"Comparative Analysis of Telecommunication Tower Mounted On Roof Top with Base Isolation System"- A Literature Review

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Abstract— The increasing trend of mobile communications has seen exponential growth in the last three years. The communication industries have seen a tremendous increase in last few years which have resulted in installation of large number of towers to increase the coverage area and network consistency. The availability of land which satisfies ideal installation conditions in urban areas is extremely limited giving no alternative but to adopt roof tops. Generally for telecommunication purpose, the four legged supporting tower are used widely. Nowadays mostly the telecommunication towers as we see are mounted on rooftops of structures like commercial buildings, hotels and etc. Non-structural components are sensitive to large ground motion which produces floor accelerations, velocities, and displacements. During an earthquake, the building produces this motion, resulting in peak floor accelerations higher than the peak ground acceleration. Thus earthquake ground motion can cause significant or severe structural damages. The use of base isolation is the best method to reduce inter-storey drift and floor accelerations. This study helps to understand the behaviour of such structures under different conditions with different systems with the help of the previous studies done on it.

Keywords: Telecommunication Tower, Seismic Effects, Wind Effects, Roof Mounted Tower, Base Isolation, Etabsv18, RCC Structures

I. INTRODUCTION

Telecommunication towers are tall structure usually designed for supporting parabolic antennas which are normally used for microwave transmission for communication, also used for sending radio, television signals to remote places and they are installed at a specific height. These towers are self-supporting structures and categorized as three-legged and four-legged space trussed structures. The self-supporting towers are normally square or triangular in plan and are supported on ground or on buildings. Triangular towers attract lesser wind loads compared with square towers.

However they are used only for smaller heights of tower due to difficulties in joint detailing and fabrication using angle sections. Telecommunication towers or lattice towers are classified into three categories that are Guyed masts, monopole and self-supporting towers. Generally, they act as cantilever trusses and are designed to carry wind load as the only source of environmental loads. Except for critical structures built in high seismic hazard areas, earthquake-induced loads are generally neglected in design. The major cause of failures of telecommunication tower throughout the world though still remains to be high intensity winds (HIW). The major problem faced is the difficulty in estimating wind loads as they are based on a probabilistic approach. There have been several studies in telecommunication towers taking into consideration the wind as well as seismic effect. These towers even though demand more steel but cover less base area, due to which they are suitable in many situations. The availability of land which satisfies ideal installation conditions in urban areas is extremely limited giving no alternative but to adopt roof top towers with marginal adjustment in position but not in height. This practice is mainly due to the fact that telecommunication towers built on ground have shown good performance in past earthquakes. However, towers mounted on rooftops respond to lateral motions differently than those built on firm ground.

Radio masts and towers are, typically, tall structures designed to support antennas (also known as aerials) for telecommunications and broadcasting, including television. There are two main types: guyed and self-supporting structures. They are among the tallest man-made structures. Masts are often named after the broadcasting organizations that originally built them or currently use them. In the case of a mast they are called radiator or radiating tower, the whole mast or tower is itself the transmitting antenna. They are also known as Telecommunication towers.

A commercial building is a building that is used for commercial purpose. Types can include office buildings, warehouses, or retail (i.e. convenience stores, big box stores, shopping malls, etc.). In urban locations, a commercial building often combines functions, such as an office on levels 2-10, with retail on floor 1. When space allocated to multiple functions is significant, these buildings can be called multi-use. Local authorities commonly maintain strict regulations on commercial zoning, and have the authority to designate any zoned area as such. A business must be located in a commercial area or area zoned at least partially for commerce.

People are structurally illiterate and want to install the telecommunication tower on the existing buildings for the sake of additional earning without caring for public safety. Such installed towers are the potential hazards for the public and may cause fatal accidents.

This study is aim to find out if the forces in telecommunication tower design to be installed at ground level is similar to the tower design with building model. Also to find out if the load on building structure is nominal and can be with stand by the building elements easily or not.

