BILINGUAL PUBLISHING CO.
Pioneer of Global Academics Since 1984

Journal of Building Material Science
http://ojs.bilpublishing.com/index.php/jbmr

ARTICLE

Describe the Process of Retrofitting Existing Buildings and Evaluate the Effectiveness of it in Improving the Seismic Performance of Structures in Earthquake-prone Regions

Chang Liu*

Independent Researcher, China

ARTICLE INFO

Article history
Received: 11 November 2020
Accepted: 30 November 2020
Published Online: 30 December 2020

Keywords:
Building structures
Seismic technology
Effective
Vibration isolation
Damper system

ABSTRACT

At present, earthquakes are a serious problem for building. Severe damages and collapses of buildings were caused by earthquakes in different degrees. It is reported that there are more than 68,858 deaths and hundreds of billions RMB losses in the May 12, 2008 Great Wenchuan Earthquake [16]. So, more attention should be paid to seismic technology. In order to face the challenges of earthquake on building, the seismic retrofitting was put forward, which "is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes" [2]

1. Introduction

At present, earthquakes are a serious problem for building. Severe damages and collapses of buildings were caused by earthquakes in different degrees.It is reported that there are more than 68,858 deaths and hundreds of billions RMB losses in the May 12, 2008 Great Wenchuan Earthquake [16]. So, more attention should be paid to seismic technology. Besides, due to the shapely increase in population, a mass of houses are needed. So, there are lots of tall buildings to satisfy people's requirements. So, it is urgent to improve seismic technology. In order to face the challenges of earthquake on building, the seismic retrofitting was put forward, which "is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes"[2]. There are many strategies to improve the target performance level of structures, such as tuned mass dampers and base isolators. These methods are divided into two aspects to improve seismic ability, one is to dissipate the energy of earthquake waves isolate seismic waves, the other is to isolate seismic waves.

Comparing tuned mass dampers with base isolators, it

**Corresponding Author:*
Chang Liu,
Independent Researcher, China;
Email: 1061440761@qq.com

DOI: https://doi.org/10.30564/jbms.v1i2.2543

shows that TMD adds dampers to convert potential energy into internal energy; however, the latter one applies a layer between the foundation and superstructure [14]. Although two different methods have certain advantages and disadvantages, they are all effective methods to control the seismic response of structures.Totally, the former is better one, which works more effectively and newly.And the essay would make a detailed contrast and will argue the superiority of tuned mass dampers.

2. The Superiority of Tuned Mass Dampers

In the existing structure vibration control devices,tuned mass dampers (TMD) are the oldest one. Dating back to the year 1909,Frahm invented a vibration control device which was called a dynamic vibration absorber and then the concept became widely used [13].Tuned mass damper uses a movable counterweight on the vibrational energy generated in the structure, which is achieved by the combination of inertial dissipation and material damping [5]. For example, in Taiwan, Taipei 101 is currently representative buildings of applying tuned mass damper systems to enhance the serviceability performance. In Taipei 101, a golden globe which runs like a simple pendulum is called TMD. Poon [12] showed after adding the dampers on the top of the building, the acceleration of building top would reduce 40%. The reason is that TMD changes the frequency to control displacement and acceleration to lower the risks brought by earthquakes.

The system has numerous advantages. It can be applied on very tall, light buildings to impart earthquake resistance, such as the CN Tower in Canada and Taipei 101 in Taiwan [9,15]. Besides, it can work without inputting any energy,like electricity, and thus ensures reliability in earthquake emergencies, which also can save energy and protect the environment. TMDs could transform the earthquake vibration energy into heat. And Pan [11] found a new type of TMDs which could transform into electricity. Moreover, it is worth mentioning, because it just designs and installs at the beginning for perpetual use, which definitely reduces the expense to maintenance and repairing. Different from the tradition hidden dampers, TMDs are placed on the most appropriate position to play an important role as dampers based on the substantive research and calculation work. So, the TMD system can steadily work for a long time and don't need to exchange and adjust. In consequence, the tuned mass dampers system is more convenient to construct,for multi-storeys residential, and with the development of technology, different kinds of tuned mass dampers are widely studied and used to adapt the building structures [9].

