Comparison of Chinese and American Code for Design of Building Structures Against Progressive Collapse

Wanqin Yu

School of Southwest Petroleum University, Chengdu, China

569488804@qq.com

Abstract

The design specification of anti collapse Chinese building structure (CECS 392:2014)), since May 1, 2015, before this, Chinese all relevant research on anti progressive collapse, most reference of the progressive collapse design specification. Here, the United States of America's DOD, GSA and Chinese norms to do a comparison, for the future research to provide a reference.

Keywords

Continuous collapse; Standard; Comparison.

1. Introduction

From the world in 60s, Britain's Ronan Point apartment collapse, the continuity of the building collapsed first into the US, which is about building progressive collapse first appeared in 1995 in the United States Alfred P.Murrah specification; the federal government office building collapse incident, once again aroused the scholars of the building structure to resist progressive collapse on 2001; the world trade center in New York Twin Towers suffered terrorist attacks of progressive collapse events, once again attracted wide attention of scholars all of the world and the construction of anti progressive collapse studies met the boom, the United States is issued specifically for the construction of progressive collapse resistance design specification, the American Public Affairs Administration issued, U.S. Department of defense has released GSA2003 and DOD2005. At the same time, the research on the resistance to continuous collapse of building structure has been paid more and more attention.As shown in Fig.1, 2, 3.

Fig.1 Ronan Point

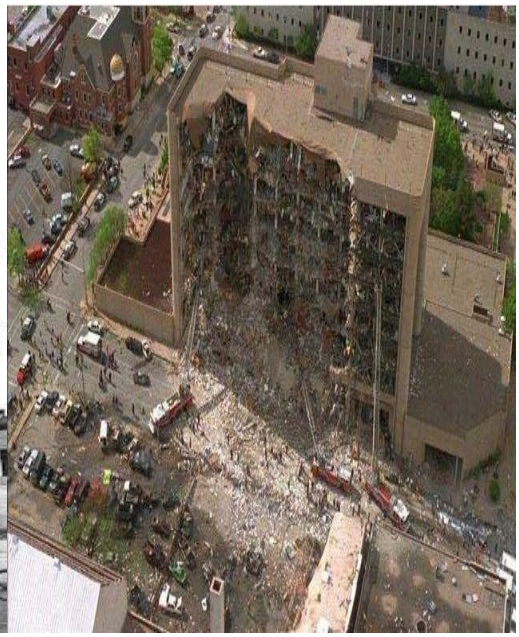

Fig.2 Alfred P.Murrah

Fig.3 World Trade Center

Prior to May 1, 2015 in China, the Chinese scholars on the construction of progressive collapse of the study, most of the reference to the United States, Britain, Europe, or Japan's resistance to the collapse of the standard specification. China building structure anti collapse design code (392:2014 CECS) since May 1, 2015 implementation. At this point, China's scholars can also refer to the design code for the collapse of the Chinese building structure to carry out anti collapse research. Therefore, this article through to China and the United States against the collapse of the design code for comparison, focusing on the differences between the two countries against the collapse of norms.

2. The United States anti progressive collapse of the relevant norms

2.1 Concept of progressive collapse of building structures

The American Society of Civil Engineering (the American society of Civil Engineers, ASCE) in ASCE7-05[2], the definition of progressive collapse: "the spread of an initial local failure from element to element, enentually resulting in the collapse of an entire structure or a disproportionately large part of it", in which under normal conditions of use due to unexpected events, make the structure of local damage, the damage is the destruction of a component of a position along the transfer from the initial structure, eventually led to the collapse of the whole building collapsed and the initial damage or cause a disproportionate part.

DOD2016

The U.S. Department of Defense (of Defense Department, referred to as DOD) compiled by the norms in 2010, 2013 and 2015 were revised 3 times, DOD2016 is based on the DOD2013 and DOD2016 based on some of the amendments. The code is the latest in all of the collapse of the resistance, and is the most complete specification. The specification is mainly used in the United States military department, defense department and other related building anti collapse design. In a modified version of DOD2016, the temporary buildings (buildings and equipment design life of 5 years and below), semi permanent buildings (buildings and equipment service life of more than 5 years, but less than 25 years) and permanent buildings (buildings and equipment design life of 25 years and above) the collapse made different provisions[3].