A. Base Isolation

The concept of base isolation is explained through an example building resting on frictionless rollers. When the ground shakes, the rollers freely roll, but the building above does not move. Thus, no force is transferred to the building due to shaking of the ground; simply, the building does not experience the earthquake. Now, if the same building is rested on flexible pads that offer resistance against lateral movements, then some effect of the ground shaking will be transferred to the building above. If the flexible pads are properly chosen, the forces induced by ground shaking can be a few times smaller than that experienced by the building built directly on ground, namely a fixed base building. The flexible pads are called base-isolators, whereas the structures protected by means of these devices are called base-isolated buildings. The main feature of the base isolation technology is that it introduces flexibility in the structure. As a result, a robust medium-rise masonry or reinforced concrete building becomes extremely flexible. The isolators are often designed to absorb energy and thus add damping to the system. This helps in further reducing the seismic response of the building. Several commercial brands of base isolators are available in the market, and many of them look like large rubber pads, although there are other types that are based on sliding of one part of the building relative to the other. A careful study is required to identify the most suitable type of device for a particular building. Also, base isolation is not suitable for all buildings. Most suitable buildings for base-isolation are low to medium-rise buildings rested on hard soil underneath. High-rise buildings or buildings rested on soft soil are not suitable for base isolation.

B. Purpose of Base Isolation

The basic criteria while providing superior seismic resistance of a building is the difficulty in minimizing the inter storey drift and floor accelerations simultaneously. Large inter storey drifts cause damage to non- structural components. These drifts can be minimized by stiffening the structure, but this leads to amplification of the ground motion, which leads to high floor acceleration, which can damage non-structural components. Making the system more flexible can reduce floor acceleration, but this leads to large inter storey drifts. The only practical way of reducing inter storey drift and floor acceleration simultaneously is to use Base Isolation, which provides the necessary flexibility, with the displacements concentrated at the isolation level. In traditional approaches, in order to achieve capacity we should increase the elastic strength or else to maintain ductility. This leads to increase in floor accelerations and damage to structural components. Where as in Base Isolation, rather than increasing capacity we decrease demand as we cannot indefinitely increase the strength of the structure. As earth quakes cannot be predicted or controlled, we modify demand by mitigating effects of the foundation to super structure. There are many possible ways to strengthen the system by introducing several devices in structural system. These include elastomeric bearings, sliders, rollers, sliding plates, rocking foundations etc. Of these elastomeric bearings and sliding foundations are most practical ones. Seismic isolation is intended to prevent earthquake damage to structures, buildings and building contents. One type of seismic isolation system employs load bearing pads, called Isolators. Since the isolators carry large vertical loads and deform to significant lateral displacement, the components of the structure above and below the isolator need to be designed properly. Specifically, to make isolation system work in proper manner, the structure should be free to move in any direction up to the maximum specified displacement. Base isolation is achieved by inventing several isolation devices to meet the desired requirements of an earthquake resistant structure.

C. Main Objectives of Base Isolation

- To lengthen Period of vibration
- To reduce Relative displacements
- Maintain Rigidity at low seismic intensity of loads

Whenever the earth quake risk is higher and to develop an effective and economical seismic resistant structure we adopt isolation technique. Safety is the major criterion to be considered. If Earth Quake forces are dominant compared to other forces then we use Base Isolation. Flexibility and damping are the major aspects in Base isolation.

D. Isolation Devices

For superior seismic isolation of a structure we have to choose the appropriate system and the essential features for such system should be as follows:

- Capable in supporting the structure
- Provide horizontal flexibility
- Capable to dissipate energy

Isolation system should be rigid for low lateral loads to avoid vibration at frequent minor earthquakes or wind loads. Basic Requirements to develop a new base isolation device by overcoming the possible disadvantages of other devices are:

- Possibly its manufacturing should be a combination of several types of seismic isolators.
- Accommodation of tension forces should not occur suddenly but progressively in order to prevent impact loads on the isolated super structure.
- Permanent tension capacity to receive tension forces should occur in isolator.

