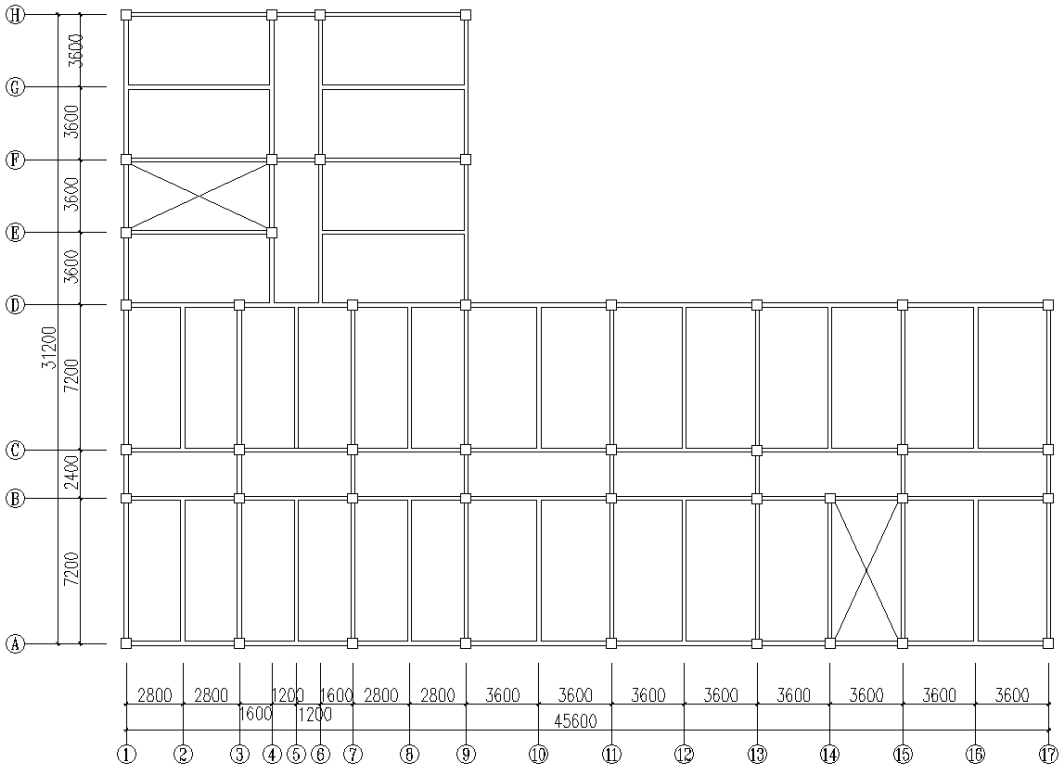

Fig. 5 The column grid layout of scheme 5

Plan 5 cancels the short side corridor of Y, and the column is evenly distributed in the three dividing point of X.

