Summary Of Feismic Performance Of Special-shaped Column Structures

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Abstract

The appearance of the special-shaped column enriches the flexibility of the interior architectural layout. Its unique multi-column section form, the thickness of the column limb is as thick as the wall, and there is no pillar protrusion in the room, which makes it quickly applied to practical engineering.However, its "innate" bearing capacity and poor seismic performance make it a great limitation in promotion and use.This paper mainly introduces the development and research status of special-shaped columns, analyzes some problems existing in the current research, and proposes future research directions and development prospects.

Keywords

Special shaped column, concrete, structure.

1. Introduction

Compared with masonry structure, reinforced concrete structure is more and more widely used. Among them, the most widely used multi-layer structure is reinforced concrete frame load-bearing and lightweight material as the frame light-weight structure of the infill wall, also known as frame light structure. The structure is not only relatively light in weight, good in seismic performance, but also convenient for industrial construction, and thus has great practical and popularization value. However, the cross-sectional dimension of the traditional rectangular column is often larger than the wall thickness, and the edge of the column is inevitably protruding outside the wall, which directly affects the furniture layout and spatial visual effect, making the narrow room more narrow. Structural designers developed from shear wall to short shear wall, and then extended to the special-shaped column structure. They boldly and innovatively adopted "L" shape, "+" shape and "T" shape columns with the same wall thickness in the structure. In practice, there are also a few "Z" and "—" shapes. The purpose of applying these shaped columns is to hide the columns in the wall, making the interior of the residential structure more beautiful and flat.

2. Research and development

The special-shaped column structure evolved from shear walls, short-limb shear walls and frame structures. They have some common principles in design methods, but there are obviously different parts. Retrospective study of reinforced concrete special-shaped columns, according to the literature research found, in the 1970s American scholar Joaguln Marin carried out the first reinforced concrete L-shaped short column analysis of the whole process, through the A large number of L-shaped short column tests and theoretical studies have proposed a set of calculation charts for designers to use[1].At this time, some Chinese design institutes, such as Tianjin light industry design institute, began to actively explore new residential structure systems with good functions, and first put forward the idea of special-shaped column structure residential system in China and put it into practice.

Hsu.cheng and Tzu Thomas have carried out theoretical research and experiments on two-way biased L-shaped, trough-shaped and T-shaped reinforced concrete columns [2-4]. The members are made of ordinary concrete, high-strength concrete and fly ash concrete respectively. At last, the strength correlation curves and load contour maps are concluded, and different cross-section forms are obtained. A unified design method for columns is proposed for practical application.

By the 1990s, Yang et al. made a model of seven-storey reinforced concrete frame structure with special-shaped column bracing with scale ratio of 1:3, and carried out a simulated earthquake ground motion test. The results show that the seismic performance is better [5]. Xiao et al. used high fluidity high performance concrete mixed with fly ash for special-shaped column frame in the test, and carried out low-cycle repeated load test . The results show that the high-performance concrete special-shaped column-side frame with large fluidity and fly ash is a typical "strong column and weak beam" structure, and its seismic performance has been improved significantly, and the energy dissipation capacity of the structure has been improved significantly[6]. Wang et al. made a 12-storey frame structure model with large bay reinforced concrete special-shaped columns with a ratio of 1/6. The elastic-plastic time history analysis program of reinforced concrete frame structures with special-shaped columns is developed by using the bar model. By comparison, the calculated results are in good agreement with the experimental values. The influence of the ratio of length to thickness of limbs on the performance of the architecture is discussed, and the corresponding design suggestions are put forward [7].