GSA2003

The United States Public Affairs Management Bureau (General Services Administration, referred to as GSA) issued a "new federal building and modern engineering anti progressive collapse analysis

and design guidelines" (Progressive Collapse Analysis Design Guidelines for New Federal Office Buildings and Major Modernization Project) the standard to reduce the continuity of the federal government for the purpose of the collapse of the building, and gives the a judge building meets the progressive collapse of standardized processes (see Figure 4)[4].

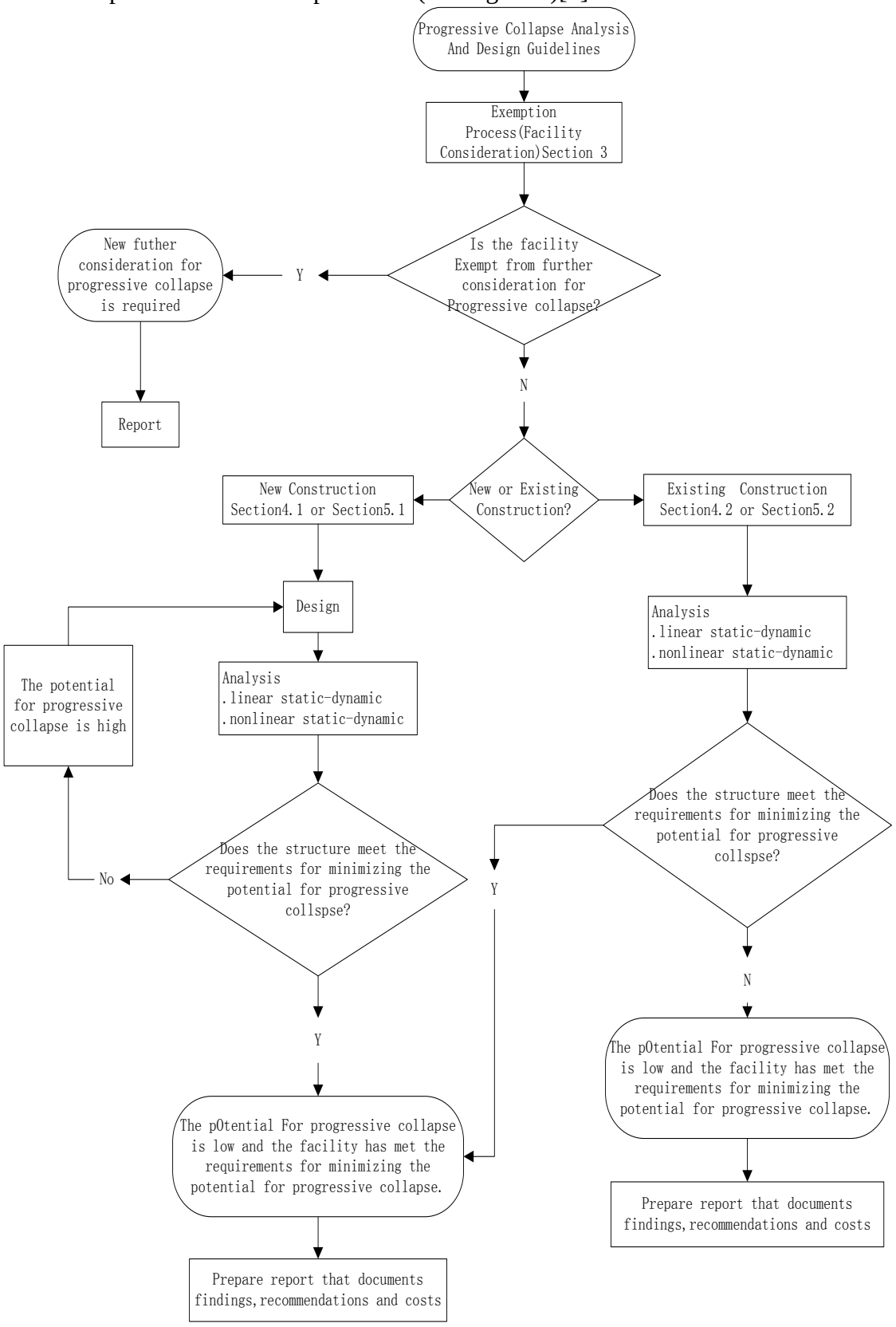

Fig.4 Overall flow for consideration of progressive collapse

3. China's resistance to progressive collapse design specifications

China's research on the collapse resistance of building structures began late, the first time in 2001, the collapse of the world trade center in the United States caused the attention of domestic scholars, began a number of research. China first appeared in the provisions of the progressive collapse "unified standard for reliability design of building structures" (GB50068-2001) in the structure of the progressive collapse resistance requirements: when accidental conditions specified in the code, the main component not structural failure or a failure, the remaining members have a certain period of time without subsequent large-scale failure reliability. In the "code for design of concrete structures" (GB50010-2010) also increased the requirements for the concrete structure design principle of anti collapse include: 1 to reduce the accidental effect to take measures; 2 important components and key parts of power