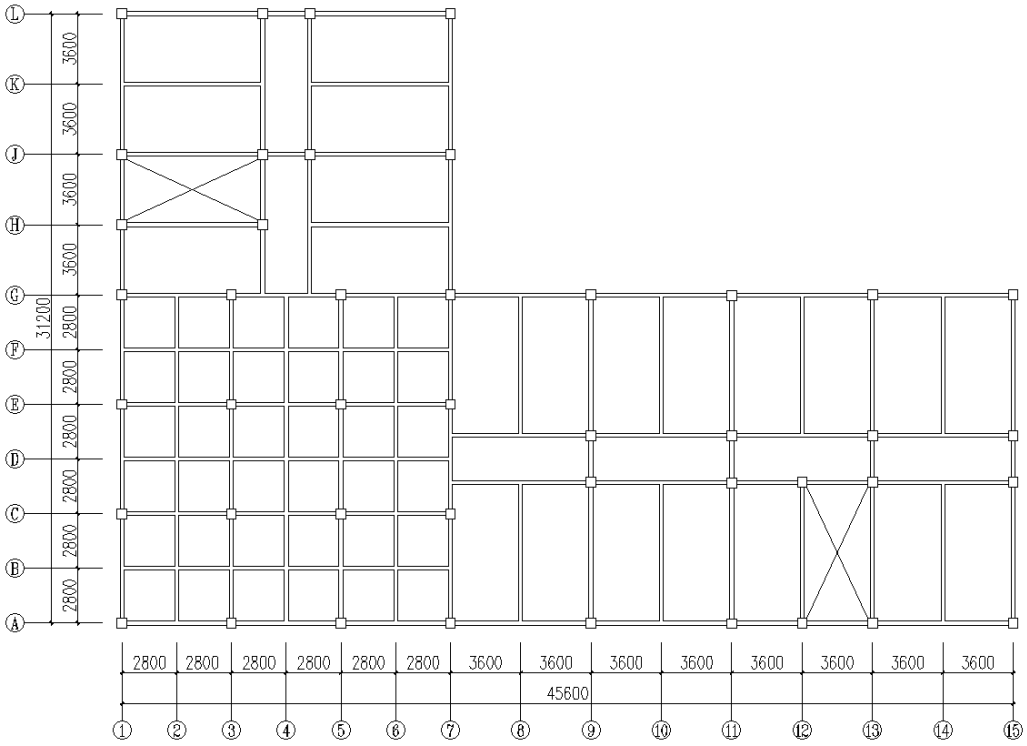

Fig. 6 The column grid layout of scheme 6

The six pillars are arranged in two directions, and the two sides are arranged the second beam in two directions, and the two sides are canceled short side corridor at the corner.

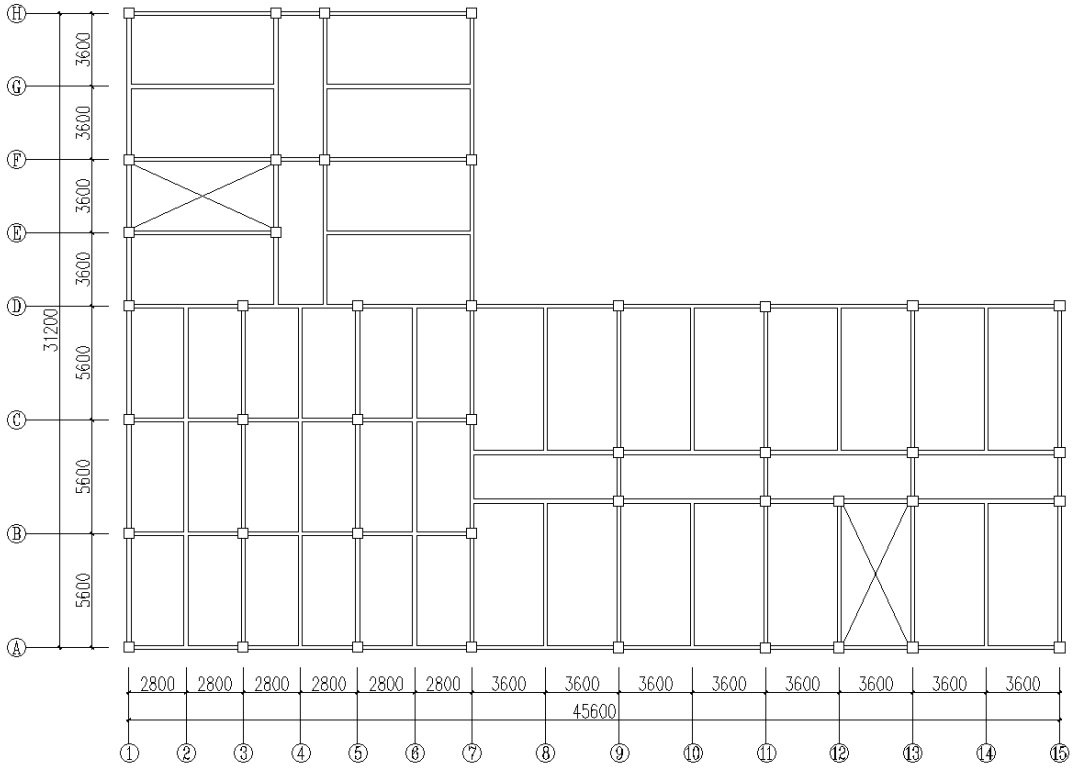

Fig. 7 The column grid layout of scheme 7

The plan 7 is similar to the plan 6, but cancels the bi-directional short side corridor at the corner, and the column is arranged in two directions, and the second beam is arranged only along the Y direction.

