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Research on Over-Strength of RC Shear Wall Structure

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ABSTRACT

Building is of a high degree of statically indeterminacy and should be designed with strict requirement on stability, load combinations, aseismic measures and so on. And in some cases, designers tend to decide dimensions and reinforcement over standards intentionally. Thus, seismic capacity exceeds standard required to design Stage in the well-operated structure abided by design code. This results in considering the problem of over-strength of buildings with high requirement of seismic demand and economic efficiency. In this paper, we decided the minimum value of over-strength factor of RC shear wall structure with evaluating the over-strength designed strictly according to Design Code of DPRK.

Keywords: over-strength, profitability, shear wall

1 Introduction

Earthquake gives great damages to mankind and minimizing its' effect is one of the important tasks in designing buildings. With the development of study on earthquakes and its' dynamic characteristics, seismic demands in designing buildings are being developed to become more universal with performance design in satisfying three levels of requirement through two design stages [1] [2].

Through analysis of casualties from earthquakes, it was found that buildings designed abided by design codes and operated well in quality could resist more seismic forces than the other ones, which means they didn't collapse [3]. This shows that real over-strength of the structures had exceeded the expected over-strength in design, inducing us in researching the over-strength of structures.

Though over-strength of structures enhance capability against collapse in earthquakes, it can make construction cost over exceed takeoff in design without considering it [4]. Most buildings are of high degree of statically indeterminacy. Design code includes reliability, load combination and seismic demands and designers tends to design structures intentionally, resulting in exceeding the capability of the structure designed according to design code and operated with high quality than the capability expected by design [5][6]. Hence, the term "over-strength of the structure system" appeared and the concept of over-strength factor was introduced [7].

Many factors affect over-strength of RC shear wall and they interact each other. Many researches shows that over-strength factor is influenced by design-level ground motion, structural system, building height and so on [8] [9].

2 Method

Over-strength factor of 2 existing buildings designed by current design code of DPRK was evaluated and influential factors were analyzed.

Evaluation of over-strength factor of existing buildings

Structral plans of the building are as following (Figure 1-2).