II. LITERATURE REVIEW

Many methods have been proposed for achieving the optimum performance of structures subjected to earthquake excitation. The use of lead rubber bearing isolators for absorbing energy is the best technique. Many papers have been published related with base isolation technique as an earthquake resistant device. Some of them are discussed below.

Amiri and Boostan (2000) studied the dynamic response of antenna-supporting structures. In this regard, self-supporting steel telecommunication towers with different heights were evaluated considering the wind and earthquake loads. A comparison is made between the results of wind and earthquake loading. These comparisons resulted in the necessity of considering earthquake loads in tower analysis and design.

Amiri et al. [5], (2002) carried out the dynamic analysis of 10 existing self-supporting telecommunication towers varying height from 18 to 67m scaled using spectra of Tabas, Naghan and Manjil earthquake with respect to Iranian 2800 seismic code, which are among major earthquakes in Iran and comparison was made between the results of wind and seismic loading. It was observed that the values obtained from wind load exceed from earthquake load.

McClure G. et al. [3], (2004) presented the seismic response of two self-supporting telecommunication lattice towers of height 30m and 40m, mounted on the rooftop of two medium-rise buildings: Burniside Hall, which is located on McGill Campus, and 2020 University, which is located nearby in downtown Montreal. The time history analyses were used to explore the correlation between the building accelerations and maximum seismic base shear as well as the base overturning moment of towers mounted on building rooftops.

Pozo et al., [9], (2006) studied the active-passive base-isolation systems used for the seismic response control of structures appears to be effective for small to medium strength earthquakes. Hybrid base isolation systems, which use an active system together with the passive base isolation system, may be used to control the response of structures subjected to larger ground motions created by larger magnitude earthquakes. The hybrid base isolation system using passive base isolation pads together with hydraulic type actuators is proposed. The system, placed between the foundation of the building and its superstructure, is used to minimize the forces imposed on the superstructure by the earthquake induced ground motion.

Iskhakov et al. [10], (2007) In some cases the displacements at the base isolation level are rather big and exceed the allowed limits. In such cases it is recommended to add dampers to the base isolation system.

Matsagar et al. [11], (2008) Analytical seismic responses of structures retrofitted using base isolation devices are investigated by Matsagar and Jangid for the retrofitting of various important structures as historical buildings, bridges, and liquid storage tanks are selected to investigate the effectiveness of the base isolation in seismic retrofitting. It is observed that the seismic response of the retrofitted structures reduces significantly in comparison with the conventional structures depicting effectiveness of the retrofitting done through the base isolation technique.

Chia-Ming et al. [12], (2010) Chia-Ming and Spencer presented development and experimental verification of an active base isolation system for a seismically excited building and modeling the complex nature of control-structure interaction (CSI).

Siddesha H. [4], (2010) presented the wind analysis of microwave antenna tower with Static and Gust Factor Method (GFM).The comparison is made between the tower with angle and square hollow section. The displacement at the top of the tower is considered as the main parameter. The analysis is also done for different configuration by removing one member as present in the regular tower at lower panels.

Jung et al [13], (2011) have investigated a smart base-isolation system using magneto-rheological (MR) elastomers, which are a new class of smart materials whose elastic modulus or stiffness can be adjusted depending on the magnitude of the applied magnetic field. The results further suggest that the feasibility of using MR elastomers as variable stiffness elements for enhancing the performance of conventional base-isolation systems.

Zhang et al. [14], (2011) have studied the influence of the action of coupling earthquake to sliding base-isolation structure for 6 story building. The results by exemplification show that the peak values of relative acceleration, relative displacement and inter-storey shear force of sliding base-isolation structure increase in different degree under the action of coupling earthquake.