2.2 The load distribution of the seven schemes

Seven schemes of interior wall and the arrangement of corridor is not the same, the result is at the corner of the program of the load distribution is also have certain differences [3]. L-plane frame structure in the corner of the different column grid layout construction use function of the various options do not completely consistent, seven kinds of scheme of load distribution as shown in the figures below. Because seven schemes is just around the corner column grid, the layout of beam is different, in the first solution was proposed a full load distribution and the remaining six schemes were only shown load distribution at the corner.

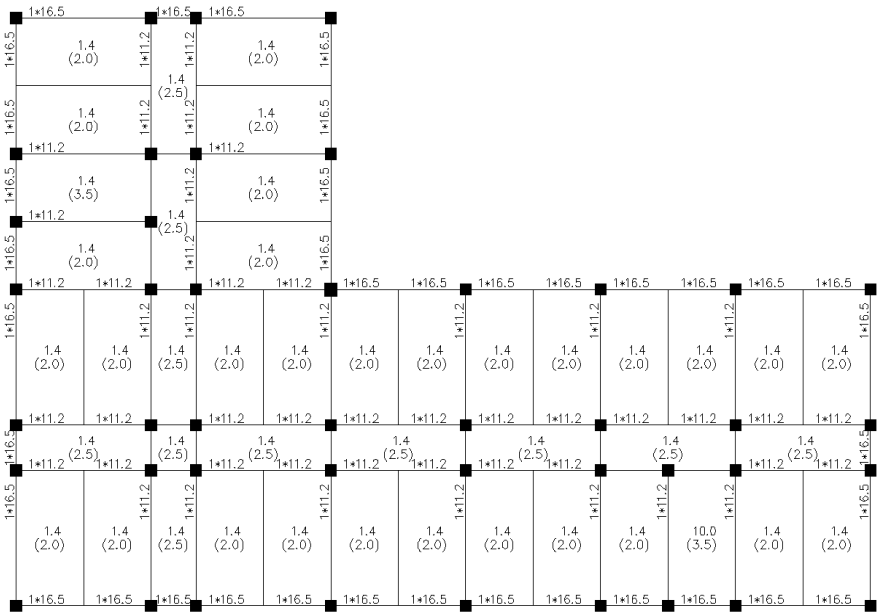

Fig. 8 The load distribution of scheme 1

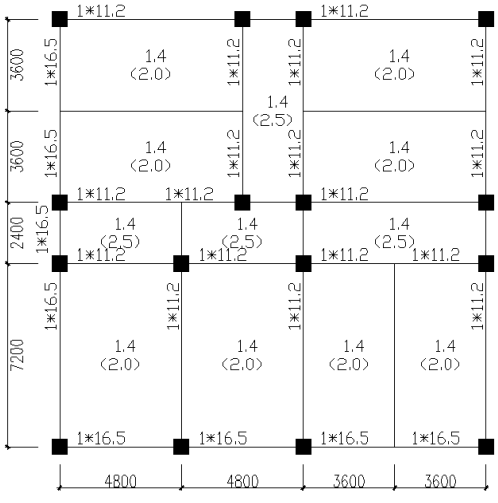

Fig. 9 The load distribution of scheme 2