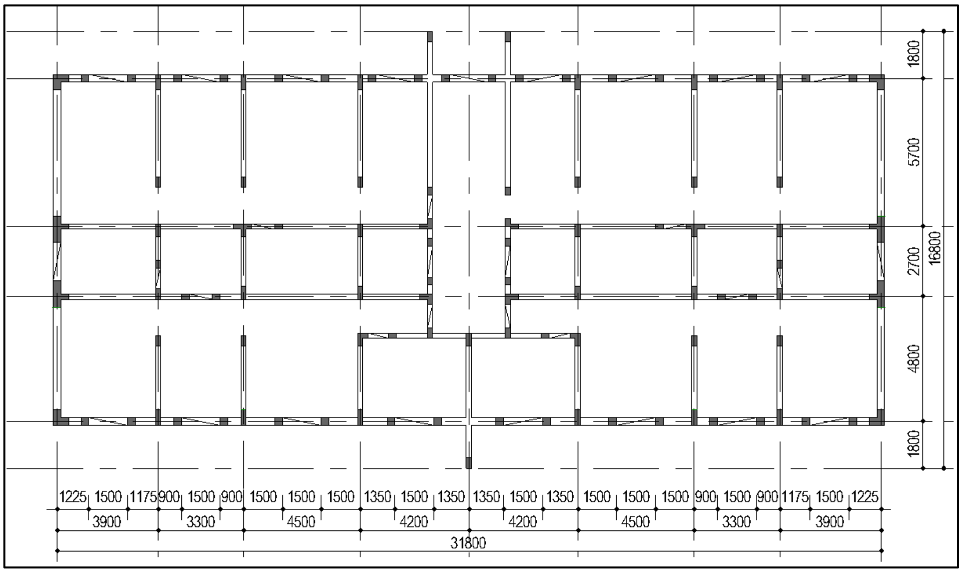


Figure 1 Structural plan of Building A

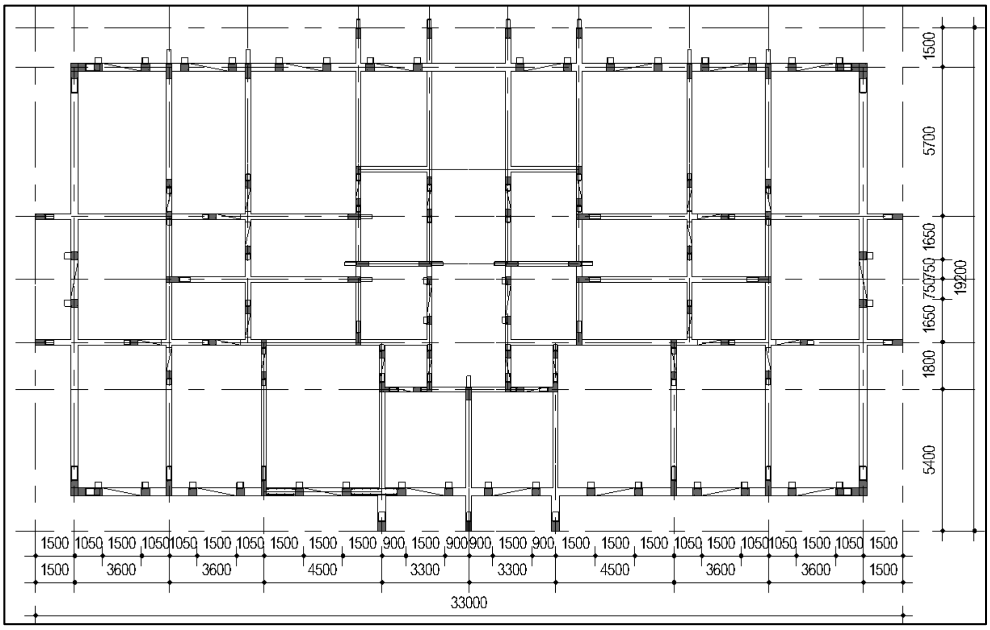


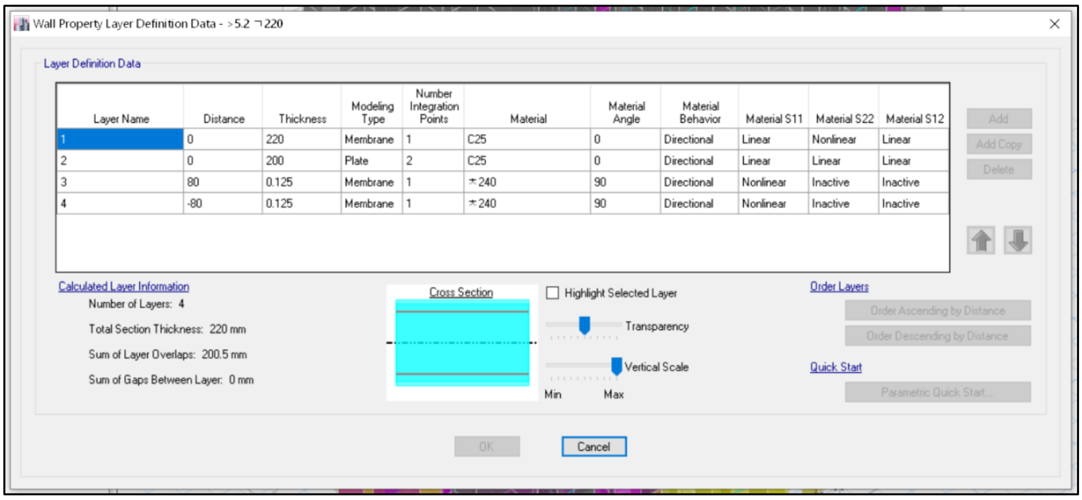
Figure 2 Structural plan of Building B

A is a twenty-story building and B is a twenty-five-story building.

Design-level ground motion is 7bar, Site classification of A is class 1(Tg=0.23s) and that of B is class 2(Tg=0.45s).

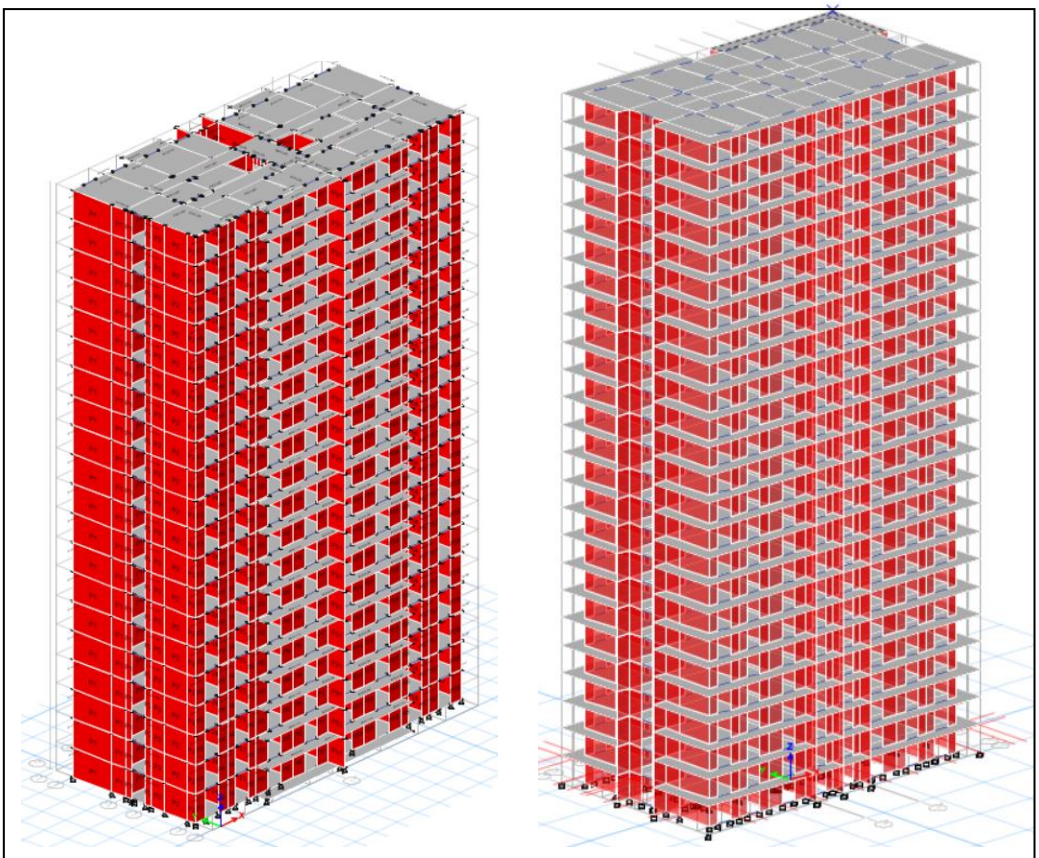
Etabs 2017 is used for a nonlinear analysis of RC shear wall structure.