Nitin Bhosale (2012) has carried out the seismic response of 4 legged telecommunication towers under the effect of design spectrum from the Indian code of practice for zone – IV. The axial forces of the tower member were considered and comparison between roof top mounted tower and tower supported at ground had been performed to find out the difference.

Richa Bhatt (2013) carried out study on the influence of modelling in lattice mobile towers under wind loading wherein the towers are analyzed for gust factor wind. Displacements, Member forces and maximum stress have been compared to find out the effect on towers.

Jithesh Rajasekharan et al. [6], (2014) In this dissertation, studies are been carried out on models of varying heights with different bracing for seismic along with the wind effect. The wind effect on the structure is studied by using the gust factor method and the seismic effect on the structure is studied by carrying out the modal analysis and response spectrum analysis. The results obtained from the above analysis are tabulated, compared

Hemal J shah et al. [7], (2014) In the present study earthquake response of 4 towers of different height are studied considering different bracing system of the tower. The towers of different height are modeled in SAP 2000 software and static and dynamic analysis of the tower has been carried out. In addition to this time history of the bhuj earthquake is applied on all towers and the response of the tower is studied.

Christoph Adam and Thomas Furtmuller in his fundamental parametric study the seismic performance of Tuned Mass Dampers (TMDs) is investigated. Earthquake excited vibration prone structures modeled as elastic single-degree-of-freedom oscillators and they are equipped with a single TMD. The TMD performance assessed by means of response reduction coefficients, which are generated from the ratio of the structural response with and without TMD attached. It is found that TMDs are effective in reducing the dynamic response of seismic excited structures with light structural damping. The results of the presented study are based on a set of 40 recorded ordinary ground motions.

Kourosh Talebi Jouneghaniin his study the application of tuned mass damper in improving the response of structures is considered. At first, three frames of 3, 9 and 20 stories are evaluated in which time history analysis is done according to El – Straw earthquake. The maximum reduction of among the three mentioned frames belongs to a 20-stories structure in which the rate of story displacement reduction is between 25 to 45%, and this indicates that by increasing the height of the structure, the performance of tuned mass damper improved. In the second part, the effect of semi-active tuned mass damper is studied on a 10-stories frame. Studies showed that using a tuned mass damper system with viscous damper with controller force decreases the average of maximum displacement of roof story down to 39.9 % and this amount of reduction is 22.8% for semi- active tuned mass damper. Finally, the performance of tuned Single and multiple mass Damper is evaluated on a 20- stories frame, and the results show that single and multiple dampers decrease structures 'responses and the performance of tuned multiple dampers depends on the mass and frequency ratio and also concluded that the performance of tuned multiple mass dampers is reduced by transition to middle of the structure stories.

Min Ho Chey in his research this thesis explores next generation passive and semi-active tuned mass damper (PTMD and SATMD) building systems for reducing the seismic response of tall structures and mitigating damage. The proposed structural configuration separates the upper storey(s) of a structure to act as the 'tuned' mass, either passively or semi actively. In the view point of traditional TMD system theory, this alternative approach avoids adding excessive redundant mass that is rarely used. In particular, it is proposed to replace the passive spring damper system with a semi active resettable device based system (SATMD). This semi-active approach uses feedback control to alter or manipulate the reaction forces, effectively re- tuning the system depending on the structural response. In this trade-off parametric study, the efficacy of spreading stiffness between resettable devices and rubber bearings is illustrated. Spectral analysis of simplified 2-DOF model explores the efficacy of these modified structural control systems and the general validity of the optimal derived parameters is demonstrated. The end result of the spectral analysis is an optimally-based initial design approach that fits into accepted design methods.

