Analysis of Anti Collapse Ability of Plane Irregular Frame Structure

Zhiping Zhao [a], Xiaowei Li [b] and Fan Yi [c]

School of Civil Engineering and Architecture, Southwest Petroleum University, Chengdu 610500, China

[a]759348387@qq.com, [b]444328411@qq.com, [c]370132696@qq.com

Abstract

The continuous collapse of the building structure,which will cause huge economic losses and casualties, has been the focus of research scholars. Now in order to study the effect of cast- in-place floor in RC frame structure in the design process according to the standard of Engineering Construction Association of China to work out a structural progressive collapse specification "housing collapse prevention design regulations" provides, set up a L shaped five story frame structure model, analyzes the influence of structure in the corner of the different column layout form the progressive collapse resistance of structures by the finite element software SAP2000. Displacement and acceleration failure column to the performance of corner column layout form different structures on the structural effects of progressive collapse resistance size, find one column layout optimal scheme. The analysis results show that: in the corner column in accordance with X, Y two directions with equal span, which can increase the redundancy of the structure to improve the distribution of load path, and avoid the local damage of the structure caused by the progressive collapse of the structures damage.

Keywords

Progressive Collapse; L Shaped Frame; Column Layout; Node Displacement.

1. Introduction

In Building safety is the basic task of building structure design, and to ensure the safety of the structure, it is necessary to prevent the collapse of the structure. In recent years, domestic and foreign buildings have suffered different degrees of attacks, especially the landmark buildings in some countries, because of its functional requirements, so that each construction accident will bring significant casualties and property losses. Therefore, how to prevent the progressive collapse of building structures has been an important topic in engineering theory and practice. The current specification of the design method of building structures under normal conditions of use have been more perfect, but in the structure of the ability of anti-progressive collapse compared to the foreign research started late, when the structure is subjected to accidental load (such as earthquake, impact and fire), destroy the remaining structure can withstand accidental load the structure, the structure is not due to local damage extends to the overall damage, remains to be studied further [1].

At present, China's research on the structure to resist progressive collapse has made great progress, from early conceptual design to recently by the China Association for engineering construction standardization to develop the "housing collapse prevention design specification"[2] standard. In this procedure, in order to building structural anti collapse design in construction engineering to implement the relevant national laws and regulations, to avoid accident occurred in building collapse, reduce casualties and economic losses; Construction Engineering Standards Association in China developed on the building structure progressive collapse specification" structural anti collapse design specification the specification, proposed to the building structure progressive collapse" defense "and" anti". Among them, "prevention" can include: to avoid the direct impact of the explosion, impact, and so on, to reduce the chance of accidental and accidental effects, control the scope of accidental action, etc. The "anti" can include: make the structure with the overall firmness, so that the structure becomes

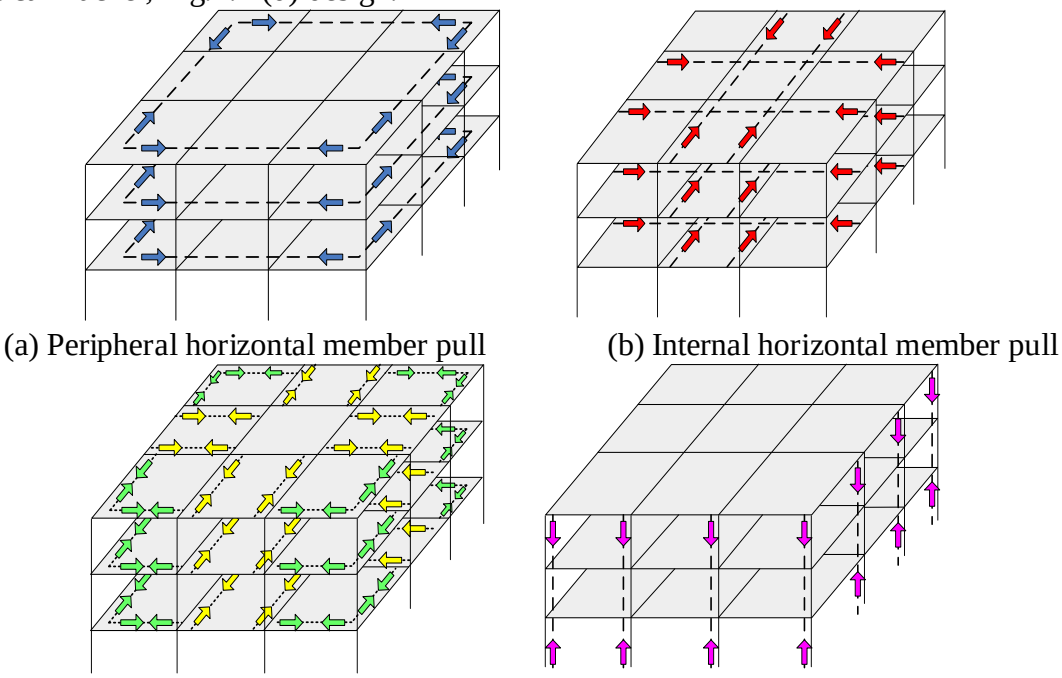
statically indeterminate structure, so that the structure, the connection has a large enough capacity and deformation capacity, etc.