2.1 The Importance of the Application of Base Isolation

In contrast, base isolator system is a different method to resist the earthquake damages on constructions. Datta et, al said base isolator is a collection of structural elements of a building,which should basically separate the structure of the building from the swaying ground in order to protect the integrity of the building and enhance its seismic performance. It is one of the important means to control passively the vibration of structure in earthquake engineering.Besides, the vibration isolation can be realized by various technical means such as rubber bearings, friction bearings,ball bearings, and spring system. Its purpose is to enable buildings and some general structures to sustain the potential and devastating the shocks of earthquakes.In some cases, the application of base isolation can significantly improve the seismic performance and seismic sustainability of the structure. For example, the LA City Hall is famous as the world's tallest building and it appropriately applies base isolation to seismic retrofit, which can effectively reduce the forces transmitted to the building from ground. City Hall is placed on the whole machine called "base isolation technology" which includes isolators, sliders and dampers. The whole system would work to reduce the violent movement in an earthquake. That is because the building is "decoupled" from the ground movement and control the process that the energy of earthquakes is passed from the ground to building during any earthquakes. In general, base isolation system would make a horizontal acceleration of building decreased by a third to a fifth compared with traditional structure [1].

2.2 The Advantages of Base Isolation

The biggest advantage of base isolation is that the input of seismic energy is fundamentally reduced [10]. Therefore, compared with other seismic measures, the base isolation technology reduces the overall vibration of the building, so the non-structure components and objects inside the building are protected completely and safely [6]. For example, the building with base isolation design is compared with the general building under the premise of the same design reliability. It shows that the former one may shake a lot but it will not collapse, but the latter will not collapse, even the decorations will not break. In terms of this advantages, it is especially suitable for important buildings such as museums and hospitals. Like hospital, during an earthquake, the bottles and cans will not break, and the operation will be carried out normally and smoothly.Another important reason to apply this

 DOI: https://doi.org/10.30564/jbms.v1i2.2543

system is because isolation can reduce the input seismic energy [4]. Besides, the application of isolation technology can reduce the required beam-column size for buildings controlled by seismic action. So the structural cost can also be reduced,and the available space for buildings is also larger.

2.3 The Disadvantages of Base Isolation

However, the base isolation also has some disadvantages. Seismic isolation requires special design of an isolation layer to occupy additional building space [7]. For example, Wenchuan is located on 7 and 8 degree seismic zone, where there are many isolation buildings. In the 2008 Wenchuan earthquake, these buildings can keep its superstructure complete, but the pipelines in the isolation layer are broken.So this problem is urgently to be improved. In the case of base isolation, in order to ensure that the building is separated from the ground movement, a seismic isolation trench is required around the building, which will bring a lot of trouble to waterproof the basement [3]. In addition, the isolation bearing would cost too much, and its installation also requires a certain period which would cause too much economic cost that may exceed the cost of structure materials [7]. More importantly than all of that, the isolation design may effectively and completely work if it is not in a strong earthquake zone, which is a waste of resources. For example, in China, base isolation system is always applied in Yunnan province which is prone to earthquakes, while other northern areas apply less [17].

3. Conclusion

In conclusion, tuned mass damper system is a technology to resist earthquake, while base isolation system is a strategy to isolate earthquake. Two different methods have their own advantages and also have certain limitations. As mentioned before, modern buildings tend to tall buildings, so tuned mass dampers system is more suitable and useful. Besides, tuned mass dampers system is a newly-developing technology to resist earthquake by consuming the energy of earthquakes. Meanwhile the technology of tuned mass dampers need to be further improved to adjust different earthquake conditions in different areas so that to strengthen the stability of structure and protect human security on property and life safety. In the future, in order to adapt to social and economic development, the materials of dampers should be more friendly to the environment and the installation of the dampers should be much easier to operate. And the development of tuned mass damper technology would provide more ideas and thoughts for future seismic technology.