In 2002, Cao et al. made 12 special-shaped columns with small shear-span ratio and concealed columns and carried out seismic performance tests. By comparing the experimental data, the application scope, design method and seismic structural measures of special-shaped columns with concealed columns were put forward, and the bearing capacity of special-shaped columns was calculated. The calculated results were in good agreement with the measured values [8].In 2006, Cao et al. put forward a non-linear finite element analysis method for prestressed concrete frame with special-shaped columns based on the research results and related basic theory at that time [9]. Chen et al. tested 17 specimens of SRC special-shaped columns under cyclic loading. The results show that the main failure modes of SRC special-shaped columns are shear baroclinic failure and bending failure with good seismic resistance [10]. Zhang et al. made eight T-shaped steel special-shaped columns with 1:2 scale to carry out quasi-static tests under low cyclic repeated loads. The test results show that under the condition that the axial compression ratio, flange width-thickness ratio and web height-thickness ratio meet the limit value, the T-section steel special-shaped columns have higher bearing capacity, better ductility and energy dissipation capacity, and can be used in strong earthquake areas [11]. Yu et al. of Beijing University of Technology designed 36 special-shaped steel columns with "+" section. The stress similarity coefficient of the model section is 1 and the scale ratio is 1:2. Then, based on the bearing capacity of seismic design and the requirement of overall seismic performance, the combination limit of flange width-thickness ratio and web height-thickness ratio of'+'shaped steel special-shaped columns which can be used in strong earthquake area is proposed[12]. In order to study the influence of stirrup ratio on the failure characteristics, hysteresis characteristics, stiffness degradation, ductility and energy dissipation of T-shaped and L-shaped columns, Liu et al. used quasi-static test method to test four special-shaped columns. The research shows that increasing the stirrup ratio can improve the failure characteristics of special-shaped columns and increase their energy dissipation capacity [13].

In 2015, Zhang et al. carried out low-cycle cyclic loading tests on four solid-web steel reinforced concrete (SSRC) cross-shaped columns. The results show that the solid-web steel reinforced concrete cross-shaped columns have high energy dissipation capacity and good ductility [15]. Ma et al. carried out low cycle reciprocating simulation on eight cross-shaped steel reinforced concrete special-shaped columns. The results show that with the increase of concrete strength and steel content, the strength decreases slowly, the energy consumption increases, and the seismic performance improves. With the increase of the axial compression ratio, the bearing capacity of the specimens increases, but the ductility and energy dissipation become worse, and the seismic performance decreases [16].In order

to study the seismic performance of T-section steel-concrete composite special-shaped columns, Rong et al. of Hebei University of Technology carried out low-cycle repeated load tests on four specimens with different steel distribution forms and axial compression ratio. The test results show that the load-bearing capacity, deformation capacity and ductility of steel-concrete composite special-shaped columns are significantly improved with the addition of section steel [17].

3. Prospect

At present, most of the research on the overall seismic performance of special-shaped column frame structures in various research institutions and colleges only stay in multi-storey structures, and few studies on high-rise structures have been done, and the results are usually qualitative analysis, and no further in-depth conclusions have been drawn. The finite element method is usually used in the calculation of special-shaped column structures. Although this method has wide applicability, it is not systematic enough and the theory is not perfect enough. It is hoped that in the near future, scientific researchers will formulate systematic and perfect analysis methods, put forward unified calculation methods, and form unified standards and industry norms. Because of the shortcomings of reinforced concrete special-shaped columns in some aspects, researchers put forward steel-reinforced concrete composite special-shaped columns on the basis of special-shaped columns research. This is a new structural form, which combines the advantages of special-shaped columns and steel-concrete composite columns. Its appearance not only makes room space large, multi-function, flexible layout, but also significantly improves its bearing capacity and seismic performance, and can be applied to multi-storey and high-rise buildings, making up for the defects of ordinary reinforced concrete special-shaped columns. The improvement of mechanical properties, seismic behavior and calculation theory of steel-reinforced concrete composite special-shaped columns and their wide application in practical engineering will be the future development direction of steel-reinforced concrete composite special-shaped columns.