2. Performance analysis and design method of RC frame structure against progressive collapse

2.1 Progressive collapse design method of reinforced concrete frame structure

From the research on the continuous collapse resistance of buildings, the design methods are divided into two categories: indirect design method and direct design method. The indirect design method usually includes the concept design method and the pull structure method; the concept design method is mainly based on the qualitative analysis, and finally the quantitative calculation is used to complete the qualitative hypothesis. Reinforced concrete structure tensile structure method of progressive collapse is mainly a long steel set level in the adjacent key parts of the beam structure, and take effective measures to improve the anchorage, overall structural continuity. Direct design method mainly includes the component removal method and local strengthening method; Fayinke component removal operation, has become the most commonly used design methods for progressive collapse of building structure design of anti-American standards, called Alternate Path Method (alternate path method, alternate path method) AP. The first is dismantled component method and a vertical component force according to certain rules to remove the pre-selected structural calculation model, and simulate the residual internal force after component failure and deformation of structure, in order to determine the component failure will lead to other component failure or whether they lead to progressive collapse of structures. The following will be based on the collapse resistance of the three design methods are introduced in detail. Pull structure method:

Drawing structure method is adopted to design and check the connection strength between structural components, the ability of load transferring path structure with the overall stability and spare, so as to improve the ability of structure to resist progressive collapse. In the design of the structure can be divided into Rachel Rachel, surrounding the horizontal member in Fig.4.1 (a) was designed, the level of internal components of Rachel, fig.4.1 (b) was designed, the level of internal components of the vertical component of the surrounding Rachel in Fig.4.1 (c) was designed and the vertical component of the vertical Rachel, Fig.4.1 (d) design.



(a) Peripheral horizontal member pull (b) Internal horizontal member pull

(c) Internal horizontal member pull (d) Vertical member drawing

Fig.4.1 Schematic drawing of structural members

2.2 Analysis method for resisting progressive collapse of reinforced concrete frame structure

From home and abroad on the progressive collapse of building structures against research, because it can accurate analysis the advantages of strong operability, dismantled component method, has gradually become the main design method of progressive collapse of the structure of the national resistance. The main methods include linear static analysis, nonlinear static analysis, linear dynamic analysis and nonlinear dynamic analysis. Regulations of the GSA2003[3]specification: linear analysis method is a simplified analysis method can only be applied to building 10 floors and 10 floors below; for more than 10 layers of buildings and irregular building, we must use the nonlinear analysis method. The process of analysis of the norms of the need to remove the component position also made detailed provisions for the reinforced concrete frame structure typical of the long side and short side column can dismantle the structure of each layer in the column, column and column in the long side.