Layered shell element is used in modeling of shear wall without considering horizontal nonlinearity (Figure 3-4).



Layer Name	Distance	Thickness	Modeling Type	Number Integration Points	Material	Material Angle	Material Behavior	Material S11	Material S22	Material S12
1	0	220	Membrane	1	C25	0	Directional	Linear	Nonlinear	Linear
2	0	200	Plate	2	C25	0	Directional	Linear	Linear	Linear
3	80	0.125	Membrane	1	⺘240	90	Directional	Nonlinear	Inactive	Inactive
4	-80	0.125	Membrane	1	⺘240	90	Directional	Nonlinear	Inactive	Inactive

Figure 3 Definition of layered shell element in Etabs 2017



a). Model A b). Model B

Figure 4 3D models created with Etabs2017

Analysis result shows that over-strength factors are 5.357 for model A and 4.01 for model B.

This means that an actual strength is many times larger than desired strength.

3 Result and Discussion

Precedent studies show that the design-level ground motion and the height of a building are the most impactful on over-strength factor [10]. So this section deals with these 2 influential factors in detail. 12 models with the same plan were used for analysis and their plan is as figure 5. Design-level ground motions were set as 7bar and 8bar. Numbers of stories were set as 10, 15, 20, 25, 30, 35. Story height is 3m and floor thickness is 140mm and dead load and live load of floors are 4.5kN/m2 and 2kN/m2.

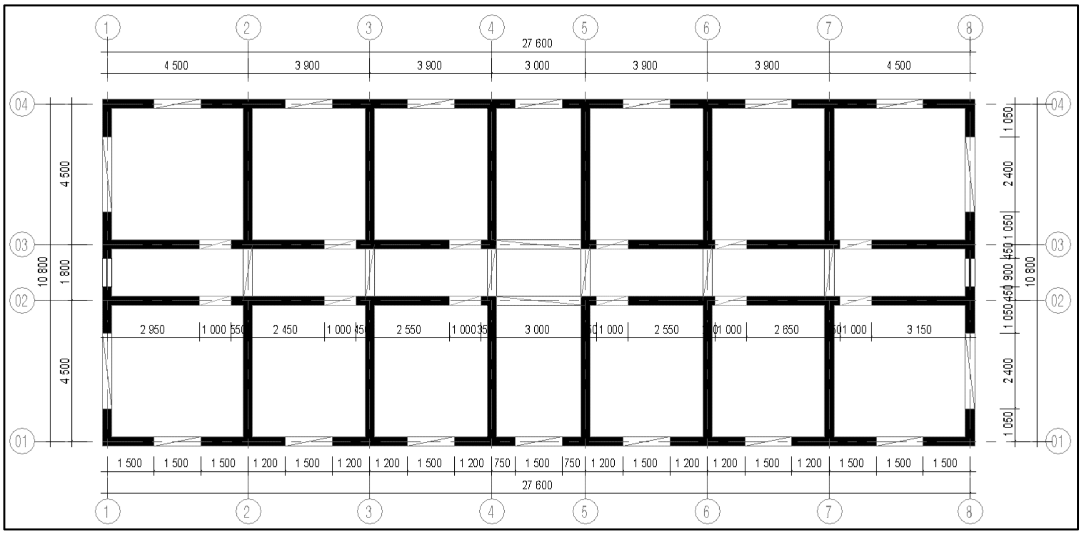


Figure 5 Structural plan of analysis models

Each models were designed based on the current design code of DPRK, changing for the purpose of nonlinear analysis.