Anthony C. Webster and Rimas Vaicaitis in his research both analysis floor vibration problems appears to be on the rise,1.2 the use of mechanical damping devices to control vibrations is limited. In a recent survey of vibration control methods, Murray3 reports that passive-mechanical damping methods, including viscous damping, viscous-elastic damping, and tuned-mass dampers, have often gone untried outside the laboratory or have had marginal impact in actual buildings. This is particularly unfortunate because mechanical dampers can sometimes control floor vibrations more cheaply than structural stiffening, and are often the only viable means of vibration control in existing structures. This paper details the successful implementation of a tuned- mass damping system to reduce the steady-state vibrations of the long span, cantilevered, composite floor system at the Terrace on the Park Building in New York City. The experience with this implementation suggests that tuned mass dampers (TMDs) can be successfully employed to control steady-state vibration problems of other composite floor systems. The potential for general application of TMDs in composite floor systems is discussed, and areas for further research are suggested.

III. CONCLUSION

Recently various studies have been done on design of Telecommunication Towers, but in most studies the researchers have considered the effect of wind and seismic forces on the four legged self-supporting towers. However, no researches have provided the measure to overcome the effects of lateral forces. In this study, the prevention of the structure with preventive measure in the form of Base Isolation is to be provided. The following points have been concluded from the previous studies to overcome the problem.

1) Considering the importance of the additional external loads due to telecommunication tower on a building structure, it is been concluded that the design of the columns get effected tremendously hence the telecommunication tower should not be installed on the building which are not designed for such loads.
2) Further, rooftop towers cannot be based on analytical results obtained for a similar configuration situated at ground level, since the member forces in the tower mounted on rooftop are more than the member forces of tower installed at ground level.
3) It is been observed that the loads on RCC structure are not nominal and cannot be withstand by the existing member and need proper design check of the RCC structural member before installation of telecommunication tower on the existing structure.
4) If ever it is been decided to install the telecommunication tower on the existing building, it is essential to check the design of building model with communication tower before installation otherwise structural failure may cause fatality to the victims as the structure is quit heavy and may cause the fatal injury.
5) To study the behaviour of building with and with roof mounted tower under strong earthquake ground motion.
6) To carry out modelling and analysis of fixed base and base isolated buildings with and without roof mounted by using E-TABS software and study the effects of earthquake ground motions on these models.
7) To design and study the effectiveness of lead rubber bearing used as base isolation system.
8) To study the behaviour and carry out comparison between fixed base and base isolated building with and without roof mounted tower and compared them on the basis of their output results in the form of maximum shear force, maximum bending moment, base shear, storey drift and storey acceleration.
9) To study correlation between seismic acceleration parameter and base of the building with alternate base isolation system.

In this manner it could be possible to decide the effectiveness of this base isolation system, giving advices for future possible applications.

REFERENCES

[1] NitinBhosale, Prabhat Kumar, PandeyA.D.[1], (2012): "Influence of host structure characteristics on response of rooftop telecommunication towers" , International journal Civil and Structural Engineering, Volume 2,Issue No 3, 2012, ISSN NO. 0976 -4399.

[2] 2) Richa Bhatt, A.D.Pandey and Vipul Prakash[2], (2013): "Influence of Modeling in the Response of Steel Lattice Mobile Tower under Wind Loading", International Journal of Scientific Engineering and Technology, Volume 2 Issue 3, April 2013, ISSN: 2277-1581.

[3] 3) McClure G., Georgi L., Assi R [3], (2004): "Seismic considerations for telecommunication towers mounted on building rooftop", 13th World Conference on Earthquake Engineering, Vancouver, Canada, Paper No.1988.

[4] 4) H.Siddhesha [4], (2010): "Wind analysis of Microwave Towers", International Journal of Applied Engineering Research, Dindigul, 1(3), pp 574-584.