3. Analysis model design of L frame structure

In strict accordance with the GB50010-2010"concrete structure design code"[4], GB50011 -2010" seismic design code for buildings"[5]and GB5009-2012"design code for the design of building structures," [6] and other relevant specifications for design. Using the PKPM software developed by China Academy of building research to calculate the reinforcement of the structure. Structural design overview [7]: the analysis of the model uses five layers of L shaped reinforced concrete frame structure, the first layer of 4.2m, and the other layer 3.0m. The section size of the main beam is 200×600mm2, the section size of the secondary beam is about 150×500mm2, and the section size of the frame column is from 400×400mm2. In addition to building corridor beams, beams are cloth 200mm masonry wall. Class B building, the site of the class II, seismic fortification intensity of 7 degrees (0.10g) design, the cycle reduction factor of 0.7, the earthquake was grouped into groups of second. The basic wind pressure is W_0=0.30KN/m^2, and the surface roughness is C. Material information: the strength grade of concrete beams and columns are respectively C35 and C25, the axial compressive degree standard value is 20.1Mpa, beam and column longitudinal reinforcement are used HRB400, the tensile strength standard value of 335Mpa, considering the design of the actual strength of the strength of the material is generally greater than the GSA specified by strength coefficient to increase the strength of materials used in the design of reinforced concrete members[8], are 1.25 provisions of the tensile strength and compressive reinforced concrete increase coefficient. Plate reinforced beam and the column hoop are made of HPB300. Load information: 4.5KN/m2 floor dead load, live load is 2.0KN/m2; corridor live load is 3.5KN/m2; the dead load of 8KN/m2 roof, roof live load is 0.5KN/m2 (not on the roof), partition and envelope line load standard value of 8.5KN/m.

Different column layout form of the L shaped RC framework proposed in this paper, the corner area as the main part of the change, the other part of the structure does not change [9]. The specific arrangement of the structure corner area is as follows. A scheme (Fig.4.2): corner two-way corridor by connectivity, can reduce large torsion structure caused by plane irregular arrangement; and the use of X to form the same column layout, between the two main beams are set equal a secondary beam, in order to meet the requirements of practical engineering design. This arrangement is an arrangement of the most common form of L shaped column arrangement in the plane. Scheme two (Fig.4.3): the corner column arrangement connected to the plane of X Y to the corridor, corridor connectivity, and to the 1-4 axis by 4.8m Zhuju two across the X. In the structure of the corner across A-B and X using the same to the column layout, cross C-E and Y using the same form to column layout. Scheme three (Fig.4.4): take the corner column layout is not connected to the form in the structure of plane X, Y, 1-4 and B-E in the axis adopts two span 4.8m column, the structure corner of A-B and X with the cross to the same column layout, B-E and Y to the cross the same column grid layout. Scheme four (Fig. 4.5): connected Y to the corridor, to the three points in the Y column to the X position, and spacing of 7.2m span, and equal set of secondary beam. The corner column layout and Y to the same. Scheme five (Fig. 4.6): connected X to the corridor, to the three points in the X column position, the spacing of two Y to span 7.2m, and equal set of secondary beam. The corner column layout and X to

the same. Scheme six (Fig.4.7): cancel the structure plane of the corridor, to the three decile in the corner areas X, Y, and to the point as a new axis, secondary beam along the X, Y to the layout of the cross.