4. Summary

Because of some shortcomings of special-shaped columns, the popularization and application of special-shaped columns are limited. Although some measures have been put forward to enhance the seismic performance of special-shaped columns in materials and structures, these improved methods need a lot of experimental research before they can be popularized and applied.In addition, it is necessary to further study some convenient and economical improvement methods.In short, special-shaped column structure as a new type of structure, although there are some shortcomings, but with the emergence and development of new materials, new technologies, methods to solve the shortcomings of special-shaped column will continue to emerge, special-shaped column structure will be more widely promoted and applied.In short, special-shaped column structure as a new type of structure, although there are some shortcomings, but with the emergence and development of new materials, new technologies, methods to solve the shortcomings of special-shaped column will continue to emerge, special-shaped column structure will be more widely promoted and applied.

References

[1] Joaguin Marin.Design Aids for L-shaped Reinfored Concrete Cloumns.ACI Sturctural Journal,November,1979,pp1197-1216

[2] Hsu.Cheng-Tzu Thomas. Biaxially Loaded L-shaped Reinforced Concrete Columns. Journal of Structural Engineering, ASCE, V.111, No.12, Dec.1985, pp2576-2595.

[3] Hsu.Cheng-Tzu Thomas. Channel-shaped Reinforced Concrete Compression Members under Biaxial Bending. ACI Sturctural Journal, V 84, No. 3, May-June, 1987, pp201-211

[4] Hsu.Cheng-Tzu Thomas.T-shaped Reinforced Concrete Members under Biaxial Bending and Axial Compression. ACI Sturctural Journal, V86, No.4, July-August, 1989, pp460-468

[5] Yang Yucheng, Huang Haohua, Sun Jingjiang, Lu Xilei.Study on shaking table test of seven-story reinforced concrete special-shaped column supporting frame structure model[J].Earthquake Engineering and Engineering Vibration,1995(01):53-66.(Yang Yucheng, Huang Haohua, Sun Jingjiang, Lu Xilei. Experimental study on model vibration table of seven-storey reinforced concrete special-shaped column supported frame structure [J]. Earthquake engineering and engineering vibration, 1995(01): 53-66. (in Chinese)

[6] Xiao Jianzhuang, Huang Wei, Zhang Jianrong, Li Jie.Experimental study on seismic behavior of high performance concrete profiled column frame[J].Journal of Building Structures, 2002(06): 19-25.(Xiao Jianzhuang, Huang jue, Zhang Jianrong, Li Jie . Experimental study on seismic behavior of special-shaped column-edge frame of high performance concrete [J]. Journal of building structures, 2002 (06): 19-25. (in Chinese)

[7] Wang Zijun, Liu Weiqing, Jiang Yongsheng, Wang Jie, Xu Cheng.Experimental and theoretical research on frame structure of reinforced concrete special-shaped columns in middle and high-rise buildings[J].Earthquake Engineering and Engineering Vibration,2002(05):62-65.(Wang zijun, Liu Weiqing Jiang Yongsheng, Wang Jie, Xu Cheng. Experimental and theoretical research on medium and high-rise reinforced concrete special-shaped column frame structure [J]. Earthquake engineering and engineering vibration,2002(05):62-65. (in Chinese))

[8] Cao Wanlin, Hu Guozhen, Cui Lichang, Zhou Mingjie, Hao Chunsen, Qu Yinghua.Experimental and analysis of seismic behavior of reinforced concrete columns with dark columns[J].Journal of Building Structures,2002(01):16-20+26.(Cao Wanlin, Hu Guozhen, Cui Lichang, Zhou Mingjie, Hao Chunsen, Qu Yinghua. Seismic performance test and analysis of special-shaped reinforced concrete columns with dark columns [J]. Journal of building structures, 2002(01): 16-20+26. (in Chinese))

[9] Cao Yunzhong, Gan Gang, Tang Jinchun.Study on seismic behavior of prestressed concrete special-shaped column frame[J].Journal of Science and Technology,2006(06):796-801.(Cao Yunzhong, Gan Gang, Tang Jinchun. Research on seismic behavior of prestressed concrete frame With special-shaped columns [J]. Science and technology bulletin,2006(06):796-801. (in Chinese))