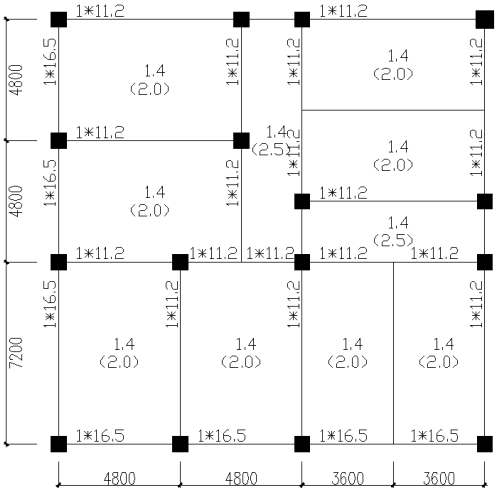

Fig. 10 The load distribution of scheme 3

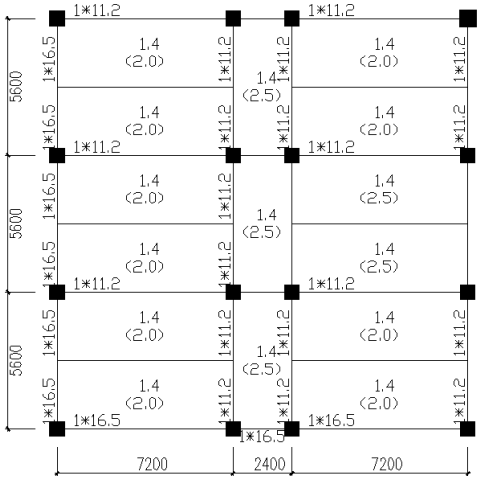

Fig. 11 The load distribution of scheme 4

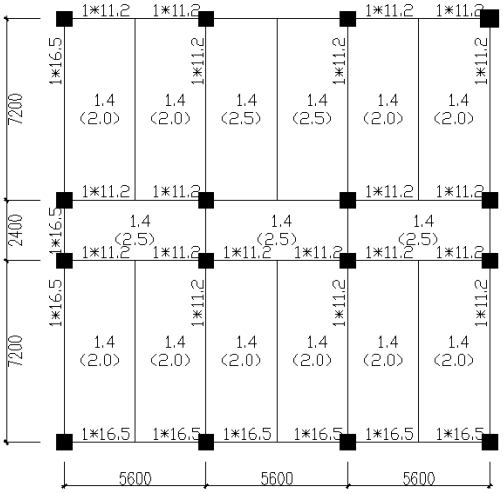

Fig. 12 The load distribution of scheme 5

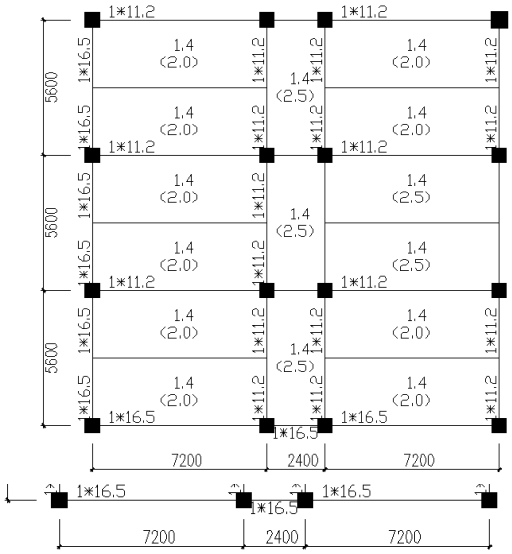

Fig. 13 The load distribution of scheme 6

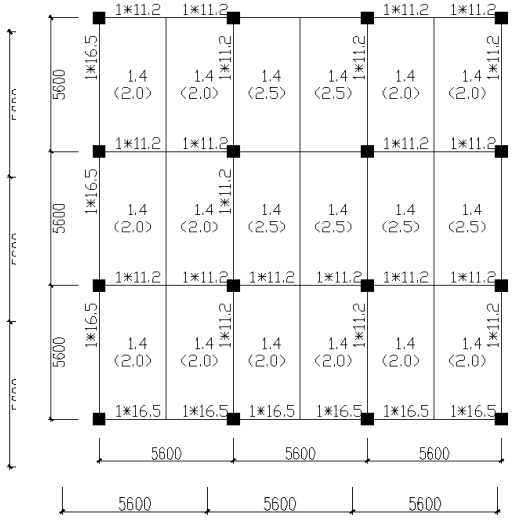

Fig. 14 The load distribution of scheme 7

3. Each scheme optimization result and analysis

The standard layer model of seven kinds of column grid was established by the PKPM software [4], then the internal force design value of each scheme was read and the optimized design was carried out. Through MATLAB optimization program optimizated seven kinds of schemes of column grid for the first time, the section size of column grid are some differences, so we need to adjust the model and optimization and check again.