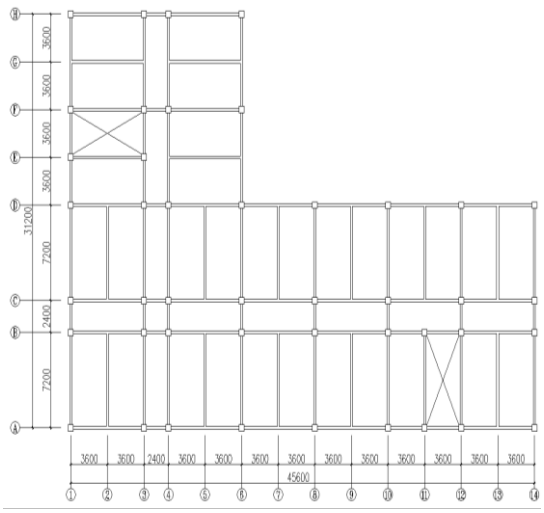


Fig.4.2 A column grid layout scheme

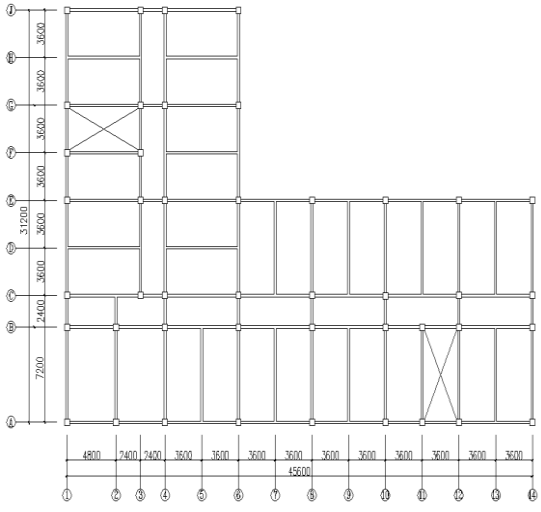


Fig.4.3 The second column grid layout scheme

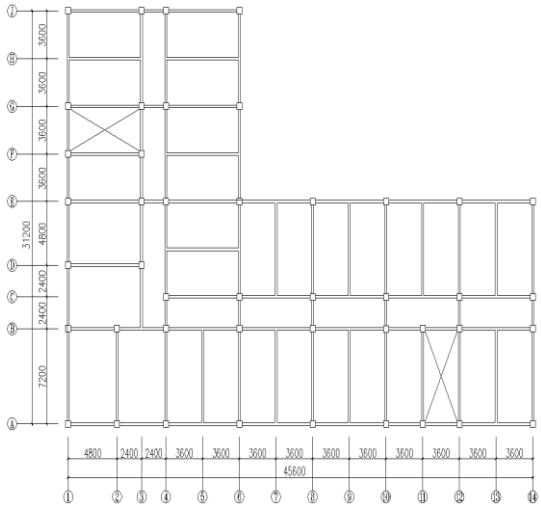


Fig.4.4 Three column grid layout scheme

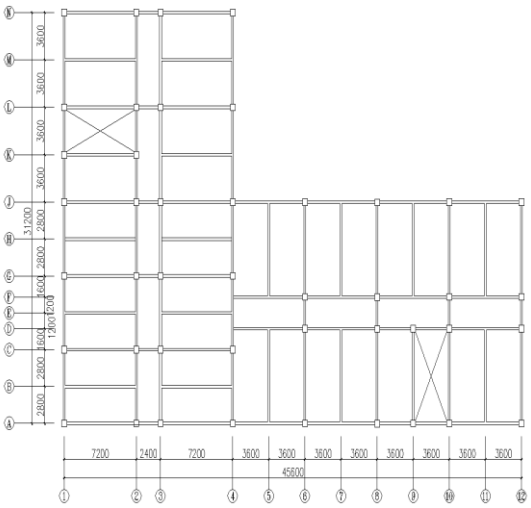


Fig.4.5 Four column grid layout scheme

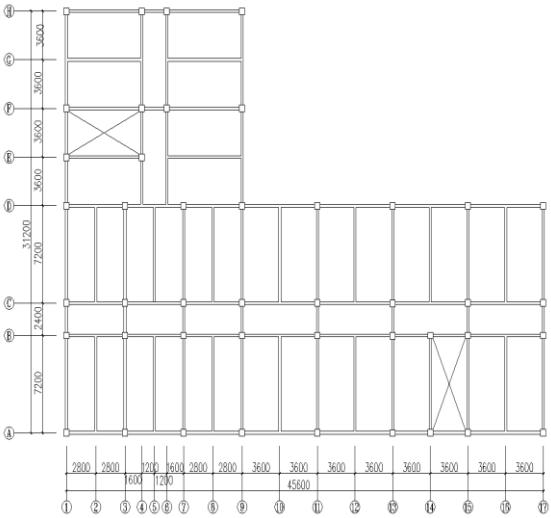


Fig.4.6 Five column grid layout scheme

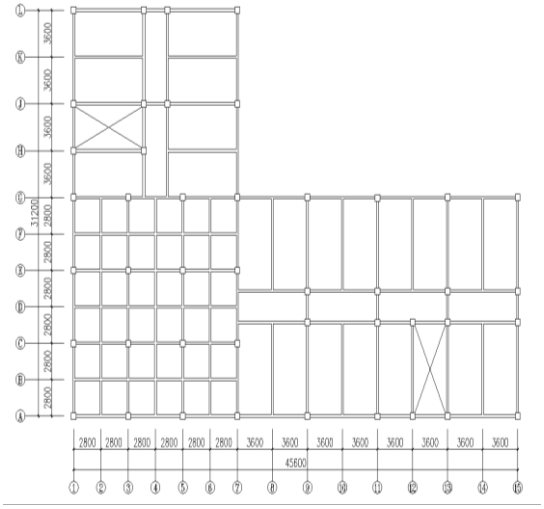
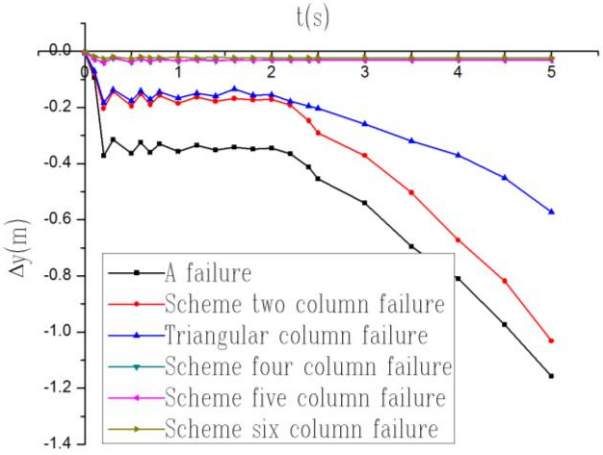


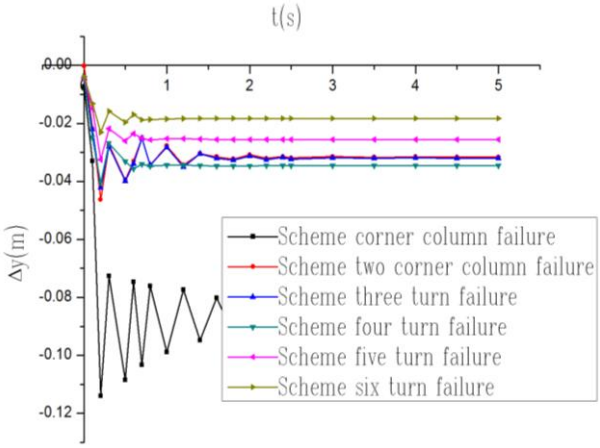
Fig.4.7 Six column grid layout scheme

