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Design Approach for Isolated Buildings in Adequacy with Algerian Regulations and Their Comparison with Several International Codes

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Abstract: In recent decades, base Isolation represented a new approach and a very promising alternative, allowing the protection of structures against strong earthquakes and winds. Therefore, several codes around the world have introduced chapters relating to the base isolation technique. It is essential to put forward a new methodology design relating to isolated buildings in the Algerian earthquake regulations. The aims of this research suggest a new design approach for LRB type isolators (Lead Rubber Bearing), based on the equivalent static method, and it employs an iterative process that determines the isolator's displacement design depending on the mechanical and geometric characteristics of the building. Thus, to confirm the proposed model validity, a vast parametric study was undertaken using an isolated building with the same geometric and mechanical characteristics, as well as, the same soil conditions used in different regulations in the world such as Japanese, Chinese, Taiwanese, Italian, IBC 2000 and Algerian. The results obtained from this new design approach show a very good agreement with the various international codes envisaged.

Keywords: Base isolation, Lead Rubber Bearing, Algerian seismic code, Hysteresis behaviour

1. Introduction

Following the devastating earthquakes affecting several countries in the world, such as the Northridge in 1994 in the USA, Hyogoken-Nanbu in 1995 in Japan, Chi-Chi in 1999 in Taiwan, Wenchuan in 2008 in China, and the L'Aquila earthquake 2009 Italy, the base isolation technology has been extensively deployed in these countries with high seismicity. During this period, seismic codes have been revised and improved to introduce requirements for buildings seismic design with base isolation [9].
At the national level and following the recent earthquake events in Algeria, considerable damages and heavy casualties were recorded; this is due to the shortcomings of the design practices and even the inadequacy of controlling buildings seismic response.
The equivalent linear method analysis, based primarily on one DOF system, is used in several international anti-seismic regulations. However, the restrictive assumptions and conditions for applying this method involve certain limitations.
Following the normative code development in the world, a new review is important for improving the current Algerian regulations by introducing the vibration control techniques to mitigate significantly the excess of energy developed by earthquakes. Therefore, the introduction of a chapter on the vibration control technique in the Algerian seismic code becomes essential.

2. Equivalent linear analysis in accordance with the Algerian seismic regulations

2.1. Process of the proposed method

The convergence process of the equivalent linear analysis method is summarized as follows:

1. It is assumed an initial displacement of the isolation system D_D ,
2. The effective stiffness and the effective damping (ξ) of the isolation system were calculated,

$$K_e = \frac{Q_d}{D_d} + K_2 \qquad \xi = \frac{2.Q_d}{\pi K_e D_d}\left[1 - \frac{Q_d}{(\beta - 1)\mathrm{D}_d\, K_2}\right] \qquad \beta = 13$$

3. The equivalent period of the isolation system was computed as follows: $T_e = 2.\pi.\sqrt{\frac{M}{K_e}}$

4. The reduction factor and the spectral acceleration: $\eta = \sqrt{\frac{7}{(2+\xi)}}$ $S_a(T_e)$

5. A new design displacement was acquired: $D_d = \frac{F_{ek}}{K_e}$

6. Steps 1 to 5 are repeated until convergence of the design displacement.

2.2 Analytical model and assumptions

The model used in this analysis is a ten-stories building in reinforced concrete with a rectangular plan of 15 × 20 m² composed of four bays in the longitudinal direction and three bays in the transverse direction with a length of 5 m each. The beams are of section 30 × 45 cm², the columns are of section 50 × 50 cm² and the story height is 3 m with solid 20 cm thick slabs [21].

The bilinear behavior of the LRB isolation system, making it possible to successively determine the geometric and mechanical characteristics of the different types of isolators considered in this study.

3. Results

This investigation allowed us to obtain the following results:

- The design displacement of the LRB isolator obtained by the American code IBC2000, estimated at 22.41 cm, is very close to the value found by the proposed approach for the Algerian earth-quake code, estimated at 28.46 cm.
- The base shear force evaluated by the novel approach for the Algerian seismic code concords with the nonlinear analysis method according to the IBC2000 code for near source seismic exci-tations, with more than 90% similar results.