[5] 5) Amiri G., Boostan A.[5], (2002): "Dynamic response of antenna-supporting structures", 4th Structural Specialty Conference of the Canadian Society for Civil Engineering, pp.1-9.
[6] 6) JitheshRajasekharan, S. Vijaya[6], (2014): "Analysis of Telecommunication Towers Subjected to Seismic and Wind Loading" Volume, Issue 2July 2014, ISSN No.2349 – 3224.
[7] 7) Hemal J shah, Dr.Atul K Desai[7], (2014): "Seismic Analysis of Tall TV Tower Considering Different Bracing Systems", International Journal of Engineering, Business and Enterprise Applications (IJEBEA),ISSN NO. 2279-0039.
[8] 8) Konno T, Kimura E. [8], (1973): "Earthquake effects on steel tower structures atop buildings". Proceedings of the 5th World Conference on Earthquake Engineering, Rome, Italy, 1, pp 184-193.
[9] Pozo, F., Ikhouane, F., and Pujol, G.[9], (2006): "Adaptive back stepping control of hysteretic based isolated structures." Journal of Vibration and Control, Vol. 12, No. 4, pp. 373-394.
[10] Iskhakov, I. and Ribakov, Y.[10], (2007): "Modern trends in base isolation applications for seismic protection of historic buildings." in 10th International Conference on Studies, Repairs and Maintenance of Heritage Architecture, STREMAH 2007, June 4, 2007 - June 6, 2007, Prague, Czech republic, pp. 623-632.
[11] Matsagar, V. A. and Jangid, R. S.[11], (2008): "Base isolation for seismic retrofitting of structures." Practice Periodical on Structural Design and Construction, Vol. 13, pp. 175-185.
[12] Salic R. B., Garevski M. A. And Milutinovic Z. V., "Response of Lead-Rubber Bearing isolated Structure," The 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing, China.
[13] Kilar V. And Koren D., "Usage Of Simplified N2 Method For Analysis Of Base Isolated Structures," The 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing, China.
[14] Saiful Islam A. B. M., Jameel M., Ahmad S.I. And Jumaat M. Z., "Study On Corollary of Seismic Base Isolation System On Buildings With Soft Storey," International Journal of the Physical Sciences Vol. 6(11), pp. 2654-2661, 4 June, 2011 ISSN1992-1950 ©2011 Academic Journals.
[15] Di Sarno, L., Cosenza, E.and Pecce, M.R., "Application Of Base Isolation To A Large Hospital In Naples, Italy,"10thWorld Conference on Seismic Isolation, Energy Dissipation and active Vibrations Control of Structures, Istanbul, Turkey, May 27-30, 2007.
[16] Nakashima M.,Chusilp P., "A Partial View of Japanese Post-Kobe Seismic Design and Construction Practices",Disaster Prevention Research Institute, Kyoto University, Uji, Kyoto 611-0011, Japan.
[17] Ramallo J. C.,Johnson E. A.,Spencer B.F., Jr.,And Sain M.K, "Semiactive Building Base Isolation", The 1999 American Control Conference, San Diego, California, June 2–4, 1999.
[18] Ramallo J. C.; Johnson E. A., A. M. Asce; and B. F. Spencer Jr., M.Asce, "Smart Base Isolation Systems", 10.1061/ASCE/0733-9399/2002/128:10/1088.
[19] Jalali1 and P. Narjabadifam, "Optimum Modal Characteristics for Multi-Story Buildings Isolated with Lead rubber bearings", 4th International Conference on Earthquake Engineering, Taipei, Taiwan, October 12-13, 2006, Paper No. 187.
[20] Wen P. And Baifeng S., "Two Step Design Method For Base Isolation Structures", The 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing, China.
[21] Pradeep Kumar T. V. And D. K. Paul, "Force-Deformation Behavior of Isolation Bearings", 10.1061/ASCE/1084-0702/2007/12:4/527.
[22] Indian Standard Criteria for Earthquake Resistant Design Structure 1839-2002
[23] Shrikhande M. and Agrawal P., "Earthquake Resistant Design structure", Tata McGra Hill Publication, 10th Edition 2004.
[24] Duggle S.K., "Earthquake Resistant Design Structure", Tata McGra Hill Publication, 10th Edition 2004.
[25] Zanaica L., "Design of Storey-Isolation System in Multi-Storey Building" MEEES programmed, May,2007.
[26] Dhawade, S.M, "Comparative Study for Seismic Performance of Base Isolated & Fixed Based RC Frame Structure", International journal of civil engineering research, ISSN 2778 3652, Volume 5, Number 2,2014 pp.183-190
[27] Deb, S.K, "Seismic Base Isolation-An Overview", current science, volume 87, No.10,25 Nov.2004, pp. 1-5
[28] Buckle IG, Mayes RL. Seismic isolation: history, application and performance Ð a world overview. Earthquake Spectra 1990;6(2):161±202.
[29] Jangid RS, Datta TK. Seismic behaviour of base isolated buildings Ð a state-of-the-art review. Journal of Structures and Buildings 1995;110:186±203.
[30] Mostaghel N, Khodaverdian M. Dynamics of resilient friction base isolator (R-FBI). Earthquake Engineering and Structural Dynamics 1987;15(3):379±90.
[31] Rajasekharan, J. & Vijaya, S. (2014) Analysis of Telecommunication Tower Subjected to Seismic & Wind loading. International Journal of Advancement in Engineering Technology, Management and applied science.
[32] Amiri, G. & Boostan, A. (2002) Dynamic Response of Antenna-Supporting Structures. 4th Structural Specialty Conference of the Canadian Society for Civil Engineering. p.1-9.
[33] Nitin Bhosale, Prabhat Kumar and Pandey.A.D (2012): "Influence of Host Structure Characteristics on Response of Rooftop Telecommunication Towers", International Journal of Civil and Structural Engineering Volume 2, No 3, February 2012, ISSN 0976 – 4399.
[34] Da Silva, J.G.S., Da S. Vellasco, P.C.G., De Andrade, S.A.L. & De Oliveir, M.I.R. (2005). Structural assessment of current steel design models for transmission and telecommunication towers. Journal of Constructional Steel Research.
[35] Richa Bhatt, A.D.Pandey and Vipul Prakash (2013): "Influence of Modeling in the Response of Steel Lattice Mobile Tower under Wind Loading", International Journal of Scientific Engineering and Technology, Volume 2 Issue 3, April 2013, ISSN: 2277-1581.