3.1 Failure node displacement analysis results

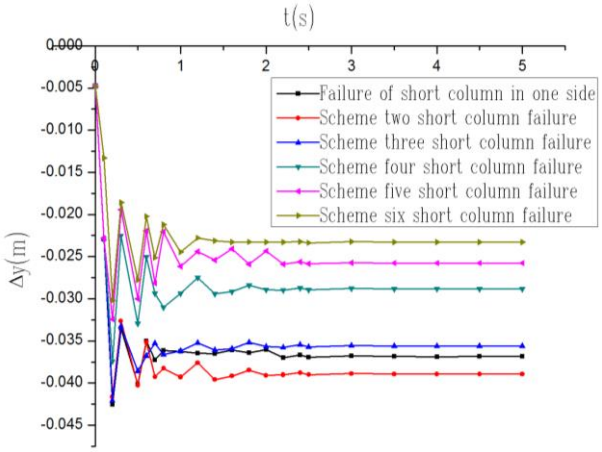
By comparing the failure node displacement, can be more intuitive to understand the decline failure node, American building collapse-resistant maximum vertical displacement will failure node value as judging whether the structure collapse failure criterion. This paper will compare the displacement of L shaped RC frame structure in the six column layout scheme of the corner at the top of the failed node, the scheme top-level failure node displacement time curve as shown in fig.4.8.