3.1 Seven schemes optimization results

The cost information for the seven models is shown in table 3 after several tuning optimization.

From the table above, you can see that plan 7 is the least cost. In other words, the building plane is L-shaped, and the pillars on the corner are evenly arranged along the two directions and the second beam is the most economical when it is arranged along the Y (vertical) direction.

After the optimization, the information of the seven schemes section of the plan is shown in figure 15 to figure 21, except that the beams and columns on the corner are different, and the rest is the same[5, 6]. Figure 15 gives the full size, the rest of the diagram only gives the section size of the beam in the corner. The dimensions of the frame columns in the other plans are 400*400 mm^2.

Table. 3 The cost of seven schemes after optimized

Scheme	The cost of total after the first optimized(RMB)	The final cost (RMB)	The ratio of comparing with the least cost
1	143050.81	140815.51	1.046
2	139475.45	136853.43	1.017
3	138101.90	136020.11	1.010
4	144849.80	139948.43	1.040
5	141507.63	139346.46	1.035
6	141600.51	140087.44	1.041
7	136164.65	134617.92	1.000

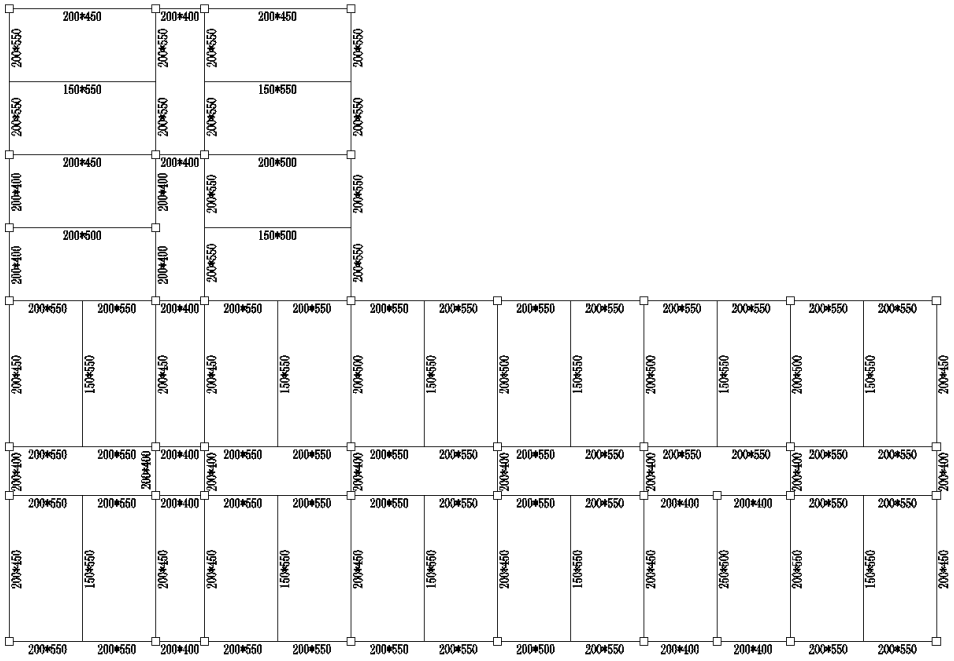

Fig. 15 The plan 1 section size

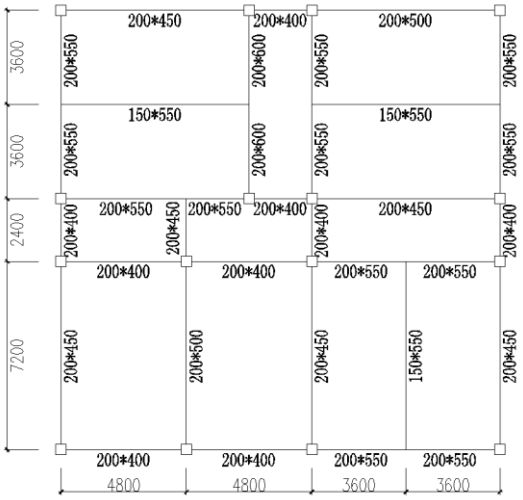

Fig. 16 The plan 2 section size

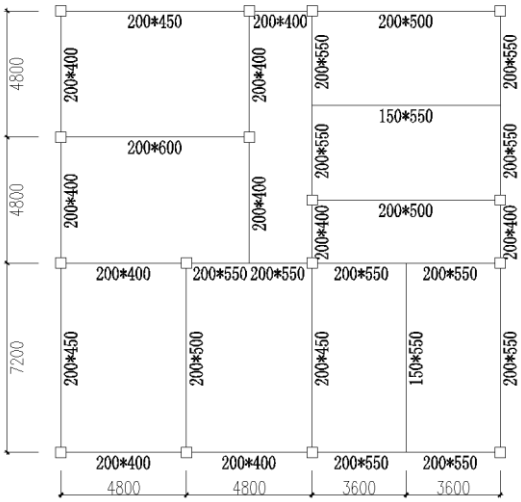

Fig. 17 The plan 3 section size

3.2 Theoretical analysis

In this paper, the seven types of structure of the frame structure of l-shaped plane are divided into four categories [7, 8]. The first is to keep the short, bi-directional corridor at the corner. The second type is similar to the first one but cancels the short side of the two-way corridor and makes a local adjustment

to the column. The third kind is on the corner, along the X (horizontal) direction, or the Y (vertical) is evenly distributed to the side, but the other side remains the same, namely plan four and plan five; The fourth class, which is arranged along the corner of the L plane, is followed by the uniform arrangement of X and Y, which is the plan 6 and the plan 7. In the second column grid scheme arrangement, the second scheme on the basis of the scheme 1 canceled the short side corridor of Y, and integrated local pillar. So the utilization rate of the beam is improved. The cost of the beam is lower than the plan 1; Plan 3 canceled the short side corridor of X base on the plan two, so that the utilization of the beam is improved further, so the plan 3 is lower. For the third type of column layout, the fourth scheme is set up the second beam along the corner of Y direction. The economic effects are clear. Plan 6 added X to the second beam at the corner, because the column from the smaller, the utilization rate of the beam will not increase with the increase of secondary beam, instead will cause unnecessary waste. As a result, the plan 7 is more economical than plan 6