transmission to avoid accidental action from direct measures; 3 in the structure vulnerable to accidental action affected area increased redundant constraints, force standby arrangement way; 4 to strengthen the important component and key components of load bearing capacity, evacuation channel and refuge space structure and deformation performance of reinforced; 5 through horizontal and vertical component configuration, take effective measures and connected with the surrounding anchorage componentreliably; 6 by setting the structure joint control may occur the scope of the progressive collapse.The design method of the design method for the structural collapse resistance is proposed, which is the method of drawing the structure, the local strengthening method and the removing component method. However, in the standard, it only gives the design goal and the principle of conceptual design, and does not give the concrete design and analysis method. In the "high construction technical specification for concrete structures" (JGJ3-2010) put forward some methods about anti progressive collapse, but the method given in the code are mostly from the United States and other relevant norms, not with the domestic situation.

Our country's first "building structure anti collapse design code" (392:2014 CECS) started in May 1, 2015, which also gives us a design technology standard system for building structures against collapse. The specification of the building structure design, building structure progressive collapse resisting seismic collapse resistance fire resistance design, building design, building structure house collapse stage of construction and reinforcement, transformation stage collapse design several categories to the indicative guidelines clear.

4. Standard contrast

Table 1 Comparison of Chinese and American buildings against progressive collapse

		UFC	GSA	CECS
Progressive collapse definition		——	——	From the initial local damage, from the component to the component expansion, eventually leading to a part of the collapse of the structure or the collapse of the whole structure
Accidental load judgment vertical load		1.2D+0.5L	D+0.25L	——
Pulling force	horizontal	$3(1.2D+0.5L)l_1$ (inside) $6(1.2D+0.5L)l_1+3(1.2D)l_1$ (periphery)	——	$F_T=\frac{\beta_c(L_1+L_2)^2q}{4\Delta}$
	vertical	The load on the upper floor of the column is not less than that of the column.		$F_T=2(G_{VK}+\sum\psi_qQ_{VK})A_F$

Removal of component position		Side column: corner, closest to the short edge and the midpoint of the pillars; In the column corner, long side and short side point attachment column.	Side column: corner, closest to the short edge and the midpoint of the pillars; In the column: corner	The middle of the side near the corner, around the column, inside the column; The floor where the column is removed can be as follows: the bottom layer and the change of the column section size.
Analysis method		Linear static analysis; Nonlinear static analysis; Nonlinear dynamic analysis.	10 floors of the following rules can be used in the construction of linear analysis, 10 or more of the fire of irregular buildings using nonlinear analysis.	Linear static analysis; Nonlinear static analysis; Nonlinear dynamic analysis.
Dynamic effect		Dynamic magnification factor of 2.0	The dynamic magnification factor is defined according to the structure and the component form.	The linear static method is used to calculate the dynamic magnification factor of 2; The nonlinear static method is used to calculate the steel structure, 1.35, the reinforced concrete frame structure, the shear wall structure is 2, and the frame shear wall structure is 1.75.
Failure criterion	structure	Floor does not damage.	Near cross area or 170m^2 smaller value.	——
	component	Deformation control: linear, strength criterion, taking into account the m coefficient; Nonlinear, angle limit; Force control, strength criterion.	Linearity: DCR; Nonlinear: ductility and rotation angle limit	——

5. Conclusion

(1)Through the comparison of Chinese and American norms, China's anti-collapse design specifications issued late, the content is not complete, for example, for earthquakes, fires and other anti-collapse design, such as explosions and other casual role is not summarized.

(2) He United States GSA and DOD specification, at present, gives the most complete anti-collapse specification, but also gives a clear specification of continuous collapse design. Moreover, the GSA standard is the United States government design specifications for its collapse, but the specification in the family position, analysis process, there are still some shortcomings. DOD specification is mainly directed against the collapse of the US military building specifications, the norms considered comprehensive, and updated updates faster, elaborate on the design of the collapse of the continuity of the understanding of a great help.

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