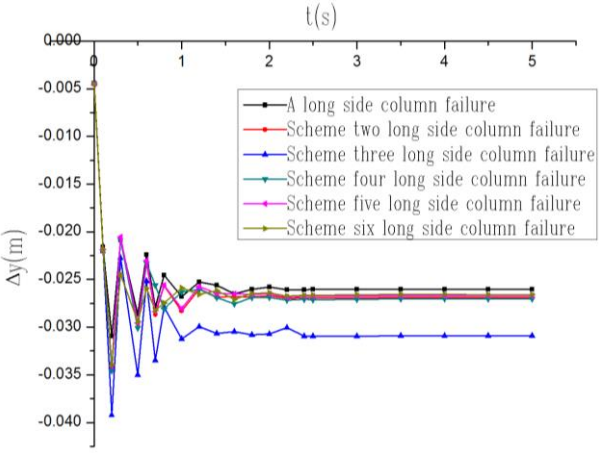
(a) Top corner failure



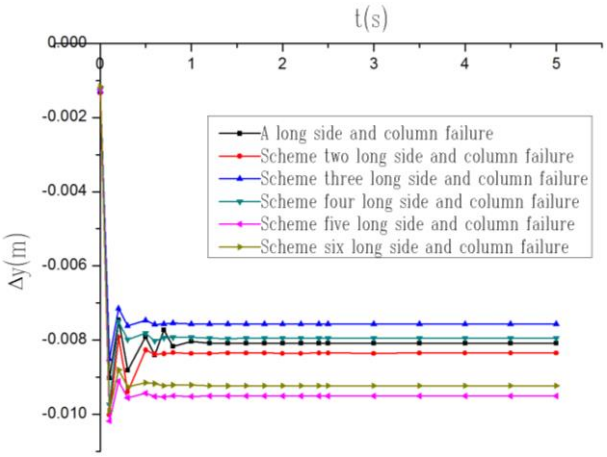
(b) Corner column failure



(c) The top short edge of column failure



(d) The top long edge of column failure



(e) Among the top long side column failure

Fig.4.8 The displacement time curves of the first and six failure nodes of the scheme

Fig4.8 lists the six L shaped corner column layout scheme layer of corner column, general Bian Zhongzhu, the short side column and corner column and the long side and column was removed, the failure node displacement curve of residual structure. In general, when the proposed demolition of column failure after failure, the vertical displacement of nodes change with time are basically the

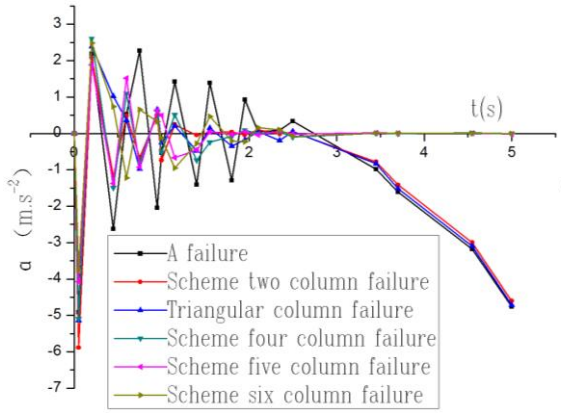
same, because the frame beam on the node Rachel makes the vertical displacement of nodes of the shock stage, its duration is basically about 2S, in addition to jiaozhu, displacement of the structure of other parts of the node failure will be stable in shock after the structure is a new equilibrium state through the redistribution of internal forces. (1) From figure 4.33 (a) can be seen, when the top of the structure of each scheme. After the failure of the vertical displacement of one or two and three node failure scheme after shock stage will occur after the mutation, and the displacement will be more and more, in the final analysis software of vertical displacement of three schemes of time were 1.158m and 1.03m and 0.572m, its value exceeds the limit value specified by the code of the 1/10 beam span (0.036m). By the time trend and standard displacement of structure collapse criterion in the top one or two, the three column scheme after the destruction, the structure will collapse. (2) when the top corner of each scheme structure failure, failure of vertical displacement is the smallest node scheme six, is the largest program, plan six vertical maximum displacement is about 0.0267m, its value is about the maximum displacement scheme of the instantaneous value of 1/14; the top corner column column failure scheme and the short side of the scheme, node failure displacement after shock stage after gradually stabilized, the structure formed a new equilibrium system, the failure node decreased the minimum displacement of the program was six, the maximum for the scheme; when the failure column of each scheme top long side when the failure node decreases the minimum displacement for a maximum. The program was three, the maximum vertical displacement for three node failure is 0.0385m, 1.22 times the maximum displacement node failure scheme; when the long side and top solution column failure, the maximum of six schemes The displacement of the vertical displacement and the final balance is not large, the minimum displacement for the program three, its value is about 0.00847m, the maximum displacement value of program five, its value is about 0.0102m.