[36] Islam ABMS, Ahmad SI (2010). Isolation System Design for Buildings in Dhaka: Its Feasibility and Economic Implication. Proceedings of the International Conference on Engineering Research, Innovation and Education. SUST. 11-13 January; Bangladesh, Sylhet. pp. 99-104.
[37] Balkaya C, Kalkan E (2003). Nonlinear seismic response evaluation of tunnel form building structures. Comput. Struct., 81: 153-165.
[38] Bhuiyan AR, Okui Y, Mitamura H, Imai T (2009). A rheology model of high damping rubber bearings for seismic analysis: Identification of nonlinear viscosity. Int. J. Solids Struct., 46: 1778-1792.
[39] Matsagar VA, Jangid RS (2004). Influence of isolator characteristics on the response of base-isolated structures. Eng. Struct., 26: 1735- 1749.
[40] Casciati F, Hamdaoui K (2008). Modelling the uncertainty in the response of a base isolator. Probabilistic Eng. Mechanics. 23: 427- 437.
[41] Yegian M.K.&Kadakkal U.- Foundation isolation for seismic protection using a smooth synthetic liner. Journal Of Geotechnical And Geoenvironmental Engineering © Asce / November 2004 /1123Bowman, M., Debray, S. K., and Peterson, L. L. 1993. Reasoning about naming systems.
[42] Kilar V, Koren D (2009). Seismic behaviour of asymmetric base isolated structures with various distributions of isolators. EngStruct., 31: 910- 921.
[43] Olsen A, Aagaard B, Heaton T (2008). Long-period building response to earthquakes in the San Francisco Bay Area. Bull. Seismological Society Am., 98(2): 1047-1065.