References

[1] Archive.org. Internet Archive: Wayback Machine, 2019. [online] Available at: http://archive.org/web/web.php [Accessed 2 Aug. 2019].

[2] Aycardi, L., J. Mander, A. Reinhorn. Seismic Resistance of Reinforced Concrete Frame Structures Designed Only for Gravity Loads: Experimental Performance of Subassemblages. ACI Structural Journal, 1994, 91(5): 552-63.

[3] Chesi, Mitsopoulou. Effect of waterproof linings on the seismic response of a building. Engineering Structures, 1981, 3(4): 203 -209.

[4] Danila, G., Ealangi, I. & Bica, A. Comparative Study on Provisions Regarding the Base Isolation and the Seismic Energy Dissipation in Three Building Codes. Scientific Bulletin. Series, Mathematical Modeling in Civil Engineering, 2012(4): 60 -69.

[5] Jabary, Madabhushi. Tuned Mass Damper Effects on the Response of Multi-storied Structures Observed in Geotechnical Centrifuge Tests. Soil Dynamics and Earthquake Engineering, 2015, 77: 373-80.

[6] Jalali, A., Cardone, D. Narjabadifam, P. Smart restorable sliding base isolation system. Bulletin of Earthquake Engineering, 2011, 9(2): 657 -673.

[7] Li, H., Huo, L. Advances in Structural Control in Civil Engineering in China. Mathematical Problems in Engineering, 2010, (2010): 1 -23.

[8] Lin, Cheng‐Horng. Seismicity Increase after the Construction of the World's Tallest Building: An Active Blind Fault beneath the Taipei 101. Geophysical Research Letters, 2005, 32(22).

[9] Mishra, S. K., Gur, S., Chakraborty, S. An improved tuned mass damper (SMA-TMD) assisted by a shape memory alloy spring. Smart Materials and Structures, 2013, 22(9): 16.

[10] Nanda, R.P., Agarwal, P., Shrikhande, M. Base isolation by geosynthetic for brick masonry buildings. Journal of Vibration and Control, 2012, 18(6): 903 -910.

[11] Pan, P. et al. Development of piezoelectric energy-harvesting tuned mass damper. Science China Technological Sciences, 2017, 60(3): 467 -478.

[12] Poon, D., Shieh, S.S., Joseph, L.M., Chang, C. Structural design of taipei 101, the world's tallest building. In Proceedings of the CTBUH 2004 Seoul Conference, Seoul, Korea, 2004: 271-278.

[13] Rana, Soong. Parametric Study and Simplified Design of Tuned Mass Dampers. Engineering Structures, 1998, 20(3): 193-204.

DOI: https://doi.org/10.30564/jbms.v1i2.2543

[14] Singh, M.P., Verma, N.P., Moreschi, L.M. Seismic analysis and design with Maxwell dampers. Journal of Engineering Mechanics, 2003, 129(3): 273-282.

[15] Soleymani, M., Khodadadi, M. Adaptive fuzzy controller for active tuned mass damper of a benchmark tall building subjected to seismic and wind loads. Structural Design of Tall and Special Buildings, 2014, 23(10): 781 -800.

[16] Wang, Z. A preliminary report on the Great Wenchuan Earthquake. Earthquake Engineering and Engineering Vibration, 2008, 7(2): 225-234.

[17] Ynyeda.com. Yunnan Province Exploration and Design Association, 2019. [online] Available at: http://www.ynyeda.com/Home/Article/34 [Accessed 2 Aug. 2019].

 DOI: https://doi.org/10.30564/jbms.v1i2.2543