3.2 Failure node acceleration analysis

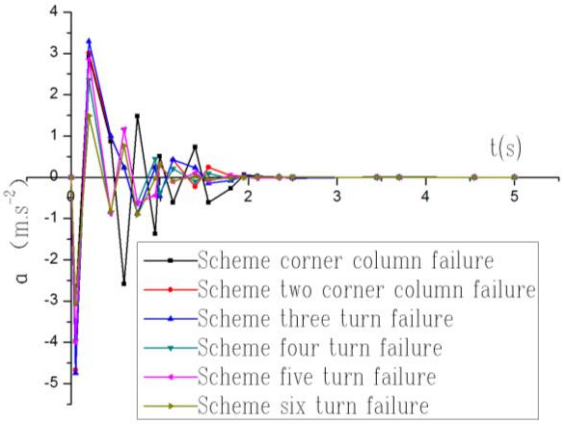
In the study of continuous collapse of structures, the time has been a major consideration, the longer the time required for the collapse of the structure, people will have enough time to escape, so the casualties caused by the accident will be smaller. The acceleration of structural failure node is a time varying parameter, which can be used to understand the dynamic response process of frame beam after failure. Fig.4.9 shows the acceleration time curve of each failure node of the L shaped structure.

Fig 4.9 lists the six L shaped corner column layout scheme layer of corner column, general Bian Zhongzhu, the short side column and corner column and the long side and column were removed after the failure node acceleration curve residual structure. In general, when the proposed demolition column after the failure of different schemes of node failure of vertical acceleration will go through three stages, the sudden increase in acceleration phase, acceleration and acceleration shock stage flat stage, when node failure acceleration appears flat stage, indicating that the node down speed tends to zero, the displacement will gradually become stable structure will form a new balance. That is, the structure will not collapse because of the failure of the frame column. (1) From figure 4.33 (a) can be seen, when the top of the structure of each scheme. After the failure of one or two and three, plan the failed node acceleration after shock stage will occur after the mutation, and the displacement will be more and more, in the final analysis software of three schemes of vertical acceleration time were 4.718m/s2, 4.712m/s2 and 4.694m/s2. (2) when the top of the structure of each scheme column failure, scheme one or two and three mutations occur in the shock acceleration stage, the curve, the node of the rate of decline will be more and more, one in the shock stage amplitude was significantly greater than other schemes, that party a case at the top corner of the structure of anti-failure the progressive collapse of the greatest impact on the performance of each scheme; column failure top corner column and short side when the failure node displacement scheme after shock stage after gradually stabilized, the structure formed a new equilibrium system, the failure node decreased the value of the minimum acceleration program was six, the maximum for the program; when the column failure the top long side when the failure node decreased the minimum displacement for the program, the largest program was six, 3.917m/s2 maximum vertical acceleration scheme of six node failure, 1.08 times three failure maximum displacement of nodes; when the long side and top solution column failure, the amplitude of the scheme two and four is the largest, shows that the failure node elastic

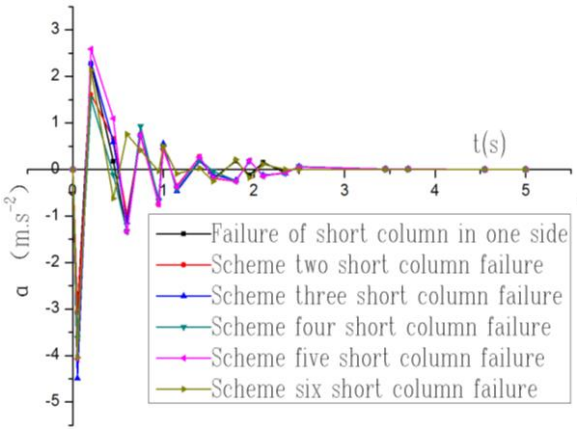
deformation is greater than that of other schemes, the maximum acceleration value of four is the largest project in the six schemes, its value is about 3.326m/s2 the minimum value for acceleration, scheme six.