After that, static pushover analysis were proceeded for each models. Table 1 shows over-strength factors of each models.

Table 1 Over-strength factors of each models

No	Design-level ground motion	Numbers of stories	Building height	Aseismic level	Ω_d
1	7bar	10	30m	3	4.292
2	7bar	15	45m	3	3.485
3	7bar	20	60m	3	3.136
4	7bar	25	75m	3	2.913
5	7bar	30	90m	2	2.844
6	7bar	35	105m	2	2.810
7	8bar	10	30m	2	2.981
8	8bar	15	45m	2	2.736
9	8bar	20	60m	2	2.520
10	8bar	25	75m	2	2.397
11	8bar	30	90m	1	2.321
12	8bar	35	105m	1	2.280

From these results, we can induce several conclusions as following. First, design-level ground motion has a great influence on over-strength factor. The bigger design-level ground motion the smaller over-strength factor. Second, as the number of stories increases over-strength factor reduces. The result shows that over-strength factor reduces rapidly as the number of stories increases but if the number of stories are larger than 30, the value of over-strength factor doesn't change.

Decision of minimum value of over-strength factor of RC shear wall structure designed according to codes of the DPRK

This problem is very important for economical design. It is economical to reduce the difference between actual strength and desired strength and because of these designers try to reduce over-strength and it can be realized by over-strength factor. Minimum over-strength factor can have a meaning of desired strength.

In this paper 72 models were used which have different plans, design-level ground motions and numbers of stories and over-strength of them were intentionally minimized in the stage of design by setting desired parameters at limit value like limit of n-the ratio of axial force to compression capability of the section, minimum reinforcement ratio, etc. After analyzing over-strength factors, minimum values of over-strength factors for each aseismic levels were decided. They were shown in table 2.

Table 2 Range of over-strength factors for each aseismic levels

Aseismic levels	Range of over-strength factors
1	1.8~2.7
2	2.1~2.9
3	2.3~3.4

4 Conclusion

Deciding over-strength factor of RC shear wall structure is very important to guarantee seismic performance and economic value of structures. In this paper, over-strength factors of structures designed with current design code of DPRK were calculated and influence of design-level ground motion and building height were analyzed. Minimum values of over-strength factor were decided so that economic efficiency of design could be improved.

5 Conflicting of Interests

The authors declare that there is no conflict of interest with respect to the publication of this article.

Reference

[1] Bertero, V. V. Performance-based seismic engineering: A critical review of proposed guidelines. Seismic design methodologies for the next generation of codes, 1-31. 2019.

[2] Estrella, X., Guindos, P., Almazán, J. L., Malek, S., Santa María, H., Montaño, J., & Berwart, S. Seismic performance factors for timber buildings with woodframe shear walls. Engineering Structures, 248, 113185. 2021.

[3] (Augenti, N., & Parisi, F. (2010). Learning from construction failures due to the 2009 L'Aquila, Italy, earthquake. Journal of Performance of Constructed Facilities, 24(6), 536-555. 2010.

[4] Hussain, R. R., Wasim, M., & Hasan, S. Computer Aided Seismic and Fire Retrofitting Analysis of Existing High Rise Reinforced Concrete Buildings. Springer Netherlands. 2016

[5] Liel, A. B., Haselton, C. B., & Deierlein, G. G. Seismic collapse safety of reinforced concrete buildings. II: Comparative assessment of nonductile and ductile moment frames. Journal of Structural Engineering, 137(4), 492-502. 2011.

[6] Iervolino, I., Baraschino, R., & Spillatura, A. Evolution of seismic reliability of code-conforming Italian buildings. Journal of Earthquake Engineering, 27(7), 1740-1768. 2023

[7] A.S. Elnashai and A.M. Mwafy. Overstrength and force reduction factors of multistory reinforced-concrete buildings [J]. The Structural Design of Tall Buildings.2002, 11:329-351.

[8] D. Mitchell and P. Paultre. Ductility and over-strength in seismic design of reinforced concrete structures [J]. Canadian Journal of Civil Engineering.1994, 21:1049-1060.

[9] J.L. Humar and M.A. Ragozar. Concept of over-strength in seismic design[C]. Proc.11th WCEE.IAEE. Acapulco.Mexico.1996: Paper No.639.

[10] Haselton, C. B., Baker, J. W., Stewart, J. P., Whittaker, A. S., Luco, N., Fry, A., ... & Pekelnicky, R. G. Response history analysis for the design of new buildings in the NEHRP provisions and ASCE/SEI 7 standard: Part I-Overview and specification of ground motions. Earthquake Spectra, 33(2), 373-395. 2017.