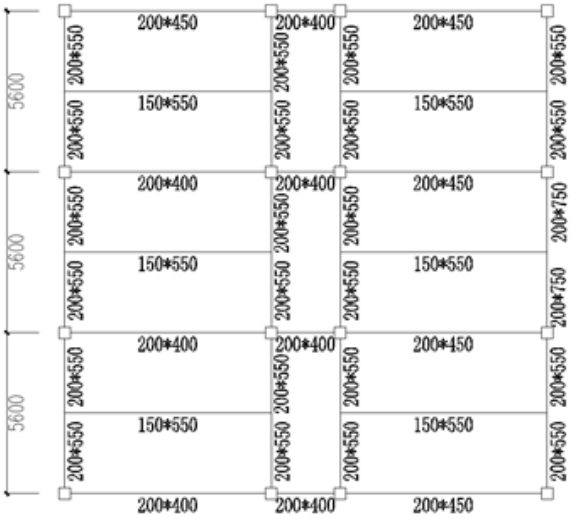

Fig. 18 The plan 4 section size

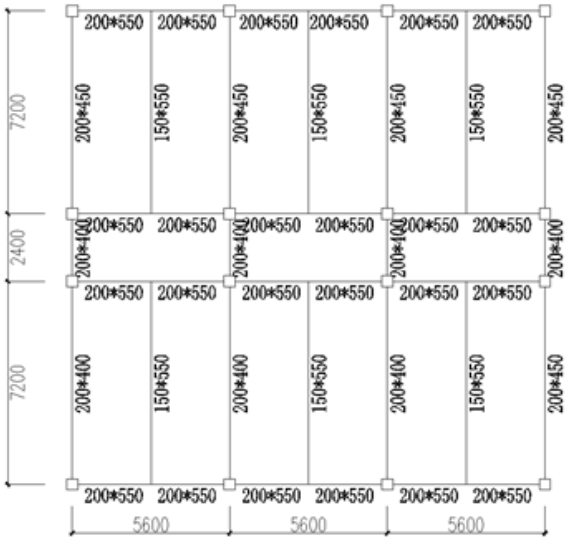

Fig. 19 The plan 5 section size

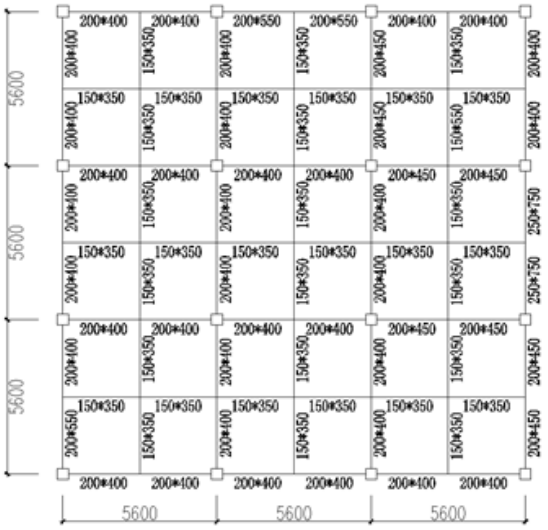

Fig. 20 The plan 6 section size

Fig. 21 The plan 7 section size

4. Conclusion

In this paper, the L-shaped plane frame structure in the corner of the different column grid decorate a form to make generalizations, and determine the common column grid layout, set up the standard layer model of each scheme. Through MATLAB optimized each model [9]. And comparing the economy of each scheme [10]. In the end, the plan 7 is the most economical design .There are come to two conclusions:

(1)When the column at the corner of the L-shaped plane frame structure is arranged in two directions, it is economical to arrange the secondary beam in one way.

(2)There is little impact on the total cost of the structure, if only change part of columns layout direction and don't change the column layout form.

References

[1] C. J. Fan: *The Optimized Study of The Structure about Column Grid and Stair of The L-shaped RC Frame in The Earthquake Zone* (MS., Southwest Petroleum University, China 2014), p.31.

[2] J. J. Zhu, Y. Hong: Practical optimization of spatial concrete frame structure, Journal of Shang Hai University, Vol. 14 (2008) No. 2, p.201.
[3] J. Wang: Research on Reinforced Concrete Frame Structure Optimization Design (MS., Hebei University of Engineering, China 2014), p.39.
[4] H. Gao: The Discussion of Several Problems in The Modeling of PKPM Software (MS., China Academy of Building Research, China 2006), p.7.
[5] Y. S. Chen: Research on Optimization Design of Reinforced Concrete Frame Structure and it's System Development (MS., Xi an University of Architecture and Technology, China 2010), p.23.
[6] J. J. Zhu, X. R. Zheng: The Multilevel Optimal Design of Space RC Frame Structures and it's Program Development, Building Science ,Vol. 25 (2009) No. 1, p.91.
[7] X. Cai, X. W. Guo, X. M. Zhang: Engineering structure optimization design (China Water & Power Press, China 2003).
[8] H. L. Lu, N. Xu, C. S. Ma:Optimized CAD system for reinforced concrete frame structure, Journal of Jianghan Petroleum Institute, Vol. 21 (1996) No. 2, p70.
[9] N. N. Schraudolph, R. K. Belew:Dynamic Parameter Encoding for Genetic Algorithms, Machine Learning, Vol. 9 (1992) No. 1, p. 9.
[10] H. A.Eshenauer, N. Olhoff:Topology Optimization of Continuum Structures:A Review, Applied Mechanics Reviews, Vol. 54 (2001) No. 4, p. 1453.