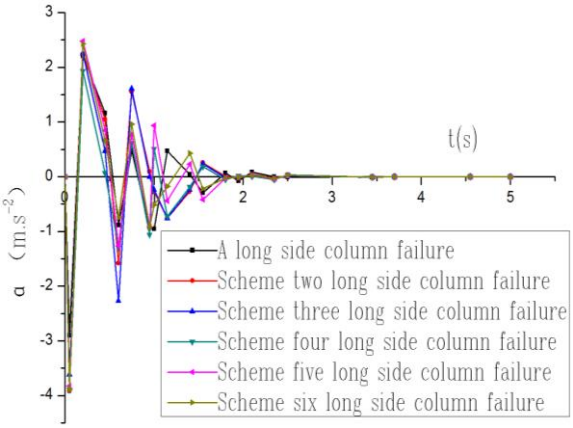
(a) Top corner failure



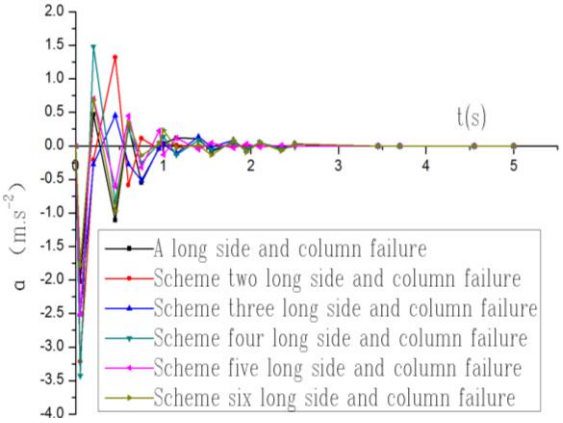
(b) Corner column failure



(c) The top short edge of column failure



(d) The top long edge of column failure



(e) Among the top long side column failure

Fig.4.9The acceleration time curve of the first and six failure nodes

4. Conclusion

The research of this article is to influence the corner L shape RC frame structure in column arrangement different forms of structure progressive collapse resistance. The main content of this study is the use of building collapse-resistant specification limit condition of six kinds of L this paper selected shape frame corner column layout form of progressive collapse resistance of the structure, and on the basis of comparing the displacement and acceleration of node failure analysis of six column layout in the form of influence extent of structure to resist progressive collapse the

performance of the selected structure of a L continuous anti collapse ability the most favorable shape RC frame corner column layout scheme.

(1)Through the analysis of the structure sensitivity coefficient, sensitivity coefficient of columns and the long side of the selected L shaped frame structure intends to demolish the corner, corner column and short column, in which the long side column were 0.317, 0.295, 0.188, 0.141 and 0.113. The sensitivity coefficient of the structure corner maximum, illustrates the influence of column damage to structure progressive collapse resistance of frame column is more obvious than the other. Corner in the structure to resist progressive collapse is more important.

(2) The maximum L - RC frame structure, this paper selected six kinds of corner column arrangement forms the displacement angle between the minimum program was six, and the maximum displacement of each scheme angle is less than the standard limit value, namely the model selected in accordance with the specification and design requirements, and has practical value.

(3)The six column layout structure progressive collapse analysis of SAP2000 finite element software, the vertical displacement of the failure column joints the maximum floor to the top of the structure. When a program, three of the top corner and the top and bottom corner two scheme after the failure of the displacement value exceeds the limit value specified by the code, the structure will collapse; for other quasi failure column failure, displacement node failure will appear flat stage, namely the structure through the redistribution of internal forces, the formation of the new balance system.

(4) The sensitivity coefficient of each component as the basis, compared the effects of six kinds of column arrangement form of structure progressive collapse resistance of corner column layout form size, improve the ability to resist progressive collapse the size of the scheme from high to low order in the framework of different order to improve the progressive collapse resistance of the structure is: scheme six, scheme four, scheme five, scheme three, scheme two. When the corner column can make the structure have good resistance to progressive collapse along the two-way layout.

(5)In order to improve the structure of the progressive collapse resistance, in architectural design, such as cut down the column distance, to avoid the floor with large openings and the floor with the big Cuoceng structure; in structural design, such as strengthening the connection between components, increase the redundancy of the structure and improve the ductility.

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