[10] Chen Zongping, Xue Jianyang, Zhao Hongtie, Shao Yongjian, Zhao Yonghong, Men Jinjie.Experimental study on seismic behavior of steel reinforced concrete columns[J].Journal of Building Structures,2007(03):53-61.(Chen Zongping, Xue Jianyang, Zhao Hongtie, Shao Yongjian, Zhao Yonghong, Men Jinjie. Experimental study on seismic performance of profile-shaped steel concrete column [J]. Journal of building structures, 2007 (03): 53-61. (in Chinese)

[11] ZHANG Ai-lin, YU Jin, XU Min, LI Jian, LIU Hui-jun.Experimental study on seismic behavior of T-section steel special-shaped columns under cyclic loading[J].Journal of Building Structures,2010,31(02):20-28. Ailin, Yu Jin, Xu Min, Li Jian, Liu Huijun. Experimental study on seismic performance of t-shaped steel special-shaped column under low cyclic and repeated loading [J]. Journal of building structures,2010,31(02): 20-28. (in Chinese))

[12] YU Jin,ZHANG Ai-lin,LIU Hui-jun,XU Min.Study on seismic behavior and width-thickness ratio of cross-section steel special-shaped columns[J].Industrial Construction, 2010,40(03): 116-123. (Yu Jin, Zhang Ailin, Liu Huijun, Xu Min. Research on seismic performance and plate width ratio limits of steel special-shaped columns with cross section [J]. Industrial buildings, 2010, 40(03): 116-123. (in Chinese))

[13] Liu Ping, Li Yanyan, Chen Yanfeng, Xu Liying.Experimental study on seismic behavior of high strength reinforced concrete special-shaped columns[J].Industrial Construction, 2013,43(06): 52-55.(Liu Ping, Li Yanyan, Chen Yanfeng, Xu Liying. Experimental Study on seismic performance of special-shaped reinforced concrete columns with high strength [J]. Industrial buildings,2013,43(06):52-55. (in Chinese))

[14] LI Yan-yan,ZHANG Jian-xin,CHEN Yan-feng,HAN Hong-xia.Experimental study on seismic behavior of channel-shaped steel-reinforced special-shaped column joints[J].Journal of Guangxi

University(Natural Science Edition),2014,39(01):64-70.(Li Yanyan, Zhang jianxin , Chen Yanfeng, Han Hongxia. Experimental study on seismic performance of special-shaped column joints strengthened by channel steel bones [J]. Journal of guangxi university (natural science edition), 2014,39(01):64-70. (in Chinese))

[15] Zhang Bo,Fang Lin,Jin Guofang,Li Kaiwen.Comparative study on seismic behavior of steel reinforced concrete cross-shaped columns with different steel forms[J].Structural Engineer,2015,31(03):98-105+188.(Zhang Bo, Fang Lin, Jin Guofang, Li Kaiwen. Comparative study on seismic performance of shaped steel concrete cruciform special-shaped column with different steel distribution forms [J]. Structural engineer,2015,31(03):98-105+188. (in Chinese))

[16] Ma Jianglin,Zi Bo,Wang Ning,Zhou Nannan.Study on seismic behavior of cross-shaped steel concrete special-shaped columns[J].Low Temperature Building Technology,2018, 40(08): 66-69+73. (Ma Jianglin, Pang Bo, Wang Ning, Zhou Nannan. Research on seismic performance of cross shaped steel concrete special-shaped column [J]. Low temperature construction technology, 2008,40(08):66-69+73. (in Chinese))

[17] Geng Xian,Wang Hao,Zhang Jianxin.Experimental study on seismic behavior of T-section steel-concrete composite special-shaped columns[J].Journal of Wuhan University(Engineering Science),2019,52(05):408-413.(Rong Xian, Wang Hao , Zhang Jianxin. Experimental study on seismic performance of t-shaped steel-concrete composite special-shaped column [J]. Journal of wuhan university (engineering science edition), 2019, 52 (05): 408-413. (in Chinese))