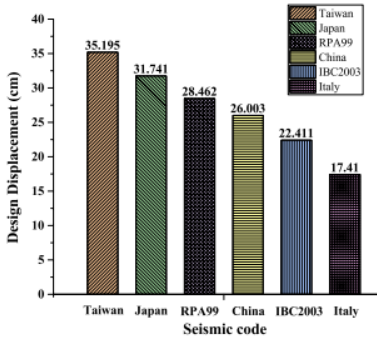

Fig. 6 Design displacement between different codes

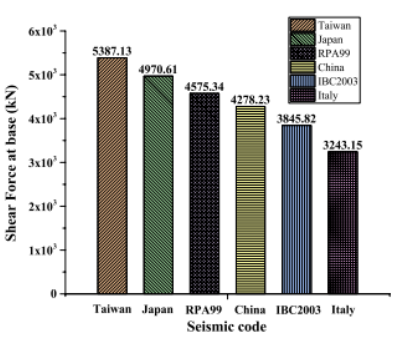

Fig. 7 Shear base between different codes

4. Conclusion

The new approach gives very good results according to various regulations cited in literature. The response in design displacement and shear force at the base obtained by the proposed method represents an average value considering the various regulations.
A comparative analysis of the proposed approach, based mainly on the equivalent linear method, with the nonlinear history analysis shows good agreement for seismic excitations at near field.

5. References

[1] KANAMORI H: QUANTIFICATION OF EARTHQUAKES. NATURE (1978),**271**(5644): 411
[2] TAKEWAKI I: *BUILDING CONTROL WITH PASSIVE DAMPERS OPTIMAL PERFORMANCE-BASED DESIGN FOR EARTHQUAKES*. JOHN WILEY & SONS, 2011.
[3] KELLY J. M: ASEISMIC BASE ISOLATION: REVIEW AND BIBLIOGRAPHY. SOIL DYNAMICS AND EARTHQUAKE ENGINEERING 1986, **5**(4): 202-216.
[4] CAMERON, W I., GREEN R. A. DAMPING CORRECTION FACTORS FOR HORIZONTAL GROUND-MOTION RESPONSE SPECTRA. BULLETIN OF THE SEISMOLOGICAL SOCIETY OF AMERICA, 2007,**97**(3), 934–960.
[5] DJEDOUI N, OUNIS A., MAHDI A. AND S. ZAHRAI M. SEMI-ACTIVE FUZZY CONTROL OF TUNED MASS DAMPER TO REDUCE BASE-ISOLATED BUILDING RESPONSE UNDER HARMONIC EXCITATION. JORDAN JOURNAL OF CIVIL ENGINEERING 2018, **12**(3).
[6] BHANDARI M., BHARTI S., SHRIMALI M. AND DATTA T. PERFORMANCE OF BASE-ISOLATED BUILDING FRAME FOR EXTREME EARTHQUAKES. RECENT ADVANCES IN STRUCTURAL ENGINEERING 2019, VOLUME 1, SPRINGER: 1025-1036.
[7] OUNIS, H. M. AND OUNIS A. PARAMETERS INFLUENCING THE RESPONSE OF A BASE-ISOLATED BUILDING. SLOVAK JOURNAL OF CIVIL ENGINEERING 2013, **21**(3): 31-42.
[8] FENG D., MIYAMA T., LIU W., YANG Q. AND CHAN T.-C. (). "A NEW DESIGN PROCEDURE FOR SEISMICALLY ISOLATED BUILDINGS BASED ON SEISMIC ISOLATION CODES WORLDWIDE." PROCEEDINGS OF 15WCEE 2012.
[9] MEVADA, S. V. AND JANGID R. SEISMIC RESPONSE OF TORSIONALLY COUPLED SYSTEM WITH SEMI-ACTIVE VARIABLE DAMPERS." JOURNAL OF EARTHQUAKE ENGINEERING 2012, **16**(7): 1043-1054